Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Volume III: Appendix III.K.10

2015 Regional Haze Progress Report

Appendix to Section III. K: Areawide Pollutant Control Program for Regional Haze

Adopted

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Alaska Regional Haze Progress Report

A. INTRODUCTION

Regional haze (RH) is pollution that impairs visibility over a large region, including national parks, forests, and wilderness areas. Regional haze is caused by sources and activities emitting fine particles and their precursors, often transported over large regions. Particles affect visibility through the scattering and absorption of light. Reducing fine particles in the atmosphere is an effective method of improving visibility. In Alaska, the largest source of haze forming emissions is wildland fire, followed by area sources and point sources.

Visibility impairment is tracked using a Haze Index in units of deciview (dv), which is related to the cumulative sum of visibility impairment from individual aerosol species as measured by monitors in the Interagency Monitoring of Protective Visual Environments (IMPROVE) network. Emissions that affect visibility include a wide variety of natural (e.g., wildland fires) and anthropogenic, or man-made, sources (e.g., industrial sources and vehicles).

In Section 169A of the 1977 Amendments to the Clean Air Act (CAA), Congress established a program for protecting visibility in 156 mandatory Federal "Class I" areas. Class I areas consist of national parks exceeding 6000 acres, wilderness areas and national memorial parks exceeding 5000 acres, and all international parks that were in existence on August 7, 1977. In the 1990 Amendments to the CAA, Congress added Section 169B and called on the U.S. Environmental Protection Agency (EPA) to issue rules addressing regional haze impairment from manmade air pollution and establishing a comprehensive visibility protection program for Class I areas.

The EPA promulgated the RH rule on July 1, 1999 (64 FR 35713). States are required under 40 CFR § 51.308 to submit state implementation plans (SIPs) to the EPA that set out each states' plan for complying with the RH rule. States must demonstrate reasonable progress toward meeting the national goal of a return to natural visibility conditions by 2064. The rule directs states to graphically show what would be a "uniform rate of progress," also known as the "glide path," toward natural conditions for each Class I area within the State and certain ones outside the State.

On March 29, 2011, the Alaska Department of Environmental Conservation (DEC) submitted its RH SIP to EPA. On February 14, 2013, EPA published final approval of the Alaska SIP submittal.[1]

1. State Implementation Plan Requirements for the 5-year Progress Report

Provisions of the RH rule contained in 40 CFR § 51.308(g) and (h) require each state to submit a progress report five years after the submittal of their initial RH SIP. The progress report must be in the form of a SIP revision and must include a determination regarding the adequacy of the existing regional haze SIP. This report has been prepared to fulfill all applicable requirements pertaining to the 5-year progress report of the initial regional haze SIP.

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[1] Federal Register 78 FR 10546.

The progress report SIP must include

1. The status of implementation of control measures included in the original regional haze SIP
2. A summary of emission reductions achieved through the implementation of control measures
3. An assessment of visibility conditions
4. An analysis of the changes in emissions of visibility impairing pollutants
5. An assessment of significant changes in anthropogenic emissions that may have limited or impeded progress in improving visibility
6. An assessment of whether the current SIP elements and strategies are sufficient to meet reasonable progress goals
7. A review of the state's visibility monitoring strategy
8. Determination of the adequacy of the existing implementation plan.

Much of the technical data included in this progress report are from the *"Western Regional Air Partnership Regional Haze Rule Reasonable Progress Summary Report"* (WRAP Report) developed by the Western Regional Air Partnership (WRAP)[2] in June of 2013 and the WRAP Technical Support System (TSS), see Appendices A-D. The WRAP Report was prepared 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 Class I areas located in the western states. Data are presented in this report on a regional, state, and Class I area specific basis to characterize the difference between 2000-2004 baseline conditions and current conditions, represented here by the first progress period 5-year average, that is, the 2005-2009 period. In addition to the information provided in the WRAP Report, this Alaska Progress Report includes analysis reflecting 5-year averages through 2013, prepared by DEC. Changes in visibility impairment are characterized using aerosol measurements from the IMPROVE network, and the differences between emissions inventory years represent both the baseline and current progress period.

As required by 40 CFR §51.308(i), the regional haze SIP must include procedures for continuing consultation between the States and federal land managers (FLMs) on the implementation of the visibility protection program, including development and review of implementation plan revisions and 5-year progress reports, and on the implementation of other programs having the potential to contribute to impairment of visibility in any mandatory Federal Class I area within the State. The State of Alaska reaffirms its commitment to participate in a Regional Planning Process with Arizona, California, Colorado, Idaho, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming, the United States Department of Interior (USDI) Fish and Wildlife Service (FWS) and National Park Service (NPS), and the United States Department of Agriculture (USDA) Forest Service (FS). Consultation through WRAP also includes consultation with other regional planning organizations.

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[2] 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 RH regulations. Detailed information regarding WRAP support of air quality management issues for western states is provided on the WRAP website (www.wrapair2.org). Data summary descriptions and tools specific to RHR support are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

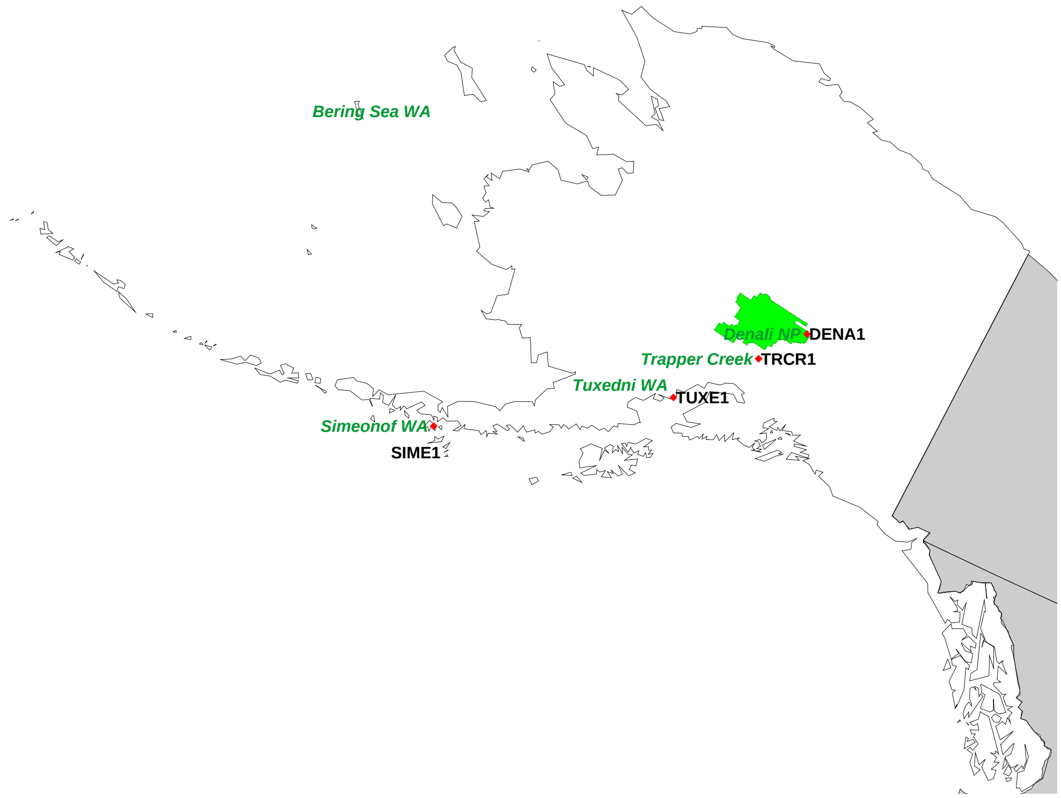
In addition to consultation with the FLMs, the State continues to work with tribes in Alaska. Tribes can provide input on this plan during the public comment period offered by the state and have the opportunity for consultation with EPA on this report.

The State of Alaska concludes the current RH SIP is adequate to address the reasonable progress goals of the state's four Class I areas. Based on the progress made over the 5-year period reviewed, no revisions to the Alaska Regional Haze SIP are needed at this time.

2. Alaska Class I Areas

Alaska has four Class I areas within its borders: Denali National Park and Preserve, Tuxedni National Wildlife Refuge, Simeonof Wilderness Area, and the Bering Sea Wilderness Area, see Exhibit 1. In developing the initial RH SIP, DEC determined that visibility in Alaska's Class I areas is not affected by emission sources in other states. Likewise, it was determined that Alaskan emission sources do not affect visibility in Class I areas in other states. Therefore, no emission sources or Class I areas outside Alaska are reviewed in this report.

Exhibit 1 – Map of Federal Class I Areas and Representative IMPROVE Monitors in Alaska[3,4]



[3] The Bering Sea Wilderness Area is not equipped with a IMPROVE monitor due to its geographical remoteness and lack of infustructure required to support contionous monitoring.
[4] The Trapper Creek Monitor (TRCR1) is a monitor for the Denali Class I area.

B. PROGRESS TOWARDS REASONABLE PROGRESS GOALS

Progress towards visibility goals during the first progress period varied by Class I area. Based on IMPROVE monitoring data, Simeonof and Tuxedni showed improved visibility on the 20% worst days in both the first and the most recent 5-year averaging period (2005-2009 and 2009-2013 respectively) when compared to the baseline monitoring values. Visibility at Trapper Creek and Denali decreased in the first progress period, but improved during the 2009 to 2013 period. Even though Denali showed an improvement during the second 5 year period (2009-2013) it remained above the initial baseline visibility, shown in Exhibit 2.

During the 2009-2013 averaging period, Trapper Creek, Tuxedni, and Simeonof all showed deciviews values below the 2018 reasonable progress goal.

On the 20% best days, during the first progress period (2005-2009), visibility remained the same at Denali Headquarters and decreased at the three other sites. During the 2009-2013 averaging period, visibility decreased at Denali by 0.1 deciview and improved at the other sites compared to the first averaging period. Nonetheless, visibility at Trapper Creek, Tuxedni, and Simeonoff remained above the baseline values. A contributing factor to results from Denali and Trapper Creek during the 2009-2013 reporting period were wildfires which burnt nearly three million acres in 2009. Analysis of the first progress period, 2005-2009, in the WRAP Report indicates that none of the deciview increases on the 20% worst days are statistically significant. The visibility improvement during that same period at Tuxedni was deemed statistically significant.[5]

The only statistically significant change in visibility on the 20% best days was a decrease in visibility at Trapper Creek.

The baseline and current visibility conditions, as well as the reasonable progress goals for 2018, for the 20% worst and 20% best days are displayed in Table 2.1. Additional information on source contributors and contributing aerosols can be found in Section C.4.

[5] Statistical significance was measured at the 85% confidence level.

Exhibit 2 – Class I Area IMPROVE Sites – Visibility Conditions 20% Most and Least Impaired Days

Class I Area	Baseline (2002-2004) (dv)	First Progress Period (2005-2009) (dv)	Most Recent (2009-2013) (dv)	2018 Reasonable Progress Goal (dv)	Natural Conditions (dv)
20% Worst Days					
Denali (DENA1)	9.9	10.6	10.2	9.3	7.3
Trapper Creek (TRCR1)	11.6	11.9	10.7	10.9	8.4
Tuxedni (TUXE1)	14.1	13.5*	12.2	13.4	11.3
Simeonof (SIME1)	18.6	18.5	17.7	17.9	15.6
20% Best Days					
Denali (DENA1)	2.4	2.4	2.5	–	1.77
Trapper Creek (TRCR1)	3.5	3.9	3.8	–	2.71
Tuxedni (TUXE1)	4.0	4.1	3.9	–	3.15
Simeonof (SIME1)	7.6	8.0	7.9	–	5.28

*Underlined values indicate that the change was statistically significant.

C. REGIONAL HAZE PROGRESS REPORT

1. Progress Report Requirements (40 CFR § 51.308(g))

The requirements for the progress report are outlined in 40 CFR § 51.308(g) and (h). The progress report must be in the form of a formal SIP submittal and must contain the following elements:

(g)*Requirements for periodic reports describing progress towards the reasonable progress goals.* Each State identified in § 51.300(b)(3) must submit a report to the Administrator every 5 years evaluating progress towards the reasonable progress goal for each mandatory Class I Federal area located within the State and in each mandatory Class I Federal area located outside the State which may be affected by emissions from within the State. The first progress report is due 5 years from submittal of the initial implementation plan addressing paragraphs (d) and (e) of this section. The progress reports must be in the form of implementation plan revisions that comply with the procedural requirements of § 51.102 and § 51.103. Periodic progress reports must contain at a minimum the following elements:

Control Measures (1) A description of the status of implementation of all measures included in the implementation plan for achieving reasonable progress goals for mandatory Class I Federal areas both within and outside the State.

Emission reductions (2) A summary of the emissions reductions achieved throughout the State through implementation of the measures described in paragraph (g)(1) of this section.

Visibility Conditions (3) For each mandatory Class I Federal area within the State, the State must assess the following visibility conditions and changes, with values for most impaired and least impaired days expressed in terms of 5-year averages of these annual values.

(i) The current visibility conditions for the most impaired and least impaired days

(ii) The difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions

(iii) The change in visibility impairment for the most impaired and least impaired days over the past 5 years

Tracking emissions changes by source (4) An analysis tracking the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State. Emissions changes should be identified by type of source or activity. The analysis must be based on the most recent updated emissions inventory, with estimates projected forward as necessary and appropriate, to account for emissions changes during the applicable 5-year period.

Significant anthropogenic emissions (5) An assessment of any significant changes in anthropogenic emissions within or outside the State that have occurred over the past 5 years that have limited or impeded progress in reducing pollutant emissions and improving visibility.

Sufficiency of current SIP (6) An assessment of whether the current implementation plan elements and strategies are sufficient to enable the State, or other States with mandatory Federal Class I areas affected by emissions from the State, to meet all established reasonable progress goals.

Monitoring plan (7) A review of the State's visibility monitoring strategy and any modifications to the strategy as necessary.

Determination of Adequacy (8) Determination of the adequacy of the existing implementation plan. At the same time the State is required to submit any 5-year progress report to the EPA in accordance with the monitoring plan, the State must also take one of the following actions based upon the information presented in the progress report:

(1) If the State determines that the existing implementation plan requires no further substantive revision at this time in order to achieve established goals for visibility improvement and emissions reductions, the State must provide to the Administrator a negative declaration that further revision of the existing implementation plan is not needed at this time.

(2) If the State determines that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another State(s) which participated in a regional planning process, the State must provide notification to the Administrator and to the other State(s) which participated in the regional planning process with the

> States. The State must also collaborate with the other State(s) through the regional planning process for the purpose of developing additional strategies to address the plan's deficiencies.
>
> (3) Where the State determines that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another country, the State shall provide notification, along with available information, to the Administrator.
>
> (4) Where the State determines that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources within the State, the State shall revise its implementation plan to address the plan's deficiencies within one year.

The following sections address these periodic review requirements.

2. Status of Implementation Control Measures: 40 CFR 51.308(g)(1)

40 CFR § 51.308(g)(1) requires *"a description of the status of implementation of all measures included in the implementation plan for achieving reasonable progress goals for Class I areas both within and outside the State."*

This section provides a description of the emission reduction measures that were included in the State of Alaska's RH SIP. A summary is provided below of those emission sources that were identified to impact Class I areas in Alaska and the status of controls.

Ammonium sulfate, particulate organic matter, sea salt are the largest contributors to visibility impairment at Alaska's Class I areas. Many of the contributing sources to visibility impairment in Alaska are natural, rather than anthropogenic, and are not controllable. Additional sources are located outside of the United States and are not controllable. The primary sources of ammonium sulfate are point and commercial marine sources. For particulate organic matter, the primary source of emissions is wildfire. Sea salt mostly affects Simeonof and Tuxedni, both of which are in marine environments. This report focuses on emission sources that are anthropogenic and produced within Alaska.

a. Emission Reductions due to Ongoing Air Pollution Programs

A number of existing air pollution programs contribute to visibility improvements in Alaska's Class I areas, some are state programs, and others are federal requirements. Relevant programs are discussed in the sections below.

b. Prevention of Significant Deterioration/New Source Review Regulations

The primary regulatory programs for addressing visibility impairment from industrial sources are the Prevention of Significant Deterioration (PSD) and New Source Review (NSR) rules. These rules protect visibility in Class I areas from new industrial sources and major changes to existing sources. Alaska's regulations (18 AAC 50 Article 3) and SIP require visibility impact assessment and mitigation associated with emissions from new and modified major stationary sources through protection of air quality relative values (AQRVs). AQRVS are scenic and environmentally related resources that may be adversely affected by a change in air quality, including visibility, odor, noise, vegetation, and soils. These visibility requirements were approved by EPA in 1983.

c. Reasonably Attributable Visibility Impairments BART Requirements

Reasonably Attributable Visibility Best Available Retrofit Technology (BART) requirements are separate and distinct from the Regional Haze BART rule and are initiated by a Federal Land Manager certifying impairment at a Class I area. Since the RH SIP was adopted, no action has been requested under this rule in Alaska.

d. Regional Haze BART Control

As part of the initial RH SIP development, point sources in Alaska were reviewed to determine their eligibility for BART. Six facilities were identified as being BART eligible and subsequently three were determined to benefit visibility with BART installed.

ConocoPhilips' Kenai LNG Plant has limits in place from a 2009 consent order by consent (COBC). This order limits the facility's emissions to levels that would have modeled visibility impacts of less than 0.5 deciview. An amendment to the COBC was signed by both parties in August 2013 and has since been incorporated into the facility's operating permit. The amendment modifies NO_X source testing and fuel H_2S monitoring and recordkeeping requirements such that they only apply in years when emission units are operating.

At the time of the initial RH SIP, the Agrium Plant was shut down and was determined to have zero emissions for BART eligible units. The plant is now seeking air quality permits to restart some operations. Under air quality permitting regulations, the plant is being treated as a new facility and must obtain a construction permit under PSD and NSR rules including an analysis of impacts to Air Quality Related Values.

The third facility needing to address BART requirements was Golden Valley Electric Association's (GVEA) Healy Power Plant. The facility includes two coal-fired steam generators: Unit 1 is 25 MWh and Unit 2 is 50 MWh. Unit 2 had not operated since test runs were completed in the late 1990's, but GVEA began making upgrade and started testing in 2015. GVEA anticipates beginning commercial operation by 2016. These activities occurred outside of the most recent 5-year period considered in this review. GVEA came to agreement with EPA on controls to meet BART requirements in a consent decree signed November 19, 2012. The decree requires GVEA to install additional controls for sulfate, nitrate, and particulate matter as Unit 2 comes online and requires specific milestones be met regarding the operations of Unit 1.

e. Implementation of Programs to Meet PM NAAQS

Both Mendenhall Valley in Juneau and Eagle River are now classified as maintenance areas for PM_{10}.

For the $PM_{2.5}$ nonattainment area in the Fairbanks North Star Borough, the state continues to work closely with local entities and submitted a SIP for the area on December 31, 2014. The SIP includes measures for increasing the supply of dry wood for use in area wood-fired heating devices, limits on opacity from solid-fuel fired heating devices during air quality episodes, emission requirements on new wood-fired heating devices, and additional public education. The state continues to pursue the expansion of natural gas availability for space heating; the borough's solid fuel heating device change out program continues, as well.

f. Measures to Mitigate Impacts of Construction Activities

There have been no changes to the requirements for construction activities in Alaska since the initial RH SIP was adopted.

g. Emission Limitations and Schedules for Compliance

The Alaska RH SIP did not contain specific emission limits or compliance schedules outside of BART.

h. Source Retirement and Replacement Schedules

DEC continues to track changes at point sources through its permit program. In 2013, several significant changes were made to the electricity production sector in South Central Alaska:

- Anchorage Municipal Light and Power's George Sullivan Plant Two's unit 1, GTG-5 Gas Turbine Generator rated for 480 Million BTU/hr, was reduced to operating as a reserve unit.
- Chugach Electric Association's reduced their Beluga plant's units 3 and 5, both GE Frame 7 engines, rated for 940 million BTU/hr each, to operating as reserve units.

In 2014, Alaska Electricity and Energy Cooperative's Nikiski plant added a steamer unit to improve efficiency, reducing overall fuel requirements within the railbelt grid.

Because these changes occurred after 2008, they are not reflected in the inventory used to evaluate progress in this report. Their emission reductions will be included in future inventories. Additional description of these changes is included in the discussion of anthropogenic emissions below.

i. Smoke Management for Agricultural and Forestry Burning

Wildfire smoke continues to be a major contributor to visibility impairment in Alaska.

DEC is a non-voting member of the Alaska Wildfire Coordinating Group (AWFCG) and works closely with member agencies to address air quality impacts from wildland fire. The AWFCG approved an update to the Alaska Enhanced Smoke Management Plan (ESMP) on June 3, 2015. Alaska's air quality open burning regulations have not changed over the last five years. DEC continues to work with entities wishing to conduct open burns to minimize smoke impacts.

j. Enforceability of Emission Limitations and Control Measures

40 CFR § 51.308(d)(3)(v)(F) of the RH rule requires that emission limitations and control measures used to meet reasonable progress goals be enforceable. Alaska has ensured that all existing emission limitations and control measures used to meet reasonable progress goals, for which the State of Alaska is responsible, are enforceable by embodying these in state regulations (18 AAC 50).

k. Anticipated Net Effect on Visibility over the Long-Term Strategy Period

Alaska's contribution of anthropogenic emissions to visibility impairment at Alaska's Class 1 areas is decreasing and is expected to decrease as the rules, regulations, and requirements discussed above continue to be implemented. However, emissions from uncontrollable sources, including natural events (wildfire and dust), international sources, global transport of emissions, and offshore shipping in the Pacific continue to impair visibility in Alaska. It is difficult to quantify the effects of uncontrollable emissions on visibility at Alaska's Class I areas.

3. Summary of Emissions Reductions Achieved: 40 CFR 51.308(g)(2)

40 CFR § 51.308(g)(2) requires *"a summary of the emissions reductions achieved throughout the state through implementation of the measures in paragraph (g)(1)."*

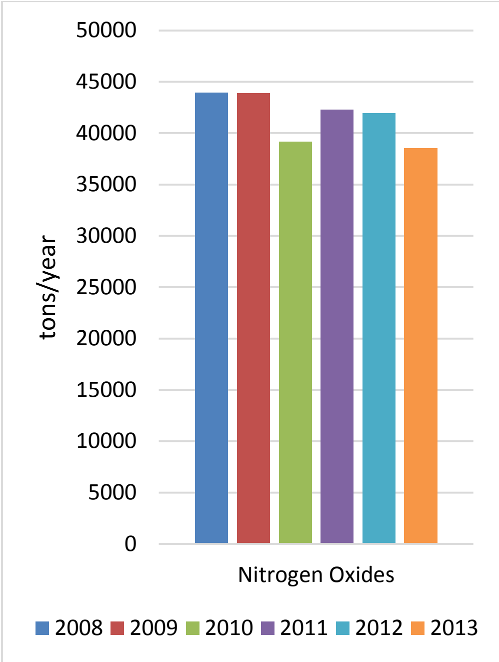
This section summarizes the emission reductions achieved from the measures discussed in section 2. All of these measures reduce emissions from pollutants that contribute to regional haze from controllable sources within Alaska. For most of the measures, it is difficult to calculate the emissions reduced, and even harder to correlate the contribution towards improving visibility within Class I areas.

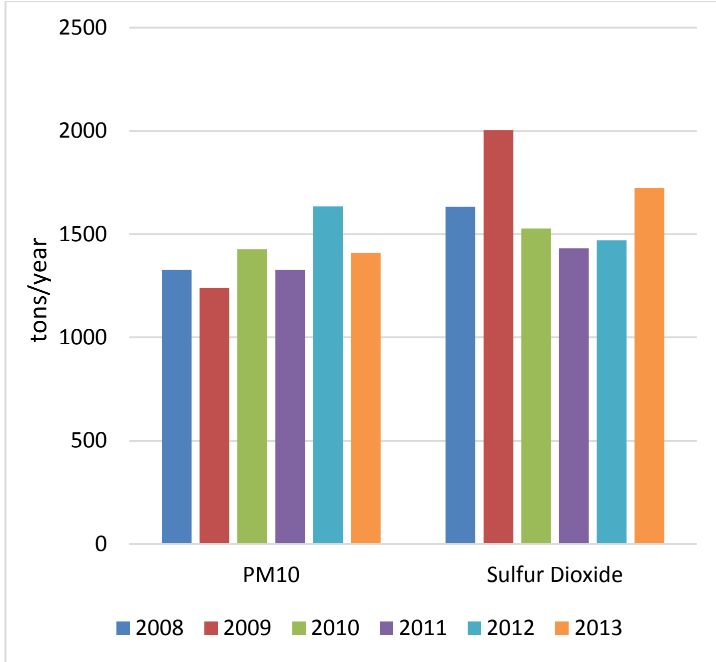
a. Anthropogenic Emissions

On-going emission reduction programs, such as federal motor vehicle requirements and local programs to reduce $PM_{2.5}$ emissions in the Fairbanks North Star Borough Nonattainment Area continue to take place and will have a positive impact on visibility.

Exhibit 3 displays emission changes at the largest point sources in Alaska between 2008 and 2013. Emissions from these sources vary from year to year. Overall, NO_X emissions show a downward trend for the 2008-2013 period. Over the same period, PM_{10} emissions have been increasing. It appears this trend is related to changes in electricity productions combined with fugitive dust from mining operations. Like NO_X, the SO_2 emissions generally show a downward trend with the exception of 2009, when emissions were noticeably higher. This increase during 2009 appears to be primarily driven by operational changes at the North Pole Power Plant. The quantity of fuel combusted at this one power plant dropped by almost half from 2009 to 2010. The quantity consumed in 2008 is not available.

Exhibit 3 – Large Permitted Point Source Emissions for SO_2, NO_2 and PM_{10} from 2008-2013[6]





More generally, some of the reductions in point source emissions result from electricity generation source installing cleaner generation units. Over the last several years, power plant owners and operators in South Central Alaska have brought new generation facilities online and are reducing the use of older, more polluting equipment; typically, these older units have become spinning reserves. Many of these changes are too recent to be captured in the emissions inventory data.

In 2013, Chugach Electric Association installed three new combined cycle gas-fired turbines at their International Power Plant location in Anchorage. As these units have come online, their simple cycle units at the Beluga River Power Plant are being used less. Matanuska Electric Association is completing construction of a new facility, the Eklutna Generating Station, which comprises 10 new 17 MW gas-fired generators. These units will offset purchased generation from Chugach's Beluga River Power Plant. The George Sullivan Plant Two's Unit 1 has been reduced to reserve operations. And at AEEC's Nikiski facility, a steamer unit has been installed, increasing the plant's efficiency. Additional new facilities are planned in the coming years, as well as additional renewable generation.

b. <u>Managing Fire Emissions</u>

Alaska continues to implement the Enhanced Smoke Management Plan (ESMP) to reduce the impact of prescribed burns on air quality. Prescribed burns in Alaska are primarily conducted in

[6] Data from Alaska's point source emissions inventory of sources that report every year.

military areas to reduce available fuels on live fire ranges and, thereby, the likelihood of ordinance starting a wildfire. Other prescribed fires are conduced to improve habitat.

In recent years, prescribed fires have reduced the emissions from the area burned by close to half of what they would have been if they had burned during a wildfire. Additional emissions reductions from prevented wildfires are not calculated. Acres treated, tons of $PM_{2.5}$ emissions averted, and tons of $PM_{2.5}$ emissions released from prescribed fires from 2005 through 2013 are shown in Exhibit 4. Information on wildland fires, which are responsible for a majority of $PM_{2.5}$ tons emitted, will be addressed later in Section C.5 and Exhibit 26.

Exhibit 4 – Prescribed Fire Acres and Emissions (tons/year)

Year	Acres Treated	Tons Averted[7]	Rx Tons Emitted
2005	626	–	215
2006	9,110	–	200
2007	21,761	79	4570
2008	4,081	16	454
2009	3,740	153	172
2010	22,136	261	227
2011	10,585	160	189
2012	12,095	172	193
2013	6,549	247	260

4. Assessment of Visibility Conditions: 40 CFR 51.308(g)(3)

40 CFR § 51.308(g)(3) requires "*for each mandatory Class I Federal area within the State, the state must assess the following visibility conditions and changes, with values for most impaired and least impaired days expressed in terms of 5-year averages of these annual values*

(i) The current visibility conditions for the most impaired and least impaired days;

(ii) The difference between current visibility conditions for the most impaired and least days and baseline visibility conditions;

(iii) The changes in visibility impairment for the most impaired and least impaired days over the past 5-years.

This section addresses RH rule requirements for monitored data as measured by IMPROVE monitors representing Federal Class I areas in Alaska. These summaries are supported by regional data presented and more detailed site-specific tables and charts presented in Appendices A, B, and C.

[7] Information not available for 2005 and 2006.

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

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

a. <u>Current Visibility Conditions for the Most and Least Impaired Days</u>

EPA Regional Haze Guidance, issued in 2003, specifies that 5-year averages be calculated over successive 5-year periods; i.e., 2000-2004, 2005-2009, 2010-2014, etc.[8] In 2013, EPA released "General Principles for the 5-year Regional Haze Progress Reports for the Initial Regional Haze State Implementation Plans" to assist states and regions with developing and reviewing the progress reports. In this second document, EPA recommends evaluating regional haze in successive 5-year rolling averages. Throughout this document, visibility is presented for three periods for which analysis is readily available:

- Baseline period (2000-2004)
- First progress period (2005-2009)
- Most recent five year average (2009-2013)

Exhibit 2, includes visibility conditions for all three periods. The statistical significance of the changes between the baseline and first progress period was determined and is noted in the table. Statistical significance was not determined for the most recent 5-year progress period. The following Exhibits (5 through 12) show annual average extinction as well as the 5-year rolling average for the period from 2000 through 2013 at the Denali IMPROVE site and beginning in 2002 at the other IMPROVE sites.

[8] EPA's September 2003 *Guidance for Tracking Progr4ess 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).

Exhibit 5 – Annual Average Speciated Extinction, DENA1, 20% Worst Days

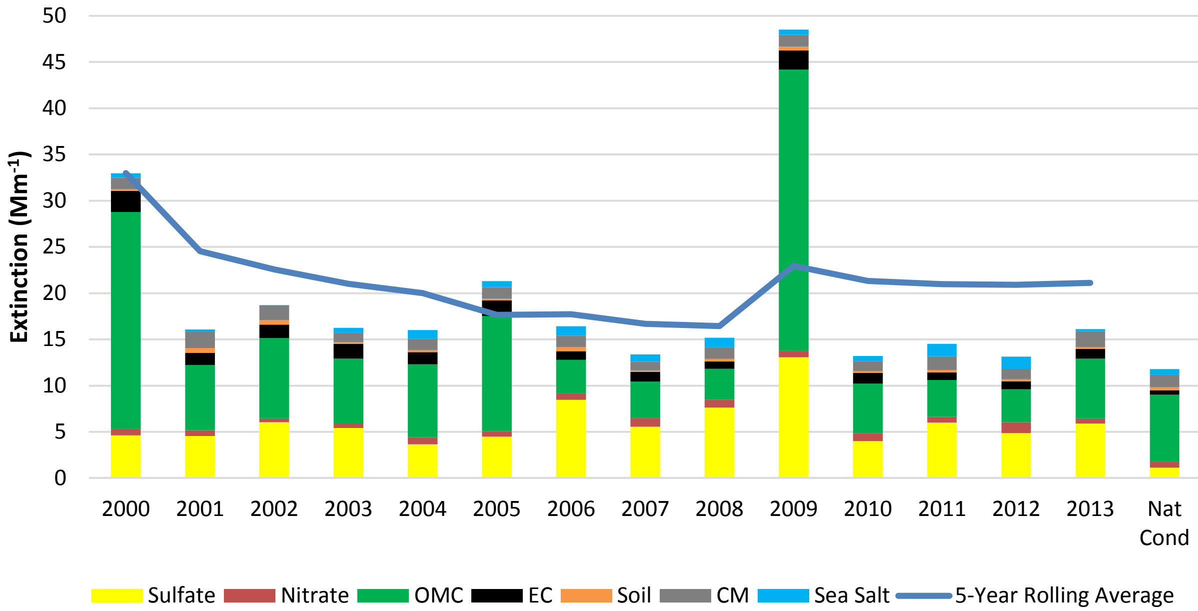


Exhibit 6 – Annual Average Speciated Extinction, DENA1, 20% Best Days

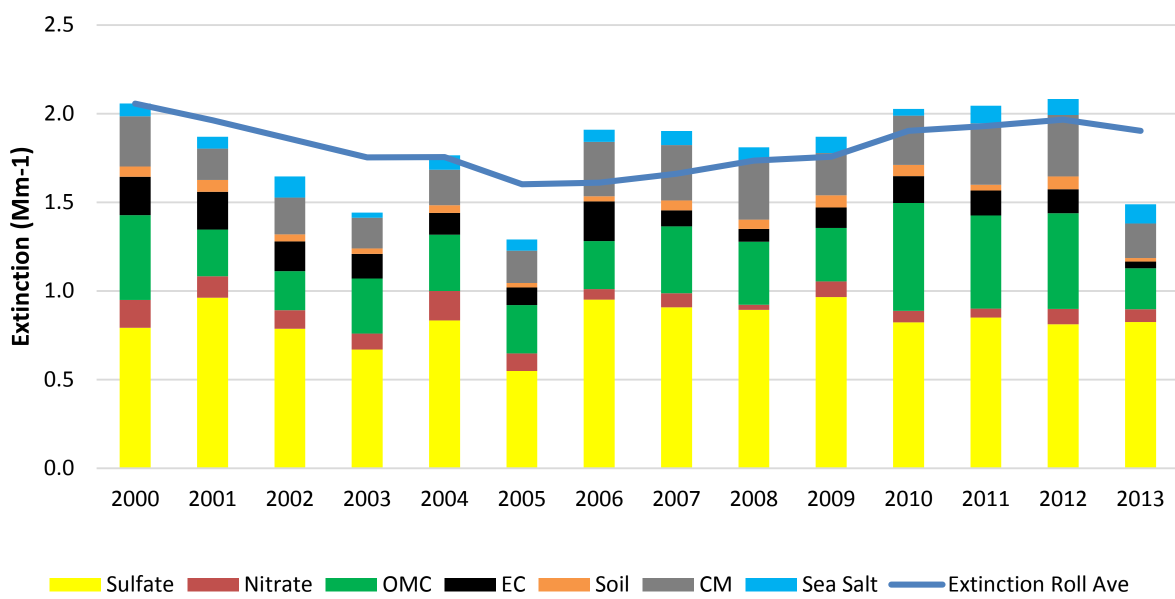


Exhibit 7 – Annual Average Speciated Extinction, SIME1, 20% Worst Days

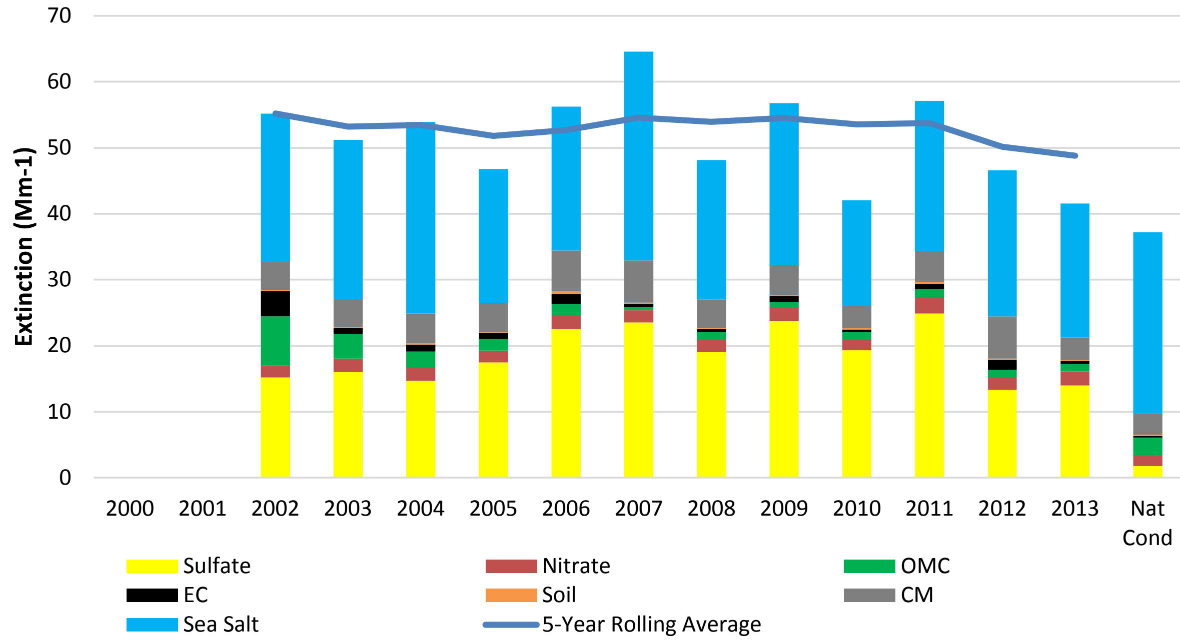


Exhibit 8 – Annual Average Speciated Extinction, SIME1, 20% Best Days

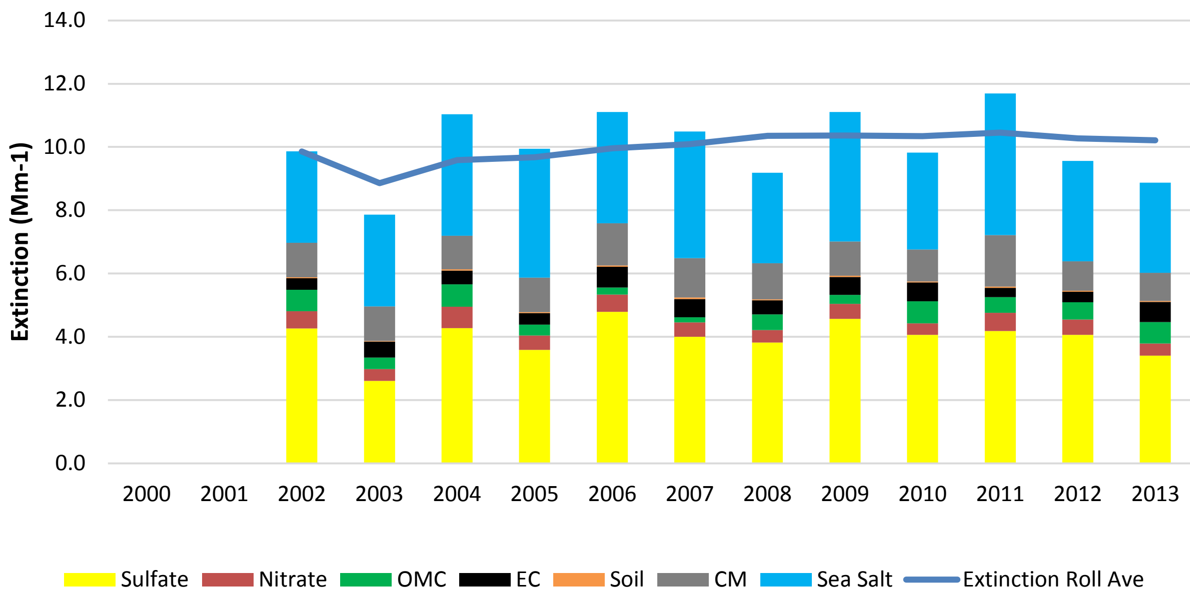


Exhibit 9 – Annual Average Speciated Extinction, TRCR1, 20% Worst Days

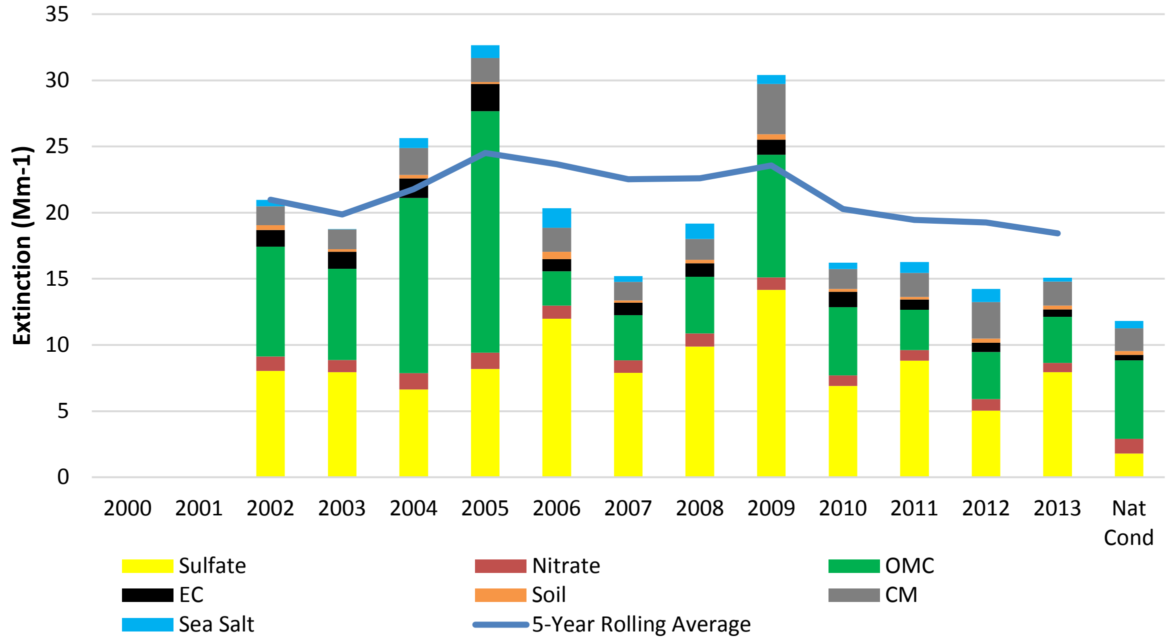


Exhibit 10 – Annual Average Speciated Extinction, TRCR1, 20% Best Days

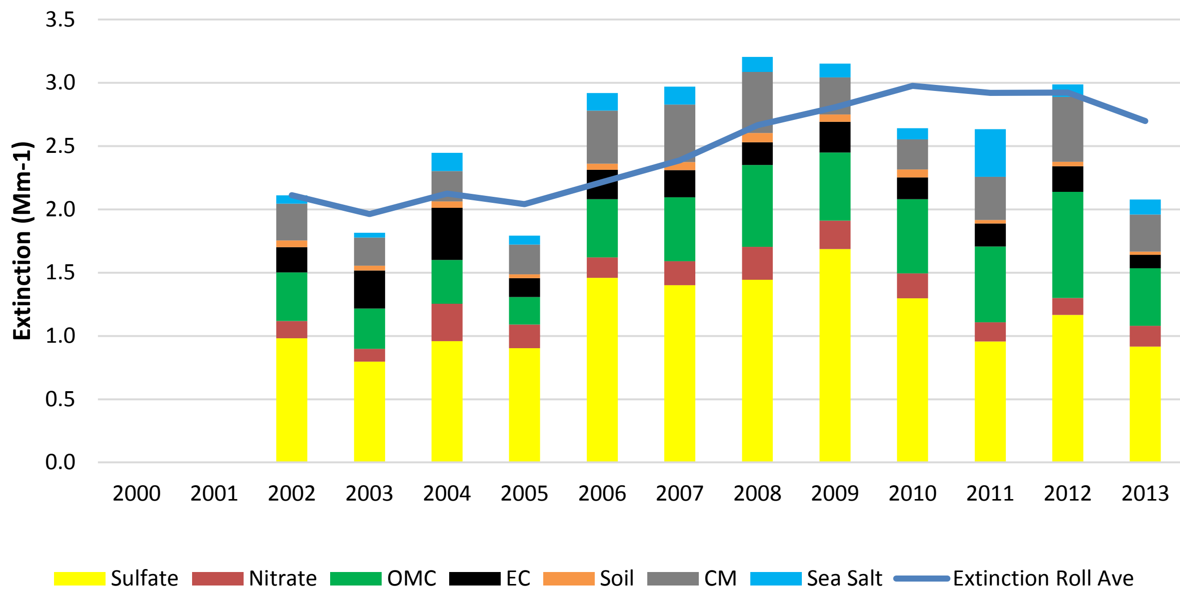


Exhibit 11 – Annual Average Speciated Extinction, TUXE1, 20% Worst Days

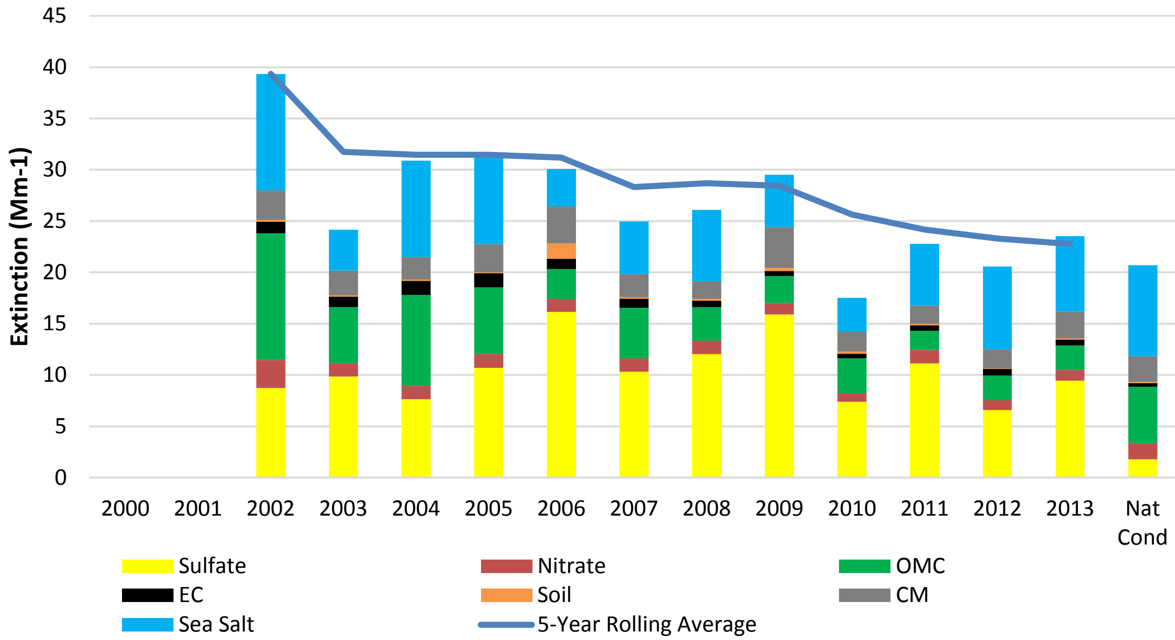
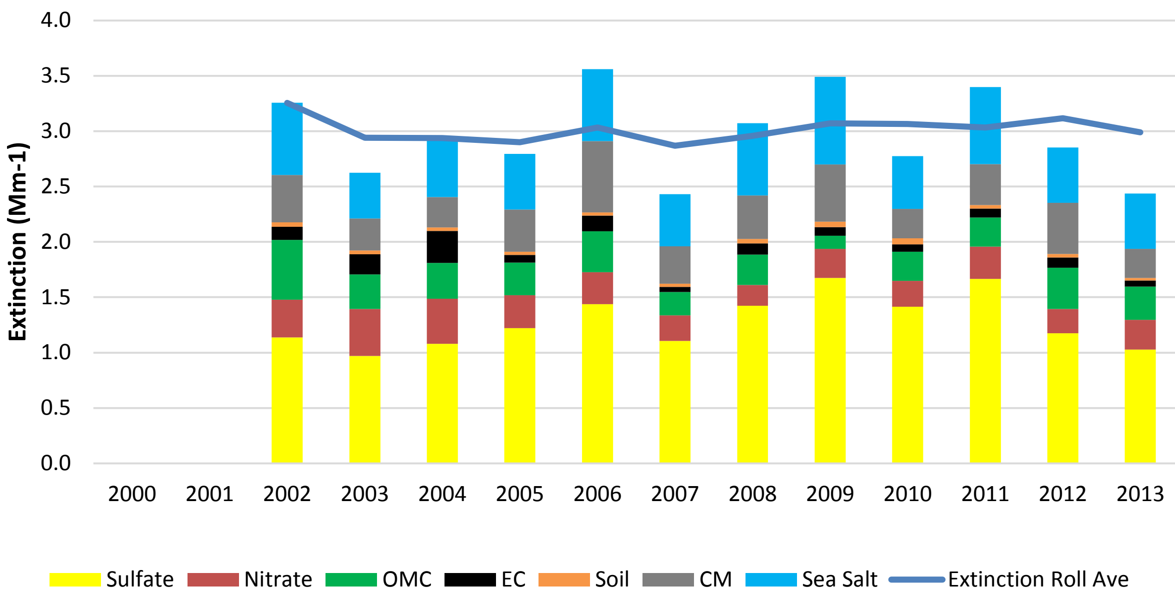


Exhibit 12 – Annual Average Speciated Extinction, TUXE1, 20% Best Days



Exhibits 13 and 14 present the calculated deciview values for first progress period, along with the percent contribution to extinction from each aerosol species for the 20% worst and 20% best days for each of the Federal Class I area IMPROVE monitors in Alaska.

Exhibit 15 presents 5-year average extinction for the first progress period for the 20% worst and best days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

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

- The largest contributors to aerosol extinction at each Alaska IMPROVE monitors
  - Denali and Trapper Creek – sulfate and particulate organic mass
  - Tuxedni – sulfate, particulate organic mass, and sea salt
  - Simeonof – sulfate and sea salt
- The highest aerosol extinction (18.6 dv) was measured at the SIME1 site, where sea salt was the largest contributor to aerosol extinction, followed by sulfate. The lowest aerosol extinction (10.6 dv) was measured at the DENA1 site. The largest contributors at this site were particulate organic mass, followed by sulfate.

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

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

Additional detail is presented in Appendix C.

Exhibit 13 – Visibility Conditions, 2005-2009 Progress Period, 20% Most Impaired Days

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

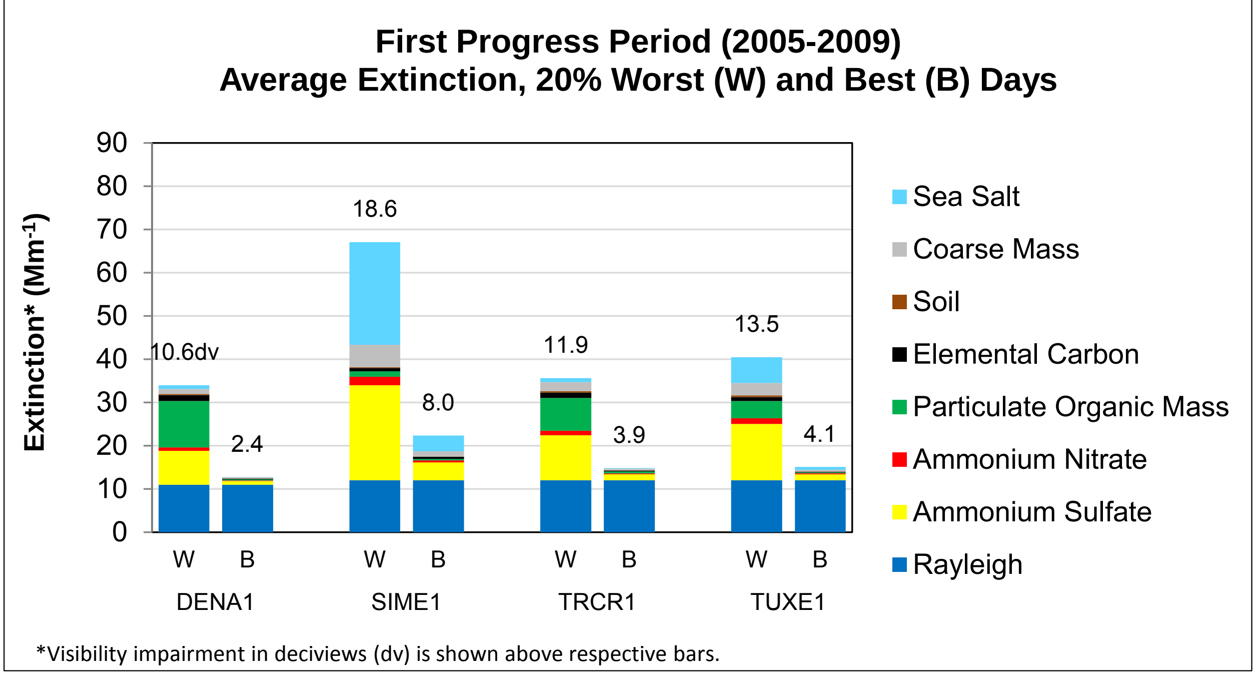
*Highest contribution per site is highlighted in bold.

Exhibit 14 – Visibility Conditions, 2005-2009 Progress Period, 20% Least Impaired Days

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

*Highest contribution per site is highlighted in bold.

Exhibit 15 – Average Extinction for First Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days



b. <u>Differences Between Current Visibility Conditions for the Most and Least Impaired Days and Baseline Visibility Conditions</u>

Included here are comparisons between the 5-year average baseline conditions (2000-2004) and the current progress period extinction (2005-2009) as reported in the WRAP Report (Appendix C). The most recent 5-year averaging period is included where analysis is available.

Exhibit 16 presents the differences between the 2000-2004 baseline period average extinction, the 2005-2009 progress period average extinction, and the most recent (2009-2013) 5-year averaging period for each site in Alaska for the 20% most impaired days; Exhibit 17 presents similar data for the least impaired days. Averages that changed by more than 0.5 deciview are depicted in bold text; red text indicates an increase, blue a decrease in impairment.

Exhibit 18 presents the 5-year average extinction for the baseline and first progress (2005-2009) period averages for the worst days and Exhibit 19 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Exhibits 20 and 21 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric remained the same or decreased at SIME1 and TUXE1 sites for the first progress period and the 2009-2013 averaging period. At DENA1, the deciview value increased during the first progress period compared to the baseline period. The 2009-2013 averaging period showed a decrease from the first progress period, but remained slightly above the baseline period. The TRCR1 site saw a small deciview increase during the first progress period and a decrease in the 2009-2013 averaging period.

Notable differences for individual component averages were as follows:

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

For the 20% least impaired days, the 5-year average RH rule deciview metric remained the same or increased very slightly at all sites with no statistically significant changes. As with the worst days, the best days' deciviews metrics were generally slightly lower in the 2009-2013 averaging period compared to the first progress period. Notable differences for individual component averages on the 20% least impaired days were as follows:

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

Exhibit 16 – Difference in Aerosol Extinction by Component, 2000-2004 Baseline Period to 2005-2009 Progress Period, 20% Most Impaired Days

Site	Averaging Period	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
		2000-04 Baseline	Averaging Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
DENA1	2005-2009	9.9	10.6	**+0.7**	**+3.0**	+0.2	-0.1	-0.3	0.0	-0.2	+0.4
	2009-2013	9.9	10.2	+0.3	**+1.9**	+0.2	**-0.9**	-0.4	-0.1	0.0	+0.4
SIME1	2005-2009	18.6	18.6	0.0	**+6.7**	0.0	**-3.3**	**-1.1**	0.0	**+0.8**	**-1.4**
	2009-2013	18.6	17.7	**-0.8**	**+3.7**	+0.1	**-3.4**	**-1.2**	0.0	**+0.1**	**-4.0**
TRCR1	2005-2009	11.6	11.9	+0.3	**+2.9**	-0.1	**-1.5**	-0.1	0.0	**+0.5**	**+0.5**
	2009-2013	11.6	10.7	**-1.0**	**+1.0**	-0.3	**-4.6**	**-0.5**	0.0	**+0.7**	+0.2
TUXE1	2005-2009	14.1	13.5	**-0.6**	**+4.3**	**-0.5**	**-4.8**	-0.3	+0.3	+0.4	**-2.3**
	2009-2013	14.1	12.2	**-1.9**	**+1.4**	**-0.7**	**-6.3**	**-0.6**	0.0	**-0.1**	**-2.3**

*Change is calculated as progress period average minus baseline period average. Bold and colored values indicate a difference of 0.5 deciview or greater; red indicates increases in extinction, values in blue indicate decreases.

Exhibit 17 – Difference in Aerosol Extinction by Component, 2000-2004 Baseline Period to 2005-2009 Progress Period, 20% Least Impaired Days

Site	Averaging Period	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
		2000-04 Baseline	Averaging Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
DENA1	2005-2009	2.4	2.4	0.0	0.0	-0.1	0.0	-0.1	0.0	+0.1	0.0
	2009-2013	2.4	2.5	+0.1	+0.0	-0.1	+0.1	-0.1	0.0	+0.1	0.0
SIME1	2005-2009	7.6	8.0	+0.4	+0.4	-0.1	-0.3	+0.1	0.0	+0.1	**+0.5**
	2009-2013	7.6	7.9	+0.3	+0.3	-0.1	0.0	+0.1	0.0	0.0	0.3
TRCR1	2005-2009	3.5	3.9	+0.4	+0.4	0.0	+0.1	-0.1	0.0	+0.1	0.0
	2009-2013	3.5	3.8	+0.4	+0.3	0.0	+0.3	-0.1	0.0	0.1	0.1
TUXE1	2005-2009	4.0	4.1	+0.1	+0.3	-0.1	-0.1	-0.1	0.0	+0.1	+0.1
	2009-2013	4.0	4.0	+0.0	+0.3	-0.1	-0.1	-0.1	0.0	0.0	0.1

*Change is calculated as progress period average minus baseline period average. Bold and colored values indicate a difference of 0.5 deciview or greater; red indicates increases in extinction, values in blue indicate decreases.

Exhibit 18 – Average Extinction for Baseline and Progress Period Extinction – Worst (Most Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

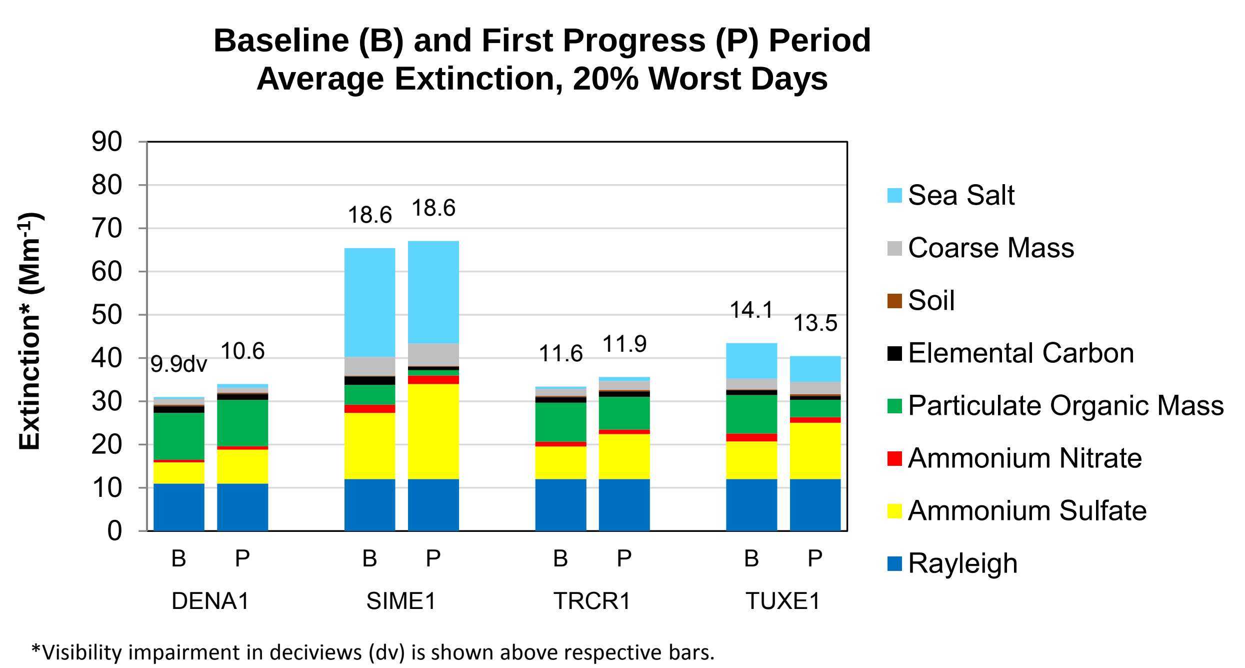


Exhibit 19 – Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) – Worst (Most Impaired) Days

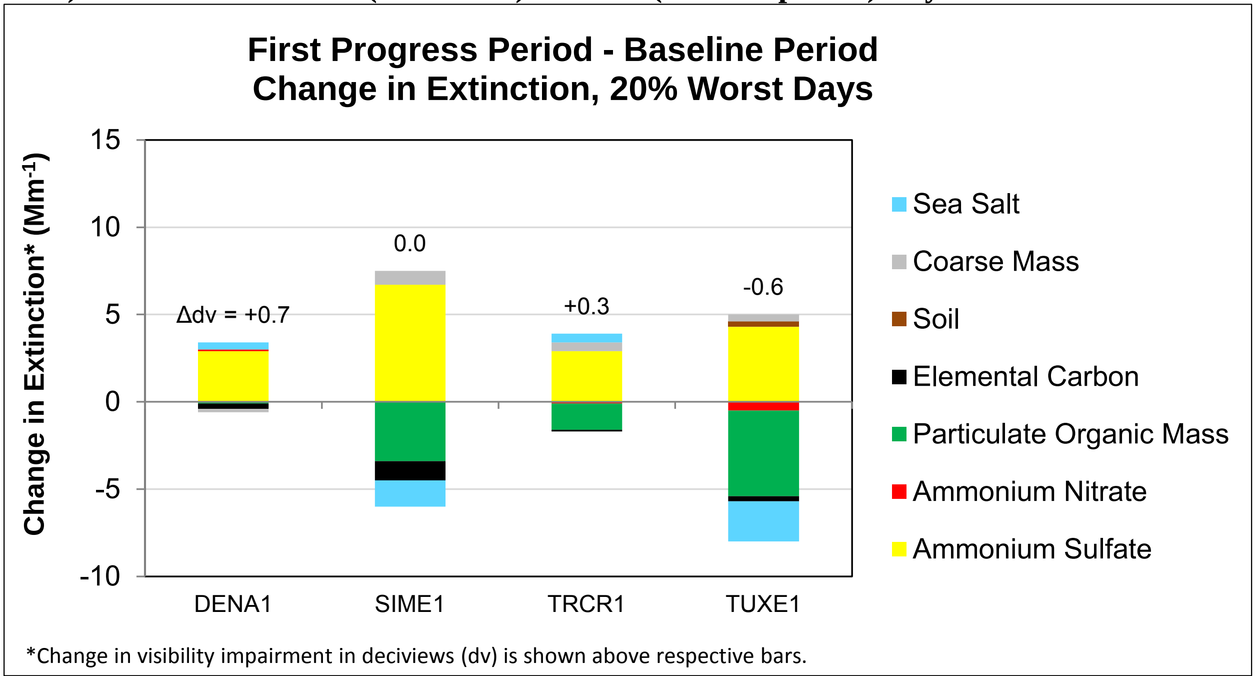


Exhibit 20 – Average Extinction for Baseline and Progress Period – Best (Least Impaired) Days

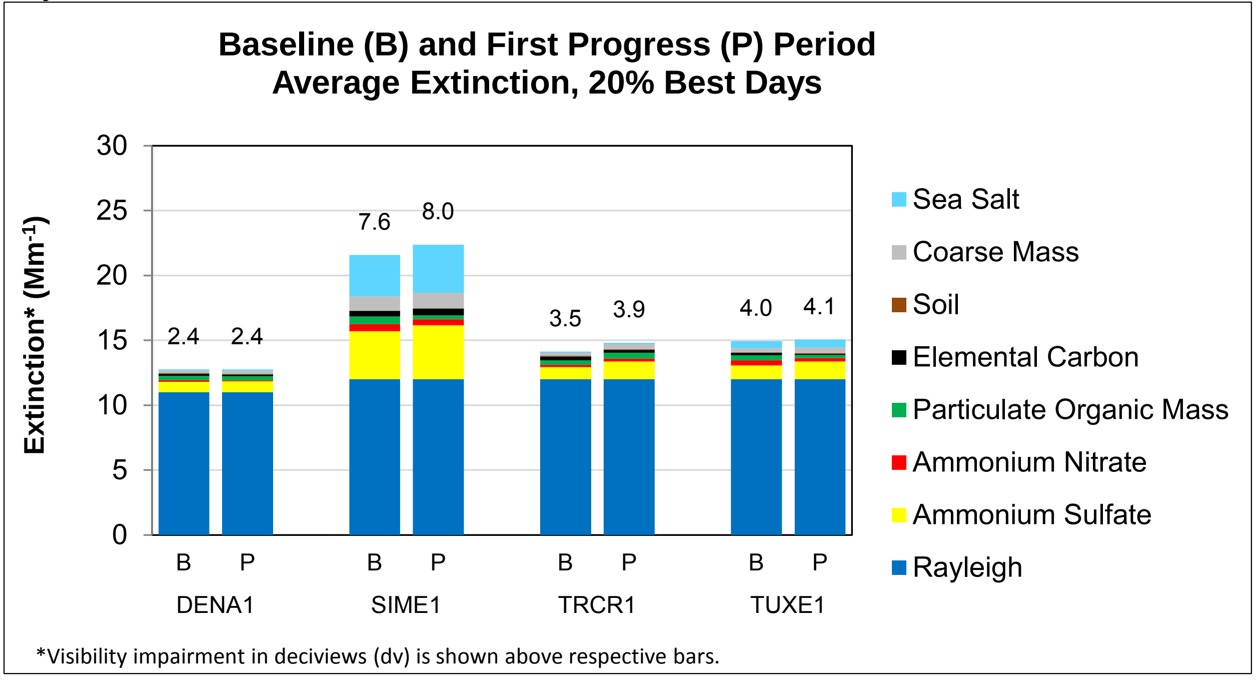
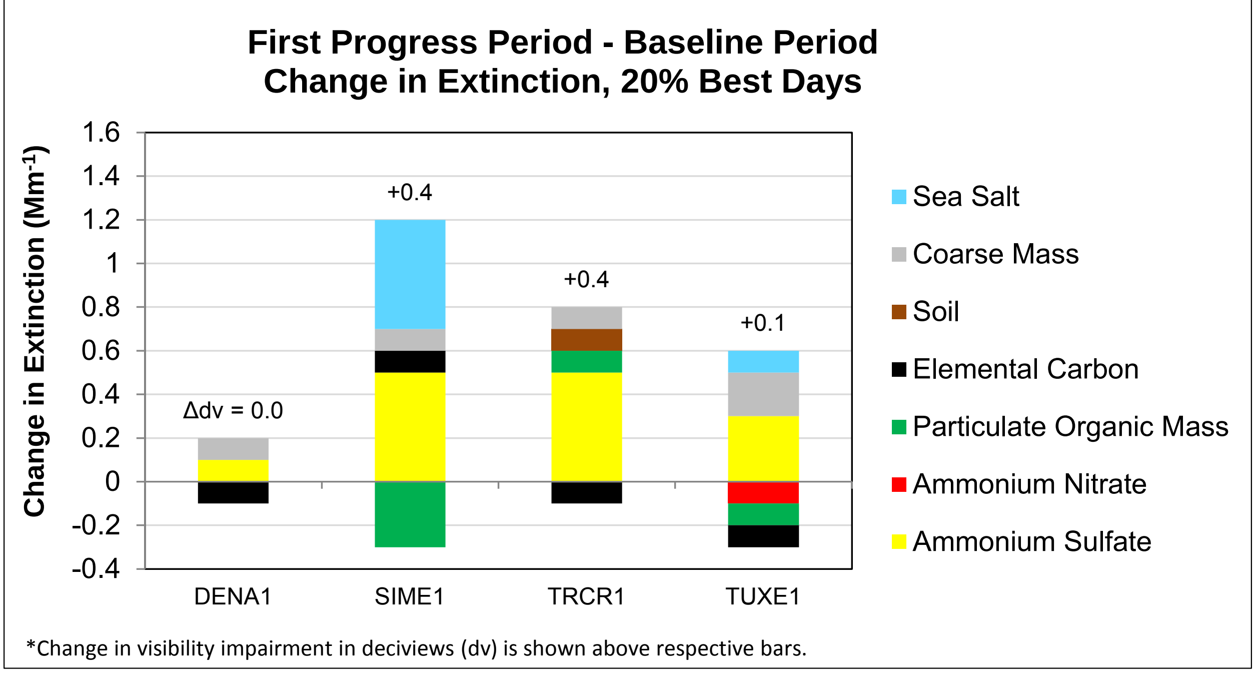


Exhibit 21 – Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) – Best (Least Impaired) Days



c. Change in Visibility for the Most Impaired and Least Impaired Days

This section discusses changes in visibility impairment as characterized by annual average trend statistics, and provides general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regional haze rule requires a description of changes over the past 5-year period. Because trend analysis is better suited to longer periods, trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Alaska are summarized in Exhibit 22.[9] Only trends for aerosol species with p-value statistics less than 0.15 (85% confidence level) are presented in the exhibit here, with increasing slopes in red and decreasing slopes in blue.[10] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa). In these cases, the 5-year average for the best and worst days is the important metric for regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendices C and D. Additionally, the Appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. Some general observations regarding changes in visibility impairment at sites in Alaska are as follows:

- 5-year average ammonium sulfate increased at all Alaska sites, and all sites measured statistically significant increasing annual ammonium sulfate trends.
- For particulate organic mass and elemental carbon, the SIME1 and TUXE1 sites showed statistically significant decreasing annual trends.
- As depicted in monthly and daily charts in Appendix D, large particulate organic events, likely due to wildfires, were measured at the TRCR1 site in August of 2005 and at the TRCR1 and DENA1 sites in July and August of 2009.

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

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

Exhibit 22 – 2000-2009 Annual Average Trends in Aerosol Extinction by Species

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

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

5. Analyses of Emissions: 40 CFR 51.308(g)(4)

40 CFR § 51.308(g(4) requires "*An analysis tracking the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State. Emissions changes should be identified by type of source or activity. The analysis must be based on the most recent updated emissions inventory, with estimates projected forward as necessary and appropriate, to account for emissions changes during the applicable 5-year period.*"

Summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods are included here. For reference, Exhibit 23 lists the pollutants inventoried, the related aerosol species, some of the key sources for each pollutant, and some notes regarding implications of these pollutants. Emission inventory results from the baseline and progress period are reported here and key contributors to visibility impairment are discussed.

Exhibit 23 – Pollutants, Aerosol Species, and Major Sources

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

For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RH SIP strategy development. The 2008 inventory is based primarily on data in EPA's National Emission Inventory. Note that the differences between inventories do not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories (see Appendix C).

Inventories for all major visibility impairing pollutants are presented for major source categories; emissions are categorized as either anthropogenic or natural emissions. Exhibits 24 and 25 present the 2002 and 2008 inventory data for all pollutants by category. General observations of emission inventory differences are noted here; more detailed inventory information is available in Appendix C.

- Fire emission inventory estimates decreased. Note that these differences are not necessarily reflective of changes in monitored data, as the 5-year baseline period is represented by a 2000-2004 average of fire emissions developed by the WRAP, and the 5-year progress period is represented by fires that occurred in 2008. Fire effects on monitored data also depend on the location of fires to the monitor and can vary greatly from year to year.
- Point source inventories showed decreases for all species.
- Area source inventories showed increases in SO_2 and NO_X, but large decreases in VOCs, fine soil, and coarse mass. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category (now termed non-point) in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed increases in SO_2, NO_X, fine soil, and coarse mass, but a decrease in VOCs.
- Off-road mobile source inventories showed decreases in NO_X, but increases in VOCs. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.
- Commercial marine sources showed large increases in NO_X inventories, and only small changes in other parameters. This increase is likely due, at least in part, to different methodologies.

In Alaska, during high fire years, emissions from wildland fires can make up a significant portion of the state's overall emissions for some pollutants. In addition, wildfire activity varies greatly from year to year and, unlike other emission sources, the locations vary from year to year. The proximity of fires to, or even within, Class I areas, along with meteorology, determines a fire's effect on visibility in the Class I areas. The total acres burned and $PM_{2.5}$ emissions released are summarized, by year, in Exhibit 26.

As described above, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of the entire 5-year monitoring periods compared.

Exhibit 24 – Sulfur Dioxide, Nitrogen Oxides, and Ammonia Emissions (tons/year)

	SO_2		NO_X		Ammonia	
	2002	**2008**	**2002**	**2008**	**2002**	**2008**
Point	6,813	5,039	74,471	68,564	580	178
Area	1,872	3,365	14,742	19,404	0	356
On-Road Mobile	324	490	7,077	15,696	307	230
Off-Road Mobile	49	395	4,111	3,387	8	7
Aviation	335	*	3,265	*	6	*
Commercial Marine	4,979	5,180	11,258	24,370	5	11
Total Anthropogenic	14,037*	14,469*	111,659*	131,421*	900*	782*
Fire	34,304	4,482	125,110	16,344	26,233	3,417
Total	48,341*	18,951*	236,769*	147,765*	27,133*	4,199*

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

Exhibit 25 – Volatile Organic Compound, Fine Soil, and Coarse Mass Emissions(tons/year)

	VOC		Fine Soil		Coarse Mass	
	2002	**2008**	**2002**	**2008**	**2002**	**2008**
Point	5,697	4,582	1,237	563	4,696	2,392
Area	128,271	10,890	30,636	2,289	76,349	121
On-Road Mobile	7,173	6,740	158	1,194	46	164
Off-Road Mobile	7,585	19,094	392	670	24	46
Aviation	1,566	*	667	*	20	*
Commercial Marine	356	609	643	1,114	32	64
Total Anthropogenic	149,082*	41,915*	33,066*	5,830*	81,147*	2,787*
Fire	274,436	35,761	478,057	63,330	79,346	10,495
Total	423,518*	77,676*	511,123*	69,160*	160,493*	13,282*

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

Exhibit 26 – Wildland Fires, Acres Burned, and $PM_{2.5}$ Emissions

Year	Number of Fires	Acres Burned	Total $PM_{2.5}$ (tons/year)*
2000	–	756,296	–
2001	–	216,039	–
2002	–	2,186,681	–
2003	–	602,718	–
2004	–	6,590,000	–
2005	624	4,663,880	2,018,974
2006	307	266,268	96,391
2007	509	649,411	269,928
2008	367	103,649	63,327
2009	527	2,951,593	1,597,321
2010	688	1,125,419	549,721
2011	515	293,018	181,165
2012	416	286,888	89,753
2013	613	1,316,289	574,756

*Emissions data not available for years 2004 and earlier.

6. Significant Changes to Anthropogenic Emissions: 40 CFR 51.308(g)(5)

40 CFR § 51.309(d)(10)(i)(E) requires "*an assessment of any significant changes in anthropogenic emissions within or outside the State that have occurred over the past 5 years that have limited or impeded progress in reducing pollutant emissions and improving visibility.*"

Exhibit 27 shows the changes in emissions between the 2002 and 2008 emission inventories. Because the two inventories used somewhat different methodologies, the inventories cannot be directly compared.

Exhibit 28 displays the average light extinction for the 20% worst days at the four regional haze IMPROVE monitors in Alaska over three 5-year periods.

The exhibit demonstrates that on the 20% worst days in the Class I areas in Alaska, ammonium sulfate and particulate organic matter are the major contributors to visibility impairment. The emission inventories show that anthropogenic emissions of SO_2 within Alaska have remained roughly the same between 2002 and 2008. The inventory comparison also reveals that in high fire years, fire contributes a large portion of the inventoried pollutants and the difference in fire years substantially drives the changes between years. The state of Alaska continues to implement the policies in its Enhanced Smoke Management Plan to minimize smoke effects from prescribed burns. By far the majority of wildland fire emissions come from wildfires, not prescribed fires.

One contributing source of anthropogenic emissions not included in the inventory is international emissions. Alaska receives globally transported pollution, particularly from Asia and Russia. Continued industrial growth in these areas is likely contributing to regional haze in Alaska, although the extent of the contribution is not quantified as the international data required to do so is unavailable to DEC. Similar to wildland fire emissions, the state is not able to control these international emissions affecting visibility.

As noted previously, during 2009, sulfate impairment appears to be higher than typical on the 20% worst days. This effect is most prominent at the IMPROVE sites farther north, DENA1 and TRCR1. The following exhibits, 29 to 34, show the extinction values by species for 2008-2010 at the DENA1 and TRCR1 monitors. These exhibits demonstrate that one source of this increased sulfate was likely wildfires during the summer of 2009. This year was a high fire year, burning almost 3 million acres, about triple the average acreage burned annually. In addition, it is not uncommon for the sulfate levels in the spring and early summer to be higher than other times of the year. In 2009, particularly at DENA1, this trend is more prominent than in some years. Similar charts for all IMPROVE monitor sites and all years are included in Appendix D.

Exhibit 27 – 2002 and 2008 Emissions (tons/year)

Pollutant	Source	2002 (State Inventory)	2008 (WestJump2008)	Difference	Percent Change
Sulfur Dioxide	Anthropogenic	14,037	14,469	432	3%
	Natural (Fire)	34,304	4,482	-29,822	-87%
	Total	48,341	18,951	-29,390	-61%
Oxides of Nitrogen	Anthropogenic	111,659	131,421	19,762	18%
	Natural (Fire)	125,110	16,344	-108,766	-87%
	Total	236,769	147,765	-89,004	-38%
Ammonia	Anthropogenic	900	782	-118	-13%
	Natural (Fire)	26,233	3,417	-22,816	-87%
	Total	27,133	4,199	-22,934	-85%
VOC	Anthropogenic	149,082	41,915	-107,167	-72%
	Natural (Fire)	274,436	35,761	-238,675	-87%
	Total	423,518	77,676	-345,842	-82%
Fine Soil	Anthropogenic	33,066	5,830	-27,236	-82%
	Natural (Fire)	478,057	63,330	-414,727	-87%
	Total	511,123	69,160	-441,963	-86%
Coarse Mass	Anthropogenic	81,147	2,787	-78,360	-97%
	Natural (Fire)	79,346	10,495	-68,851	-87%
	Total	160,493	13,282	-147,211	-92%

Note: Inventories used different methods and data inputs. Results may not be directly comparable. The 2002 emission inventory includes aviation emissions but the 2008 inventory does not.

Exhibit 28 – Average Speciated Extinction – 20% Worst Days

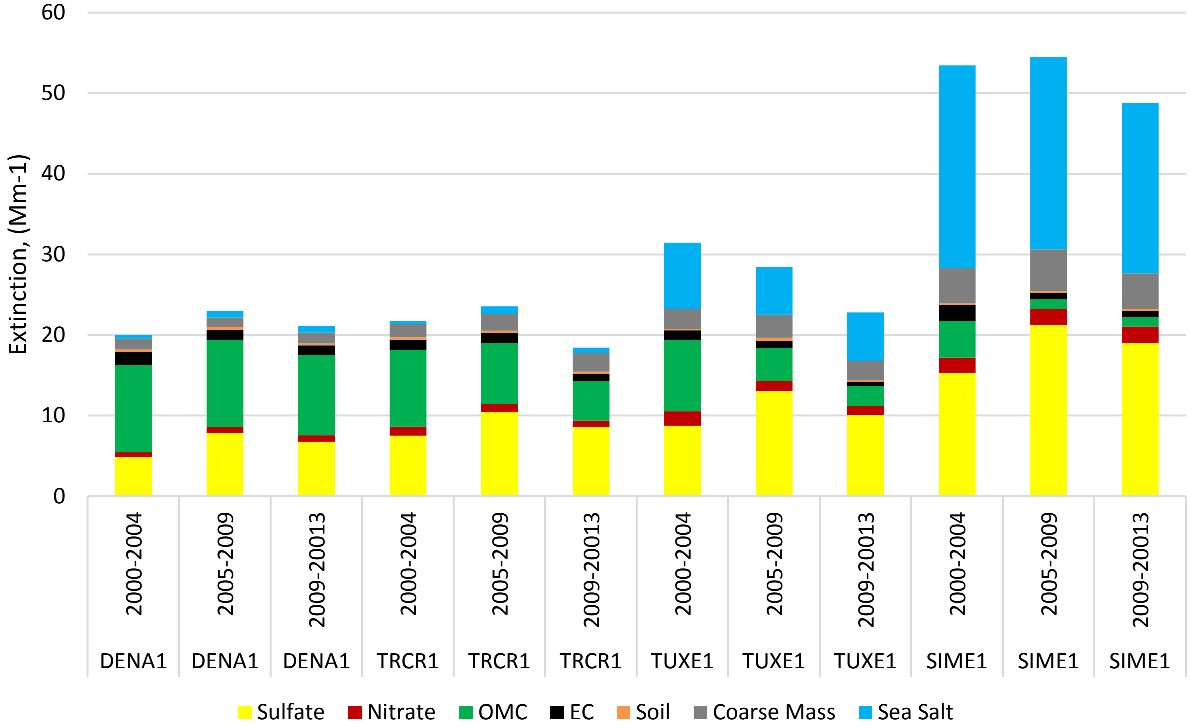


Exhibit 29 – DENA1 Monitored Extinction, 2008

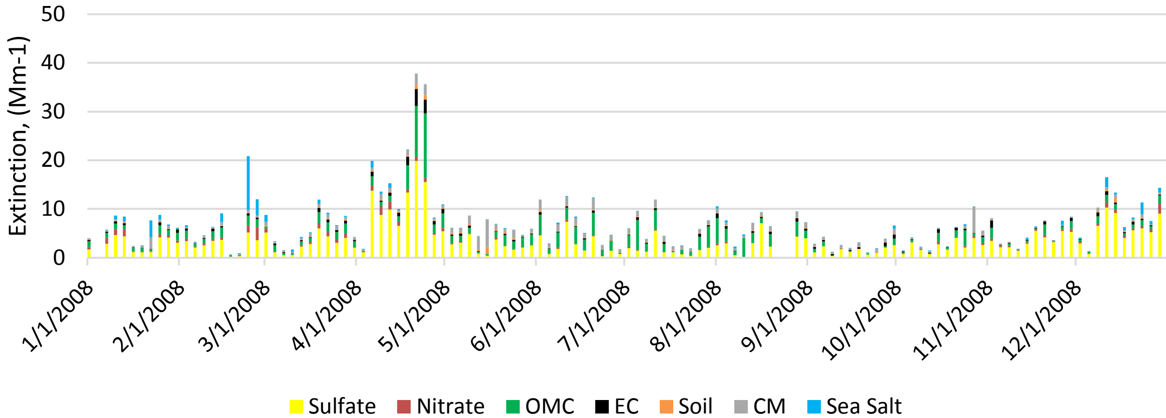


Exhibit 30 – DENA1 Monitored Extinction, 2009

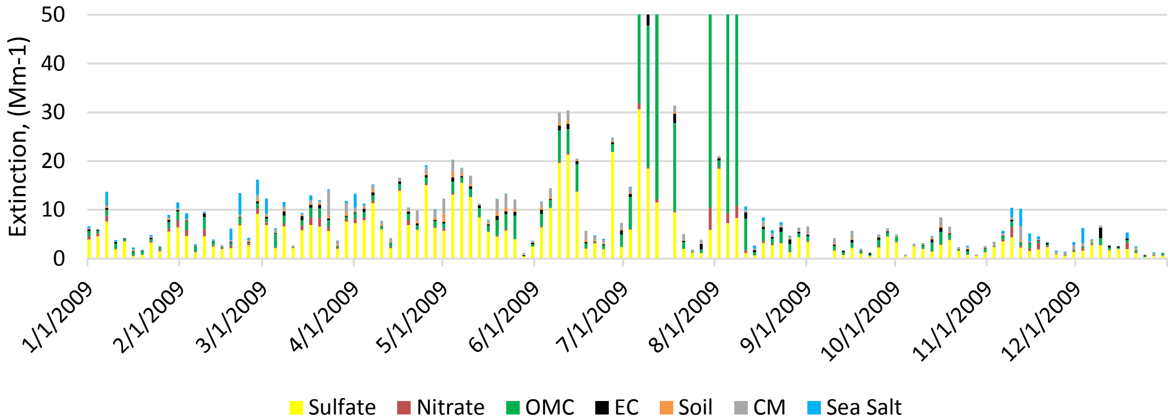


Exhibit 31 – DENA1 Monitored Extinction, 2010

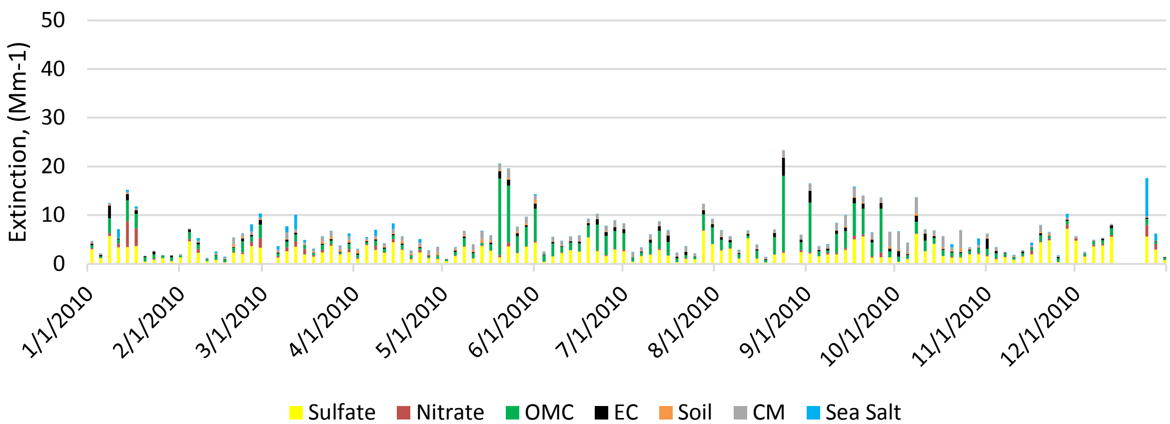


Exhibit 32 – TRCR1 Monitored Extinction, 2008

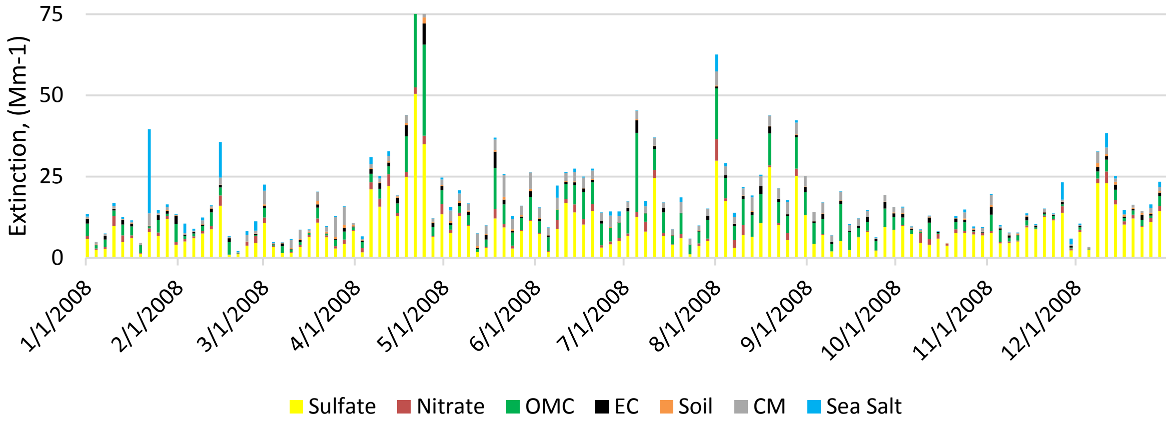


Exhibit 33 – TRCR1 Monitored Extinction, 2009

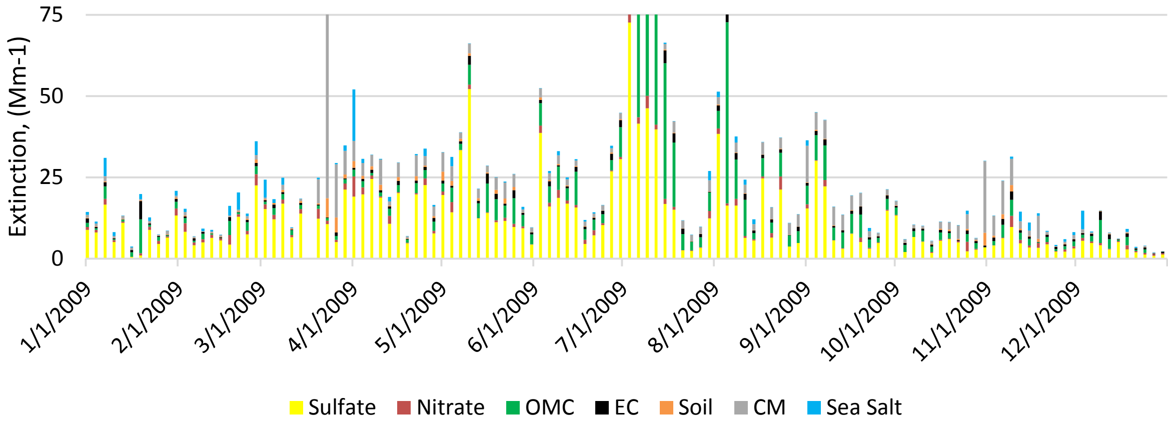
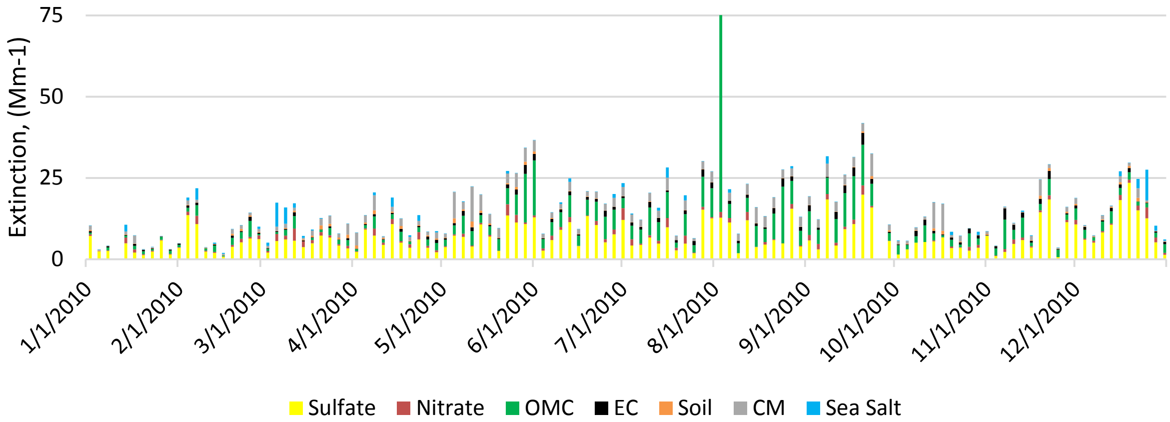


Exhibit 34 – TRCR1 Monitored Extinction, 2010



7. Assessment of Current SIP Strategy: 40 CFR 51.308(g)(6)

40 CFR § 51.308(g)(6) requires *“an assessment of whether the current implementation plan elements and strategies are sufficient to enable the State, or other States with mandatory Federal Class I areas affected by emissions from the State, to meet all established reasonable progress goals.”*

Exhibit 2 at the beginning of this report shows that the only statistically significant changes in visibility on the 20% worst days between the baseline period and the first progress period (2005-2009) is the deciview decrease at TUXE1. The deciview changes between the first progress period and the most recent 5-year period (2009-2013) show a visibility improvement at all monitors on the 20% worst days. DENA1 remains above the baseline, however once the 2009 spike is removed from the data set in future progress periods, we firmly believe that DENA1 will join the other Class I sites in compliance with the 2018 requirements.

On the 20% best days, TRCR1 saw a statistically significant increase in deciviews between the baseline and first progress periods. At other locations, visibility on the best days decreased only slightly.

Given the general insignificance of the changes in visibility between the baseline and first progress periods, the improvements in the worst day visibility for the most recent 5-year period, the strong influence of wildfire emissions, and the significant, yet undetermined, probable impacts of international emissions on visibility in Alaska, the State believes the current control strategies in the regional hazes SIP are sufficient.

8. Assessment of Current Monitoring Strategy: 40 CFR 51.308(g)(7)

40 CFR § 51.308(g)(7) requires *“a review of the State's visibility monitoring strategy and any modifications to the strategy as necessary.”*

The primary monitoring network for regional haze, both nationwide and in Alaska, is the IMPROVE monitoring network. Given that IMPROVE monitoring data from 2000-2004 serves as the baseline for the regional haze program, the future regional haze monitoring strategy must necessarily be based on, or directly comparable, to the current IMPROVE network. The IMPROVE measurements provide the only long-term record available for tracking visibility improvement or degradation and therefore Alaska intends to continue relying on the four IMPROVE sites that represent the state’s Class I areas for complying with the monitoring requirement in the RH rule.

There are currently 4 IMPROVE sites in Alaska, as noted in Exhibit 35 and displayed in Exhibit 36.

Exhibit 35 – CIAs and Representative IMPROVE Monitors

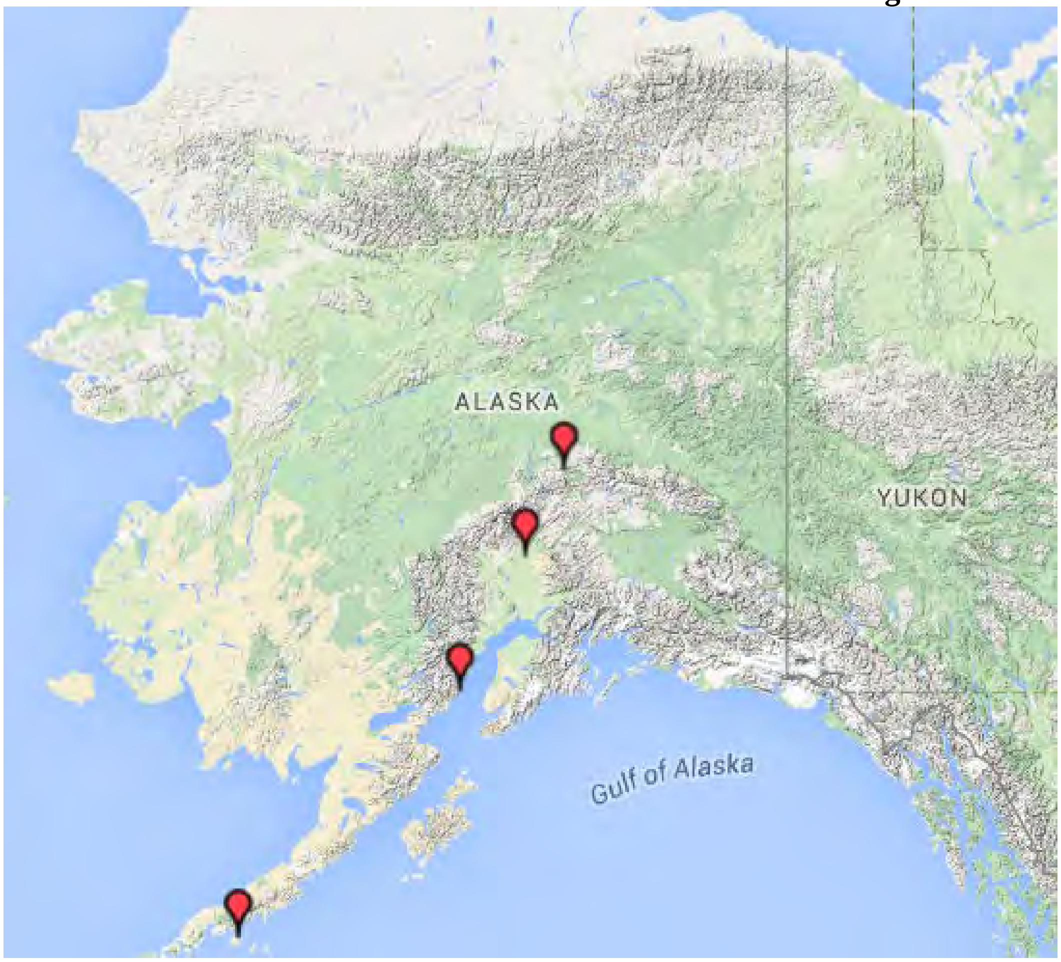
Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Denali NP*	DENA1	63.72	-148.97	658
Denali NP*	TRCR1	62.32	-150.32	155
Tuxedni WA	TUXE1	59.99	-152.67	15
Simeonof WA	SIME1	55.33	-160.51	57
Bering Sea WA	Bering Sea WA is not represented by an IMPROVE monitor.			

* Denali NP is represented by two IMPROVE monitors.

The Tuxedni monitor discontinued operation at its current location on the west side of the Cook Inlet at the end of December 2014 because the monitor host and operator indicated that he would no longer be able to operate the monitor. The monitor will be moved across the Cook Inlet to the Ninilchick area where operators can more easily be recruited. DEC visited the area and identified several potential sites. The US National Park Service and Fish and Wildlife Service are working to establish a new site.

Denali National Park and Preserve continues to be represented by two monitors: TRCR1 and DENA1. DENA1 has operated since the mid-1980s and provides a long-term data set. The Trapper Creek monitor was installed in 2001 to characterize the visibility in the southern portion of the park, which is on the south side of the Alaska Range of mountains, and includes Denali, at 20,310 feet. DEC relies on the TRCR1 monitor to understand the contributions of most populous and fastest growing areas of the state, Anchorage and the Matanuska-Susitna Valley.

Exhibit 36 – Alaska's Federal Class I area IMPROVE monitoring sites



D. DETERMINATION OF ADEQUACY

The State of Alaska affirms the adequacy of its existing Regional Haze State Implementation Plan to meet the established reasonable progress goals based on the following information:

- The historically good visibility generally observed in Alaska Class I areas when not impacted by natural or uncontrollable events.
- The trend towards improvement in visibility on the 20% worst days.
- The general insignificance in changes to visibility on the 20% best days.
- The highly variable uncontrollable emissions driving visibility impairment in Alaska:
    - Wildfire events
    - Sea salt
    - Likely influence of global transport of sulfate and other compounds
- Expected emission improvements from continued implementation of state and federal programs.

E. FEDERAL LAND MANAGER REVIEW

The State of Alaska provided an opportunity for FLM consultation at least 60 days prior to holding any public hearing on the SIP. This SIP was submitted to the FLMs on April 27, 2015 (Exhibit 37) for review and comment. Comments were received from the FLMs on June 30, 2015 (Exhibit 38). As required by 40 CFR Section 51.308(i)(3), the FLM comments and State responses are presented here.

Alaska Regional Haze Plan Response to Federal Land Manager Comments

FLM comments are paraphrased rather than quoted in their entirety. The complete comment letter follows this response.

Comment Section B: It would be helpful to refer the reader to Section C.4 for additional information on source contributions to visibility impairment, that visibility impairment (not visibility) remained slightly above the baseline at the Denali Headquarters site during the 2009-2013 averaging period, and that there was degradation of visibility on the best 20% days at DENA1, TRCR1, and SIME1 for the 2009-2013 period.

Response: The visibility improvement and degradation was clarified. A reference to Section C.4 was also added.

Comment Section C.2.a: We recommend adding a discussion of the 2010 designation by the International Maritime Organization of the North American Emission Control Area to limit emissions from marine shipping in U.S. coastal waters beginning in August 2012.

Response: ADEC recognizes the participation of a variety of organizations to curb their emissions but don't feel that this particular program affects the visibility at Alaskan Class I sites in enough capacity to affect the outcomes of the 20% best and 20% worst days as they pertain to Regional Haze. Additionally, because this program would have a relatively small impact on the air quality, quantifying their reductions would be cumbersome. As demonstrated in Section C.4.a, TUXE1 is primarily affected by salt; abundant in the marine ecosystem. The emission control area outlined by the International Maritime Organization encompasses the entirety of the lower 48 coastline where it may have direct impacts on the air quality of Class I sites. It doesn't impact either the TRCT1 or DENA1 sites being over 75 miles and 175 miles from the closest minor shipping lanes, respectively; the control area does not extend to include SIME1.

Section C.2 covers a variety of regulations that affect a number of programs and organizations. To highlight one program would come at the expense of excluding others. While the emission limits placed on marine shipping by the International Maritime Organization of North America undoubtedly has real impacts on air quality, this report isn't geared towards addressing those benefits.

Comment Section C.2.d: Please describe emission control technology, emissions limits, and projected emissions (tons per year) by 2018 for sulfur dioxide (SO_2), nitrogen oxides (NOx), and fine particulate matter (PM2.5) for Healy Unit 1 (which is subject to BART controls) and Healy Unit 2 (which will restart with coal in 2015).

Response:
While Unit 1 is in operation, a dry sorbent injection must be in operation and Unit 2 is equipped with a spray dry absorber to limit the emission of SO_2. Golden Valley Electric Association shall install and operate a Selective Non-Catalytic Reduction (SNCR) system on Unit 1 no later than 18 months after the date on which Unit 2 first fires coal. According to the GVEA website, plans are slated for installing a SCR on Unit 2 during 2017. Additionally Unit 1 and Unit 2 will continuously operate the existing baghouse to control PM.

On or before December 31, 2022, GVEA must elect to retire Unit 1 or to install SCR on Unit 1. The schedule for emission control device installation required by the Consent Decree (Permit AQ0173MSS01, finalized April 14, 2014) is outlined in Table A.

Table A. Consent Decree Schedule Requirements for Control Device Installation

Emission Unit	Consent Decree Condition	Consent Decree Requirement	Tentative Schedule
Unit 2	59	Install SCR on Unit 2 on or before September 30, 2016, or 24 months after HCCP First Fires Coal, whichever is later.	TBD – technology not yet selected
Unit 1	60	Install SNCR on Unit 1 on or before September 30, 2015 or 18 months after Unit 2 First Fires Coal, whichever is later.	TBD
Unit 1	61	On or before December 31, 2022, GVEA shall elect to retire Unit 1 or elect to install and operate SCR on Unit 1.	TBD
Unit 1	63	Install SCR on Unit 1 by December 31, 2024.	TBD

As stated in the Consent Agreement the combined SO_2 emission from Healy Unit 1 and Healy Unit 2 shall not exceed 701 tons per year beginning January 1, 2016 and continuing each 12 month period after. If GVEA elects to retire Unit 1 in lieu of installing and operating a SCR (or alternative control technology approved by the EPA) the SO_2 tonnage limitation will be restricted to 248 tpy. Unit 1 cannot exceed 0.30 pounds per million British thermal units (lb/MMBtu), 30-day rolling average, 18 months after the date on which Unit 2 first fires coal. Upon the date Unit 2 first fires coal, SO_2 emissions cannot exceed 0.10 lb/MMBtu, 30-day rolling average.

The combined nitrogen oxides (NOx) emission from Healy Unit 1 and Healy Unit 2 shall not exceed 1,239 tons per year for the first full year of operation following installation of SNCR on

Unit 1. 18 months after the date on which Unit 2 first fires coal Unit 1 cannot exceed 0.20lb/MMBtu and Unit 2 cannot exceed 0.10 lb/MMBtu, 30-day rolling average. Upon initial startup of the SCR system on Unit 2, the NOx emission rate for Unit 2 shall not exceed 0.080 lb/MMBtu, 30-day rolling average.

18 months after Unit 2 first fires coal the filterable PM emission rate from Unit 1 shall not exceed 0.0200 lb/MMBtu, 30-day rolling average. Upon the date on which Unit 2 first fires coal the filterable PM emission rate from Unit 2 shall not exceed 0.0200 lb/MMBtu, 30-day rolling average.

Comment Section C.2.h: Please add the fuel sources and capacities of the electric generating units cited in this section.

Response: The requested information has been included.

Comment Section C.3.a: Please clarify the source categories (e.g. electric generating units) that are included in Exhibit 3 and include emissions units (tons/year) on the graph. Please clarify the differences in the total point source emissions reported for 2008 in Exhibits 24-25 of Section C.5 are larger than emissions reported in Exhibit 3.

Response: Exhibit 3 shows the emissions from all point source type A (large emitters). The data provided in exhibits 24-25 includes these totals in the ‘Point’ category; this total also includes the emissions from type B (small emitters) resulting in the difference between these two values. Because of the number of categories and the complexity of the information the contributors to exhibit 3 are not broken down by industry. A very general description of the contributors are:

	NOx (tpy)		PM10 (tpy)		SO_2 (tpy)	
Year	Electrical	Other	Electrical	Other	Electrical	Other
2008	12914.45	30981.36	325.78	1002.06	958.50	674.39
2009	12648.43	31215.84	289.22	963.90	1367.16	636.40
2010	11881.19	27287.38	527.48	933.79	853.80	674.14
2011	11927.39	30340.08	452.93	875.11	789.48	641.82
2012	11543.06	30359.96	540.93	1108.51	732.50	737.45
2013	8923.11	29602.85	295.68	1114.85	418.41	1304.95

Electrical emissions are only the emissions related to electrical generation. The ‘Other’ category encompasses all other source A emitters. These could include other commercial/institutional, petroleum, oil and gas production, or chemical manufacturing emissions.

The requested information will not be incorporated into Exhibit 3 due to the confusing nature of how it would be presented. The information presented in Exhibit 24 and 25 address the requested information. The title of Exhibit 3 will be change for clarification as well as units added.

Comment Section C.3.b: This section might be better titled “Managing Fire Emissions.” It would be helpful to add that most fire emissions are due to wildfire, reference wildfire emissions data in Exhibit 26 in Section C.5, and add a reference here for calculating the tons of emissions averted by prescribed fire. Please clarify in the title for Exhibit 4 that emissions reported are tons per year of PM2.5.

Response: The title was changed to clarify units and a short sentence was added to reference the additional information presented in section C.5 and Exhibit 26.

The emissions averted by prescribed fire are calculated by subtracting the calculated emissions of a fire under prescribed burn conditions from the emissions under wildfire conditions. Emissions from fires are calculated using emission factors (EF) that estimate the tonnage of specific pollutants emitted when burning specific vegetation types. Different EF exist for vegetation burned under wildfire conditions versus prescribed fire conditions. The proportion of emissions averted is specific to each fire because each fire encompasses a unique distribution of vegetation types. The emission reductions identified in Exhibit 4 are the summation of reductions from all prescribed fires and it is impracticable to include these calculations.

Comment Section C.4: Please reorder Exhibit 5 through 22 to maintain a consistent ordering of the sites throughout the report.

Exhibit 16 indicates that ammonium sulfate is a major contributor to visibility impairment at all four monitoring sites on the 20% worst days and that light extinction due to ammonium sulfate has increased in both the 2005-2009 and the 2009-2013 periods compared to the baseline period 2000-2004. Sulfate is attributable to anthropogenic emissions in Alaska, plus international and commercial marine emissions. To demonstrate reasonable progress, it is important to demonstrate that ADEC is addressing anthropogenic sources of SO2.

Response: Exhibit 5 through 22 now have a consistent order in listing the sites in graphs and tables.

Ammonium sulfate is released as a byproduct of a variety of anthropogenic processes. Because of this, the State and other FLM have invested resources in outreach, insensitive cost share opportunities, and educational programs to reduce emissions. As stated in the Section B, 2009 was a particularly bad year for visibility at all four Class I areas.

Comment Section C.4.b: In the fifth and sixth paragraphs on page 10-19, please clarify that values cited as highest and lowest aerosol extinction on the 20% worst and best days are for the period 2005-2009.

Response: Clarification was added as to what the timeframe was for the 'first progress period.'

Comment Section C.5: Exhibit 24 shows that Alaskan anthropogenic SO2 emissions were unchanged between the 2002 and 2008 inventories (changes in inventory methods may affect this conclusion). To support ADEC's determination that Alaska is making reasonable progress in reducing anthropogenic emissions, it would be helpful to include 2011 National Emissions Inventory results for the major source categories in Exhibit 24. Please compare 2018 WRAP emissions projections to current inventories. Is Alaska on track to meet the 2018 emissions levels?

Please discuss trends in oil and gas activity and emissions since 2002. Did WRAP develop a separate 2008 oil and gas area source inventory for Alaska? Are any of Alaska's oil refineries subject to consent decrees with EPA to reduce emissions?

Please add units to tables in Exhibits 24-27. Please add y-axis units (Mm-1) to Exhibits 29-34.

Response: As mentioned in the section, a reclassification of some off-road mobile sources is a possible culprit for the anthropogenic SO_2 level not decreasing. Overall however, averaged between the total anthropogenic levels in 2002 compared to the 2008 levels show a 50% reduction in total emissions. While SO_2 may continue to be a problem, some of the changes may be the result of less efficient polluters being switched to cleaner, but in this case reportable, categories. As shown in Exhibit 2, TRCR1, TUXE1, and SIME1 all are already at or below the 2018 reasonable progress goal. The only Class I area not currently below the glidepath is DENA1 and this is largely attributed to 2009, as shown in Exhibit 5.

Since its peak in the mid to late 1980s oil production had steadily decreased from 750 million barrels to its current volume of around 200 million barrels per year. April 2015 had an average of 510 thousand barrels per day compared to 530 in April 2014. Data collected for the 2000, 2005, and 2011 Emissions Inventories shows the CO_2, NOx and PM10 levels have fluctuated yearly while SO_2 and VOC has generally decreased. This could be a result of reporting changes, or gaps in data submissions. As oil production continues to decline, a reduction in emissions would be expected. However, if any large scale projects are undertaken, the emissions would be expected to reflect those changes. There aren't currently any separate WRAP inventories for Alaska or refineries that are subject to a consent agreement with EPA.

Units were added to Exhibits 24-27. Units of extinction were added to the y-axis of Exhibits 29-34.

Comment Section C.7: At the end of the second paragraph, please remind readers that although visibility on the 20% worst days apparently improved at all four sites between the first and second progress periods, the haze index at the Denali headquarters site remained above baseline.

To demonstrate compliance with 40 CFR 51.308(g)(6), we suggest that you repeat the statement made in Section A.2 that ADEC has determined that Alaskan emission sources do not affect visibility in Class I areas in other states.

Clarify that international sources have significant but undetermined contribution to haze in Alaska Class I areas.

Statements in this section conflict with or ignore data in Exhibit 2.

Response: Requested additions and clarifications have been included.

Exhibit 2 uses underlines to show statistically significant changes in visibility. Only two changes were statistically significant.

Comment Section C.8: This section addresses the importance of long-term comparisons to the 2002-2004 baseline period. It would be helpful to discuss the implications for the long-term record of moving the Tuxedni NWR monitor to the east side of Cook Inlet. It would also be helpful to briefly discuss why the Bering Sea Class I area is not represented by a monitoring site.

Finally, the elevation of Denali is 20,320 feet.

Response: Moving the Tuxedni monitor to the Ninilchik area will have a variety of effects on the long term monitoring record that existed at TUXE1. By moving the monitor the data recorded at TUXE1 since 2001 will be negated once the sensor is moved and there won't be an established baseline for the same reporting periods as the other Class I sites.

The Bering Sea Wilderness Area consists of three islands 233 miles off the coast of western Alaska. The closest and most representative long-term NWS meteorological monitoring station is at St Paul Island, 227 miles south-southeast in the Pribilof Islands of the Bering Sea. Due to the remote location of the Class I area in the Bering Sea and the severe meteorology problems represented by installing and operating monitors at, or in proximity to, the Bering Sea Class I area. For this reason, no nearby monitoring site exists.

The USGS published findings on September 2, 2015 revising the official elevation of Denali to 20,310 feet. A 2010 IFSAR survey previously updated the elevation of Denali to20,237 feet (6,168 meters). This updated height replaces the 20,320 foot height originally measured in 1952 using photogrammetry.

Exhibit 37 – Letter Sent to Federal Land Managers

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Environmental Conservation

DIVISION OF AIR QUALITY
Director's Office

410 Willoughby Avenue, Suite 303
PO Box 111800
Juneau, Alaska 99811-1800
Main: 907-465-5105
Toll Free: 866-241-2805
Fax: 907-465-5129
www.dec.alaska.gov

CERTIFIED MAIL: 7014 0510 0001 9932 8958
Return Receipt Requested

April 27, 2015

Andrea Blakesley
Denali National Park
P.O. Box 9
Denali Park, AK 99755-0009

Subject: Alaska's Regional Haze Progress Report – 60 day FLM Review Period

Dear Ms. Blakesley:

The Alaska Department of Environmental Conservation (DEC) has prepared the attached Regional Haze Progress Report for review by the Federal Land Managers (FLM). FLM comments will be accepted until June 30, 2015. After we have addressed the FLM comments, a public review period will be conducted; you may provide additional comments during this period if you wish. Subsequent to the public review period, the report will be submitted to the US Environmental Protection Agency (EPA) to meet the Regional Haze Rule requirements for progress reports.

If you have questions regarding the report, until May 8th you can address those to Karin Landsberg, 907-269-4913, karin.landsberg@alaska.gov. After that, please send your comments or any questions you may have to Cindy Heil, 907-269-7579, cindy.heil@alaska.gov.

Sincerely,

Denise Koch, Director
Division of Air Quality

Enclosure: Regional Haze Progress Report

cc: Cindy Heil, ADEC/ Anchorage
Karin Landsberg, ADEC/ Anchorage

Clean Air

Exhibit 38 – Federal Land Manager Comments

United States Department of the Interior

NATIONAL PARK SERVICE
Air Resources Division
P.O. Box 25287
Denver, CO 80225-0287

TRANSMITTED VIA ELECTRONIC MAIL - NO HARDCOPY TO FOLLOW

N3615 (2350)

June 30, 2015

Denise Koch
Director, Division of Air Quality
Alaska Department of Environmental Conservation
410 Willoughby Avenue, Suite 303
Juneau, Alaska 99811-1800

Dear Ms. Koch:

Thank you for the opportunity to review and comment on Alaska's draft 2015 Regional Haze Progress Report. Enjoying the majestic scenery is one of the major reasons that visitors travel to Denali National Park & Preserve. We appreciate Alaska Department of Environmental Conservation (ADEC)'s efforts to protect visibility in Denali's Class I area and provide co-benefits to many other national parks in Alaska.

Alaska DEC has addressed most of the requirements for the periodic progress report as outlined in 40 CFR 51.308(g) and (h) and 40 CFR 51.309(d)(10) of the Regional Haze Rule. Below are suggestions to better support ADEC's conclusion that expected emissions reductions by 2018 are sufficient to meet the visibility improvement goals that were set in the Regional Haze State Implementation Plan.

Section B: Progress towards Reasonable Progress Goals
The progress report begins with a general summary of visibility trends from 2000 to 2013 for the 20% worst and 20% best visibility days at Class I areas in Alaska. It would be helpful to refer the reader to Section C.4 for additional information on source contributions to visibility impairment. Also, the last sentence of the first paragraph should state that visibility impairment (not visibility) remained slightly above the baseline at the Denali Headquarters site during the 2009-2013 averaging period.

Section C.2.a: Emission Reductions due to Ongoing Air Pollution Programs
We recommend adding a discussion of the 2010 designation by the International Maritime Organization of the North American Emission Control Area to limit emissions from marine

shipping in U.S. coastal waters beginning in August 2012. [1] These emissions limits should reduce visibility impacts from controllable emissions prior to 2018.

Section C.2.d: Regional Haze BART Control
In a 2012 consent decree, Golden Valley Electric Association (GVEA) committed to emissions controls for the Healy Power Plant, located 3.8 miles from Denali National Park & Preserve. Please describe emission control technology, emissions limits, and projected emissions (tons per year) by 2018 for sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter ($PM_{2.5}$) for Healy Unit 1 (which is subject to BART controls) and Healy Unit 2 (which will restart with coal in 2015).

Section C.2.h: Source Retirements and Replacement
Please add the fuel sources and capacities of the electric generating units cited in this section.

Section C.3.a: Anthropogenic Emissions
The text, but not the title, of Exhibit 3 indicates that these emissions data are for the largest point sources. Please clarify the source categories (e.g. electric generating units) that are included in Exhibit 3 and include emissions units (tons/year) on the graph. It is helpful to update the emissions trends for these large point sources since 2008. However, because the total point source emissions reported for 2008 in Exhibits 24-25 of Section C.5 are larger than emissions reported in Exhibit 3, please clarify the differences in the source categories covered in these two sections.

Section C.3.b: Wildfire Emissions
This section might be better titled "Managing Fire Emissions." Since this section describes emissions reductions under the Enhanced Smoke Management Plan, the title "Wildfire Emissions" doesn't match the content. It would be helpful to add that most fire emissions are due to wildfire, reference wildfire emissions data in Exhibit 26 in Section C.5, and add a reference here for calculating the tons of emissions averted by prescribed fire. Please clarify in the title for Exhibit 4 that emissions reported are tons per year of $PM_{2.5}$.

Section C.4: Visibility Conditions
Exhibits 5 through 22 effectively illustrate the contributions of aerosol species to visibility trends. Including the regional haze glidepaths for individual aerosol species on the 20% worst days [2] (see enclosure) would support ADEC's discussion of contributions from controllable and uncontrollable emissions. The role of particulate organic carbon (primarily attributable to wildfire) is highly variable year to year and across the four monitoring sites.

Exhibits 2 and 5-12 sequence the monitoring sites in order from north to south, which is very helpful to readers. Starting with Exhibit 13, the sites are rearranged into alphabetical order in most tables and graphs. Switching the order that data is presented makes it more difficult for

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[1] *Designation of North American Emission Control Area to Reduce Emissions from Ships*. Environmental Protection Agency, Office of Transportation and Air Quality, EPA-420-F-10-015, March 2010. http://www.epa.gov/nonroad/marine/ci/420f10015.pdf
[2] Western Regional Air Partnership, http://vista.cira.colostate.edu/tss/Results/HazePlanning.aspx

readers to scan data between sections of the report. It would be helpful to maintain a consistent ordering of the sites throughout the report.

Exhibit 16 indicates that ammonium sulfate is a major contributor to visibility impairment at all four monitoring sites on the 20% worst days and that light extinction due to ammonium sulfate has increased in both the 2005-2009 and the 2009-2013 periods compared to the baseline period 2000-2004. Sulfate is attributable to anthropogenic emissions in Alaska, plus international and commercial marine emissions. To demonstrate reasonable progress, it is important to demonstrate that ADEC is addressing anthropogenic sources of SO_2.

Section C.4.b: Differences Between Current Visibility Conditions: In the fifth and sixth paragraphs on page 10-19, please clarify that values cited as highest and lowest aerosol extinction on the 20% worst and best days are for the period 2005-2009.

Section C.5: Emissions
Exhibit 24 shows that Alaskan anthropogenic SO_2 emissions were unchanged between the 2002 and 2008 inventories (changes in inventory methods may affect this conclusion). To support ADEC's determination that Alaska is making reasonable progress in reducing anthropogenic emissions, it would be helpful to include 2011 National Emissions Inventory results for the major source categories in Exhibit 24. Please compare 2018 WRAP emissions projections to current inventories. Is Alaska on track to meet the 2018 emissions levels?

Please discuss trends in oil and gas activity and emissions since 2002. Did WRAP develop a separate 2008 oil and gas area source inventory for Alaska? Are any of Alaska's oil refineries subject to consent decrees with EPA to reduce emissions?

Please add units to the tables in Exhibits 24-27.

Section C.7: Assessment of Current SIP Strategy
Additional evidence in Section C.5 that anthropogenic SO_2 emissions have been reduced since 2008 or will be reduced by 2018 would better support ADEC's determination that the current SIP requirements are sufficient to meet ADEC's 2018 reasonable progress goals.

At the end of the second paragraph, please remind readers that although visibility on the 20% worst days apparently improved at all four sites between the first and second progress periods, the haze index at the Denali headquarters site remained above baseline.

To demonstrate compliance with 40 CFR 51.308(g)(6), we suggest that you repeat the statement made in Section A.2 that ADEC has determined that Alaskan emission sources do not affect visibility in Class I areas in other states.

Section C.8: Assessment of Current Monitoring Strategy
This section addresses the importance of long-term comparisons to the 2002-2004 baseline period. It would be helpful to discuss the implications for the long-term record of moving the Tuxedni NWR monitor to the east side of Cook Inlet. It would also be helpful to briefly discuss why the Bering Sea Class I area is not represented by a monitoring site.

Finally, the elevation of Mount McKinley is 20,320 feet.

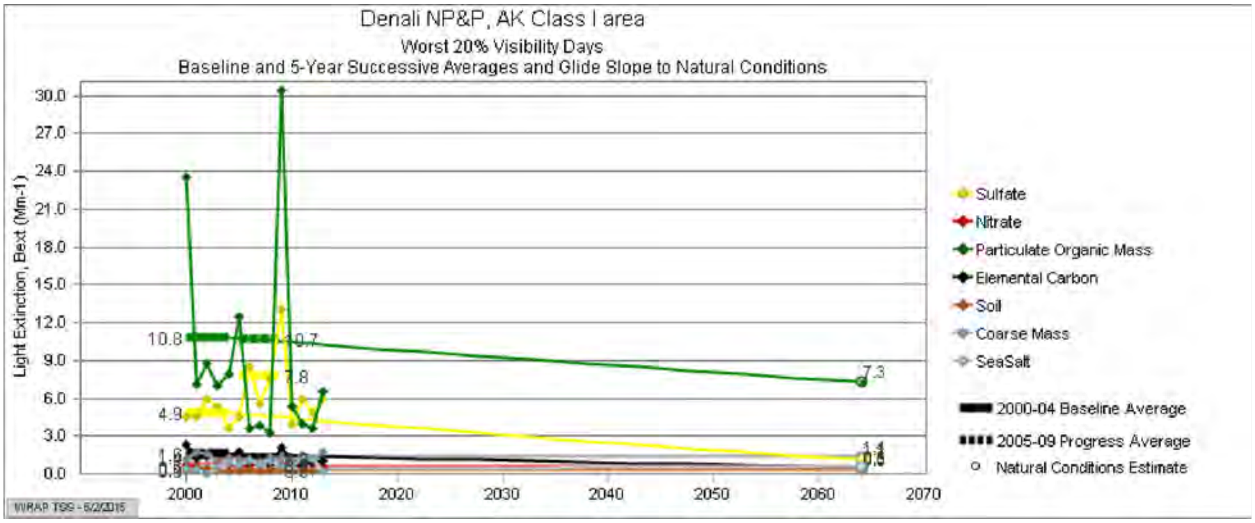
We appreciate the opportunity to work closely with Alaska DEC to improve visibility in our Class I national park and wilderness areas. If you have questions, please contact Pat Brewer at patricia_f_brewer@nps.gov or 303-969-2153.

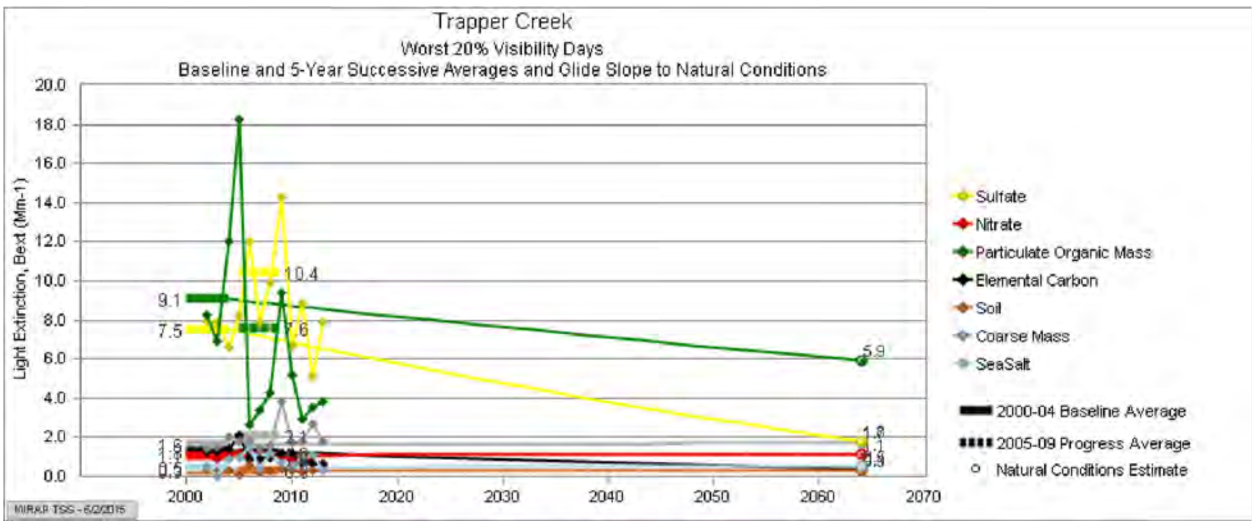
Sincerely,

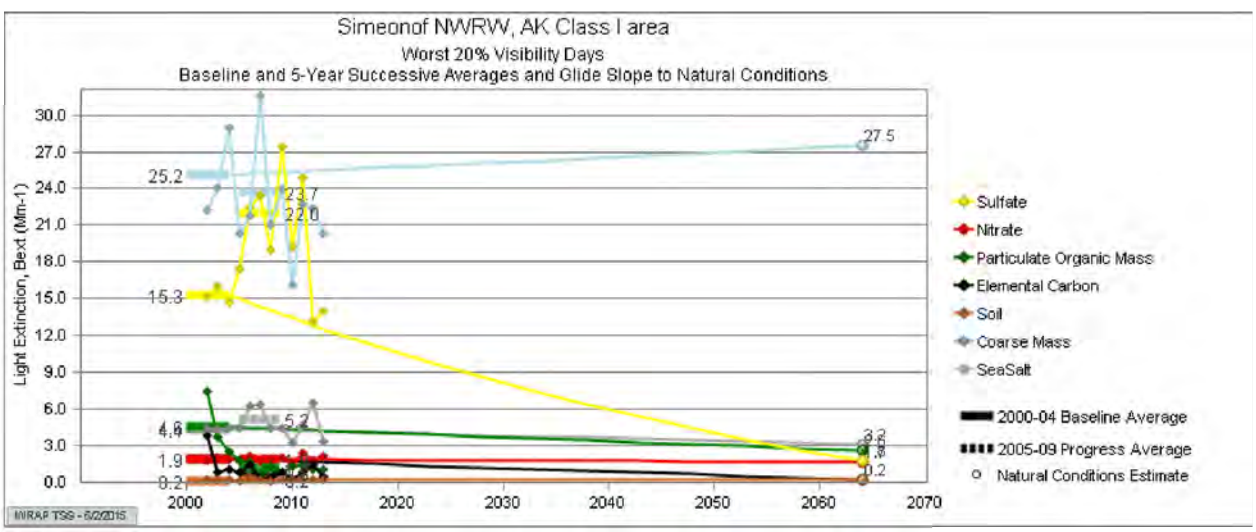
Susan Johnson
Chief, Policy, Planning, and Permit Review Branch

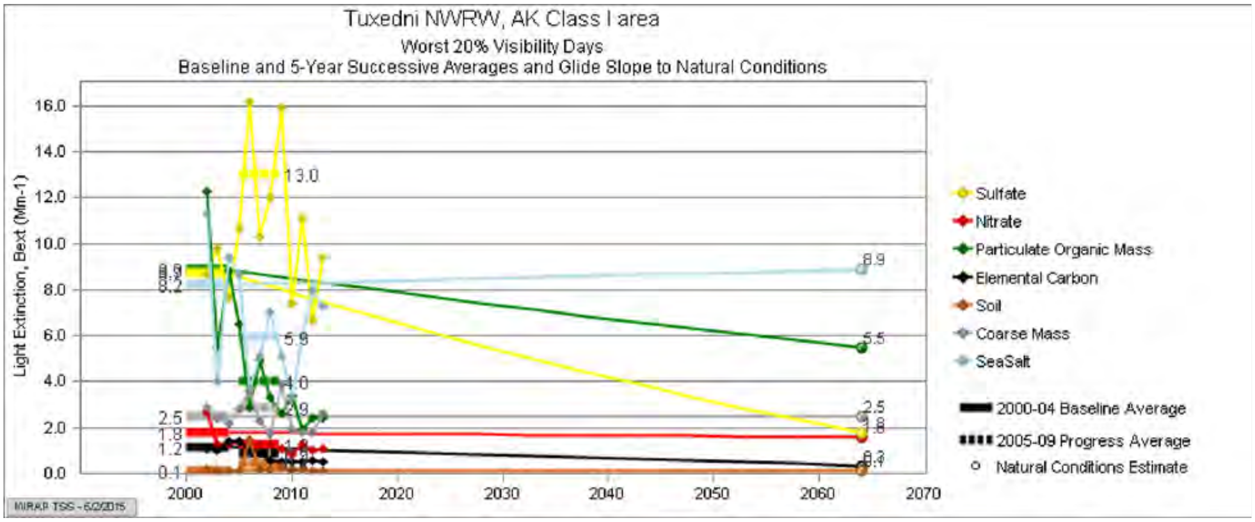
Enclosure

cc:
Keith Rose, EPA Region 10
Andrea Blakesly, Denali National Park and Preserve


Denali NP&P, AK Class I area
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Light Extinction, Bext (Mm-1)
30.0
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
2000
2010
2020
2030
2040
2050
2060
2070
10.8
10.7
7.8
4.9
7.3
Sulfate
Nitrate
Particulate Organic Mass
Elemental Carbon
Soil
Coarse Mass
SeaSalt
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate
WRAP TSS - 6/2/2015


Trapper Creek
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Light Extinction, Bext (Mm-1)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2000
2010
2020
2030
2040
2050
2060
2070
9.1
10.4
7.5
7.6
5.9
Sulfate
Nitrate
Particulate Organic Mass
Elemental Carbon
Soil
Coarse Mass
SeaSalt
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate
WRAP TSS - 6/2/2015


Simeonof NWRW, AK Class I area
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Light Extinction, Bext (Mm-1)
30.0
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
2000
2010
2020
2030
2040
2050
2060
2070
25.2
27.5
23.7
22.0
15.3
5.2
1.9
Sulfate
Nitrate
Particulate Organic Mass
Elemental Carbon
Soil
Coarse Mass
SeaSalt
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate
WRAP TSS - 6/2/2015



Tuxedni NWRW, AK Class I area
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Light Extinction, Bext (Mm-1)
Sulfate
Nitrate
Particulate Organic Mass
Elemental Carbon
Soil
Coarse Mass
SeaSalt
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate

Appendix A – WRAP Regional Haze Rule Reasonable Progress Report Support Document

Background Information

WESTERN REGIONAL AIR PARTERNERSHIP
REGIONAL HAZE RULE
REASONABLE PROGRESS SUMMARY REPORT

Prepared for:

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June 28, 2013

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GLOSSARY OF TERMS

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

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

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

Anthropogenic: Produced by human activities.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

EXECUTIVE SUMMARY

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

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

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

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[1] See CFR 40 Part 51 Regional Haze Regulations; Final Rule, July 1, 1999, available online at http://www.epa.gov/airquality/visibility/actions.html.
[2] See Section 169a of the 1977 CAA Amendments.
[3] Note that "default" natural conditions as defined by the EPA are subject to revisions, and that States can extend the period of time needed to achieve natural conditions, beyond the nominal 2064 in the RHR, defining and defending new interim reasonable progress rates, and adjusting the 2064 end year as needed (see CFR Section 51.308).
[4] See page 4-2 in EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.*
[5] See page 9 in EPA's April 2013 *General Principals for the 5-Year Regional Haze Progress reports for the Initial Regional Haze State Implementation Plans (Intended to Assist States and EPA Regional Offices in Development and Review of the Progress Reports).*

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

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

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

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

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

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

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

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

[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:

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[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.

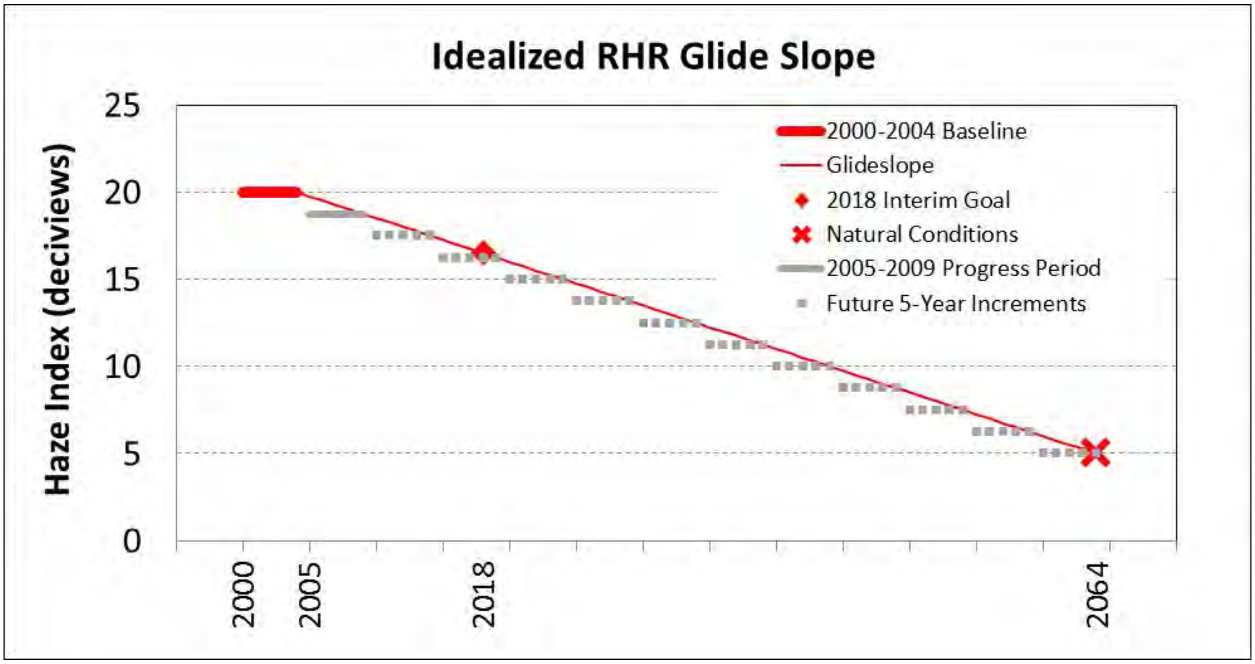

Figure 1.0-1. Idealized RHR Glide Slope Representing Linear Progress from a 2000-2004 Baseline Average to a 2064 Natural Conditions End Goal. Also Represented Are the 2018 Interim Goal and Successive 5-Year Progress Periods.

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.

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

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

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

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

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

2.2 SECTION 309

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

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

2.2.1 Monitoring and Emissions Data Summary Requirements

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

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

2.2.2 SIP Evaluation Requirements

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

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

2.3 2064 NATURAL CONDITIONS

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

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

2.4 TRIBAL CONSIDERATIONS

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

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

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[17] Note that states can extend the period of time needed to achieve natural conditions, beyond the nominal 2064 in the RHR, defining and defending new interim amounts of reasonable progress, and adjusting the 2064 end year as needed (see Section 51.308(d)(1)(i)(B) and 501.308(d)(1)(B)(ii) of the RHR).

[18] Default natural conditions estimates are described in EPA's September 2003 *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule.*

[19] See Copeland's 2008 *Regional Haze Rule Natural Level Estimates Using the Revised IMPROVE Aerosol Reconstructed Light Extinction Algorithm*, available at http://vista.cira.colostate.edu/improve/publications/graylit/032_NaturalCondIIpaper/Copeland_etal_NaturalConditionsII_Description.pdf.

[20] WRAP's archived repository of natural conditions information, projects and references is available at http://www.wrapair.org/forums/aamrf/projects/NCB/index.html.

3.0 DATA SOURCES

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

3.1 IMPROVE MONITORING DATA

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

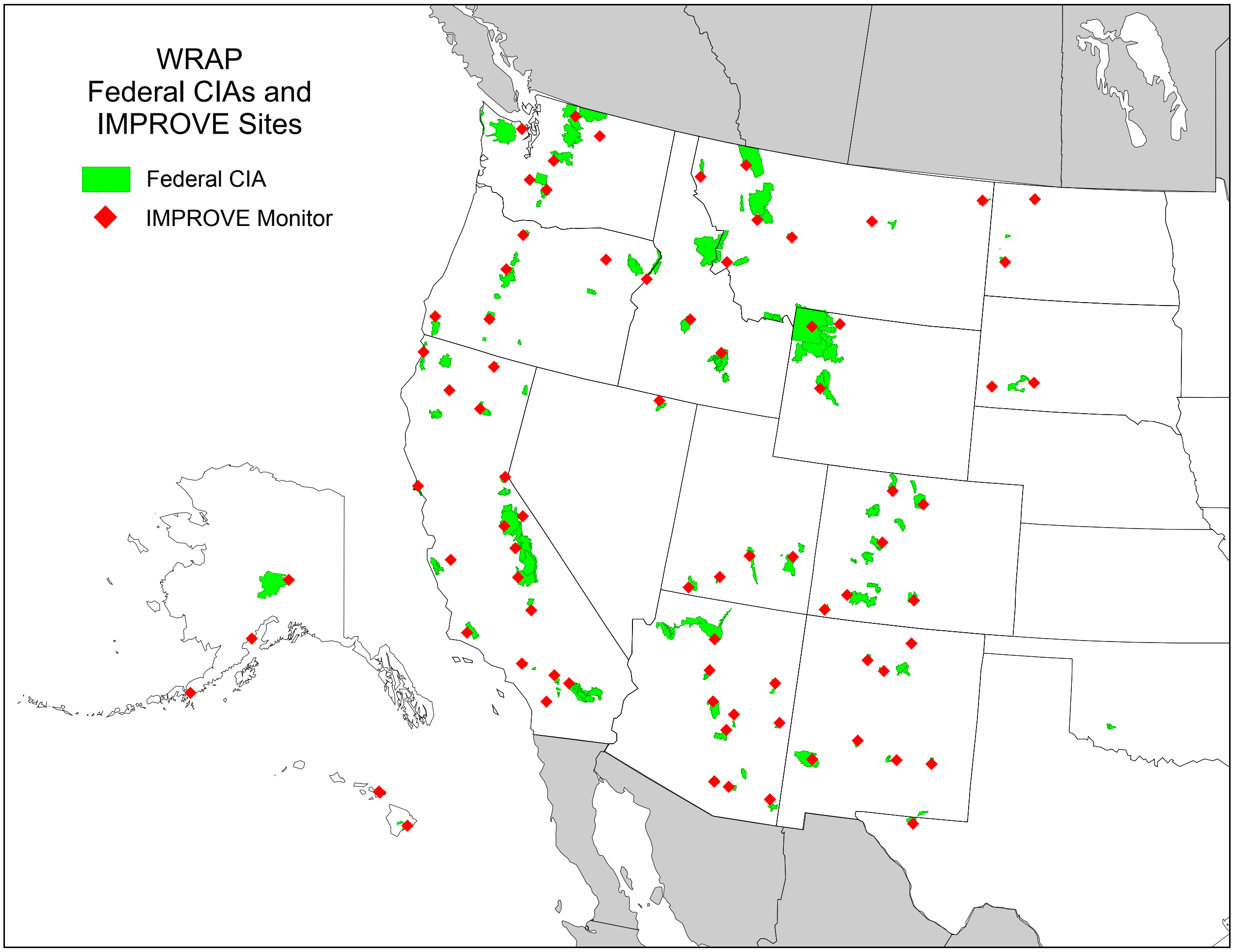

Figure 3.1-1. Map of Federal CIA IMPROVE Monitors in the WRAP Region.

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

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

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

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

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

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

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

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

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

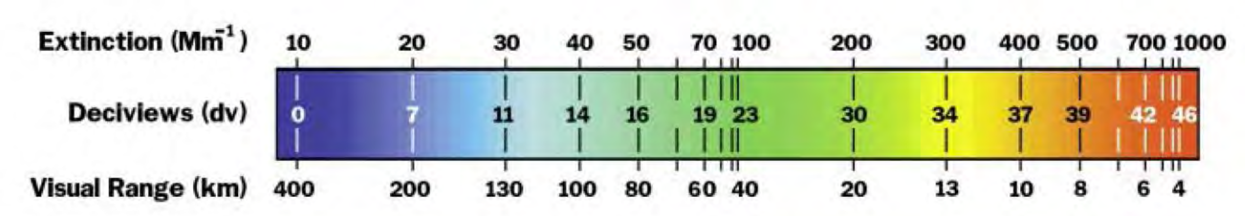

Figure 3.1-2. Comparison of Extinction (Mm^{-1}), Deciview (dv) and Visual Range (km) units.

3.1.1 Data Completeness Requirements

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

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

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

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

- **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.

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

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

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

3.1.2.1 Identification of 20% Worst Days

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

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

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

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

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

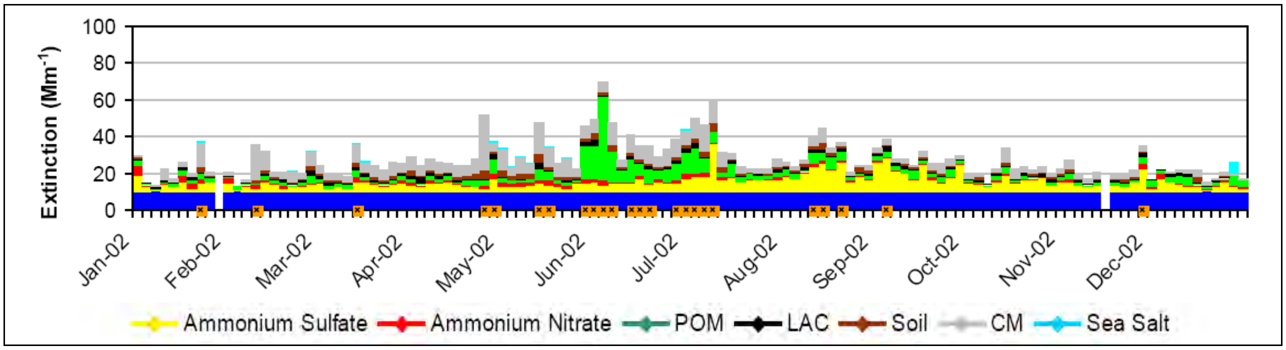

Figure 3.1-3. Daily Aerosol Extinction measured by the Chiricahua CHIR1 IMPROVE monitor during 2002.

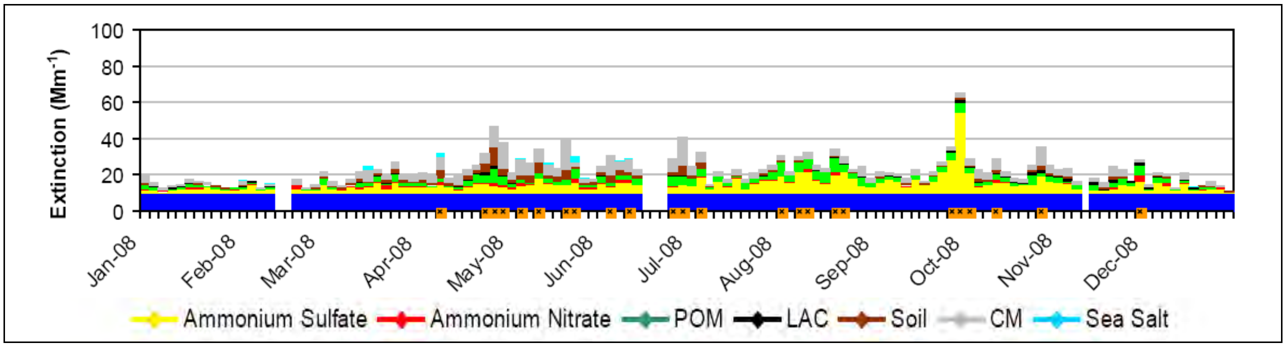

Figure 3.1-4. Daily Aerosol Extinction measured by the Chiricahua CHIR1 IMPROVE monitor during 2008.

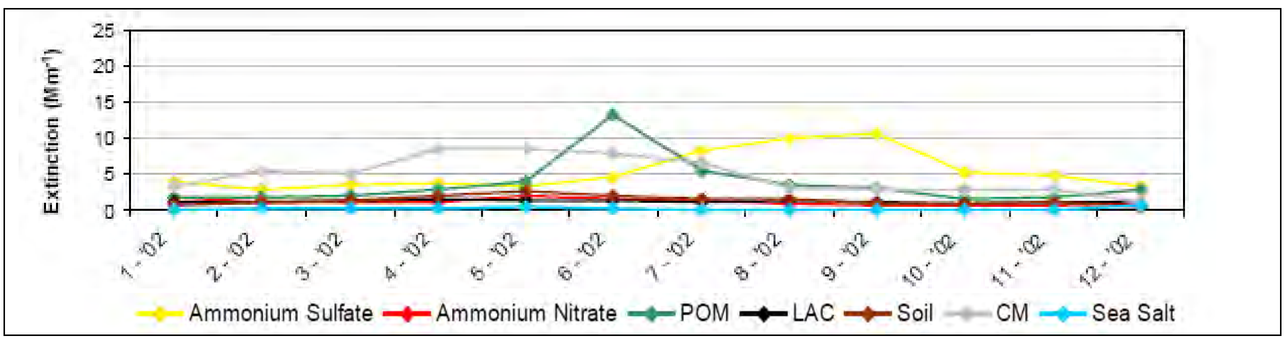

Figure 3.1-5. Monthly Average Aerosol Extinction measured by the CHIR1 IMPROVE monitor in 2002.

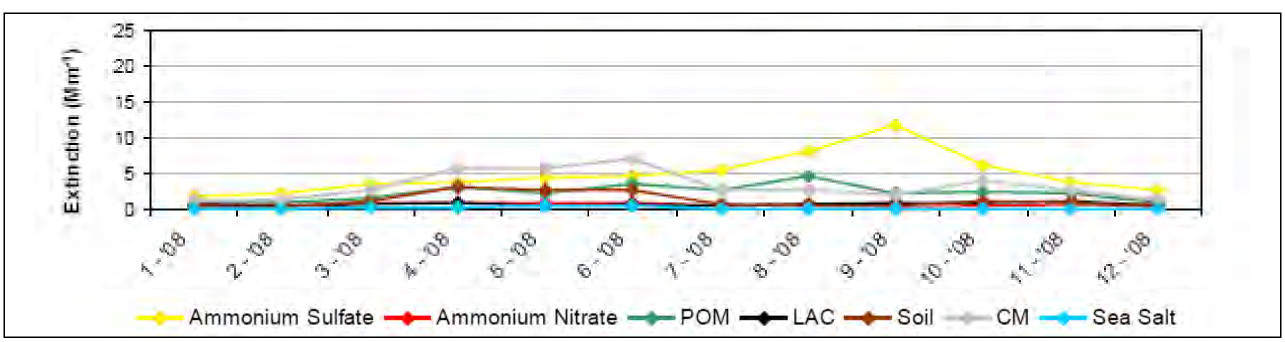

Figure 3.1-6. Monthly Average Aerosol Extinction measured by the CHIR1 IMPROVE monitor in 2008.

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

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

3.1.2.2 Discreet 5-Year Averages vs. Trends

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

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

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

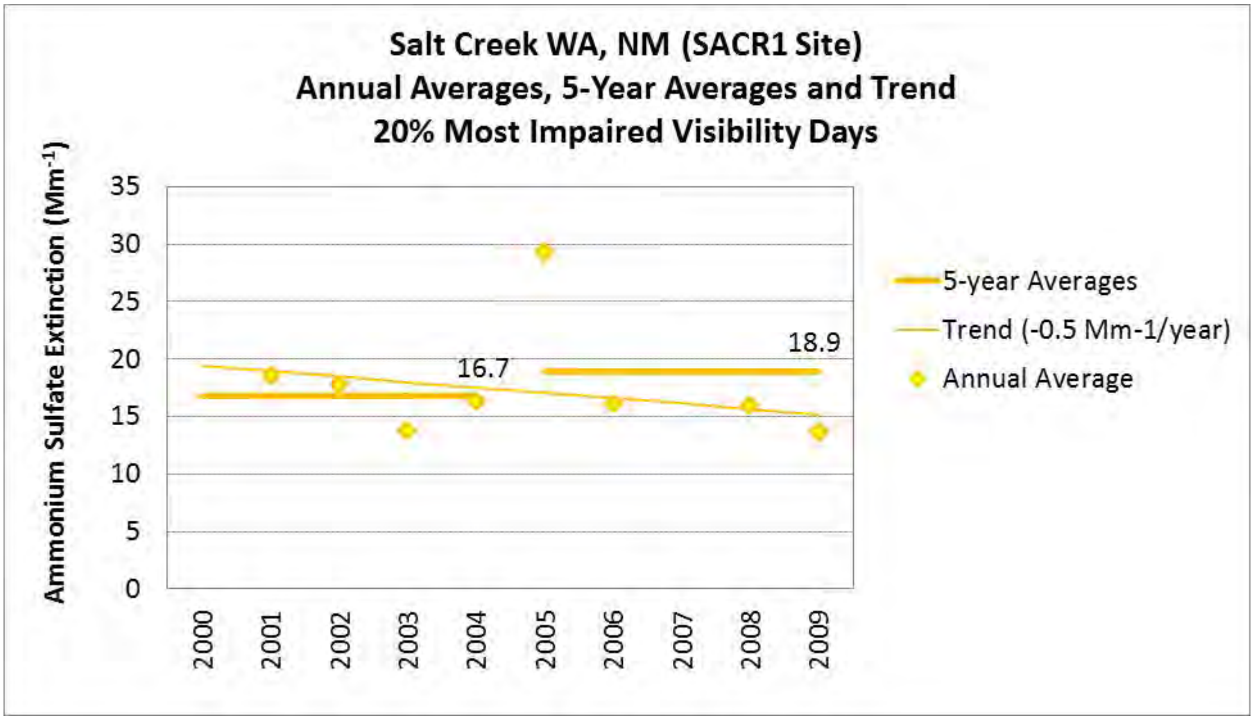

Figure 3.1-7. Annual Averages, Period Averages and Trend Statistics for Ammonium Sulfate Measured at the SACR1 IMPROVE Site in New Mexico.

3.1.2.3 Averaging Considerations for Deciview Calculations

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

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

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

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

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

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

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

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

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

3.2 EMISSIONS INVENTORIES

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

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

3.2.1 Inventory Descriptions

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

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

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

- *On-Road Mobile Sources:* These include vehicular sources that travel on roadways. Emissions from these sources can be computed either as being spread over a spatial extent or as being assigned to a line location (called a link). Emissions are estimated as the product of emissions factors and activity data, such as vehicle miles traveled (VMT). Examples of on-road mobile sources include light-duty gasoline vehicles and heavy-duty diesel vehicles.
- *Off-Road Mobile Sources:* Off-road mobile sources are vehicles and engines that encompass a wide variety of equipment types that either move under their own power or are capable of being moved from site to site. Examples include agricultural equipment such as tractors or combines, aircraft, locomotives and oil field equipment such as mechanical drilling engines. Emissions from marine vessels are included here separately as offshore emissions.
- *Off-shore:* Commercial marine emissions comprise a wide variety of vessel types and uses. Emissions can be estimated for deep draft vessels within shore and near port using port call data, and offshore emissions generated from ship location data.
- *Oil and Gas Sources:* Oil and gas sources consist of a number of different types of activities from engine sources for drill rigs and compressor engines, to sources such as condensate tanks and fugitive gas emissions. The variety of emissions types for sources specific to oil and gas activity can, in some cases, overlap with mobile, area or point sources, but these can also be extracted and treated separately.
- *Biogenic Emissions:* Biogenic emissions are based on the activity fluxes modeled from biogenic land use data, which characterizes the types of vegetation that exist in particular areas. Emissions are generally derived using modeled estimates of biogenic gas-phase pollutants from land use information, emissions factors for different plant species, and meteorology data.
- *Dust:* Dust emissions may have a variety of sources that could include anthropogenic sources, natural sources, and natural sources that may be influenced by anthropogenic activity. In order to better distinguish between the natural and anthropogenic sources, the WRAP undertook a Definitions of Dust project, with a final report available here: http://www.wrapair.org/forums/dejf/documents/defdust/index.html. For emissions summary purposes, dust is classified here as fugitive dust and windblown dust. Fugitive dust includes sources such as road dust, agricultural operations, construction and mining operations and windblown dust from vacant lands. The windblown dust category includes more of the natural influences such as wind erosion on natural lands.
- *Fire:* Fire sources are difficult to predict and control, and may have a mix of natural and anthropogenic influences. Natural sources include wildland fires, while anthropogenic sources can include agricultural and prescribed fires. In order to better

distinguish between natural and anthropogenic fires, the WRAP has created an operational policy level definition of fire activity as discretely natural or anthropogenic, which included allowing certain types of prescribed fires to be treated as natural.[30]

3.2.1.1 Contiguous WRAP States

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

The WRAP has continued to support emissions data tracking and related technical analyses focused on understanding current and evolving regional air quality issues in the western states. Methods for estimating emissions of many of the source categories that affect regional haze have continued to evolve and be refined over time. This is especially true for inventories of natural emissions categories including windblown dust and biogenic emissions, and also for rapidly evolving industries such as oil and gas exploration. To represent current conditions, this progress report support document leverages 2008 emissions data inventories which have been recently developed as part of the WRAP's West-wide Jumpstart Air Quality Modeling Study (WestJumpAQMS) and Deterministic and Empirical Assessment of Smoke's Contribution to Ozone ($DEASCO_3$) study, which are described briefly below:

- The WestJumpAQMS project (http://wrapair2.org/WestJumpAQMS.aspx) sponsored by the WRAP includes coordination and harmonization with the EPA 2008 National Emissions Inventory (2008 NEI v2). Among other goals, this project is intended to provide technical updates and improvements for multiple air quality issues, including regional haze, ozone, particulate pollution and nitrogen deposition.
- The $DEASCO_3$ study (http://www.wrapfets.org/deasco3.cfm) is a project sponsored by the Joint Fire Sciences Program (JFSP) that looks at impact of weather and fires on ozone formation. This project has included the development of a detailed and comprehensive 2008 fire emissions inventory, which will eventually be incorporated into the WestJumpAQMS project.

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

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

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

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

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

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

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

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

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

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Fires (Natural and Anthro-pogenic)	Baseline estimates used the WRAP Phase III fire inventory, which represent a 2000-2004 5-year average of fire activity. Inventories included both anthropogenic and natural emissions.	2008 estimates use $DEASCO_3$ fire summaries, which account for fires in 2008, and include separate reporting of anthropogenic and natural fires. [36]	Baseline conditions are represented with a 5-year average of fire, while progress period conditions are represented with 2008 data. Comparisons between these inventories are complicated by the variable and sporadic nature of wildfires. Also, differences between methodologies will affect comparisons of inventories used for 2002 and 2008 estimates.

[36] Additional details regarding fire inventory descriptions for development of the $DEASCO_3$ inventory are available on the WRAP project page at http://www.wrapfets.org/deasco3.cfm.

3.2.1.2 Alaska

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

Table 3.2-2
Emissions Inventory Descriptions
Alaska

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

3.2.1.3 Hawaii

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

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

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

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

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

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

[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.

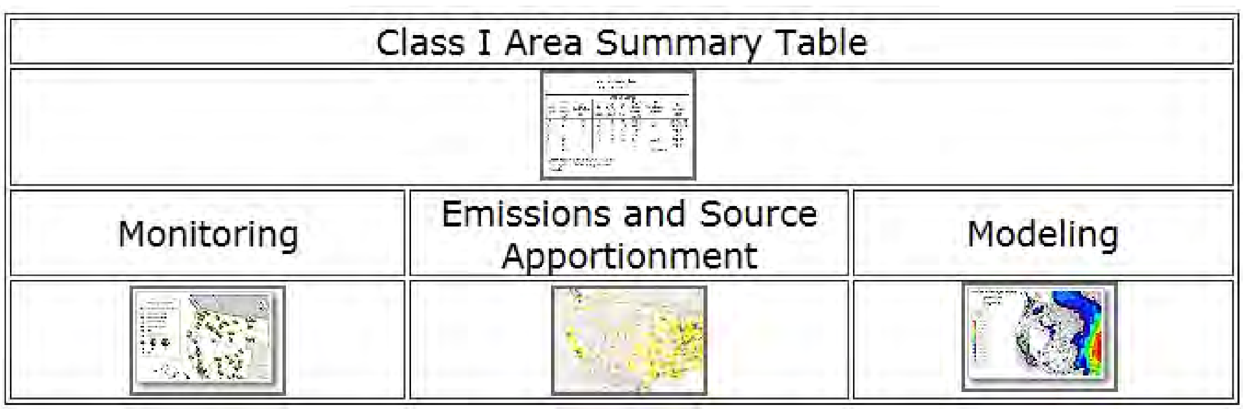

Figure 3.3-1. The WRAP TSS Summary Tools Interface.

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).

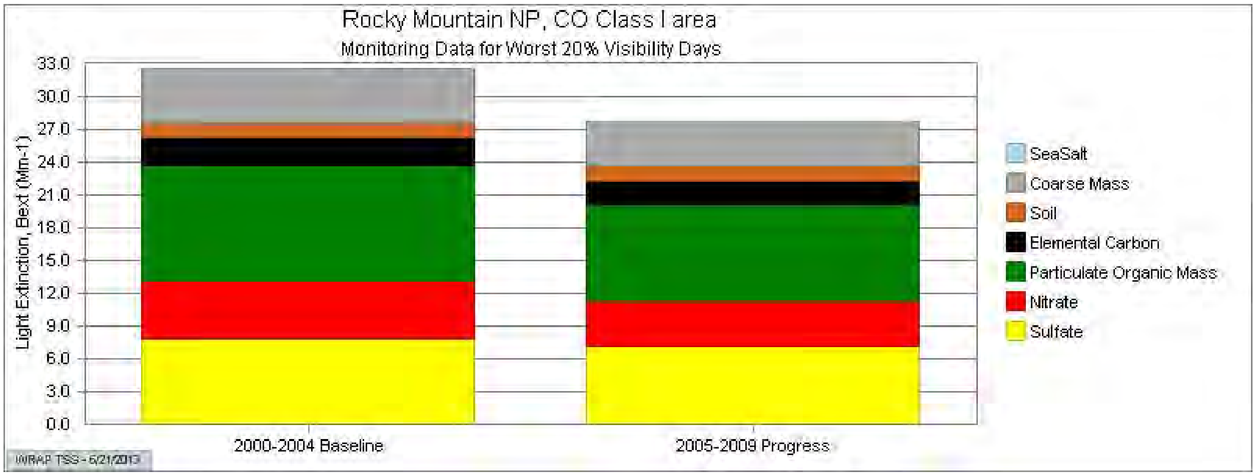

Figure 3.3-2. Example TSS Comparison of 2000-2004 and 2005-2009 period averages for Rocky Mountain National Park in CO.

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)

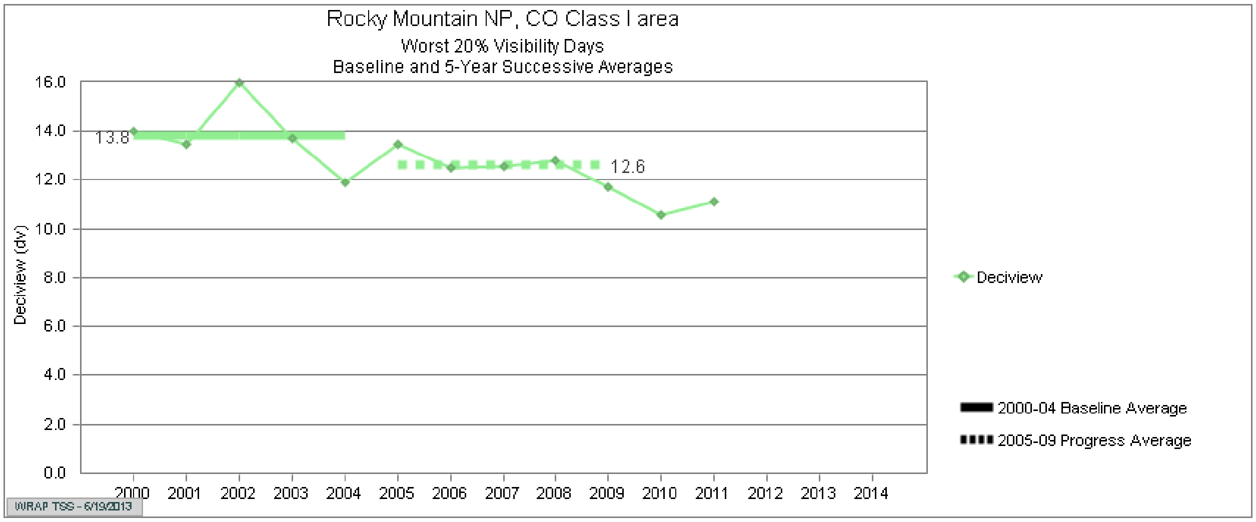

Figure 3.3-3. Example TSS Plot of 5-Year Successive Averages, Showing the 2000-2004 Baseline Average and 2005-2009 Period Averages for Rocky Mountain National Park in CO.

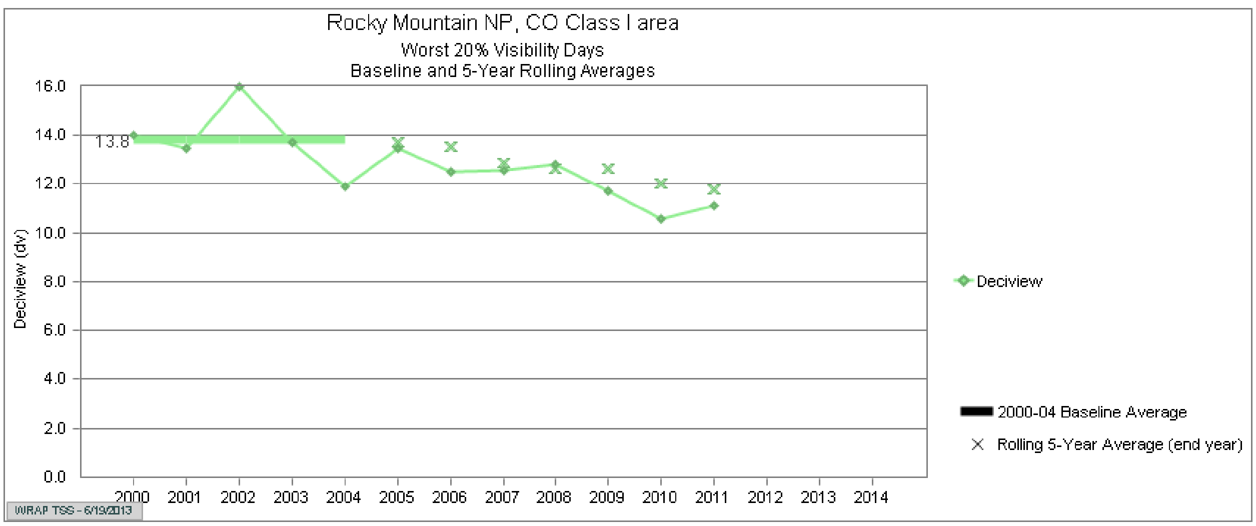

Figure 3.3-4. Example TSS Plot of 5-Year Rolling Averages, Showing the 2000-2004 Baseline Average and Rolling Averages Beginning With 2001-2005 through 2007-2011, for Rocky Mountain National Park in CO.

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.

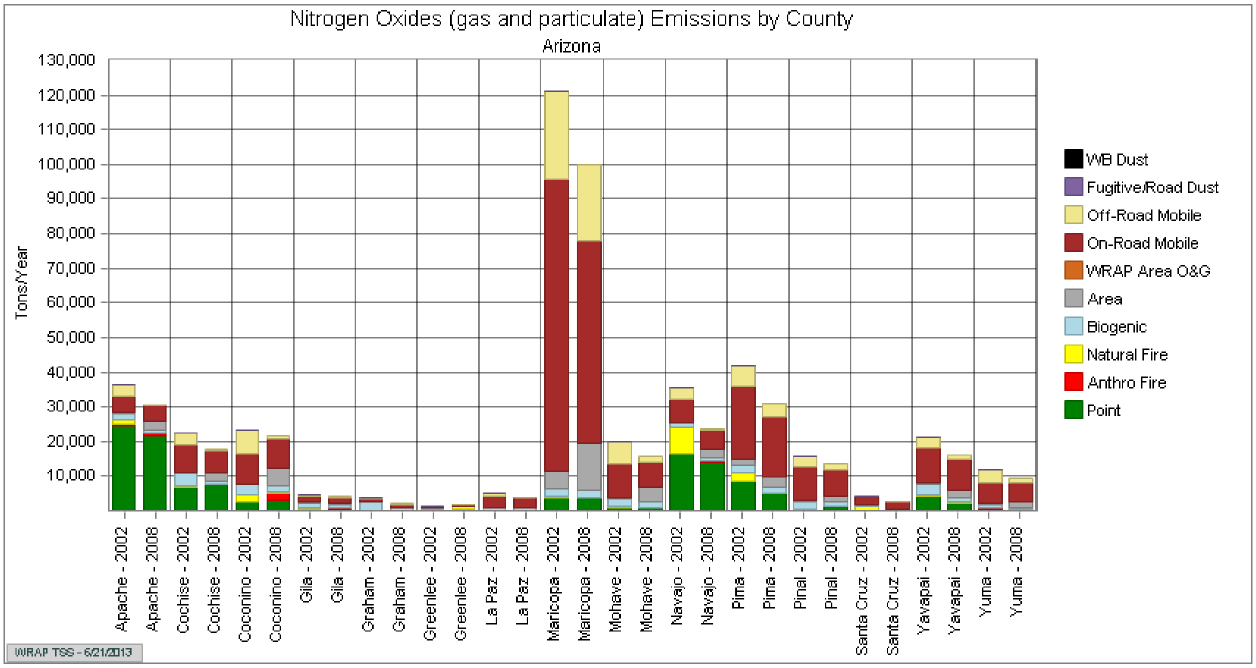

Figure 3.3-4. Example TSS Plot Showing Side-by-Side Comparisons of 2002 and 2008 Emission Inventories for Counties in Arizona.

Appendix B – WRAP Regional Haze Rule Reasonable Progress Report Support Document

WRAP Regional Summaries

4.0 WRAP REGIONAL SUMMARIES

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

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

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

4.1 MONITORING DATA

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

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

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

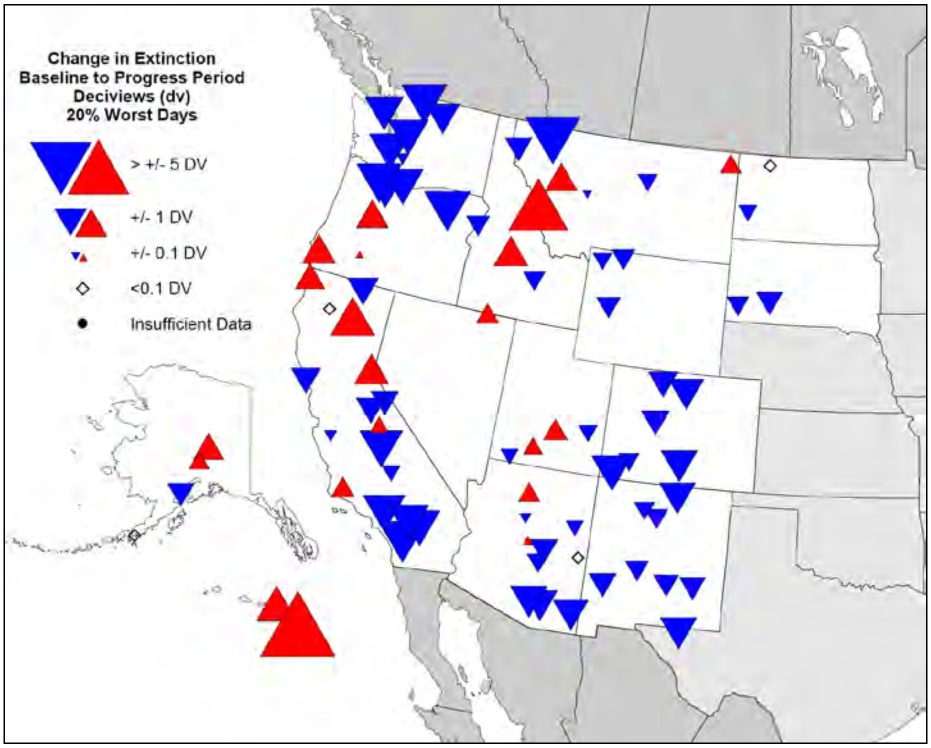

Figure 4.1-1. Change in Deciview Extinction between Baseline Period Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Worst Visibility Days.

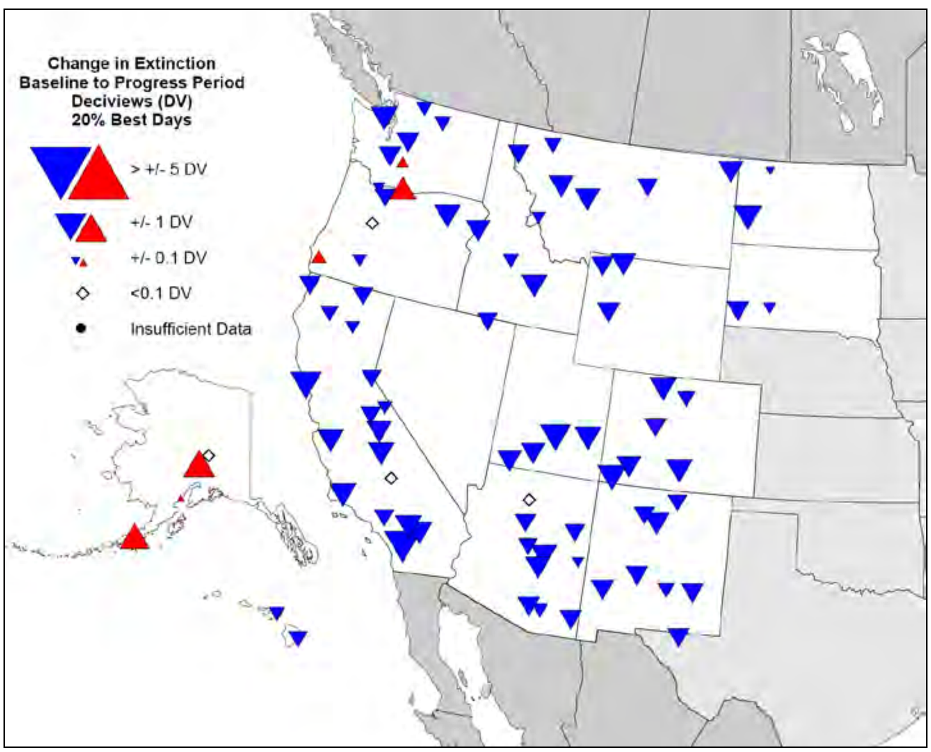

Figure 4.1-2. Change in Deciview Extinction between Baseline Period Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Best Visibility Days.

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

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

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

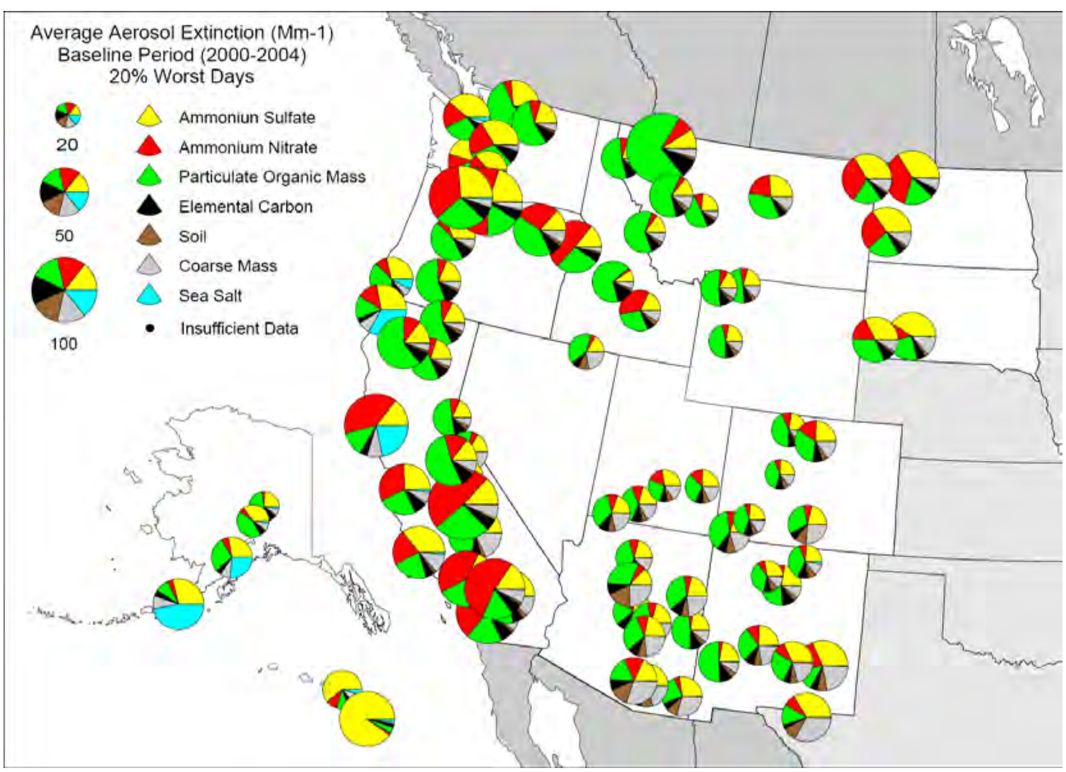

Figure 4.1-3. Regional Average of Aerosol Extinction by Pollutant for Baseline Period Average (2000-2004) for 20% Worst Days.

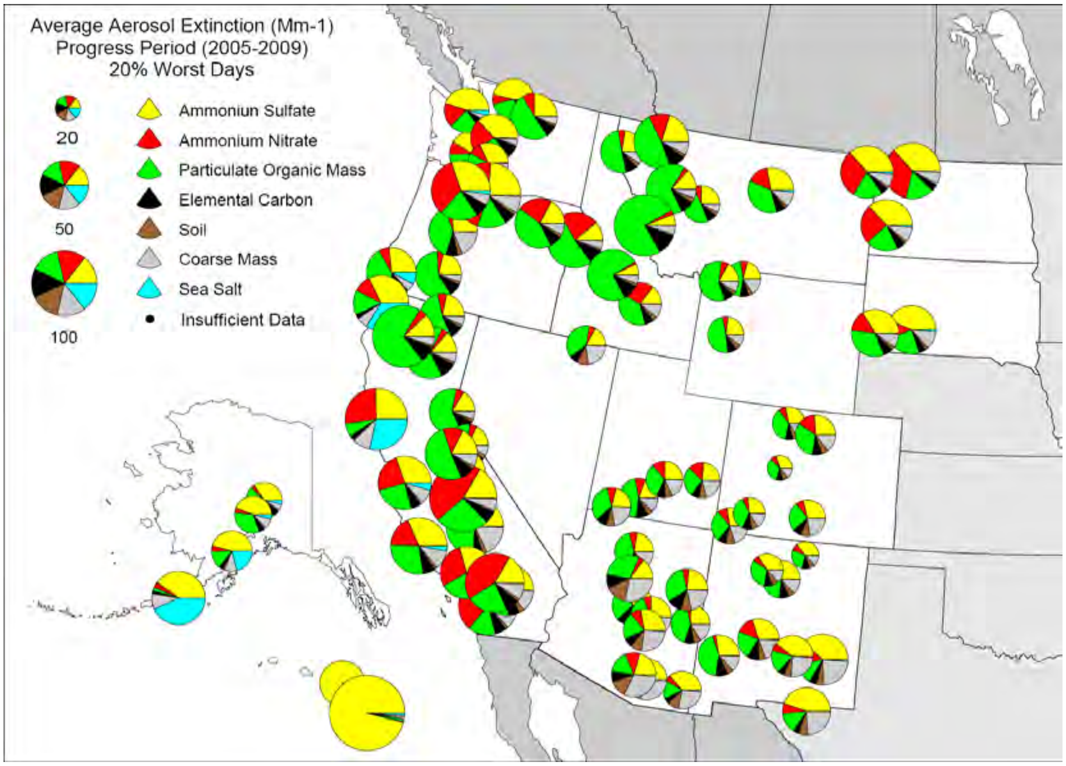

Figure 4.1-4. Regional Average of Aerosol Extinction by Pollutant for the First Progress Period Average (2005-2009) for 20% Worst Days.

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

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

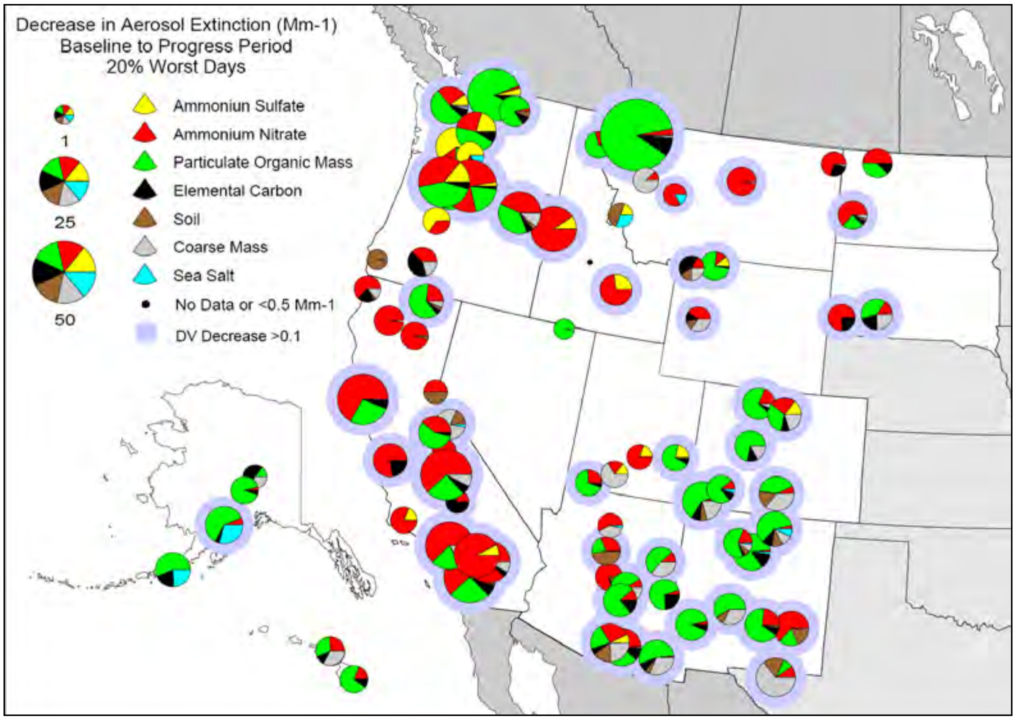

Figure 4.1-5. Magnitude of Aerosol Extinction Species That Have Decreased Between the Baseline Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Worst Days.

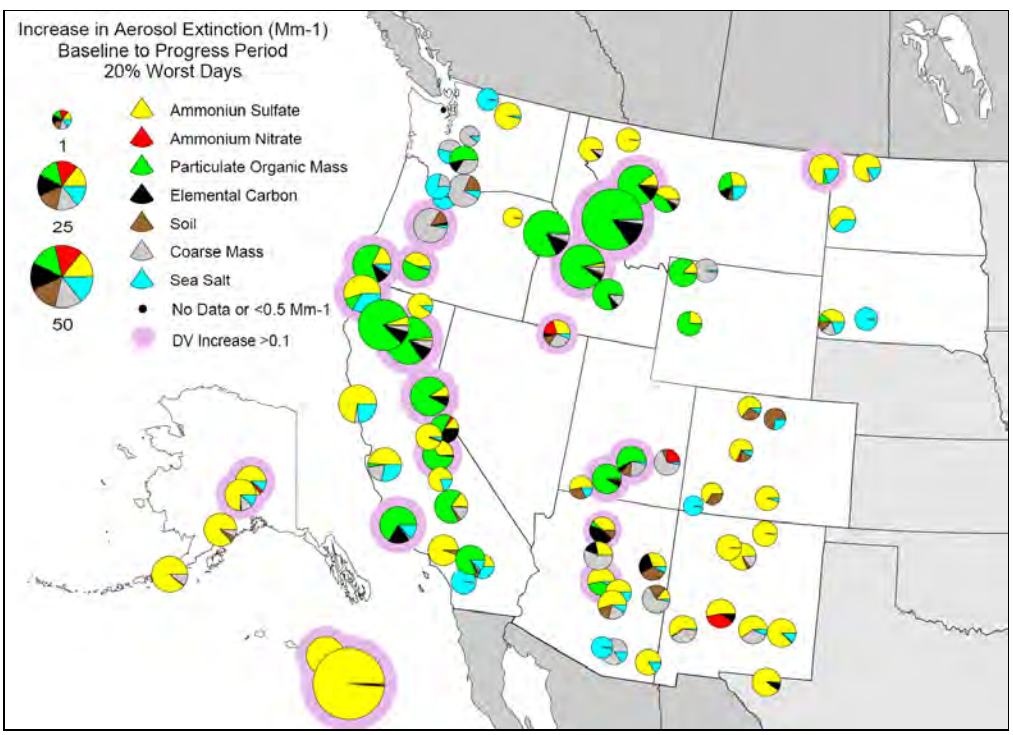

Figure 4.1-6. Magnitude of Aerosol Extinction Species That Have Increased Between the Baseline Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Worst Days.

4.1.1 Annual Trends

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

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

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

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

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

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[51]Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)
[52] The 2010 IMPROVE data were not included in trend analysis, but 2010 annual averages are included for reference in states specific appendices.
[53] Seasonality effects of the identification of worst days are discussed further in Section 3.1.2.1.

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

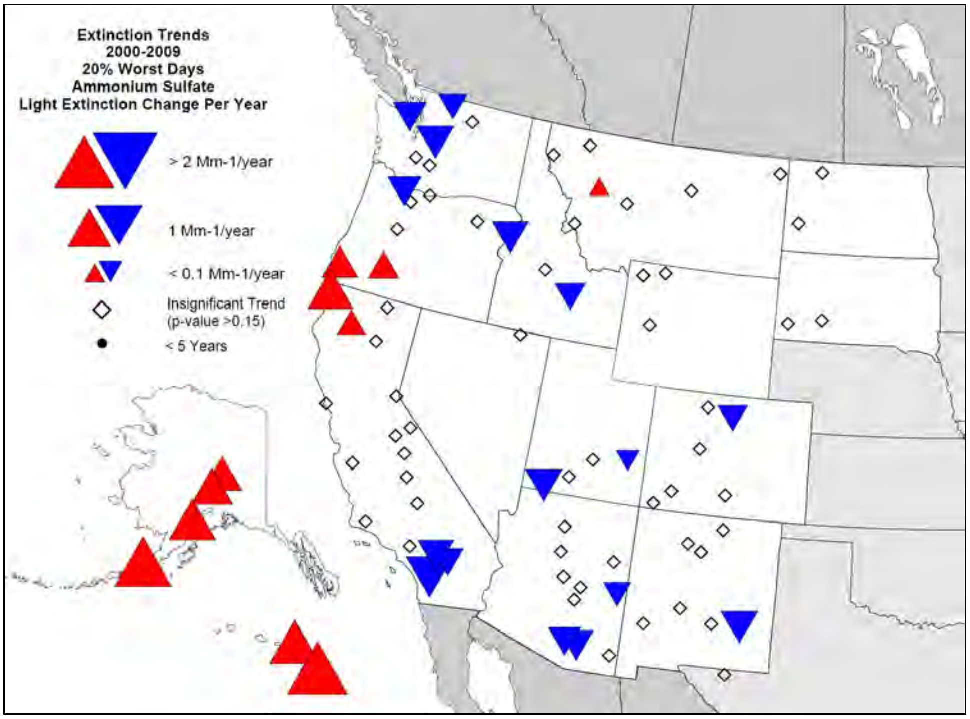

Figure 4.1-7. 10-Year Annual Average Ammonium Sulfate Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

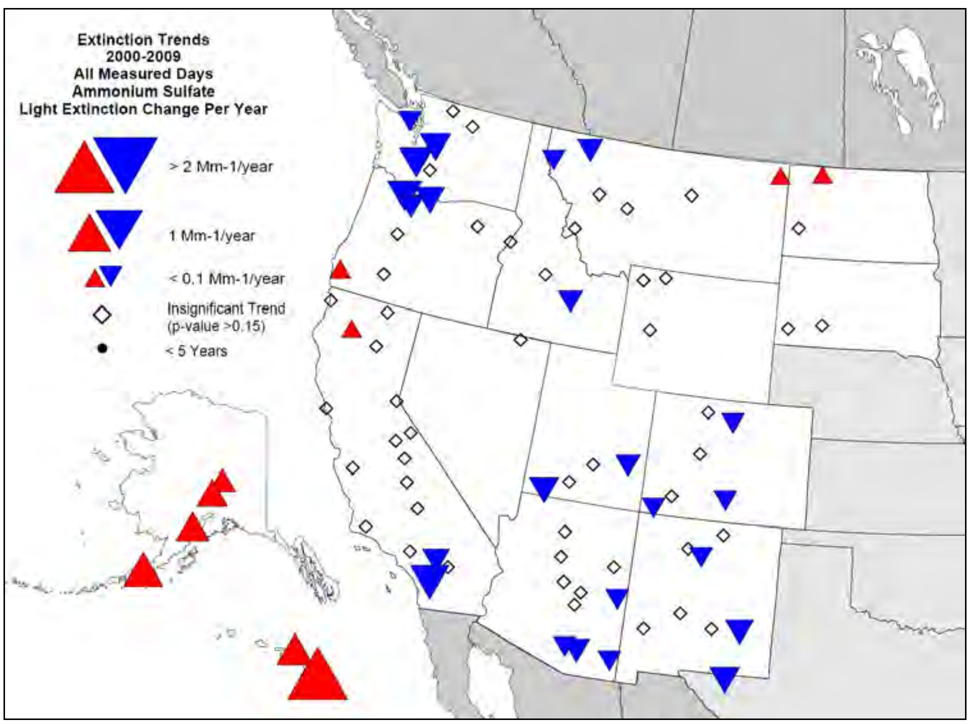

Figure 4.1-8. 10-Year Annual Average Ammonium Sulfate Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

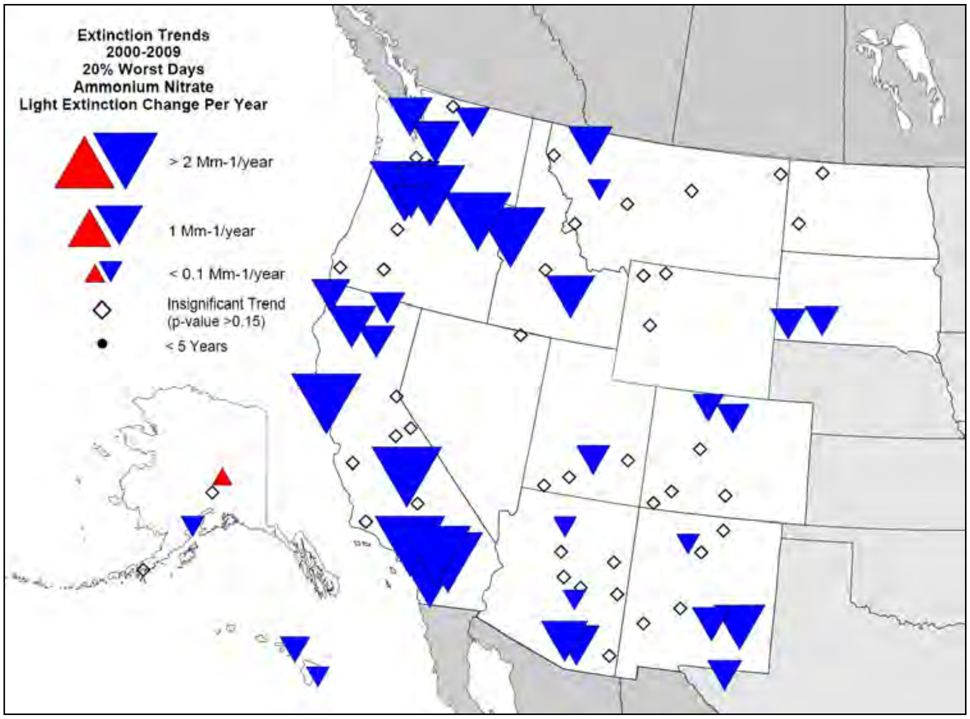

Figure 4.1-9. 10-Year Annual Average Ammonium Nitrate Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

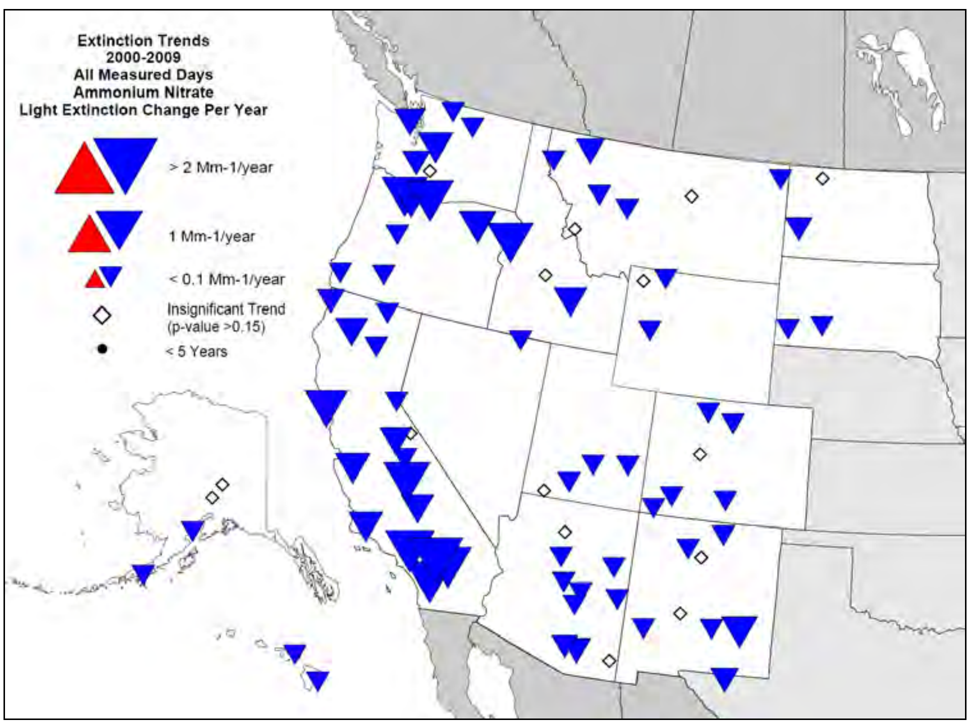

Figure 4.1-10. 10-Year Annual Average Ammonium Nitrate Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

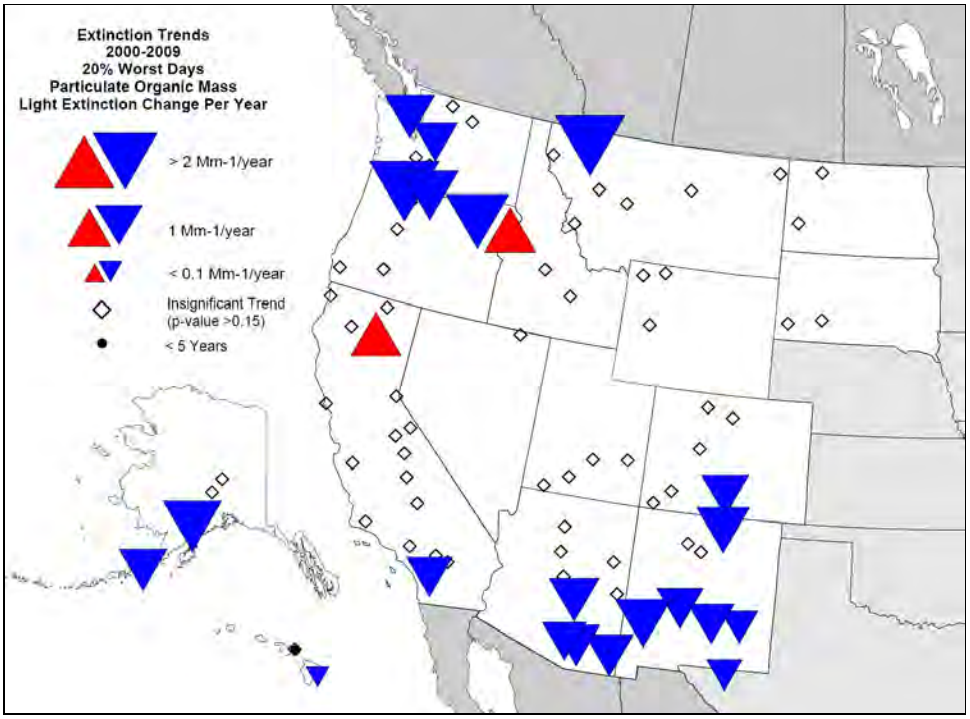

Figure 4.1-11. 10-Year Annual Average Particulate Organic Matter Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

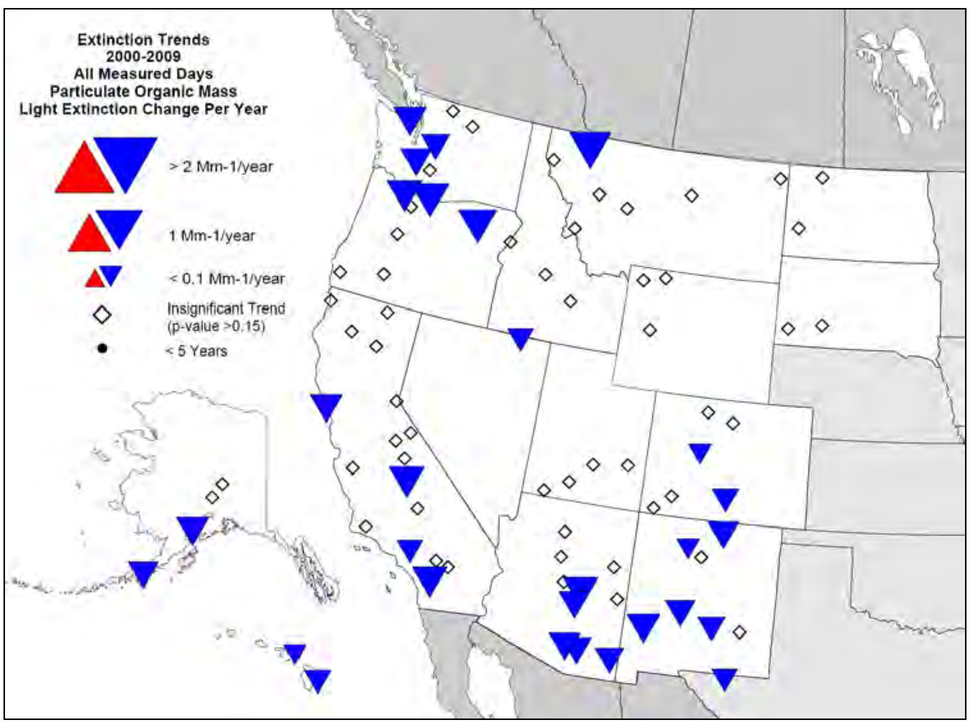

Figure 4.1-12. 10-Year Annual Average Particulate Organic Matter Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

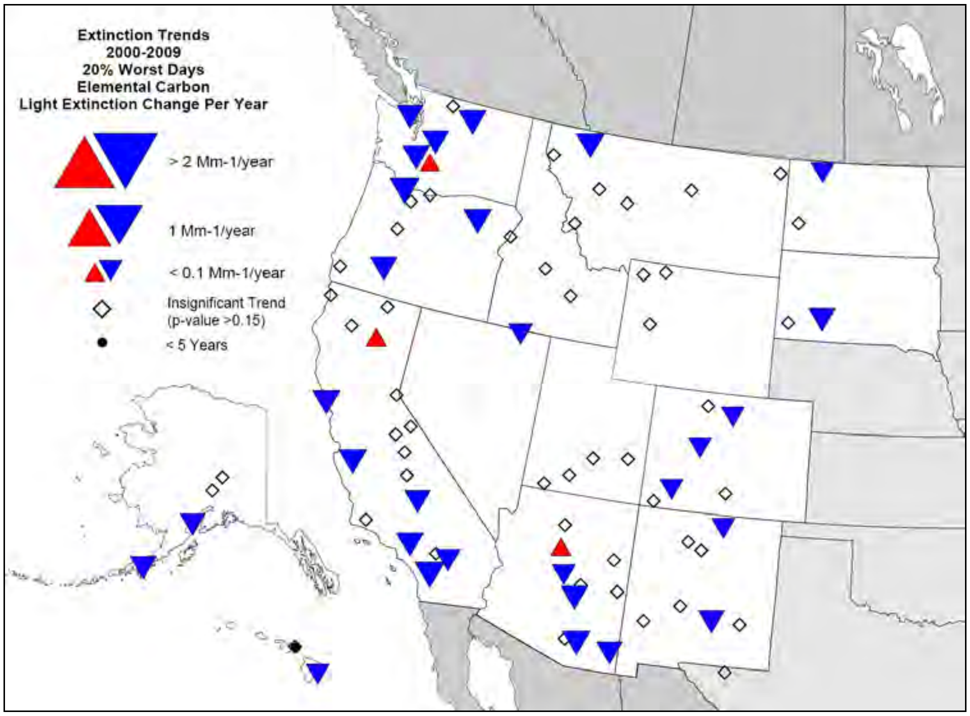

Figure 4.1-13. 10-Year Annual Average Light Absorbing Carbon Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

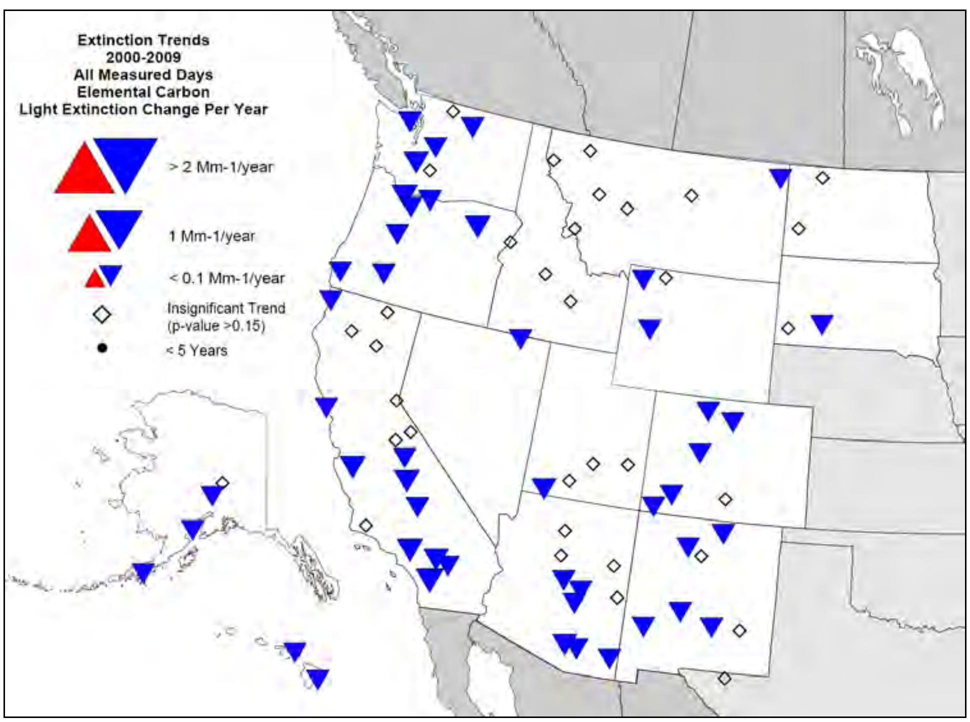

Figure 4.1-14. 10-Year Annual Average Light Absorbing Carbon Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

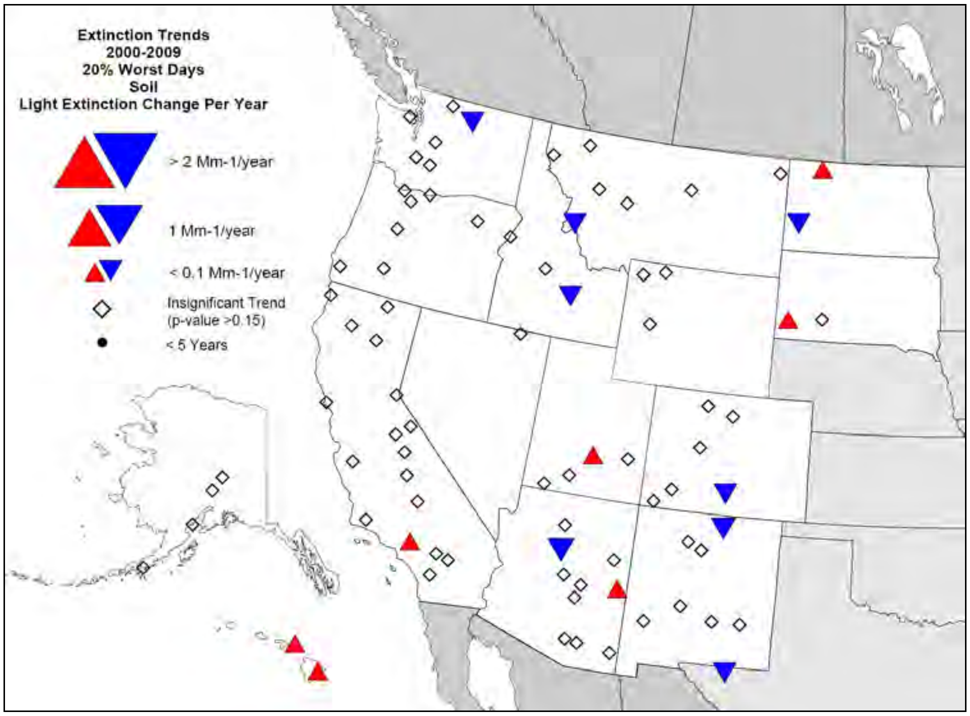

Figure 4.1-15. 10-Year Annual Average Soil Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

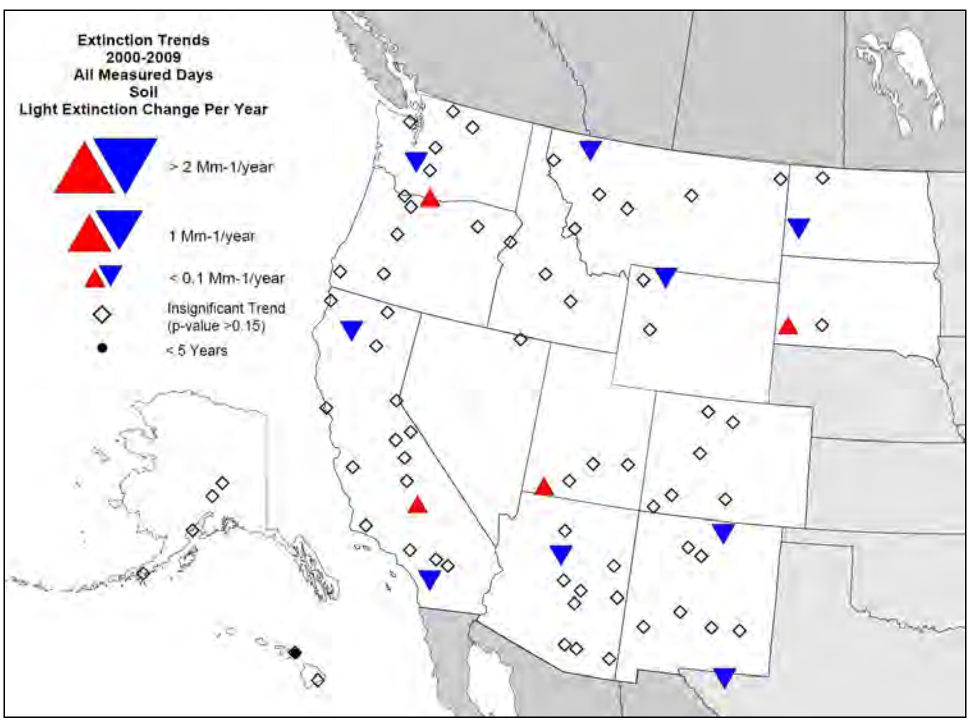

Figure 4.1-16. 10-Year Annual Average Soil Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

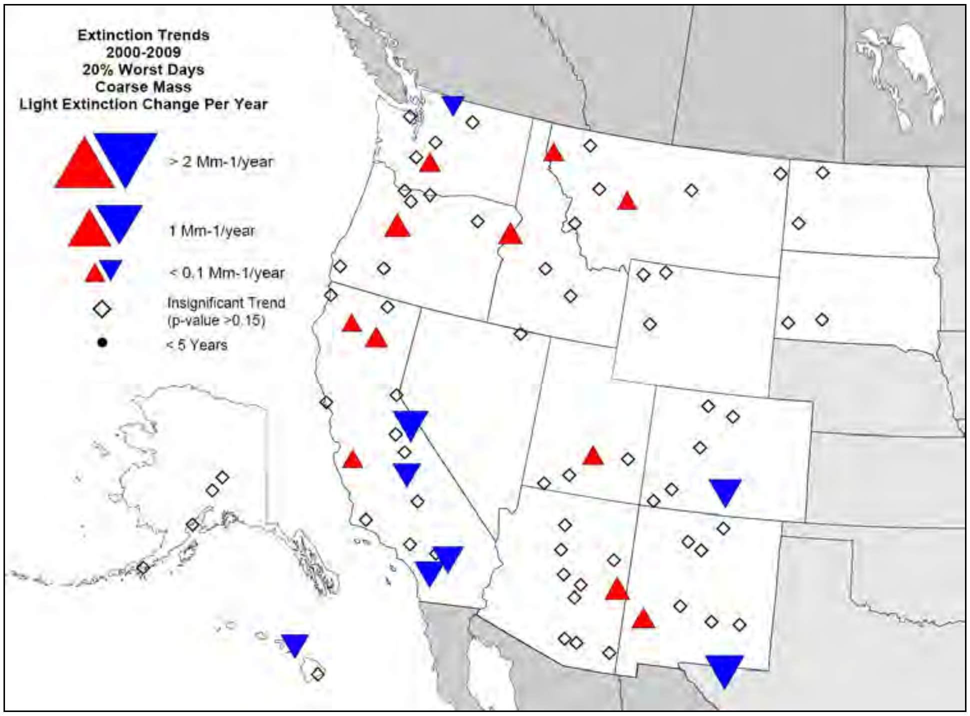

Figure 4.1-17. 10-Year Annual Average Coarse Mass Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

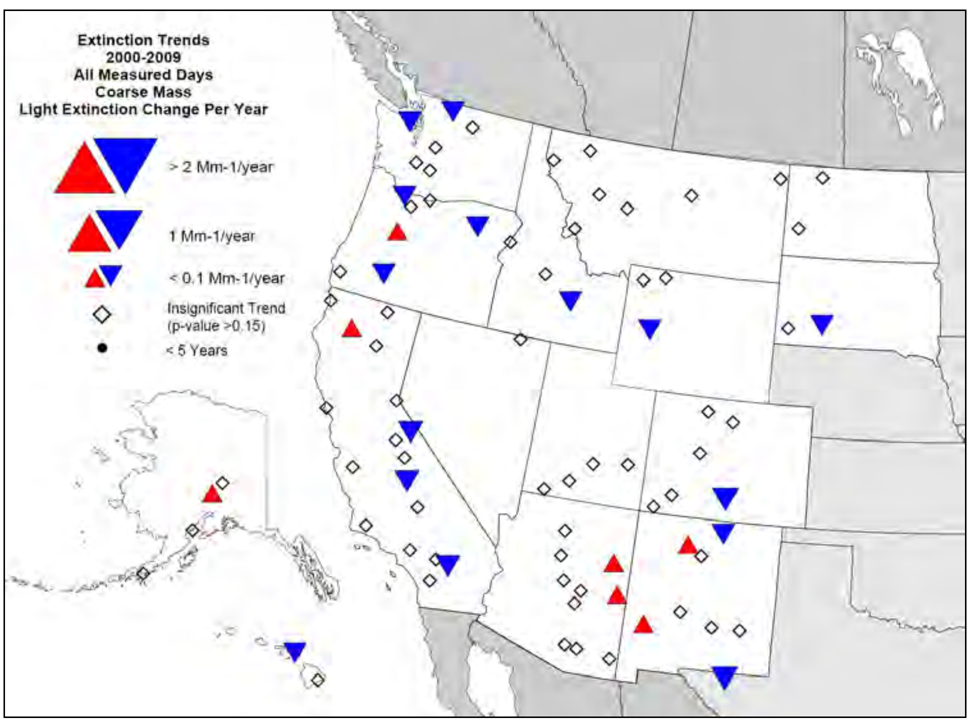

Figure 4.1-18. 10-Year Annual Average Coarse Mass Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

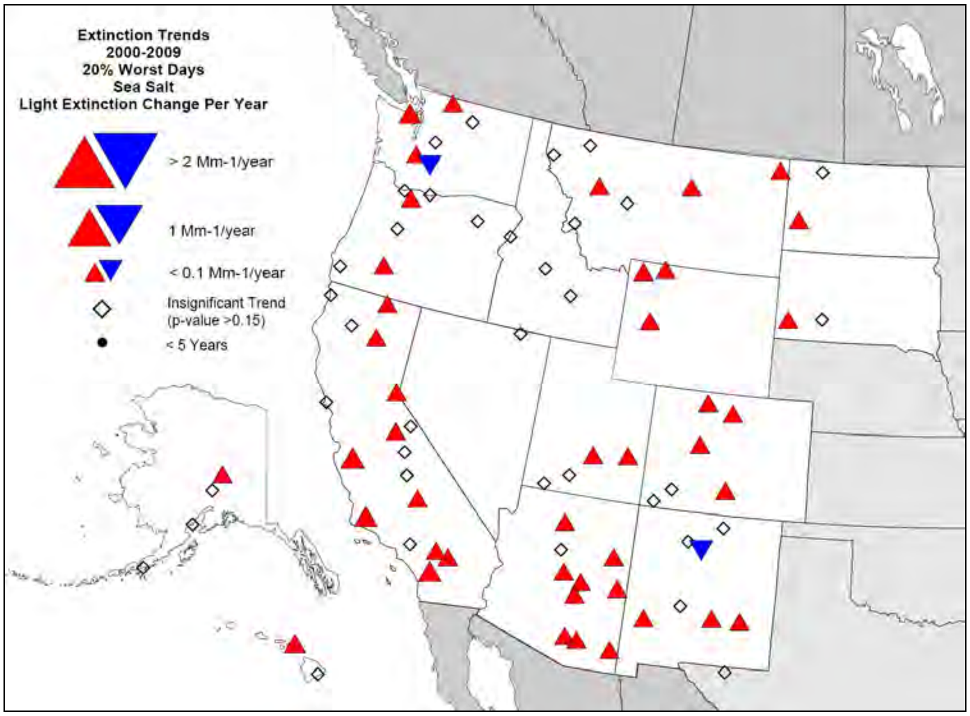

Figure 4.1-19. 10-Year Annual Average Sea Salt Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

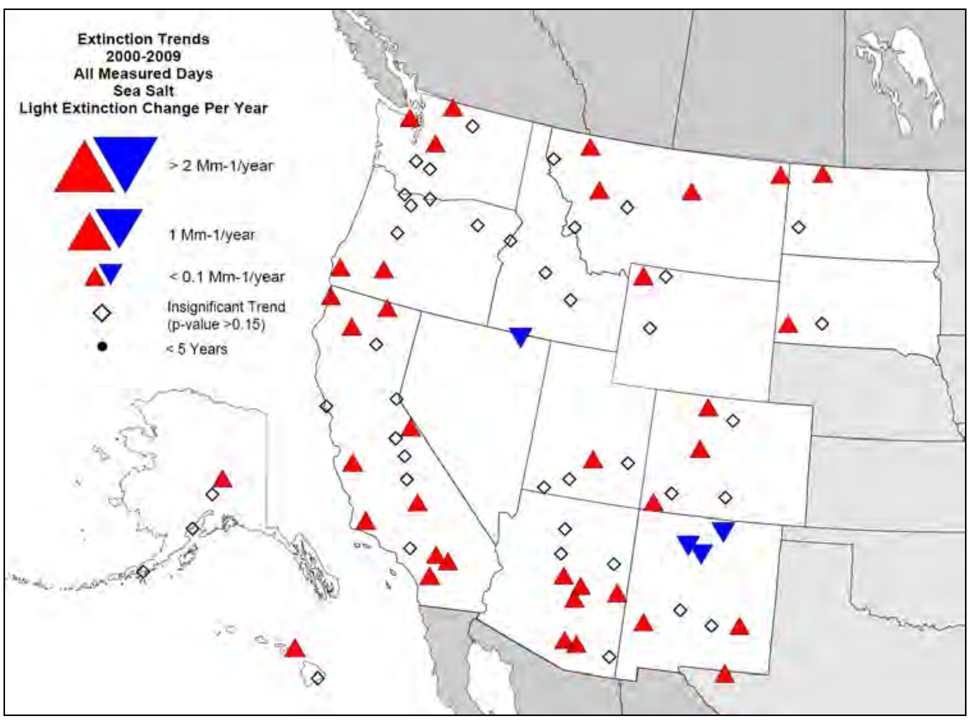

Figure 4.1-20. 10-Year Annual Average Sea Salt Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

4.1.2 Regional Events

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

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

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

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

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

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[54] The WRAP FETS is available online at http://www.wrapfets.org/.
[55] IMPROVE Steering committee meeting minutes are available at http://vista.cira.colostate.edu/improve/Activities/activities.htm.

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

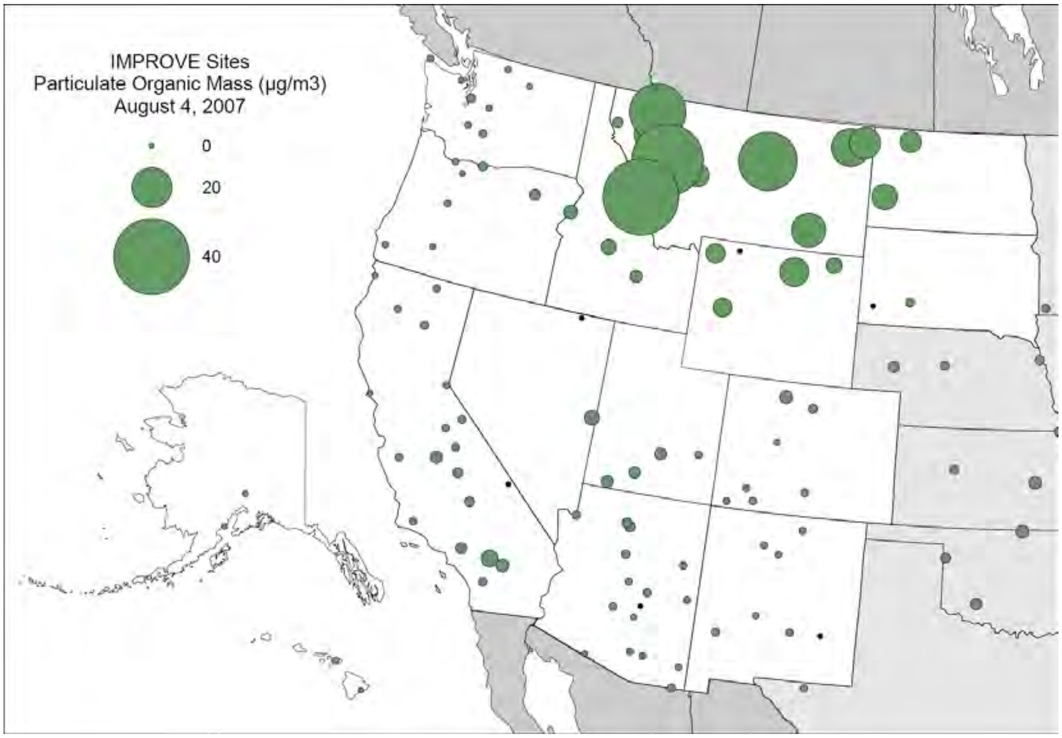

Figure 4.1-21. Particulate Organic Mass Event Measured on August 4, 2007, Affecting Most Montana IMPROVE Sites.

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

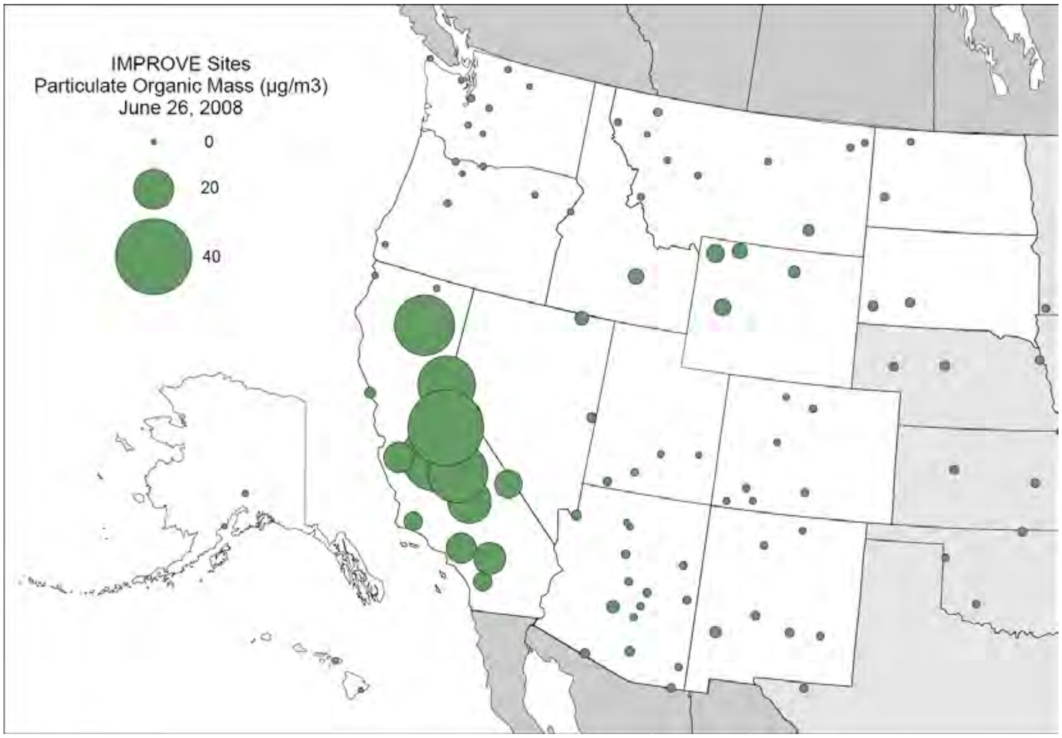

Figure 4.1-23. Particulate Organic Mass Event Measured on June 26, 2008, Affecting Most California IMPROVE Sites.

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

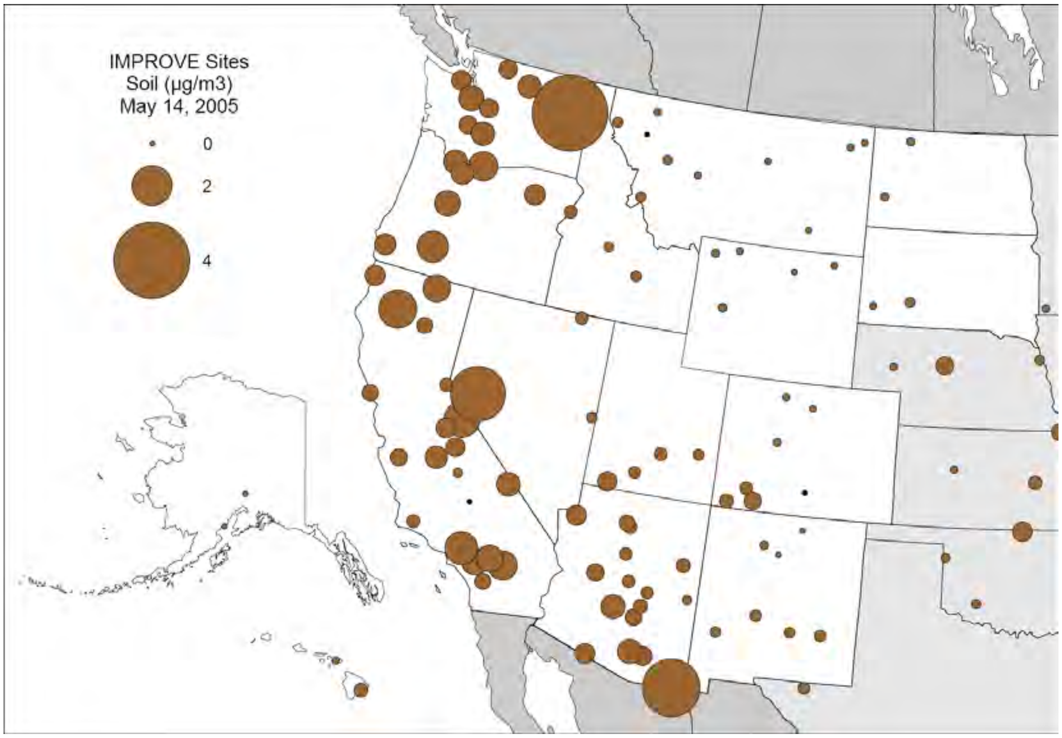

Figure 4.1-25. Soil Event Measured on March 14, 2005, Affecting Coastal IMPROVE Sites.

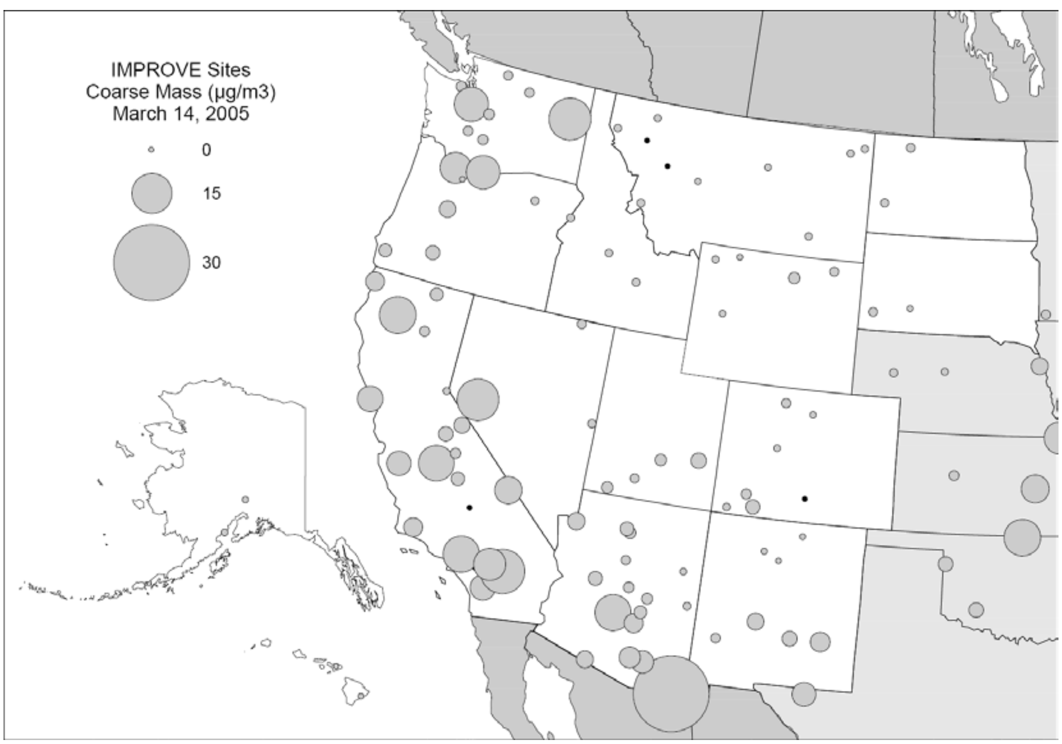

Figure 4.1-26. Coarse Mass Event Measured on March 14, 2005, Affecting Coastal IMPROVE Sites.

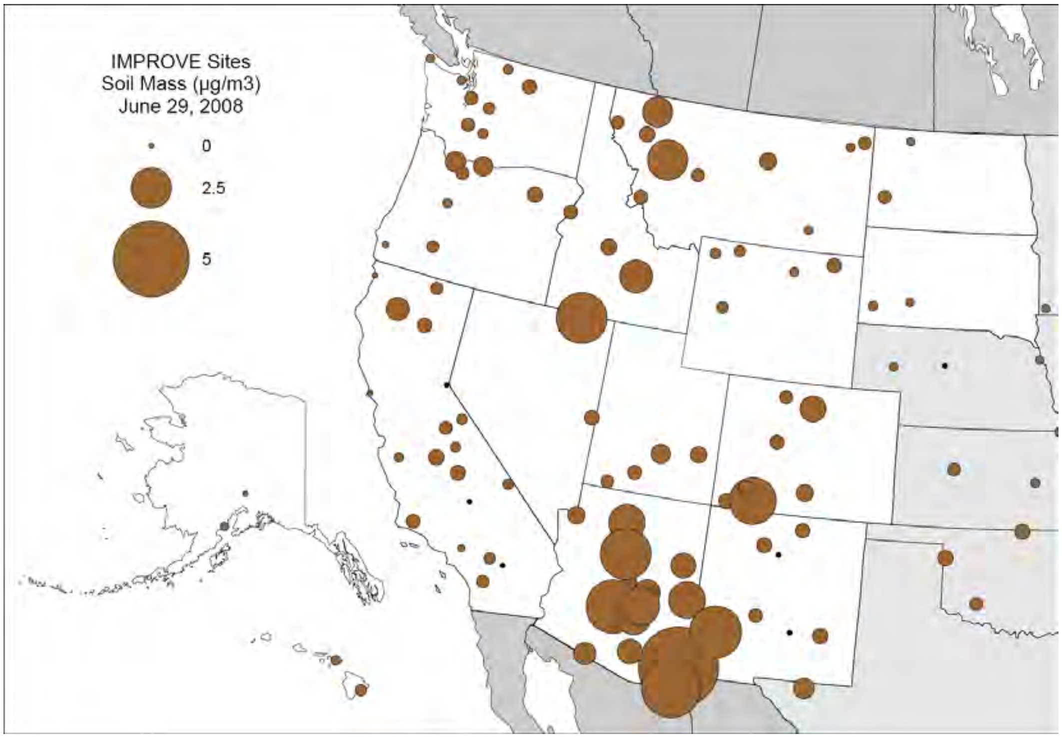

Figure 4.1-27. Soil Event Measured on June 29, 2008, Affecting Most Arizona IMPROVE Sites.

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

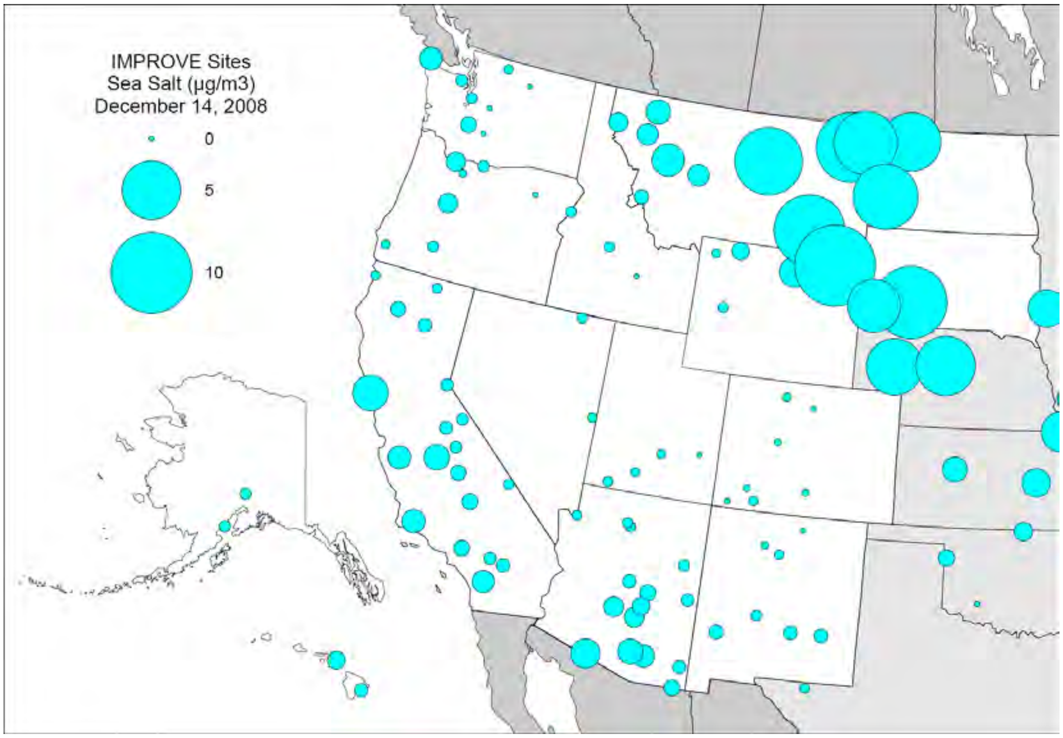

Figure 4.1-29 Sea Salt Event Measured on December 14, 2008, Affecting Inland IMPROVE Sites.

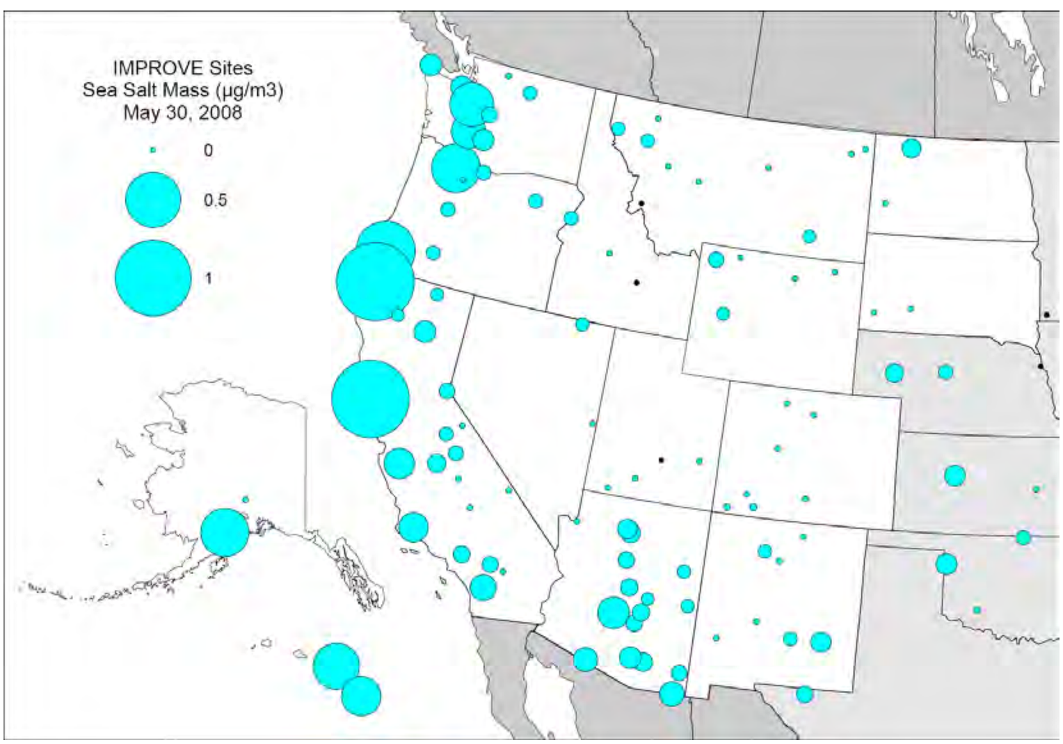

Figure 4.1-30. Sea Salt Event Measured on May 30, 2008, Affecting Coastal IMPROVE Sites.

4.2 EMISSIONS DATA

Included here are summaries depicting differences between an annual emission inventory representing the baseline period and an annual inventory representing the current progress period for the contiguous WRAP states.[56] For these summaries, emissions during the baseline years are represented using a 2002 inventory (termed plan02) which was developed with support from the WRAP for use in the original RHR SIP strategy development. Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages more recent inventory development work performed by the WRAP for the WestJumpAQMS and Deterministic and Empirical Assessment of Smoke's Contribution to Ozone (DEASCO$_3$) modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1.

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

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

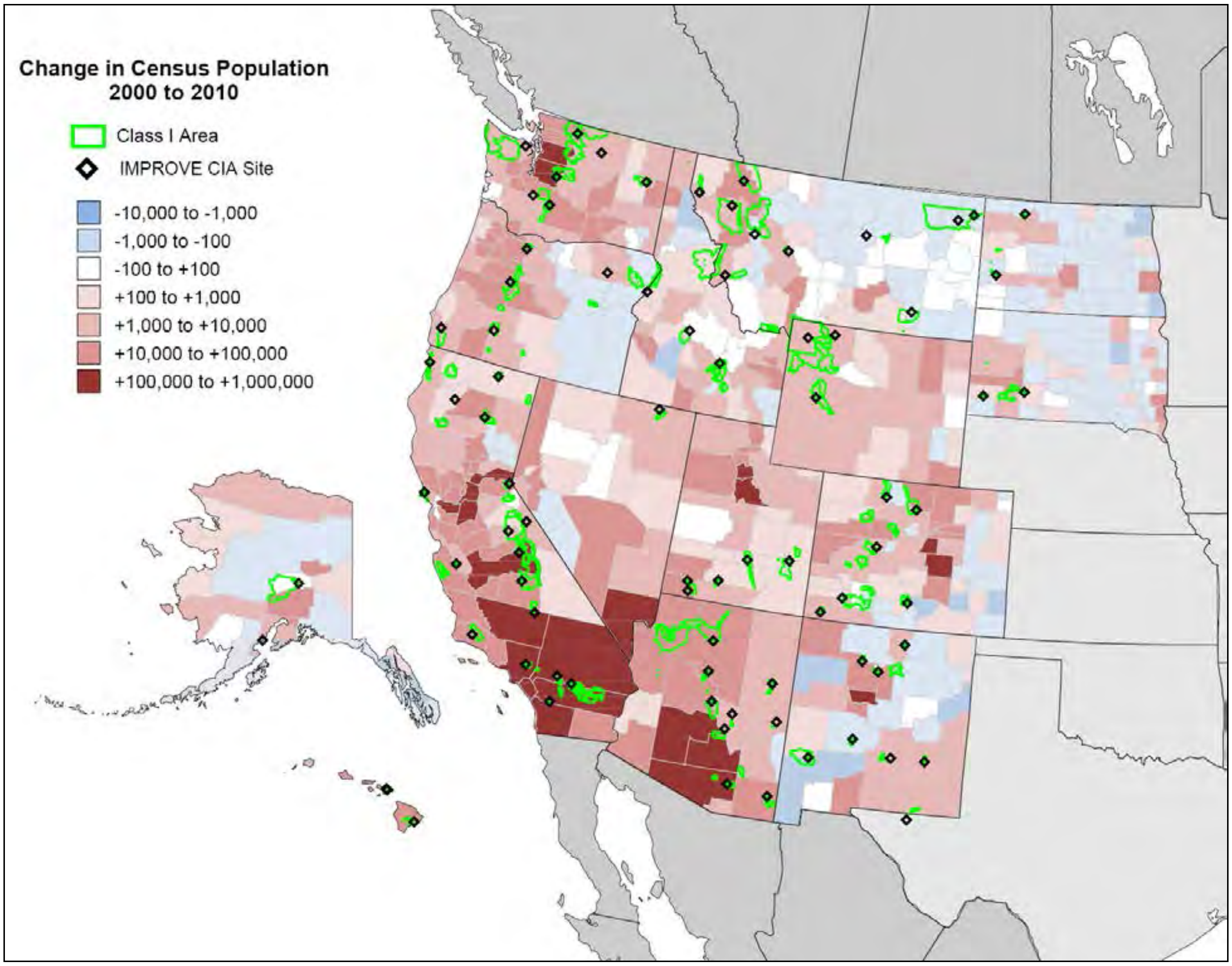

Figure 4.2-1. Difference Between 2000 and 2010 Census Population for the WRAP Region.

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

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

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

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

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

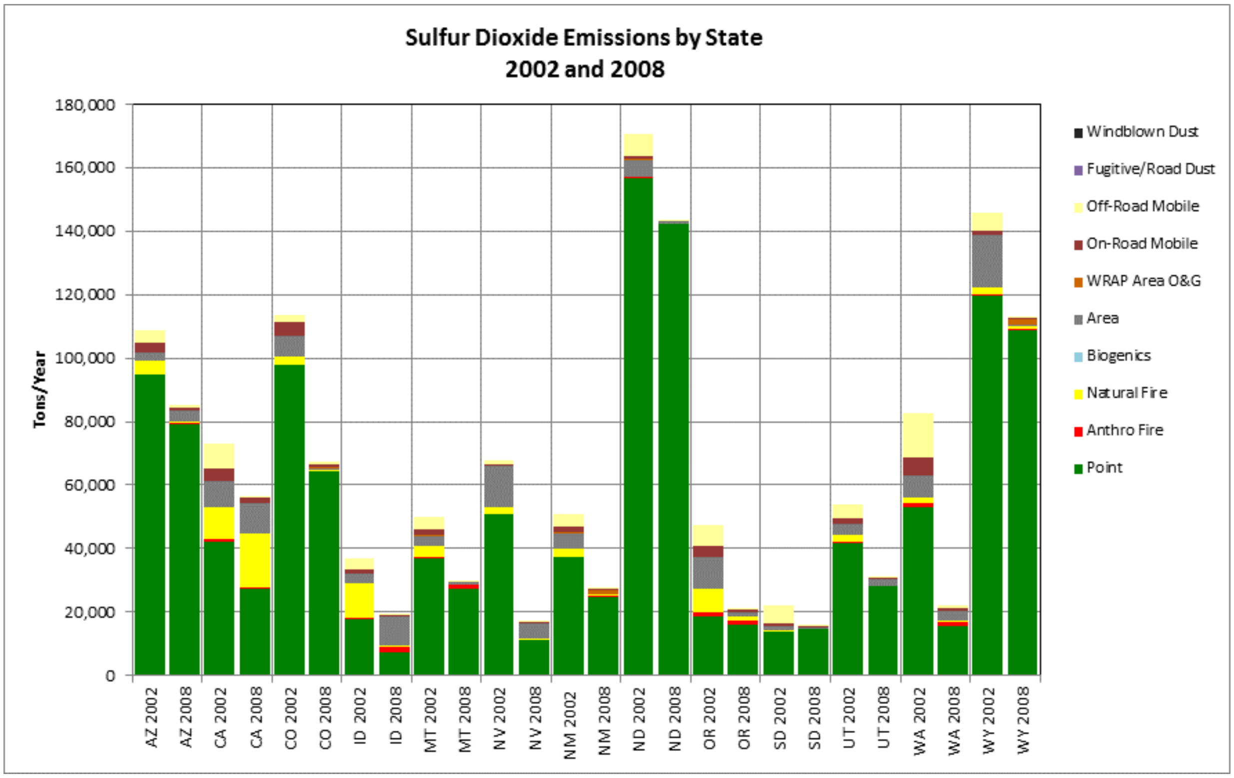

Figure 4.2-2. Comparison for 2002 and 2008 Sulfur Dioxide Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

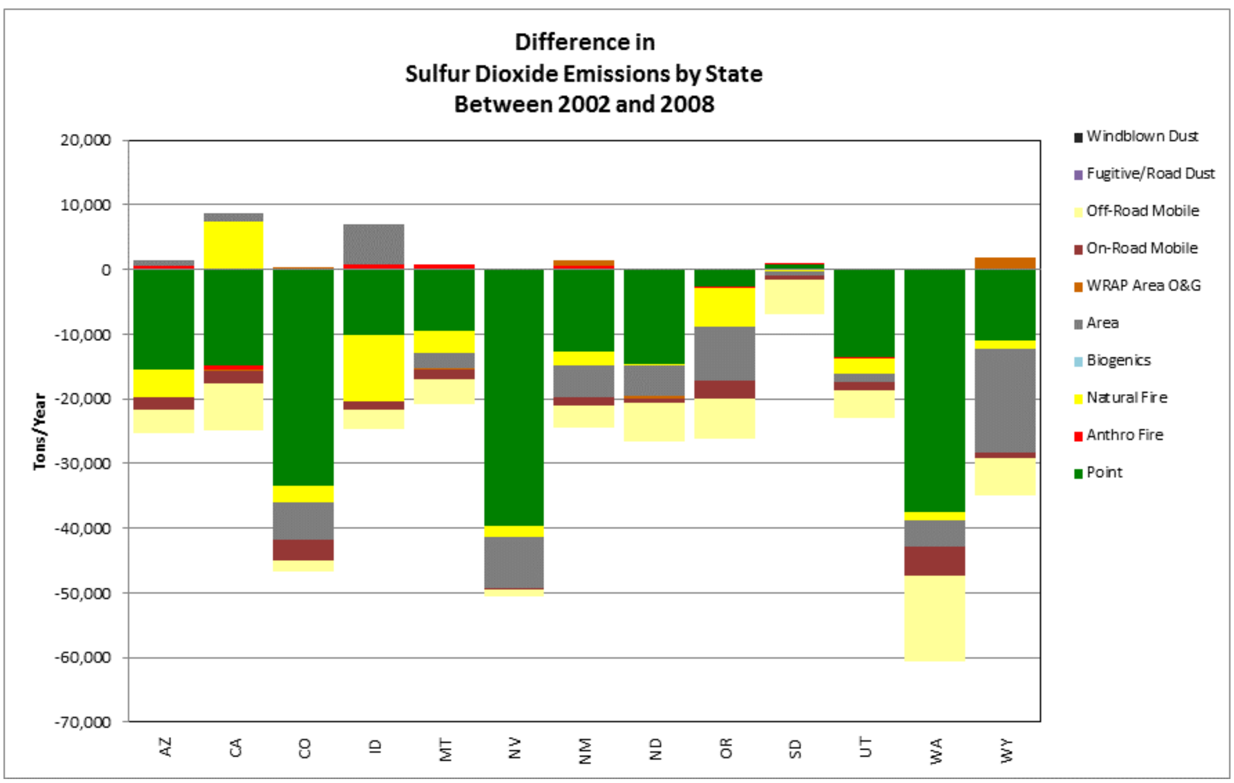

Figure 4.2-3. Differences between 2008 and 2002 Sulfur Dioxide Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

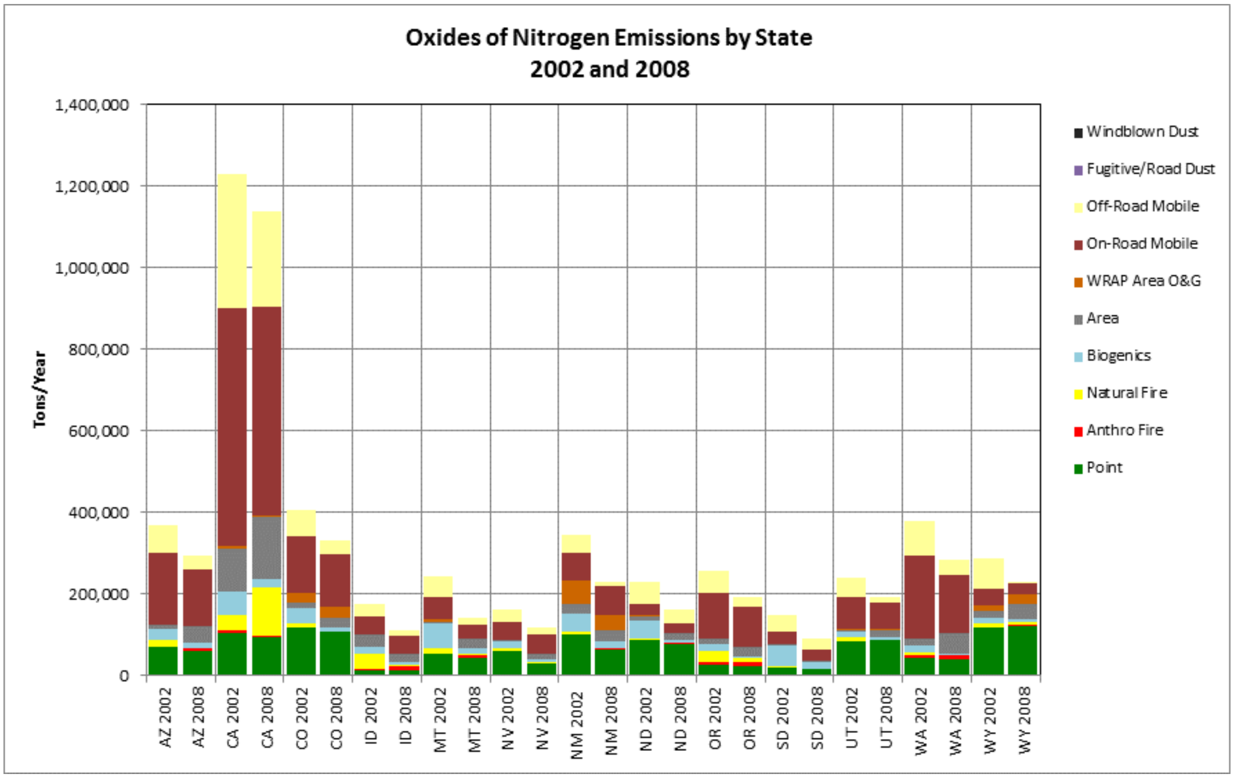

Figure 4.2-4. Comparison for 2002 and 2008 Oxides of Nitrogen Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

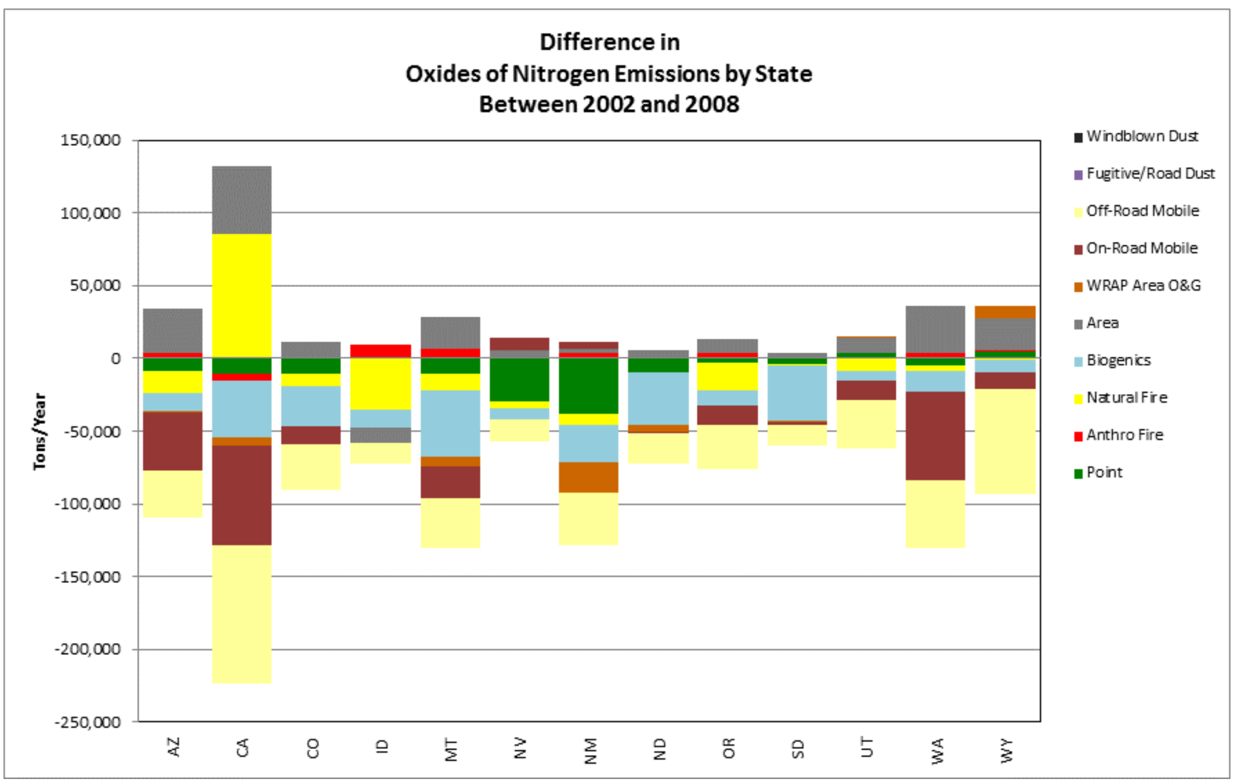

Figure 4.2-5. Differences between 2008 and 2002 Oxides of Nitrogen Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

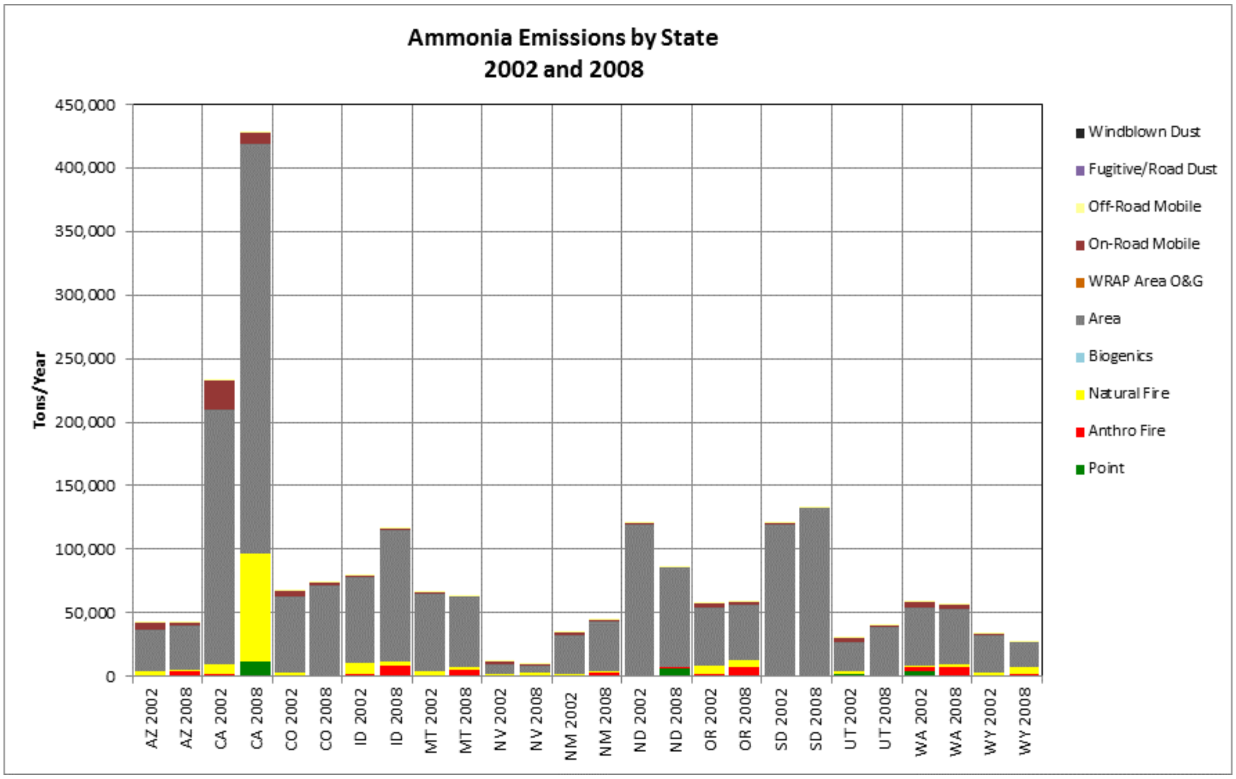

Figure 4.2-6. Comparison for 2002 and 2008 Ammonia Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

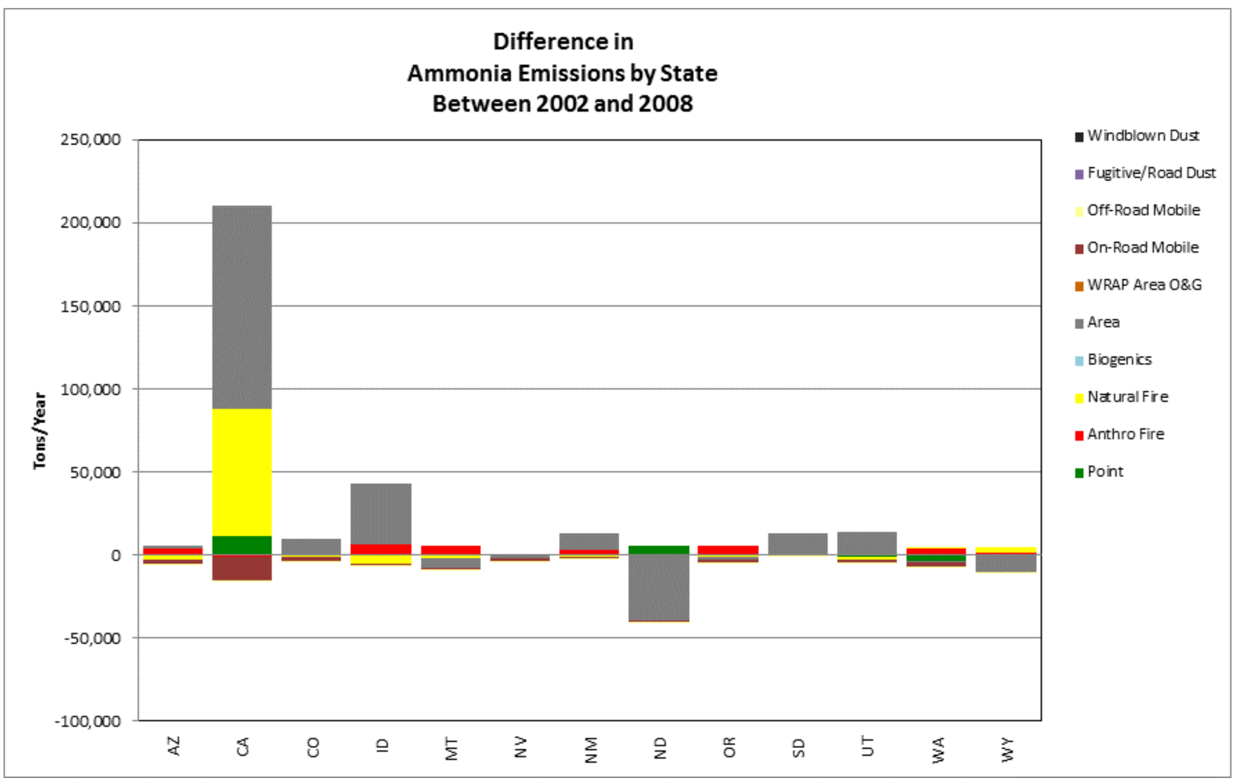

Figure 4.2-7. Differences between 2008 and 2002 Ammonia Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

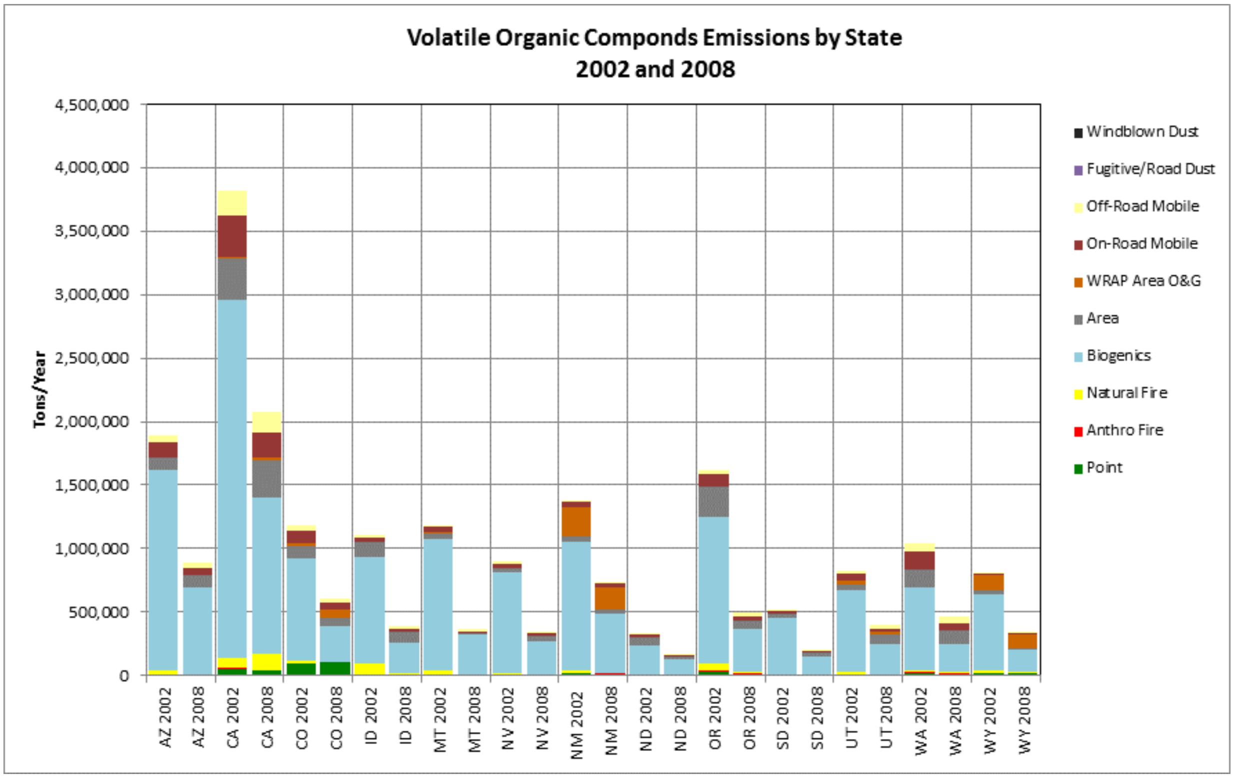

Figure 4.2-8. Comparison for 2002 and 2008 Volatile Organic Compound Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

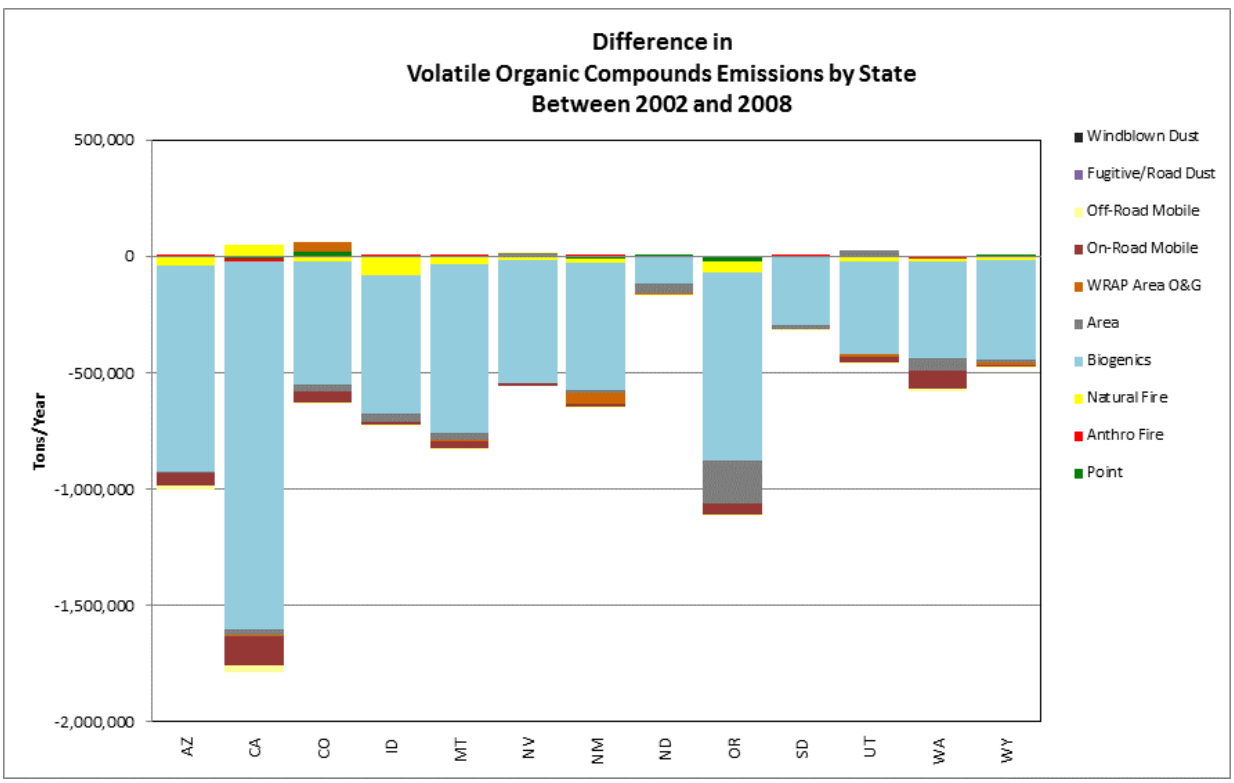

Figure 4.2-9. Differences between 2008 and 2002 Volatile Organic Compound Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

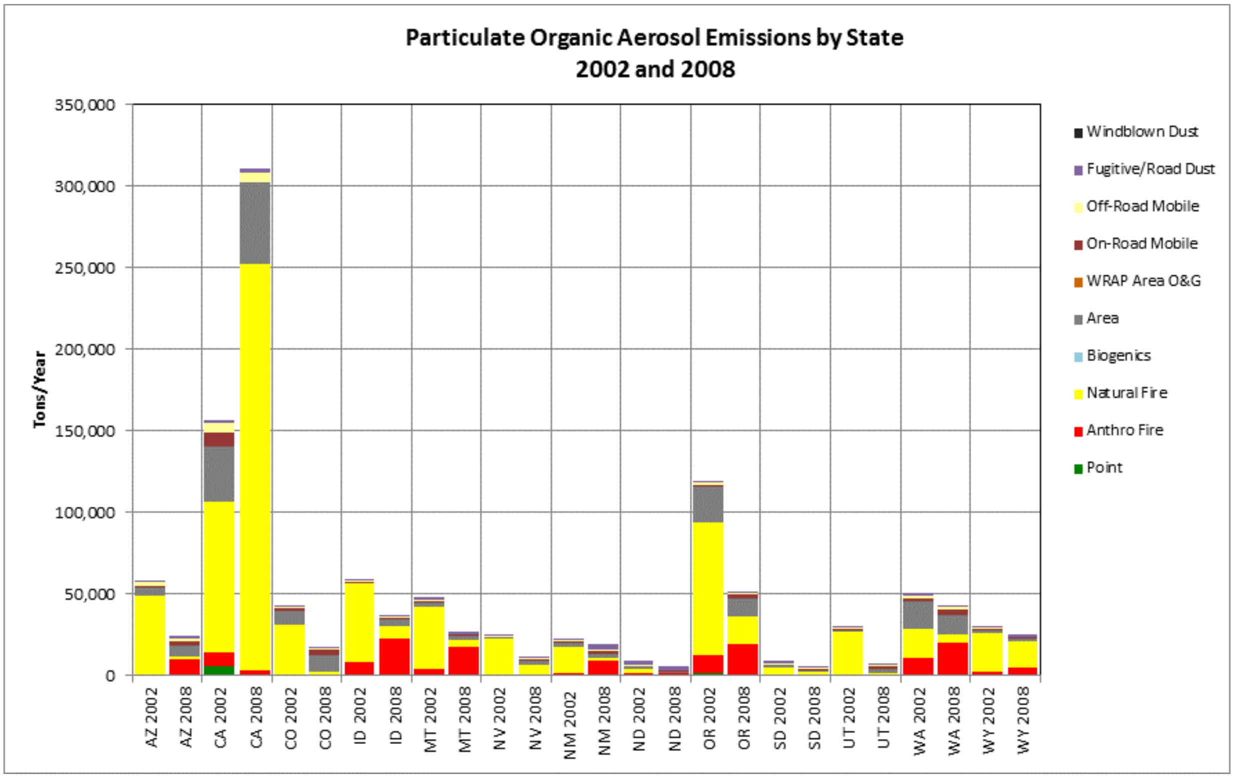

Figure 4.2-10. Comparison for 2002 and 2008 Particulate Organic Aerosol Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

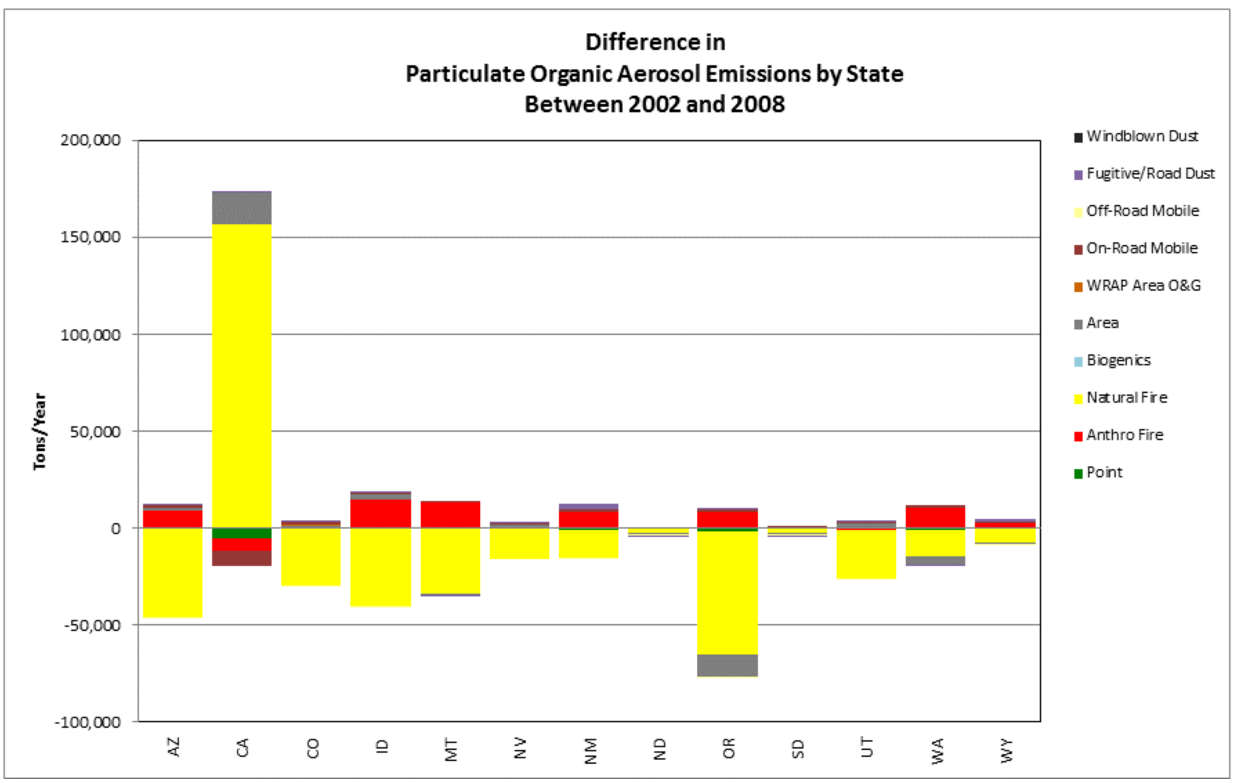

Figure 4.2-11. Differences between 2008 and 2002 Particulate Organic Aerosol Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

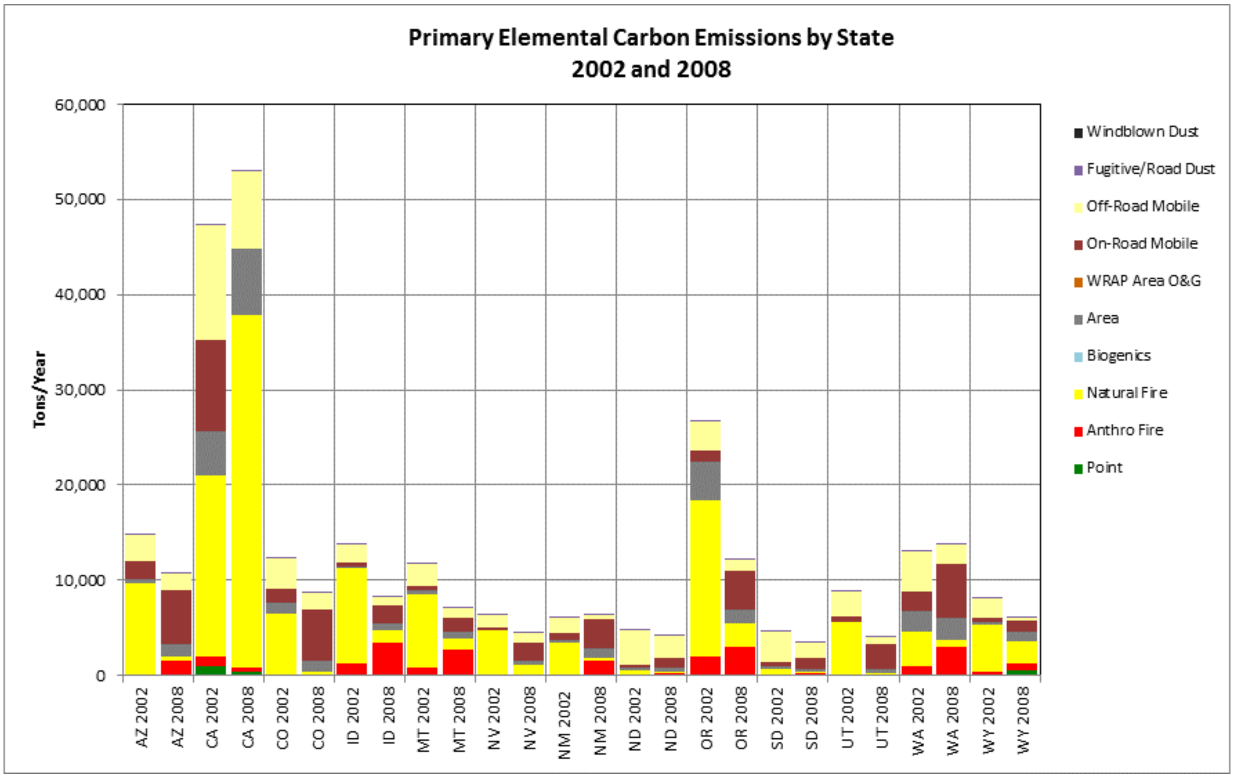

Figure 4.2-12. Comparison for 2002 and 2008 Elemental Carbon Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

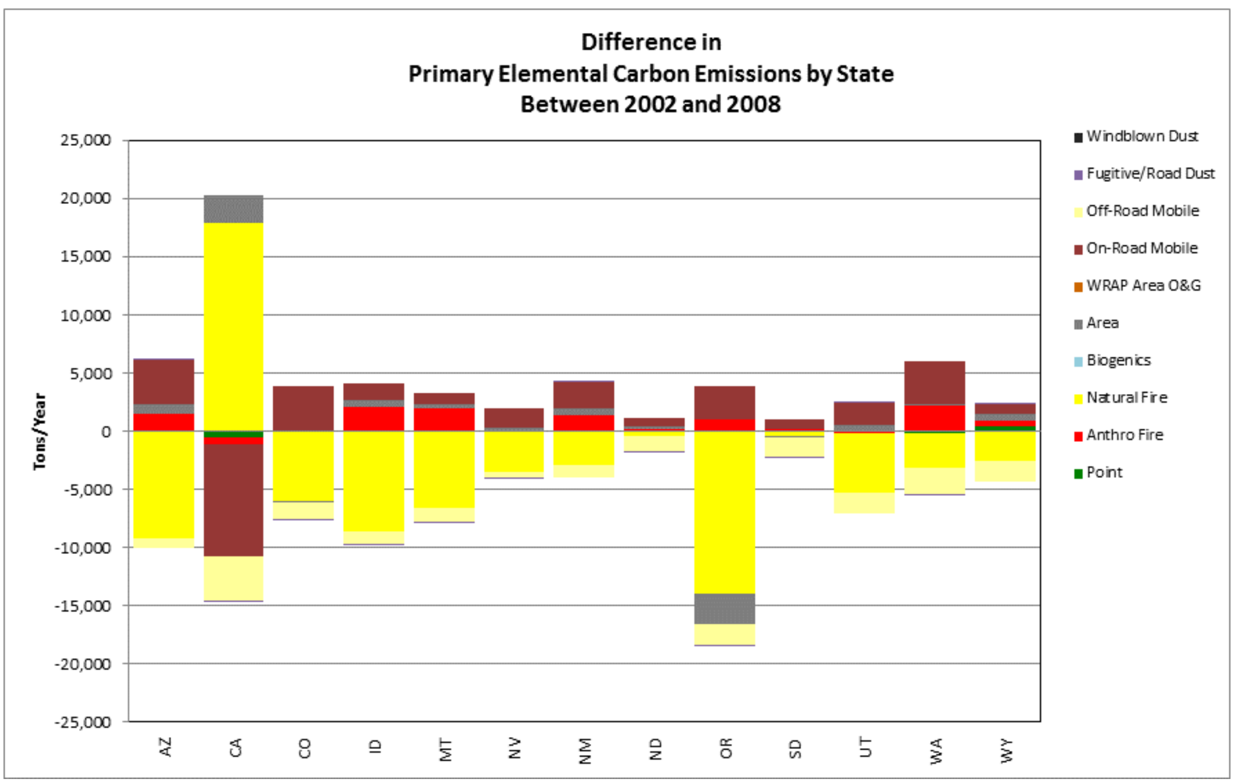

Figure 4.2-13. Differences between 2008 and 2002 Elemental Carbon Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

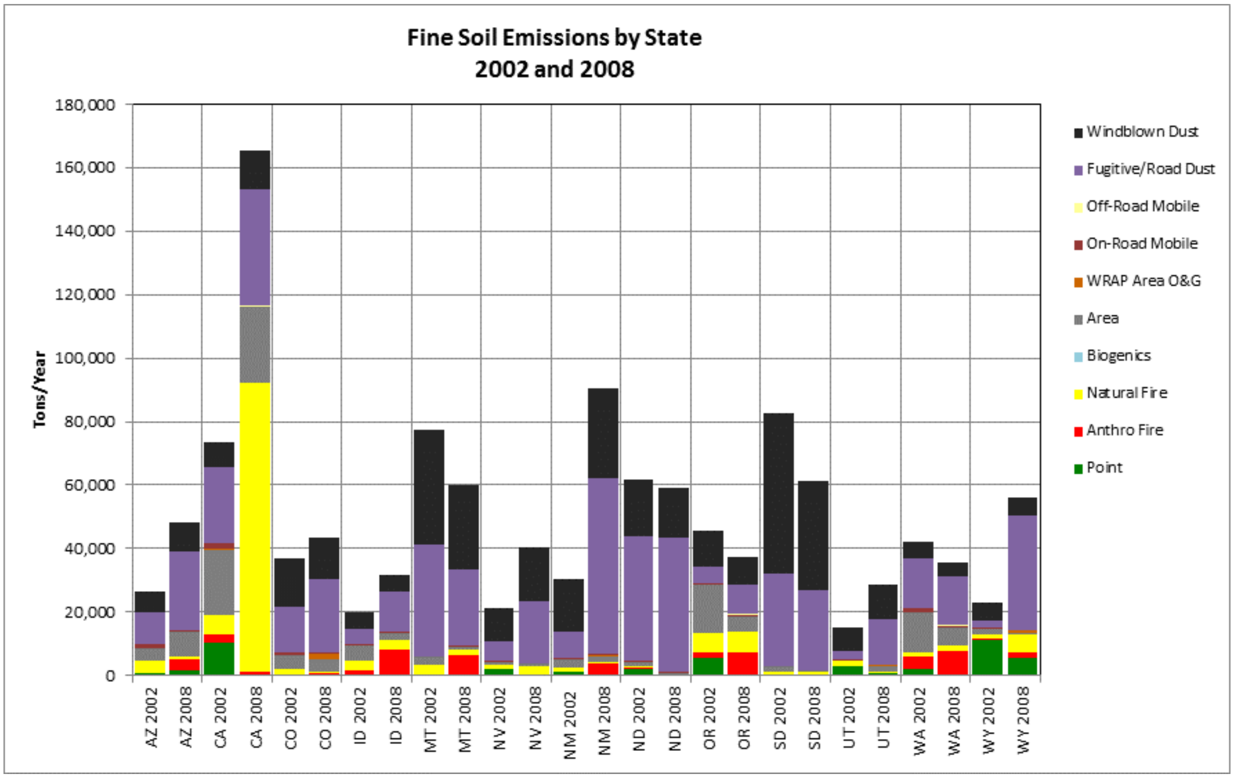

Figure 4.2-14. Comparison for 2002 and 2008 Fine Soil Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

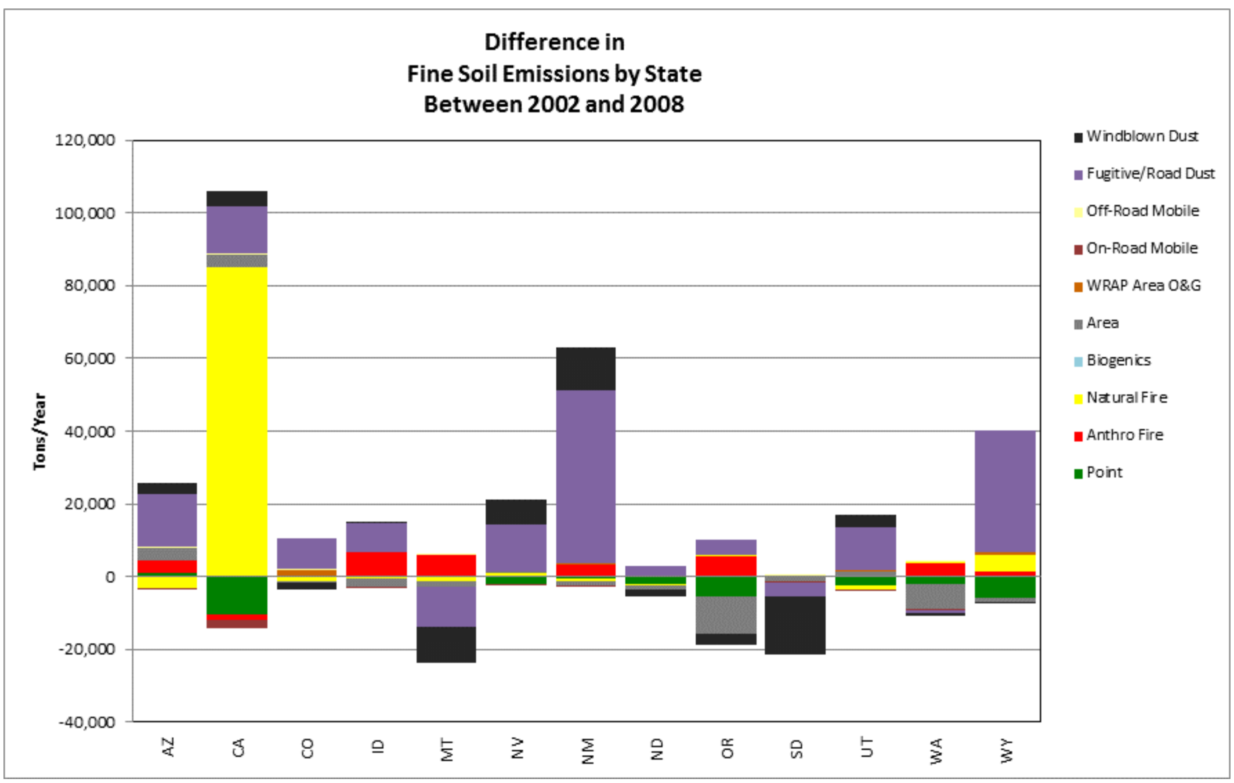

Figure 4.2-15. Differences between 2008 and 2002 Fine Soil Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

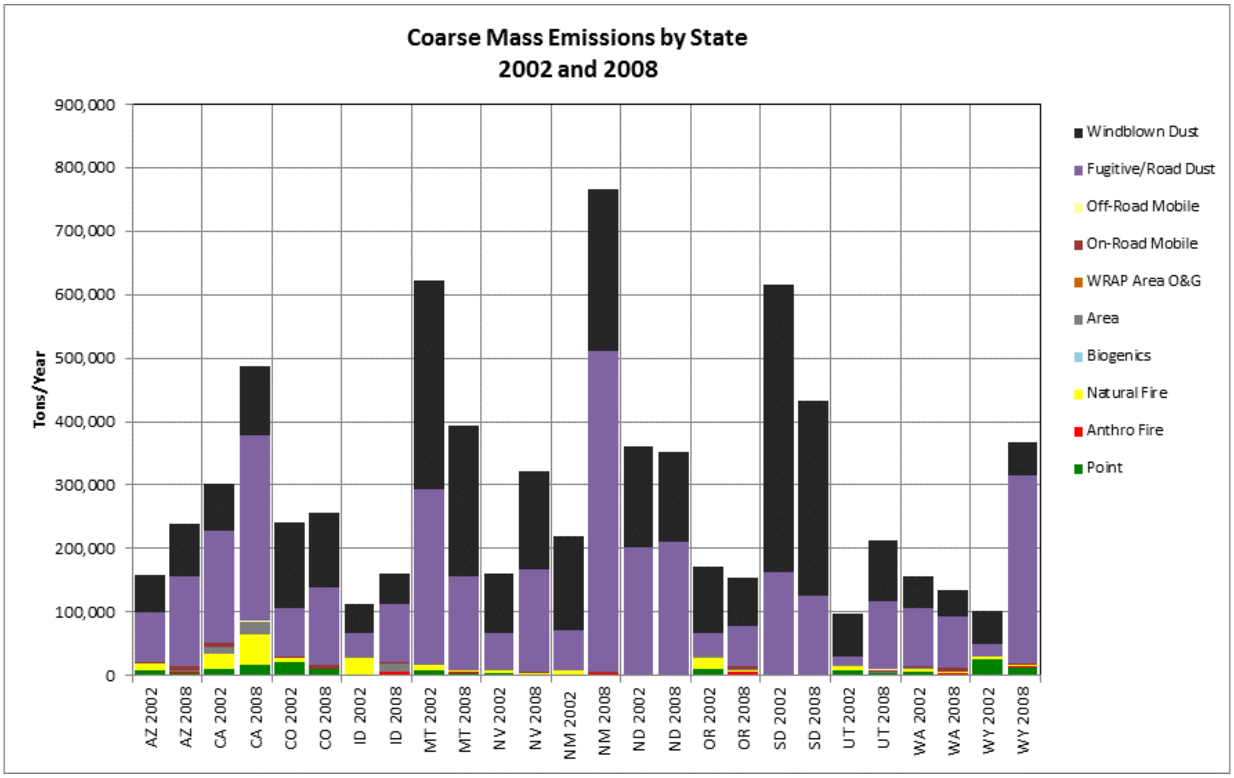

Figure 4.2-16. Comparison for 2002 and 2008 Coarse Mass Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

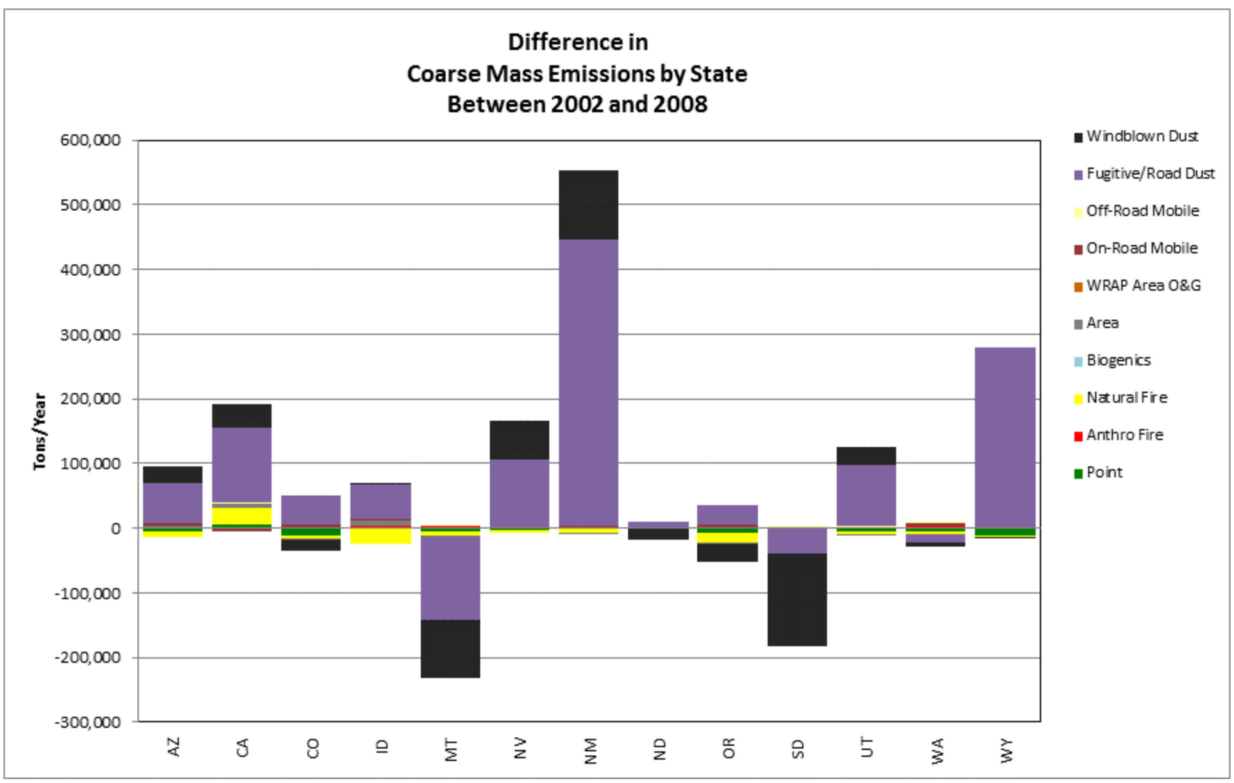

Figure 4.2-17. Differences between 2008 and 2002 Coarse Mass Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

4.2.1 EGU Summary

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

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

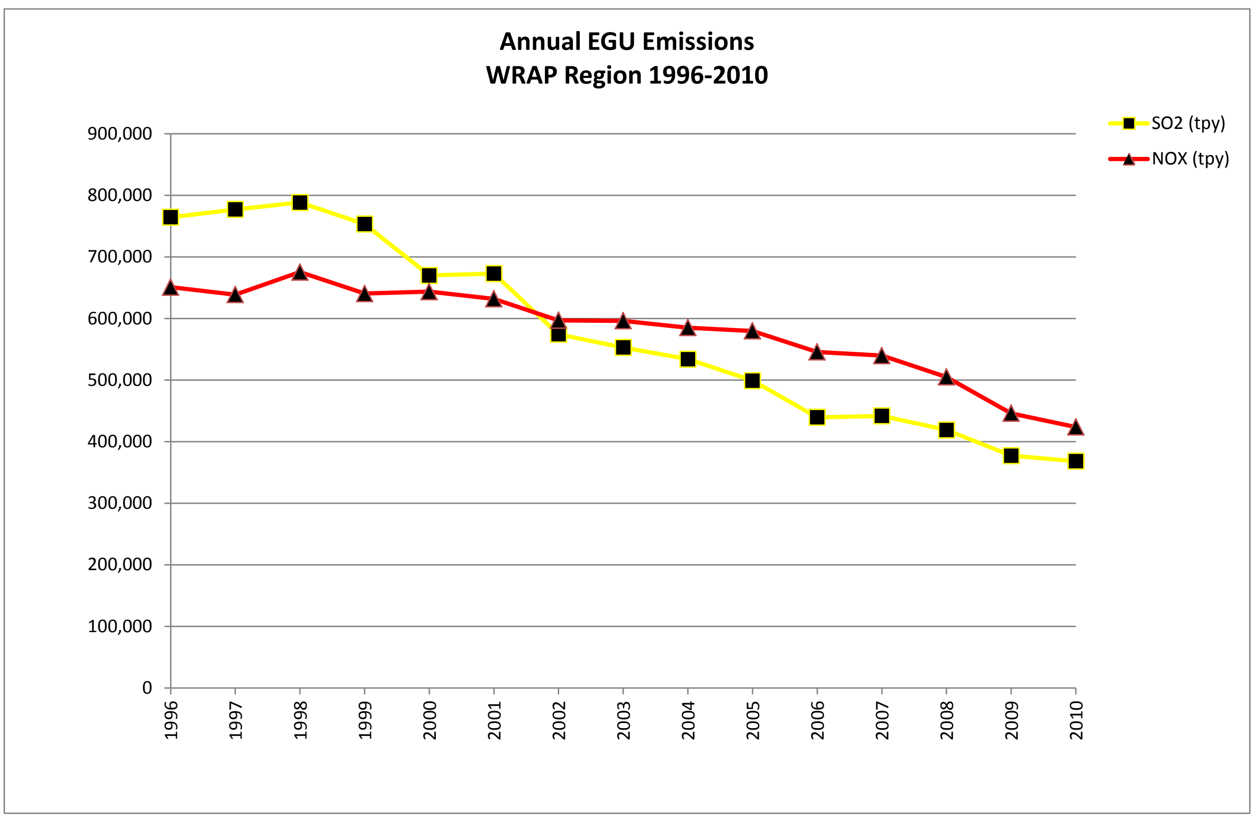

Figure 6.2-18. Sum of EGU Emissions of SO_2 and NOx Reported between 1996 and 2010 for the WRAP Region.

Appendix C – WRAP Regional Haze Rule Reasonable Progress Report Support Document

State Class I Area Summaries

6.0 STATE AND CLASS I AREA SUMMARIES

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

6.1 ALASKA

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

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

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

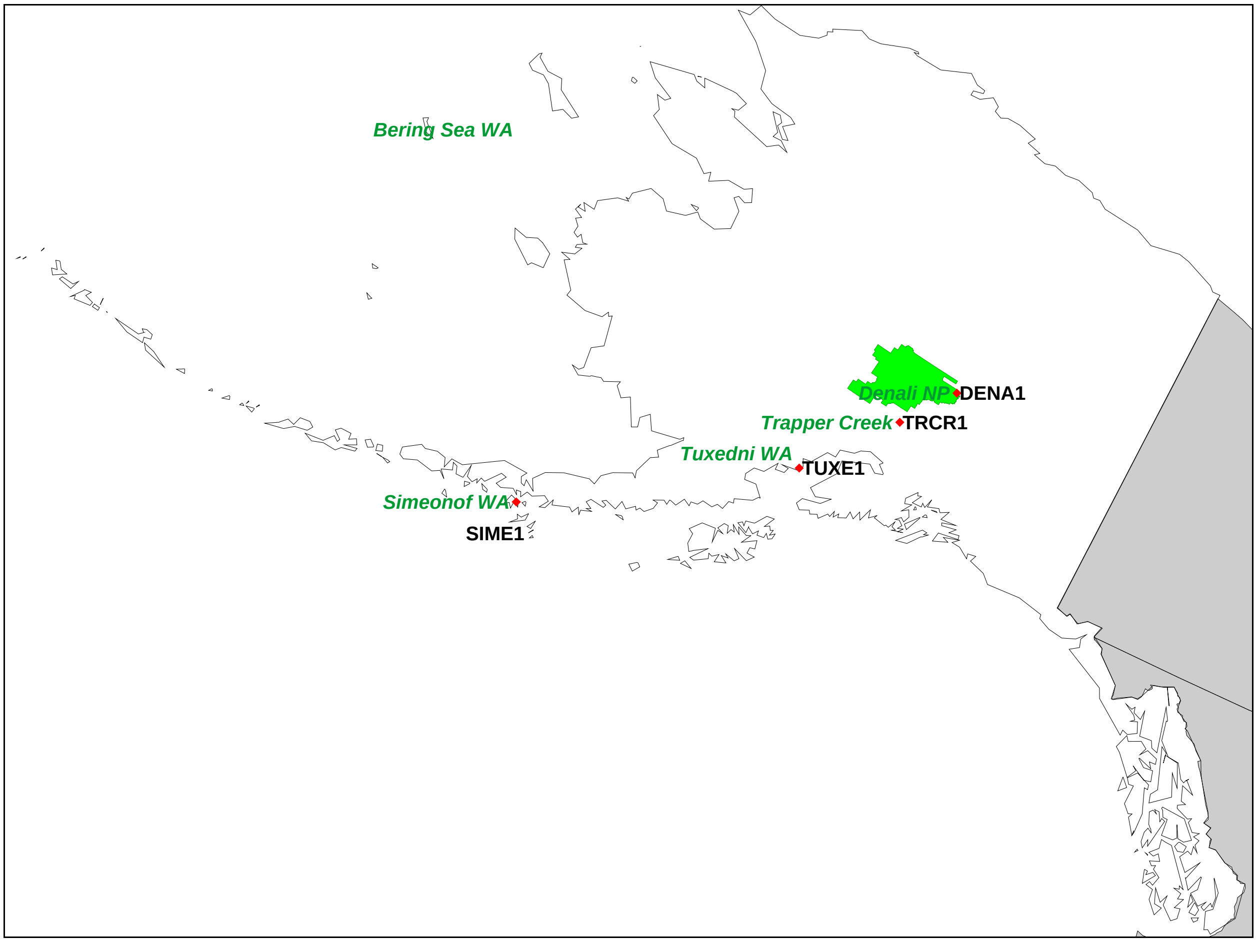

Figure 6.1-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Alaska.

Table 6.1-1
Alaska CIAs and Representative IMPROVE Monitors

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

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

6.1.1 Monitoring Data

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

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

6.1.1.1 Current Conditions

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

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

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

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

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

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

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

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

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

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

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

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

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

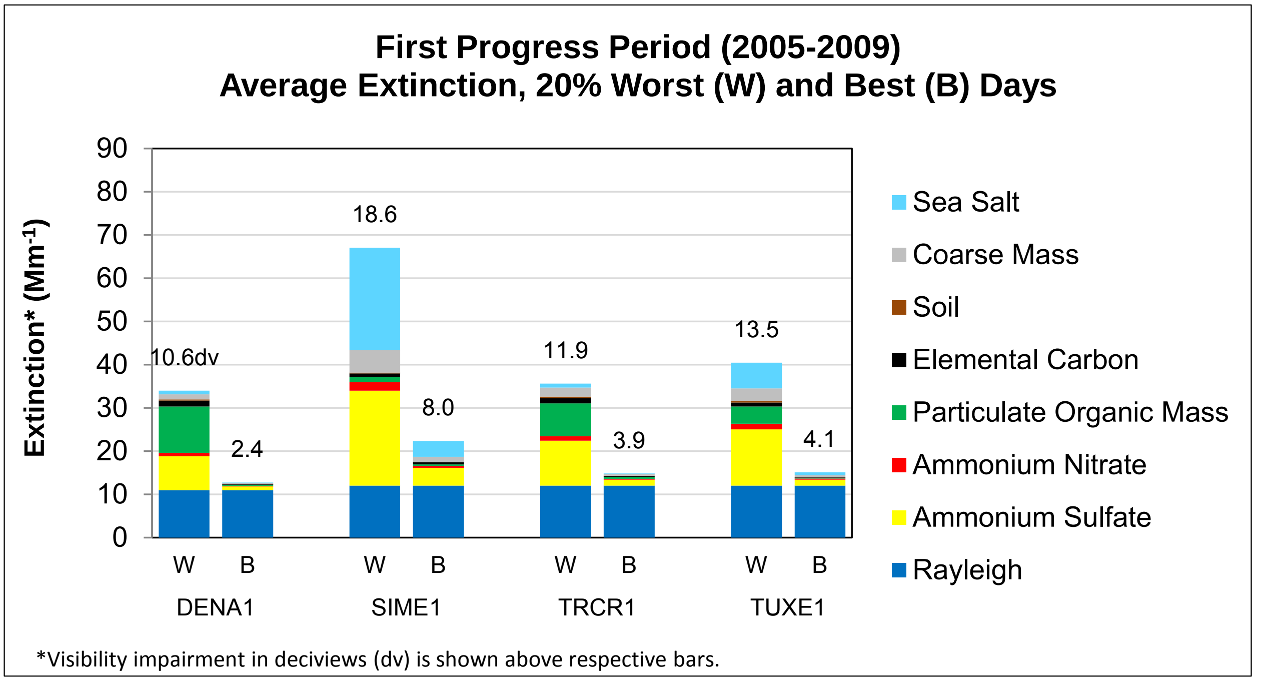

Figure 6.1-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

6.1.1.2 Differences between Current and Baseline Conditions

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

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

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

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

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

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

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

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

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

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

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

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

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

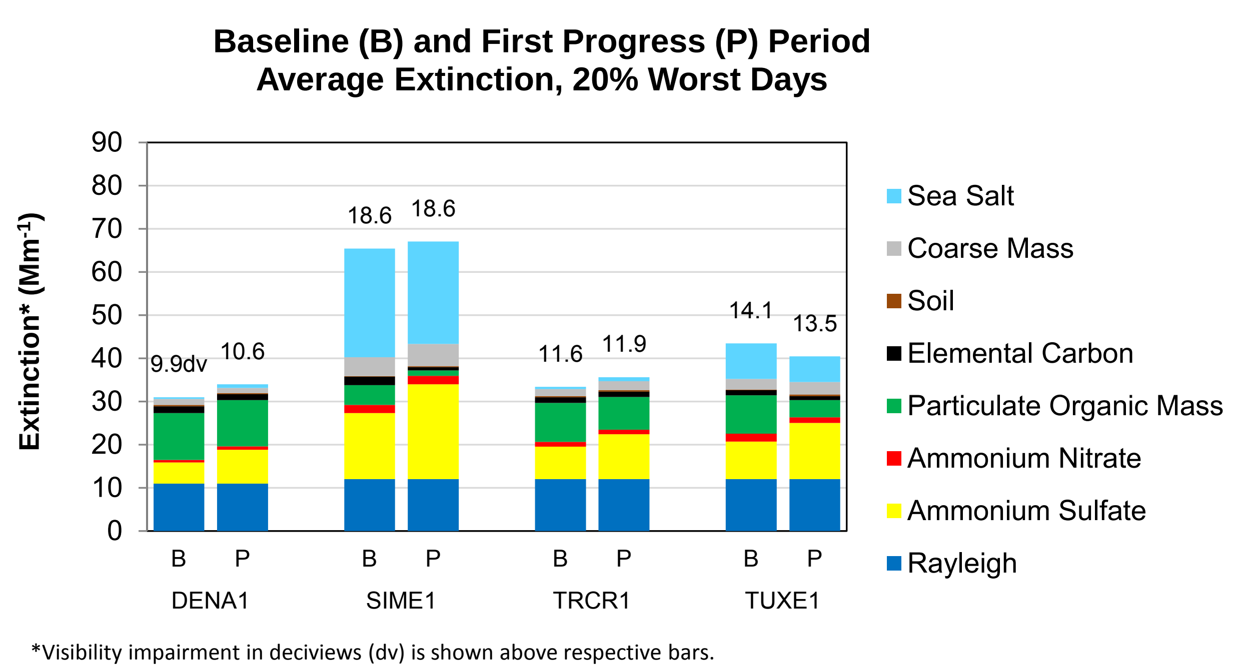

Figure 6.1-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

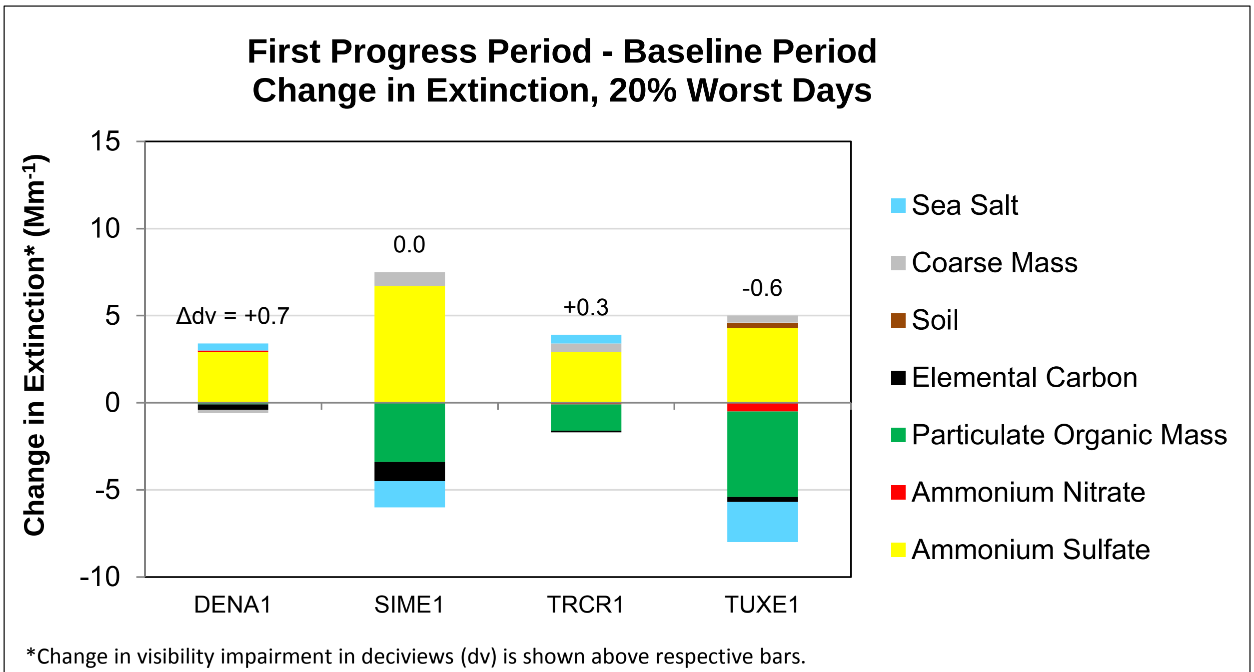

Figure 6.1-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

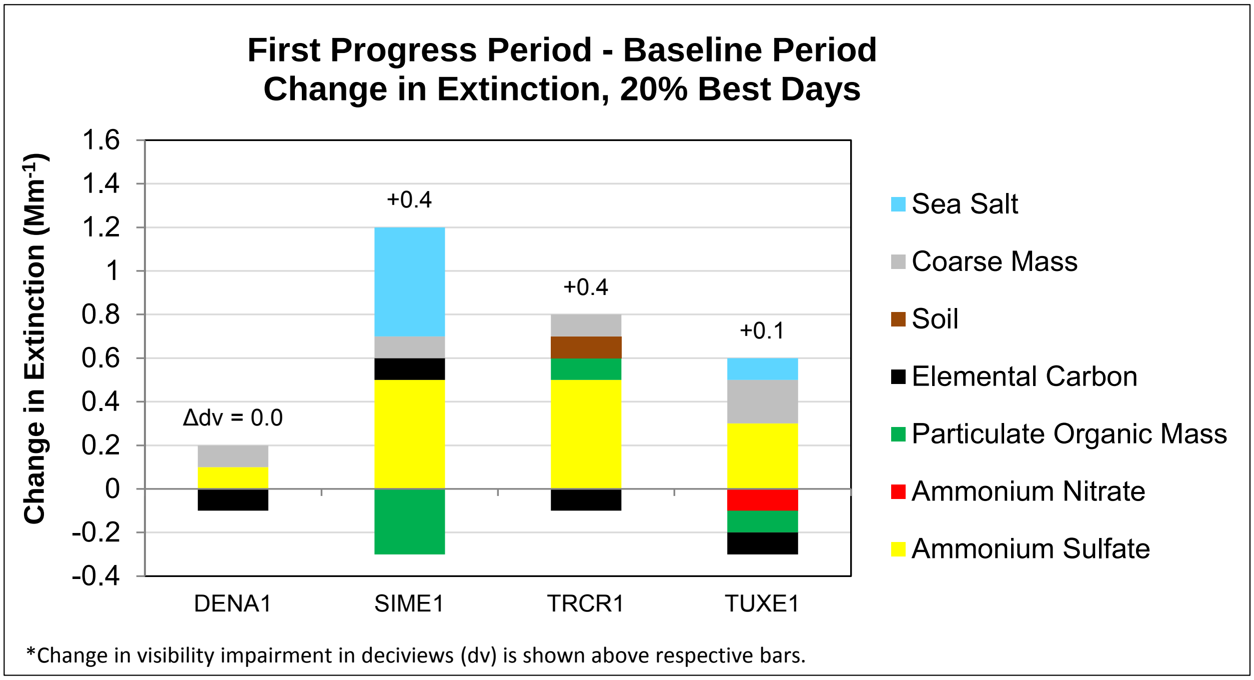

Figure 6.1-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

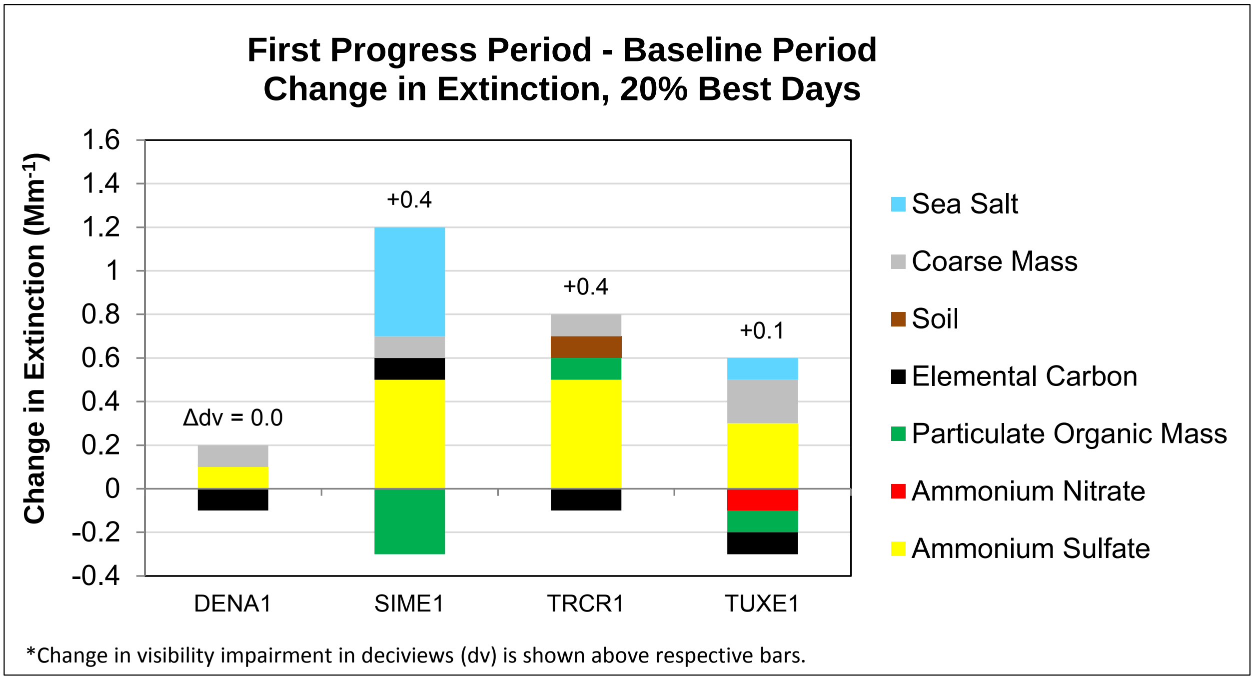

Figure 6.1-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

6.1.1.3 Changes in Visibility Impairment

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

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

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

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

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

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

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

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

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

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

6.1.2 Emissions Data

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

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

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

6.1.2.1 Changes in Emissions

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

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

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

Table 6.1-8
Alaska
Sulfur Dioxide Emissions by Category

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

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

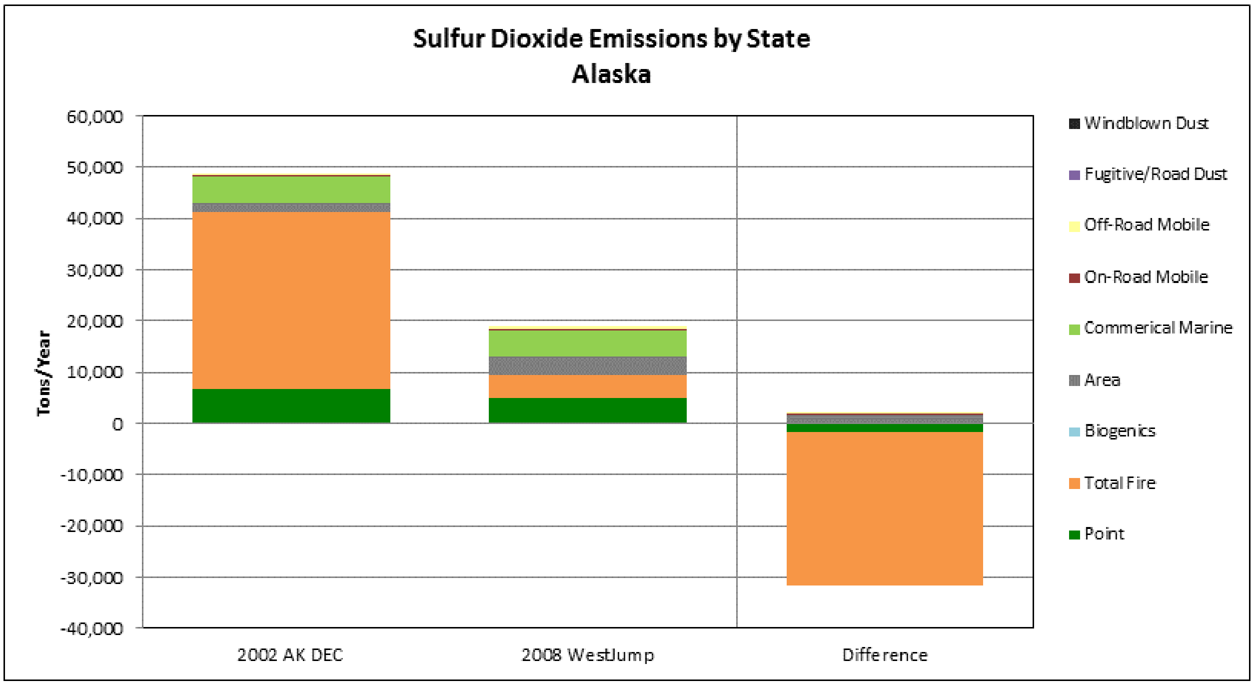


Figure 6.1-7. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Alaska.

Table 6.1-9
Alaska
Oxides of Nitrogen Emissions by Category

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

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

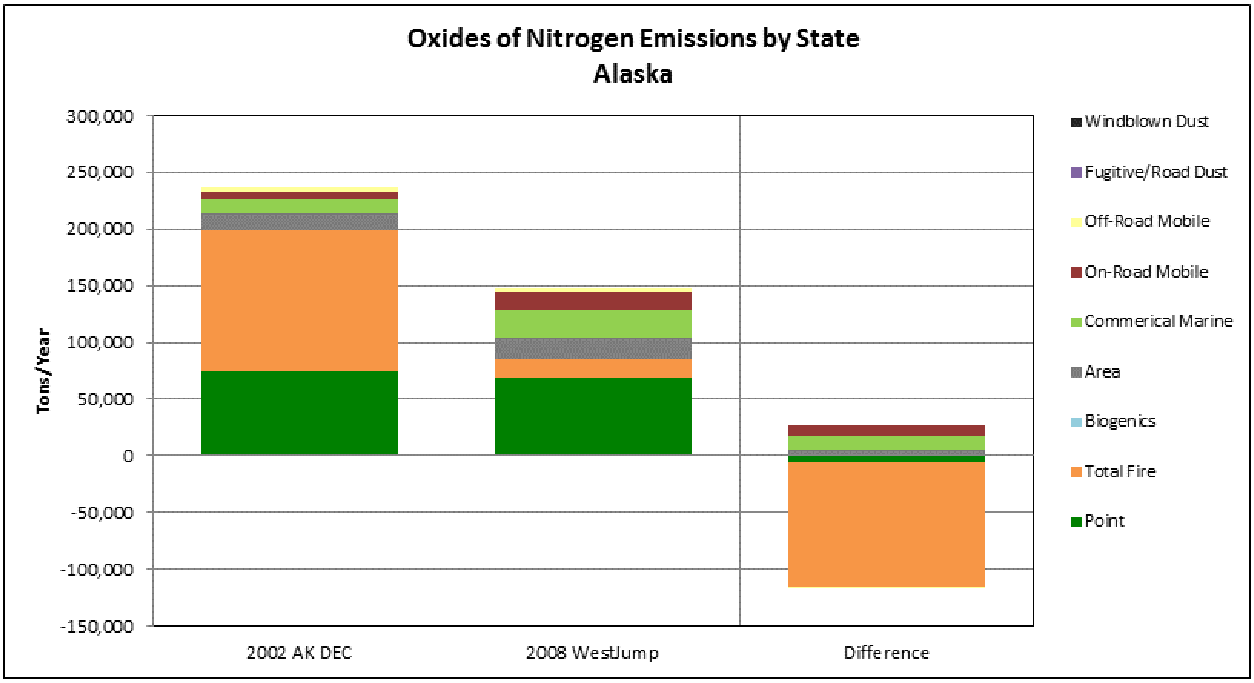


Figure 6.1-8. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Alaska.

Table 6.1-10
Alaska
Ammonia Emissions by Category

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

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

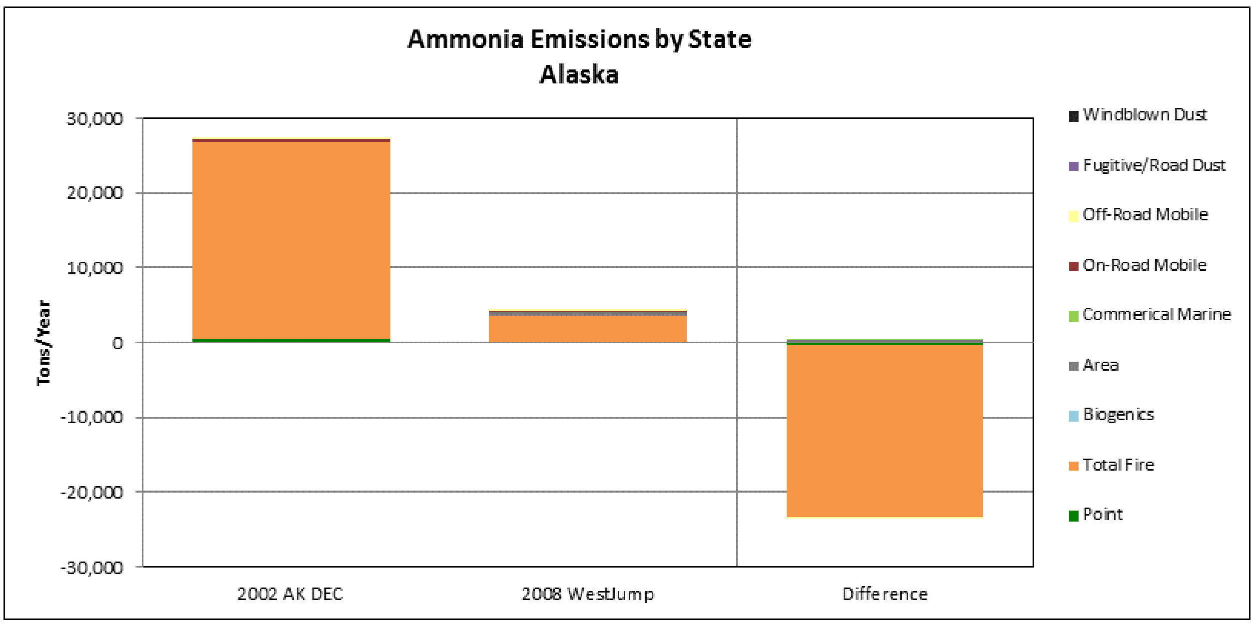


Figure 6.1-9. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Alaska.

Table 6.1-11
Alaska
Volatile Organic Compound Emissions by Category

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

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

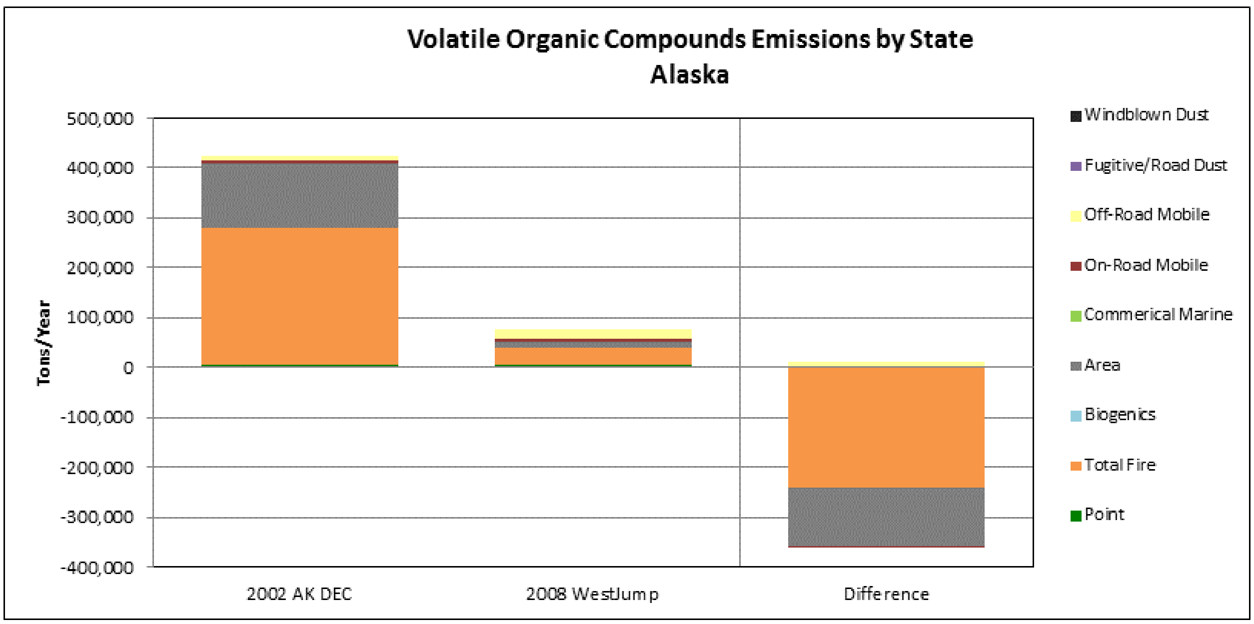


Figure 6.1-10. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Alaska.

Table 6.1-12
Alaska
Fine Soil Emissions by Category

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

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

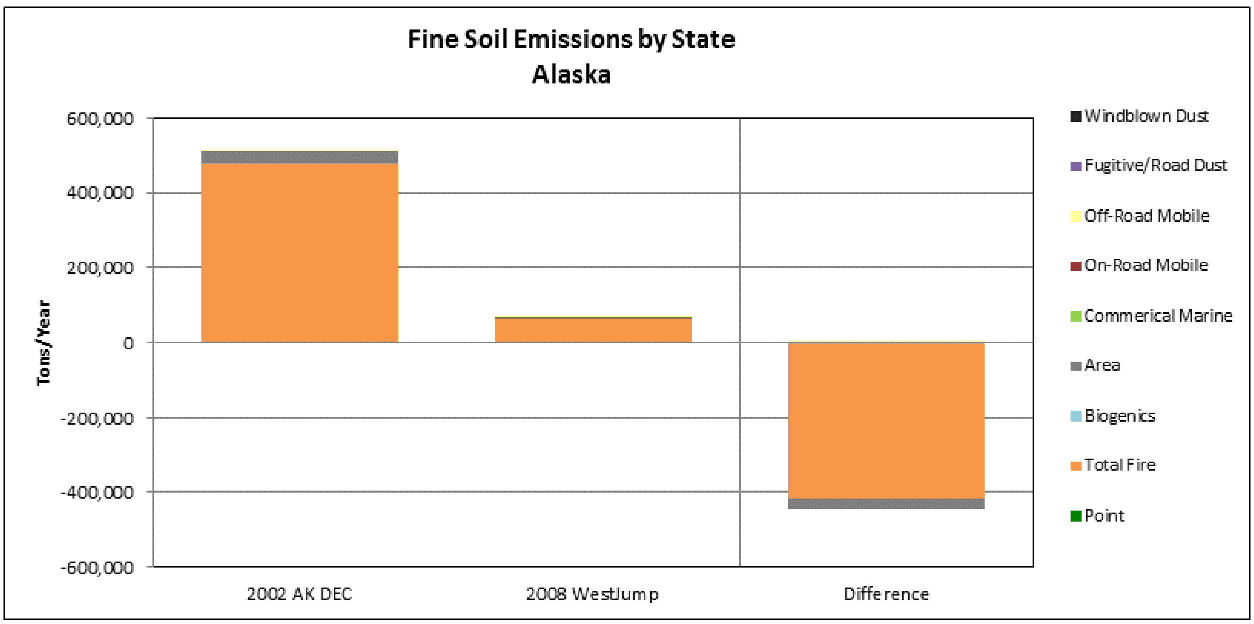


Figure 6.1-11. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Alaska.

Table 6.1-13
Alaska
Coarse Mass Emissions by Category

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

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

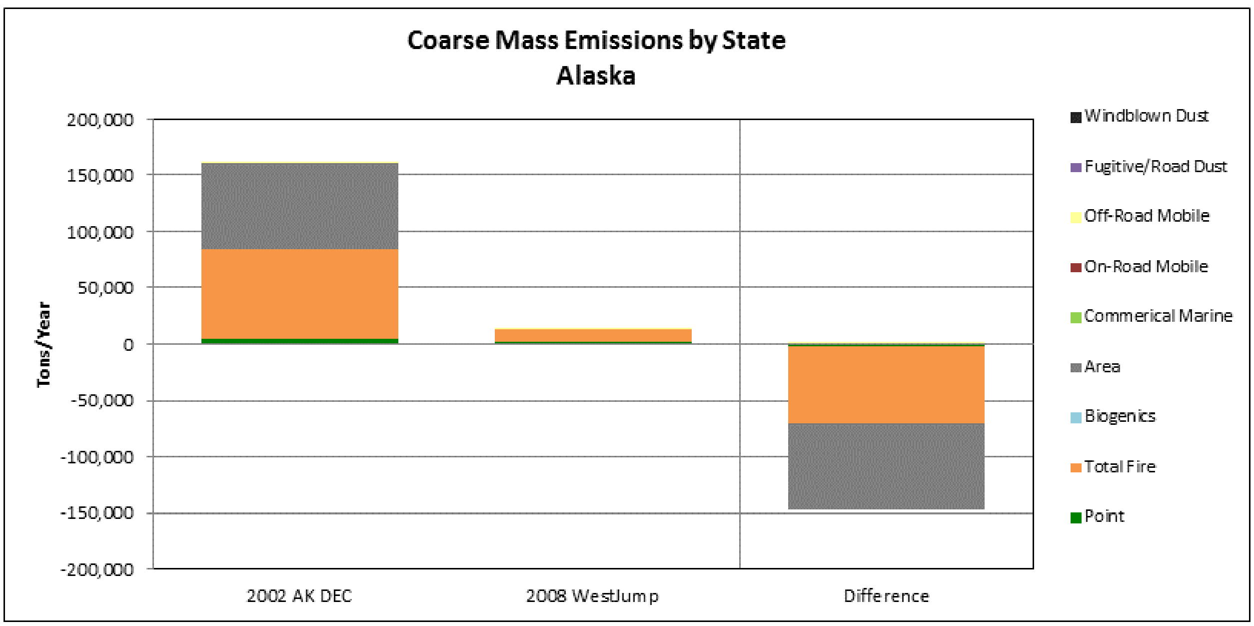


Figure 6.1-12. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Alaska.

Appendix D – WRAP Regional Haze Rule Reasonable Progress Report Support Document

Alaska Class I Area Monitoring Data Summary Tables and Charts

APPENDIX A:

Alaska Class I Area Monitoring Data Summary Tables and Charts

Includes the following subsections:

Subsection	IMPROVE Monitor	Class I Area(s) Represented
A.1	DENA1	Denali NP
A.2	SIME1	Simeonof WA
A.3	TRCR1	Trapper Creek*
A.4	TUXE1	Tuxedni WA

*Not a Federal Class I Area

A.1. DENALI NP (DENA1)

The following tables and figures are presented in this section for Denali National Park represented by the DENA1 IMPROVE Monitor:

- **Table A.1-1: Annual Averages, 5-Year Period Averages, and Trends:** Table of averages and other metrics for the 20% least impaired days, the 20% most impaired days, and all sampled days is presented.
- **Figure A.1-1: Annual and 5-Year Period Averages for the 20% Most Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.
- **Figure A.1-2: Annual and 5-Year Period Averages for the 20% Least Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.
- **Figure A.1-3: 20% Most Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component for the 20% most impaired days are presented.
- **Figure A.1-4: 20% Least Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component are presented.
- **Figure A.1-5: 2000-2004 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the baseline period are presented.
- **Figure A.1-6: 2005-2009 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the progress period are presented.
- **Figure A.1-7: 2000-2004 Progress Period Extinction, All Sampled Days:** Stacked bar charts depicting daily averages by year and component for the baseline period are presented.
- **Figure A.1-8: 2000-2004 Progress Period Extinction, All Sampled Days**: Stacked bar charts depicting daily averages by year and component for the progress period are presented.

Table A.1-1
Denali NP, AK (DENA1 Site)
Annual Averages, 5-Year Period Averages and Trends

Group	Baseline Period					Progress Period						2000-2009 Trend Statistics*		Period Averages**			
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Slope (change/yr.)	p-value	Baseline (B)	Progress (P)	Difference (P -B)	Percent Change
Deciview (dv)																	
Best 20% Days	2.7	2.5	2.3	2.2	2.4	2.1	2.5	2.5	2.5	2.5	2.4	0.0	0.5	2.4	2.4	0.0	0%
Worst 20% Days	10.6	9.1	10.2	9.9	9.4	10.4	9.8	8.8	9.3	14.7	8.5	0.0	0.4	9.9	10.6	0.7	7%
All Days	5.5	5.2	5.4	5.5	5.2	5.2	5.6	5.2	5.5	7.0	5.2	0.0	0.2	5.3	5.7	0.4	8%
Total Extinction (Mm-1)																	
Best 20% Days	13.1	12.9	12.6	12.4	12.8	12.3	12.9	12.9	12.8	12.9	12.8	0.0	0.5	12.8	12.8	0.0	0%
Worst 20% Days	44.0	27.1	29.7	27.3	27.0	32.3	27.4	24.4	26.2	59.5	23.8	-0.2	0.3	31.0	34.0	3.0	10%
All Days	21.2	17.7	18.3	18.0	17.6	18.4	18.3	17.2	18.1	25.5	17.2	0.0	0.5	18.6	19.5	0.9	5%
Ammonium Sulfate Extinction (Mm-1)																	
Best 20% Days	0.8	1.0	0.8	0.7	0.8	0.5	1.0	0.9	0.9	1.0	0.8	0.0	0.2	0.8	0.9	0.1	13%
Worst 20% Days	4.6	4.6	6.0	5.4	3.6	4.5	8.5	5.6	7.6	13.1	4.0	0.5	0.1	4.9	7.8	2.9	59%
All Days	2.4	2.5	2.8	2.7	2.1	2.5	3.8	2.7	3.5	5.1	2.4	0.1	0.0	2.5	3.5	1.0	40%
Ammonium Nitrate Extinction (Mm-1)																	
Best 20% Days	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0%
Worst 20% Days	0.7	0.6	0.4	0.5	0.8	0.6	0.7	0.9	0.8	0.7	0.9	0.0	0.1	0.6	0.7	0.1	17%
All Days	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.0	0.4	0.3	0.4	0.1	33%
Particulate Organic Mass Extinction (Mm-1)																	
Best 20% Days	0.5	0.3	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.0	0.4	0.3	0.3	0.0	0%
Worst 20% Days	23.5	7.1	8.7	7.0	7.9	12.5	3.6	3.9	3.3	30.4	5.0	-0.6	0.2	10.8	10.7	-0.1	-1%
All Days	5.7	2.1	2.6	2.3	2.5	3.1	1.5	1.7	1.6	6.9	1.7	-0.1	0.3	3.0	3.0	0.0	0%
Elemental Carbon Extinction (Mm-1)																	
Best 20% Days	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.1	-0.1	-50%
Worst 20% Days	2.3	1.3	1.4	1.6	1.3	1.7	0.9	1.1	0.8	2.1	1.1	-0.1	0.2	1.6	1.3	-0.3	-19%
All Days	0.8	0.6	0.7	0.7	0.5	0.6	0.5	0.5	0.4	0.7	0.5	0.0	0.1	0.6	0.5	-0.1	-17%
Soil Extinction (Mm-1)																	
Best 20% Days	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.5	0.0	0.0	0.0	0%
Worst 20% Days	0.2	0.5	0.5	0.2	0.2	0.2	0.4	0.2	0.3	0.4	0.2	0.0	0.4	0.3	0.3	0.0	0%
All Days	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.0	0.3	0.1	0.2	0.1	100%
Coarse Mass Extinction (Mm-1)																	
Best 20% Days	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.3	0.0	0.1	0.2	0.3	0.1	50%
Worst 20% Days	1.2	1.8	1.6	1.0	1.3	1.2	1.2	0.9	1.3	1.3	1.1	0.0	0.2	1.4	1.2	-0.2	-14%
All Days	0.7	0.8	0.7	0.6	0.6	0.6	0.7	0.6	0.7	0.8	0.8	0.0	0.4	0.7	0.7	0.0	0%
Sea Salt Extinction (Mm-1)																	
Best 20% Days	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.1	0.1	0.0	0%
Worst 20% Days	0.5	0.3	0.0	0.5	0.9	0.7	1.0	0.8	1.0	0.6	0.6	0.1	0.0	0.4	0.8	0.4	100%
All Days	0.2	0.2	0.1	0.3	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.0	0.0	0.2	0.3	0.1	50%

*Values highlighted in blue (red) indicate statistically significant decreasing (increasing) annual trend. Significance is measured at the 85% confidence level (p-value ≤0.15).
**Values highlighted in blue indicate a decrease in the 5-year average, values highlighted in red indicate an increase.
"---" Indicates a missing year that did not meet RHR data completeness criteria.

Figure A.1-1
Denali NP, AK (DENA1 Site)
Annual and 5-Year Period Averages
20% Most Impaired Visibility Days

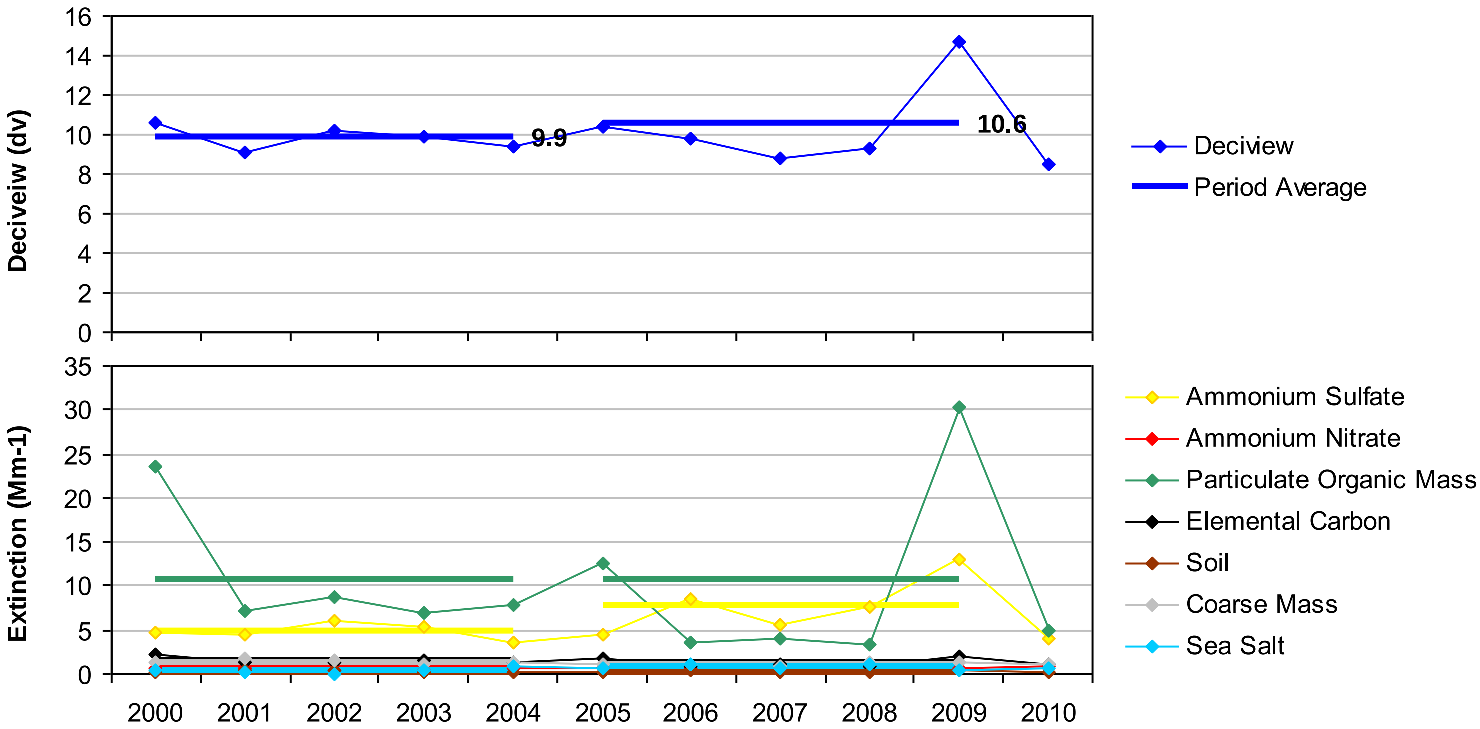


Figure A.1-2
Denali NP, AK (DENA1 Site)
Annual and 5-Year Period Averages
20% Least Impaired Visibility Days

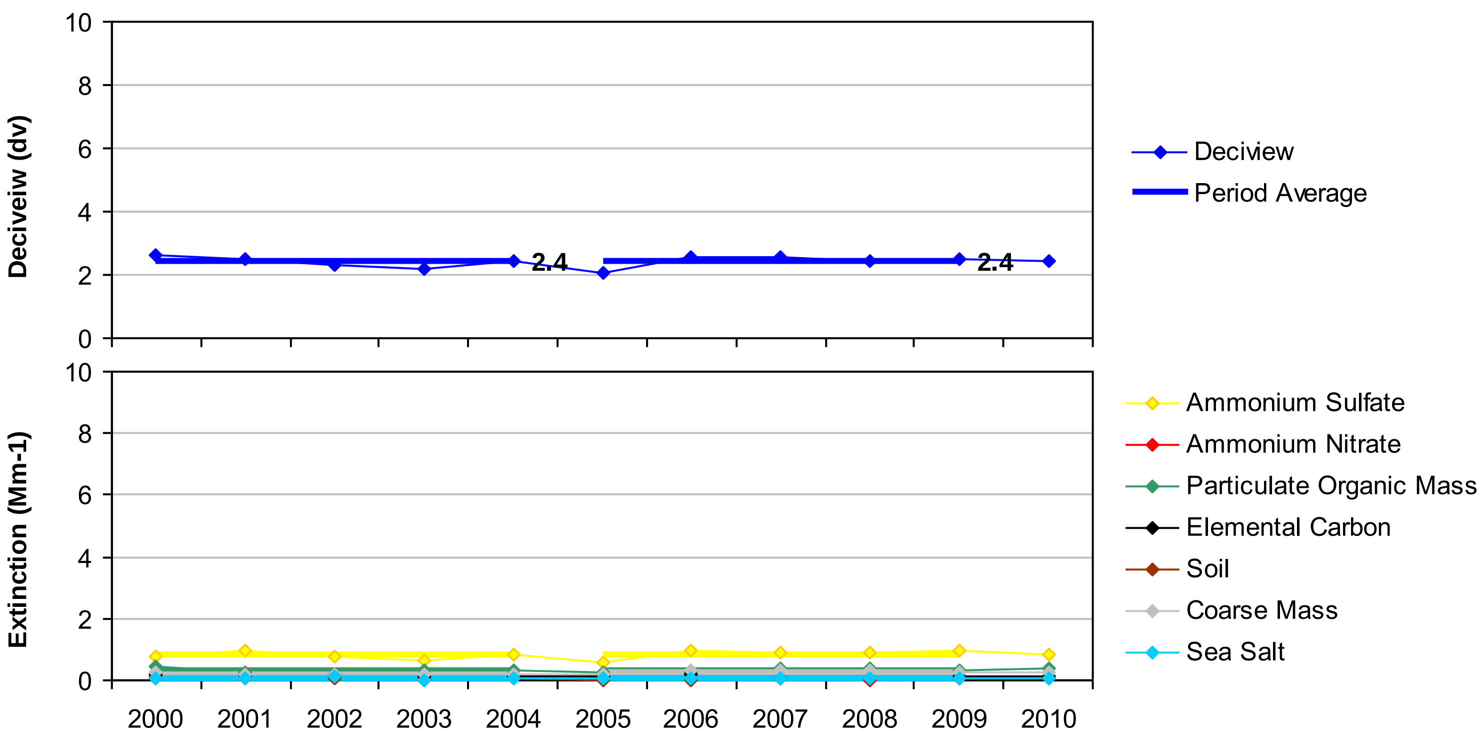


Figure A.1-3
Denali NP, AK (DENA1 Site)
20% Most Impaired Visibility Days

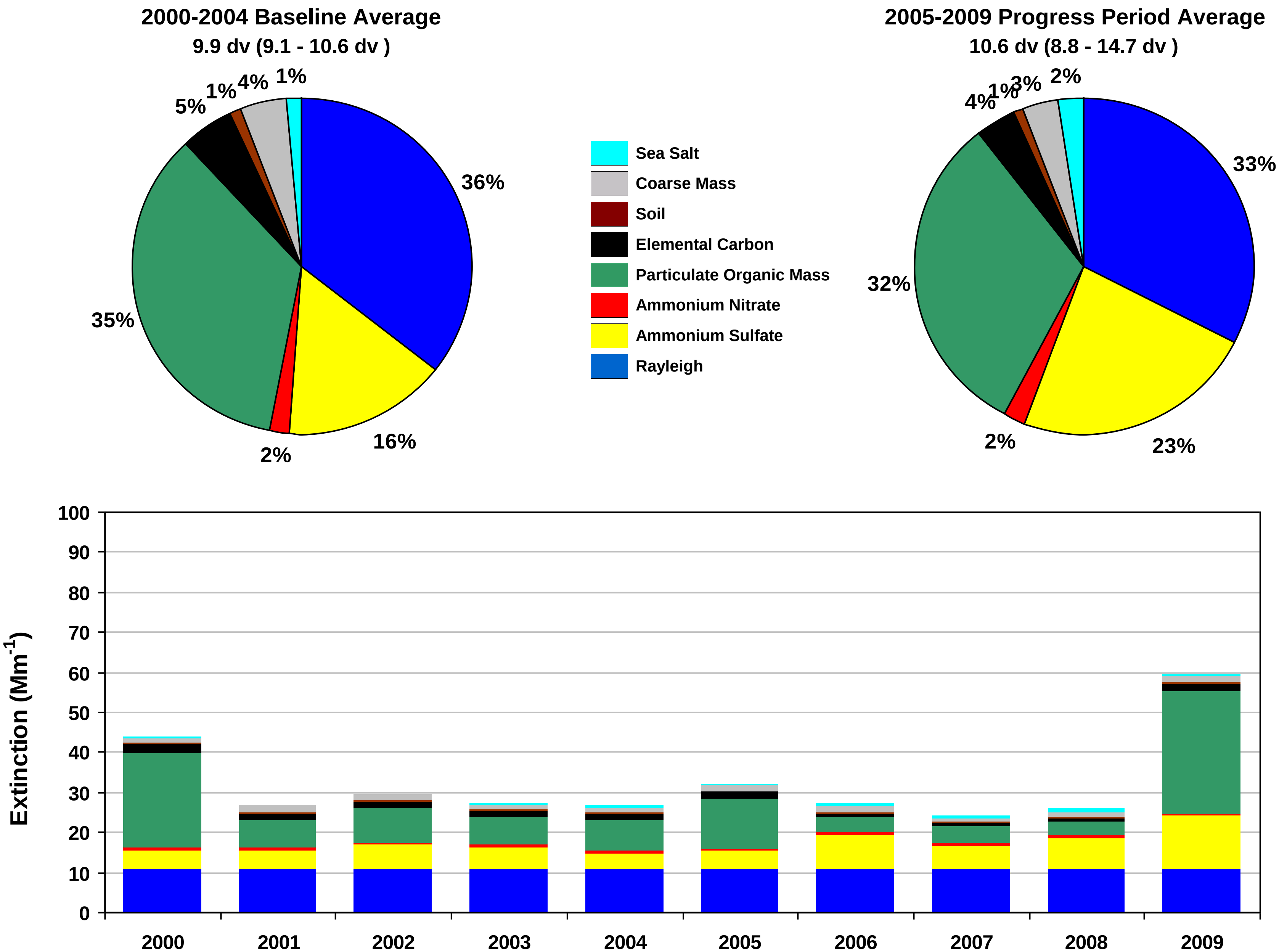


Figure A.1-4
Denali NP, AK (DENA1 Site)
20% Least Impaired Visibility Days

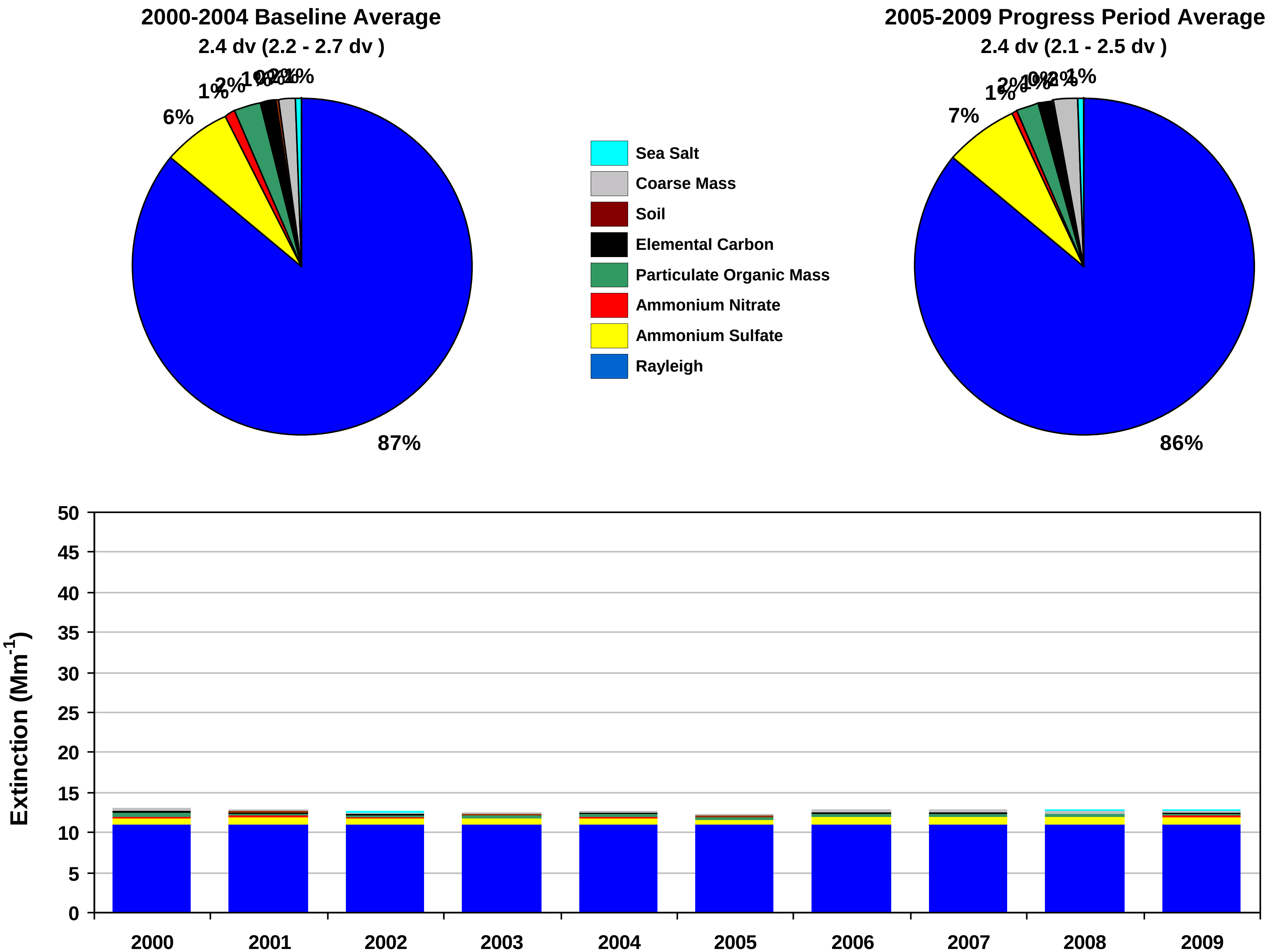


Figure A.1-5
Denali NP, AK (DENA1 Site)
2000-2004 Monthly Average Aerosol Extinction, All Monitored Days

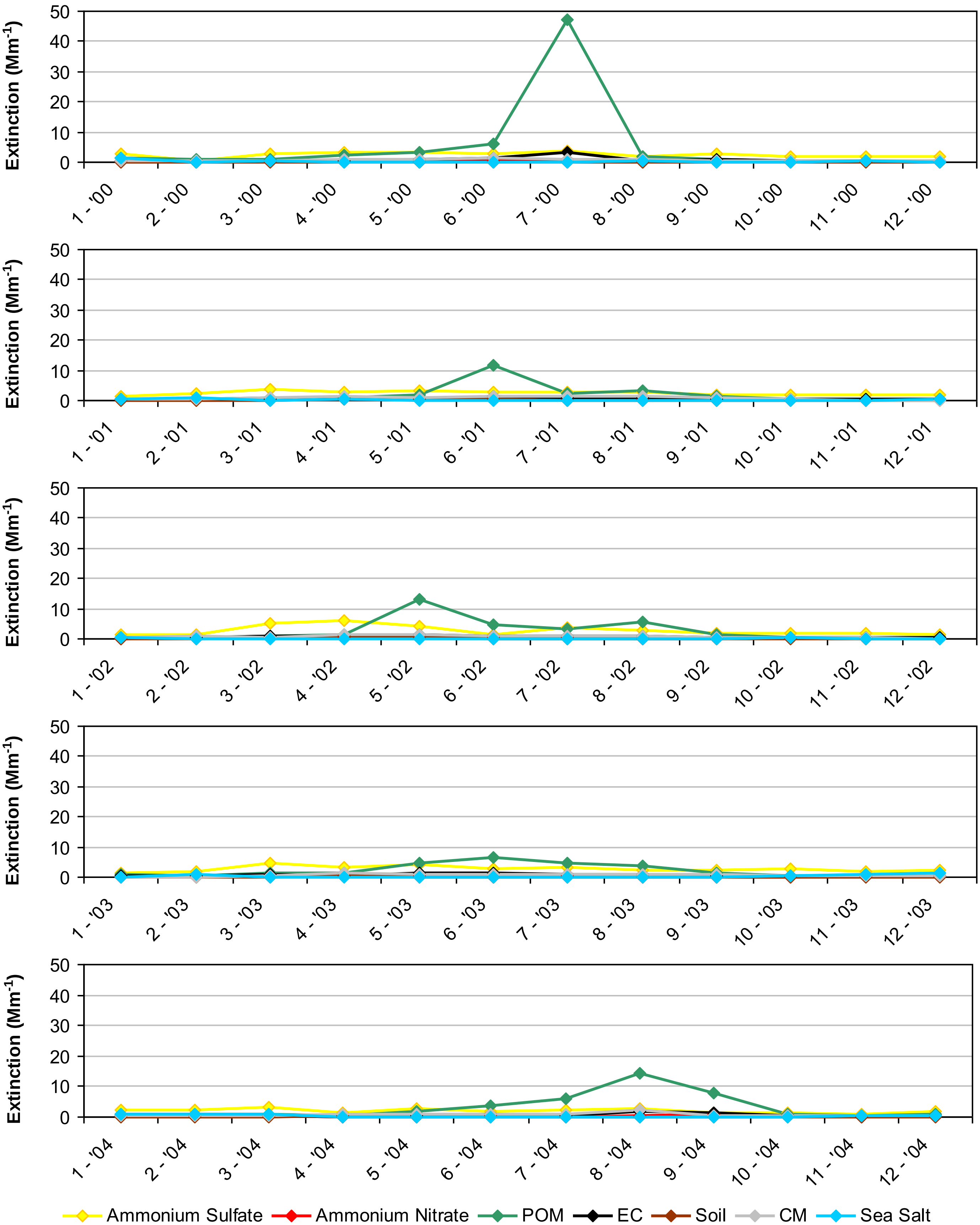


Figure A.1-6
Denali NP, AK (DENA1 Site)
2005-2009 Monthly Average Aerosol Extinction, All Monitored Days

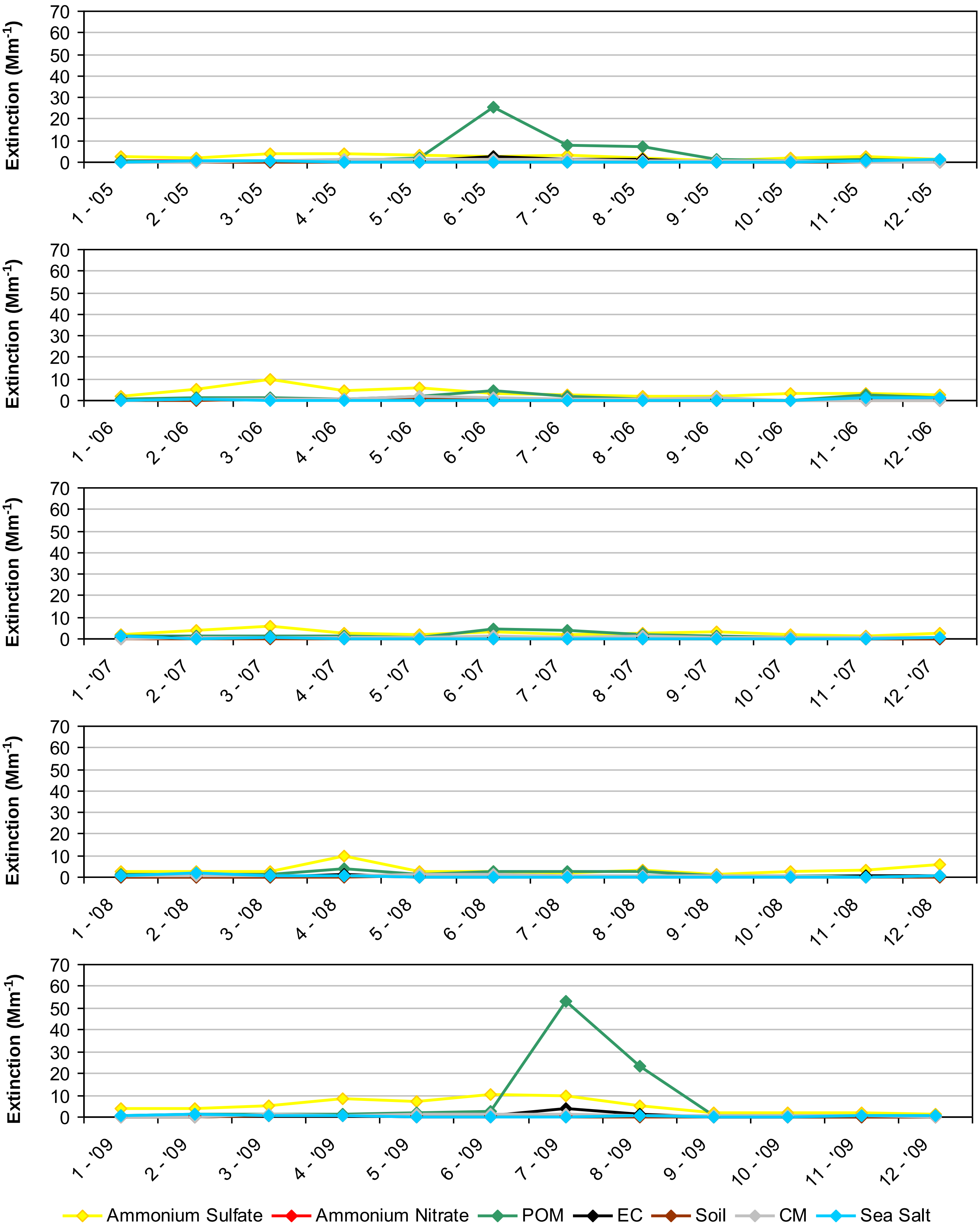


Figure A.1-7
Denali NP, AK (DENA1 Site)
2000-2004 Progress Period Extinction, All Sampled Days

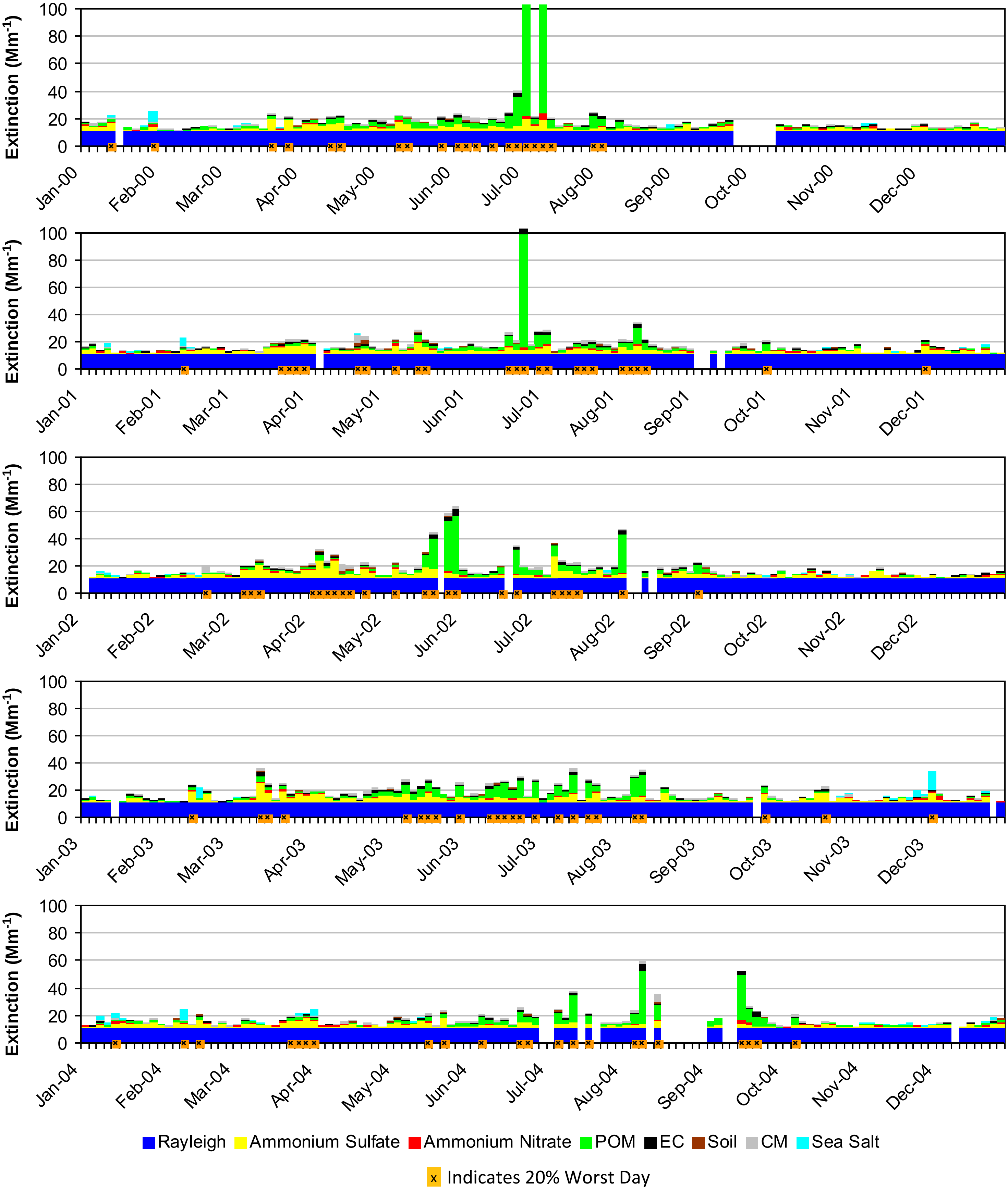
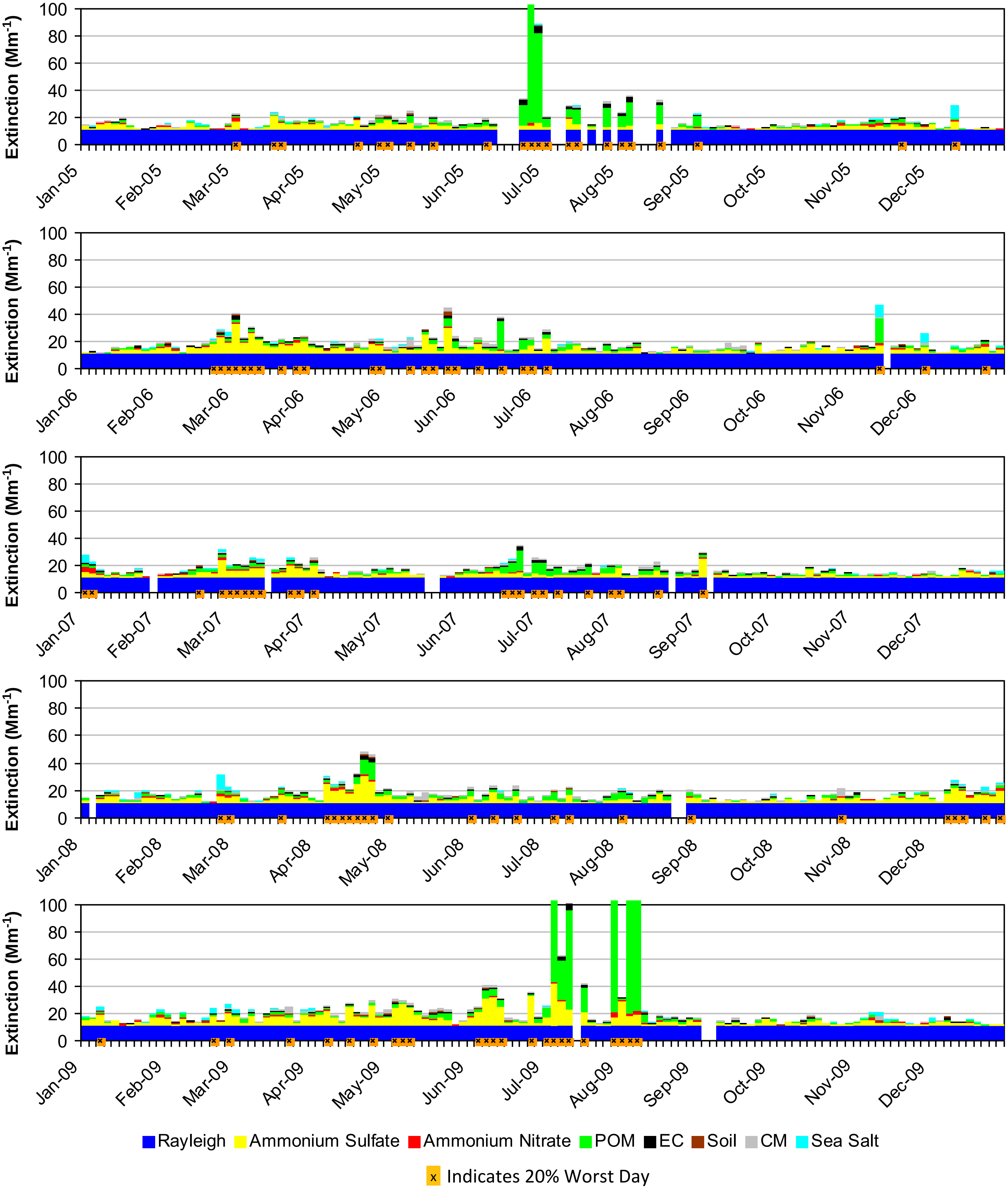


Figure A.1-8
Denali NP, AK (DENA1 Site)
2005-2009 Progress Period Extinction, All Sampled Days



A.2. SIMEONOF WA (SIME1)

The following tables and figures are presented in this section for the Simeonof Wilderness Area represented by the SIME1 IMPROVE Monitor:

- **Table A.2-1: Annual Averages, 5-Year Period Averages, and Trends:** Table of averages and other metrics for the 20% least impaired days, the 20% most impaired days, and all sampled days is presented.

- **Figure A.2-1: Annual and 5-Year Period Averages for the 20% Most Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.

- **Figure A.2-2: Annual and 5-Year Period Averages for the 20% Least Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.

- **Figure A.2-3: 20% Most Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component for the 20% most impaired days are presented.

- **Figure A.2-4: 20% Least Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component are presented.

- **Figure A.2-5: 2000-2004 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the baseline period are presented.

- **Figure A.2-6: 2005-2009 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the progress period are presented.

- **Figure A.2-7: 2000-2004 Progress Period Extinction, All Sampled Days:** Stacked bar charts depicting daily averages by year and component for the baseline period are presented.

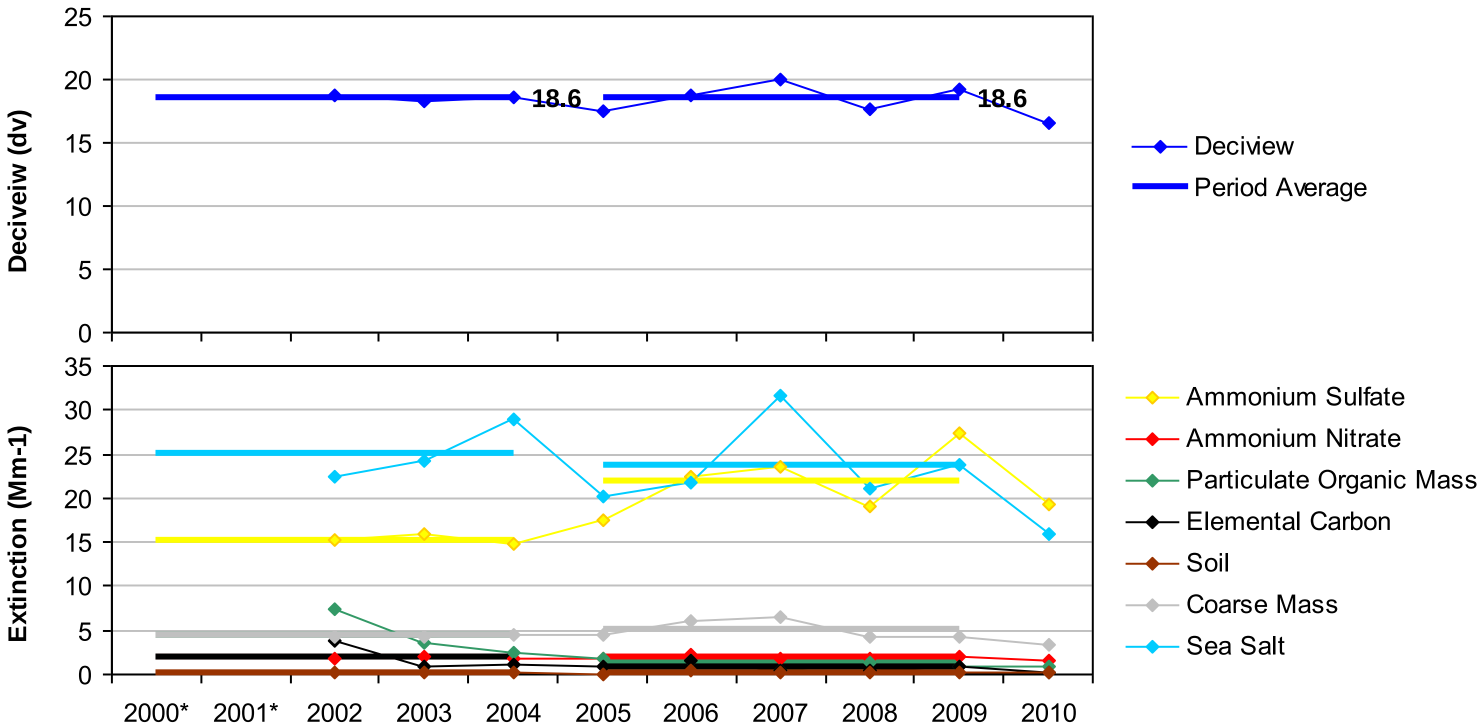
- **Figure A.2-8: 2000-2004 Progress Period Extinction, All Sampled Days**: Stacked bar charts depicting daily averages by year and component for the progress period are presented.

Table A.2-1
Simeonof WA, AK (SIME1 Site)
Annual Averages, 5-Year Period Averages and Trends

Group	Baseline Period					Progress Period						2000-2009 Trend Statistics*		Period Averages**			
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Slope (change/yr.)	p-value	Baseline (B)	Progress (P)	Difference (P -B)	Percent Change
Deciview (dv)																	
Best 20% Days	---	---	7.8	6.8	8.3	7.8	8.3	8.1	7.5	8.3	7.6	0.1	0.2	7.6	8.0	0.4	5%
Worst 20% Days	---	---	18.8	18.2	18.6	17.4	18.7	20.0	17.7	19.2	16.6	0.1	0.4	18.6	18.6	0.0	0%
All Days	---	---	13.0	12.2	12.9	12.4	13.2	13.3	12.0	13.4	11.4	0.1	0.2	12.7	12.8	0.1	1%
Total Extinction (Mm-1)																	
Best 20% Days	---	---	21.9	19.9	23.0	21.9	23.1	22.5	21.2	23.1	21.5	0.2	0.1	21.6	22.4	0.8	4%
Worst 20% Days	---	---	67.2	63.2	65.9	58.8	68.2	76.6	60.2	71.6	53.6	0.9	0.3	65.4	67.1	1.7	3%
All Days	---	---	39.8	37.0	39.1	36.8	40.5	42.0	35.9	41.7	33.1	0.3	0.4	38.6	39.4	0.8	2%
Ammonium Sulfate Extinction (Mm-1)																	
Best 20% Days	---	---	4.3	2.6	4.3	3.6	4.8	4.0	3.8	4.6	4.1	0.1	0.3	3.7	4.2	0.5	14%
Worst 20% Days	---	---	15.2	16.0	14.7	17.5	22.5	23.5	19.0	27.4	19.2	1.7	0.0	15.3	22.0	6.7	44%
All Days	---	---	9.9	9.5	9.5	9.9	12.3	12.3	10.4	14.3	9.7	0.6	0.0	9.6	11.8	2.2	23%
Ammonium Nitrate Extinction (Mm-1)																	
Best 20% Days	---	---	0.5	0.4	0.7	0.5	0.6	0.5	0.4	0.5	0.4	0.0	0.4	0.5	0.5	0.0	0%
Worst 20% Days	---	---	1.8	2.1	1.9	1.8	2.2	1.8	1.9	2.0	1.5	0.0	0.3	1.9	1.9	0.0	0%
All Days	---	---	1.3	1.2	1.3	1.2	1.2	1.2	1.0	1.2	0.9	0.0	0.1	1.3	1.2	-0.1	-8%
Particulate Organic Mass Extinction (Mm-1)																	
Best 20% Days	---	---	0.7	0.4	0.7	0.3	0.2	0.2	0.5	0.3	0.5	-0.1	0.1	0.6	0.3	-0.3	-50%
Worst 20% Days	---	---	7.5	3.7	2.5	1.8	1.7	0.5	1.3	0.9	1.0	-0.6	0.0	4.6	1.2	-3.4	-74%
All Days	---	---	2.8	1.7	1.2	1.0	0.7	0.6	0.9	0.7	0.7	-0.2	0.0	1.9	0.8	-1.1	-58%
Elemental Carbon Extinction (Mm-1)																	
Best 20% Days	---	---	0.4	0.5	0.4	0.4	0.7	0.6	0.4	0.6	0.6	0.0	0.2	0.4	0.5	0.1	25%
Worst 20% Days	---	---	3.8	0.9	1.1	0.9	1.5	0.4	0.4	0.8	0.3	-0.2	0.0	1.9	0.8	-1.1	-58%
All Days	---	---	1.5	0.8	0.7	0.9	1.0	0.7	0.5	0.7	0.7	-0.1	0.1	1.0	0.8	-0.2	-20%
Soil Extinction (Mm-1)																	
Best 20% Days	---	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0%
Worst 20% Days	---	---	0.2	0.2	0.2	0.1	0.4	0.2	0.1	0.2	0.2	0.0	0.5	0.2	0.2	0.0	0%
All Days	---	---	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.3	0.1	0.1	0.0	0%
Coarse Mass Extinction (Mm-1)																	
Best 20% Days	---	---	1.1	1.1	1.1	1.1	1.3	1.2	1.1	1.1	1.0	0.0	0.4	1.1	1.2	0.1	9%
Worst 20% Days	---	---	4.4	4.3	4.5	4.5	6.2	6.4	4.4	4.4	3.3	0.0	0.5	4.4	5.2	0.8	18%
All Days	---	---	2.7	2.5	2.5	2.5	3.0	3.2	2.6	2.3	1.9	0.0	0.6	2.6	2.7	0.1	4%
Sea Salt Extinction (Mm-1)																	
Best 20% Days	---	---	2.9	2.9	3.8	4.1	3.5	4.0	2.9	4.1	3.0	0.1	0.1	3.2	3.7	0.5	16%
Worst 20% Days	---	---	22.3	24.1	29.0	20.3	21.8	31.6	21.1	23.9	16.0	0.1	0.6	25.2	23.7	-1.5	-6%
All Days	---	---	9.5	9.2	11.8	9.3	10.0	11.9	8.5	10.4	7.2	0.1	0.4	10.1	10.0	-0.1	-1%

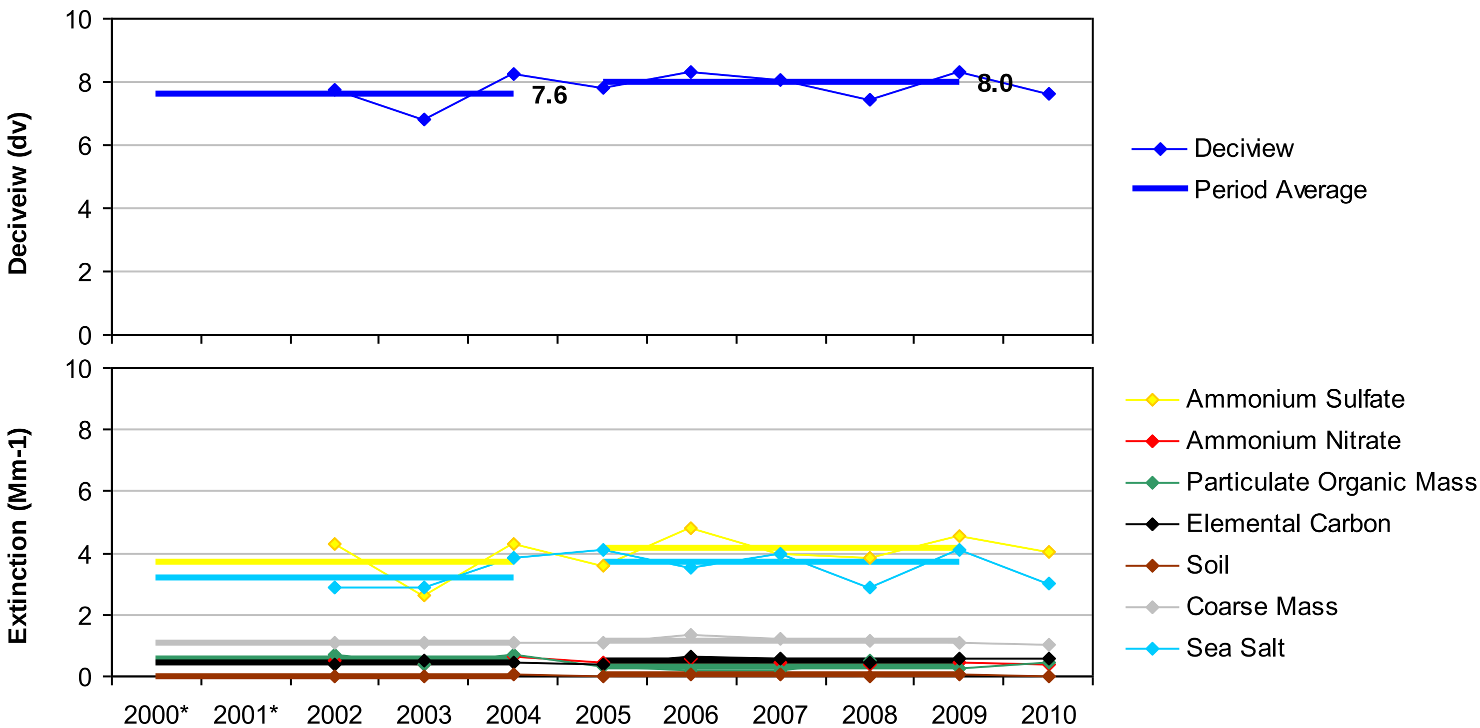
*Values highlighted in blue (red) indicate statistically significant decreasing (increasing) annual trend. Significance is measured at the 85% confidence level (p-value ≤0.15).
**Values highlighted in blue indicate a decrease in the 5-year average, values highlighted in red indicate an increase.
"---" Indicates a missing year that did not meet RHR data completeness criteria.

Figure A.2-1
Simeonof WA, AK (SIME1 Site)
Annual and 5-Year Period Averages
20% Most Impaired Visibility Days



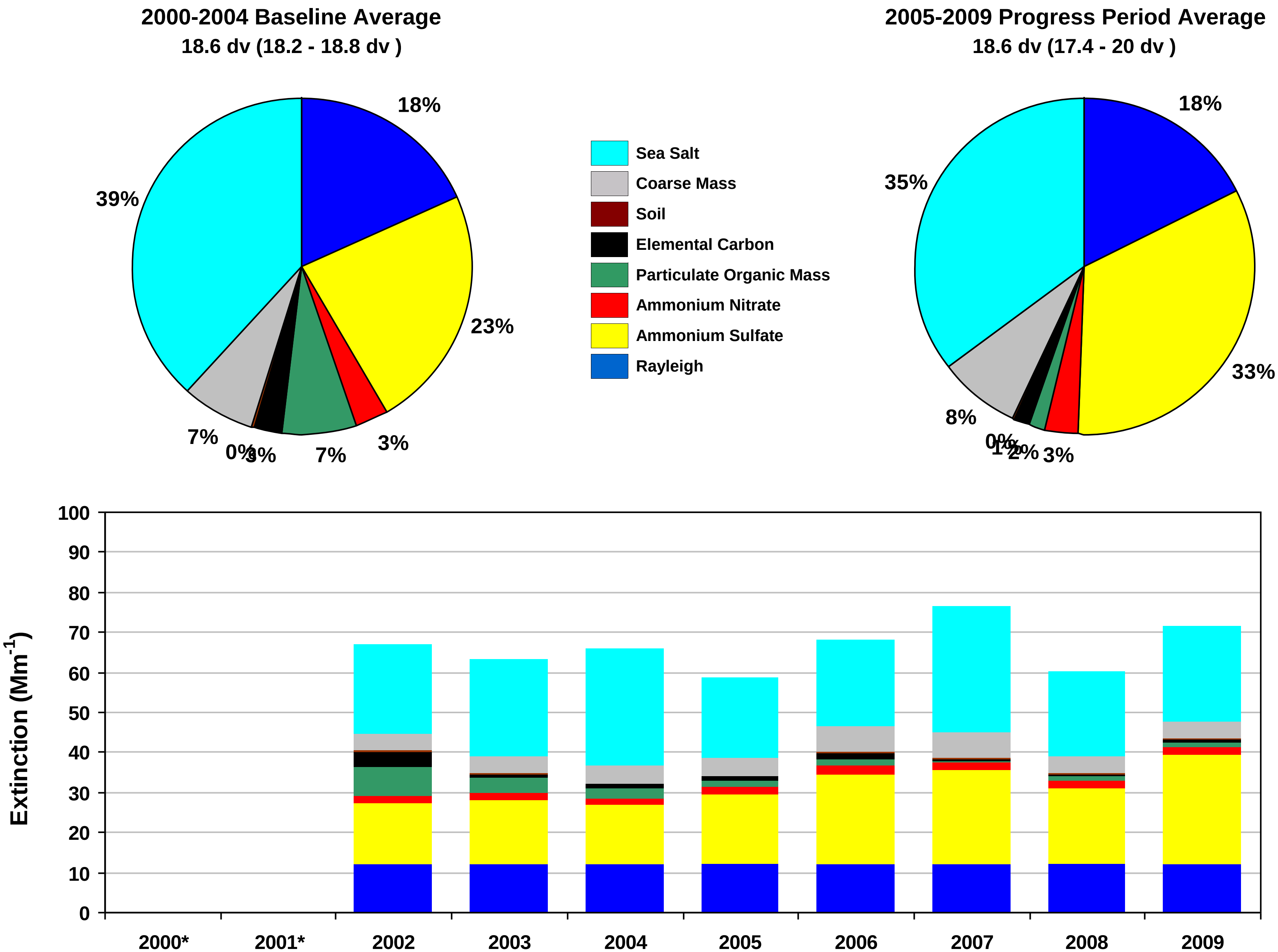
*Missing years did not meet RHR data completeness criteria.

Figure A.2-2
Simeonof WA, AK (SIME1 Site)
Annual and 5-Year Period Averages
20% Least Impaired Visibility Days



*Missing years did not meet RHR data completeness criteria.

Figure A.2-3
Simeonof WA, AK (SIME1 Site)
20% Most Impaired Visibility Days

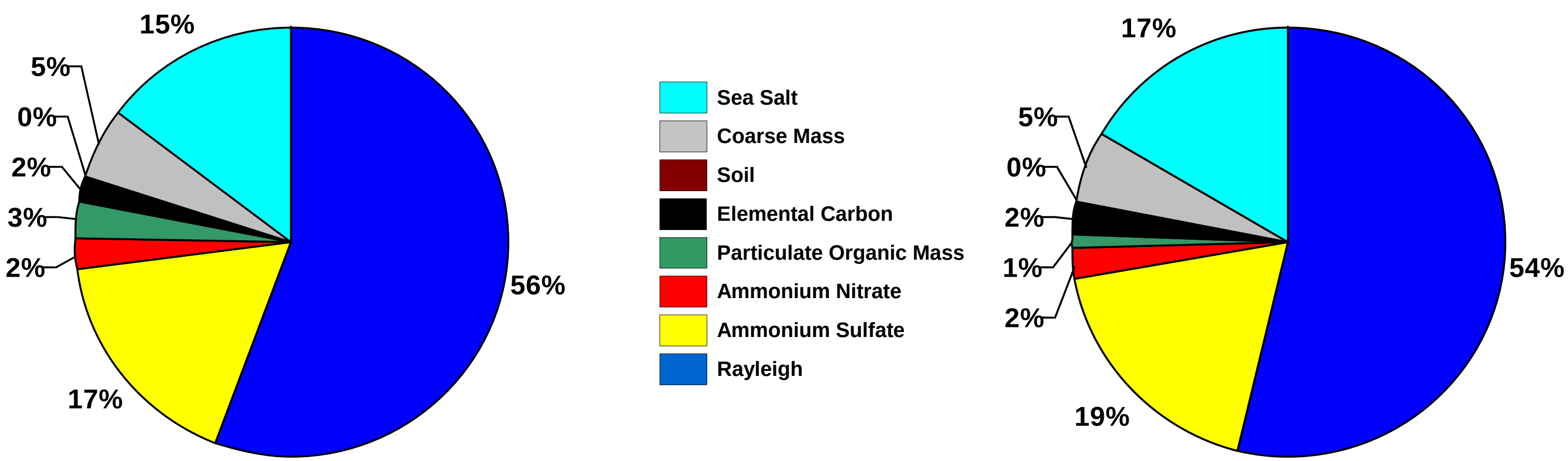


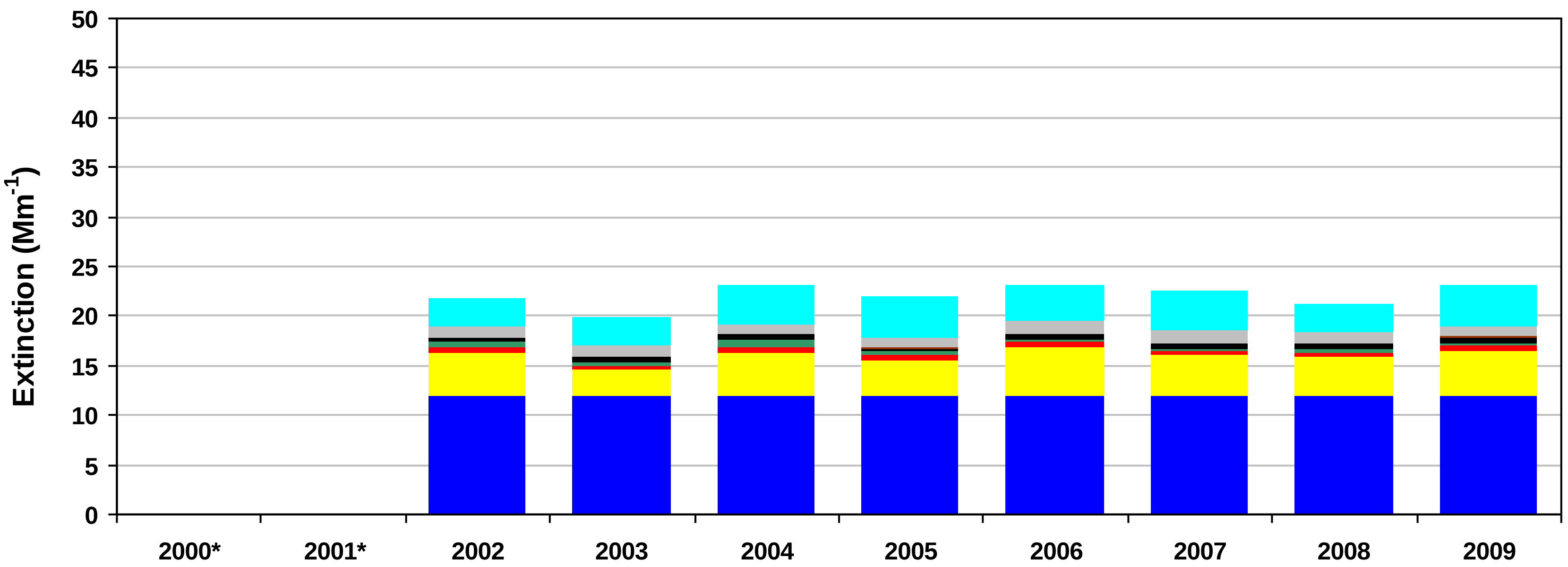
*Missing years did not meet RHR data completeness criteria. Only complete years are included in 5-year average pie charts.

Figure A.2-4

Simeonof WA, AK (SIME1 Site)

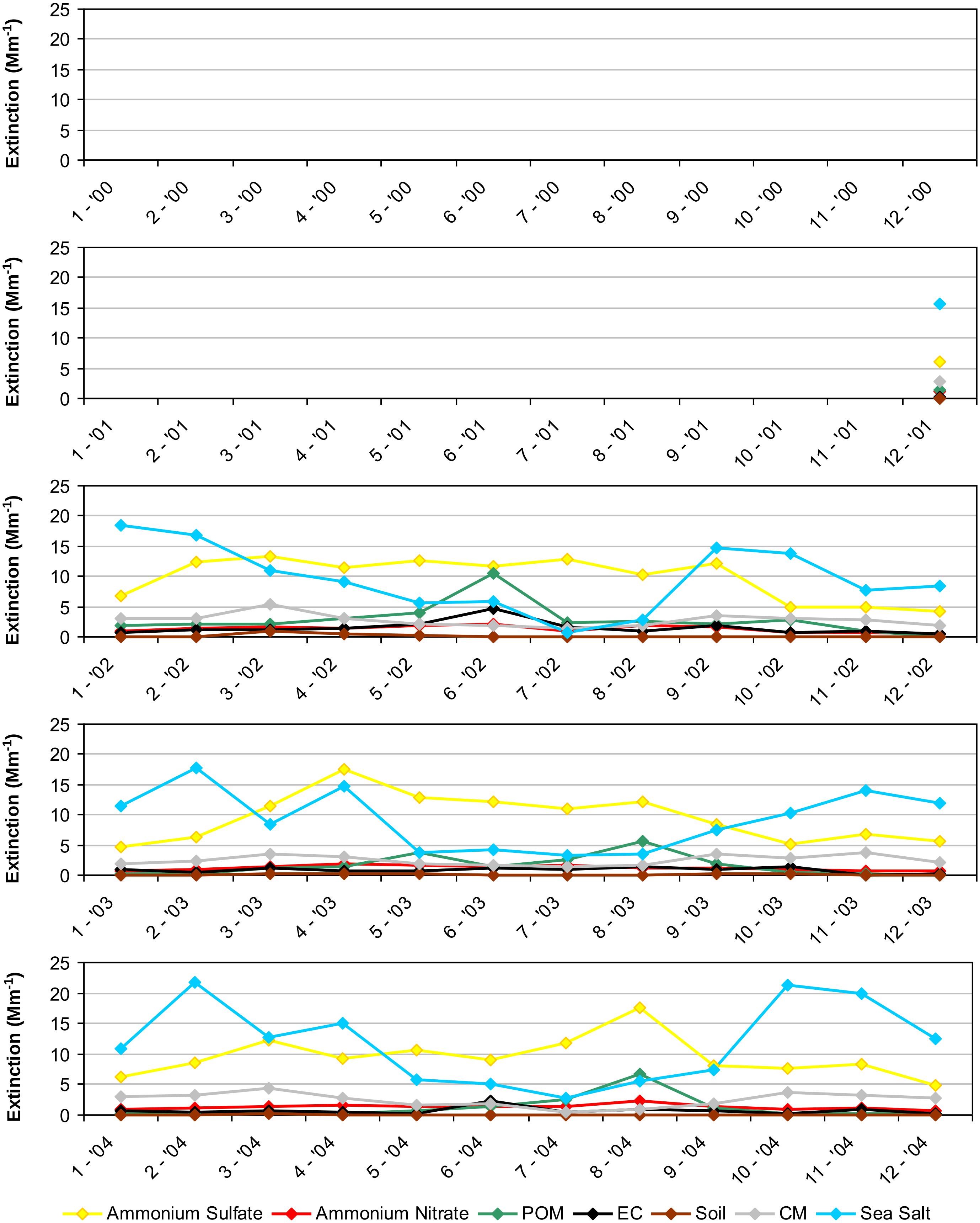
20% Least Impaired Visibility Days





*Missing years did not meet RHR data completeness criteria. Only complete years are included in 5-year average pie charts.

Figure A.2-5
Simeonof WA, AK (SIME1 Site)
2000-2004 Monthly Average Aerosol Extinction, All Monitored Days



*Note that monthly averages for the years 2000 and 2001 are shown here, but these years did not meet RHR data completeness criteria.

Figure A.2-6
Simeonof WA, AK (SIME1 Site)
2005-2009 Monthly Average Aerosol Extinction, All Monitored Days

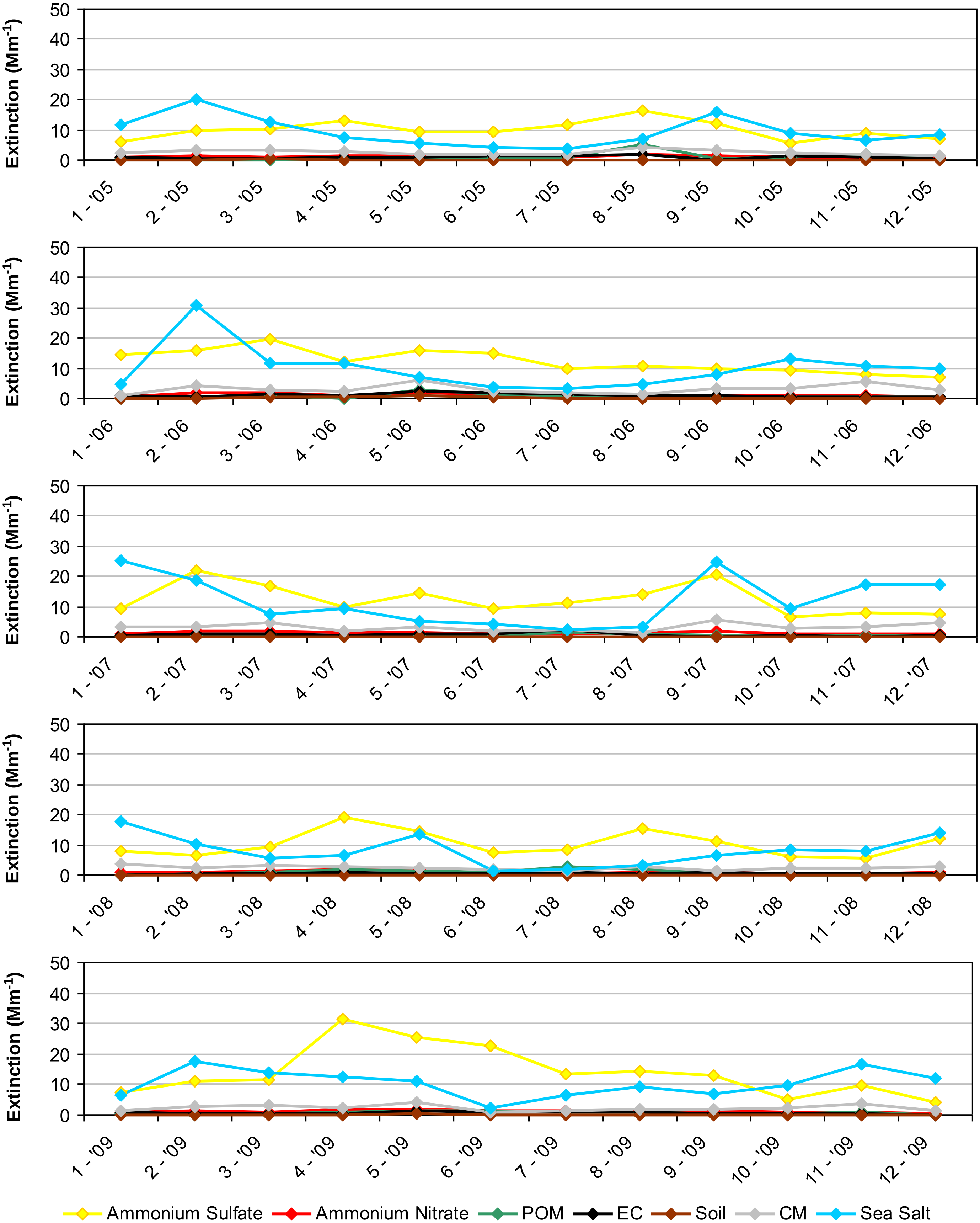
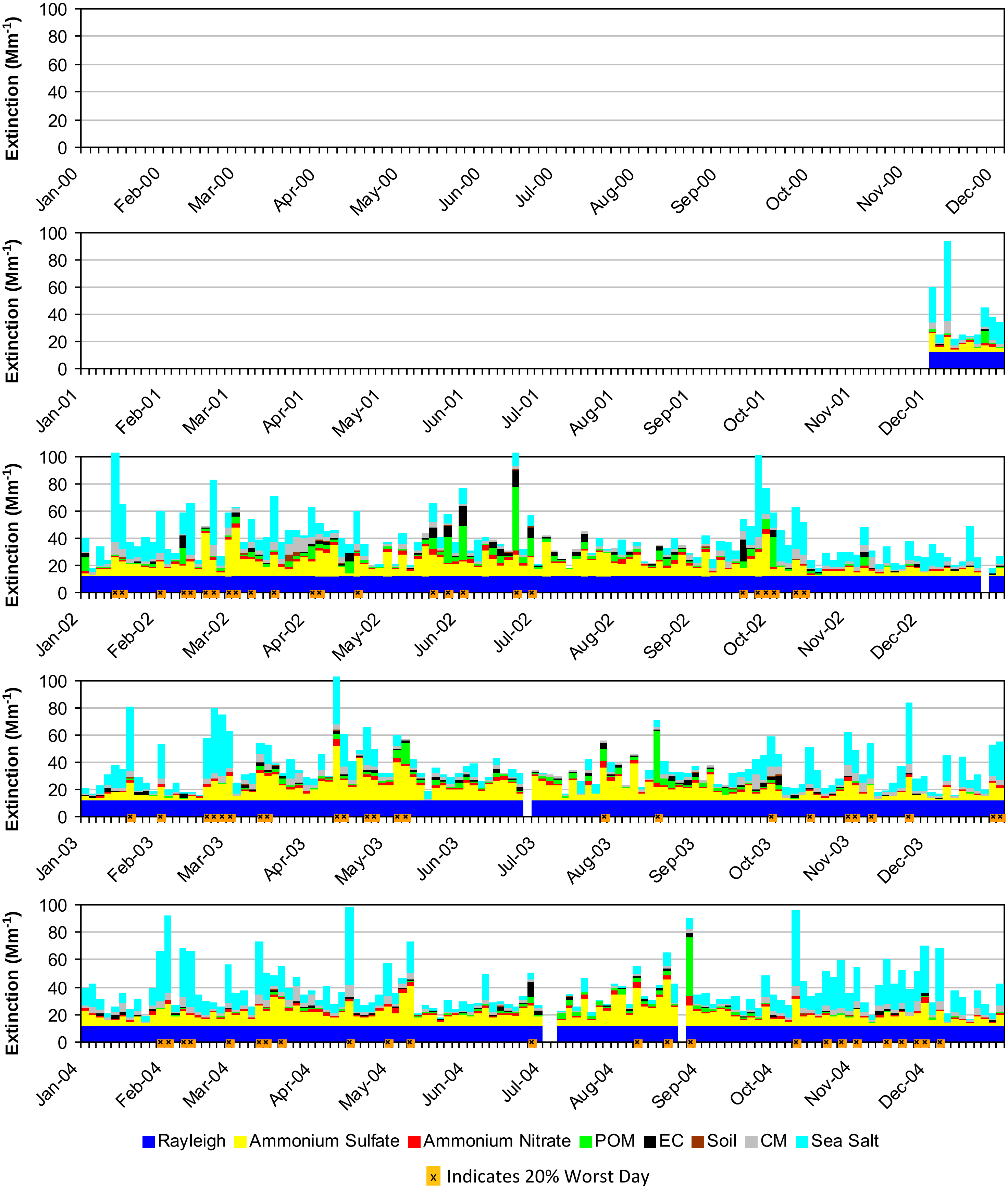
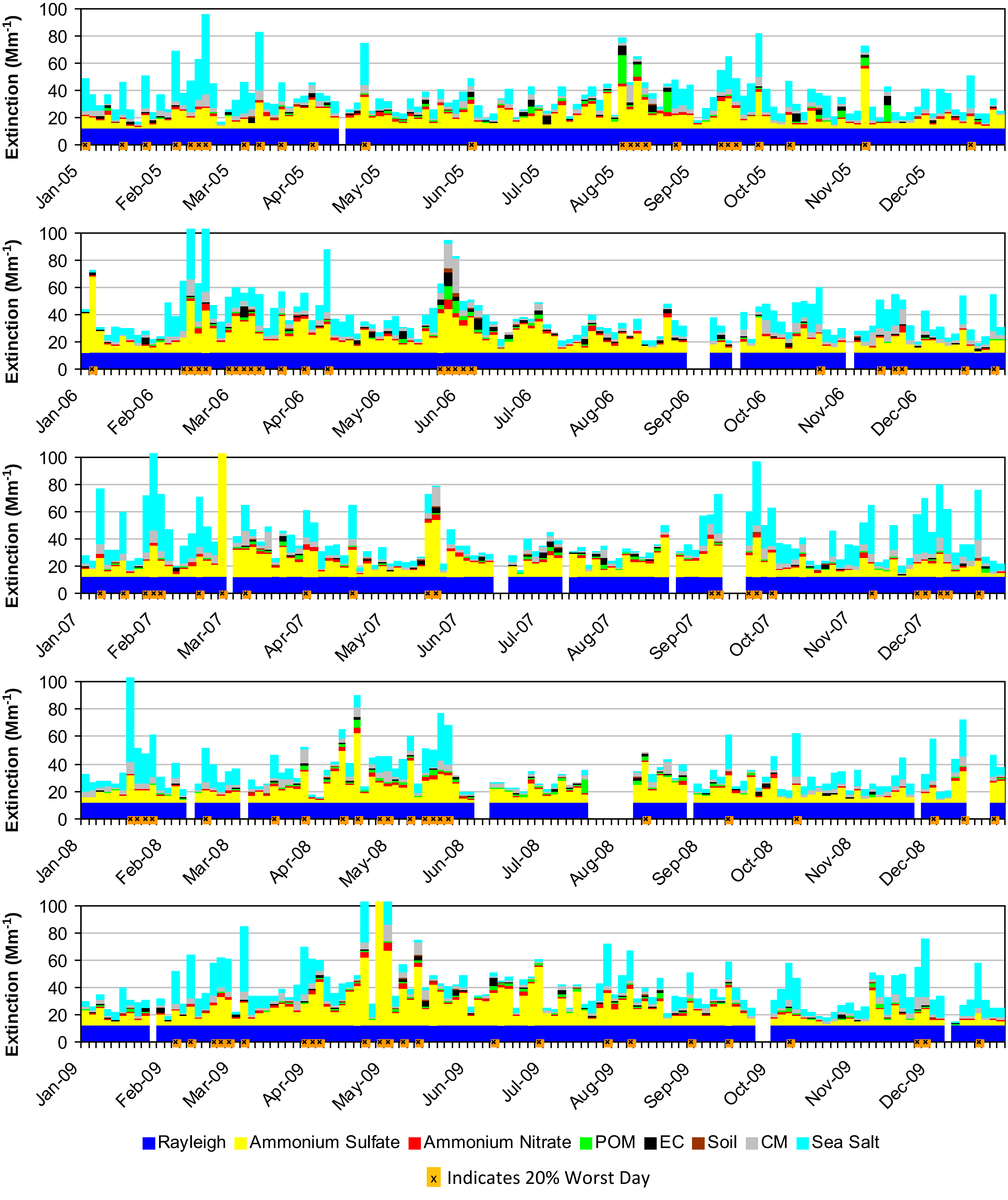


Figure A.2-7
Simeonof WA, AK (SIME1 Site)
2000-2004 Progress Period Extinction, All Sampled Days



*Note that daily averages for the years 2000 and 2001 are shown here, but these years did not meet RHR data completeness criteria.

Figure A.2-8
Simeonof WA, AK (SIME1 Site)
2005-2009 Progress Period Extinction, All Sampled Days



A.3. TRAPPER CREEK (TRCR1)

The following tables and figures are presented in this section for Trapper Creek represented by the TRCR1 IMPROVE Monitor:

- **Table A.3-1: Annual Averages, 5-Year Period Averages, and Trends:** Table of averages and other metrics for the 20% least impaired days, the 20% most impaired days, and all sampled days is presented.

- **Figure A.3-1: Annual and 5-Year Period Averages for the 20% Most Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.

- **Figure A.3-2: Annual and 5-Year Period Averages for the 20% Least Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.

- **Figure A.3-3: 20% Most Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component for the 20% most impaired days are presented.

- **Figure A.3-4: 20% Least Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component are presented.

- **Figure A.3-5: 2000-2004 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the baseline period are presented.

- **Figure A.3-6: 2005-2009 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the progress period are presented.

- **Figure A.3-7: 2000-2004 Progress Period Extinction, All Sampled Days:** Stacked bar charts depicting daily averages by year and component for the baseline period are presented.

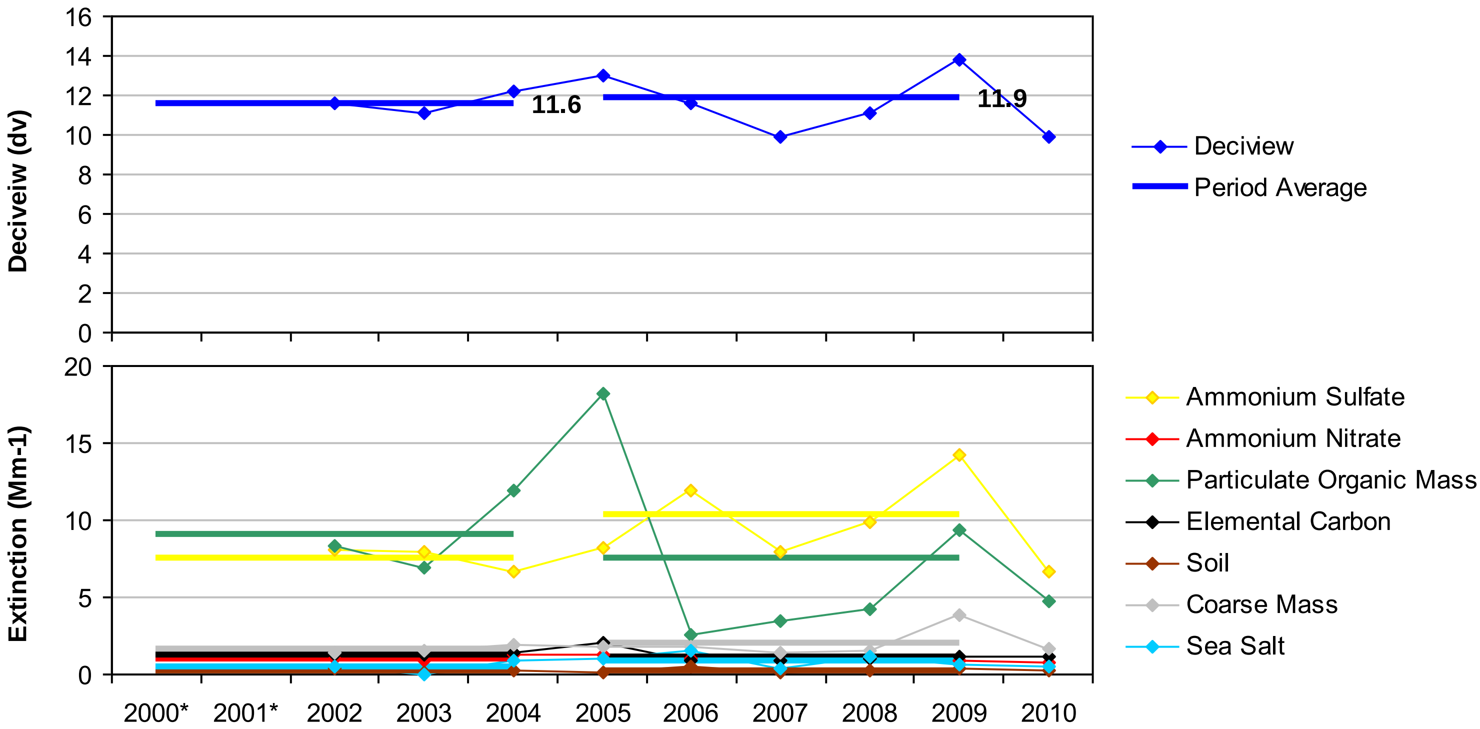
- **Figure A.3-8: 2000-2004 Progress Period Extinction, All Sampled Days**: Stacked bar charts depicting daily averages by year and component for the progress period are presented.

Table A.3-1
Trapper Creek, AK (TRCR1 Site)
Annual Averages, 5-Year Period Averages and Trends

Group	Baseline Period					Progress Period						2000-2009 Trend Statistics*		Period Averages**			
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Slope (change/yr.)	p-value	Baseline (B)	Progress (P)	Difference (P -B)	Percent Change
Deciview (dv)																	
Best 20% Days	---	---	3.4	3.2	3.7	3.2	4.0	4.0	4.2	4.1	3.6	0.1	0.0	3.5	3.9	0.4	11%
Worst 20% Days	---	---	11.6	11.1	12.2	13.0	11.6	9.9	11.1	13.8	9.9	0.1	0.5	11.6	11.9	0.3	3%
All Days	---	---	6.8	6.6	6.9	7.1	7.5	6.6	7.1	8.1	6.4	0.2	0.1	6.7	7.3	0.6	9%
Total Extinction (Mm-1)																	
Best 20% Days	---	---	14.1	13.8	14.5	13.8	14.9	15.0	15.2	15.2	14.4	0.2	0.0	14.1	14.8	0.7	5%
Worst 20% Days	---	---	33.0	30.7	36.4	44.7	32.3	27.2	31.2	42.7	27.8	0.0	0.6	33.4	35.6	2.2	7%
All Days	---	---	20.8	20.2	21.4	23.2	22.0	19.7	21.1	24.6	19.7	0.3	0.2	20.8	22.1	1.3	6%
Ammonium Sulfate Extinction (Mm-1)																	
Best 20% Days	---	---	1.0	0.8	1.0	0.9	1.5	1.4	1.4	1.7	1.2	0.1	0.0	0.9	1.4	0.5	56%
Worst 20% Days	---	---	8.0	7.9	6.6	8.2	12.0	7.9	9.9	14.3	6.7	0.7	0.1	7.5	10.4	2.9	39%
All Days	---	---	3.7	3.5	3.1	3.7	5.5	3.6	4.5	6.0	3.4	0.2	0.1	3.4	4.7	1.3	38%
Ammonium Nitrate Extinction (Mm-1)																	
Best 20% Days	---	---	0.1	0.1	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.0	0.1	0.2	0.2	0.0	0%
Worst 20% Days	---	---	1.1	0.9	1.2	1.2	1.0	0.9	1.0	1.0	0.7	0.0	0.3	1.1	1.0	-0.1	-9%
All Days	---	---	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.0	0%
Particulate Organic Mass Extinction (Mm-1)																	
Best 20% Days	---	---	0.4	0.3	0.4	0.2	0.5	0.5	0.6	0.5	0.4	0.0	0.0	0.4	0.5	0.1	25%
Worst 20% Days	---	---	8.3	6.9	12.0	18.3	2.6	3.4	4.3	9.4	4.8	-0.5	0.5	9.1	7.6	-1.5	-17%
All Days	---	---	2.6	2.4	3.5	4.7	1.5	1.7	2.0	3.0	1.9	-0.1	0.5	2.8	2.6	-0.2	-7%
Elemental Carbon Extinction (Mm-1)																	
Best 20% Days	---	---	0.2	0.3	0.4	0.1	0.2	0.2	0.2	0.2	0.2	0.0	0.5	0.3	0.2	-0.1	-33%
Worst 20% Days	---	---	1.3	1.3	1.4	2.1	0.9	0.9	1.0	1.2	1.1	0.0	0.4	1.3	1.2	-0.1	-8%
All Days	---	---	0.6	0.7	0.7	0.8	0.6	0.5	0.5	0.6	0.5	0.0	0.1	0.6	0.6	0.0	0%
Soil Extinction (Mm-1)																	
Best 20% Days	---	---	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0%
Worst 20% Days	---	---	0.4	0.2	0.3	0.1	0.6	0.2	0.3	0.4	0.3	0.0	0.4	0.3	0.3	0.0	0%
All Days	---	---	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.3	0.2	0.0	0.3	0.2	0.2	0.0	0%
Coarse Mass Extinction (Mm-1)																	
Best 20% Days	---	---	0.3	0.2	0.3	0.2	0.4	0.5	0.5	0.3	0.3	0.0	0.1	0.3	0.4	0.1	33%
Worst 20% Days	---	---	1.4	1.5	2.0	1.8	1.8	1.4	1.6	3.8	1.6	0.1	0.3	1.6	2.1	0.5	31%
All Days	---	---	0.9	0.9	0.9	1.0	1.1	0.9	1.0	1.8	1.0	0.0	0.0	0.9	1.2	0.3	33%
Sea Salt Extinction (Mm-1)																	
Best 20% Days	---	---	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3	0.1	0.1	0.0	0%
Worst 20% Days	---	---	0.5	0.0	0.9	1.0	1.5	0.4	1.2	0.7	0.5	0.1	0.2	0.5	1.0	0.5	100%
All Days	---	---	0.2	0.2	0.5	0.4	0.5	0.3	0.5	0.4	0.3	0.0	0.2	0.3	0.4	0.1	33%

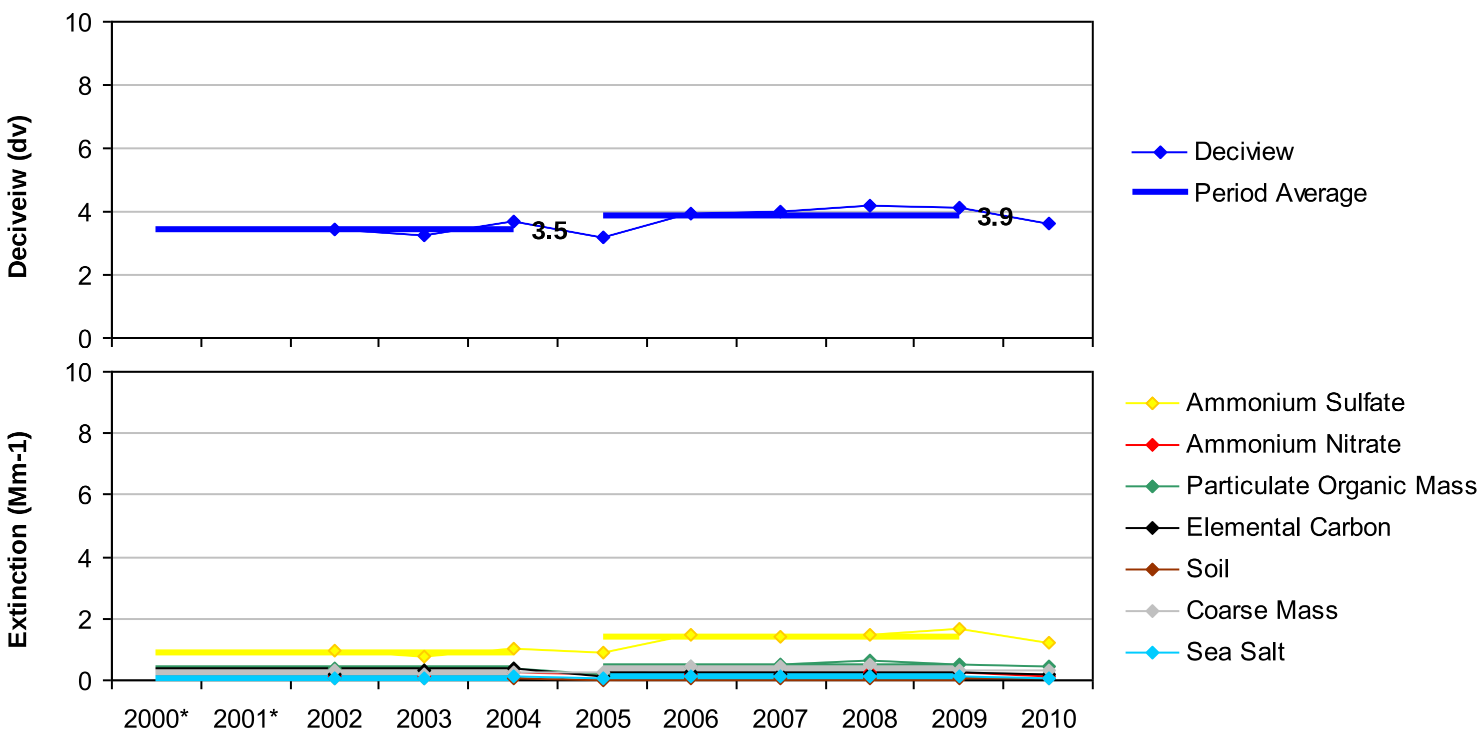
*Values highlighted in blue (red) indicate statistically significant decreasing (increasing) annual trend. Significance is measured at the 85% confidence level (p-value ≤0.15).
**Values highlighted in blue indicate a decrease in the 5-year average, values highlighted in red indicate an increase.
"---" Indicates a missing year that did not meet RHR data completeness criteria.

Figure A.3-1
Trapper Creek, AK (TRCR1 Site)
Annual and 5-Year Period Averages
20% Most Impaired Visibility Days



*Missing years did not meet RHR data completeness criteria.

Figure A.3-2
Trapper Creek, AK (TRCR1 Site)
Annual and 5-Year Period Averages
20% Least Impaired Visibility Days

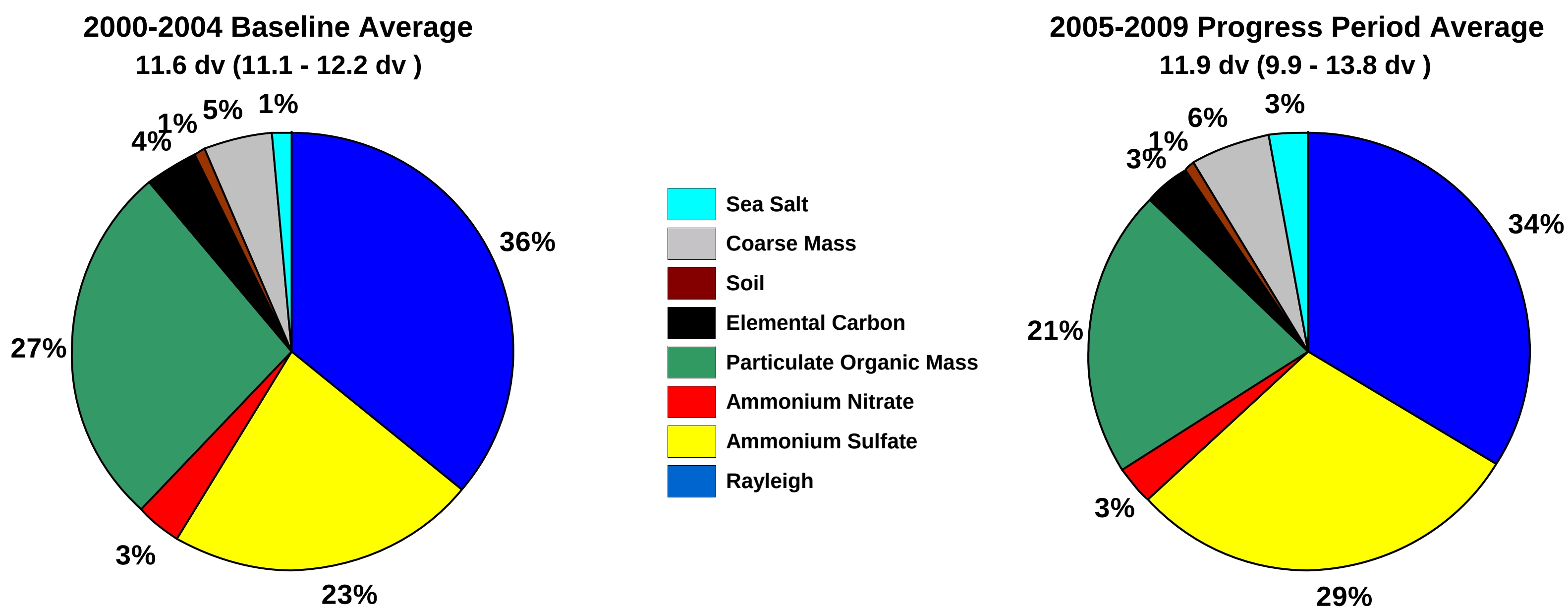


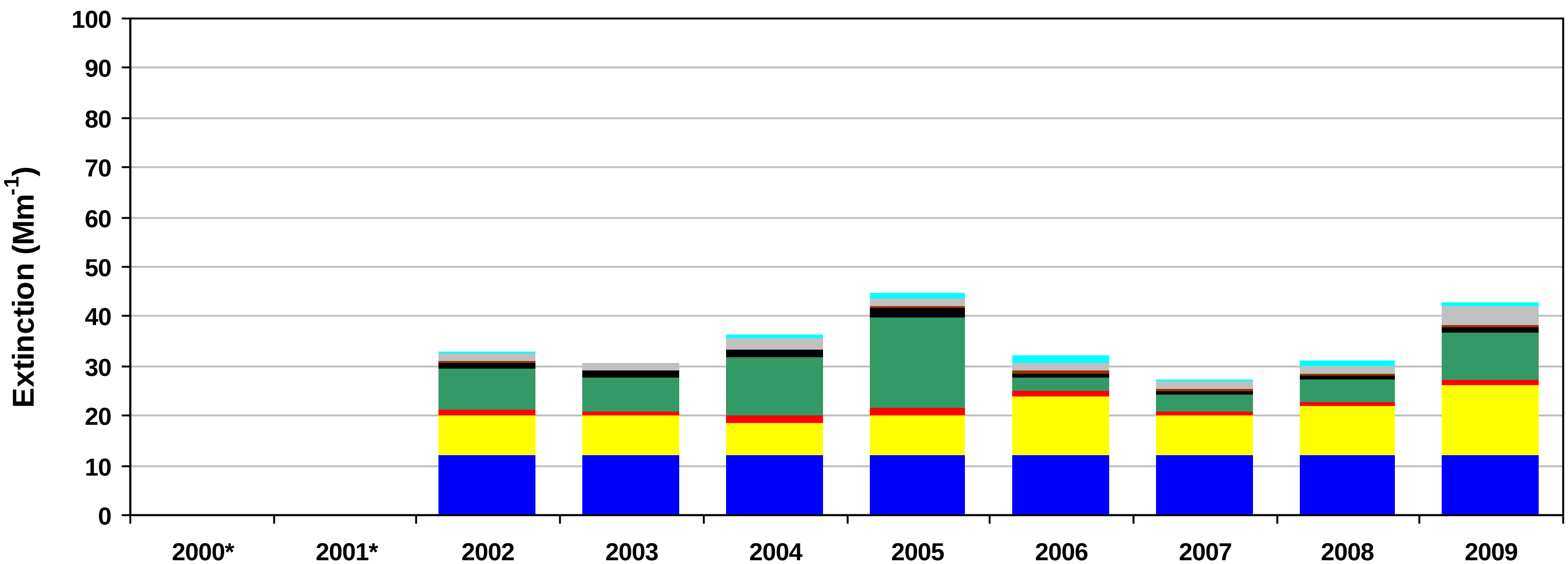
*Missing years did not meet RHR data completeness criteria.

Figure A.3-3

Trapper Creek, AK (TRCR1 Site)

20% Most Impaired Visibility Days



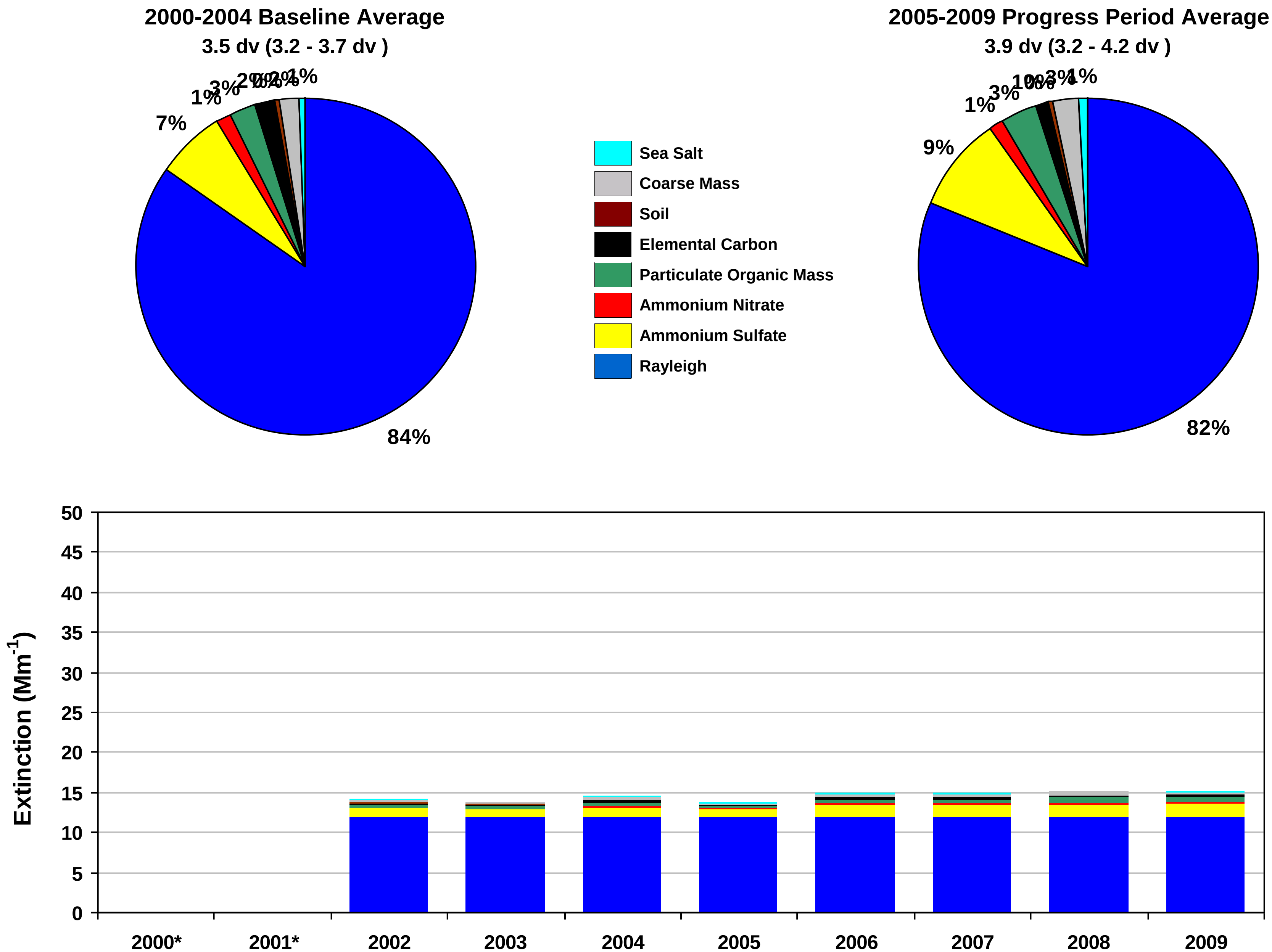


*Missing years did not meet RHR data completeness criteria. Only complete years are included in 5-year average pie charts.

Figure A.3-4

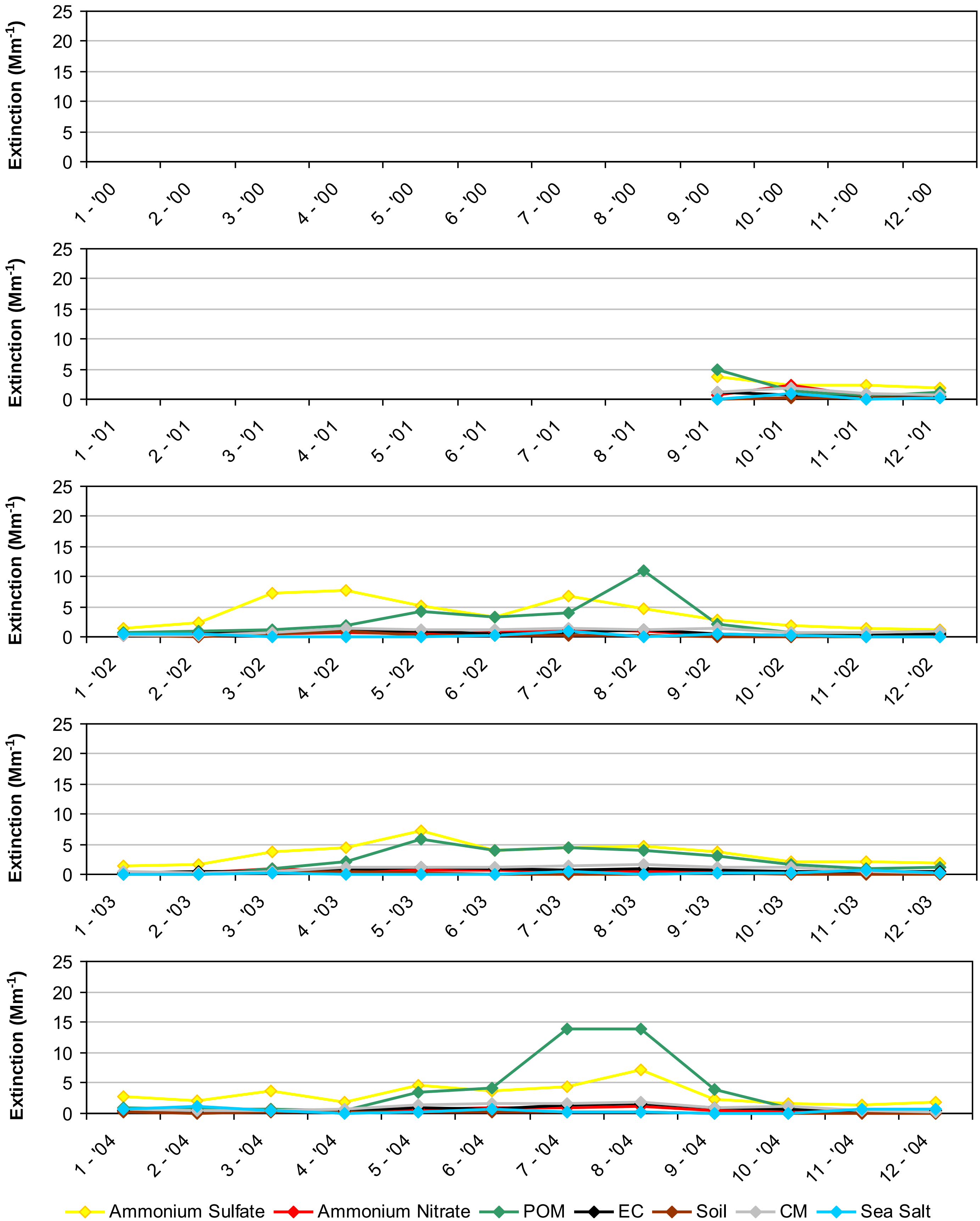
Trapper Creek, AK (TRCR1 Site)

20% Least Impaired Visibility Days



*Missing years did not meet RHR data completeness criteria. Only complete years are included in 5-year average pie charts.

Figure A.3-5
Trapper Creek, AK (TRCR1 Site)
2000-2004 Monthly Average Aerosol Extinction, All Monitored Days



*Note that monthly averages for the years 2000 and 2001 are shown here, but these years did not meet RHR data completeness criteria.

Figure A.3-6
Trapper Creek, AK (TRCR1 Site)
2005-2009 Monthly Average Aerosol Extinction, All Monitored Days

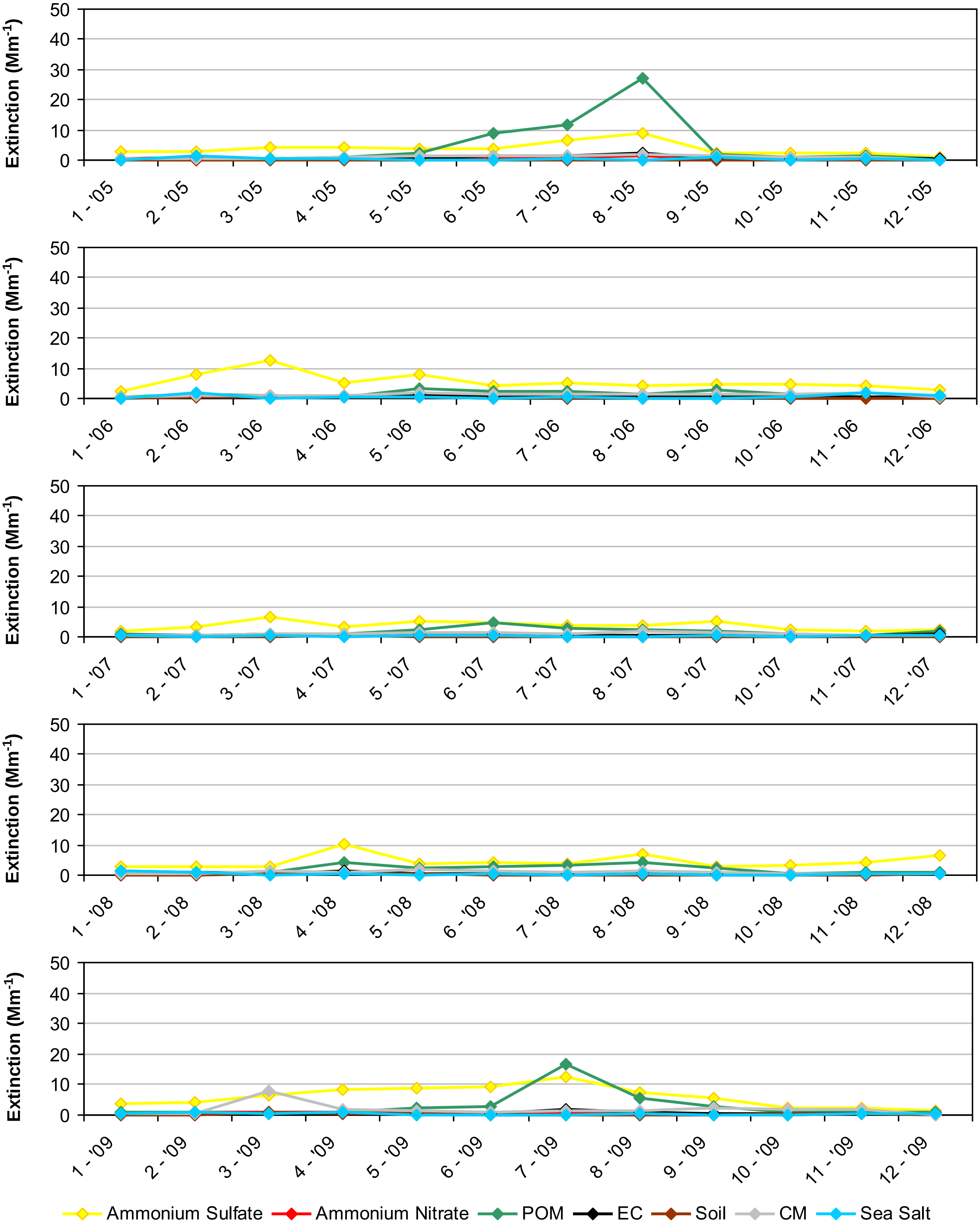
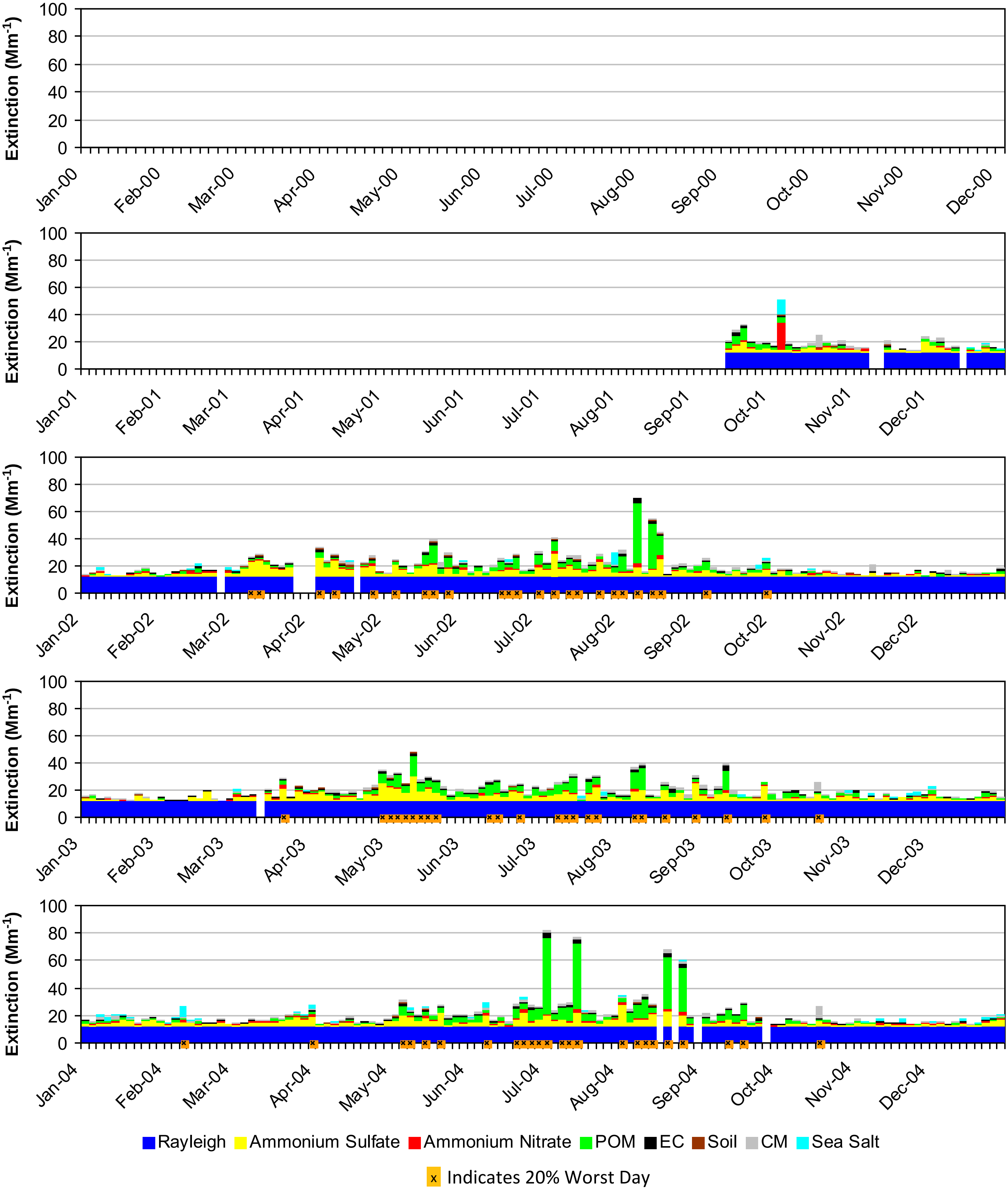
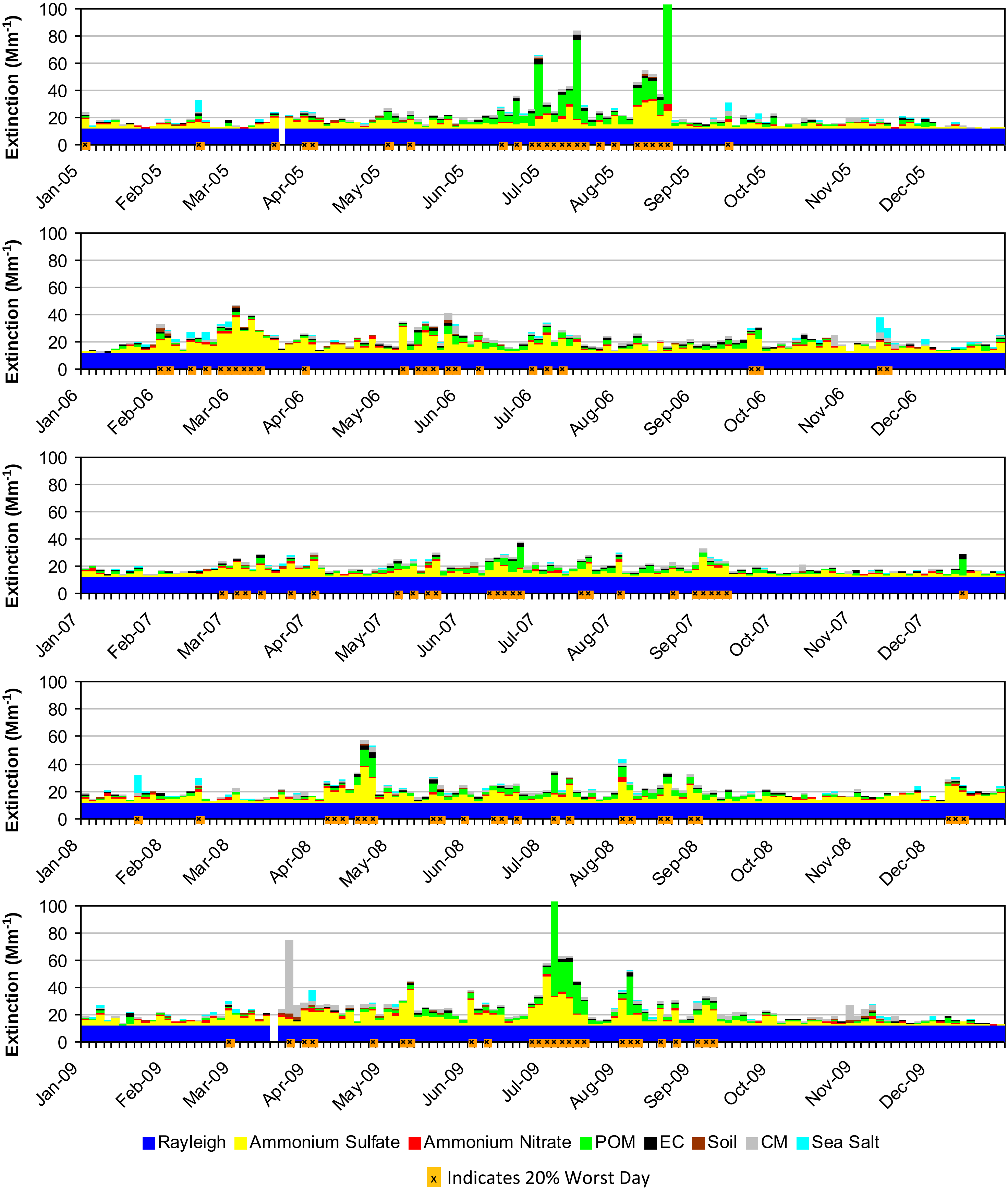


Figure A.3-7
Trapper Creek, AK (TRCR1 Site)
2000-2004 Progress Period Extinction, All Sampled Days



*Note that daily averages for the years 2000 and 2001 are shown here, but these years did not meet RHR data completeness criteria.

Figure A.3-8
Trapper Creek, AK (TRCR1 Site)
2005-2009 Progress Period Extinction, All Sampled Days



A.4. TUXEDNI WA (TUXE1)

The following tables and figures are presented in this section for the Tuxedni Wilderness Area represented by the TUXE1 IMPROVE Monitor:

- **Table A.4-1: Annual Averages, 5-Year Period Averages, and Trends:** Table of averages and other metrics for the 20% least impaired days, the 20% most impaired days, and all sampled days is presented.

- **Figure A.4-1: Annual and 5-Year Period Averages for the 20% Most Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.

- **Figure A.4-2: Annual and 5-Year Period Averages for the 20% Least Impaired Visibility Days:** Line graphs depicting annual and period averages by component are presented.

- **Figure A.4-3: 20% Most Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component for the 20% most impaired days are presented.

- **Figure A.4-4: 20% Least Impaired Visibility Days:** Pie charts depicting period averages and stacked bar charts depicting annual averages by component are presented.

- **Figure A.4-5: 2000-2004 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the baseline period are presented.

- **Figure A.4-6: 2005-2009 Monthly Average Aerosol Extinction, All Monitored Days:** Line graphs depicting monthly averages by year and component for the progress period are presented.

- **Figure A.4-7: 2000-2004 Progress Period Extinction, All Sampled Days:** Stacked bar charts depicting daily averages by year and component for the baseline period are presented.

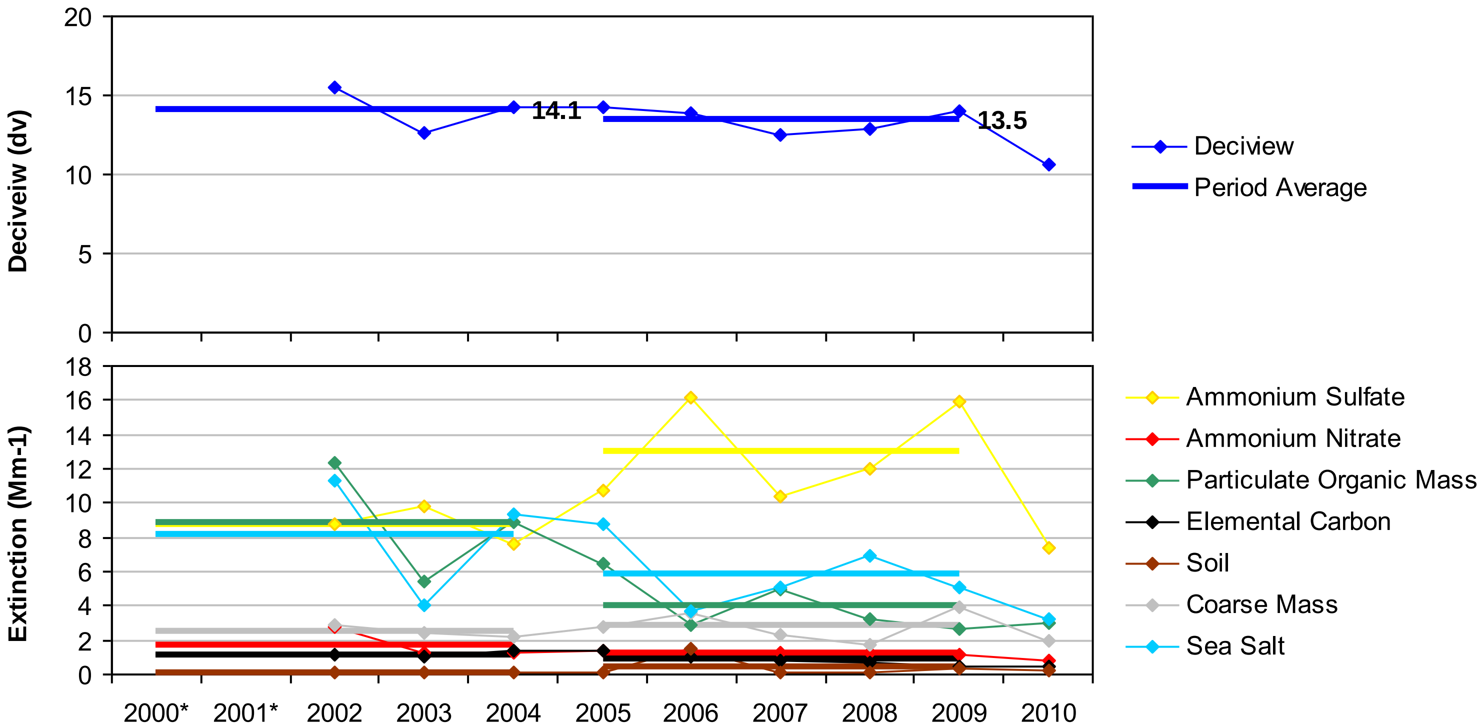
- **Figure A.4-8: 2000-2004 Progress Period Extinction, All Sampled Days**: Stacked bar charts depicting daily averages by year and component for the progress period are presented.

Table A.4-1
Tuxedni WA, AK (TUXE1 Site)
Annual Averages, 5-Year Period Averages and Trends

Group	Baseline Period					Progress Period						2000-2009 Trend Statistics*		Period Averages**			
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Slope (change/yr.)	p-value	Baseline (B)	Progress (P)	Difference (P -B)	Percent Change
Deciview (dv)																	
Best 20% Days	---	---	4.2	3.8	4.0	3.9	4.4	3.6	4.1	4.3	3.8	0.0	0.4	4.0	4.1	0.1	3%
Worst 20% Days	---	---	15.5	12.6	14.2	14.2	13.9	12.6	12.9	14.0	10.6	-0.2	0.1	14.1	13.5	-0.6	-4%
All Days	---	---	8.8	7.6	8.4	8.2	8.6	7.6	7.8	8.7	7.0	0.0	0.5	8.3	8.2	-0.1	-1%
Total Extinction (Mm-1)																	
Best 20% Days	---	---	15.3	14.6	14.9	14.8	15.6	14.4	15.1	15.5	14.6	0.1	0.4	14.9	15.1	0.2	1%
Worst 20% Days	---	---	51.3	36.2	42.9	43.5	42.1	37.0	38.1	41.5	29.1	-0.8	0.2	43.5	40.4	-3.1	-7%
All Days	---	---	27.0	22.7	25.0	24.7	25.4	22.8	23.2	25.6	20.8	-0.1	0.6	24.9	24.3	-0.6	-2%
Ammonium Sulfate Extinction (Mm-1)																	
Best 20% Days	---	---	1.1	1.0	1.1	1.2	1.4	1.1	1.4	1.7	1.4	0.1	0.0	1.1	1.4	0.3	27%
Worst 20% Days	---	---	8.7	9.8	7.7	10.7	16.2	10.3	12.0	15.9	7.4	1.0	0.0	8.7	13.0	4.3	49%
All Days	---	---	4.7	4.4	3.8	5.0	6.9	4.8	5.5	7.1	4.2	0.3	0.0	4.3	5.9	1.6	37%
Ammonium Nitrate Extinction (Mm-1)																	
Best 20% Days	---	---	0.3	0.4	0.4	0.3	0.3	0.2	0.2	0.3	0.2	0.0	0.0	0.4	0.3	-0.1	-25%
Worst 20% Days	---	---	2.7	1.3	1.3	1.4	1.3	1.3	1.3	1.1	0.8	0.0	0.0	1.8	1.3	-0.5	-28%
All Days	---	---	1.2	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.5	0.0	0.0	0.9	0.7	-0.2	-22%
Particulate Organic Mass Extinction (Mm-1)																	
Best 20% Days	---	---	0.5	0.3	0.3	0.3	0.4	0.2	0.3	0.1	0.1	0.0	0.0	0.4	0.3	-0.1	-25%
Worst 20% Days	---	---	12.3	5.5	8.8	6.5	2.9	4.9	3.3	2.6	3.0	-1.2	0.0	8.9	4.0	-4.9	-55%
All Days	---	---	3.8	2.2	3.2	2.2	1.2	1.5	1.2	1.1	1.1	-0.3	0.0	3.0	1.5	-1.5	-50%
Elemental Carbon Extinction (Mm-1)																	
Best 20% Days	---	---	0.1	0.2	0.3	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.2	0.1	-0.1	-50%
Worst 20% Days	---	---	1.1	1.0	1.4	1.4	1.0	0.9	0.6	0.5	0.4	-0.1	0.0	1.2	0.9	-0.3	-25%
All Days	---	---	0.7	0.5	0.8	0.6	0.5	0.3	0.3	0.3	0.2	-0.1	0.0	0.7	0.4	-0.3	-43%
Soil Extinction (Mm-1)																	
Best 20% Days	---	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0%
Worst 20% Days	---	---	0.2	0.1	0.1	0.1	1.5	0.2	0.2	0.3	0.2	0.0	0.3	0.1	0.4	0.3	>100%
All Days	---	---	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.1	0.0	0.4	0.1	0.2	0.1	100%
Coarse Mass Extinction (Mm-1)																	
Best 20% Days	---	---	0.4	0.3	0.3	0.4	0.6	0.3	0.4	0.5	0.3	0.0	0.2	0.3	0.5	0.2	67%
Worst 20% Days	---	---	2.9	2.4	2.2	2.8	3.6	2.3	1.7	3.9	1.9	0.0	0.6	2.5	2.9	0.4	16%
All Days	---	---	1.3	1.3	1.1	1.3	1.6	1.1	0.9	1.9	0.9	0.0	0.5	1.2	1.4	0.2	17%
Sea Salt Extinction (Mm-1)																	
Best 20% Days	---	---	0.7	0.4	0.5	0.5	0.7	0.5	0.7	0.8	0.5	0.0	0.2	0.5	0.6	0.1	20%
Worst 20% Days	---	---	11.3	4.0	9.4	8.7	3.7	5.1	7.0	5.1	3.3	-0.7	0.2	8.2	5.9	-2.3	-28%
All Days	---	---	3.3	1.5	3.2	2.7	2.1	2.2	2.5	2.4	1.6	-0.1	0.3	2.7	2.4	-0.3	-11%

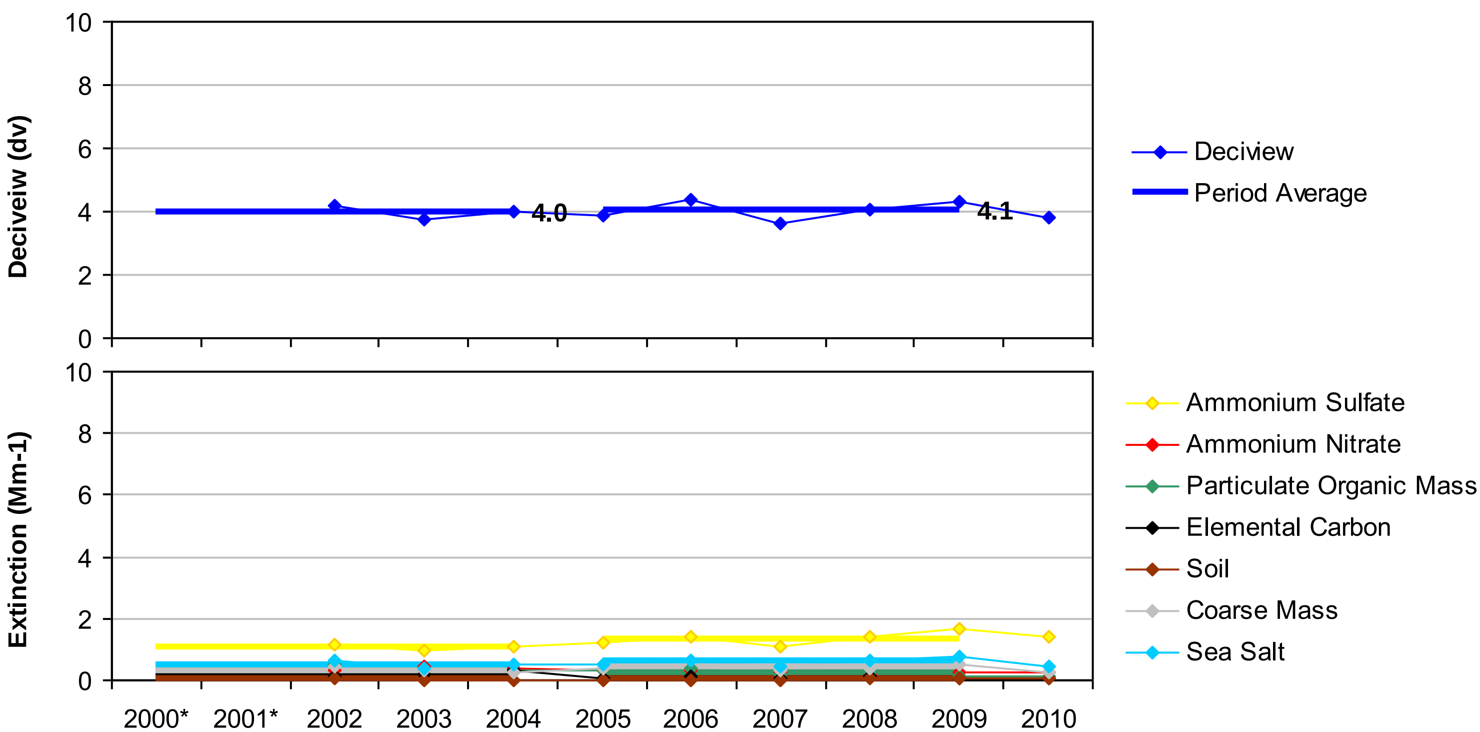
*Values highlighted in blue (red) indicate statistically significant decreasing (increasing) annual trend. Significance is measured at the 85% confidence level (p-value ≤0.15).
**Values highlighted in blue indicate a decrease in the 5-year average, values highlighted in red indicate an increase.
"---" Indicates a missing year that did not meet RHR data completeness criteria.

Figure A.4-1
Tuxedni WA, AK (TUXE1 Site)
Annual and 5-Year Period Averages
20% Most Impaired Visibility Days



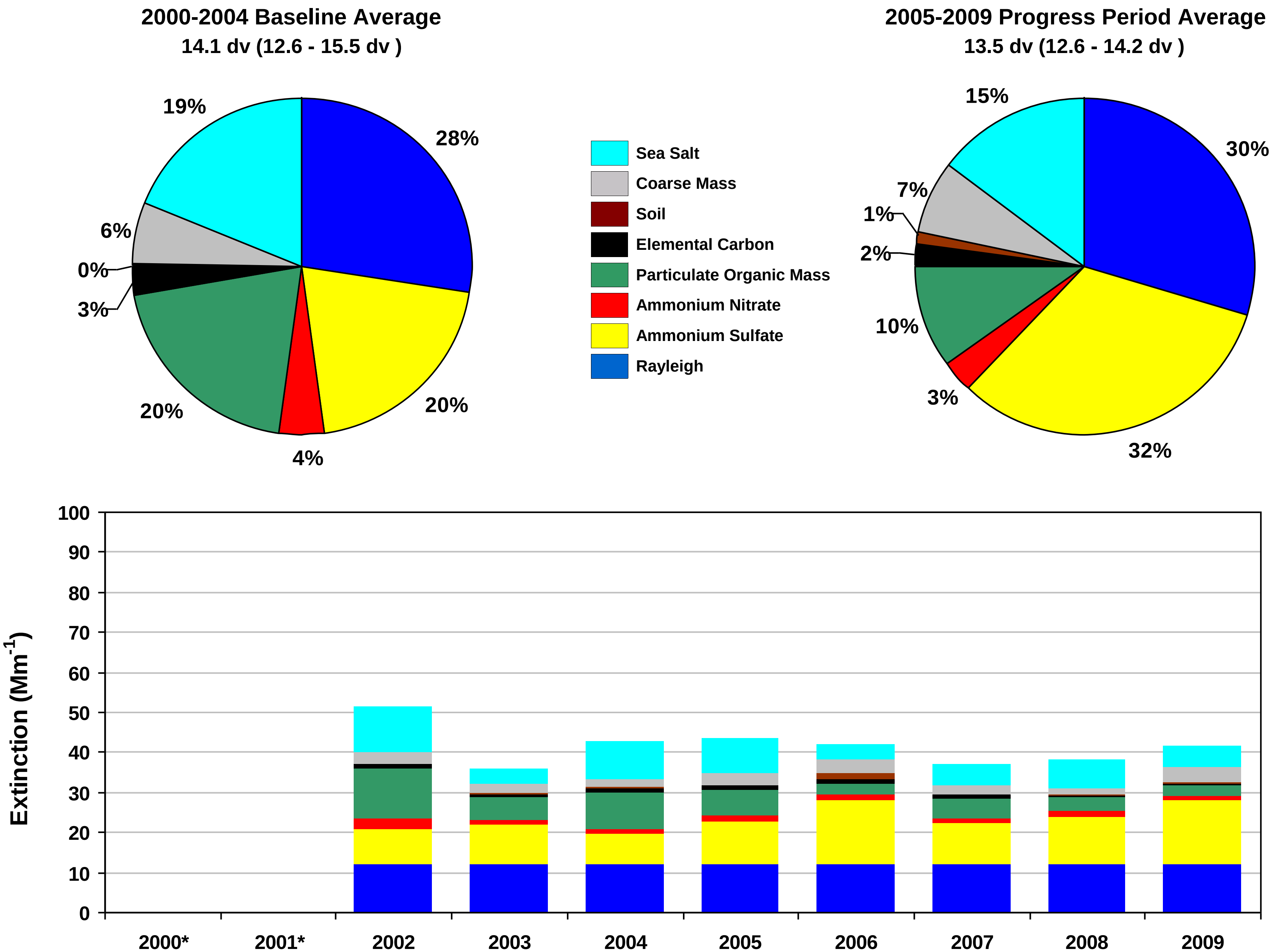
*Missing years did not meet RHR data completeness criteria.

Figure A.4-2
Tuxedni WA, AK (TUXE1 Site)
Annual and 5-Year Period Averages
20% Least Impaired Visibility Days



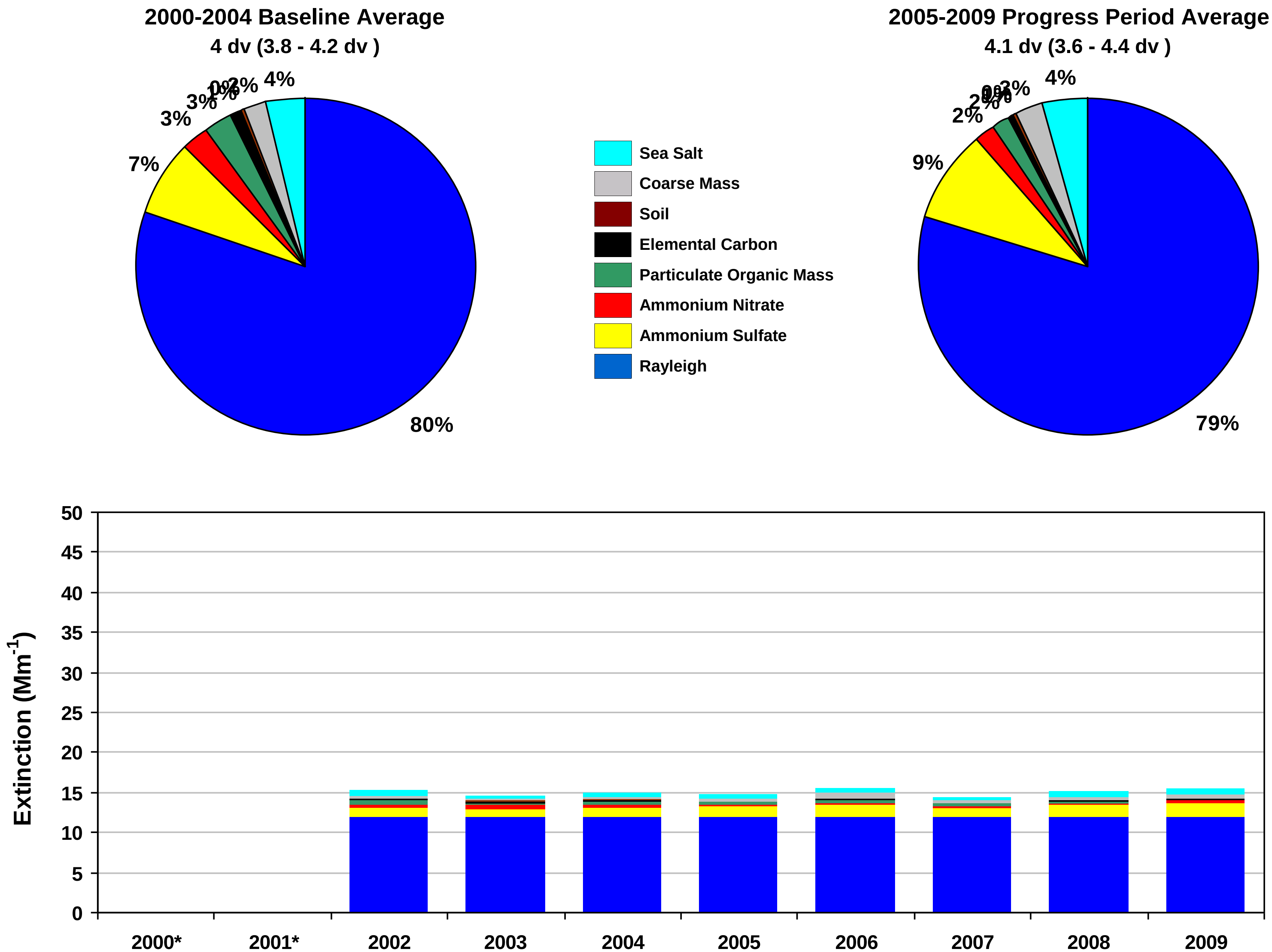
*Missing years did not meet RHR data completeness criteria.

Figure A.4-3
Tuxedni WA, AK (TUXE1 Site)
20% Most Impaired Visibility Days



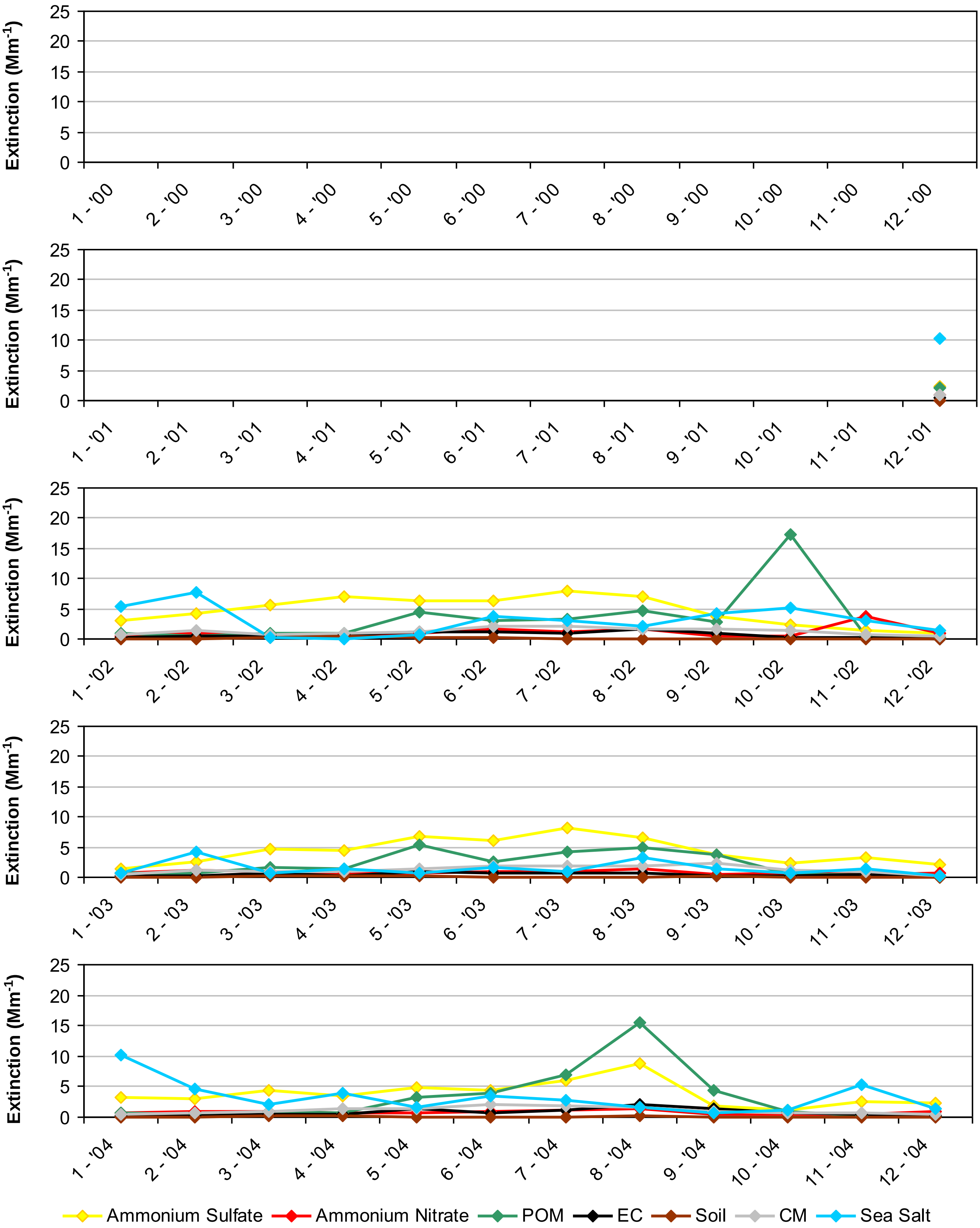
*Missing years did not meet RHR data completeness criteria. Only complete years are included in 5-year average pie charts.

Figure A.4-4
Tuxedni WA, AK (TUXE1 Site)
20% Least Impaired Visibility Days



*Missing years did not meet RHR data completeness criteria. Only complete years are included in 5-year average pie charts.

Figure A.4-5
Tuxedni WA, AK (TUXE1 Site)
2000-2004 Monthly Average Aerosol Extinction, All Monitored Days



*Note that monthly averages for the years 2000 and 2001 are shown here, but these years did not meet RHR data completeness criteria.

Figure A.4-6
Tuxedni WA, AK (TUXE1 Site)
2005-2009 Monthly Average Aerosol Extinction, All Monitored Days

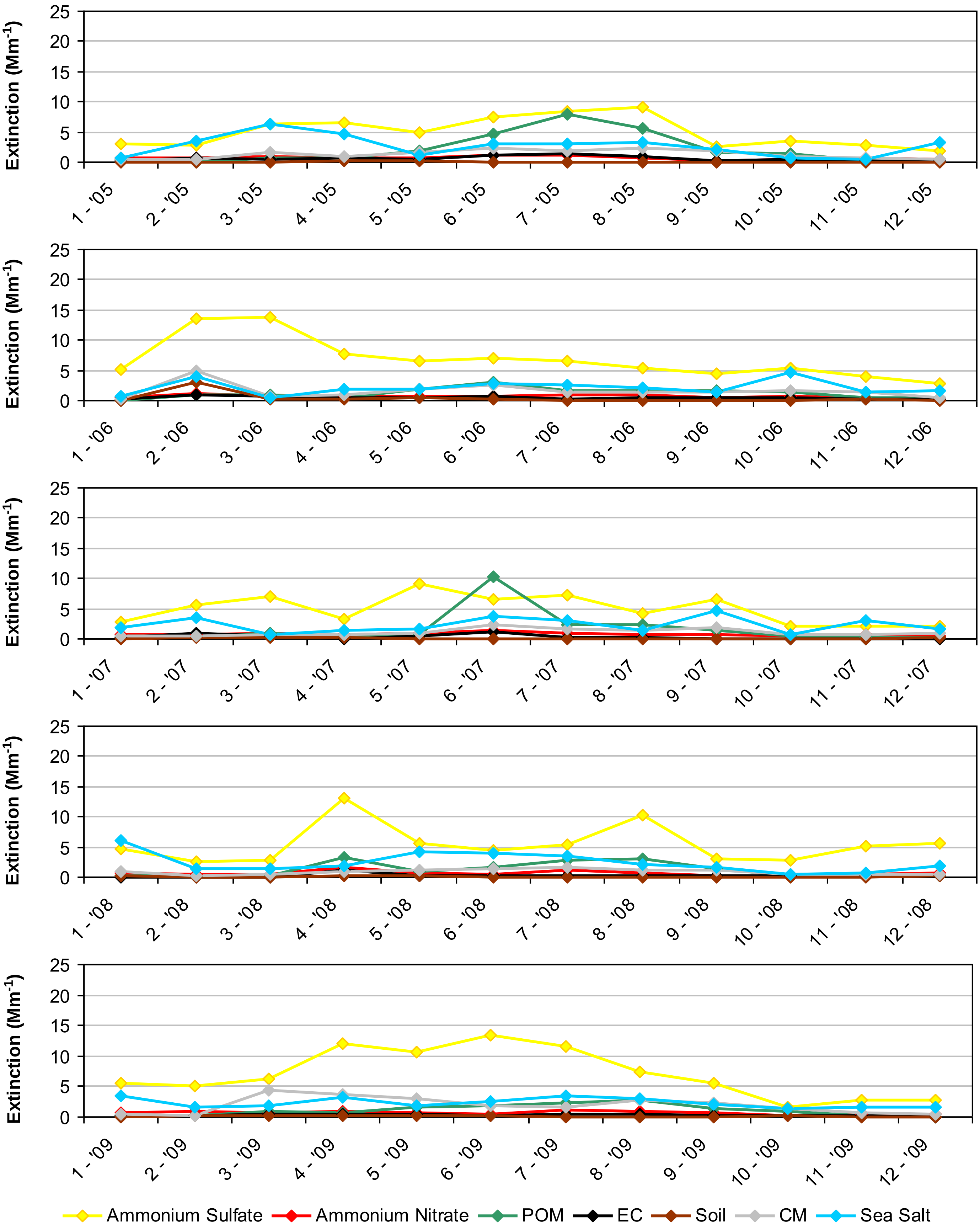
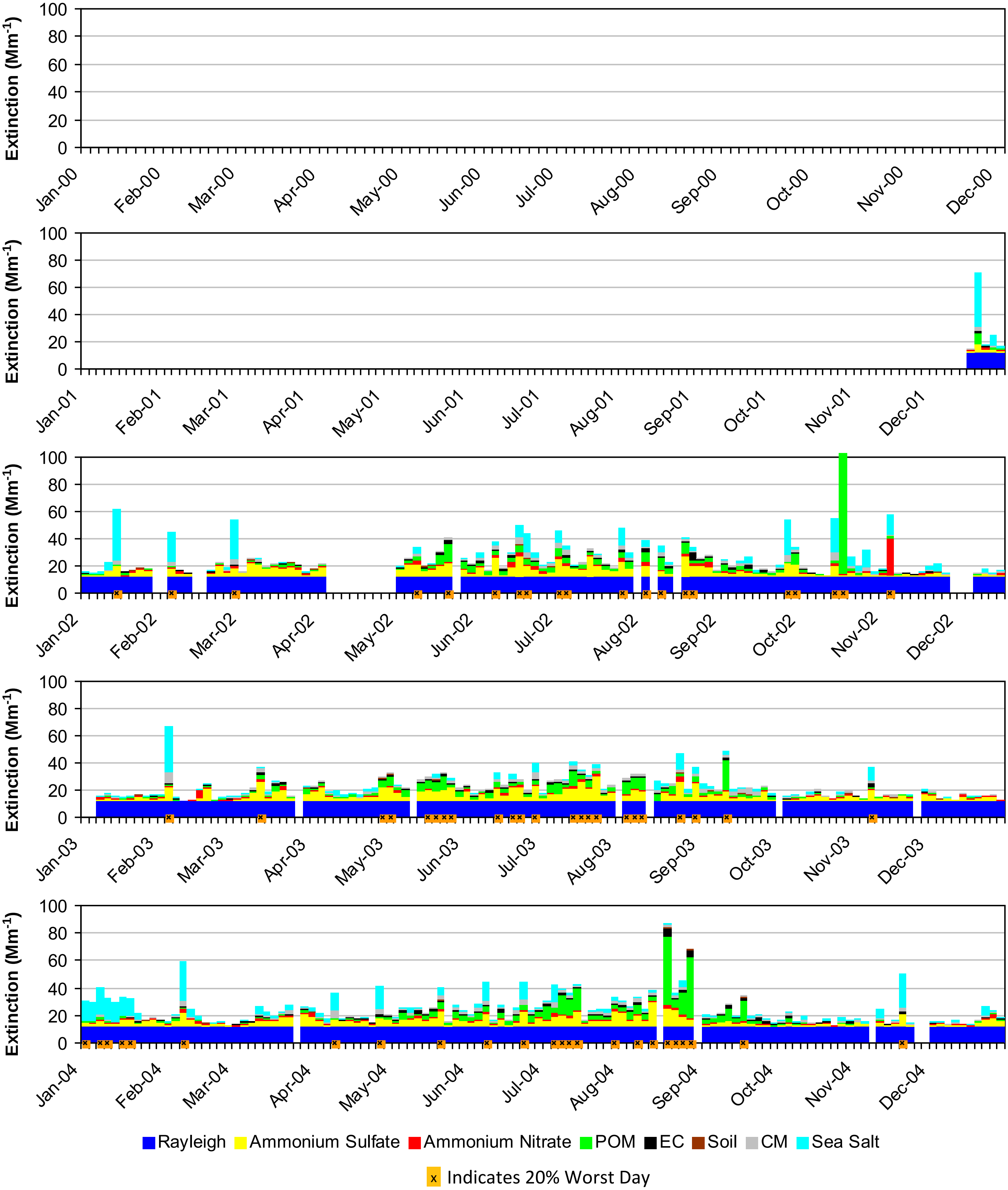


Figure A.4-7
Tuxedni WA, AK (TUXE1 Site)
2000-2004 Progress Period Extinction, All Sampled Days



*Note that daily averages for the years 2000 and 2001 are shown here, but these years did not meet RHR data completeness criteria.

Figure A.4-8
Tuxedni WA, AK (TUXE1 Site)
2005-2009 Progress Period Extinction, All Sampled Days