Chapter One – Overview

1.1 NEVADA'S CLASS I AREA – JARBIDGE WILDERNESS AREA

1.1.1 Geographic and Physiographic Setting
1.1.2 Visibility Impairment
1.1.3 Observed Haze Events
1.1.3.1 Windblown Dust Events
1.1.3.2 Natural Fire Events

1.2 THE WESTERN REGIONAL AIR PARTNERSHIP AND NEVADA

1.3 TECHNICAL SUPPORT BACKGROUND

1.3.1 Regional Haze Monitoring Network
1.3.1.1 Overview of the IMPROVE Monitoring Network
1.3.1.2 IMPROVE Monitor JARB1
1.3.2 Emissions Analyses and Projections
1.3.2.1 Preparation of Baseline Emissions Inventories
1.3.2.2 Projected 2018 Emissions Inventories
1.3.2.3 WRAP's Technical Support System
1.3.3 Air Quality Modeling
1.3.3.1 Visibility Modeling
1.3.3.2 Source Apportionment Modeling

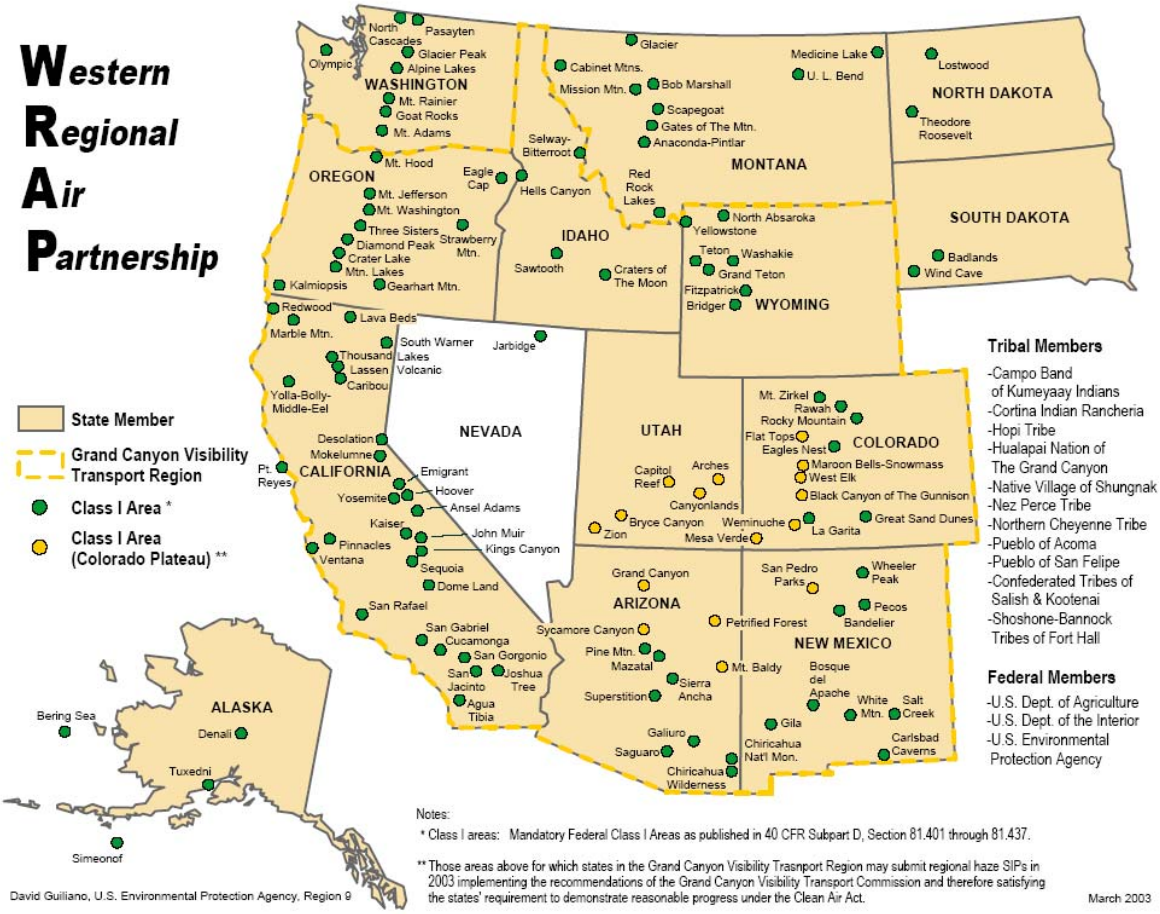
1.4 REFERENCES

1.1 NEVADA'S CLASS I AREA – JARBIDGE WILDERNESS AREA

Nevada has one mandatory Class I Area, the 113,167 acre Jarbidge Wilderness Area (Jarbidge WA), located within the Humboldt National Forest in the northeastern portion of Nevada, as shown on Figure 1-1.

FIGURE 1-1

LOCATION MAP SHOWING MANDATORY CLASS I AREAS
IN THE WRAP REGION



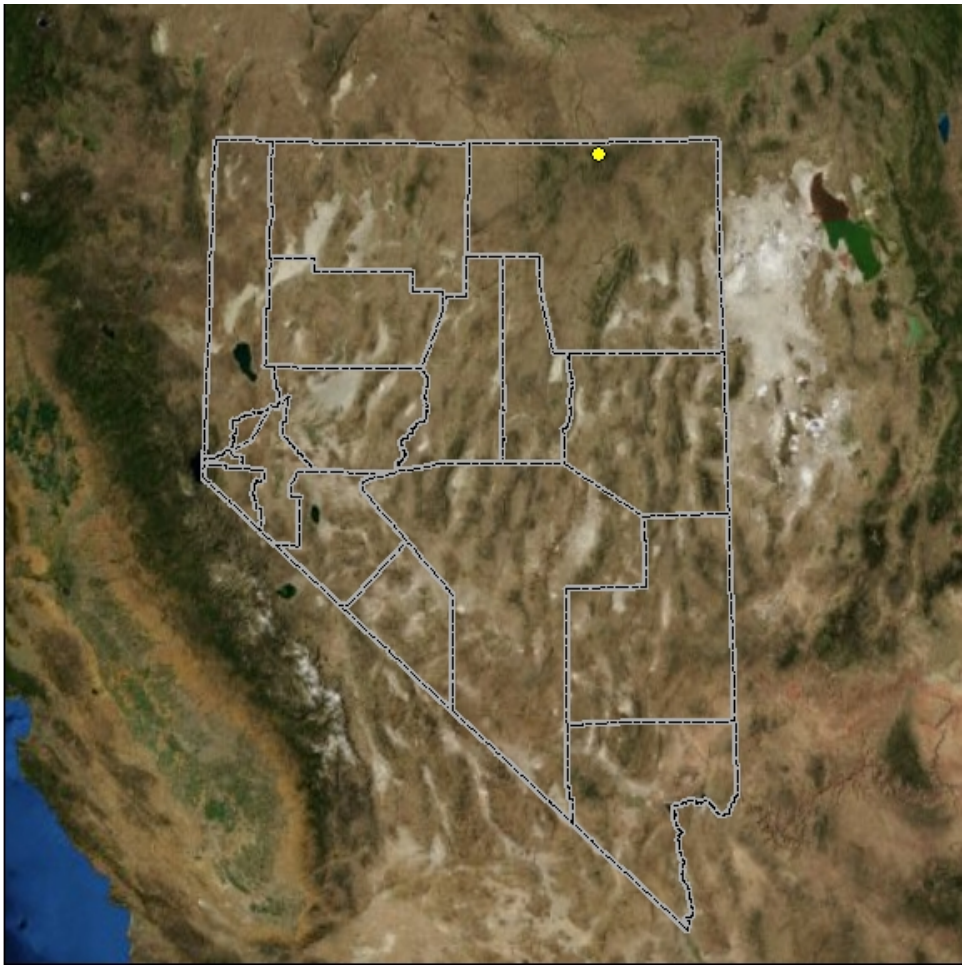
1.1.1 Geographic and Physiographic Setting

Much of the following discussion regarding the physiographic and geologic setting of Nevada is paraphrased from Stewart (1980). Nevada lies almost entirely within the Great Basin portion of the Basin and Range physiographic province. The Basin and Range is characterized by a series of generally north-trending mountain ranges separated by alluvial valleys as shown on Figure 1-2. A small portion along the western part of the state lies within the mountainous Sierra Nevada

province, and an area of moderate elevation and low relief along the northern border of the state is part of the Owyhee Upland adjacent to the Snake River Plain of Idaho.

FIGURE 1-2

LOCATION MAP OF NEVADA AND PORTIONS OF ADJACENT STATES



The mountain ranges in Nevada are generally 5 to 15 miles wide and rise 1,000 to 5,000 feet above the adjoining valleys, which are about as wide as the mountain ranges. The mountain ranges are typically elongate with many extending more than 50 miles in a north or north-east direction. The Basin and Range topography is the result of extension block faulting and the basins have trapped continental sediments derived from the adjacent highlands.

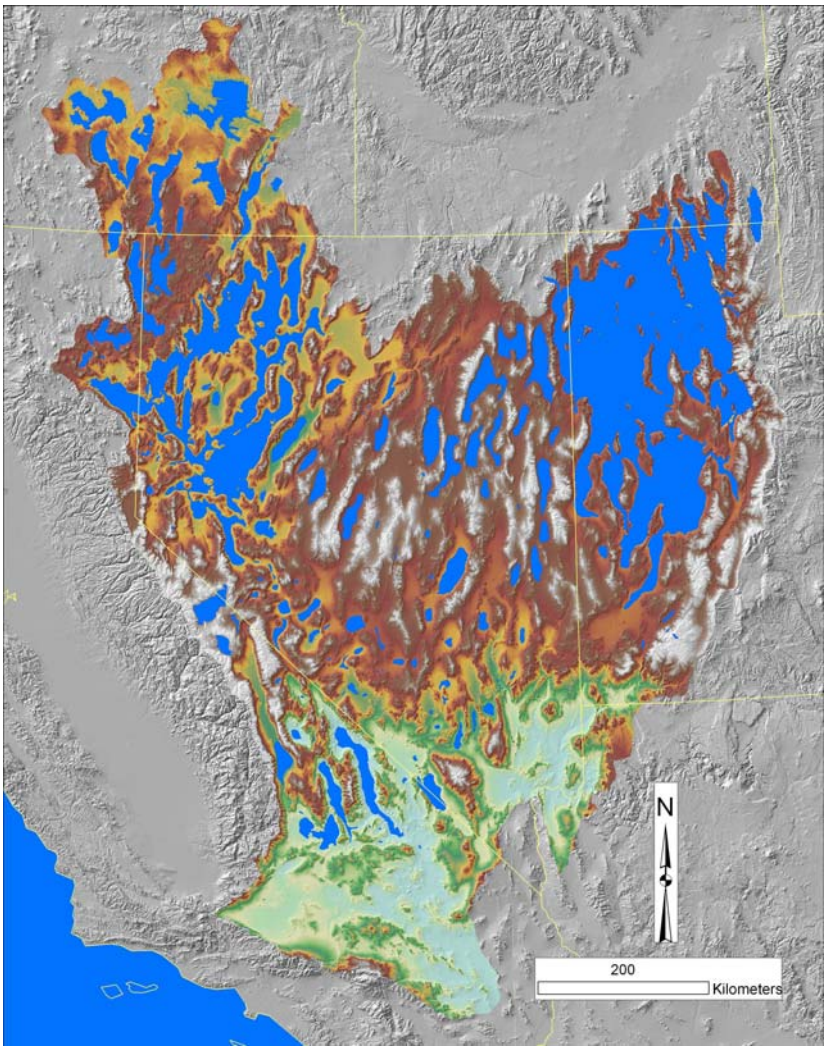
Much of Nevada is an area of internal drainage. The largest river within the Great Basin, the Humboldt, heads in the northeastern part of the state, traverses westward and then southward to terminate in the Humboldt and Carson Sinks in the western part of the state. Many of the basins in Nevada are floored by flat mud-surfaced playas that are flooded by runoff from the mountains during times of high precipitation. Playas are shown on Figure 1-2 by the whitish areas in the western and southern portions of the state.

Most of the unconsolidated sedimentary material less than six million years old forms widespread alluvial fan, stream terrace, flood plain, valley flat and playa deposits. These units grade from coarse gravel near the mountains or ranges to fine silt and clay in the valley and on the playas. Other sedimentary material in this age span forms landslide, morainal, lacustrine, shoreline and eolian (i.e., carried, deposited or eroded by the wind) sand dune deposits.

During the Pleistocene, large inland lakes occupied many of the present day broad valleys of Nevada as shown on Figure 1-3 by the blue tint. Most of the playa deposits of Nevada represent part of the little-modified bottom sediments of these lakes. Wave-cut terraces and sand and gravel beach and bar deposits occur along what were the shores of these lakes. The sandy lake margin deposits provided sand for many of the dune areas of the state.

FIGURE 1-3

EXTENT OF PLEISTOCENE LAKES IN THE GREAT BASIN



Map from Ken Adams, Desert Research Institute, 2008

The Snake River Plain, a section of the Columbia Plateau, follows the Snake River across Idaho, stretching roughly 400 miles from the Wyoming border to eastern Oregon (see Figure 1-4). The Snake River Plain is characterized by plains and low hills considerably lower and less rugged than surrounding physiographic regions. Agriculture is the main land use of the Snake River Plain, with irrigated croplands, widespread livestock grazing and locally important feedlot and dairy operations. Note the proximity of this vast agricultural area to the Jarbidge WA, shown by the yellow symbol in Figure 1-2.

FIGURE 1-4

LOCATION MAP OF SNAKE RIVER PLAIN

The following discussion of Nevada's climate is paraphrased from NOAA (1985). Nevada's principal climatic features are bright sunshine, small annual precipitation, (averaging nine inches in the valleys and deserts) heavy snowfall in the higher mountains, clean, dry air, and exceptionally large daily ranges of temperature Wide local variations of temperature and rainfall are common. The average annual number of days with precipitation of 0.01 inch or more varies considerably; Las Vegas averages 23, Reno 49, Winnemucca 67, Ely 72 and Elko 78.

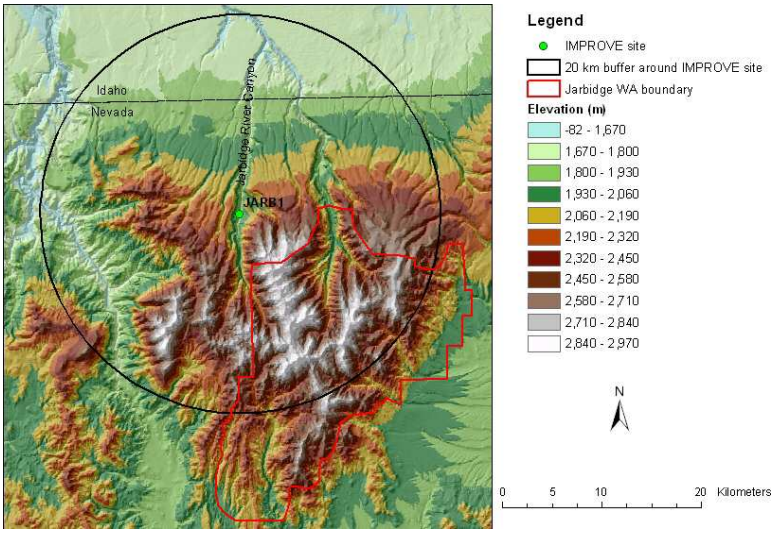
Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that markedly influences the climate of the state. The prevailing winds are from the west, and as the warm moist air from the Pacific Ocean ascends the western slopes of the Sierra Range, the air cools, condensation takes place and most of the moisture falls as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The effects of this mountain barrier are felt not only in the west but throughout the state, with the result that the lowlands of Nevada are largely desert or steppes.

Jarbidge WA lies near the Idaho border just north of the physical geographic boundary separating the Columbia Plateau region, including the Snake River Plain, and the Great Basin region to the south. It consists of the headwaters basin of the Jarbidge River East Fork that flows north from the center of the wilderness area, and the headwaters basin of Marys River that flows south from the center of the wilderness area, part of the Columbia River/Great Basin hydrographic divide. The terrain encompassed by the wilderness area consists of deep canyons with steep slopes. The Jarbidge River Canyon, which comprises the upper main headwaters of the Jarbidge River proper, is oriented south to north, with its mouth several miles to the north where it drains into the Bruneau River.

The area illustrates Nevada's typical basin and range topography (see Figure 1-5) with elevations ranging from 2,100 m (6,900 ft) where the Jarbidge River East Fork exits the wilderness into Idaho's Snake River Plains to eight peaks over 3,000 m (~10,000 ft) high along the Jarbidge Mountain crest, which includes the highest peak, Marys River Peak at 3,170 m (10,398 ft). The varied terrain is cut by deep canyons with steep slopes and supports a range of vegetation zones from sagebrush flats to glaciated alpine basins.

FIGURE 1-5

JARBIDGE WILDERNESS AREA AND VICINITY



1.1.2 Visibility Impairment

Regional haze is pollution from disparate sources that impairs visibility over a large region, including national parks, forests and wilderness areas. Of all the federal Class I areas, visibility was determined to be an important value at 156. These 156 mandatory class I areas are the subject of the Regional Haze Rule (RHR). Regional haze is caused by sources and activities emitting fine particles and their precursors. Those emissions are often transported over large regions. Particles affect visibility through the scattering and absorption of light, and fine particles – particles similar in size to the wavelength of light – are most efficient, per unit of mass, at reducing visibility. Fine particles may either be emitted directly or formed from

emissions of precursors, the most important of which are sulfur dioxide (SO_2) and nitrogen oxides (NO_x). Reducing fine particles in the atmosphere is generally considered to be an effective method of reducing regional haze, and thus improving visibility. It is also generally considered that fine particles also adversely impact human health, especially respiratory and cardiovascular systems.

Most visibility impairment occurs when pollution in the form of small particles scatter or absorb light. Air pollutants come from a variety of natural and anthropogenic sources. Natural sources include windblown dust and smoke from wildfires. Anthropogenic sources include motor vehicles, electric utility and industrial fuel burning, and manufacturing operations. Higher concentrations of pollutants result in more absorption and scattering of light, which reduce the clarity and color of a scene. Some types of particles, such as sulfates, are more effective at scattering light, particularly during humid conditions. Other particles like elemental carbon from combustion processes are highly efficient at absorbing light. Commonly, the receptor is the human eye and the object may be a single viewing target or a scene.

In the 156 mandatory Class I areas across the country, visual range has been substantially reduced by air pollution. In the West, visual range has decreased from an average of 140 miles to 35-90 miles. Much of the visibility impairment in the West can be attributed to natural emissions of smoke and dust with significant contributions resulting from international emissions from beyond the boundaries of the United States, including Canada and Mexico.

Some haze-causing particles are directly emitted to the air. Others are formed when gases emitted to the air form particles as they are carried many miles from the source of the pollutants. Some haze forming pollutants are also linked to human health problems and other environmental damage. In addition, particles such as nitrates and sulfates contribute to acid deposition potentially making lakes, rivers and streams unsuitable for some forms of aquatic life and impacting flora in the ecosystem. These same acid particles can also erode materials such as paint, buildings or other natural and manmade structures.

1.1.3 Observed Haze Events

Nevada regularly experiences regional haze events due to natural emissions of smoke and dust. The Nevada Division of Environmental Protection (NDEP) staff has witnessed numerous haze events due to fire and wind. The text below provides some anecdotal evidence and images of the significance of these haze events.

1.1.3.1 Windblown Dust Events

Observed windblown dust events occur during at least two different meteorological conditions: unstable, well-mixed atmosphere with high winds; and unstable, highly-convective atmosphere with very low winds. Examples are provided below.

Both of these windblown dust events occurred in the vicinity of Mill City, Nevada in Humboldt County along the Humboldt River. Mill City is roughly mid-way between Lovelock and Winnemucca on I-80, or approximately 30 miles southwest of Winnemucca. The upper image of

Figure 1-6 (looking northeast) shows a large plume of dust originating at the surface with a truck stop in the near background, while the lower image shows the plume mixing higher into the atmosphere. This truck stop is shown near the lower center of Figure 1-7 (i.e., adjacent to the Highway 95 marker shown on the image). Note the textured area extending to the north and west of the highway across the Humboldt River valley. This is an area of active to semi-active sand dunes demonstrating eolian transport of sediments parallel to the highway and is the source of the windblown dust shown in the figure. Figure 1-6 was taken on August 8, 2008 in the early evening.

FIGURE 1-6

AUGUST 2008 DUST EVENT NEAR MILL CITY, NEVADA

FIGURE 1-7

SOURCE AREA FOR OBSERVED DUST EVENT

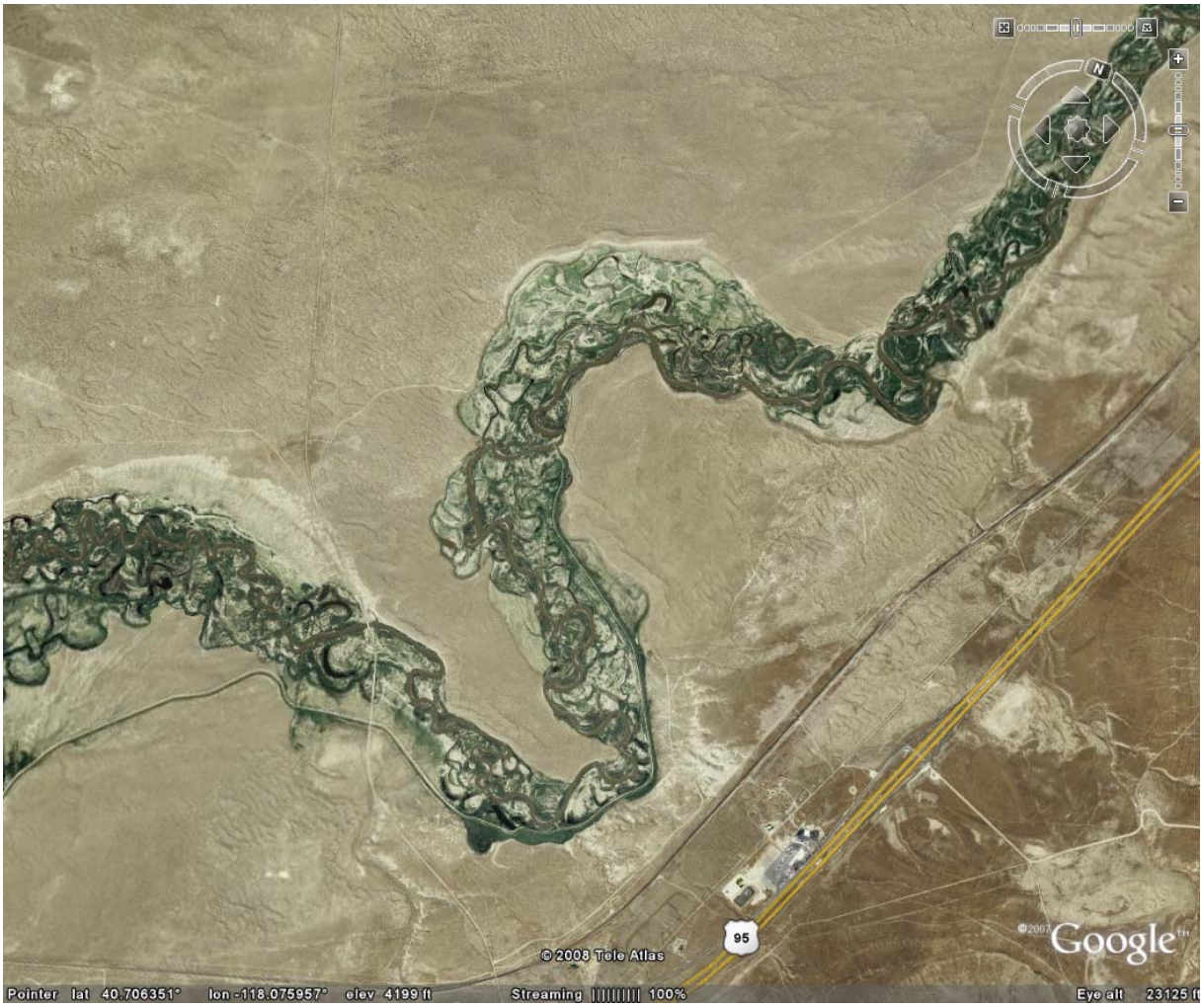


Figure 1-8 looks west and was taken midday August 17, 2008. This image shows a group of dust devils originating from an area of sand dunes adjacent to the Humboldt River approximately 10 miles north of the truck stop shown in the previous figure. The larger of these dust devils appears to be transporting dust some distance into the atmosphere. The relative significance of the contributions from this type of event to visibility impairment is not well documented or understood.

The dune fields supplying material to these two dust events are an extensive mosaic of active, semi-active and stabilized sand dunes extending much of the distance between Lovelock and Winnemucca along the sandy margins of a large Pleistocene inland lake (see Figure 1-3).

FIGURE 1-8

AUGUST 2008 CONVECTIVE DUST EVENT NEAR MILL CITY, NEVADA

In addition to the dust events described above, NDEP staff also observed a regional dust event while driving from Twin Falls, Idaho to Wells, Nevada on the morning of May 28, 2007. During this event strong northwest winds across the Snake River Plain resulted in regional transport of particulate matter, possibly from local sources as well as the Bureau Dune Field (Smith, 1982), located approximately 80 miles north of the Jarbidge WA near Mountain Home, Idaho. As the winds picked up during the morning, visibility progressively and noticeably deteriorated over the Jarbidge Mountains and the area of the Jarbidge WA visible from Highway 93 until the mountains were no longer visible. The distance from the highway to the Jarbidge WA is approximately 35 miles.

These anecdotal examples of dust events suggest the importance of natural emissions contributions to visibility impairment in the West.

1.1.3.2 Natural Fire Events

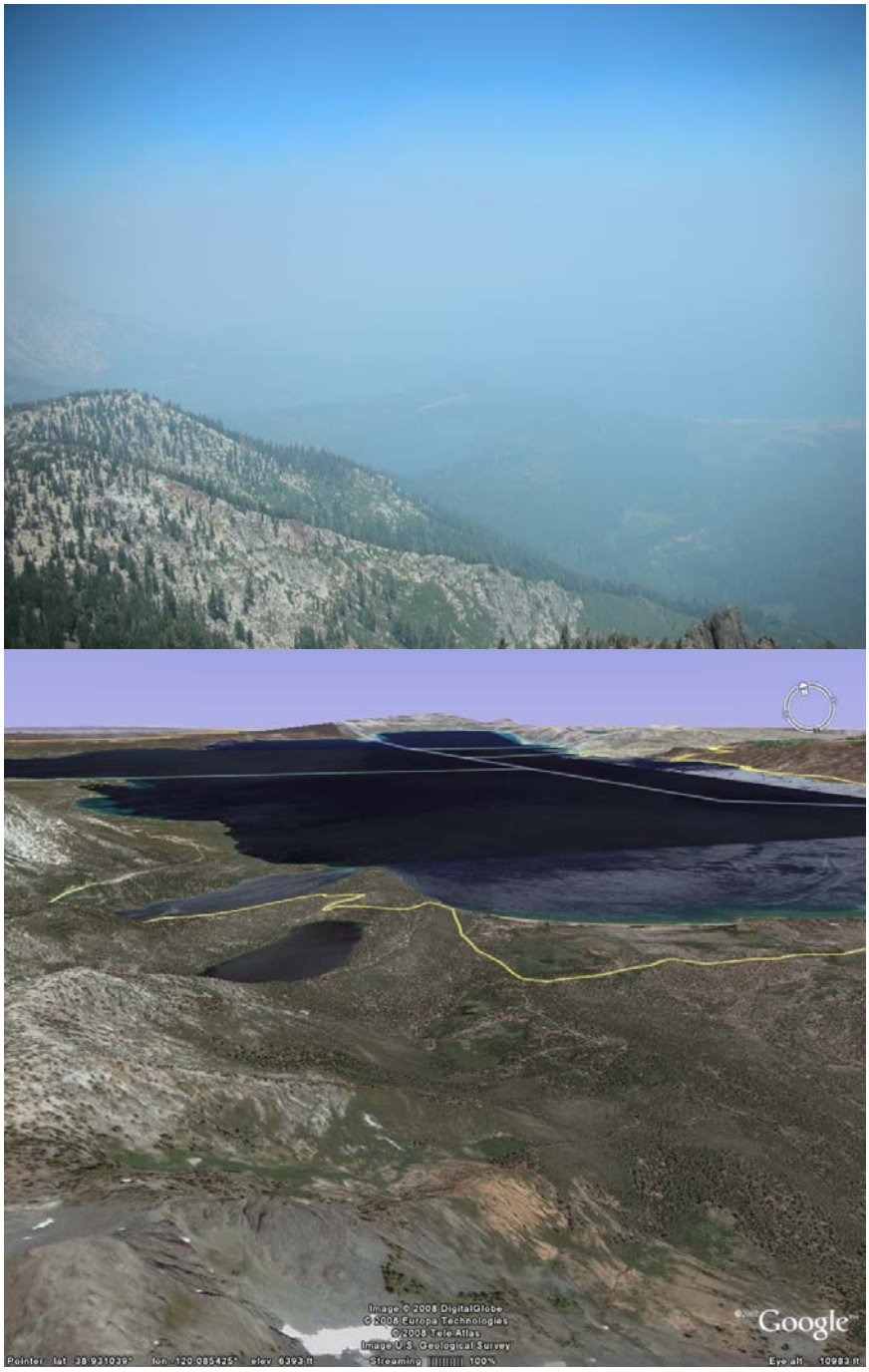
Emissions from natural fire events are common contributors to visibility impairment at Class I areas throughout the West. The summer of 2008 was a particularly bad fire year in northern California, when lightning storms started numerous fires in early summer. The upper image on Figure 1-9 is a smoke-obscured view of Lake Tahoe from Mount Tallac, located within the Desolation Wilderness Area just over four miles from the mouth of Emerald Bay and

approximately 6 miles from the BLIS1 Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor representing the Desolation Wilderness Area.

The lower image presents a similar view of Lake Tahoe from Mount Tallac created using Google Earth technology. Note the top of Mount Tallac in the lower left corner, the location of Cascade Lake in the near foreground, with Lake Tahoe and Emerald Bay in the mid-background. The BLIS1 monitor is located approximately two miles north of Emerald Bay near the shore of Lake Tahoe. The image was captured midday July 27, 2008, one of many smoke-obscured days experienced during the summer of 2008 on the east slope of the Sierra due to California wildfires. This haze event was attributed to wild fires near Yosemite National Park approximately 100 miles to the south southeast.

FIGURE 1-9

OBSERVED JULY 2008 LAKE TAHOE SMOKE EVENT



A similarly intense smoke event was also observed near the Nevada/Utah border while driving west between Delta, Utah and Ely, Nevada on Highway 50 in the vicinity of Great Basin National Park. While approaching the Nevada border from the east on September 17, 2007, the Snake Range, approximately 30 miles distant, was partially obscured by smoke as shown by the

upper image in Figure 1-10, which was taken from inside a vehicle. The lower image was recreated using Google Earth technology. The highest point visible in the lower image is Wheeler Peak, which is barely visible in the upper image.

FIGURE 1-10

SEPTEMBER 2007 REGIONAL SMOKE EVENT EASTERN NEVADA

At Sacramento Pass, where Highway 50 crosses the Snake Range, visibility across Spring Valley was completely obscured and there was a strong smell of wood smoke. This event was related to wildfires in southern California approximately 350 miles to the southwest.

This anecdotal evidence of visibility impairment from wildfires emphasizes the role of natural fire in visibility impairment, both from local and distant sources.

1.2 THE WESTERN REGIONAL AIR PARTNERSHIP AND NEVADA

USEPA funded five Regional Planning Organizations throughout the country to coordinate regional haze rule-related activities between states in each region. Nevada participates in the Western Regional Air Partnership (WRAP), the consensus organization of western states, tribes, and federal agencies, which oversees analyses of monitoring data and preparation of technical reports regarding regional haze in the western United States.

The WRAP was formed in September 1997 as the successor organization to the Grand Canyon Visibility Transport Commission. It is administered jointly by the Western Governors Association (WGA) and the National Tribal Environmental Council (NTEC). The mission of the WRAP is to identify regional or common air management issues and to develop and implement strategies to address these issues. The WRAP is a partnership of states and tribes as well as federal agencies and was designated by USEPA to assist western states in the development of regional haze plans. It provides a coordination mechanism with regard to science and technology support for policy and programmatic uses in the western United States.

WRAP member states include Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. Federal participants are the Department of the Interior (National Park Service and Fish & Wildlife Service,) the Department of Agriculture (Forest Service) and USEPA. Although Nevada is not a formal member, Nevada has been an active, cooperative participant in the WRAP and in the forums, workgroups and committees that were formed to address many elements of this Regional Haze State Implementation Plan (RH SIP).

Work by WRAP committees, forums and workgroups is accomplished by the staff time contributed by state, tribal, Federal Land Manager (FLM), USEPA and environmental, industry and public representatives, with the support of WRAP staffing through WGA and NTEC. WRAP work is also handled through contracts to environmental consulting firms, to analyze air pollution data collected by states and tribes in their regulatory programs as well as to prepare data and analyses for natural and/or uncontrollable air pollution sources.

The WRAP established stakeholder-based technical and policy oversight committees to assist in managing the development of regional haze work products. Working groups and forums were established to develop technical tools and work products the states and tribes needed to develop their implementation plans. Much of the WRAP's effort focused on regional technical analysis, which is the basis for developing strategies to meet the RHR requirement to demonstrate reasonable progress towards natural visibility conditions in Class I areas. This includes the

compilation of emission inventories, air quality modeling and ambient monitoring and data analysis.

The WRAP has developed a regionally-consistent and comparable body of technical data and analysis tools that has been invaluable in addressing regional haze in west. These data and tools are provided for use and evaluation through a transparent and open network of interrelated data support web systems and a technical decision support system:

WRAP Technical Data Support Centers

- Visibility Information Exchange Web System (http://vista.cira.colostate.edu/views/): VIEWS provides on-line access to monitoring data, research results and special studies related to visibility.
- Causes of Haze Assessment (http://www.coha.dri.edu/): COHA provides a detailed analysis of ambient monitoring data for regional haze in the WRAP region.
- Fire Emissions Tracking System (http://www.wrapfets.org/): FETS is a database with a web interface for tracking and managing planned and unplanned fire events. Users can view fire data on-screen with a mapping tool and query the database for downloads of data.
- Regional Modeling Center (http://pah.cert.ucr.edu/aqm/308/): The WRAP's RMC at the University of California Riverside provides state and tribal agencies with sophisticated modeling of regional haze and other air quality parameters in the western United States.
- Emissions Data Management System (http://wrapedms.org/default_login.asp): EDMS is an emission inventory data warehouse for states and tribes. The system provides a consistent, complete and regional approach to emissions data management and tracking.

WRAP Technical Decision Support System

- Technical Support System (http://vista.cira.colostate.edu/tss/): TSS integrates a number of different data support resources under one web-based decision support umbrella for regional haze planning and implementation.

In addition to these technical tools and work products, the WRAP has provided a forum for coordination and consultation with other states, tribes and FLMs. The major amount of interstate consultation in the development of this SIP was through the Implementation Work Group (IWG) of the WRAP. Nevada participated in the IWG, which took the products of the WRAP technical analysis and consultation process and developed a process for establishing reasonable progress goals in the western Class I areas. Chapter Nine of this document discusses the process that Nevada participated in to address the consultation requirements with FLMs, tribes and other WRAP states during the development of this plan and Nevada's commitments for future consultation.

1.3 TECHNICAL SUPPORT BACKGROUND

1.3.1 Regional Haze Monitoring Network

In response to the 1977 Clean Air Act Amendments, the IMPROVE program was established in 1985 to aid the creation of federal and state implementation plans for the protection of visibility

in Class I areas. Air monitoring devices at these locations are operated and maintained through a formal cooperative relationship between the USEPA and the National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management and U.S. Forest Service, collectively called the FLMs. In 1991, several additional organizations joined the effort: State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials (recently renamed National Association of Clean Air Agencies), Western States Air Resources Council, Mid-Atlantic Regional Air Management Association and Northeast States for Coordinated Air Use Management.

The IMPROVE program implemented an extensive long-term monitoring program to establish the current visibility conditions, track changes in visibility and determine causal mechanism for the visibility impairment in the national parks and wilderness areas. The data collected at the IMPROVE monitoring sites are used by land managers, industry planners, scientists, consultants, public interest groups and air quality regulators to better understand and protect the visual air quality resource in Class I areas. IMPROVE documents the visual air quality in wilderness areas and national parks throughout the United States.

1.3.1.1 Overview of the IMPROVE Monitoring Network

The IMPROVE network focuses on rural areas in the western Unites States. Other visibility and aerosol monitoring networks, such as that of the National Weather Service Airport Visibility Data, may focus on different air sheds and have different data collection objectives. In 1988, IMPROVE began with 20 monitoring sites. After publication of the regional haze rule in 1999, the first step in the implementation process was the upgrade and expansion of the IMPROVE network to 110 sites nationally. Figure 1-11 shows the current IMPROVE monitoring network throughout the United States.

FIGURE 1-11

MAP OF IMPROVE MONITORING NETWORK IN THE UNITED STATES

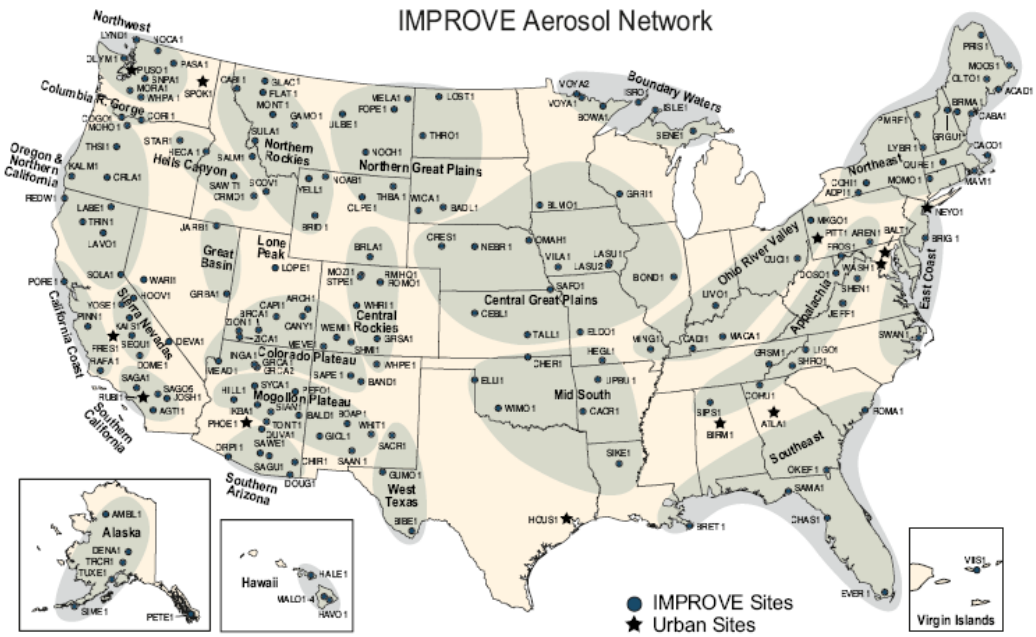


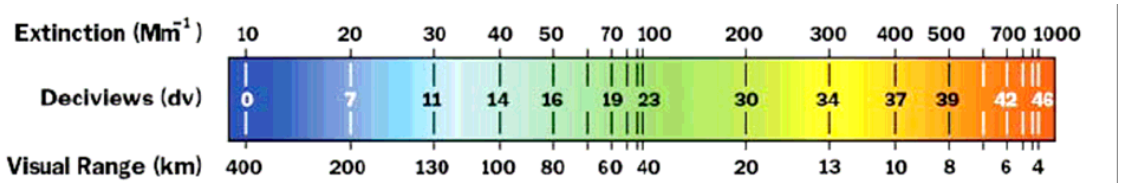
Figure S.1. The locations current and discontinued IMPROVE and IMPROVE protocol monitoring sites as of December 2004. The IMPROVE regions used for grouping the sites in some analyses in this report are indicated by green shading and bold text. Urban sites included in the IMPROVE network for quality assurance purposes are identified by stars.

The IMPROVE network consists of aerosol and optical samplers. Every IMPROVE site deploys an aerosol sampler to measure speciated fine aerosols and coarse mass. Select sites also deploy a transmissometer and nephelometers to measure light extinction and scattering respectively, as well as automatic camera systems to visually measure the scene. Particulate concentration data are obtained every third day over a 24-hour collection period and converted into reconstructed light extinction through a complex calculation using the IMPROVE equation that may be viewed at: http://vista.cira.colostate.edu/improve/Tools/ReconBext/reconBext.htm. Light extinction, the impairment of visibility, occurs due to particles and gases that reflect and absorb light.

Reconstructed light extinction (denoted as b_{ext}) is expressed in units of inverse megameters (1/Mm or Mm^{-1}). The RHR requires the tracking of visibility conditions in terms of the Haze Index (HI) metric expressed in the deciview unit (40 CFR 51.308(d)(2)). The relationship between light extinction in Mm^{-1}, Haze Index in dv and visual range in km is indicated by the scale in Figure 1-12.

FIGURE 1-12

LIGHT EXTINCTION-HAZE INDEX-VISUAL RANGE SCALE



The deciview is a unit of measurement of haze that is designed so that uniform changes in haziness correspond approximately to uniform incremental changes in perception across the entire range of conditions, from pristine to highly impaired. More information regarding tracking visibility conditions is found in USEPA's *Guidance for Tracking Progress Under the Regional Haze Rule* at: http://www.epa.gov/ttn/oarpg/t1/memoranda/rh_tpurhr_gd.pdf.

The IMPROVE data undergo extensive quality assurance and control procedures and analyses by its contractors and the National Park Service before it is released. The aerosol and optical data are made publicly available approximately nine months after collection. In addition, seasonal and annual data reports, special study data reports, technical publications and other data and analysis reports are prepared. IMPROVE program resources are available at: http://vista.cira.colostate.edu/Improve.

1.3.1.2 IMPROVE Monitor JARB1

Two operating IMPROVE monitoring sites are located in Nevada, one at Great Basin National Park and the other at the Jarbidge WA. The Walker River Paiute Tribe, a third monitoring site in Nevada, operated from June 2003 to November 2005. The IMPROVE monitor representing the air quality at the Jarbidge WA is identified as JARB1.

JARB1 was among the first 20 IMPROVE sites to start operation in 1988 and is sponsored by the U. S. Forest Service. Generally, JARB1 is expected to be representative of aerosol characteristics in the Jarbidge WA especially when the atmosphere is well mixed and regionally homogeneous. However, the site is at a low elevation in the Jarbidge River Canyon that is separate from the Jarbidge WA and upper East Fork of the Jarbidge River. Consequently, the monitoring site may at times be isolated from wilderness locations and potentially impacted by different local emission sources. Figure 1-4 shows the location of the JARB1 monitoring site by a bright green dot.

As does every IMPROVE site, JARB1 deploys an aerosol sampler to measure speciated aerosols and coarse mass. Along with other selected sites, JARB1 also has an automatic camera system to obtain a visual record, a transmissometer to measure light extinction, and a nephelometer to measure light scattering. Data from these sampling devices are used to determine the visibility status at the Jarbidge WA.

1.3.2 Emissions Analyses and Projections

USEPA's RHR requires statewide emission inventories of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any mandatory Class I area. Nevada's inventories are presented in Chapter Three. These emissions inventories are available from the WRAP TSS (http://vista.cira.colostate.edu/TSS/Results/Emissions.aspx). The TSS webpage has links to many references that describe in detail the emissions methods used in developing the point, area, mobile, dust, offshore and fire emission inventories.

Emissions scenarios used in the development of this SIP represent actual baseline emissions (Base02), typical baseline emissions (Plan02), and projected emissions (Base18 and PRP18). The baseline period includes 2000 through 2004, represented by 2002, while the projected inventories denote 2018 emissions, as discussed below. The projected inventories take into account growth, "on-the-books" and "on-the-way" controls and regulations and the application of regional haze strategies. The year 2018 was selected as it represents the first milestone date for demonstrating reasonable progress. These inventories were used for visibility and source apportionment modeling.

The pollutants examined are SO_2, sulfur oxides (SO_x), NO_x, volatile organic compound (VOC), primary organic aerosol (POA), elemental carbon (EC), fine particulate (PM fine), coarse particulate (PM coarse) and ammonia (NH_3). It is important to note that each of these pollutants have characteristics that differ in terms of ability to affect visibility. Assuming one emission unit of PM fine, for example, the same unit of SO_2 or NO_x would be about three times more effective at impairing visibility. Organic carbon is about four times more effective and elemental carbon about ten times more effective at impairing visibility. (Organic carbon is discussed in Chapter Four as part of the weighted emissions potential analysis.) Conversely, PM coarse is about half as effective as PM fine. Both VOC and NH_3 affect visibility only after certain chemical reactions occur and, therefore, cannot be compared in this manner.

1.3.2.1 Preparation of Baseline Emissions Inventories

2002 Base Case (Base02) Inventory

The Base02 inventory used actual data reported by states, locals, tribes and USEPA databases, which evolved from states' actual emissions data submitted to USEPA for the 2002 National Emission Inventory. The WRAP Stationary Sources Joint Forum contracted with Eastern Research Group (ERG) and subcontractors ENVIRON International Corporation and Alpine Geophysics to improve upon the 2002 WRAP emissions inventory, particularly for oil and gas area sources and for large point sources on selected tribal lands. The documents describing this project can be reviewed in detail by selecting the following links:

- http://www.wrapair.org/forums/ssjf/documents/Pivot_Tables/2006-01_REPORT_QA_of_the_2002_WRAP_Stationary_Sources%20EI.pdf
- http://wrapair.org/forums/ssjf/documents/eictts/OilGas/WRAP_Oil&Gas_Final_Report.122805.pdf
- http://www.wrapair.org/forums/fejf/documents/WRAP_2002_PhII_EI_Report_20050722.pdf.

The purpose of the Base02 scenario is to represent the actual conditions in calendar year 2002 with respect to ambient air quality and the associated sources of visibility-impairing air pollutants. The Base02 emissions inventories were used to validate the air quality model and associated databases and to demonstrate acceptable model performance with respect to replicating observed particulate matter air quality. Version "a" of the 2002 base case inventory, Base02a, was developed based on preliminary 2002 modeling which can be reviewed in detail at http://pah.cert.ucr.edu/aqm/308/reports/final/2002_MPE_report_main_body_FINAL.pdf. Improved 2002 emissions data for the United States, Mexico and Canada were used to create a final base 2002 annual emissions database, Base02b, for use in the Community Multi-Scale Air Quality (CMAQ) model and the Comprehensive Air Quality Model with Extensions (CAMx) model performance evaluations. Actual 2002 fire emissions data were included in this Base02b inventory.

2000 Through 2004 Baseline-Period (Plan02) Inventory

The 2000 through 2004 baseline period planning case emissions scenario is referred to as "Plan02". As with the Base02 inventories, Plan02 has undergone a number of revisions and enhancements to arrive at the final versions used in visibility and source apportionment modeling. The Plan02 series of inventories was developed to represent baseline period emissions patterns based on average, or "typical" conditions. The Plan02 inventory was developed from the Base02 emissions modeling scenarios by incorporating:

1. Replacement of actual 2002 fire emissions inventories with the baseline typical fire emissions inventories;
2. Replacement of the temporal profiles for large stationary point sources with profiles developed from an average of several years surrounding 2002; and
3. Corrections to the off-road mobile, on-road mobile, offshore Pacific shipping lane and WRAP oil and gas inventories.

The inventory series Plan02a, Plan02b and Plan02c provided a basis for comparison with the future year 2018 projected emissions, as well as for gauging reasonable progress with respect to future year visibility. The Plan02d emission inventory was based on the minor changes to the Plan02c emission inventory. These revisions to the Plan02c emission inventory included:

1. Updating the current status of point sources related to the BART requirements under the regional haze rule; and
2. Correcting erroneous or missing Standard Industrial Classification and/or source classification codes (SCC).

The Plan02c inventory was used for source apportionment modeling, whereas the Plan02d inventory was used for visibility modeling and weighted emission potential (WEP) analyses, as discussed in section 1.3.3.1 below.

1.3.2.2 Projected 2018 Emissions Inventories

2018 Base Case (Base18) Inventory

The 2018 future-year base case emissions scenario is referred to as "2018 Base Case" or "Base18". The Base18 emissions scenario is used to represent conditions in 2018 with respect to sources of visibility-impairing air pollutants, taking into consideration growth and controls. The Base18b inventory contained summaries of 2018 stationary point and area source emission inventories projected from the Plan02c inventory and was initially completed by ERG in January 2006. ERG's report is available at http://www.wrapair.org/forums/ssjf/documents/eictts/docs/WRAP_2018_EI-Version_1-Report_Jan2006.pdf.

This inventory was used for source apportionment modeling. Modeling results based on this emission inventory are used to define the future year ambient air quality and visibility metrics.

The projection methodology included the following steps:

1. Permit Limits: Adjusting projected emissions downward in cases where the projected emissions may have inadvertently exceeded an enforceable emission limit.
2. *Section §309 Flags:* Point sources in the Grand Canyon Visibility Transport states whose 2002 facility-level SO_2 emissions were at least 100 tons/year were assigned section §309 flags.
3. *Retirement and Replacement Rates:* Effects of retirement were estimated using annual retirement rates based on expected equipment lifetimes. Retired equipment was replaced by lower-emitting new equipment. Unit lifetimes were examined for natural gas-fired electric generating units (EGUs). No retirements were assumed for coal-fired EGUs.
4. *Control factors:* Emission reductions due to known (on-the-books) controls, consent decree reductions, SIP control measures and other relevant regulations that have gone into effect since 2002, or will go into effect before the end of 2018 (on-the-way). These controls do not include impacts from any future control scenarios that have yet to be determined.
5. *Growth Factors:* SCC-specific growth factors developed from the Economic Growth Analysis System (EGAS) projection factor model were included.
6. *Adjustments:*
   (a) Emissions for new facilities that have come on-line since 2002,
   (b) Corrections for facilities that retired in 2003 or 2004 and will not return to operation in the future, and
   (c) Other (i.e., ratios to correct certain PM_{10} and $PM_{2.5}$ emission factors/SCCs for combustion of natural gas)

2018 Preliminary Reasonable Progress (PRP18) Inventory

Several enhancements and corrections were subsequently made to the 2018 Base18b inventory resulting in the PRP18a inventory. The WRAP region 2018 point and area source inventory projections were updated from the 2018 Base18b inventory with information from individual state air agencies. The PRP18a inventory was created to establish the most representative source-specific emissions projections data as the basis for preparing regional haze plans. The PRP18a inventory was used for visibility modeling. Development of the PRP18a inventory is

documented in a technical memo available at http://www.wrapair.org/forums/ssjf/documents/eictts/Projections/PRP18_EI_tech%20memo_061607.pdf.

The PRP18a inventory revisions included the following elements:

1. Presumptive BART emission limits were applied to BART-eligible coal-fired EGUs for SO_2 only and not for NO_x.
2. Specific BART limits for all coal-fired EGU sources subject to BART in Colorado, North Dakota and Utah, as well as one facility in Oregon.
2. Based on state and local agency comments, SCC codes were corrected and source information was updated based on new sources, inactive sources and facility name changes.
3. For EGU facilities reporting to USEPA's Clean Air Markets Division's acid rain database, EGU facility IDs were corrected and missing EGU source records were added.
4. Revised EGU projections of future coal-fired EGU construction: used Energy Information Administration projections of 2018 energy requirements; determined existing WRAP region capacity to identify total new requirements; added existing state and local agency EGU permits; added 11 new "Model" 500MW EGU units operating at BACT levels. Of the 11 proposed future coal-fired EGU plants, one is in Nevada.
5. Revisions to the WRAP Oil and Gas point and area source emission inventory were incorporated based on work done by ENVIRON in 2007 (http://www.wrapair.org/forums/ogwg/documents/2007-10_Phase_II_O&G_Final)Report(v10-07%20rev.s).pdf).
6. Updates to the 2018 SO_2 emission projections for Non-Utility Point sources were incorporated based on work done by Pechan and Associates in 2006 (http://wrapair.org/forums/ssjf/documents/eictts/Projections/Report-WRAP_SO2-oct11_Final.pdf).

The Base18b inventory was used for source apportionment modeling, whereas the PRP18a inventory was used for visibility modeling and weighted emission potential (WEP) analyses, as discussed in section 1.3.3.1 below.

1.3.2.3 WRAP's Technical Support System

Air quality and visibility modeling in support of regional haze planning in the WRAP region is the responsibility of the WRAP Modeling Forum's RMC. The RMC uses the air pollution emissions data as described and displayed in the TSS Emissions Section to simulate historic air quality conditions and estimate the benefit of emissions reductions programs in the future. The RMC uses regional gridded dispersion models for these simulations. The RMC website (http://pah.cert.ucr.edu/aqm/308/) provides modeling inputs and data results for review and download, using pre-set data processing, visualization and download capabilities. The TSS provides key summary air quality and visibility modeling data through enhanced analysis and display tools.

1.3.3 Air Quality Modeling

The sources of $PM_{2.5}$ are difficult to quantify because of the complex nature of their formation, transport and removal from the atmosphere. This makes it difficult to simply use emissions data to determine which pollutants should be controlled to most effectively improve visibility. Photochemical air quality models offer opportunity to better understand the sources of $PM_{2.5}$ by simulating the emissions of pollutants and the formation, transport and deposition of $PM_{2.5}$. If an air quality model performs well for an historical episode, the model may then be useful for identifying the sources of $PM_{2.5}$ and helping to select the most effective emissions reduction strategies for attaining visibility goals. Although several types of air quality modeling systems are available, the gridded, three-dimensional, Eulerian models provide the most complete spatial representation and the most comprehensive representation of processes affecting $PM_{2.5}$, especially for situations in which multiple pollutant sources interact to form $PM_{2.5}$.

The WRAP RMC utilized two regulatory air quality modeling systems to conduct all regional haze modeling. A brief discussion of each of these models is provided below.

Community Multi-Scale Air Quality Model
USEPA initially developed the CMAQ modeling system in the late 1990s. The model source code and supporting data can be downloaded from the Community Modeling and Analysis System Center (http://www.cmascenter.org/), which is funded by USEPA to distribute and provide limited support for CMAQ users. CMAQ was designed as a "one atmosphere" modeling system to encompass modeling of multiple pollutants and issues, including ozone, PM, visibility and air toxics. This is in contrast to many earlier air quality models that focused on single-pollutant issues (e.g., ozone modeling by the Urban Airshed Model). CMAQ is a Eulerian model -- that is, it is a grid-based model in which the frame of reference is a fixed, three-dimensional grid with uniformly sized horizontal grid cells and variable vertical layer thicknesses. The number and size of grid cells and the number and thicknesses of layers are defined by the user, based in part on the size of the modeling domain to be used for each modeling project. The key science processes included in CMAQ are emissions, advection and dispersion, photochemical transformation, aerosol thermodynamics and phase transfer, aqueous chemistry, and wet and dry deposition of trace species. CMAQ offers a variety of choices in the numerical algorithms for treating many of these processes, and it is designed so that new algorithms can be included in the model. CMAQ offers a choice of three photochemical mechanisms for solving gas-phase chemistry: the Regional Acid Deposition Mechanism version 2 (RADM2); a fixed coefficient version of the SAPRC90 mechanism; and the Carbon Bond IV mechanism (CB-IV).

Comprehensive Air Quality Model with Extensions
The CAMx model was initially developed by ENVIRON in the late 1990s as a nested-grid, gas-phase, Eulerian photochemical grid model. ENVIRON later revised CAMx to treat PM, visibility and air toxics. While there are many similarities between the CMAQ and CAMx systems, there are also some significant differences in their treatment of advection, dispersion, aerosol formation, and dry and wet deposition.

In support of the WRAP regional haze air quality modeling efforts, the RMC developed air quality modeling inputs including annual meteorology and emissions inventories for a 2002 actual emissions base case, a planning case to represent the 2000 through 2004 regional haze

baseline period using averages for key emissions categories, and a 2018 base case of projected emissions determined using factors known at the end of 2005. All emission inventories were developed using the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system. Each of these inventories has undergone a number of revisions throughout the development process to arrive at the final versions used in CMAQ and CAMx air quality modeling. The development of each of these emission scenarios is documented under the emissions inventory sections of the TSS. In addition to various sensitivities scenarios, the WRAP performed air quality model simulations for each of the emissions scenarios.

Initial conditions are specified by the user for the first day of a model simulation. For continental-scale modeling using the Regional Planning Organization (RPO) Unified 36-km domain, the initial conditions can affect model results for as many as 15 days, although the effect typically becomes very small after about 7 days. A model spin-up period is included in each simulation to eliminate any effects from the initial conditions. For the WRAP modeling, the annual simulation is divided into four quarters, and included a 15-day spin-up period for the quarters beginning in April, July and October. For the quarter beginning in January 2002, a spin-up period covering December 16-31, 2001, using meteorology and emissions data developed for Central Regional Air Planning Association (CENRAP) were used.

Boundary conditions specify the concentrations of gas and PM species at the four lateral boundaries of the model domain. Boundary conditions determine the amounts of gas and PM species that are transported into the model domain when wind flow is into the domain. Boundary conditions have a much larger effect on model simulations than do initial conditions. For some areas in the WRAP region and for clean conditions, the boundary conditions can be a substantial contributor to visibility impairment.

For this study, boundary conditions data generated in an annual simulation of the global-scale GEOS-Chem model that was completed by Jacob et al. (http://www-as.harvard.edu/chemistry/trop/geos/) for calendar year 2002 were applied. Additional data processing of the GEOS-Chem data was required before using them in CMAQ and CAMx. The data first had to be mapped to the boundaries of the WRAP domain, and the gas and PM species had to be remapped to a set of species used in the CMAQ and CAMx models. This work was completed by Byun and coworkers (http://www-as.harvard.edu/chemistry/trop/geos/meetings/2005/ppt/Expanding_Model_Capabilities/GEOS-CMAQ_april_4_Byun.ppt).

The CMAQ model options and configuration used for the WRAP 36-km model simulations are described in Tonnesen et al. (2006) (http://pah.cert.ucr.edu/aqm/308/reports/final/2002_MPE_report_main_body_FINAL.pdf). The RMC prepared a white paper describing the air quality modeling preformed for WRAP, available at http://vista.cira.colostate.edu/docs/wrap/Modeling/AirQualityModeling.doc. The white paper provides detailed information regarding the modeling software, data sources, development and results of various model simulations, model performance evaluation, visibility projections, PM source apportionment using Particulate Matter Source Attribution Tracking (PSAT) and model sensitivity simulations.

1.3.3.1 Visibility Modeling

The RHR goals include achieving natural visibility conditions at 156 federally mandated Class I areas by 2064. In more specific terms, that goal is defined as visibility improvement toward natural conditions for the 20 percent of days that have the worst visibility (termed "20 percent worst" visibility days), and no worsening in visibility for the 20 percent of days that have the best visibility ("20 percent best" visibility days). One component of the states' demonstration to USEPA that they are making reasonable progress toward this 2064 goal is the comparison of modeled visibility projections for 2018 with what is termed a uniform rate of progress (URP) from baseline to natural conditions by 2064.

Preliminary 2018 visibility projections have been made using the Plan02d and PRP18a CMAQ 36-km modeling results, following USEPA guidance that recommends applying the modeling results in a relative sense to project future-year visibility conditions (U.S. EPA, 2001, 2003a, 2006). Projections are made using relative response factors (RRFs), which are defined as the ratio of the future-year modeling results to the current-year modeling results. The calculated RRFs are applied to the baseline observed visibility conditions to project future-year observed visibility. These projections can then be used to assess the effectiveness of the simulated emission control strategies that were included in the future-year modeling. The major features of USEPA's recommended visibility projections are as follows (U.S. EPA, 2003a,b, 2006):

- Monitoring data should be used to define current air quality.
- Monitored concentrations of PM_{10} are divided into six major components; the first five are assumed to be $PM_{2.5}$ and the sixth is $PM_{2.5-10}$.
  - SO_4 (sulfate)
  - NO_3 (particulate nitrate)
  - OC (organic carbon)
  - EC (elemental carbon)
  - OF (other fine particulate or soil)
  - CM (coarse matter).
- Models are used in a relative sense to develop RRFs between future and current predicted concentrations of each component.
- Component-specific RRFs are multiplied by current monitored values to estimate future component concentrations.
- Estimates of future component concentrations are consolidated to provide an estimate of future air quality.
- Future estimated air quality is compared with the goal for regional haze to see whether the simulated control strategy would result in the goal being met.
- It is acceptable to assume that all measured sulfate is in the form of ammonium sulfate [$(NH_4)_2SO_4$] and all particulate nitrate is in the form of ammonium nitrate [NH_4NO_3].

RRFs calculated from modeling results can be used to project future-year visibility. For the current modeling efforts, RRFs are the ratio of the 2018 modeling results to the 2002 modeling results and are specific to each Class I area and each PM species. RRFs are applied to the Baseline Condition observed PM species levels to project future-year PM levels, which are then used with the IMPROVE extinction equation listed above to assess visibility. The following six steps are used to project future-year visibility for the 20 percent best and 20 percent worst

visibility days (the discussion below is for 20 percent worst days but also applies to 20 percent best days):

1. For each Class I area and each monitored day, daily visibility is ranked using IMPROVE data and IMPROVE extinction equation for each year from the five-year baseline period (2000-2004) to identify the 20 percent worst visibility days for each year.
2. Use an air quality model to simulate a base-year period (ideally 2000-2004, but in reality just 2002) and a future year (e.g., 2018), then apply the resulting information to develop Class-I-area-specific RRFs for each of the six components of light extinction in the IMPROVE aerosol extinction equation.
3. Multiply the RRFs by the measured 24-h PM data for each day from the 20 percent worst days for each year from the five-year baseline period to obtain projected future-year (2018) 24-h PM concentrations for the 20 percent worst days.
4. Compute the future-year daily extinction using the IMPROVE aerosol extinction equation and the projected PM concentrations for each of the 20 percent worst days in the five-year baseline from Step 3.
5. For each of the 20 percent worst days within each year of the five-year baseline, convert the future-year daily extinction to units of deciview and average the daily deciview values within each of the five years separately to obtain five years of average deciview visibility for the 20 percent worst days.
6. Average the five years of average deciview visibility to obtain the future-year visibility Haze Index estimate that is compared with the 2018 progress goal.

For all of the WRAP Class I areas, the RMC performed preliminary 2018 visibility projections and compared them to the 2018 URP using the Plan02d and PRP18a CMAQ modeling results and the old and new IMPROVE equations.

1.3.3.2 Source Apportionment Modeling

Impairment of visibility in Class I areas is caused by a combination of local air pollutants and regional pollutants that are transported long distances. To develop effective visibility improvement strategies, the WRAP member states and tribes need to know the relative contributions of local and transported pollutants, and which emissions sources are significant contributors to visibility impairment at a given Class I area.

A variety of modeling and data analysis methods can be used to perform source apportionment of the PM observed at a given receptor site. One method is to implement a mass-tracking algorithm in the air quality model to explicitly track for a given emissions source the chemical transformations, transport and removal of the PM that was formed from that source. Mass-tracking methods have been implemented in the CAMx air quality model as PSAT.

Source apportionment for regional haze planning was conducted using various modeling techniques. The SO_x/NO_x Tracer and Organic Aerosol Tracer were performed using the regional PSAT air quality model. The WEP analysis included the synthesis of emissions data and meteorological back trajectories. The PMF Receptor Modeling and Causes of Dust analysis were complex statistical exercises involving IMPROVE monitoring data. Not all source apportionment techniques were applied to all pollutants.

Particle Source Apportionment Tracking

The main objective of applying CAMx/PSAT is to evaluate the regional haze air quality for conditions typical of the 2000 through 2004 baseline period (Plan02c) and future-year 2018 (Base18b) conditions. These results are used:

- To assess the contributions of different geographic source regions (e.g., states) and source categories to current (2000-2004) and future (2018) visibility impairment at Class I areas, in order to obtain improved understanding of the causes of the impairment and which states are included in the area of influence of a given Class I area.
- To determine which source categories contributing to the area of influence for each Class I area are changing, and by how much, between the 2000 through 2004 and 2018 base cases. by varying only controllable anthropogenic emissions between the 2 PSAT simulations; and
- To identify the source regions and emissions categories that, if controlled to lower emissions rates than the 2018 base case levels, would produce the greatest visibility improvements at a Class I area.

The PSAT performs source apportionment based on user-defined source groups. A source group is the combination of a geographic source region and an emissions source category. Examples of source regions include states, nonattainment areas and counties. Examples of source categories include mobile sources, biogenic sources and elevated point sources; PSAT can even focus on individual sources. The user defines a geographic source region map to specify the source regions of interest. He or she then inputs each source category as separate, gridded low-level emissions and/or elevated-point-source emissions. The model then determines each source group by overlaying the source categories on the source region map. PM source apportionment modeling was performed for aerosol SO_4 and aerosol NO_3 and their related species (e.g., SO_2, NO, NO_2, HNO_3, NH_3, and NH_4). The PSAT simulations include 9 tracers, 18 source regions (see Table 1-1) and 6 source groups (see Table 1-2).

TABLE 1-1

WRAP CAMx/PSAT SOURCE REGIONS

Source Region ID	Source Region Description[1]	Source Region ID	Source Region Description[1]
1	Arizona (AZ)	10	South Dakota (SD)
2	California (CA)	11	Utah (UT)
3	Colorado (CO)	12	Washington (WA)
4	Idaho (ID)	13	Wyoming (WY)
5	Montana (MT)	14	Pacific off-shore & Sea of Cortez (OF)
6	Nevada (NV)	15	CENRAP states (CE)
7	New Mexico (NM)	16	Eastern U.S., Gulf of Mexico, & Atlantic Ocean (EA)
8	North Dakota (ND)	17	Mexico (MX)
9	Oregon (OR)	18	Canada (CN)

[1] The abbreviations in parentheses are used to identify source regions in PSAT receptor bar plots.

TABLE 1-2

WRAP CAMx/PSAT EMISSIONS SOURCE GROUPS

Emissions Source Groups	Low-level Sources	Elevated Sources
1	Low-level point sources (including stationary off-shore)	Elevated point sources (including stationary off-shore)
2	Anthropogenic wildfires (WRAP only)	Anthropogenic wild fires (WRAP only)
3	Total mobile (on-road, off-road, including planes, trains, ships in/near port, off-shore shipping)	
4	Natural emissions (natural fire, WRAP only, biogenics)	Natural emissions (natural fire, WRAP only, biogenics)
5	Non-WRAP wildfires (elevated fire sources in other RPOs)	Non-WRAP wild fires (elevated fire sources in other RPOs)
6	Everything else (area sources, all dust, fugitive ammonia, non-elevated fire sources in other RPOs)	

The source apportionment model results are typically presented in two ways:

- *Spatial plots* showing the area of influence of a source group's PM species contributions throughout the model domain, either at a given hourly-average point in time or averaged over some time interval (e.g., monthly average).
- *Receptor bar plots* showing the rank order of source groupings that contribute to PM species at any given receptor site. These plots also can be at a particular point in time or averaged over selected time intervals—for example, the average source contributions for the 20 percent worst visibility days.

The primary products of the WRAP PSAT modeling were receptor bar plots showing the emission source groups that contribute the most to the model grid cells containing each IMPROVE monitoring site and other receptor sites identified by WRAP.

Two annual 36-km CAMx/PSAT model simulations were performed: one with the Plan02c typical-year baseline case and the other with the Base18b future-year case. It is expected that the states and tribes will use these results to assess the sources that contribute to visibility impairment at each Class I Area and to guide the choice of emission control strategies. The RMC web site includes a full set of source apportionment spatial plots and receptor bar plots for both Plan02b and Base18b. These graphical displays of the PSAT results, as well as additional

analyses of these results are available on the TSS under http://vista.cira.colostate.edu/TSS/Results/SA.aspx.

Additional information related to the CAMx air quality model and PSAT apportionment algorithm can be found at http://vista.cira.colostate.edu/docs/wrap/attribution/PSATMethods.doc.

Weighted Emissions Potential

The WEP was developed as a screening tool for states to decide which source regions have the potential to contribute to haze formation at specific Class I areas, based on both the 2002 and 2018 emissions inventories. This method does not produce highly accurate results because, unlike the air quality model and associated PSAT analysis, it does not account for chemistry and removal processes. Instead, it relies on an integration of gridded emissions data, back trajectory residence time data, a one-over-distance factor to approximate deposition and a normalization of the final results. Residence time over an area is indicative of general flow patterns, but does not necessarily imply the area contributed significantly to haze at a given receptor. Therefore, users are cautioned to view the WEP as one piece of a larger, more comprehensive weight of evidence analysis.

The emissions data used were the annual, 36km grid SMOKE-processed, model-ready emissions inventories provided by the WRAP RMC. The analysis was performed for nine pollutants (maps were generated for all but the last three):

- Sulfur oxides
- Nitrogen oxides
- Organic carbon
- Elemental carbon
- Carbon monoxide
- Fine particulate matter
- Coarse particulate matter
- Ammonia
- Volatile organic carbon

The following source categories for each pollutant were identified and preserved through the analysis:

- Biogenic
- Natural fire
- Point
- Area
- WRAP oil and gas
- Off-shore
- On-road mobile
- Off-road mobile
- Road dust
- Fugitive dust
- Windblown dust
- Anthropogenic fires.

The back trajectory residence times were provided by the WRAP COHA. The COHA project used NOAA's HYSPLIT model to generate eight back trajectories daily for each WRAP Class I area for the entire five-year baseline period (2000 through 2004). From these individual trajectories, residence time fields were generated for one-degree latitude by one-degree longitude grid cells. Residence time analysis computes the amount of time (e.g., number of hours) or percent of time an air parcel is in a horizontal grid cell. Plotted on a map, residence time is shown as percent of total hours in each grid cell across the domain, thus allowing an interpretation of general air flow patterns for a given Class I area. The residence time fields for the 20 percent worst and best IMPROVE-monitored extinction days were selected for the WEP analysis to highlight the potential emissions sources during those specific periods. Additional

information regarding back trajectory modeling can be found at http://vista.cira.colostate.edu/docs/wrap/Modeling/BackTrajectoryModeling.doc.

The WEP analysis consisted of weighting the annual gridded emissions (by pollutant and source category) by the worst and best extinction days residence times for the five-year baseline period. To account for deposition along the trajectories, the result was further weighted by a one-over-distance factor, measured as the distance in km between the centroid of each emissions grid cell and the centroid of the grid cell containing the Class I area monitoring site under investigation. (The "home" grid cell of the monitoring site was weighted by one fourth of the 36km grid cell distance, or one-over-9km, to avoid a large response in that grid cell.) The resulting weighted emissions field was normalized by the highest grid cell to ease interpretation.

The WEP is not a rigorous, stand-alone analysis, but a simple, straightforward use of existing data. As such, there are several caveats to keep in mind when using WEP results as part of a comprehensive weight of evidence analysis:

- This analysis does not take into account any emissions chemistry.
- While actual emissions may vary considerably throughout the year, this analysis pairs up annual emissions data with 20 percent worst/best extinction days residence times – this is likely most problematic for carbon and dust emissions, which can be highly episodic.
- Coarse particle and some fine particle dust emissions tend not to be transported long distances due to their large mass.
- The WEP results are unitless numbers, normalized to the largest-valued grid cell. Effective use of these results requires an understanding of actual emissions values and their relative contribution to haze at a given Class I area.

Additional information regarding WEP analysis can be found at http://vista.cira.colostate.edu/docs/wrap/attribution/WEPMethods.doc.

1.4 REFERENCES

NOAA, 1985. Climate Narrative of the States-Volume 1. Gale Research Company.

R.S.U. Smith, "Sand Dunes in the North American Deserts." in G. Bender(ed.), Reference Handbook of the Deserts of North America, Greenwood Press, Westport, Conn., 1982. pp. 481-554.

J.H. Stewart, Geology of Nevada: Special Publication 4. Nevada Bureau of Mines and Geology, 1980.

WRAP 2002. Visibility Model Performance Evaluation-Final Report. Western Regional Air Partnership, February 24, 2006.