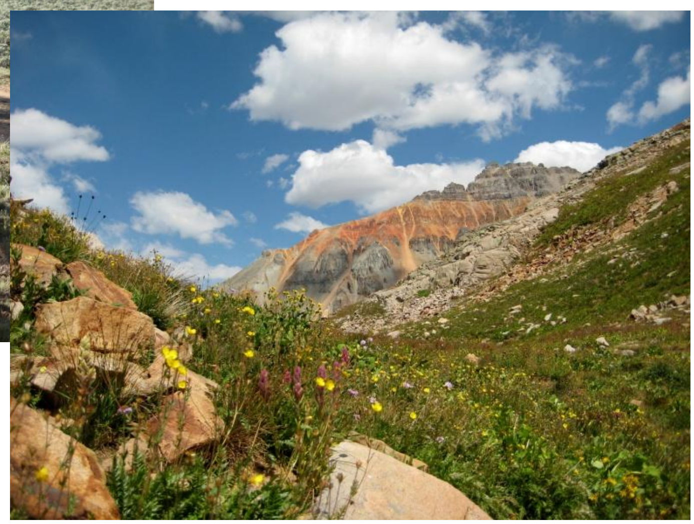
Colorado

2009 Air Quality Data Report



Air Pollution Control Division

Colorado Department of Public Health and Environment

Cover photos

Top Left: Colorado Route 742, Southern Sawatch Range

Top Right: Lizard Head Wilderness

Bottom: Panoramic view from Mt. Princeton

COLORADO AIR QUALITY DATA REPORT

2009

Colorado Department of Public Health and Environment

Air Pollution Control Division
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1. Purpose of the Annual Data Report

The Colorado Department of Public Health and Environment, Air Pollution Control Division (APCD) publishes the Colorado Air Quality Data Report as a companion document to the Colorado Air Quality Control Commission Report to the Public. The Air Quality Data Report addresses changes in ambient air quality measured by Division monitors. The Report to the Public discusses the policies and programs designed to improve and protect Colorado's air quality.

1.1. Symbols and Abbreviations

The following symbols and abbreviations have been used throughout this report:

APCD	Air Pollution Control Division
CDPHE	Colorado Department of Public Health and Environment
CO	Carbon monoxide
EPA	U.S. Environmental Protection Agency
Met	Meteorological measurements, wind speed, wind direction, temperature, relative humidity and standard deviation of horizontal wind direction
NAAQS	National Ambient Air Quality Standard
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
NOy	Reactive oxides of nitrogen
O_3	Ozone
PM_{10}	Particulate matter less than 10 microns in aerometric diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerometric diameter
Pb	Lead
ppm	parts per million – used with gaseous pollutants
SO_2	Sulfur dioxide
SO_X	Oxides of sulfer
TSP	Total suspended particulates
$\mu g/m^3$	micrograms per cubic meter – used with particulate pollutants

1.2. Description of Monitoring Areas in Colorado

The state has been divided into five multi-county areas that are generally based on topography. The areas are: (1) the Eastern Plains, (2) the Northern Front Range, (3) the Southern Front Range, (4) the Mountains, and (5) the Western Counties. These divisions are a somewhat arbitrary grouping of monitoring sites that have similar characteristics.

The Eastern Plains consist of those counties east of the urbanized I-25 corridor to the eastern border of Colorado from the northern to the southern border. These counties are generally rolling agricultural plains below the elevation of 6,000 feet.

The Front Range counties are generally those along the I-25 corridor from the northern border of Colorado to the southern border. They are split into north and south areas with the Palmer Ridge as the dividing area. While the northern counties all have a direct association with I-25, that association is not as well defined in the southern counties. Teller, Fremont, Custer, Alamosa, and Costilla counties are included with the Southern Front Range counties because they have more in common meteorologically with that group than they do with the Mountain counties.

The Mountain counties are generally those counties along the Continental Divide. The Western counties are those adjacent to the Utah border. Other divisions can and have been made, but these five divisions seemed appropriate for this report. Figure 1 shows the approximate boundaries of these areas. Counties with monitors are colored yellow, and the pin symbols on the map mark the approximate locations of the monitors in that county.

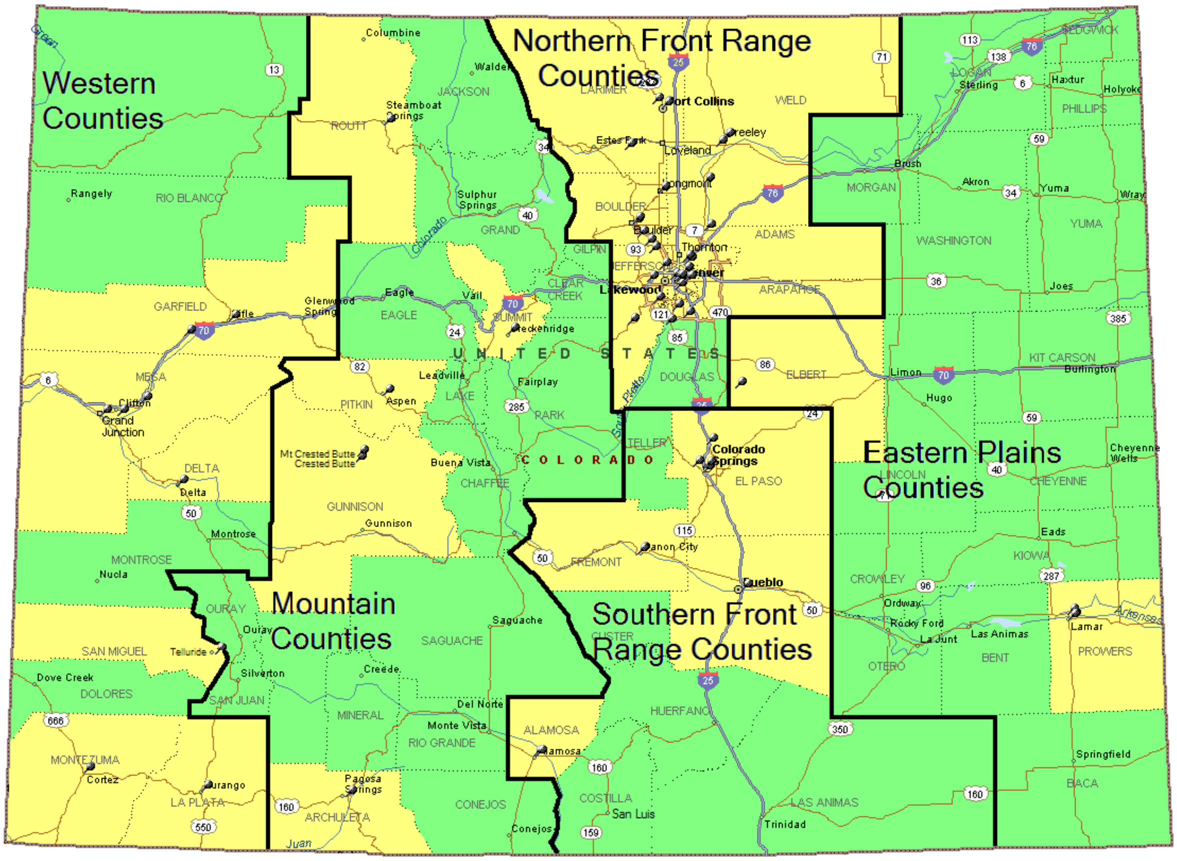


Figure 1. Monitoring Areas in Colorado[1]

1.2.1 Eastern Plains Counties

The Eastern Plains Counties are those east of the urbanized I-25 corridor. Historically, there have been a number of communities that were monitored for particulates and meteorology but not for any of the gaseous pollutants. In the northeast along the I-76 corridor, the communities of Sterling, Brush and Fort Morgan have been monitored. Along the I-70 corridor only the community of Limon has been monitored for particulates. Along the US-50/Arkansas River corridor the Division has monitored for particulates in the communities of La Junta, Rocky Ford, and Trinidad. These monitors were all discontinued in the late 1970's and early 1980's after a review showed that the concentrations were well below the standard and trending downward.

Currently, there are two PM_{10} monitoring sites and a meteorology station in Lamar, a background $PM_{2.5}$ monitor in Elbert County, but no gaseous pollutant monitors in the area. Table 1 and Table 2 list the locations of the pollutant monitors by area.

The Lamar monitors did record five separate exceedances of the 24-hour PM_{10} standard in 2009. These have been associated with high winds and dry conditions that can occur anytime of the year, but especially in the springtime. The Elbert County monitor is located on the Palmer Divide and operates as a background $PM_{2.5}$ monitor. This monitor provides baseline $PM_{2.5}$ readings away from urban sources of manmade particulates.

1 Counties with monitors are in yellow and the pin symbols on the map show the approximate location of the monitors within the county.

1.2.2 Northern Front Range Counties

The Northern Front Range Counties are those along the urbanized I-25 corridor from the Colorado/Wyoming border to just south of the city of Castle Rock. This area has the majority of the larger cities in the state. The majority of monitors are located in the Denver metropolitan area (Denver-metro) and the rest are located in or near Boulder, Fort Collins, Greeley, Longmont, and Platteville. Currently, there are 28 gaseous pollutant monitors, 23 particulate monitors, and 16 meteorological monitors in the Northern Front Range area. There are 6 CO, 16 O_3, 2 NO_2, and 2 SO_2 monitors. By the end of 2010 there will be additional CO, NOy and SO_2 trace gas monitors installed at the Denver Municipal Animal Shelter site. There are 9 PM_{10}, 13 $PM_{2.5}$, and 2 TSP/Pb monitoring sites. Table 1 and Table 2 list the locations of the pollutant monitors by area. There were no NAAQS exceedances of CO, NO_2, SO_2, PM_{10}, or TSP/Pb in 2009. There were two exceedances of the 24-hour $PM_{2.5}$ NAAQS. One exceedance was at the Boulder Chamber of Commerce site due to a nearby wildfire. The second exceedance was at the Greeley – Hospital site. There were 4th maximum 8-hour O_3 NAAQS exceedances at eleven different sites in 2009. These sites were Welby, Highland, Aurora East, South Boulder Creek, Chatfield State Park, Arvada, Welch, Rocky Flats North, NREL, Aspen Park and Ft. Collins West.

1.2.3 Southern Front Range Counties

The Southern Front Range Counties are those along the urbanized I-25 corridor from south of the city of Castle Rock to the southern Colorado border. The cities with monitoring in the area are Colorado Springs, Pueblo, Cañon City, and Alamosa. These last two cities are not strictly in the Front Range I-25 corridor but meteorologically fit better with those cities than they do the Mountain Counties. Colorado Springs is the only city in the area that is monitored for CO and O_3 by the APCD. The other cities are only monitored for particulates. In the past the APCD has conducted particulate monitoring in both Walsenburg and Trinidad but that monitoring was discontinued in 1979 and 1985 respectively, due to low concentrations. Currently, there are 3 gaseous pollutant monitors and 7 particulate monitors in the Southern Front Range area. There are 1 CO and 2 O_3 monitors in the Colorado Springs area. There are 5 PM_{10} and 2 $PM_{2.5}$ monitoring sites in the region. Table 1 and Table 2 list the locations of the pollutant monitors by area. There were two exceedances of the PM_{10} NAAQS in 2009, one at the Alamosa – Municipal site and one at the Alamosa – Adams State College site on separate days. These exceedances were the result of a dust storm and are being documented as exceptional events. There were no NAAQS exceedances of CO, O_3, or $PM_{2.5}$ in 2009.

1.2.4 Mountain Counties

The Mountain Counties are generally those that are on or near the Continental Divide. They consist of mostly small towns located in tight mountain valleys. Their primary monitoring concern is with particulate pollution from wood burning and road sanding. These communities range from Steamboat Springs in the north to Breckenridge near the I-70 corridor, as well as Aspen, Crested Butte and Mt. Crested Butte in the central mountains and Pagosa Springs in the south. Currently, there are no gaseous and 6 particulate monitoring sites operated by the APCD in the Mountain Counties region. Table 1 and Table 2 list the locations of the pollutant monitors by area. The Pagosa Springs School monitor recorded three exceedances of the PM_{10} NAAQS in 2009.

1.2.5 Western Counties

The Western Counties are generally smaller towns, usually located in fairly broad river valleys. Grand Junction is the only large city in the area, and the only location that monitors for carbon monoxide and air toxics on the western slope. In 2008, Rifle, Palisade, and Cortez began monitoring for ozone. The other Western County locations monitor only for particulates. They are located in Delta, Durango, Parachute, and Telluride. Currently, there are 4 gaseous pollutant monitors and 11 particulate monitors in the Western Counties area. There are 1 CO, 3 O_3, 8 PM_{10}, and 3 $PM_{2.5}$ monitoring sites. Table 1 and Table 2 list the locations of the pollutant monitors by area. There were no NAAQS exceedances for ozone or carbon monoxide in 2009. There were three PM_{10} NAAQS exceedances in 2009, two at the Durango – River City Hall site and one at the Delta Health Dept. site. There were six $PM_{2.5}$ NAAQS exceedances at the Grand Junction – Powell site in 2009.

Table 1. Statewide Gaseous and Meteorological Monitors in Operation for 2009

County	*Site Name*	*Location*	*CO*	*SO_2*	*NO_X*	*O_3*	*Met*
Eastern Plains Counties							
Prowers	Lamar - POE	7100 Hwy 50					**X**
Northern Front Range Counties							
Adams	Commerce City	7101 Birch St.					**X**
	Welby	3174 E. 78th Ave.	**X**	**X**	**X**	**X**	**X**
Arapahoe	Aurora East	36001 Quincy Ave.				**A**	**A**
	Highland Res.	8100 S. University Blvd.				**X**	**X**
Boulder	South Boulder Creek	1405½ S. Foothills Hwy.				**X**	
	Longmont	440 Main St.	**X**				
Denver	Auraria Lot R	12th St. & Auraria Parkway					**X**
	Denver CAMP	2105 Broadway	**X**	**X**	**X**		**X**
	Denver Carriage	2325 Irving St.				**X**	**X**
	DESCI Building	1901 13th Ave. (Visibility)					
	Firehouse #6	1300 Blake St.	**X**				
	Denver Animal Shelter	678 S. Jason St	+	+	+	**X**	**X**
Douglas	Chatfield Res.	11500 N. Roxborough Pk. Rd.				**X**	**X**
Jefferson	Arvada	9101 W. 57th Ave.				**X**	**X**
	Aspen Park	26137 Conifer Rd.				**A**	**A**
	NREL	2054 Quaker St.				**X**	
	Rocky Flats - N	16600 W. Hwy. 128				**X**	**X**
	Rocky Flats - SE	9901 Indiana St.					**X**
	Welch	12400 W. Hwy. 285				**X**	**X**
Larimer	Fort Collins - Mason	708 S. Mason St.	**X**			**X**	**X**
	Rist Canyon	11835 Rist Canyon Rd.				**A**	**A**
	Fort Collins - Viz	300 Remington St. (Visibility)					
	Fort Collins - West	3416 W. La Porte Ave.				**X**	
Weld	Greeley – West Annex	905 10th Ave.	**X**				
	Weld County Tower	3101 35th Ave.				**X**	+
Southern Front Range Counties							
El Paso	Colorado Springs	USAFA Rd. 640				**X**	
	Colorado Springs	690 W. Hwy. 24	**X**				+
	Manitou Springs	101 Banks Pl.				**X**	
Western Counties							
Garfield	Rifle - Health	195 W. 14th Ave.				**X**	
Mesa	Grand Junction	645¼ Pitkin Ave.	**X**				**X**
	Palisade Water Treatment	865 Rapid Creek Dr.				**X**	**X**
Montezuma	Cortez	106 W. North Ave.				**X**	

(X) – Continued, (A) – Added, (D) – Discontinued, (+) – to be added by end of 2010

Table 2. Statewide Particulate Monitors in Operation for 2009

County	***Site Name***	***Location***	***TSP***	***Pb***	***PM_{10}***	***$PM_{2.5}$***
Eastern Plains Counties						
Elbert	Elbert	24950 Ben Kelly Rd				**X**
Prowers	Lamar - Power Plant	100 2nd St.			**X**	
	Lamar - Municipal	104 Parmenter St.			**X**	
Northern Front Range Counties						
Adams	Commerce City	7101 Birch St.			**X**	**X/H/S**
	Welby	3174 E. 78th Ave.			**X/H**	
Arapahoe	Arapahoe Comm. College	6190 S. Santa Fe Dr.				**X**
	Centennial Airport	7800 S. Peoria St.	**A**	**A**		
Boulder	Longmont - City Hall	350 Kimbark St.			**X**	**X/H**
	Boulder - Chamber	2440 Pearl St.			**X**	**X**
	Boulder - CU/Athens	2102 Athens St.				**H**
Denver	Denver CAMP	2105 Broadway			**X/H**	**X/H**
	Denver NJH	14th Ave. & Albion St.				**H**
	Denver Visitor Center	225 W. Colfax Ave.			**X**	
	Denver Animal Shelter	678 S. Jason St.	**X**	**X**	**X/H**	**X/H**
	Swansea Elementary Sch.	4650 Columbine St.				**X**
Douglas	Chatfield Reservoir	11500 Roxborough Park Rd.				**X/H**
Larimer	Fort Collins - CSU	251 Edison St.			**X**	**X**
Weld	Greeley - Hospital	1516 Hospital Rd.			**X**	**X/H**
	Platteville	1004 Main St.				**X/S**
Southern Front Range Counties						
Alamosa	Alamosa - ASU	208 Edgemont Blvd.			**X**	
	Alamosa- Municipal	425 4th St.			**X**	
El Paso	Colorado College	130 W. Cache la Poudre			**X**	**X/H**
Fremont	Cañon City	128 Main St.			**X**	
Pueblo	Pueblo	211 E. D St.			**X**	**X**
Mountain Counties						
Archuleta	Pagosa Springs	309 Lewis St.			**X**	
Gunnison	Crested Butte	603 6th St.			**X**	
	Mt. Crested Butte	19 Emmons Rd.			**X**	
Pitkin	Aspen	120 Mill St.			**X/H**	
Routt	Steamboat Springs	136 6th St.			**X**	
Summit	Breckenridge	501 N. Park Ave.			**X**	
Western Counties						
Delta	Delta	560 Dodge St.			**X**	
Garfield	Parachute	100 E. 2nd St.			**X**	
	Rifle - Henry Building	144 E. 3rd Ave.			**X**	**X/H**
La Plata	Durango - River City Hall	1235 Camino del Rio			**X**	
Mesa	Grand Junction - Powell	650 South Ave.			**X**	**X/H/S**
	Grand Junction - Pitkin	645 ¼ Pitkin Ave.			**X/H**	
	Clifton	141 & D St.			**X**	
Montezuma	Cortez	106 W. North St.				**X**
San Miguel	Telluride	333 W. Colorado Ave.			**X**	

(X) – Continued, (A) – Added, (D) – Discontinued, (H) – Hourly particulate monitor, (S) – Chemical Speciation

2. Criteria Pollutants

Criteria pollutants are those for which the federal government has established ambient air quality standards in the Federal Clean Air Act and its amendments. There are six criteria pollutants. They are carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead, and particulate matter split into two size fractions. The standards for criteria pollutants are established to protect the most sensitive members of society. These are usually defined as those with heart and / or respiratory problems, the very young, and the elderly. The standards for each of the criteria pollutants are discussed in the following sections. A summary of these levels are presented in Table 3 (1). Nitrogen dioxide and sulfur dioxide have new one-hour standards beginning in 2010. These standards are mentioned in the table below but are not considered for the 2009 data set. The primary standards are set to protect human health. The secondary standards are set to protect public welfare, and take into consideration such factors as crop damage, architectural damage, damage to ecosystems, and visibility in scenic areas.

Table 3. National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
CO (1)	9 ppm (10 µg/m^3)	8-hour	None	
	35 ppm (40 µg/m^3)	1-hour		
Pb	0.15 µg/m^3 (2)	Rolling 3-Month Average	Same as Primary	
	1.5 µg/m^3	Quarterly Average	Same as Primary	
NO_2	53 ppb (3)	Annual (Arithmetic Avg.)	Same as Primary	
	100 ppb	1-hour (4)	None	
PM_{10}	150 µg/m^3	24-hour (5)	Same as Primary	
$PM_{2.5}$	15.0 µg/m^3	Annual (Arithmetic Avg.) (6)	Same as Primary	
	35 µg/m^3	24-hour (7)	Same as Primary	
O_3	0.075 ppm	8-hour (8)	Same as Primary	
SO_2	0.03 ppm	Annual (Arithmetic Avg.)	0.5 ppm	3-hour (1)
	0.14 ppm	24-hour (1)		
	75 ppb (9)	1-hour	None	

1 Not to be exceeded more than once per year.
2 Final rule signed October 15, 2008.
3 The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.
4 To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).
5 Not to be exceeded more than once per year on average over 3 years.
6 To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
7 To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
8 To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. (effective May 27, 2008).
9 Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

2.1. Exceedance Summary Table

Table 4 is a summary of the sites with exceedances of the ambient air quality standards for Colorado for 2008 and 2009, with the number of exceedances listed for 2009. Exceedances are not necessarily violations of the NAAQS. Violations depend on the form of the standard and are generally based on multi-year averages or multiple exceedances of the standard per year. The form of the PM_{10} standard is discussed in Section 2.2.5.2 below. The changes in the ozone standard are discussed in Section 2.2.2.1 below. The form of the $PM_{2.5}$ standard is discussed in 2.2.6.1 below.

Table 4. Exceedance Summary Table

Location	2008		2009	
	O_3	PM_{10}	O_3	PM_{10}
Alamosa State College				1
Alamosa Municipal		X		1
Arvada			1	
Aspen Park			2	
Aurora East			1	
Boulder Chamber of Commerce				
Chatfield Reservoir	X		3	
Delta Health Department				1
Fort Collins West	X		1	
Grand Junction – Powell				
Greeley Hospital				
Highland			2	
Lamar Municipal				2
Lamar Power Plant		X		3
National Renewable Energy Laboratory	X		2	
Pagosa Springs School				4
Parachute		X		
River City Hall (Durango)				2
Rocky Flats North	X		5	
South Boulder Creek	X		2	
Welby	X		2	
Welch			1	

2.2. General Statistics for Significant Pollutants

The EPA produces a National Emissions Inventory every three years. The latest complete inventory is for 2005. A partial inventory has been done for 2008 though the lead inventory was not completed. However, for 2009, the EPA states that it "is assessing its data systems, including AirData reports and maps. Data updates are suspended while the assessment is underway. The last update included data through January 10, 2009" (2). Because of this, the emissions trends graphs and tables reflect only data through 2008 except for lead which still reflects the 2005 inventory.

Additionally, the EPA's monitor ranking report for 2009 has not yet been published. Monitors across the nation have been ranked in the following sections by the CDPHE, based on maximum relevant concentrations found in the respective references. Should a conflict occur between this report and a future publication of the EPA's monitor ranking, it should be considered that the EPA is correct.

Finally, in this section NAAQS are used in the discussions. This comparison is for reference only because the NAAQS apply to one station and not an average of all concentrations across the state. Section 4 below discusses concentrations in a manner directly relatable to the NAAQS.

2.2.1 Carbon Monoxide

CO is a colorless and odorless gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust, which contributes about 50 percent of all carbon monoxide emissions nationwide. Non-road vehicles account for the remaining carbon monoxide emissions from transportation sources. High concentrations of carbon monoxide generally occur in areas with heavy traffic congestion. In cities, as much as 85 percent of all carbon monoxide emissions may come from automobile exhaust. Peak carbon monoxide concentrations typically occur during the colder months of the year when carbon monoxide automotive emissions are greater, and nighttime inversion conditions (where air pollutants are trapped near the ground beneath a layer of warm air) are more frequent (3).

2.2.1.1 Carbon Monoxide - Standards

The EPA has developed two national standards for carbon monoxide. They are 35 ppm averaged over a 1-hour period and 9 ppm averaged over an 8-hour period. These values are not to be exceeded more than once in a year at the same location. A site will violate the standard with a second exceedance of either the 1-hour or 8-hour standard in the same calendar year. The EPA directive states that comparison with the carbon monoxide standards will be made in integers. Fractions of 0.5 or greater are rounded up, thus, actual concentrations of 9.5 ppm and 35.5 ppm or greater are necessary to exceed the 8-hour and 1-hour standards, respectively (4).

2.2.1.2 Carbon Monoxide - Health Effects

Carbon monoxide affects the central nervous system by depriving the body of oxygen. It enters the body through the lungs, where it combines with hemoglobin in the red blood cells, forming carboxyhemoglobin. Normally, hemoglobin carries oxygen from the lungs to the cells. The oxygen attached to the hemoglobin is exchanged for the carbon dioxide generated by the cell's metabolism. The carbon dioxide is then carried back to the lungs where it is exhaled from the body. Hemoglobin binds approximately 240 times more readily with carbon monoxide than with oxygen.

How quickly the carboxyhemoglobin builds up is a factor of the concentration of the gas being inhaled (measured in parts per million or ppm) and the duration of the exposure. Compounding the effects of the exposure is the long half-life of carboxyhemoglobin in the blood. Half-life is a measure of how quickly levels return to normal. The half-life of carboxyhemoglobin is approximately 5 hours. This means that for a given exposure level, it will take about 5 hours for the level of carboxyhemoglobin in the blood to drop to half its current level after the exposure is terminated.

The health effects of carbon monoxide vary with concentration. At low concentrations, effects include fatigue in healthy people and chest pain in people with heart disease. At moderate concentrations, angina, impaired vision, and reduced brain function may result. At higher concentrations, effects include impaired vision and coordination, headaches, dizziness, confusion and nausea. It can cause flu-like symptoms that clear up after leaving the polluted area. Carbon monoxide is fatal at very high concentrations.

The EPA has concluded that the following groups may be particularly sensitive to carbon monoxide exposures: angina patients, individuals with other types of cardiovascular disease, persons with chronic obstructive pulmonary disease, anemic individuals, fetuses, and pregnant women. Concern also exists for healthy children because of increased oxygen requirements that result from their higher metabolic rate (5).

2.2.1.3 Carbon Monoxide – Emissions and Sources

The 2008 National Emissions Inventory estimates that 50 percent of carbon monoxide emissions are from highway vehicle sources. They also estimate that off-highway sources contribute an additional 23 percent of emissions. Table 5 gives a breakdown of carbon monoxide emissions by source for 2008 (6). Figure 2 illustrates the downward trend of national carbon monoxide emissions from 1970 through 2008.

Table 5. Carbon Monoxide National Emissions for 2008

Description	National	
	Thousand-Tons/Year	Percent
Fuel Combustion – Electrical Utilities	699	0.9
Fuel Combustion - Industrial	1,216	1.6
Fuel Combustion - Other	3,369	4.3
Chemical Processing/Mfg	265	0.3
Metal Processing	947	1.2
Petroleum Processing	355	1.5
Other Industrial Processes	500	0.6
Solvent Utilization	2	0.0
Storage & Transportation	115	0.2
Waste Disposal & Recycling	1,584	2.0
Highway Vehicles	38,866	50.0
Off- Highway	18,036	23.2
Miscellaneous	11,731	15.1
Total	***77,685***	***100.0***

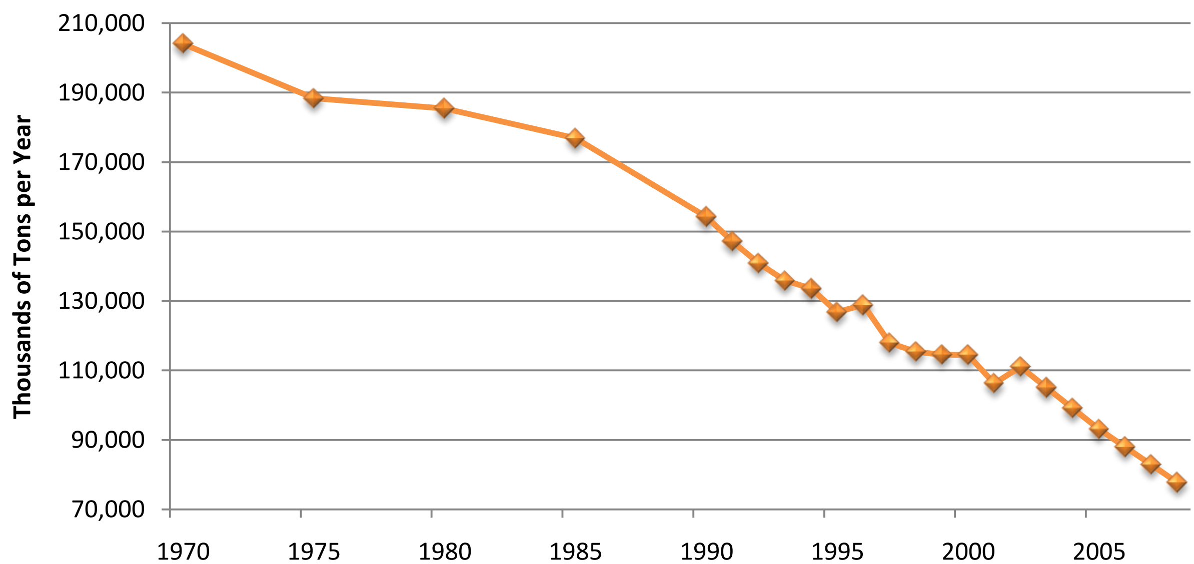


Figure 2. Changes in National Carbon Monoxide Emissions from 1970 to 2008

2.2.1.4 Carbon Monoxide – Statewide Summaries

Carbon monoxide concentrations have dropped dramatically from the early 1970s. This change can be seen in both the concentrations measured and the number of monitors that exceeded the level of the 8-hour standard. In 1975, 9 of the 11 (81%) state-operated monitors exceeded the 8-hour standard. In 1980, 13 of the 17 (77%) state-operated monitors exceeded the 8-hour standard. Since 1996 none of the state-operated monitors have recorded a violation of the 8-hour standard. In 2009 the highest statewide 2nd maximum 8-hour concentration was 2.6 ppm recorded at the Colorado Springs monitor located at 690 Highway 24.

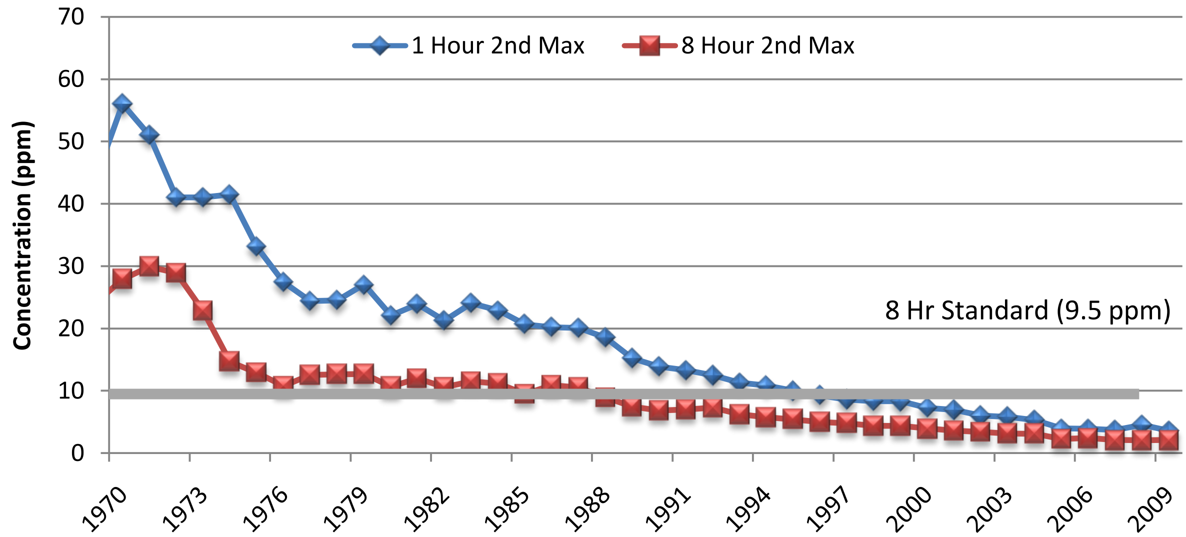


Figure 3. Statewide Ambient Trends for Carbon Monoxide

Figure 3 shows the trend of the statewide average for the second maximum 1-hour and 8-hour concentrations for carbon monoxide between 1970 and 2009 by averaging sites state-wide. There are two important notes. First, before 1989 the average 2nd maximum 8-hour concentration for all state-operated carbon monoxide monitors was greater than the 8-hour standard of 9.5 ppm. Second, for the last several years the downward trend in concentrations has continued, but at a slower rate. The statewide average 8-hour concentration is now less than half of the standard.

The trend in the second maximum1-hour average carbon monoxide concentrations statewide has fallen more dramatically than the 8-hour concentrations. The maximum 1-hour concentration ever recorded at any of the state-operated monitors was a 79.0 ppm recorded at the Denver CAMP monitor in 1968. In 2009, the maximum 1-hour concentration recorded was 6.9 ppm recorded at the Denver CAMP monitor. The 1-hour annual maximum concentrations have declined from more than twice the standard in the late 1960s to about one quarter of the standard. Table 6 presents the historical maximum values (7).

Table 6. Historical Maximum 1-Hour and 8-Hour Carbon Monoxide Concentrations

1-Hour (ppm)	Location	Date	Number of Annual Exceedances	8-Hour (ppm)	Location	Date	Number of Annual Exceedances
79.0	CAMP	11-20-68	13	48.1	CAMP	12-21-73	133
70.0	CAMP	11-21-74	15	33.9	CAMP	12-28-65	197
67.0	CAMP	12-21-73	21	33.4	CAMP	12-04-81	42
65.0	CAMP	12-21-73	21	33.2	CAMP	12-23-71	188
64.9	NJH-W	11-16-79	15	33.1	CAMP	11-20-68	98
2009 Maximum Carbon Monoxide Concentration							
6.9	CAMP	01-27-09	0	2.6	Highway 24	12-29-09	0

2.2.1.5 Carbon Monoxide – National Comparisons

According to the EPA's emissions trends report, between 1980 and 2008, national average ambient carbon monoxide concentrations decreased 79 percent (6). The National Ranking of Carbon Monoxide monitors in 1998 showed that the top sixteen monitors recorded at least one exceedance of the 8-hour carbon monoxide standard with nine monitors reporting two or more exceedances (8). In 2009, no monitor reported an exceedance of the level of the 1-hour standard. This data is illustrated in Table 7 below (7).

Table 7. National Ranking of Carbon Monoxide Monitors by 8-hour Concentrations in ppm

Nationwide (353 monitors)					Colorado (9 Monitors)				
National Rank	**City/Area**	**Max**	**2nd Max**	**# ≥9.5**	**National Rank**	**City/Area**	**Max**	**2nd Max**	**# ≥9.5**
1	Calexico, CA	7.5	5.5	0	58	Highway 24	2.6	1.9	0
2	Cleveland, OH	7.1	6.6	0	70	CAMP	2.5	2.2	0
3	Birmingham, AL	7.0	6.7	0	89	Greeley Annex	2.3	2.1	0
4	Anchorage, AK	6.1	5.8	0	109	Pitkin	2.2	2.2	0
5	Ogden, UT	6.0	2.9	0	129	Welby	2	1.9	0

2.2.2 Ozone

Ozone (O_3) is a gas composed of three oxygen atoms. It is not usually emitted directly into the air, but at ground-level is created by a chemical reaction between oxides of nitrogen (NO_X) and volatile organic compounds (VOC) in the presence of sunlight. Ozone has the same chemical structure whether it occurs miles above the earth or at ground-level and can be "good" or "bad," depending on its location in the atmosphere.

In the earth's lower atmosphere, ground-level ozone is considered "bad." Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents as well as natural sources emit NO_X and VOCs that help form ozone. Ground-level ozone is the primary constituent of smog. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air. As a result, it is known as a summertime air pollutant. Many urban areas tend to have high levels of "bad" ozone, but even rural areas are also subject to increased ozone levels because wind carries ozone and pollutants that form it hundreds of miles away from their original sources.

In the troposphere, the air closest to the Earth's surface, ground-level or "bad" ozone is a pollutant that is a significant health risk, especially for children with asthma. It also damages crops, trees and other vegetation. It is a main ingredient of urban smog.

In the stratosphere the "good" ozone layer extends upward from about 6 to 30 miles and protects life on Earth from the sun's harmful ultraviolet (UV) rays. This natural shield has been gradually depleted by man-made chemicals like chlorofluorocarbons (CFCs). A depleted ozone shield allows more UV from the sun to reach the ground, leading to more cases of skin cancer, cataracts, and other health problems." (9)

2.2.2.1 Ozone - Standards

In May 2008, the EPA established a new ozone standard. The reasons for these changes were: *"Based on its review of the air quality criteria for ozone (O_3) and related photochemical oxidants and national ambient air quality standards (NAAQS) for O_3, EPA is making revisions to the primary and secondary NAAQS for O_3 to provide requisite protection of public health and welfare, respectively. With regard to the primary standard for O_3, EPA is revising the level of the 8-hour standard to 0.075 parts per million (ppm), expressed to three decimal places. With regard to the secondary standard for O_3, EPA is revising the current 8-hour standard by making it identical to the revised primary standard."*(10)

In January 2010 EPA proposed stricter standards for smog. The EPA is examining the epidemiological and clinical studies available. Pending results of the scientific review, EPA intends to set a final standard by the end of July, 2011, expected to be between 0.060 and 0.070 ppm. For more details, see http://www.epa.gov/air/ozonepollution/pdfs/fs20100106std.pdf.

2.2.2.2 Ozone - Health Effects

Exposure to ozone has been linked to a number of health effects, including significant decreases in lung function, inflammation of the airways, and increased respiratory symptoms, such as cough and pain when taking a deep breath. Exposure can also aggravate lung diseases such as asthma, leading to increased medication use and increased hospital admissions and emergency room visits. Active children are the group at highest risk from ozone exposure because they often spend a large part of the summer playing outdoors. Children are also more likely to have asthma, which may be aggravated by ozone exposure. Other at-risk groups include adults who are active outdoors (e.g., some outdoor workers) and individuals with lung diseases such as asthma and chronic obstructive pulmonary disease. In addition, long-term exposure to moderate levels of ozone may cause permanent changes in lung structure, leading to premature aging of the lungs and worsening of chronic lung disease.

Ozone also affects vegetation and ecosystems, leading to reductions in agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests, and other environmental stresses (e.g., harsh weather). In long-lived species, these effects may become evident only after several years or even decades and may result in long-term effects on forest ecosystems. Ground level ozone injury to trees and plants can lead to a decrease in the natural beauty of our national parks and recreation areas (11).

2.2.2.3 Ozone – Emissions and Sources

Ozone is not emitted directly from a source, as are other pollutants, but forms as a secondary pollutant. Its precursors are certain reactive hydrocarbons and oxides of nitrogen, which react chemically in sunlight to form ozone. The main sources for these reactive hydrocarbons are automobile exhaust, gasoline, oil storage and transfer facilities, industrial paint solvents, degreasing agents, cleaning fluids, and ink solvents. High temperature combustion combines nitrogen and oxygen in the air to form oxides of nitrogen. Vegetation can also emit reactive hydrocarbons such as terpenes from pine trees (11).

Although some ozone is produced all year, the highest concentrations usually occur in the summer. The stagnant air and intense sunlight on hot, bright summer days provide the conditions for the precursor chemicals to react and form ozone. The ozone produced under these stagnant summer conditions remains as a coherent air mass and can be transported many miles from its point of origin. The way to reduce ozone in the atmosphere is to reduce the compounds that react to form it. Table 8 and Figure 4 are included in the ozone section because of the importance of volatile organic compounds (VOC's) in the formation of ozone. Emissions of oxides of nitrogen, which are the other key items for ozone formation, are shown in Table 8 (12) and Figure 4.

Table 8. VOC National Emissions for 2008

Description	**National**	
	Thousand-Tons/Year	**Percent**
Fuel Combustion – Electrical Utilities	50	0.3
Fuel Combustion - Industrial	130	0.8
Fuel Combustion - Other	1,269	8.0
Chemical Processing/Mfg	228	1.4
Metal Processing	46	0.3
Petroleum Processing	561	3.5
Other Industrial Processes	404	2.5
Solvent Utilization	4,226	26.5
Storage & Transportation	1,303	8.2
Waste Disposal & Recycling	374	2.3
Highway Vehicles	3,418	21.5
Off- Highway	2,586	16.2
Miscellaneous	1,332	8.4
Total	***15,927***	***100.0***

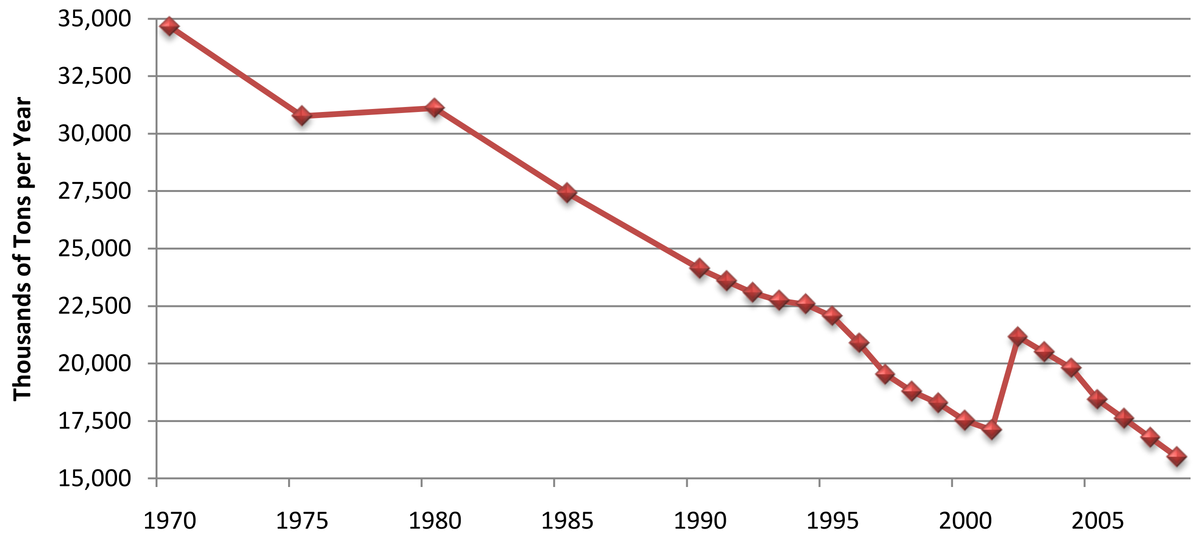


Figure 4. Changes in National VOC Emissions from 1970 to 2008

2.2.2.4 Ozone – Statewide Summaries

In the past, this report has focused on a now revoked 1-hour ozone standard, and used a simple linear regression to discuss a reduction in 1-hour ozone concentrations. This decline in concentrations since 1985 was more apparent in the 1-hour than in the 8-hour ozone averages that are applicable to current standards. A complete analysis of the trend in ozone values over time is more complex than the simple linear regression since it must deal with variations in meteorological conditions from year to year.

As illustrated in Figure 5, an average of sites state-wide, O_3 averages have fluctuated around the standard. In recent years, the trend has been downward, but the averages seem to fluctuate within the amount of variance seen for the last several years.

Ozone monitoring began in 1972 at the Denver CAMP station, and eight exceedances of the then-applicable 1-hour standard were recorded that year. Table 9 lists the 5 highest 8-hour ozone concentrations recorded in Colorado (13). Note that four of the top five were within the first two years of ozone monitoring.

Table 9. Historical Maximum 8-Hour Ozone Concentrations

8-Hour ppm	Monitor	Date
0.310	Denver CAMP	1972
0.264	Denver CAMP	1973
0.198	Arvada	1973
0.194	Denver Carriage (CARIH at the time)	1973
0.146	Denver CAMP	1980
2009 Maximum Ozone Concentration		
0.086	Rocky Flats North	08-22-09

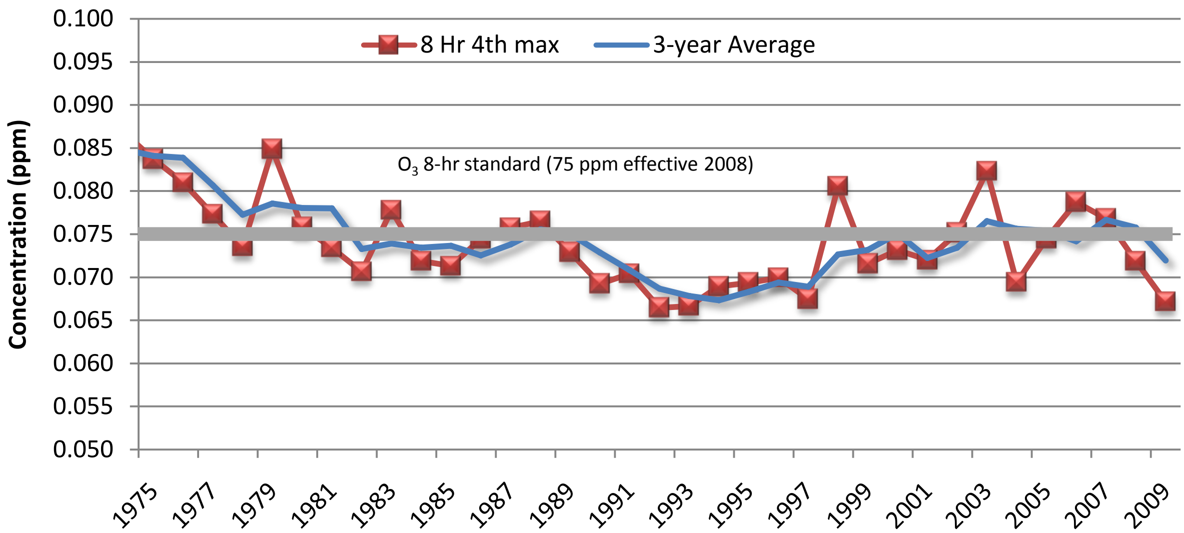


Figure 5. Statewide Ambient Trends for Ozone

2.2.2.5 Ozone – National Comparisons

Between 1990 and 2007, NO_X and VOC emissions have declined 33 percent and 35 percent respectively. These are two of the primary factors in ozone production. This decline has been accomplished in spite of increases in energy consumption (up 20 percent), population (up 21 percent), vehicle miles traveled (up 45 percent) and gross national product (up 63 percent) (14). Table 10 lists the five highest ranked ozone monitors nationwide and in Colorado (13).

Table 10. National Ranking of Ozone Monitors by 8-hour Concentration in ppm

Nationwide (1,230 Monitors)					Colorado (27 Monitors)				
National Rank	**City/Area**	**Max**	**2nd Max**	**Days ≥0.075**	**National Rank**	**City/Area**	**Max**	**2nd Max**	**Days ≥0.075**
1	Ukiah, CA	0.187	0.108	3	146	Rocky Flats North	0.086	0.085	5
2	Yosemite National Park	0.133	0.076	2	164	Chatfield Reservoir	0.085	0.078	3
3	Fontana, CA	0.128	0.104	48	189	South Boulder Creek	0.084	0.079	2
4	San Bernardino, CA	0.126	0.102	61	238	Fort Collins West	0.082	0.074	1
5	Santa Clara, CA	0.122	0.104	64	268	NREL	0.081	0.076	2

2.2.3 Sulfur Dioxide

Sulfur dioxide (SO_2) belongs to the family of sulfur oxide gases. These gases dissolve easily in water. Sulfur is prevalent in all raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. Sulfur dioxide gases are formed when fuel containing sulfur, such as coal and oil, is burned, when gasoline is extracted from oil, or metals are extracted from ore. Sulfur dioxide dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and their environment (15).

2.2.3.1 Sulfur Dioxide - Standards

There are three primary standards for sulfur dioxide. The first is a long-term, one year arithmetic average not to exceed 0.03 ppm. The second is a short-term, 24-hour average where concentrations are not to exceed 0.14 ppm more than once per year. Beginning on June 22, 2010, a third standard for sulfur dioxide was introduced as a 3-year average of the 99th percentile of the daily maximum 1-hour average not to exceed 0.075 ppm. While the first two standards are revoked as of the final rule on the 0.075 ppm standard, they were still in use during 2009. The secondary standard is a 3-hour average not to exceed 0.5 ppm more than once per year (16).

2.2.3.2 Sulfur Dioxide - Health Effects

High concentrations of sulfur dioxide can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Short-term exposures of asthmatic individuals to elevated sulfur dioxide levels during moderate activity may result in breathing difficulties that can be accompanied by symptoms such as wheezing, chest tightness, or shortness of breath. Other effects that have been associated with longer-term exposures to high concentrations of sulfur dioxide, in conjunction with high levels of particulate matter, include aggravation of existing cardiovascular disease, respiratory illness, and alterations in the lungs' defenses. The subgroups of the population that may be affected under these conditions include individuals with heart or lung disease, as well as the elderly and children (17). Sulfur dioxide also is a major precursor to $PM_{2.5}$, which is a significant health concern, and a main contributor to poor visibility (18).

2.2.3.3 Sulfur Dioxide – Emissions and Sources

Nationwide, over 66 percent of sulfur dioxide released to the air, or more than 7 million tons per year, comes from electric utilities, especially those that burn coal. Other sources of sulfur dioxide are industrial facilities that derive their products from raw materials like metallic ore, coal, and crude oil, or that burn coal or oil to produce process heat. Examples are petroleum refineries, cement manufacturing, and metal processing facilities. Also, locomotives, large ships, and some non-road diesel equipment currently burn high sulfur fuel and release sulfur dioxide emissions to the air in large quantities (15). Table 11 (19) and Figure 6 illustrate the national emissions quantities and trends for sulfur dioxide.

Table 11. Sulfur Dioxide National Emissions For 2008

Description	National	
	Thousand-Tons/Year	Percent
Fuel Combustion – Electrical Utilities	7,552	66.1
Fuel Combustion - Industrial	1,670	14.6
Fuel Combustion - Other	578	5.1
Chemical Processing/Mfg	255	2.1
Metal Processing	203	1.8
Petroleum Processing	206	21.8
Other Industrial Processes	329	2.9
Solvent Utilization	0	0.0
Storage & Transportation	4	0.0
Waste Disposal & Recycling	27	0.2
Highway Vehicles	64	0.6
Off- Highway	456	4.0
Miscellaneous	85	0.7
Total	***11,472***	***100.0***

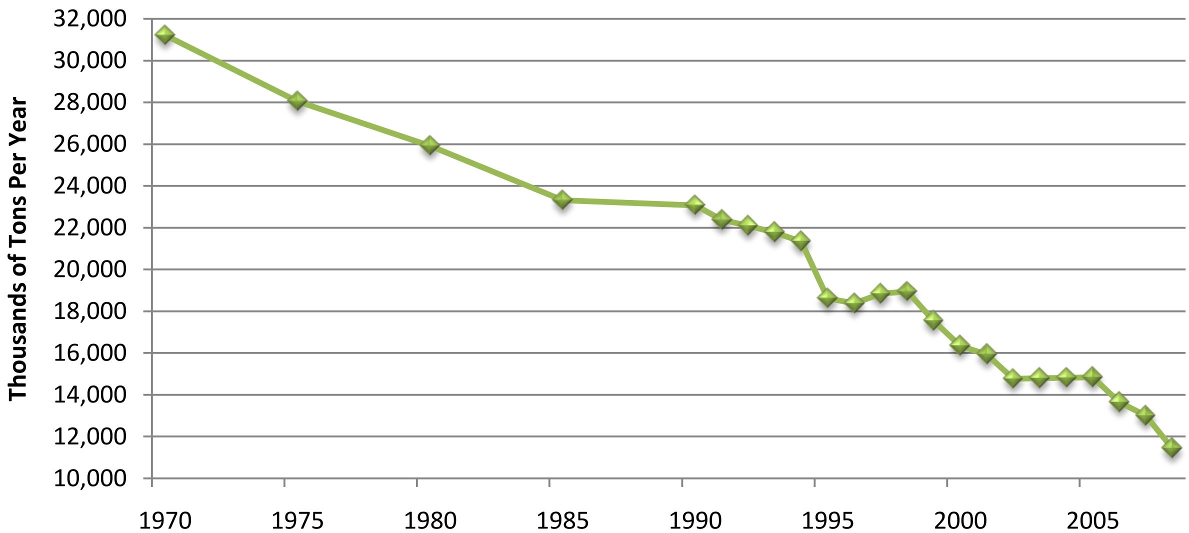


Figure 6. Changes in National Sulfur Dioxide Emissions from 1970 to 2008

2.2.3.4 Sulfur Dioxide – Statewide Summaries

The concentrations of sulfur dioxide in Colorado have never been a major health concern since we have few industries that burn large amounts of coal. The concern in Colorado with sulfur dioxide has been associated with acid deposition and its effects on the mountain lakes and streams, as well as the formation of fine aerosols. Historically the maximum annual concentration recorded by APCD monitors was 0.018 ppm in 1979 at the Denver CAMP monitor. The annual standard is 0.030 ppm. Since 1990, the annual average at the Denver CAMP monitor has declined from a high in 1992 of 0.010 ppm to 0.002 ppm in 2009. CAMP only had valid results for 4th quarter 2009.

Table 12 (20) and Figure 7 show both the declining trend in sulfur dioxide readings, as well as the generally low concentrations of sulfur dioxide recorded at the APCD's monitors. This same trend is evident, although not as pronounced, in the 3-hour and 24-hour averages as well.

Table 12. Historical Maximum Annual Average Sulfur Dioxide Concentrations

Annual Average (ppm)	Monitor	Date
0.018	CAMP	1979
0.013	CAMP	1981
0.013	CAMP	1983
0.013	CAMP	1980
0.011	CAMP	1984
2009 Maximum Sulfur Dioxide Concentration		
0.001	Welby	2009

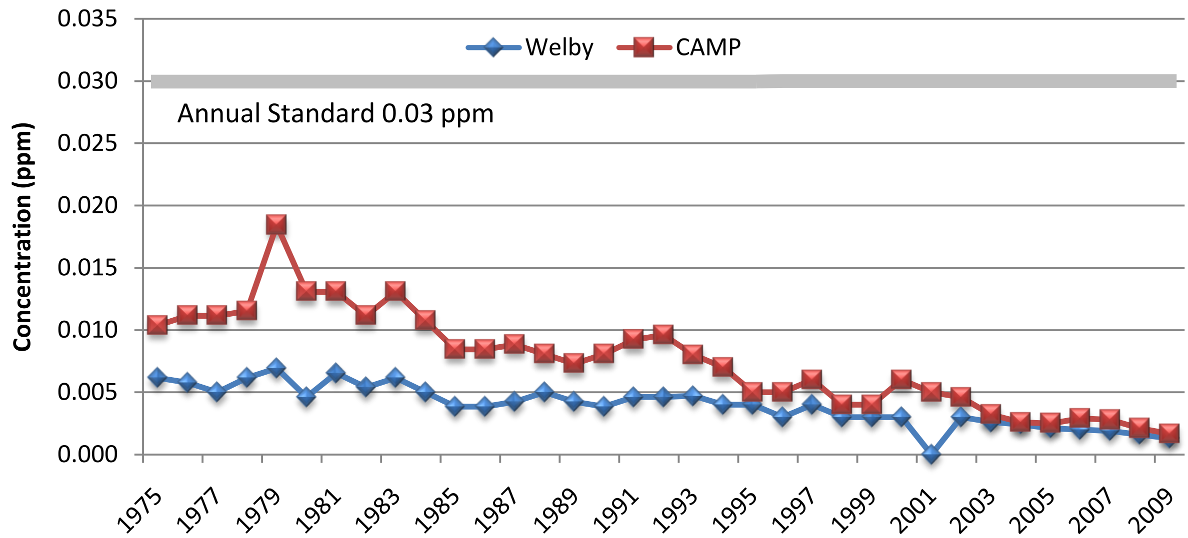


Figure 7. Statewide Ambient Trends for Sulfur Dioxide

2.2.3.5 Sulfur Dioxide – National Comparisons

"Nationally, average sulfur dioxide ambient concentrations have decreased 71 percent from 1980 to 2008 and 37 percent over the more recent 10-year period of 1999 to 2008. Reductions in sulfur dioxide concentrations and emissions since 1990 are due, in large part, to controls implemented under EPA's Acid Rain Program beginning in 1995." (17) Table 13 lists the national ranking of sulfur dioxide monitors by 24-hour concentration nationwide, and for the State of Colorado. (20)

Table 13. National Ranking of Sulfur Dioxide Monitors by 24-hour Concentration in ppm

Nationwide (470 Monitors)					Colorado (2 Monitors)				
National Rank	City/Area	Max	2nd Max	#>0.14	National Rank	City/Area	Max	2nd Max	#>0.14
1	Hawaii VNP, HI	0.370	0.349	27	279	Welby	0.008	0.006	0
2	3150 Pikake St., HI	0.290	0.215	19	323	Denver CAMP	0.006	0.005	0
3	860 Volcano Road, HI	0.217	0.183	2					
4	Mountain View, HI	0.159	0.105	1					
5	Chalmette, LA	0.116	0.108	0					

2.2.4 Nitrogen Dioxide

In its pure state, NO_2 is a reddish brown gas with a characteristic pungent odor. It is corrosive and a strong oxidizing agent. As a pollutant in ambient air, however, it is virtually colorless and odorless. NO_2 can be an irritant to the eyes and throat. Oxides of nitrogen (nitric oxide and NO_2) are formed when the nitrogen and oxygen in the air are combined in high temperature combustion.

2.2.4.1 Nitrogen Dioxide – Standards

The standard for NO_2 was first established by the EPA in 1971. Both the primary standard, to protect public health, and the secondary standard, to protect public welfare, were set as an annual average of 0.053 ppm or 53 ppb. On June 26, 2009, EPA proposed to strengthen the primary National Ambient Air Quality Standards for nitrogen dioxide. The proposed changes would protect public health, especially the health of sensitive populations, people with asthma, children, and the elderly.

On January 22, 2010, EPA established a new 1-hour nitrogen dioxide standard at 100 ppb, over a 3-year average of the 98^{th} percentile of the annual distribution of daily 1-hour maximum nitrogen dioxide concentrations. This new standard does not alter the existing standard of 0.053 ppm annual average, and as with sulfur dioxide, was not in place during 2009 (21).

2.2.4.2 Nitrogen Dioxide – Health Effects

Elevated concentrations of nitrogen dioxide cause respiratory distress, degradation of vegetation, clothing, and visibility, and increased acid deposition. Nitrate aerosols, which result from nitric oxide and nitrogen dioxide combining with water vapor in the air, have been consistently linked to Denver's visibility problems. Nitrogen dioxide also causes concern with the formation of fine aerosols.

2.2.4.3 Nitrogen Dioxide – Emissions and Sources

Nationally, about 58 percent of the oxides of nitrogen emissions come from on and off-road vehicles and about 36 percent come from industrial sources (22). In Denver, about 44 percent of the emissions of nitrogen dioxide in the Denver area come from large combustion sources such as power plants. Almost 33 percent comes from motor vehicles, 15 percent from space heating, 3 percent from aircraft and 5 percent from miscellaneous off-road vehicles. Minor sources include fireplaces and woodstoves and high temperature combustion processes used in industrial work (23). Table 14 (24) and Figure 8 illustrate the oxides of nitrogen emissions values and trends.

Table 14. Oxides of Nitrogen National Emissions for 2008

Description	National	
	Thousand-Tons/Year	**Percent**
Fuel Combustion – Electrical Utilities	3,006	18.4
Fuel Combustion - Industrial	1,838	11.2
Fuel Combustion - Other	727	4.4
Chemical Processing/Mfg	67	0.4
Metal Processing	68	0.4
Petroleum Processing	350	2.1
Other Industrial Processes	418	2.6
Solvent Utilization	6	0.0
Storage & Transportation	18	0.1
Waste Disposal & Recycling	120	0.7
Highway Vehicles	5,206	31.9
Off- Highway	4,255	26.0
Miscellaneous	260	1.6
Total	***16,339***	***100.0***

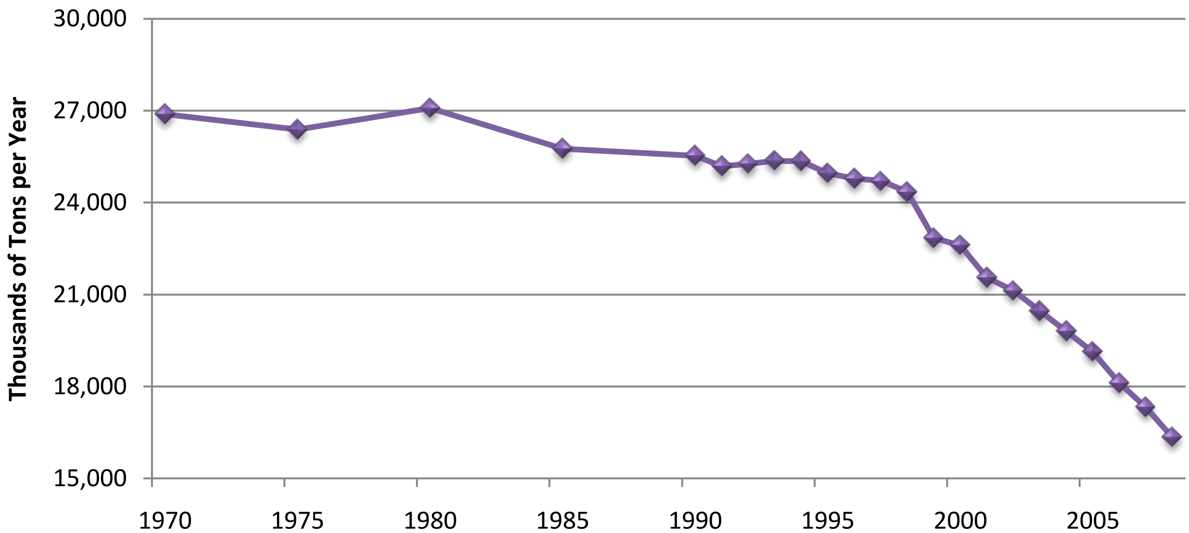


Figure 8. Changes in National Oxides of Nitrogen Emissions from 1970 to 2008

2.2.4.4 Nitrogen Dioxide – Statewide Summaries

Colorado exceeded the NO_2 standard in 1977 at the Denver CAMP monitor. Concentrations have shown a gradual decline for the past 20 years. However, the trend of annual averages for the past ten years has been nearly flat. Figure 14 shows that levels have declined at the Welby monitor over the past ten years while the annual average at the Denver CAMP monitor has shown little to no change at all. The cause of this is most likely due to an increase in the number of vehicles and increased power generation associated with the increases in population in the Denver-metro area. CAMP only had valid results for 4th quarter 2009. Table 15 (25) and Figure 9 illustrate the NO_2 trends for the State of Colorado.

Table 15. Historical Maximum Annual Average Nitrogen Dioxide Concentrations

Annual Average (ppm)	Monitor	Date
0.0540	CAMP	1977
0.0523	CAMP	1983
0.0517	CAMP	1979
0.0515	CAMP	1975
0.0515	CAMP	1976
2009 Maximum Nitrogen Dioxide Concentration		
0.0308	CAMP	2009

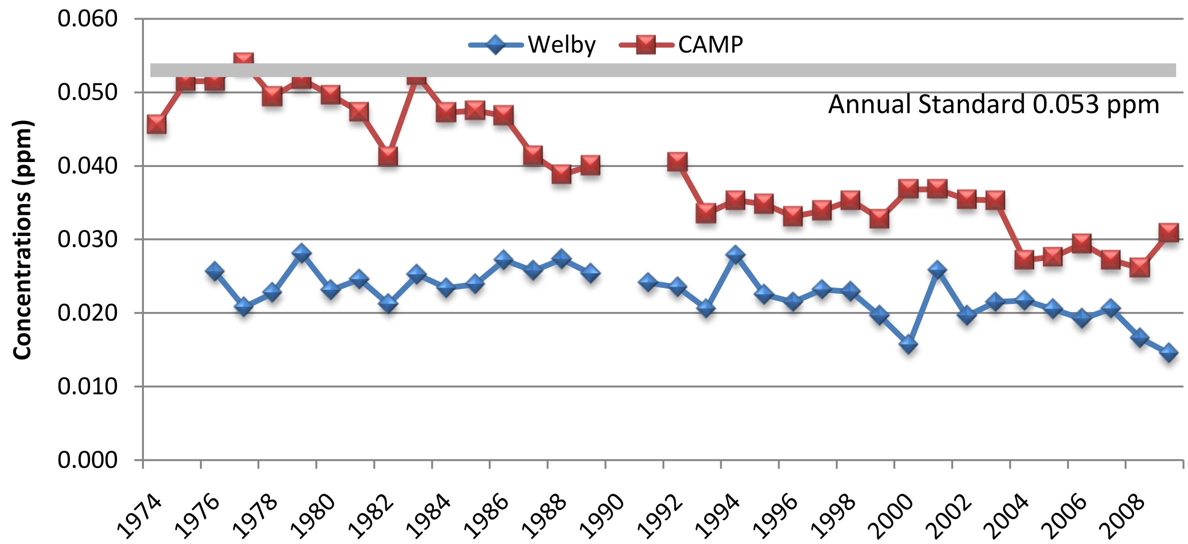


Figure 9. Statewide Ambient Trends for Nitrogen Dioxide

2.2.4.5 Nitrogen Dioxide – National Comparisons

"Since 1983, monitored levels of nitrogen dioxide have decreased 21 percent. These downward trends in national nitrogen dioxide levels are reflected in all regions of the country. Nationally, average nitrogen dioxide concentrations are well below the NAAQS and are currently at the lowest levels recorded in the past 20 years. All areas of the country that once violated the NAAQS for nitrogen dioxide now meet that standard. Over the past 20 years, national emissions of oxides of nitrogen have declined by almost 15 percent. While overall oxides of nitrogen emissions are declining, emissions from some sources such as nonroad engines have actually increased since 1983. These increases are of concern given the significant role oxides of nitrogen emissions play in the formation of ground-level ozone (smog) as well as other environmental problems like acid rain and nitrogen loadings to water bodies described above. In response, EPA has proposed regulations that will significantly control oxides of nitrogen emissions from nonroad diesel engines" (26) including construction and mining vehicles as well as power generators.

Table 16 shows national and state ranking for nitrogen dioxide monitors (25). The annual mean for all Colorado sites is well below the annual NAAQS of 0.053 ppm.

Table 16. National Ranking of Nitrogen Dioxide Monitors by 1-hour Concentration in ppm

Nationwide (400 Monitors)					**Colorado (5 Monitors)**				
National Rank	**City/Area**	**1-hr Max**	**2nd Max**	**Annual Mean**	**National Rank**	**City/Area**	**1-hr Max**	**2nd Max**	**Annual Mean**
1	Middlesex County, MA	0.197	0.095	0.015	44	Welby	0.084	0.072	0.014
2	New York City, NY	0.153	0.133	0.025	56	Denver CAMP	0.080	0.069	0.031
3	St. Louis, MO	0.148	0.080	0.013	136	La Plata 7001	0.060	0.056	0.008
4	Wind Cave National Park, SD	0.135	0.047	0.001	207	La Plata 7003	0.051	0.049	0.007
5	Northbrook, IL	0.133	0.128	0.015	345	Weminuche Wilderness Area	0.031	0.022	0.002

2.2.5 PM_{10}

Particle pollution is a mixture of microscopic solids and liquid droplets suspended in air. This pollution, also known as particulate matter, is made up of a number of components, including acidic aerosols (such as nitrates and sulfates), organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mold spores).

The size of particles is directly linked to their potential for causing health problems. Small particles, less than 10 micrometers (microns) in diameter, pose the greatest problems. Since PM_{10} contains all particles smaller than 10 microns, $PM_{2.5}$ and ultrafine particles which are <0.1 microns are included in the PM_{10} measurement. The smallest particles, like $PM_{2.5}$, can get deep into the lungs, and some, like ultrafine particles, may even get into the bloodstream. Exposure to such particles can affect both the lungs and heart. Larger particles are of less concern, although they can irritate the eyes, nose, and throat (18).

2.2.5.1 An Explanation of Exceptional Events

In general, in order to qualify for exclusion, a value (or values) has to be associated with a regional natural or exceptional phenomenon, called an “exceptional event”. One such event was the large wind and dust storm that occurred on March 31, 1999 when monitors from Steamboat Springs to Telluride reported high PM_{10} concentrations. Similar exceptional events have been documented in Lamar and Alamosa. These events are not included in NAAQS determinations, not because they are without any health risk but because they are natural and are not reasonably controllable. The EPA must concur on events that the Division flags and documents as exceptional. The Exceptional Events Rule was revised on March 22, 2007, with an effective date of May 21, 2007. The EPA has been much more restrictive on concurring natural events since the revision. Thus, the Division now has twelve exceedances in 2009 on nine separate days in Alamosa, Delta, Durango, Lamar, and Pagosa Springs. These events are being documented as exceptional due to regional dust storms. There are also several other high concentrations (between 98 and 155 $\mu g/m^3$) that were caused by regional dust storms that are being documented as exceptional events. Concentrations between 98 and 155 $\mu g/m^3$ that are located in SIP maintenance areas are allowed by the Exceptional Events Rule to be flagged and documented as exceptional events.

2.2.5.2 PM_{10} - Standards

The nation's air quality standards for particulate matter were first established in 1971 as total suspended particulates and were not significantly revised until 1987, when EPA changed the indicator of the standards to regulate inhalable particles smaller than, or equal to, 10 micrometers in diameter (that's about 1/4 the size of a single grain of table salt).

Ten years later, in 2006, the EPA revised the particulate matter standards, setting separate standards for fine particles ($PM_{2.5}$) and for PM_{10} based on their link to serious health problems ranging from increased symptoms, hospital admissions and emergency room visits for people with heart and lung disease, to premature death in people with heart or lung disease. They decided to retain the existing 24-hour PM_{10} standard of 150 $\mu g/m^3$. The EPA revoked the annual PM_{10} standard, because available evidence does not suggest a link between long-term exposure to the coarse fraction of PM_{10} and health problems. The $PM_{2.5}$ standard covers the non-course fraction of PM_{10}, and is discussed in Section 2.2.6 below.

2.2.5.3 PM_{10} - Health Effects

“…With regard to $PM_{2.5}$, various toxicological and physiological considerations suggest that fine particles may play the largest role in effecting human health. For example, they may be more toxic because they include sulfates, nitrates, acids, metals, and particles with various chemicals adsorbed onto their surfaces. Furthermore, relative to larger particles, particles indicated by $PM_{2.5}$ can be breathed more deeply into the lungs, remain suspended for longer periods of time, penetrate more readily into indoor environments, and are transported over much longer distances. PM_{10}, an indicator for inhalable particles that can penetrate the thoracic region of the lung, consists of particles with an aerodynamic diameter less than or equal to a 10-µm cut point and includes fine particles and a subset of coarse particles. $PM_{10–2.5}$ consists of the PM_{10} coarse fraction defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations and, for regulatory purposes, serves as an indicator for thoracic coarse particles. (27)

The welfare effects of particulate exposure may be the most widespread of all the pollutants. No place on earth has been spared from the particulate pollution generated by urban and rural sources. This is due to the potential for extremely long-range transport of fine particles and chemical reactions that occur in the atmosphere. The effects of particulates range from visibility degradation to climate changes and vegetation damage. General soiling, commonly thought to be just a nuisance, can have long-term adverse effects on building paints and other materials. Acid deposition as particulates can be detected in the most remote areas of the world.

2.2.5.4 PM_{10} – Emissions and Sources

The majority of PM_{10} pollution is from miscellaneous sources, which are mainly fugitive dust sources. Fugitive emissions are those not caught by a capture system and are often due to equipment leaks, earth moving, equipment and vehicles, and windblown disturbances. While the amount of miscellaneous emissions isn't broken down specifically, the miscellaneous category contains sources such as agricultural crops, agricultural livestock, paved road re-suspension, unpaved roads, construction activities, and mining and quarrying (28). Table 17 (29) and Figure 10 illustrate the national emissions trends for PM_{10}.

Table 17. PM_{10} National Emissions for 2008

Description	**National**	
	Thousand-Tons/Year	**Percent**
Fuel Combustion – Electrical Utilities	5.34	3.6
Fuel Combustion - Industrial	330	2.2
Fuel Combustion - Other	466	3.1
Chemical Processing/Mfg	39	0.3
Metal Processing	78	0.5
Petroleum Processing	24	0.2
Other Industrial Processes	967	6.5
Solvent Utilization	8	0.1
Storage & Transportation	57	0.4
Waste Disposal & Recycling	288	1.9
Highway Vehicles	171	1.2
Off- Highway	304	2.1
Miscellaneous	11,540	77.9
Total	***14,806***	***100.0***

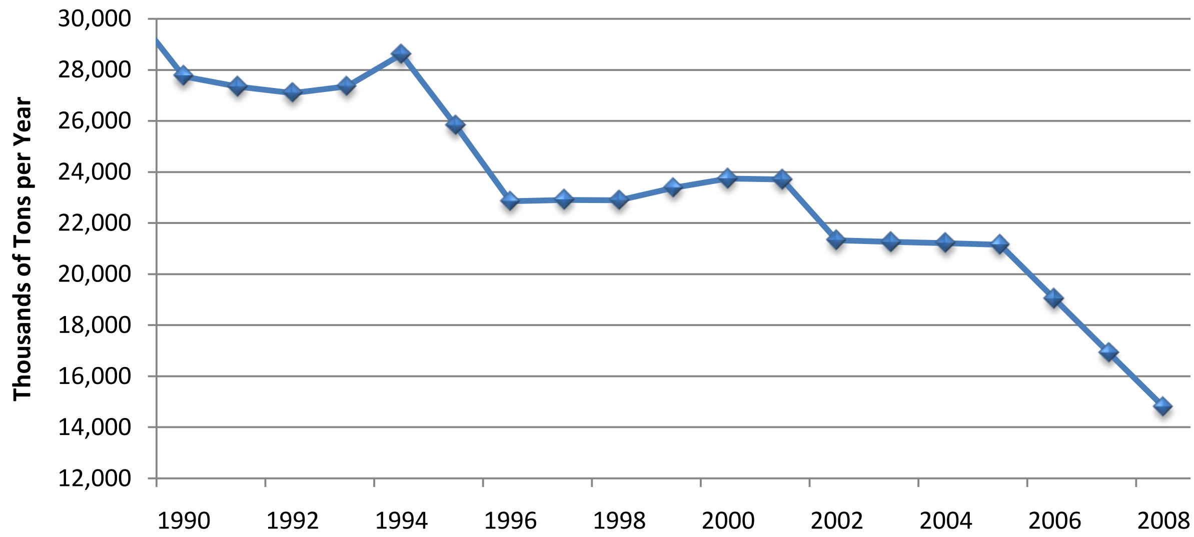


Figure 10. Changes in National PM_{10} Emissions from 1990 to 2008

2.2.5.5 PM_{10} – Statewide Summaries

PM_{10} data have been collected in Colorado since 1985. The samplers were modified in 1987 to conform to the requirements of the new standard when it was established in July of 1987. Therefore, annual trends are only valid back to July 1987. Since 1988, the state has had at least one monitor exceed the level of the 24-hour PM_{10} standard (150 $\mu g/m^3$) every year except 2004. By contrast, no monitor with at least 75 percent data recovery has exceeded the level of the annual standard (50 $\mu g/m^3$).

More so than other pollutants, PM10 is a localized pollutant where concentrations vary considerably. Thus, local averages and maximum concentrations of PM10 are more meaningful than averages covering large regions or the entire state. The APCD has concluded that it is inappropriate to display a state-wide average graph for PM10. Regional averages for all pollutants are discussed in more detail in Section 4 below.

The data contained in Table 18 include those concentrations that are the result of exceptional events (30). See Section 2.2.5.1. There have been several of these events documented in Colorado since PM_{10} monitoring began in 1988.

Table 18. Historical Maximum 24-Hour PM_{10} Concentrations

24-Hour Maximum ($\mu g/m^3$)	Monitor	Date
494	Alamosa - Municipal	06-06-2007
473	Alamosa - ASC	06-06-2007
424	Alamosa - ASC	02-10-2006
412	Alamosa - ASC	04-10-1991
367	Lamar, Power Plant	05-02-2008
2009 Maximum PM_{10} Concentration		
255	Pagosa Springs School	04-03-2009

2.2.5.6 PM_{10} – National Comparisons

In the past several years the top five locations on the list have generally included Keeler, CA; Olancha, CA; the sites around Owens Lake, CA; and sites around Mono Lake, CA. The last two years have seen rankings from Casa Grande in Arizona. All of these levels are associated with hot dry winds. The levels around Owens Lake are associated with the high winds that blow across the large dry lake bed. In the past several years monitors in that area have recorded levels in excess of 20,000 μg/m^3 as a 24-hour average. The nationwide and statewide ranking of PM_{10} monitors can be seen in Table 19 (30).

Table 19. National Ranking of PM_{10} Monitors by 24-hour Maximum Concentration in μg/m^3

Nationwide (1,071 Monitors)					Colorado (39 Monitors)				
National Rank	**City/Area**	**1st Max**	**2nd Max**	**Annual Mean**	**National Rank**	**City/Area**	**1st Max**	**2nd Max**	**Annual Mean**
1	Olancha, CA	1,506	469	23.6	40	Pagosa Springs School	255	225	25
2	Lee Vining, CA	1,461	1,414	41.7	53	Lamar Power Plant	233	174	28.3
3	Casa Grande, AZ	1,445	887	75.3	66	Alamosa - ASC	207	135	20.9
4	North Beach, CA	1,406	416	30.2	69	Durango – River City Hall	203	198	23.3
5	Casa Grande, AZ	848	274	46.6	79	Delta Health Department	186	114	27.2

2.2.6 $PM_{2.5}$

EPA generally defines $PM_{2.5}$ as particulate matter with an aerodynamic diameter less than or equal to 2.5 microns in size. According to the Environmental Protection Agency's Latest Findings on National Air Quality: 2000 Status and Trends, Particulate Matter:

"$PM_{2.5}$ is composed of a mixture of particles directly emitted into the air and particles formed in the air by the chemical transformation of gaseous pollutants. The principle types of secondary pollutants are ammonium sulfate and ammonium nitrate formed in the air from gaseous emissions of sulfur dioxide and oxides of nitrogen, reacting with ammonia. The main source of sulfur dioxide is combustion of fossil fuels in boilers and the main source of oxides of nitrogen are the combustion of fossil fuels in boilers and mobile sources. Some secondary particles are also formed from semi-volatile organic compounds which are emitted from a wide range of combustion sources."

2.2.6.1 $PM_{2.5}$ - Standards

In 1997, the EPA added 24- hour and annual fine particle standards, $PM_{2.5}$, to the existing PM_{10} standards. EPA added an annual $PM_{2.5}$ standard set at a concentration of 15 μg/m^3 and a 24-hour $PM_{2.5}$ standard set at 65 μg/m^3. The annual component of the standard was set to provide protection against typical day-to-day exposures as well as longer-term exposures, while the daily component protects against more extreme short-term events. EPA revised the air quality standards for particle pollution in 2006 to be more protective of human health. The 2006 standards tighten the 24-hour fine particle standard from the current level of 65 μg/m^3 to 35 μg/m^3, and retain the current annual fine particle standard at 15 μg/m^3.

2.2.6.2 $PM_{2.5}$ - Health Effects

The health effects of $PM_{2.5}$ are not just a function of their size, about 1/20th the width of an average human hair, which allows them to be breathed deeply into the alveoli of the lungs. It is also a function of their composition. These tiny particles can remain in the lungs for a long time and cause a great deal of damage to the lung tissue. They can reduce lung function as well as cause or aggravate respiratory problems. They can increase the long-term risk of lung cancer or lung diseases such as emphysema or pulmonary fibrosis. The smaller of the $PM_{2.5}$ particles, also called ultrafine particles (those with a diameter <0.1 μm) can be transported from the lungs into the blood stream and affect the heart.(31)

2.2.6.3 $PM_{2.5}$ – Emissions and Sources

Figure 11 shows the nationwide changes in emissions of $PM_{2.5}$ particulates from 1990 through 2008. Table 20 lists the national $PM_{2.5}$ emissions for 2008. (32) The primary source of fine particles emitted directly into the air is carbonaceous material from combustion sources such as cars, trucks, and industrial boilers. Secondary particles are another large source of "fine" particulates. Secondary particles are those that are created in the atmosphere by chemical reactions of gaseous pollutants and water vapor to form a semi-solid particle. (33)

$PM_{2.5}$ are the major contributors to visibility problems because of their ability to scatter or absorb light. In Denver, the effects of this particulate pollution can be seen as the "Brown Cloud" or more appropriately, the "Denver Haze" because it is frequently neither brown nor an actual cloud. As with PM_{10}, the majority of emissions come from the miscellaneous category which includes sources such as agricultural crops, agricultural livestock, paved road re-entrained dust, unpaved roads, construction activities, and mining and quarrying. (28)

Table 20. $PM_{2.5}$ National Emissions for 2008

Description	National	
	Thousand-Tons/Year	Percent
Fuel Combustion – Electrical Utilities	410	8.4
Fuel Combustion - Industrial	175	3.6
Fuel Combustion - Other	421	8.6
Chemical Processing/Mfg	29	0.6
Metal Processing	52	1.1
Petroleum Processing	11	0.3
Other Industrial Processes	355	7.3
Solvent Utilization	7	0.1
Storage & Transportation	22	0.1
Waste Disposal & Recycling	267	5.5
Highway Vehicles	110	2.2
Off- Highway	283	5.8
Miscellaneous	2,742	56.1
Total	***4,890***	***100.0***

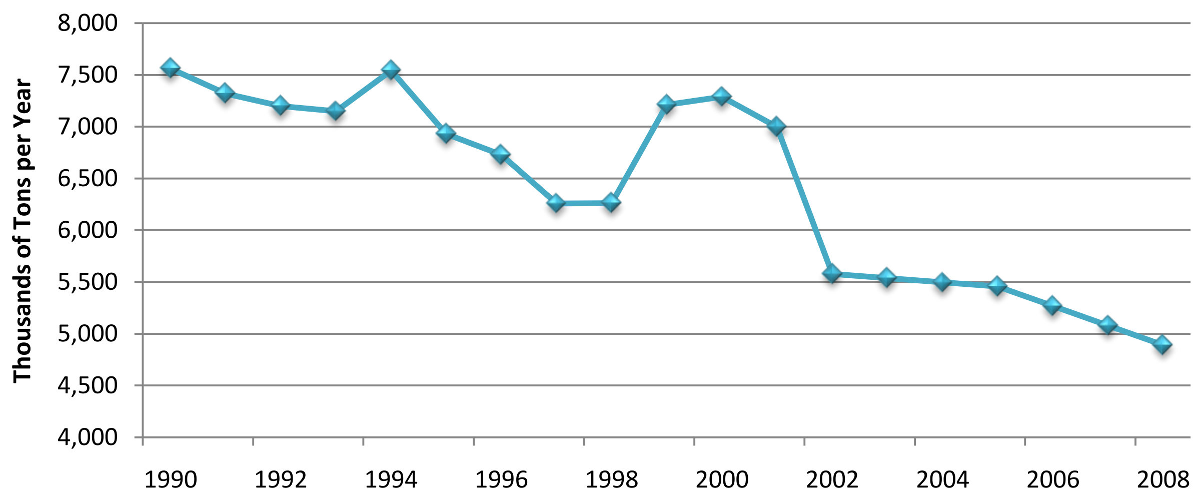


Figure 11. Changes in National $PM_{2.5}$ Emissions from 1990 to 2008

2.2.6.4 $PM_{2.5}$ – Statewide Summaries

Monitoring for $PM_{2.5}$ in Colorado began with the establishment of sites in Denver, Grand Junction, Steamboat Springs, Colorado Springs, Greeley, Fort Collins, Platteville, Boulder, Longmont, and Elbert County in 1999. Additional sites were established nearly every month until full implementation of the base network was achieved in July of 1999. In 2004, there were 20 $PM_{2.5}$ monitoring sites in Colorado. Thirteen of the 20 sites were selected based on the population of the metropolitan statistical areas. This is a federal selection criterion that was developed to protect the public health in the highest population centers. In addition, there were seven special-purpose-monitoring (SPM) sites. These sites were selected due to historically elevated concentrations of PM_{10} or because citizens or local governments had concerns of possible high $PM_{2.5}$ concentrations in their communities. All SPM sites were removed as of December 31, 2006 due to low concentrations and a lack of funding.

Table 21 shows the historical maximum readings for $PM_{2.5}$. (34) Though data has only been collected for the past nine years, the levels of $PM_{2.5}$ appear to be essentially flat. Figure 12 shows the three-year average of the top 95th percentile, and the 3-year average of the annual mean. There is an apparent upward trend for the 95th percentile, but there are too few data points to draw any definitive conclusions. Since the standard is based on a three-year average of the top 95th percentile of samples, the 24-hour standard has not been violated at any site[1]. Neither has the three-year average annual standard of 15 $\mu g/m^3$.

Table 21. Historical Maximum $PM_{2.5}$ Concentrations

24-Hour Maximum ($\mu g/m^3$)	Monitor	Date
68.4	Denver CAMP	2-15-2001
68.0	Denver CAMP	2-17-2001
60.5	Denver CAMP	2-08-2007
60.2	Arapahoe Community College	2-08-2007
57.3	Commerce City	2-17-2001
2009 Maximum $PM_{2.5}$ Concentration		
59.1	Grand Junction - Powell	1-1-2009

[1] In 2001, before the current standard went into effect (in 2006), the Adams City monitor showed a three-year 98th percentile average of 35.1 $\mu g/m^3$. Due to rounding conventions, 35.5 $\mu g/m^3$ is needed to violate the 24-hour NAAQS. Data collection at this site began in 1999.

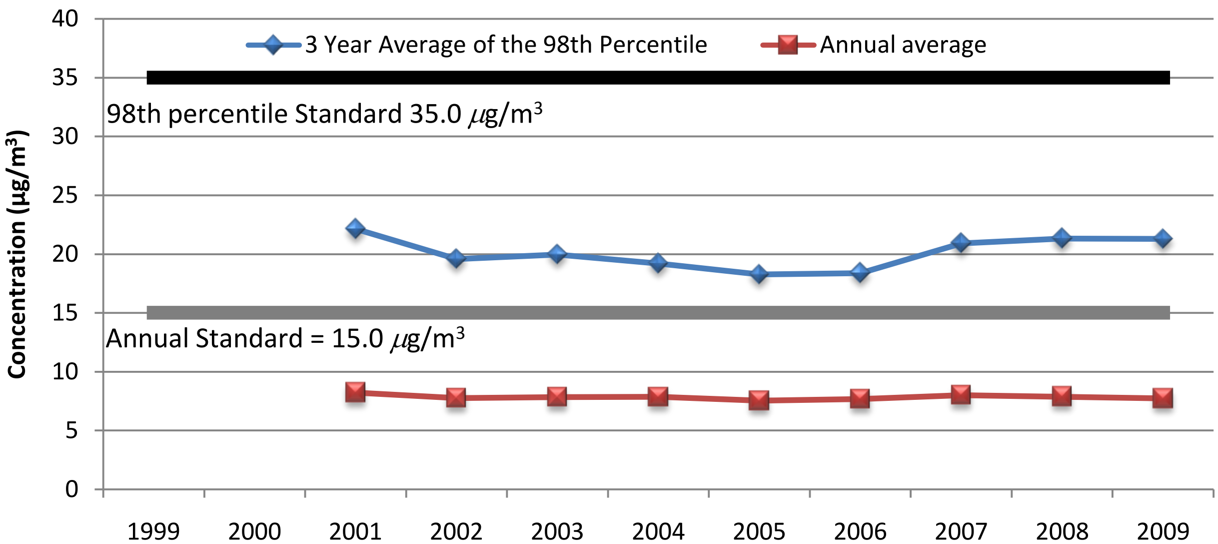


Figure 12. Statewide Ambient Trends for $PM_{2.5}$

2.2.6.5 $PM_{2.5}$ – National Comparisons

In 2009, the nine highest annual average $PM_{2.5}$ concentrations were in California. The highest 24-hour $PM_{2.5}$ concentrations were in South Dakota, Georgia, California, and Alaska, shown in Table 22. (34) Even though California continues to show improvement, they remain the state with the highest concentrations.

Some sites had high 24-hour $PM_{2.5}$ concentrations but low annual $PM_{2.5}$ concentrations, and vice versa. Sites that have high 24-hour concentrations but low or moderate annual concentrations exhibit substantial variability from season to season. (32)

Table 22. National Ranking of $PM_{2.5}$ Monitors by 24-hour Maximum Concentrations in µg/m^3

Nationwide (1,259 Monitors)					Colorado (22 Monitors)				
National Rank	City/Area	1st Max	2nd Max	Annual Mean	National Rank	City/Area	1st Max	2nd Max	Annual Mean
1	Wind Cave National Park, SD	303.6	121.8	6.46	61	Grand Junction - Powell	59.1	48.9	9.74
2	Gordon, GA	212.5	28.8	12.51	211	Boulder COC	39.4	15.3	6.43
3	Bakersfield, CA	195.5	85.2	18.97	238	Greeley - Hospital	38.2	27.7	7.83
4	Bakersfield, CA	167.7	72	22.49	566	Denver CAMP	29.5	25.7	7.52
5	Fairbanks, AK	159.6	132.8	17.49	614	Fort Collins CSU	28.7	18.5	6.78

2.2.7 Lead

Pb is a metal found naturally in the environment as well as in manufactured products. The major sources of ambient air lead emissions have historically been motor vehicles (such as cars and trucks) and industrial sources (such as lead smelters). Due to the phase out of leaded gasoline for automobiles, piston engine aircraft and metals processing are now the major source of lead emissions to the air today. The highest levels of lead in air are generally found near lead smelters and general aviation airports. Other stationary sources are waste incinerators, utilities, and lead-acid battery manufacturers. (35)

2.2.7.1 Lead - Standards

The Clean Air Act requires EPA to review the latest scientific information and standards every five years. Before new standards are established, policy decisions undergo rigorous review by the scientific community, industry, public interest groups, the general public, and the Clean Air Scientific Advisory Committee (CASAC).

On October 15, 2008, EPA strengthened the National Ambient Air Quality Standards for lead. The level for the previous lead standard was 1.5 $\mu g/m^3$, not to be exceeded as an average for a calendar quarter, based on an indicator of lead in total suspended particles (TSP). The new standard, also in terms of lead in TSP, has a level of 0.15 $\mu g/m^3$, not to be exceeded as an average for any rolling three-month period within three years. In conjunction with the revision of the lead standard, EPA also modified the lead air quality monitoring rules. Ambient lead monitoring is now required near lead emissions sources emitting one or more tons per year, and also in urban areas with a population equal to or greater than half a million people. Monitoring sites are required to sample every sixth day. (36)

2.2.7.2 Lead - Health Effects

Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues and can adversely affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ. Recent studies also show that lead may be a factor in high blood pressure and subsequent heart disease. Lead can also be deposited on the leaves of plants, presenting a hazard to grazing animals and humans through ingestion. (37)

2.2.7.3 Lead – Emissions and Sources

"Because of the phase-out of leaded gasoline for vehicles… emissions of lead decreased 96 percent over the 24-year period 1980–2004. These large reductions in long-term lead emissions from transportation sources have changed the nature of the ambient lead problem in the United States. Because industrial processes are now responsible for all violations of the lead NAAQS, the lead monitoring strategy currently focuses on emissions from these point sources." (37) However, leaded fuel is still used in piston-engine aircraft as a lubricant and octane enhancer. Thus airports with general aviation are another significant source of lead emissions.

Figure 13 shows the decline in lead emissions between 1975 and 2005. Table 23 shows the emission sources for 2005. (38)

Table 23. Lead National Emissions for 2005

Description	**National**	
	Tons/Year	**Percent**
Aviation Gasoline	561	45
Metallurgical Industries	283	23
Manufacturing	171	14
Incineration	94	8
Boilers	70	6
Miscellaneous smaller categories	57	5
Total	***1236***	***100***

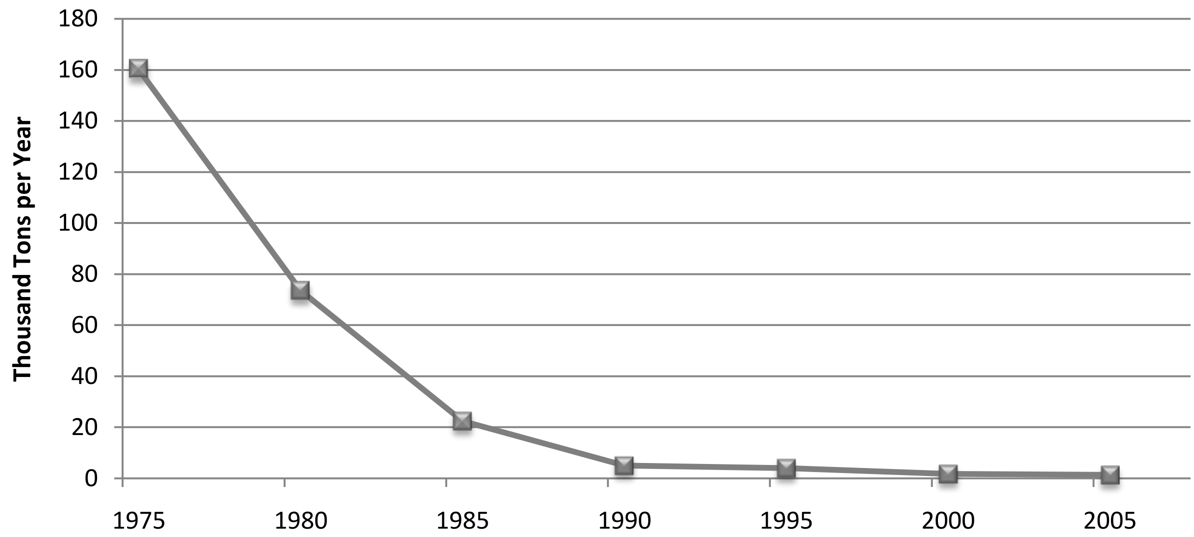


Figure 13. Changes in National Lead Emissions from 1975 to 2005

2.2.7.4 Lead – Statewide Summaries

In Colorado the last violation of the old 1.5 µg/m^3 lead standard occurred in the first quarter of 1980 at the Denver CAMP monitor. Since then, the concentrations recorded at all monitors have shown a steady decline. This decline is the direct result of the use of unleaded gasoline and replacement of older cars with newer ones that do not require leaded gasoline. The reduction in atmospheric lead shows what pollution control strategies can accomplish. In 2006, monitoring for lead by the APCD was reduced from six locations to one. In 2007, that lead monitor was moved from the Denver CAMP location to the Denver Municipal Animal Shelter at 678 S. Jason St.

The EPA established a new level for the lead standard on October 15, 2008. A more complete discussion of the new standard is covered in Section 2.2.7.1 above. Colorado currently operates two lead monitors. Table 24 (39) and Figure 14 illustrate the historic statewide lead trends.

Table 24. Historical Maximum Quarterly Lead Concentrations

Quarterly Maximum (µg/m^3)	Monitor	Date
3.47	Denver CAMP, 2105 Broadway	1st Qtr 1979
3.40	Denver, 414 14th St.	4th Qtr 1969
3.03	Denver, 414 14th St.	1st Qtr 1973
3.03	Denver CAMP, 2105 Broadway	4th Qtr 1978
3.02	Denver, 414 14th St.	4th Qtr 1972
2009 Maximum Quarterly Lead Concentration		
0.006	Denver Animal Shelter	3rd Qtr 2009

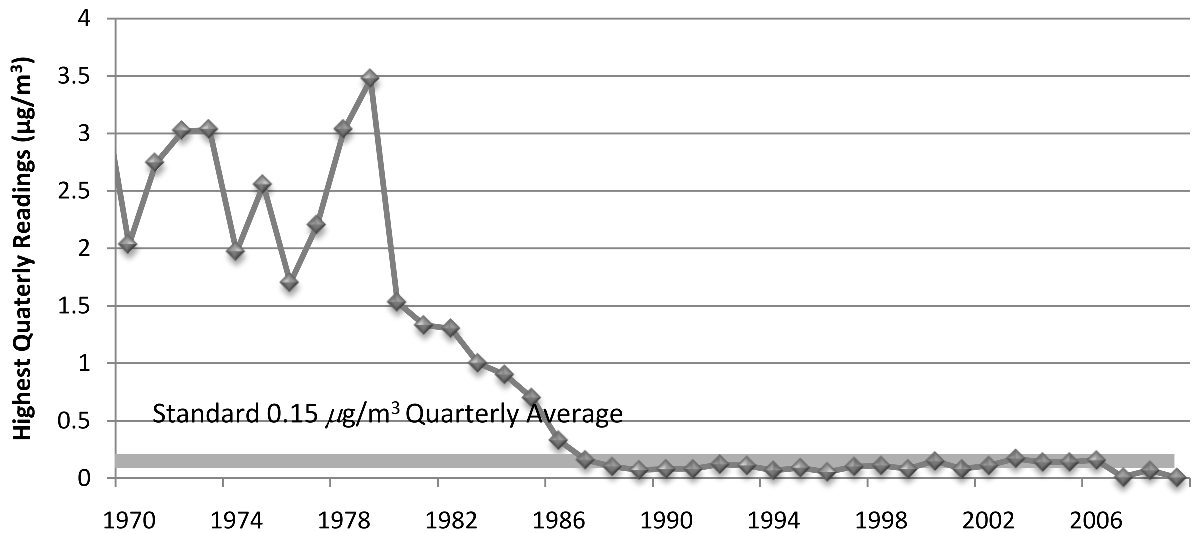


Figure 14. Statewide Ambient Trends for Lead

2.2.7.5 Lead – National Comparisons

"On October 15, 2008, EPA strengthened the National Ambient Air Quality Standards for lead. The level for the previous lead standards was 1.5 $\mu g/m^3$, not to be exceeded as an average for a calendar quarter, based on an indicator of lead in total suspended particles (TSP). The new standards, also in terms of lead in TSP, have a level of 0.15 $\mu g/m^3$, not to be exceeded as an average for any three-month period within three years." (14) Table 25 lists the nationwide comparisons of lead concentrations. (39)

Table 25. National Ranking of Lead Monitors by 24-hour Maximum Concentration in $\mu g/m^3$

Nationwide (142 Monitors)					Colorado (1 Monitors)				
National Rank	**City/Area**	**24-hr Max**	**Max Qtr**	**Running 3 Month Average >0.15**	**National Rank**	**City/Area**	**24-hr Max**	**Max Qtr**	**Running 3 Month Average >0.15**
1	Vernon, CA	6.7	0.49	0	98	DMAS	0.01	0.006	0
2	Eagan, MN	1.3	0.25	0					
3	Laureldale, PA	1.1	0.18	0					
4	Bellefontaine, OH	0.8	0.07	0					
5	Cleveland, OH	0.7	0.10	0					

3. Non-Criteria Pollutants

Non-criteria pollutants are those pollutants for which there are no current national ambient air quality standards. These include but are not limited to the pollutants that impair visibility, certain oxides of nitrogen species, total suspended particulates, and air toxics. Meteorological measurements of wind speed, wind direction, temperature, and humidity are also included in this group, as is chemical speciation of $PM_{2.5}$ analyses.

3.1. Visibility

Visibility is unique among air pollution effects in that it involves human perception and judgment. It has been described as the maximum distance that an object can be perceived against the background sky. Visibility also refers to the clarity with which the form and texture of distant, middle and near details can be seen as well as the sense of the trueness of their apparent coloration. As a result, measures of visibility serve as surrogates of human perception. There are several ways to measure visibility but none of them tell the whole story or completely measure visibility as we experience it.

3.1.1 Visibility - Standards

The Colorado Air Quality Control Commission established a visibility standard in 1990 for the Front Range cities from Fort Collins to Colorado Springs. The standard, an atmospheric extinction of 0.076 per kilometer, was based on the public's definition of unacceptable amounts of haze as judged from slides of different haze levels taken in the Denver area. At the standard, 7.6 percent of the light in a kilometer of air is blocked. The standard applies from 8 A.M. to 4 P.M. each day, during those hours when the relative humidity is less than 70 percent. Visibility, along with meteorology and concentrations of other pollutants for which National Ambient Air Quality Standards exist, is used to determine the need for mandatory wood burning and voluntary driving restrictions.

There is no quantitative visibility standard for Colorado's pristine and scenic rural areas. However, in the 1977 amendments to the Federal Clean Air Act, Congress added Section 169a (40) and established a national visibility goal that created a qualitative standard of “the prevention of any future and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution.” The implementation of Section 169a has led to federal requirements to protect visual air quality in large national parks and wilderness areas (41). Colorado has 12 of these Class I areas. Federal and state law prohibits visibility impairment in national parks and wildernesses due to large stationary sources of air pollution.

3.1.2 Visibility - Health Effects

Visual air quality is an element of public welfare. Specifically, it is an important aesthetic, natural, and economic resource of the State of Colorado. EPA, the US Forest Service, and the US National Park Service have made studies that show that good visibility is something that people undeniably value. They have also shown that impaired visibility affects the enjoyment of a recreational visit to a scenic mountain area.

The APCD believes although the worth of visibility is difficult to measure, people prefer to have clear views from their homes and offices. These concerns are reflected in residential property values and office rents. Any loss in visual air quality may contribute to corresponding losses in tourism and usually make an area less attractive to residents, potential newcomers, and industry.

Researchers have found this link strongest with concentrations of fine particles, which also contribute to visibility impairment. In July 1997, the EPA developed a NAAQS for $PM_{2.5}$ (more detail is in Section 2.6). Any control strategies to lower ambient concentrations of fine particulate matter for health reasons will also improve visibility.

3.1.3 Visibility - Sources

The cause of visibility impairment in Colorado is most often fine particles in the 0.1 to 2.5 micrometer size range (one micrometer is a millionth of a meter). Light passing from a vista to an observer is either scattered away from the sight path or absorbed by the atmospheric fine particulate. Sunlight entering the pollution cloud may be scattered into the sight path adding brightness to the view and making it difficult to see elements of the vista. Sulfate, nitrate, elemental carbon, and organic carbon are the types of particulate matter most effective at scattering and/or absorbing light. The man-made sources of these particulates include wood burning, electric power generation, industrial combustion of coal or oil, and emissions from cars, trucks, and buses.

Visibility conditions vary considerably across the state. Usually, visibility in Colorado is among the best in the country. Our prized western vistas exist due to unique combinations of topography and scenic features. Air in much of the West contains low humidity and minimal levels of visibility-degrading pollution. Nevertheless, visibility problems occur periodically throughout the state. Wood burning haze is a concern in several mountain communities each winter. Denver has its “Brown Cloud.” Even the national parks, monuments, and wilderness areas shows pollution related visibility impairment on occasion due to regional haze, the interstate or even regional-scale transport of visibility-degrading pollution. The visibility problems across the state have raised public concern and spurred research. The goal of Colorado's visibility program is to protect visual air quality where it is presently good and improve visibility where it is degraded.

3.1.4 Visibility - Monitoring

There are several ways to measure visibility. Currently, the Division uses camera systems to provide qualitative visual documentation of a view. Transmissometers and nephelometers are used to measure the atmosphere’s ability to attenuate light quantitatively.

A visibility site was installed in Denver in late 1990 using a long-path transmissometer. Visibility in the downtown area is monitored using a receiver located near Cheesman Park at 1901 E. 13th Avenue, and a transmitter located on the roof of the Federal Building at 1929 Stout Street (Figure 15). Renovations at the Federal Building forced the transmissometer to temporarily move to 1255 19th Street in 2010. This instrument directly measures light extinction, which is proportional to the ability of atmospheric particles and gases to attenuate image-forming light as it travels from an object to an observer. The visibility standard is stated in units of atmospheric extinction. Days when the visibility is affected by rain, snow, or high relative humidity are termed “excluded” (as shown in Figure 27) and are not counted as violations of the visibility standard.

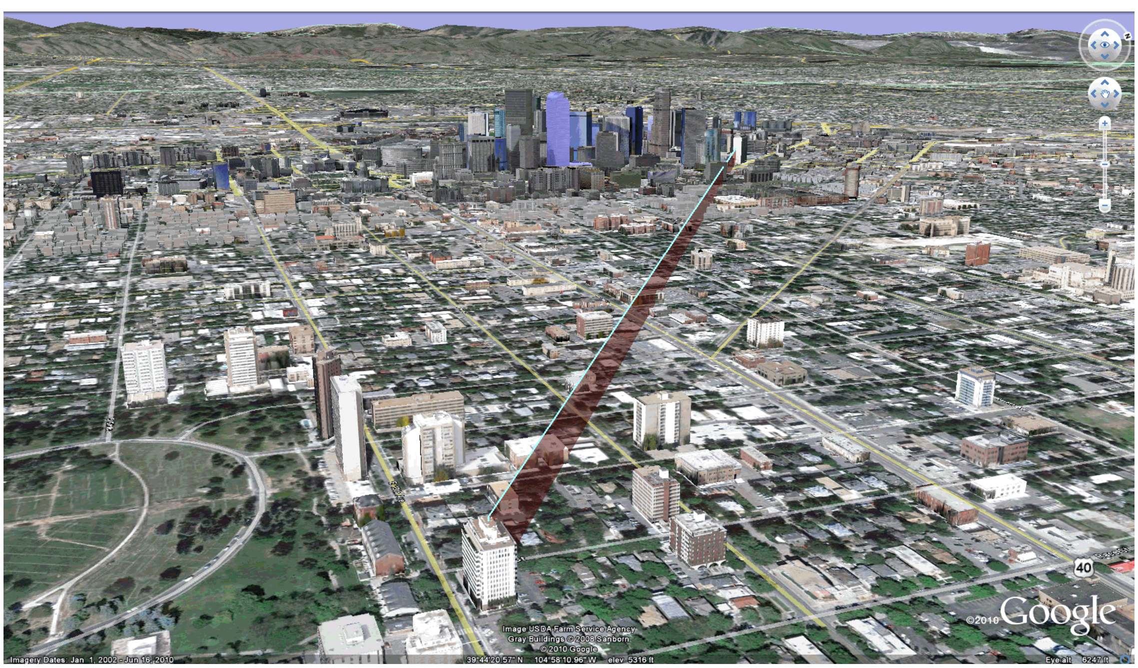


Figure 15. Transmissometer Path (Illustration Purposes Only)

In September 1993, a transmissometer and nephelometer were purchased by the city of Fort Collins to monitor visibility. Elsewhere in Colorado, several agencies of the federal government, in cooperation with regional and nationwide state air pollution organizations, also monitor visibility in a number of national parks and wilderness “Class I” areas, either individually or jointly through the Inter-agency Monitoring of Protected Visual Environments (IMPROVE) program. The goals of the monitoring programs are to establish background visibility levels, identify trends of deterioration or improvement, identify suspected sources of visibility impairment, and to track regional haze. Visibility and the atmospheric constituents that cause visibility degradation are characterized with camera systems, transmissometers, and extensive fine particle chemical composition measurements by the monitoring network. There are currently monitoring IMPROVE sites in Rocky Mountain National Park, Mesa Verde National Park, Weminuche Wilderness, Mount Zirkel Wilderness, Great Sand Dunes National Monument, and White River National Forest. These data are not contained in this report, but are available at:
http://vista.cira.colostate.edu/improve/

3.1.5 Visibility - Denver Camera

The Division operates a web-based camera that can be viewed by clicking on the Live Image of Denver tab on the left side of the screen under Quick Links at the Air Pollution Control Division’s web site http://www.colorado.gov/airquality. There is a great deal of other information available from this site in addition to the image from the visibility camera, including the Front Range Air Quality Forecast, Air Quality Advisory, Monitoring Reports, and Open Burning Forecast.

The images in Figure 16 show the visibility on one of the best and worst days for the year. The best visibility day was May 31, 2009 (0.013 1/km). The worst visibility day was October 14, 2009 (0.507 1/km). Both pictures were taken at 12:00 P.M.

Figure 16. Best (left) and Worst (right) Visibility Days in Denver

These two pictures are images made by the web camera at the visibility monitor located at 1901 E. 13th Avenue in Denver. These images are centered on the Federal Building at 1929 Stout Street. The difference in these two pictures is not just the brightness but the detail that can be seen between the two images. On the best day, buildings can be clearly resolved, and the Front Range is visible. On the worst day, however, contrast between buildings is lower, and the Front Range is entirely obscured.

3.2. Nitric Oxide

Nitric oxide is the most abundant of the oxides of nitrogen emitted from combustion sources. There are no known adverse health effects at normal ambient concentrations. However, nitric oxide is a precursor to nitrogen dioxide, nitric acid, particulate nitrates, and ozone, all of which have demonstrated adverse health effects. (42) There are no federal or state standards for nitric oxide.

3.3. Total Suspended Particulates

Total suspended particulates (TSP) were first monitored in Colorado in 1960 at 414 14th Street in Denver. This location monitored TSP until 1988. The Adams City and Gates TSP monitors began operation in 1964 and the Denver CAMP monitor at 2105 Broadway began operating in 1965. Either the EPA or the City of Denver operated these monitors until the mid-1970s, when daily operation was taken over by the Colorado Department of Public Health and Environment. None of these monitors are in operation today.

Particulate monitoring expanded to more than 70 locations around the state by the early 1980s. The primary standards for total suspended particulates were 260 $\mu g/m^3$ as a 24-hour sample and 75 $\mu g/m^3$ as an annual geometric mean. On July 1, 1987, with the promulgation of the PM_{10} standards, the old particulate standards were eliminated. Until December 2006 the Division operated six TSP samplers to measure lead. On January 1, 2007 the number of lead monitoring sites was reduced to one, at the Denver Municipal Animal Shelter located at 678 S. Jason Street. The reason for the change in the number of TSP monitors is that the ambient concentrations of lead have been reduced dramatically, and federal monitoring requirements have been changed for Pb.

3.4. Air Toxics

Toxic air pollutants, or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects. Air toxics may also cause adverse environmental and ecological effects. EPA is required to reduce air emissions of 188 air toxics listed in the Clean Air Act. Examples of air toxics include benzene (found in gasoline), perchloroethylene (emitted from some dry cleaning facilities), and methylene chloride (used as a solvent by a number of industries). Most air toxics originate from man-made sources, including mobile sources (like cars, trucks, and construction equipment) and stationary sources (like factories, refineries, and power plants), as well as indoor sources (some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires. (43)

People exposed to air toxics at sufficient concentrations may experience various health effects including cancer and damage to the immune system, as well as neurological, reproductive (including reduced fertility), developmental, respiratory, and other health problems. In addition to exposure from breathing air toxics, risks are also associated with the deposition of toxic pollutants onto soils or surface waters, where they are taken up by plants and ingested by animals and eventually magnified up through the food chain. Like humans, animals may experience health problems due to air toxics exposure.

The APCD currently monitors for air toxics in Grand Junction as part of EPA's National Air Toxics Trend Stations project. The data from this study are available in a separate report.

3.5. Meteorology

The Air Pollution Control Division takes a limited set of meteorological measurements at 19 locations around the state. These measurements include wind speed, wind direction, temperature, standard deviation of horizontal wind direction, and select monitoring of relative humidity. Relative humidity measurements are also taken in conjunction with the two visibility monitors. The humidity data are not summarized in this report since they are used primarily to validate the visibility measurements taken at the specific locations. The Division does not collect precipitation measurements. The wind speed, wind direction, and temperature measurements are collected primarily for air quality forecasting and air quality modeling. These instruments are on ten-meter towers and the data are collected as hourly averages and sent along with other air quality data to be stored on the EPA's Air Quality Systems database. The wind speed and wind direction data are shown as wind roses at the end of each area in Section 4 below.

The wind roses displayed in this report are placed on a background map that shows the approximate location of the meteorological site. The wind roses are based on the direction that the wind is blowing from. Another way of visualizing a wind rose is to picture you standing in the center of the plot and facing into the wind. The wind direction is broken down in the 16 cardinal directions (ESE, for example). The wind speed is broken down in six categories. The roses in Section 4 below use 1-3 mph, 4-5 mph, 7-11 mph, 12-14 mph, 15-38 mph, and greater than 38 mph. The length of each arm of the wind rose represents the percentage of time the wind was blowing from that direction at that speed. The longer the arm, the greater the percentage of time the wind is blowing from that direction. A review of the wind rose in Figure 31, for example, shows that in Arvada the majority of the winds come from the west and west-northwest and that these winds are generally in the 1-3 mph and 4-6 mph ranges.

3.6. $PM_{2.5}$ Chemical Speciation

Chemical speciation analysis is conducted for several elements, ions, and chemical compounds which can cause serious health effects, premature deaths, visibility degradation, and regional haze. There are two broad categories of $PM_{2.5}$ – primary and secondary particles. Primary $PM_{2.5}$ particles include those emitted directly to the air from crushed geologic materials, and carbonaceous particles from incomplete combustion. Secondary $PM_{2.5}$ is formed from gases that combine in the atmosphere through chemical processes and form liquid aerosol droplets. If the $PM_{2.5}$ pollution needs to be controlled, it is important to know the composition of $PM_{2.5}$ particles so that the appropriate sources can be targeted for control (see Section 2.2.6.3 above for more information on $PM_{2.5}$ sources).

Numerous health effects studies have correlated negative health effects to the total mass concentration of $PM_{2.5}$ in ambient air. (18) However, it has not yet been completely determined if the health correlation is to total mass concentration, or to concentrations of specific chemical species in the $PM_{2.5}$ mix. When the EPA promulgated the NAAQS for $PM_{2.5}$ in 1997, a compliance monitoring network based on total $PM_{2.5}$ mass was established. Mass concentrations from the compliance network are used to determine attainment of the NAAQS. EPA soon supplemented the $PM_{2.5}$ network with the Speciation Trends Network (STN) monitoring to provide information on the chemical composition of $PM_{2.5}$. The main purpose of the STN is to identify sources, develop implementation plans to reduce $PM_{2.5}$ pollution, and support health effects research.

Colorado began chemical speciation monitoring at the Commerce City site in February 2001 at the state's only STN site. Four other chemical speciation sites were established in 2001 in the following areas: Colorado Springs, Durango, Grand Junction, and Platteville. The Durango site was closed in September 2003. The Colorado Springs site was closed in December, 2006. These sites were eliminated when funding was reduced for the project. The Grand Junction site was closed in December 2009 and moved to DMAS where it began sampling in January of 2010.

Each speciation sample set is analyzed for gravimetric mass, 48 elemental concentrations (like sodium and lead), four types of organic and elemental carbon, and five ions (ammonium, sodium, potassium, sulfate, and nitrate). Selected filters can also be analyzed for semi-volatile organics and microscopic analyses. The results of these samples can be obtained from the APCD upon request.

4. Monitoring Results by Area in Colorado

4.1. Eastern Plains Counties

The Eastern Plains counties are those to the east of the urbanized I-25 corridor. Historically, there have been a number of communities that were monitored for particulates and meteorology but not for any of the gaseous pollutants. In the northeast along the I-76 corridor, the communities of Sterling, Brush, and Fort Morgan have been monitored. Along the I-70 corridor only the community of Limon has been monitored for particulates. Along the US-50/Arkansas River corridor, the APCD has monitored for particulates in the communities of La Junta, Rocky Ford, and Trinidad. These monitors were discontinued in the late 1970's and early 1980's after a review showed that the concentrations were well below the standard and trending downward.

Currently, there are two PM_{10} monitoring sites and one meteorological site in Lamar and a background $PM_{2.5}$ monitor in Elbert County. The Lamar monitors have recorded exceedances of the 24-hour PM_{10} standard. These have been associated with high winds and dry conditions. The Elbert County monitor operates as a background $PM_{2.5}$ monitor. This monitor provides baseline $PM_{2.5}$ readings away from any influence of manmade particulate sources along the Front Range of Colorado. Table 26 lists the 2009 concentration values for the Eastern Plains particulate monitors, while Figure 17 is an illustration of the wind rose overlain on a map of the monitoring site.

Table 26. Eastern Plains Particulate Values for 2009

Location	PM_{10} (µg/m^3)			$PM_{2.5}$ (µg/m^3)			
	Annual Avg.	**24-hour Max**	**3-Year Avg. Exceedances**	**Annual Avg.**	**3-Year Weighted Avg.**	**24-hour Max**	**3-Year Average of 98th %ile**
Elbert							
24950 Ben Kelly Rd.				3.91	4.4	10.5	11.0
Prowers							
100 2nd St.	28.3	233	1.66				
104 Parmenter St.	21.3	176	0.66				

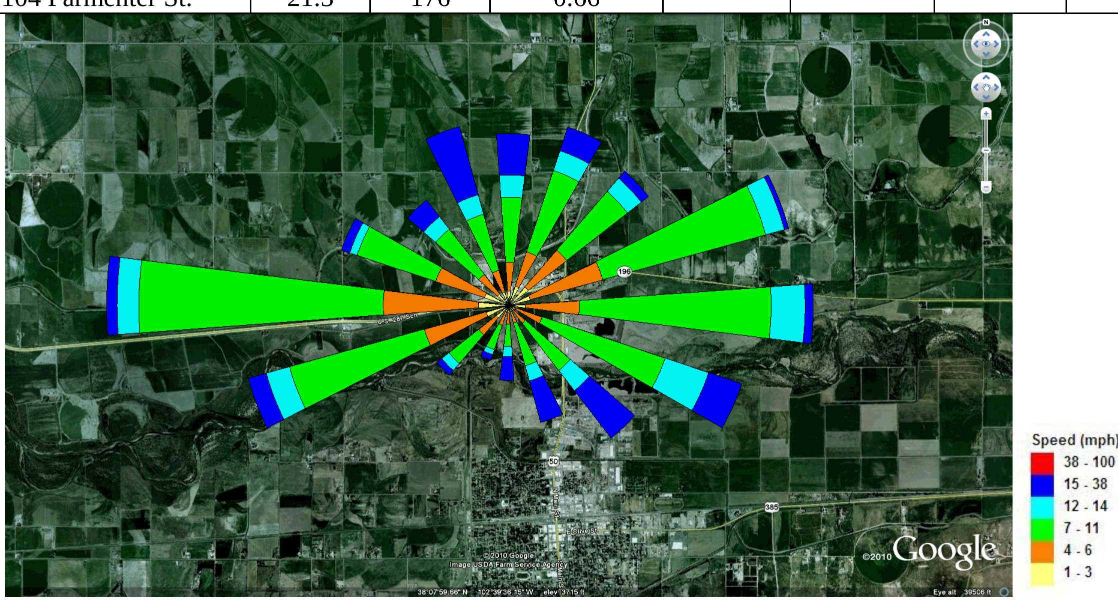


Figure 17. Eastern Plains Wind Rose, Lamar Port of Entry, 7100 US Hwy 50

The Lamar Power Plant station has had an average of 1.66 exceedances per year over the last 3 years (0, 2, and 3 exceedances for 2007, 2008, and 2009 respectively), which is in violation of the annual average primary standard, if natural wind-related dust events are not excluded (1). See Section 2.2.5.1. However, the Lamar Power Plant site is inappropriately sited and does not represent ambient air exposure. It is located inside the fenced power plant property on the roof of the old power plant near an obstructing wall.

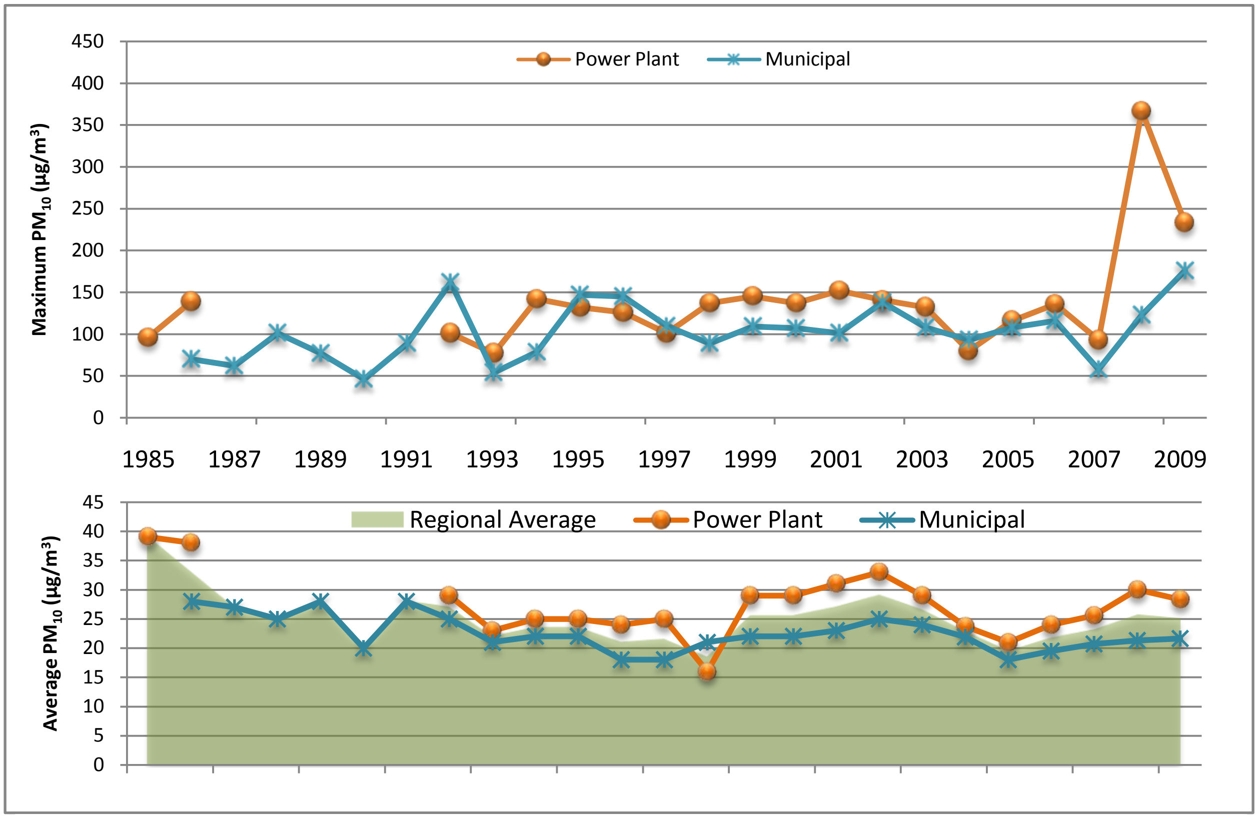


Figure 18. Average and Maximum PM_{10} Concentrations for the Eastern Plains Counties

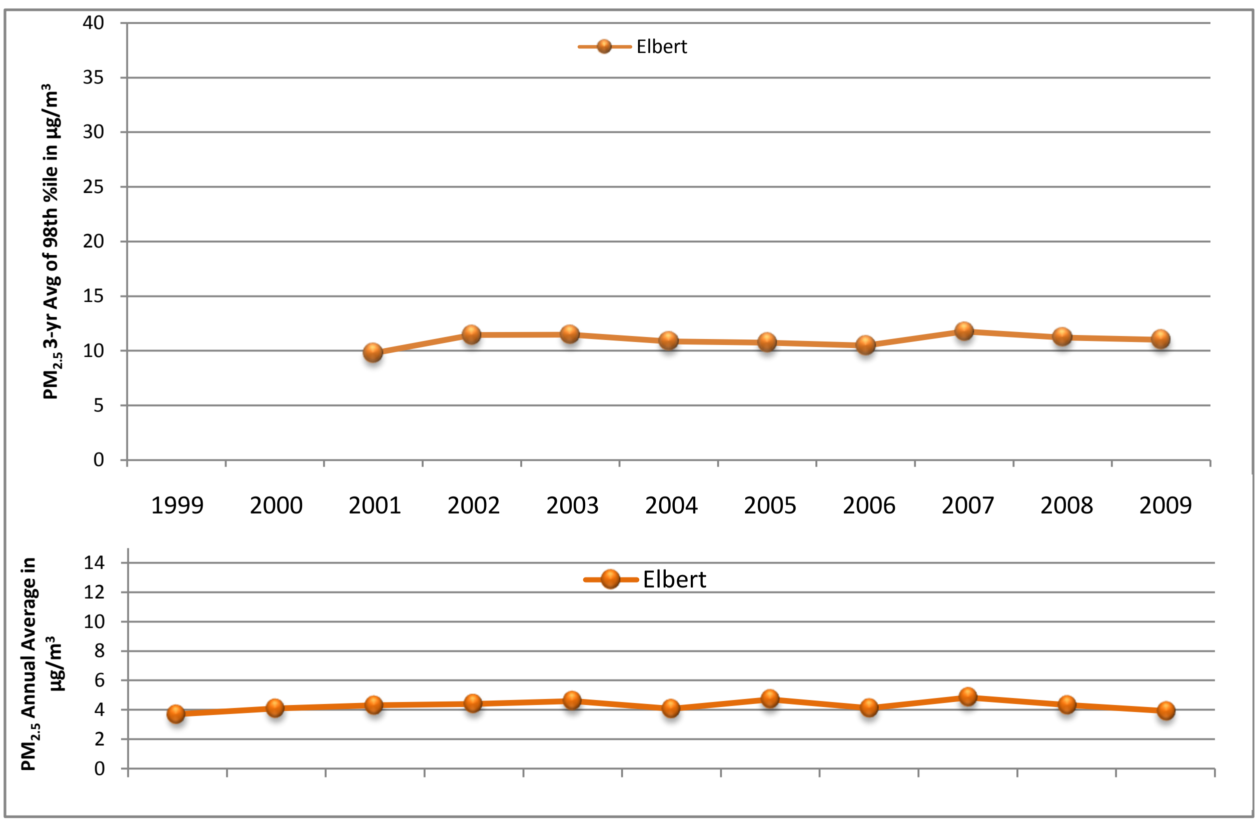


Figure 19. 3-Year 98th Percentile and Weighted Averages for $PM_{2.5}$ for Eastern Plains Counties

4.2. Northern Front Range Counties

The Northern Front Range Counties are those along the urbanized I-25 corridor from the Colorado/Wyoming border to Castle Rock. This area has the majority of the larger cities in the state. The majority of monitors are located in the Denver metro area and the rest are located in or near Fort Collins, Greeley, Longmont, and Boulder. Table 27 shows there were no violations in the northern Front Range counties for particulates.

Table 27. Northern Front Range Particulate Values for 2009

Site Name	PM_{10} ($\mu g/m^3$)			$PM_{2.5}$ ($\mu g/m^3$)			
	Annual Average	24-hour Maximum	3-Year Average Exceedance	Annual Average	3-Year Weighted Average	24-hour Maximum	3-Year Average of 98th %ile
Adams							
Commerce City (Continuous)	28.1	96	0	8.12	9.43	34.4	28.9
				6.35		26.2	
Welby (Continuous)	26.4	54	0				
	23.7	66					
Arapahoe							
Arapahoe Com. College				6.43	7.24	21.1	18.2
Boulder							
Longmont (Continuous)	19.9	40	0	7.29	7.96	27.0	23.3
				7.81		26.9	
Boulder, 2440 Pearl St.	18.5	38	0	6.43	6.77	24.9	19.1
Boulder, 2102 Athens St. (Continuous)				(3.58)		(26.8)	
Denver							
Denver CAMP (Continuous)	26.0	60	0	7.52	8.32	32.7	22.5
	21.4	62		7.81		26.6	
Denver – NJH (Continuous)				7.47		25.7	
Visitor Center	23.7	53	0				
Swansea School				7.66	8.71	30.7	23.6
DMAS (Continuous)	23.4	50	0	7.25	8.37	26.9	19.5
	23.4	56		10.23		26.9	
Douglas							
Chatfield Reservoir (Continuous)				5.70	6.16	15.1	17.0
				8.98		26.6	
Larimer							
Fort Collins	17.8	61	0	6.78	7.13	24.8	18.2
Weld							
Greeley (Continuous)	20.7	63	0	7.83	8.36	25.2	24.7
				6.51		23.8	
Platteville				7.51	8.24	25.5	25.7

() indicates <75% data recovery

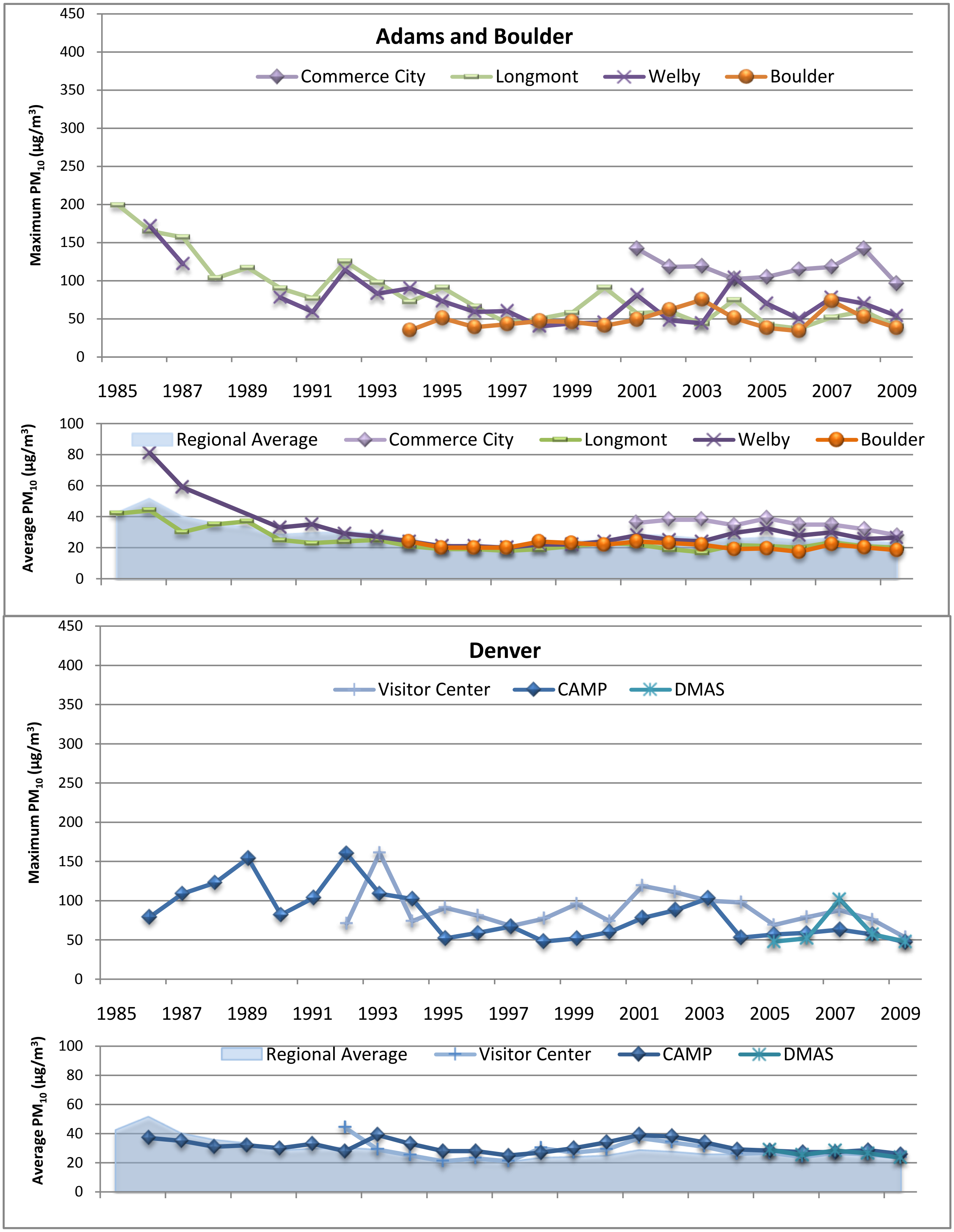
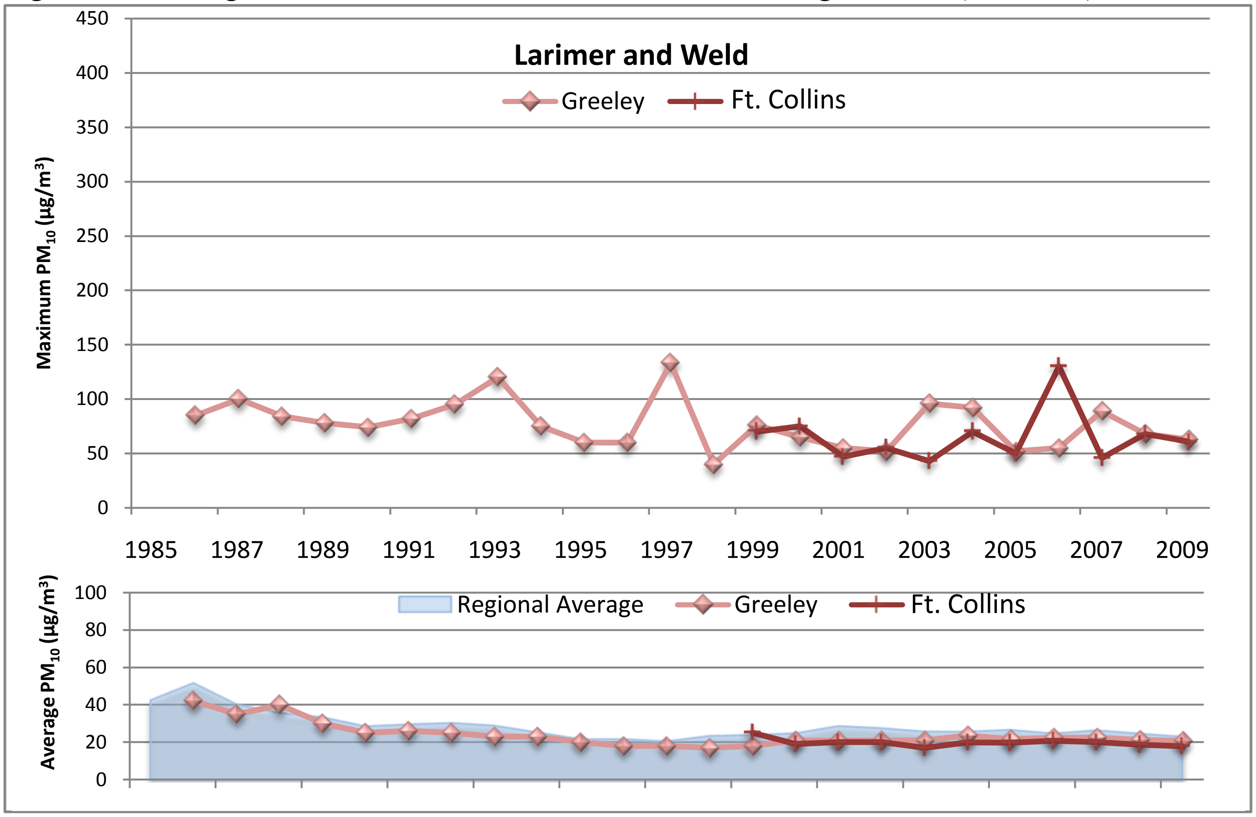


Figure 20. Average and Maximum PM_{10} Concentrations for the Northern Front Range Counties

Figure 20. Average and Maximum Pm10 for the Northern Front Range Counties (Continued)



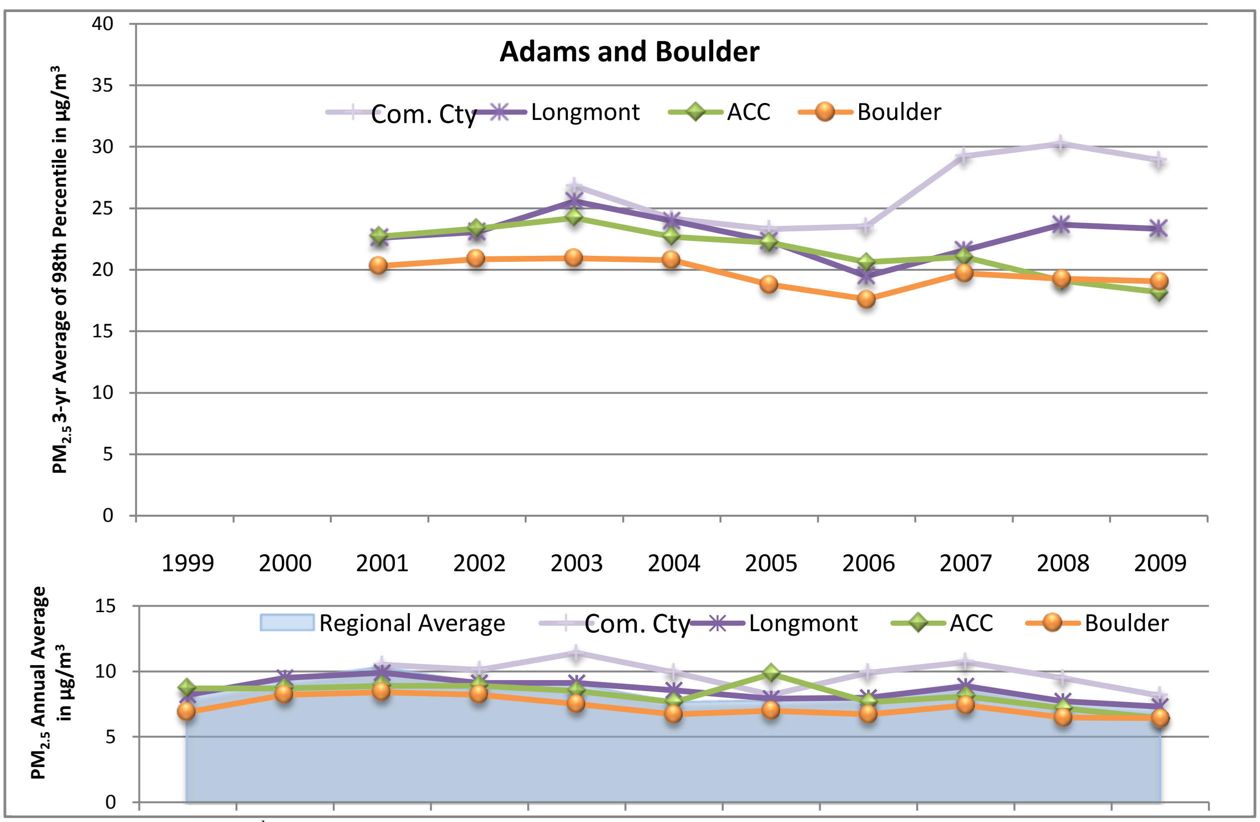


Figure 21. 3-Year 98th Percentile and Weighted Averages for $PM_{2.5}$ for the Northern Front Range Counties

Figure 21. 3-Yr 98th Percentile and Weighted Averages for PM2.5 for the Northern Front Range (Continued)

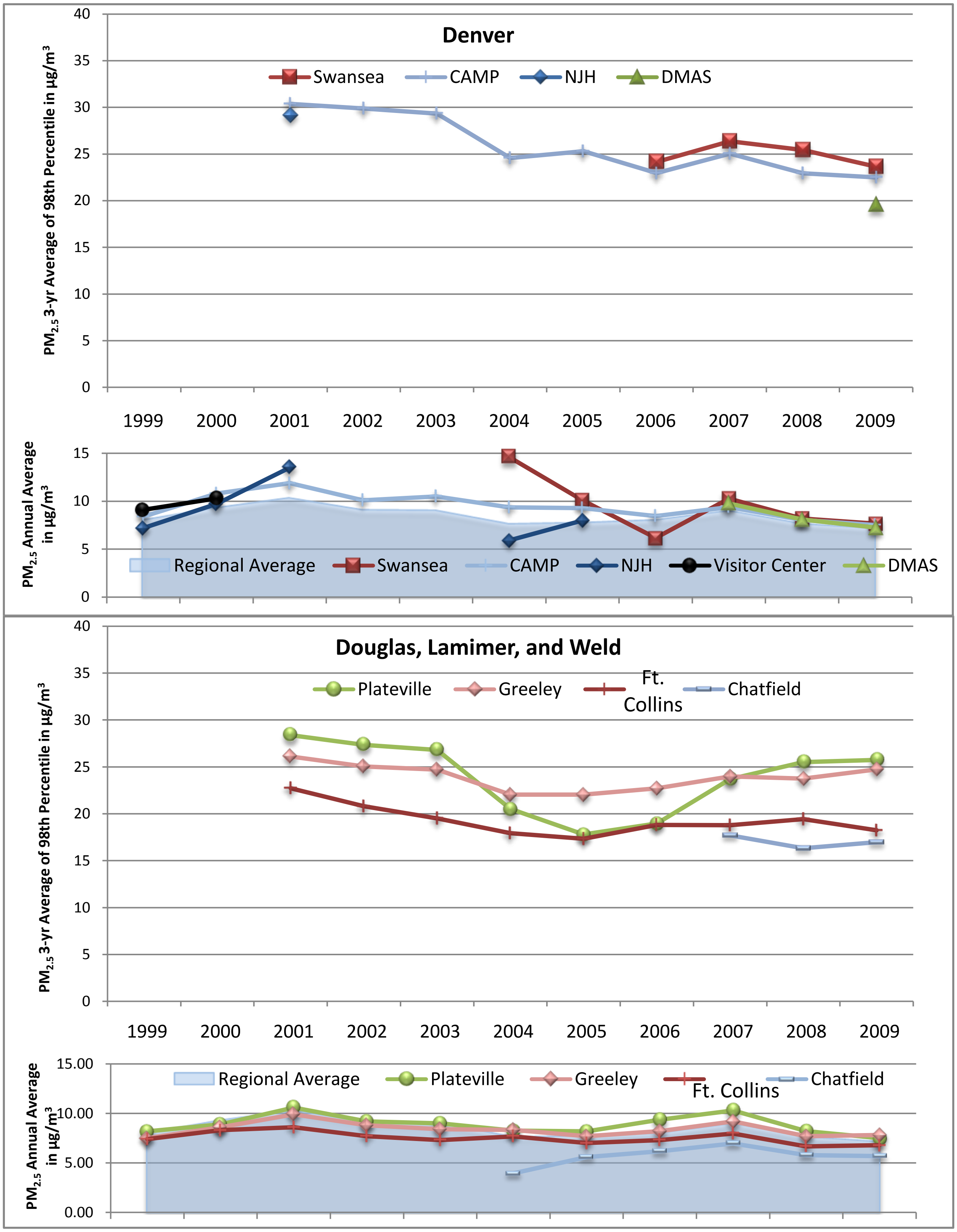


Table 28. Northern Front Range TSP and Lead Values for 2009

Site Name	Location	TSP (µg/m³)		Lead (µg/m³)	
		Annual Geometric Mean	24-hour Maximum	Maximum Quarter	24-hour Maximum
Denver					
DMAS	678 S. Jason St.	49.2	106	0.0063	0.0126

() indicates less than 75 percent data for one or more quarters.

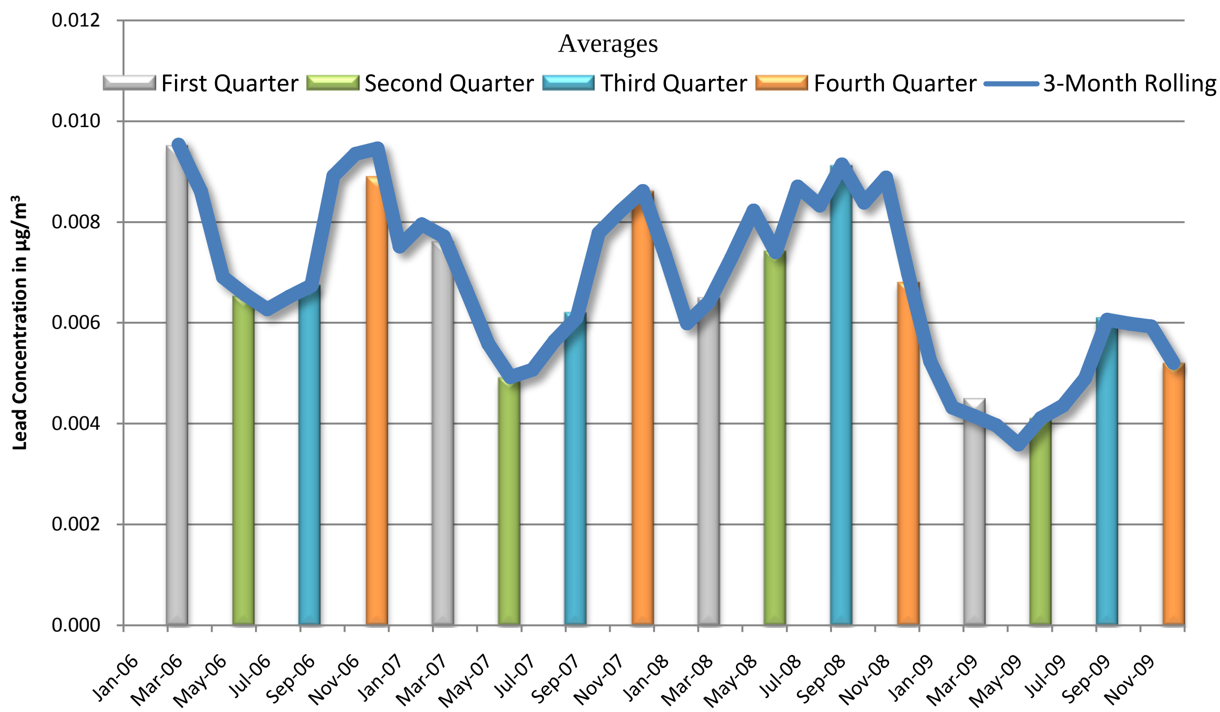


Figure 22. Quarterly Lead Averages for the Northern Front Range Counties

Table 29. Northern Front Range Carbon Monoxide Values for 2009

Site Name	Location	CO 1-hour Avg. (ppm)		CO 8-hour Avg. (ppm)	
		1st Maximum	2nd Maximum	1st Maximum	2nd Maximum
Adams					
Welby	3174 E. 78th Ave.	2.8	2.6	2.0	1.9
Boulder					
Longmont	440 Main St.	3.5	3.2	1.9	1.6
Denver					
Denver-CAMP	2105 Broadway	6.9	6.8	2.5	2.2
Firehouse #6	1300 Blake St.	3.6	3.6	1.8	1.8
Larimer					
Fort Collins	708 S. Mason St	3.5	3.0	1.9	1.8
Weld					
Greeley	905 10th Ave.	4.3	3.6	2.3	2.1

Figure 23. 1-hour and 8-hour 2nd Maximum Carbon Monoxide Averages for the Northern Front Range Counties

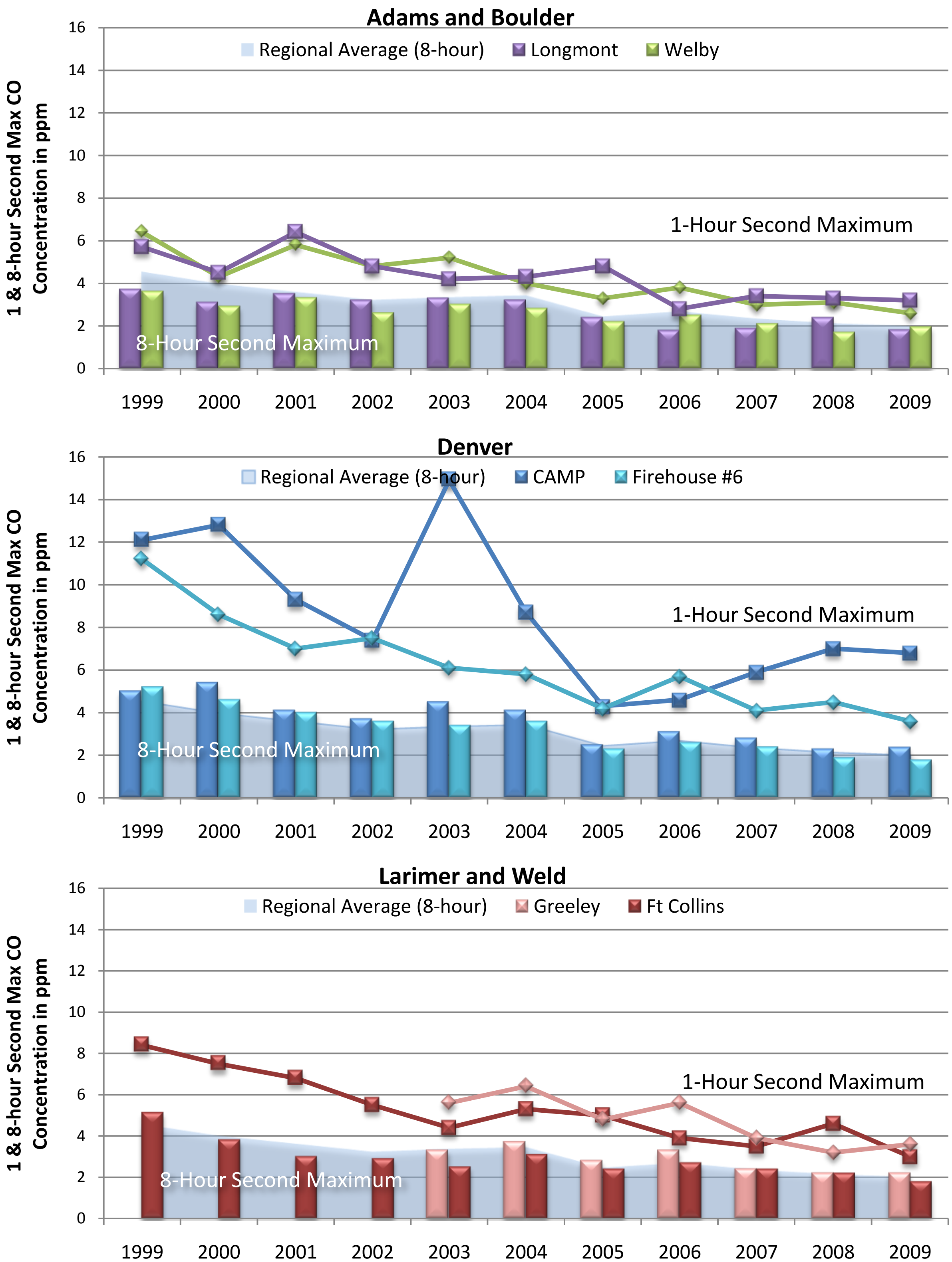


Table 30. Northern Front Range Ozone Values for 2009

Site Name	Location	Ozone 8-hour Avg. (ppm)		
		1st Maximum	4th Maximum	3-year Average of 4th Maximum
Adams				
Welby	3174 E. 78th Ave.	0.078	0.072	0.073
Arapahoe				
Highland Reservoir	8100 S. University Blvd	0.079	0.069	0.068
Aurora East	36001 E. Quincy Ave.	0.079	0.066	<3 years of data
Boulder				
Boulder	1405½ Foothills Parkway	0.084	0.073	0.078
Denver				
Denver Carriage	2325 Irving St.	0.068	0.063	0.070
Denver Animal Shelter	678 S. Jason St.	0.070	0.062	<3 years of data
Douglas				
Chatfield Reservoir	11500 N. Roxborough Park Rd.	0.085	0.071	0.078
Jefferson				
Arvada	9101 W. 57th Ave.	0.078	0.070	0.074
Welch	12400 W. Hwy 285	0.078	0.070	0.074
Rocky Flats-N	16600 W. Colorado 128	0.086	0.079	0.083
NREL	2054 Quaker St.	0.081	0.068	0.076
Aspen Park	26137 Conifer Rd.	0.077	0.067	<3 years of data
Larimer				
Fort Collins-W	3416 La Porte Ave.	0.082	0.073	0.074
Rist Canyon	11835 Rist Canyon Rd.	0.071	0.069	<3 years of data
Fort Collins-Mason	708 S. Mason St.	0.074	0.063	0.066
Weld				
Weld County Tower	3101 35th Ave.	0.071	0.067	0.071

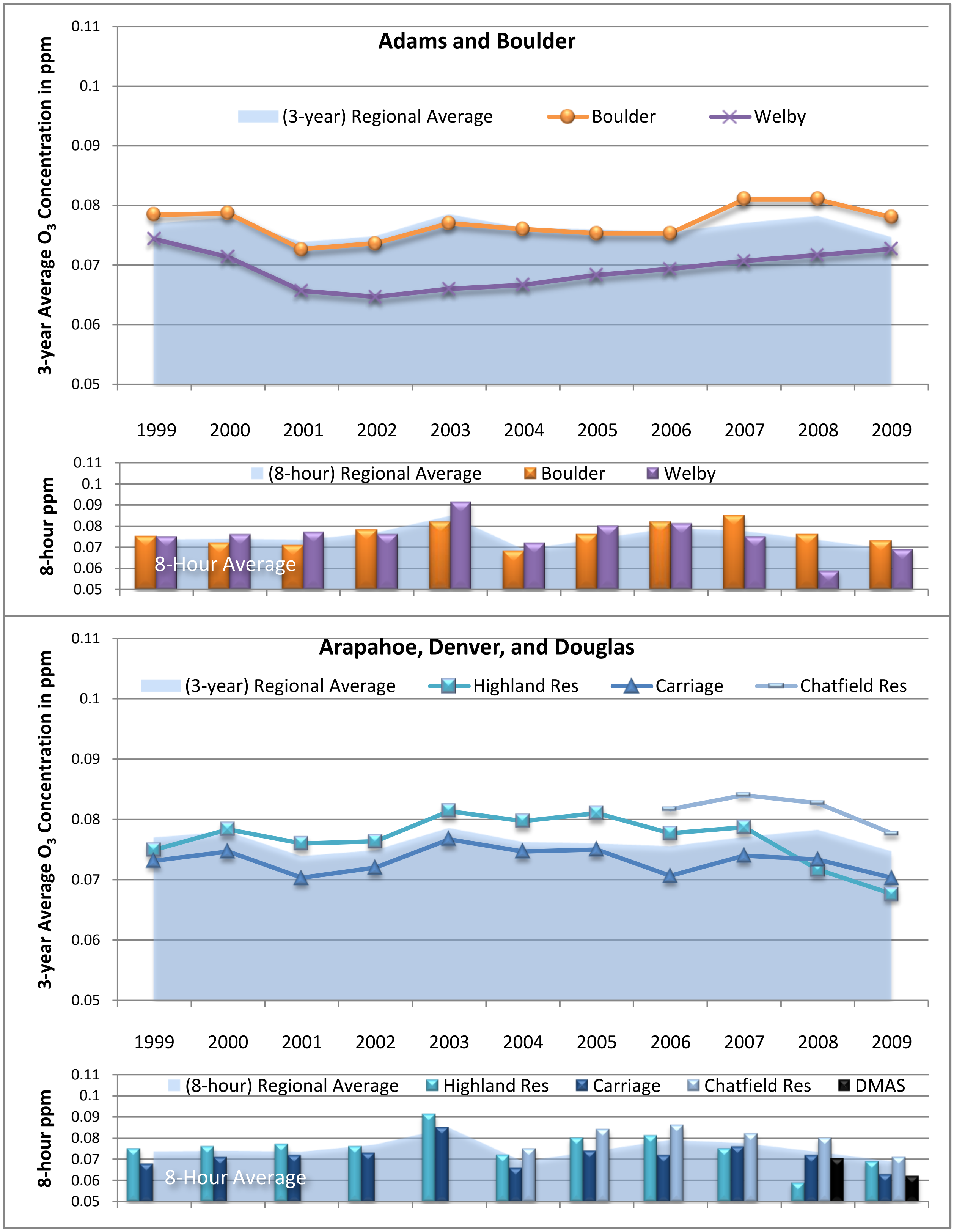


Figure 24. 3-year 4th Maximum Average and 8-hour 4th Maximum Ozone Concentrations for the Northern Front Range Counties

Figure 24. 3-year 4th Max Avg and 8-hour 4th Max Ozone for the Northern Front Range (Continued)

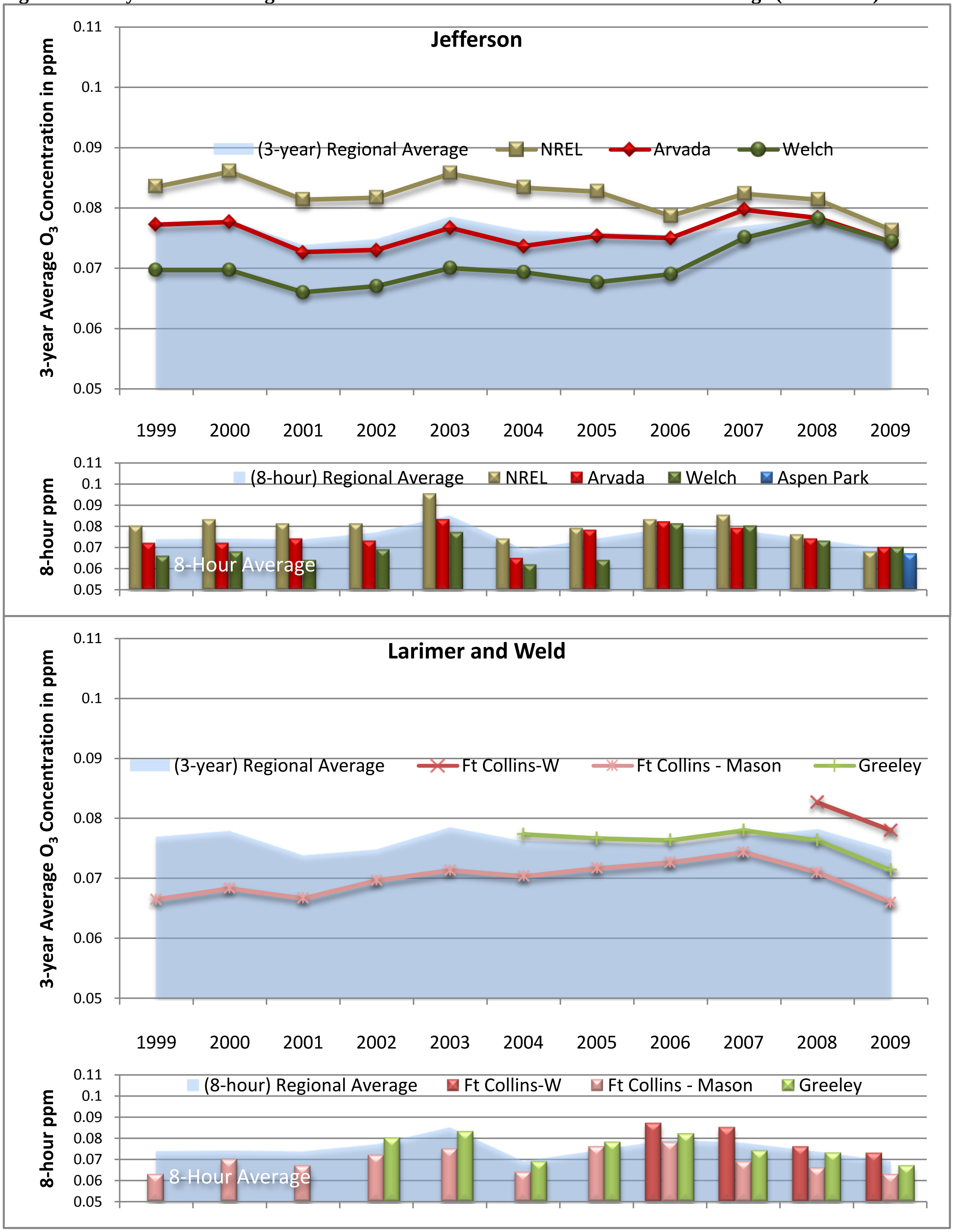


Table 31. Northern Front Range Oxides of Nitrogen and Sulfur Dioxide Values for 2009

Site Name	Location	Nitrogen Dioxide (ppm)		Nitric Oxide (ppm)	Sulfur Dioxide (ppm)			
		Annual Mean	3-year Avg 2nd 1-hr Max	Annual Avg.	3-hour 2nd Max	24-hour 2nd Max	Annua l Mean	3-year Avg
Adams								
Welby	3174 E 78th Ave.	0.0143	0.085	0.0216	0.021	0.006	0.0019	0.0647
Denver								
Denver CAMP	2105 Broadway	(0.0308)	0.093	0.0438	0.017	0.005	(0.0022)	0.0397

() indicates <75% data recovery

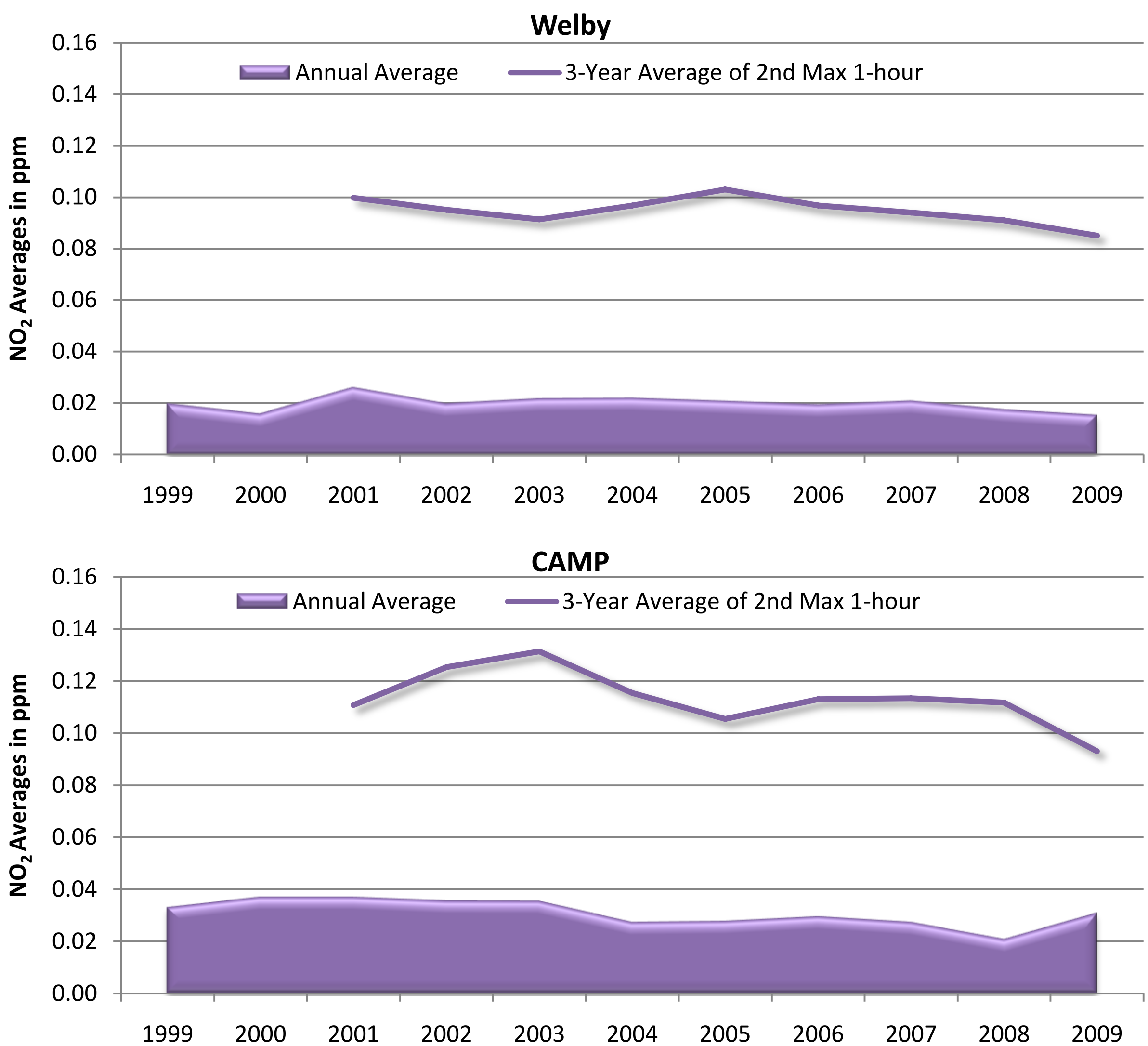


Figure 25. Annual and 3-year Average Nitrogen Dioxide Concentrations for Northern Front Range Counties

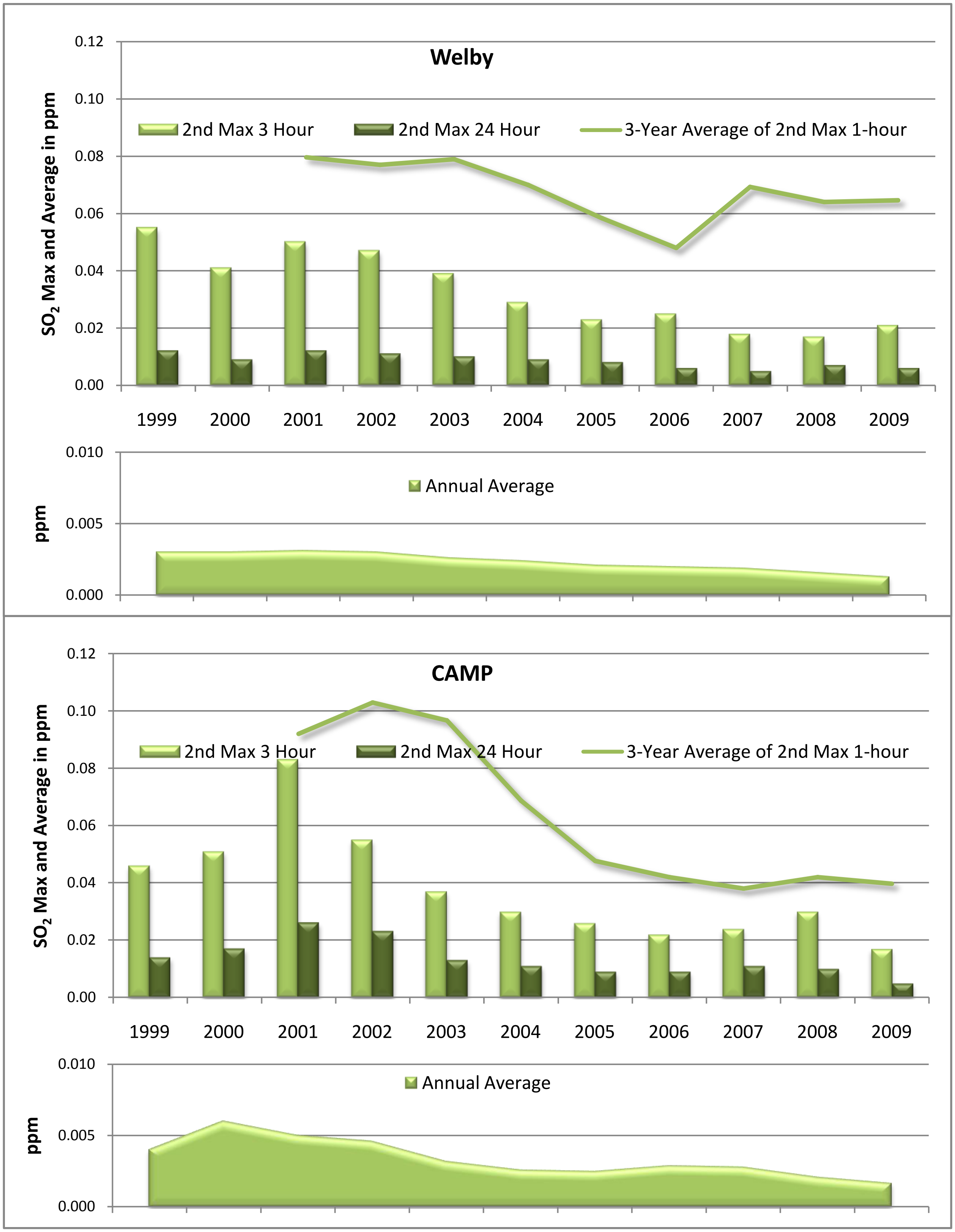


Figure 26. Sulfur Dioxide Maximums and Averages for Northern Front Range Counties

Table 32. Denver Visibility Standard Exceedance Days (Transmissometer Data) for 2009

Month	Days	EX POOR	POOR	FAIR	GOOD	Missing	(>70% RH)
January	31	2	1	10	15		3
February	28		2	19	6		1
March	31		6	19	5		1
April	30	1	2	16	6		5
May	31		2	15	9		5
June	30	1	4	16	7		2
July	31		3	25	2		1
August	31		5	24	2		
September	30	1	12	16		1	
October	31	3	4	14	2		8
November	30		5	20	2		3
December	31	1	6	17	1		6
Totals							
	365	9	52	211	57	1	35

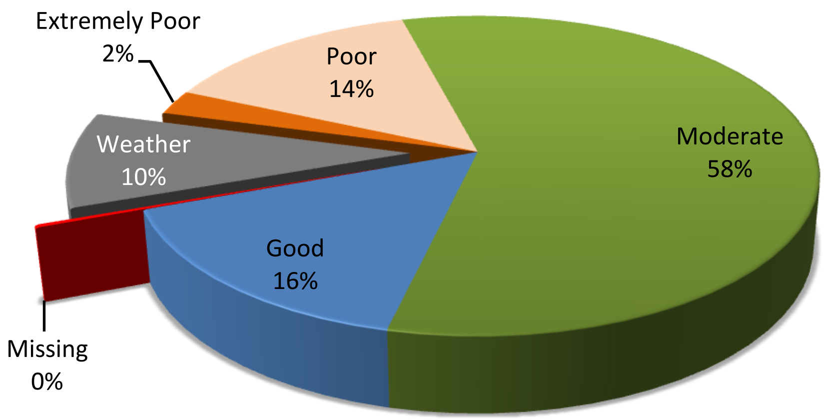


Figure 27. Denver Visibility Data

In Figure 28, days above the standard are shown as positive numbers and days below the standard are shown as negative numbers. In addition, error bars in the positive direction indicate the number of days where data is missing, and error bars in the negative direction indicate the number of days with data excluded for weather. In 2009 in Denver, for example, there were 52 days in the “Poor” category and 9 in the “Extremely Poor” category. There was one day of missing data, and 35 days excluded for weather. 2009 showed an overall improvement in visibility compared with previous years. Part, but not all, of the improvement may be attributed to better data retention rates.

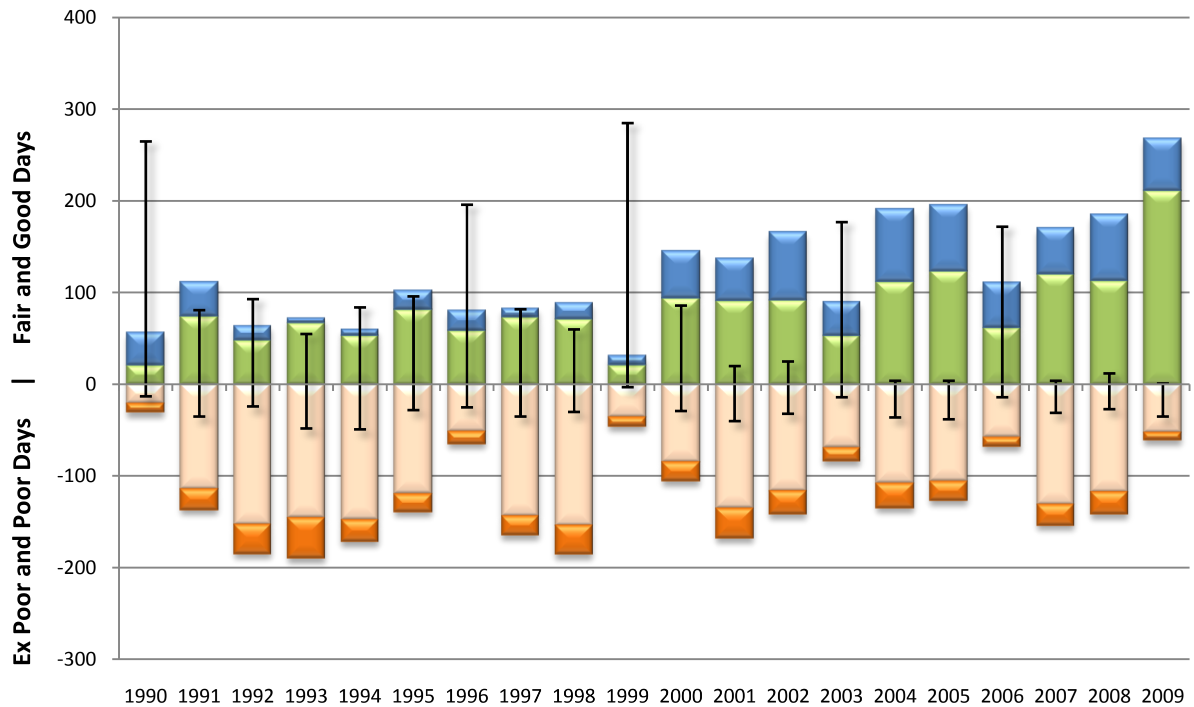


Figure 28. Annual Comparison of Visibility Data in Denver Between 1991 and 2009

Table 33. Fort Collins Visibility Standard Exceedance Days (Transmissometer Data) for 2009

Month	Days	EX POOR	POOR	FAIR	GOOD	Missing	(>70% RH)
January	31			4	19	4	4
February	28		1	14	12		1
March	31		5	9	15	1	1
April	30		4	2	18		6
May	31	1	2	3	21		4
June	30		9	13	2		6
July	31		14	12	2	1	2
August	31		22	8			1
September	30	3	15	9		2	1
October	31		6	9	4	5	7
November	30		5	7	14	2	2
December	31		4	7	7	10	3
Totals							
	365	4	87	97	114	25	38

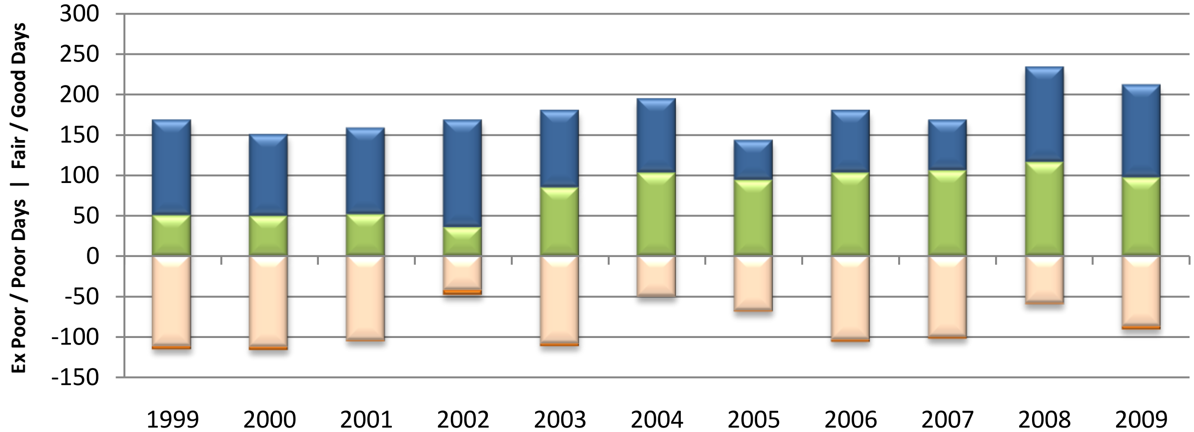


Figure 29. Annual Comparison of Visibility Data in Ft. Collins between 1991 and 2009

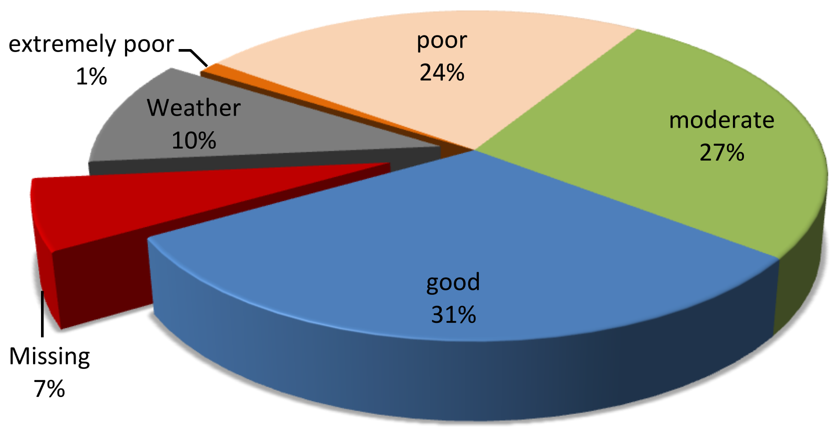
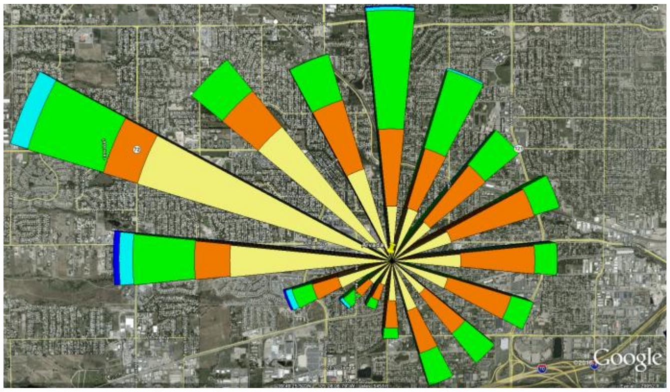


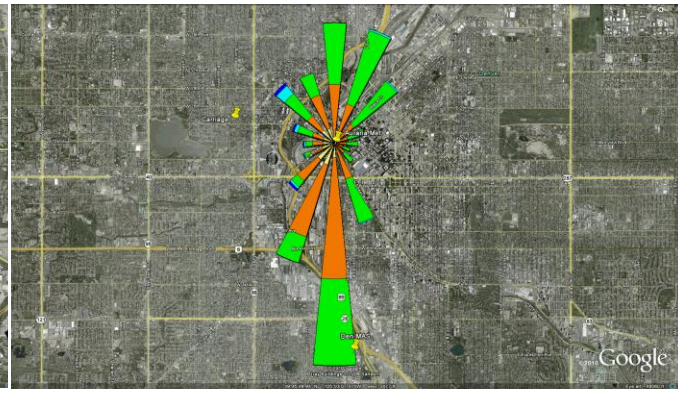
Figure 30. Ft. Collins Visibility Data

Figure 29 shows that since 1999, Fort Collins has averaged 88 days per year where the visibility was either “Fair” or “Good” and only 44 days where the visibility was either “Poor” or “Ex Poor.” The missing days are lost due to either high relative humidity (greater than 70 percent) or machine maintenance.

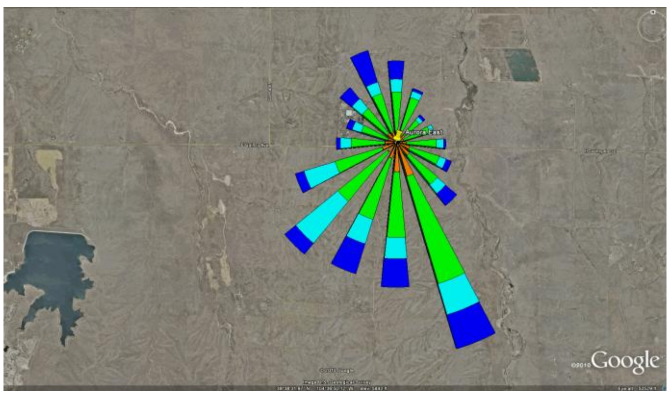
Figure 31. Northern Front Range Wind Roses (Pages 52-54)



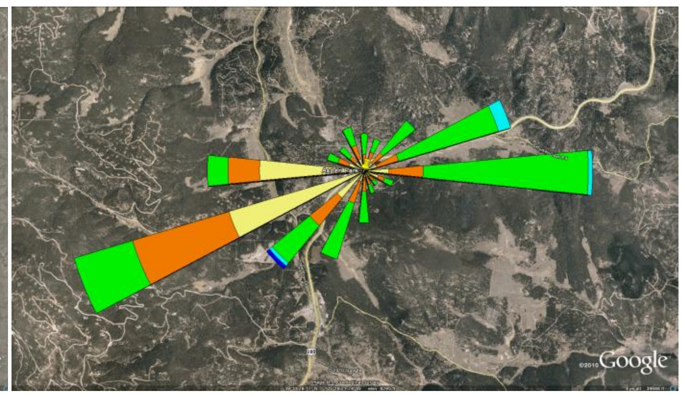
Arvada, 9101 W. 57th Ave.



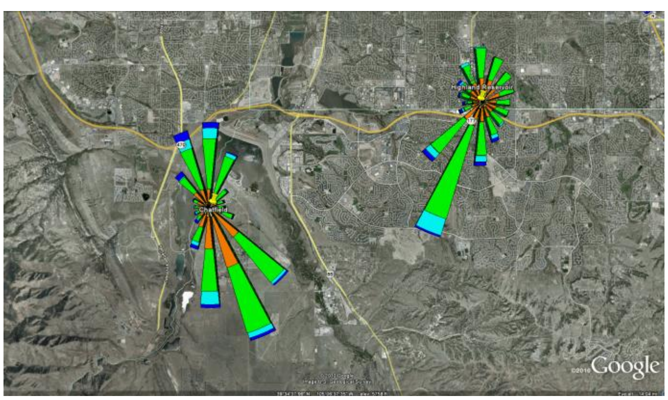
Auraria, Parking Lot R



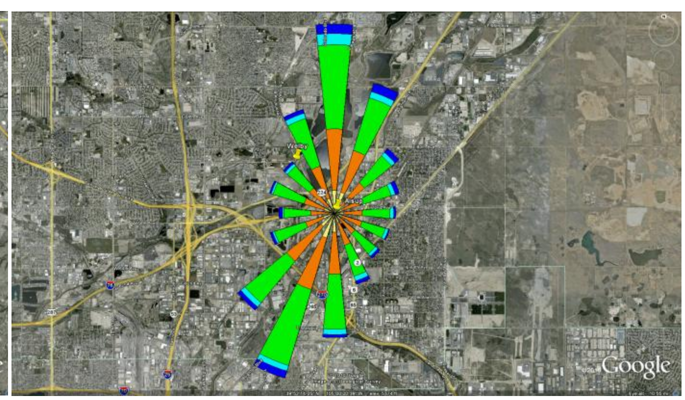
Aurora East, 36001 East Quincy Ave. (6/9/09 – 12/31/09)



Aspen Park, 26137 Conifer Rd. (5/18/09 – 12/31/09)



Chatfield Reservoir, 11500 N. Roxborough Pk. Rd.
and Highlands Reservoir, 8100 South University Blvd. (Highlands: 2/1/09 – 12/31/09)



Commerce City, 7101 Birch St.

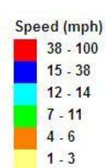
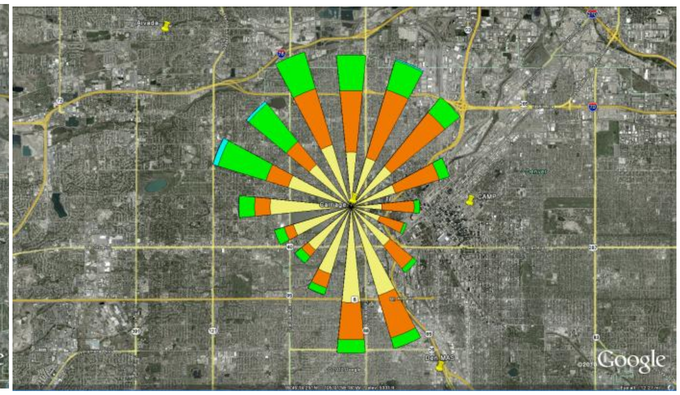
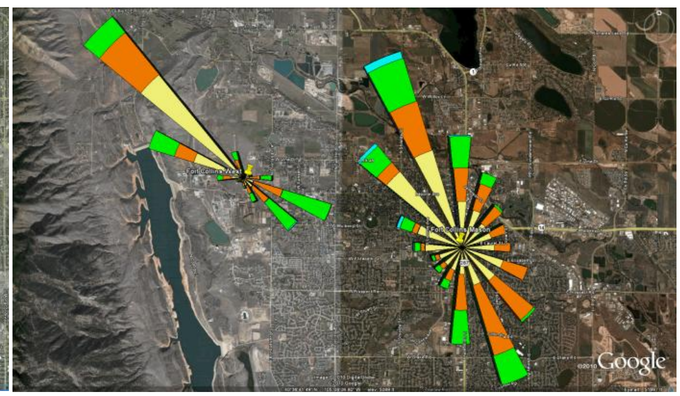


Figure 31. Northern Front Range Wind Roses (Pages 52-54) (Continued)



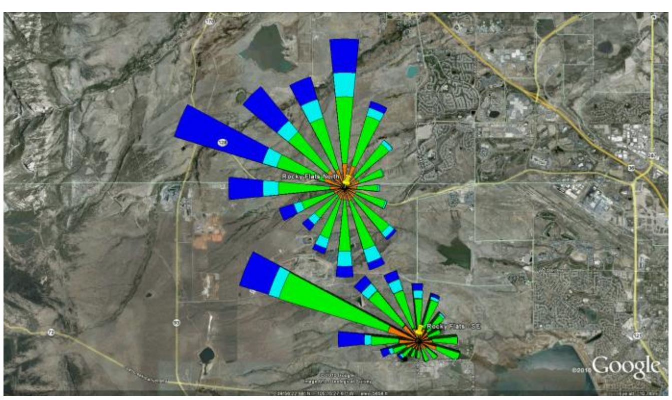
Denver CAMP, 2105 Broadway

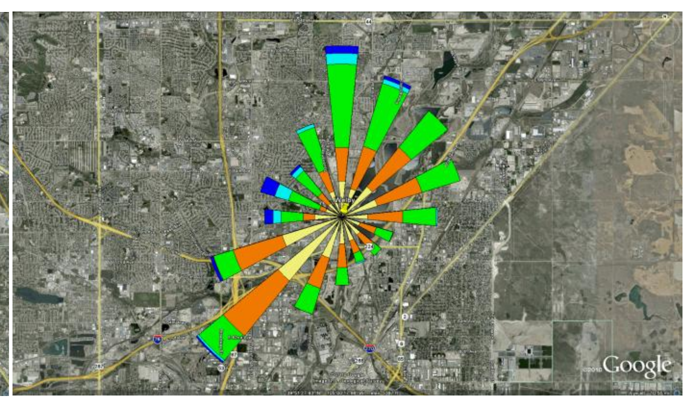
Denver Carriage, 2325 Irving St.



Denver Municipal Animal Shelter, 678 S. Jason St.

Rist Canyon (5/13/09 – 12/31/09) and 708 S. Mason St.

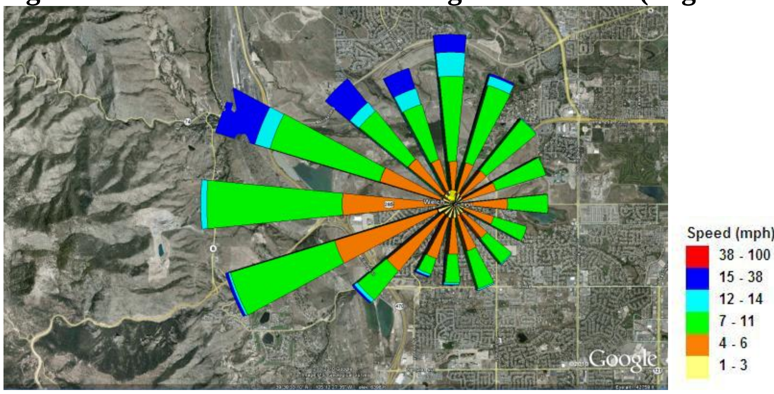




Rocky Flats-N, 16600 W. Hwy. 128 and Rocky Flats- SE, 9901 Indiana St.

Welby, 3174 E. 78th Ave.

Figure 31. Northern Front Range Wind Roses (Pages 52-54) (Continued)



Welch, 12400 W. Hwy. 285

4.3. Southern Front Range Counties

The Southern Front Range Counties are those along the urbanized I-25 corridor from south of the city of Castle Rock to the southern Colorado border. The cities with monitoring in the area are Colorado Springs, Pueblo, Cañon City, and Alamosa. These last three cities are not strictly in the Front Range I-25 corridor but fit better with those cities than they do the Mountain Counties. Colorado Springs is the only city in the area that is monitored for carbon monoxide and ozone by the APCD. The other cities are only monitored for particulates. In the past the APCD has conducted particulate monitoring in both Walsenburg and Trinidad but that monitoring was discontinued in 1979 and 1985 respectively. Data below may include exceptional events. See Section 2.2.5.1.

Table 34. Southern Front Range Particulate Values for 2009

Site Name	**Location**	**PM_{10} (µg/m^3)**			**$PM_{2.5}$ (µg/m^3)**			
		Annual Avg.	**24-hour Max**	**3-Year Avg. Exceedances**	**Annual Avg.**	**3-Year Weighted Avg.**	**24-hour Max**	**3-Year Average of 98th %ile**
Alamosa								
Alamosa	208 Edgemont Blvd. (ASC)	20.8	207	0.66				
	425 4TH St. (Municipal)	24.6	157	1.33				
El Paso								
Colorado Springs	130 W. Cache la Poudre	17.3	35	0	5.58	<3 years of data	11.2	<3 years of data
	(Continuous)				8.88		47.4	
Fremont								
Cañon City	128 Main St.	16.2	38	0				
Pueblo								
Pueblo	211 D St.	35.1	99	0	7.44	7.40	17.3	15.7

The Alamosa 4th Street station has had an average of 1.66 exceedances per year over the last 3 years (1, 2, and 1 exceedances for 2007, 2008, and 2009 respectively), which is in violation of the annual average primary standard (1).

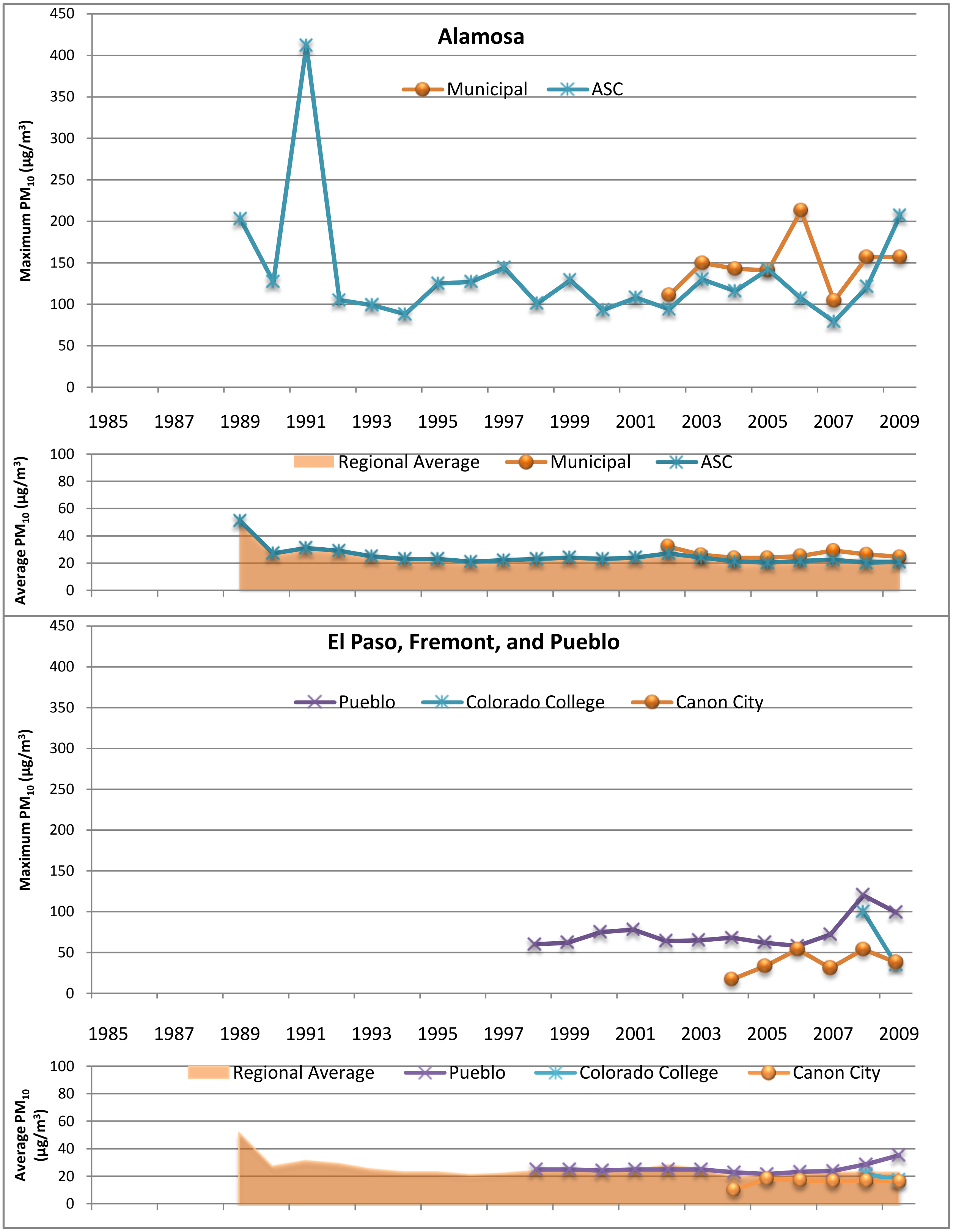


Figure 32. Average and Maximum PM_{10} Concentrations for Southern Front Range Counties

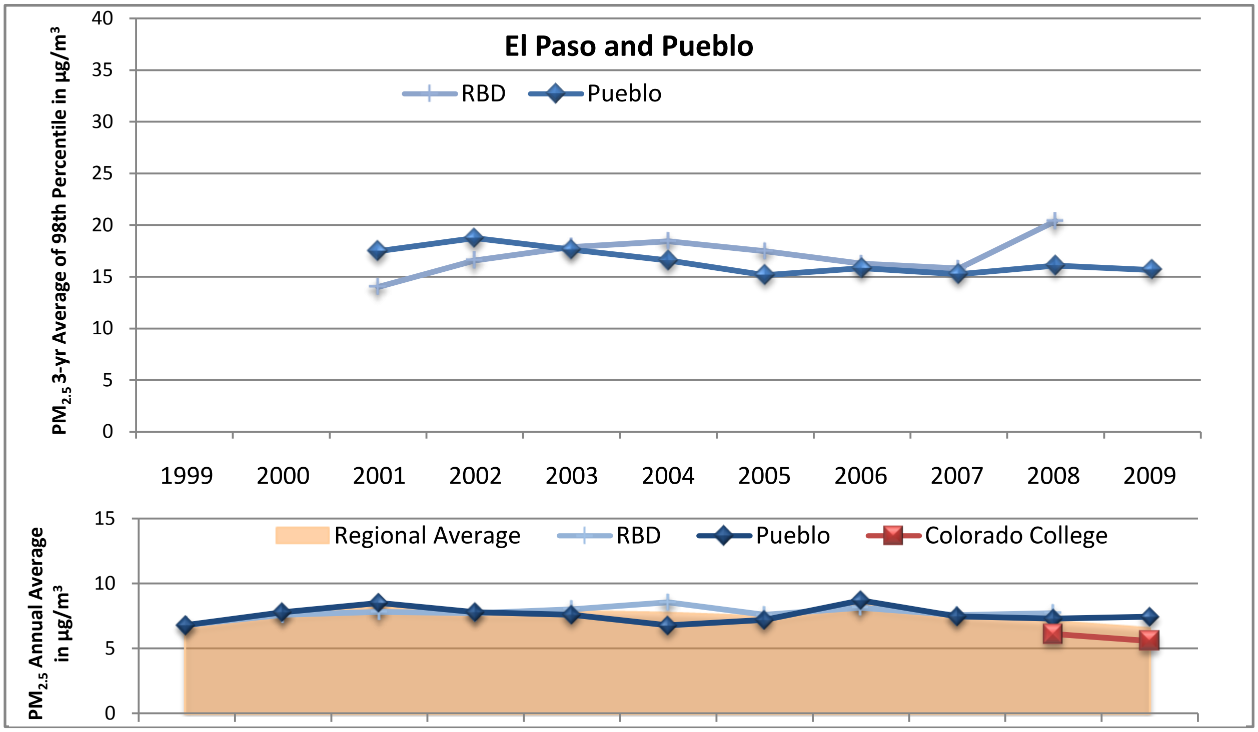


Figure 33. 3-Year 98th Percentile and Weighted Averages for $PM_{2.5}$ for the Southern Front Range Counties

Table 35. Southern Front Range Carbon Monoxide Values for 2009

Site Name	Location	CO 1-hour Avg. (ppm)		CO 8-hour Avg. (ppm)	
		1st Maximum	2nd Maximum	1st Maximum	2nd Maximum
El Paso					
Colorado Springs	690 W. Hwy 24	3.8	3.6	2.7	1.9

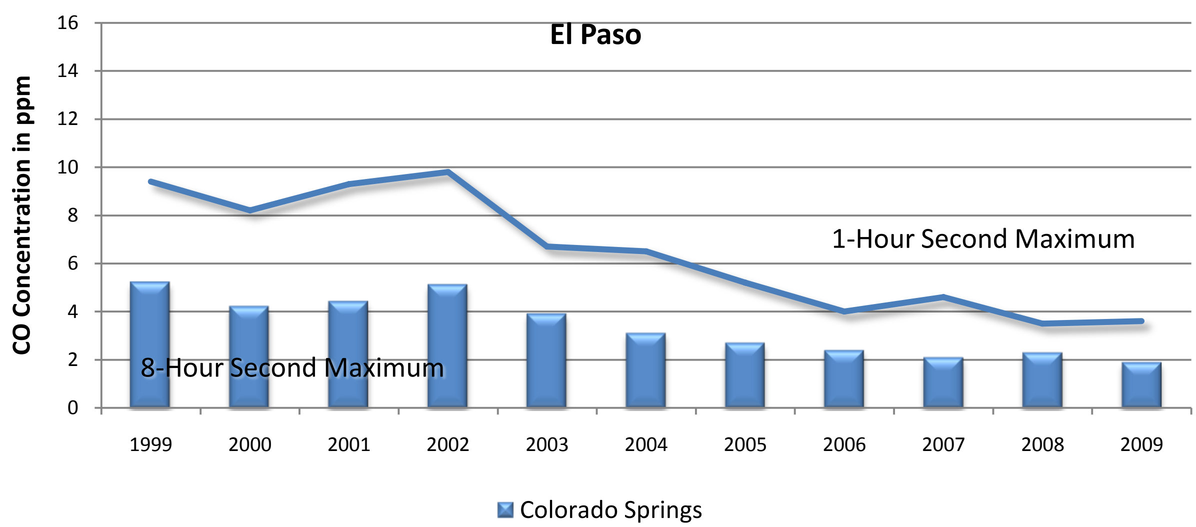


Figure 34. 1-hour and 8-hour 2nd Maximum Carbon Monoxide Averages for the Southern Front Range Counties

Table 36. Southern Front Range Ozone Values for 2009

Site Name	Location	Ozone 8-hour Avg. (ppm)		
		1st Maximum	4th Maximum	3-year Average of 4th Maximum
		Adams		
USAFA	USAFA Rd 640	0.064	0.060	0.067
Manitou Springs	101 Banks Pl.	0.071	0.064	0.069

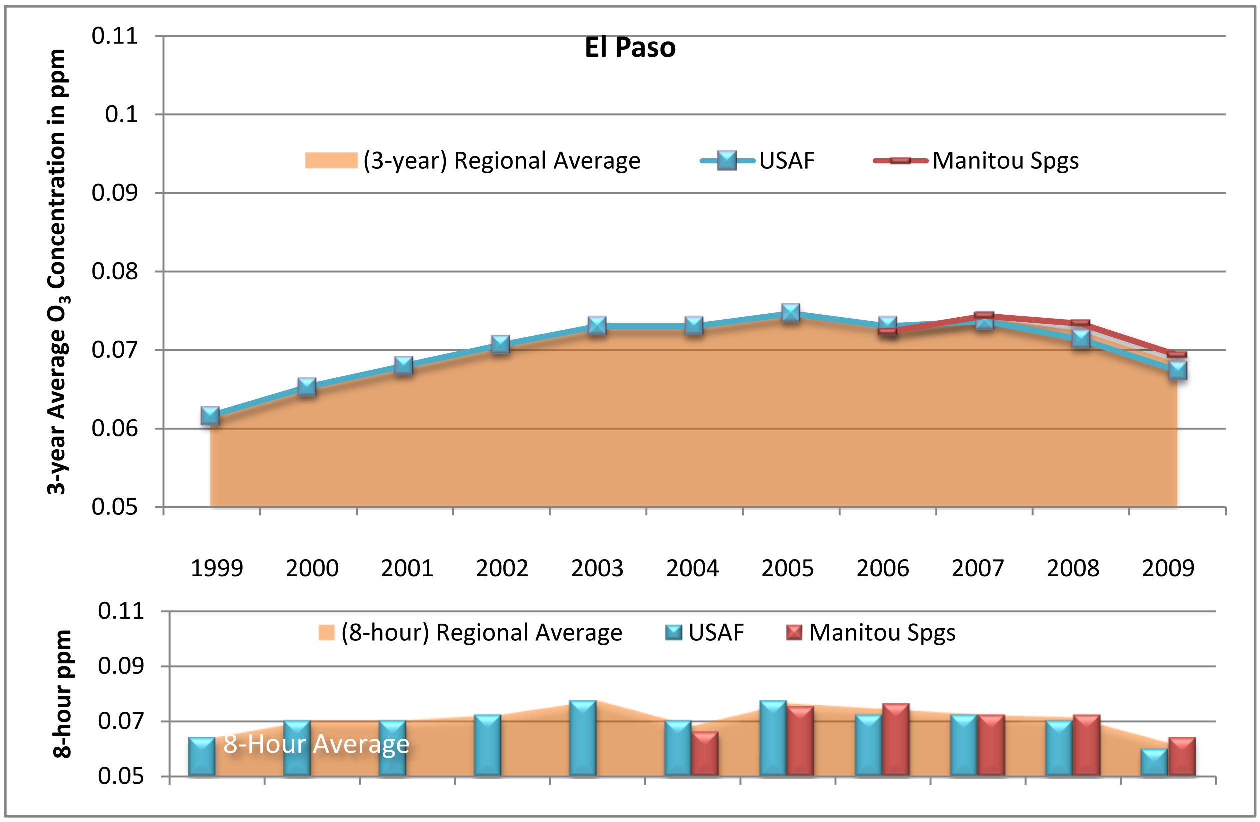


Figure 35. 3-year 4th Maximum Average and 8-hour 4th Maximum Ozone Concentrations for the Northern Front Range Counties

4.4. Mountain Counties

The Mountain Counties are generally the towns near the Continental Divide. They are mostly small towns in tight mountain valleys. Their primary monitoring concern is with particulate pollution from wood burning and road sanding. These communities range from Steamboat Springs in the north to Breckenridge in the I-70 corridor, as well as Aspen, Crested Butte and Mt. Crested Butte in the central mountains and Pagosa Springs in the south. The data below may include exceptional events. See Section 2.2.5.1.

Table 37. Mountain Counties Particulate Values for 2009

Site Name	**Location**	**PM_{10} (µg/m^3)**		
		Annual Avg.	**24-Hr Max**	**3-Year Avg. Exceedances**
Archuleta				
Pagosa Springs	309 Lewis St.	25.0	255	1.33
Gunnison				
Crested Butte	603 6th St.	27.4	103	0
Mt. Crested Butte	19 Emmons Loop	18.0	93	0.33
Pitkin				
Aspen	120 Mill St	16.3	47	0
Routt				
Steamboat Springs	136 6th St.	23.5	83	0
Breckenridge	501 N. Park Ave.	17.6	101	0

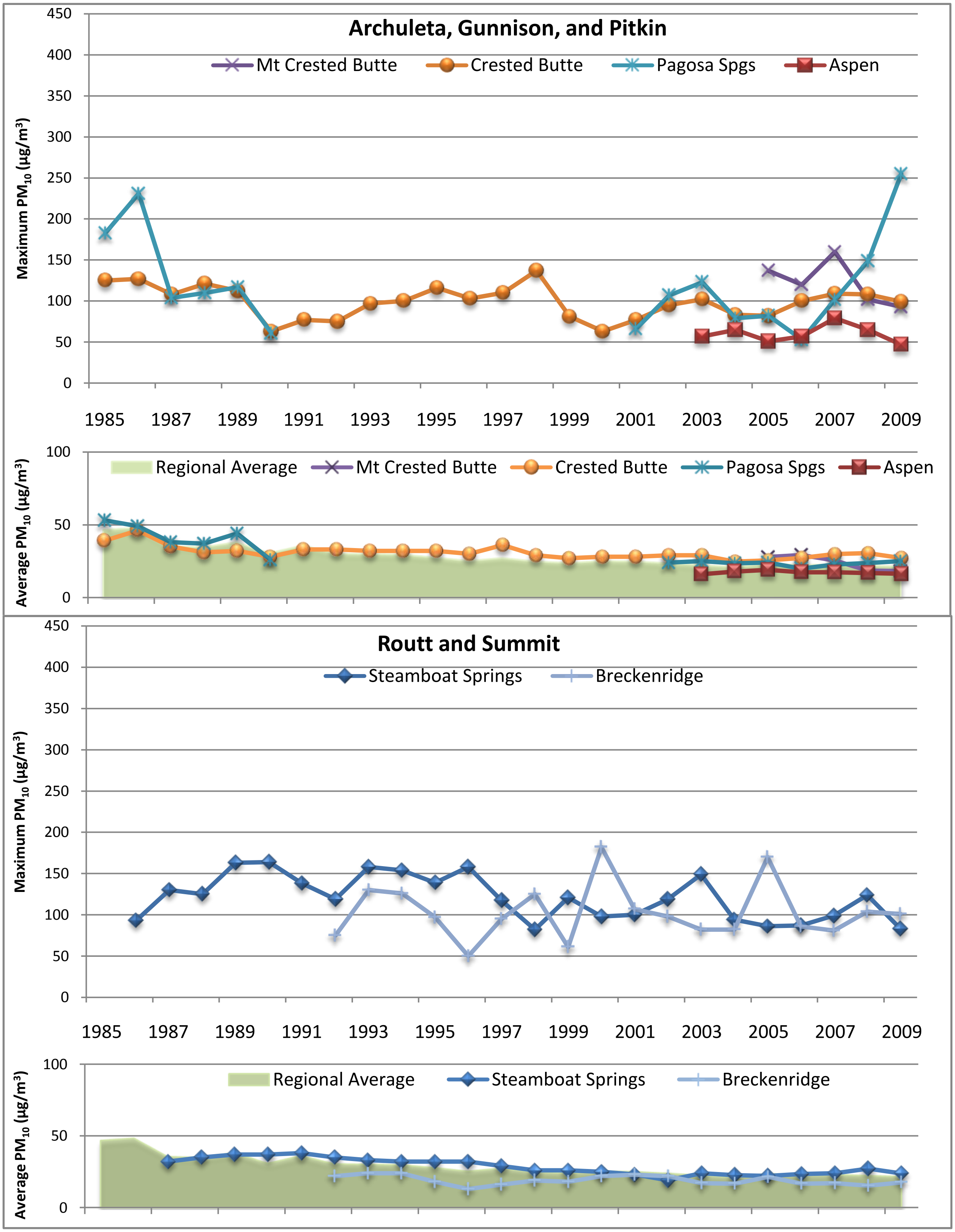


Figure 36. Average and Maximum PM_{10} Concentrations for the Mountain Counties

4.5. Western Counties

The Western Counties are generally smaller towns, and are usually located in fairly broad river valleys. Grand Junction is the only large city in the area, and the only location that monitors for carbon monoxide and air toxics on the western slope. In 2008, Rifle, Palisade, and Cortez began monitoring for ozone. The other Western County locations monitor only for particulates. They are located in Delta, Durango, Parachute, and Telluride. The data below may include exceptional events. See Section 2.2.5.1.

Table 38. Western Counties Particulate Values for 2009

Site Name	Location	PM_{10} ($\mu g/m^3$)			$PM_{2.5}$ ($\mu g/m^3$)			
		Annual Avg.	24-hour Max	3-Year Avg. Exceedances	Annual Avg.	3-Year Weighted Avg.	24-hour Max	3-Year Average of 98th %ile
Delta								
Delta	560 Dodge St.	26.8	186	0.33				
Garfield								
Parachute	100 E. 2nd Ave.	25.3	88	0.33				
Rifle	144 E. 3rd Ave.	24.5	83	0				
La Plata								
Durango	1235 Camino Del Rio	23.2	203	0.66				
Mesa								
Grand Junction	650 South Ave.	25.3	69	0	9.74	9.44	59	30.6
	(Continuous)	24.5	65		6.12		148	
Clifton	141 & D St.	31.7	147	0				
Montezuma								
Cortez	106 W. North St.				6.75	<3 years of data	19	<3 years of data
San Miguel								
Telluride	333 W. Colorado Ave.	18.4	130	0				

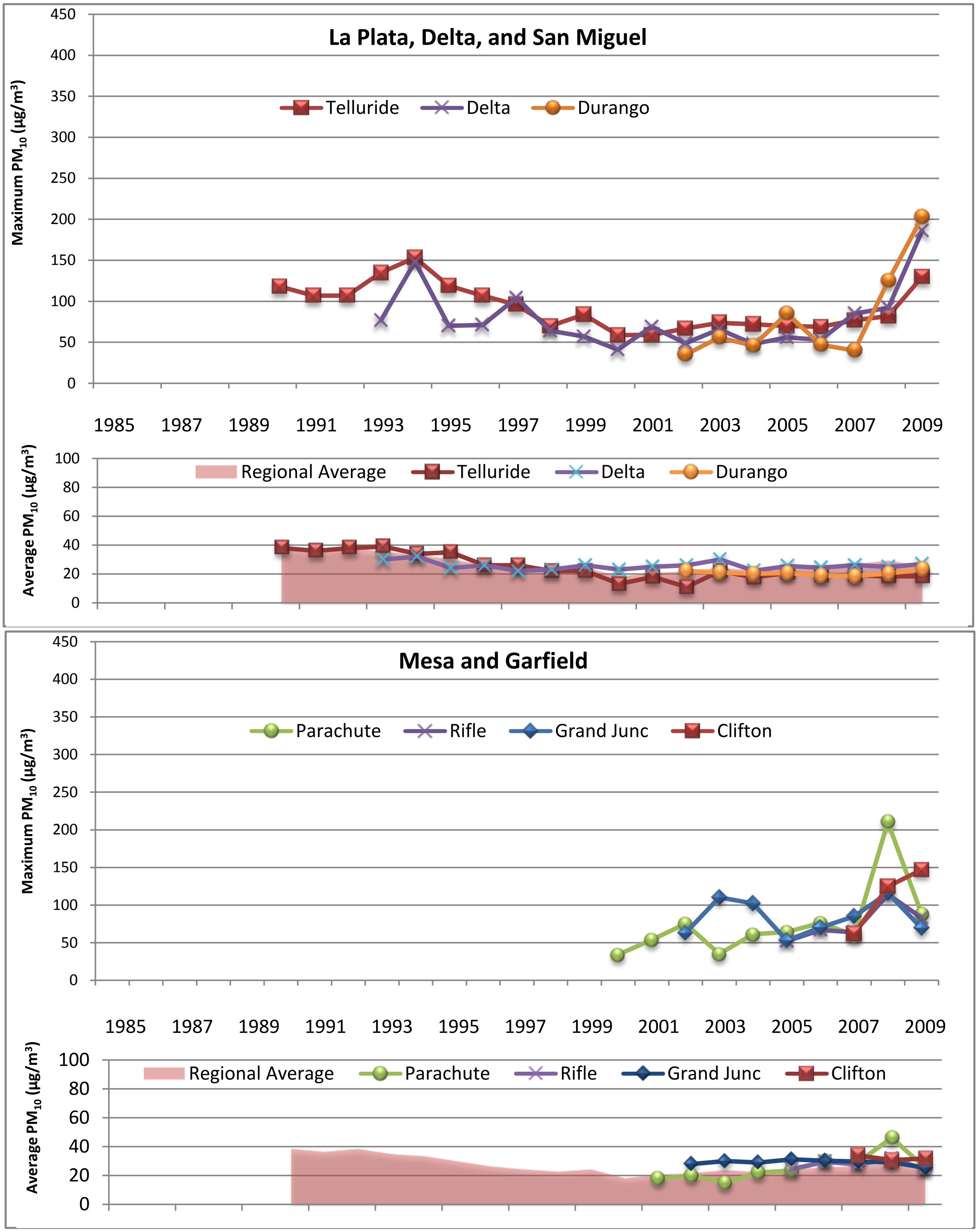


Figure 37. Average and Maximum PM10 Concentrations for Western Counties

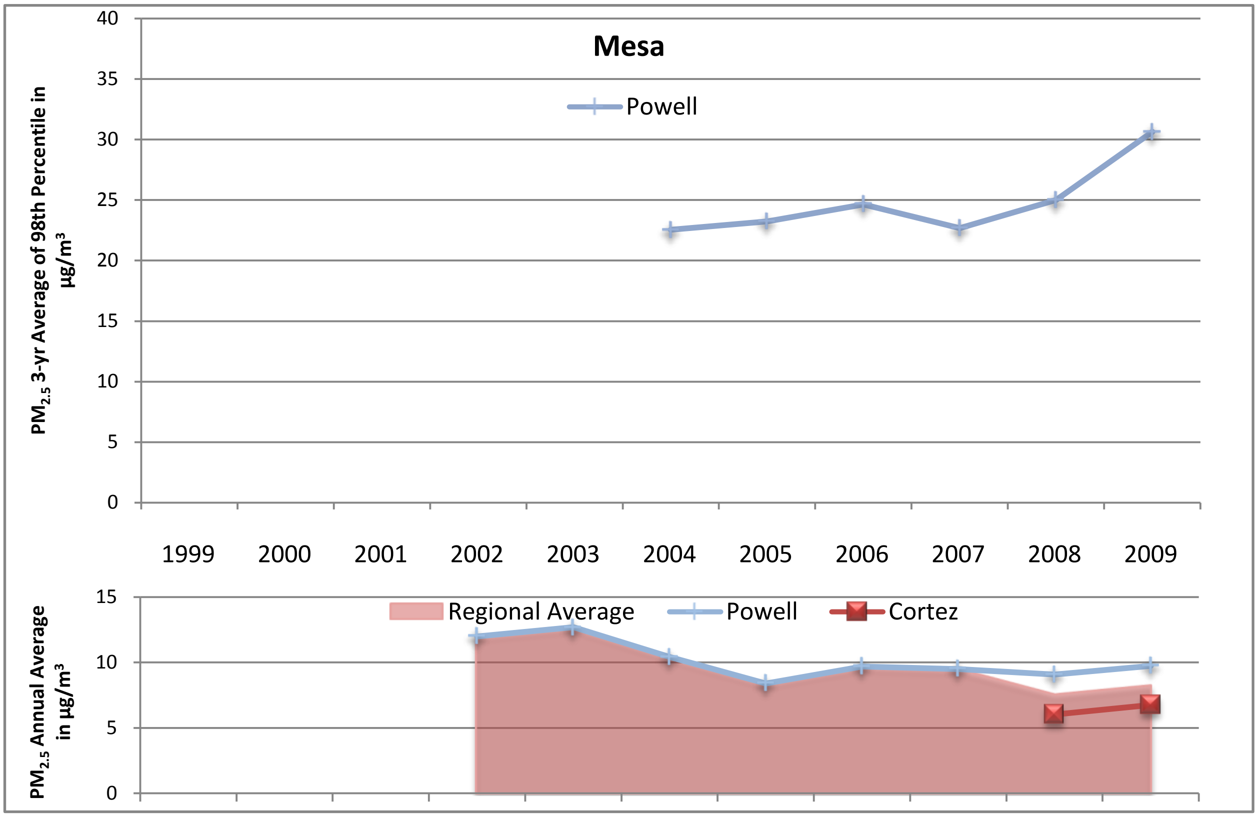


Figure 38. 3-Year 98th Percentile and Weighted Averages for $PM_{2.5}$ for the Western Counties

Table 39. Western Counties Carbon Monoxide Values for 2009

Site Name	**Location**	**CO 1-hour Avg.(ppm)**		**CO 8-hour Avg.(ppm)**	
		1st Maximum	**2nd Maximum**	**1st Maximum**	**2nd Maximum**
Mesa					
Grand Junction	645 ½ Pitkin Ave.	2.3	2.3	2.2	2.2

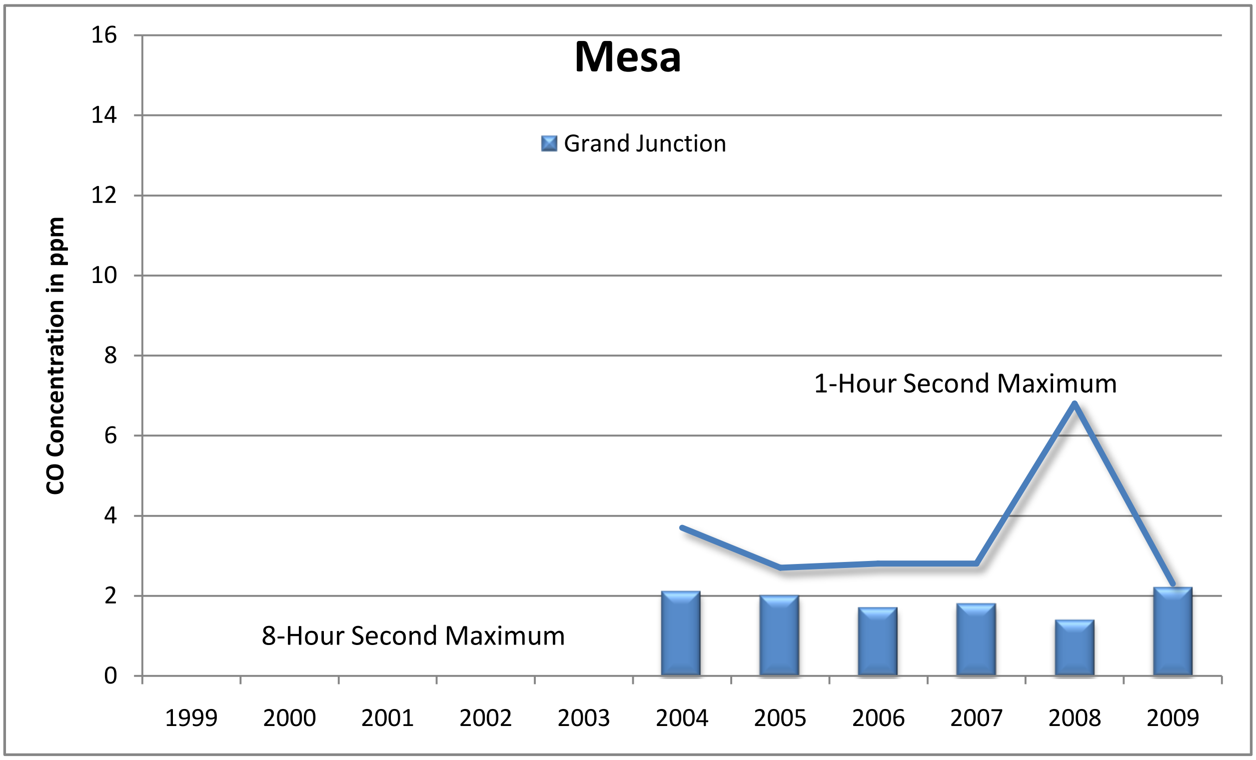


Figure 39. 1-hour and 8-hour 2nd Maximum Carbon Monoxide Averages for the Western Counties

Table 40. Western Counties Ozone Values for 2009

Site Name	Location	Ozone 8-hour Avg. (ppm)		
		1st Maximum	4th Maximum	3-year Average of 4th Maximum
Garfield				
Rifle	195 W. 14th St.	0.064	0.062	<3 years of data
Mesa				
Palisade Water Treatment Plant	865 Rapid Creek Dr.	0.067	0.064	<3 years of data
Montezuma				
Cortez	106 W. North Ave.	0.066	0.064	<3 years of data

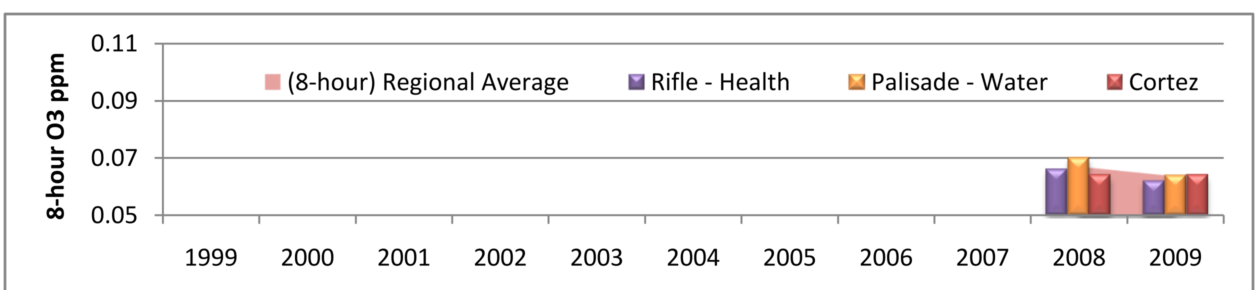
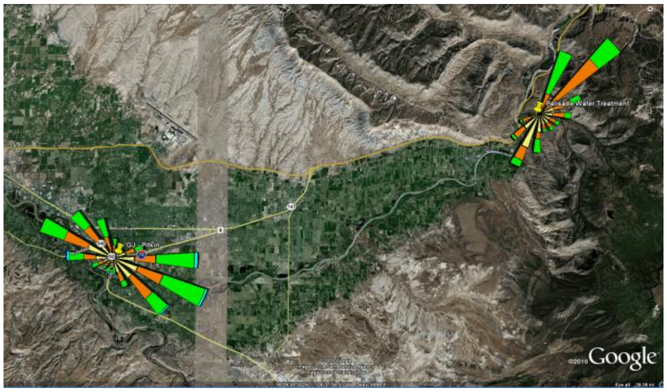
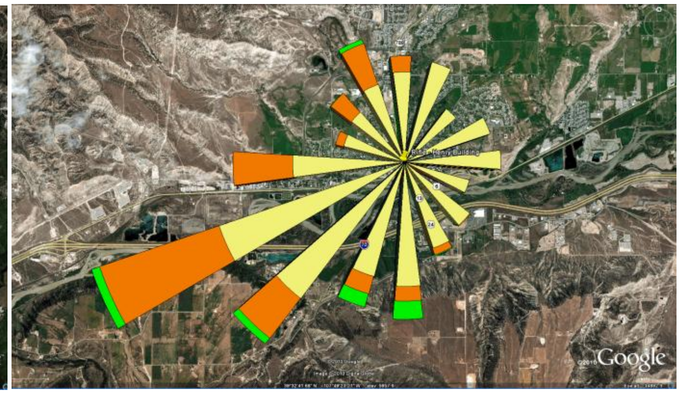


Figure 40. Ozone 8-hour 4th Maximum Concentrations for the Western Counties

Figure 41. Western Counties Wind Roses





Grand Junction, 645¼ Pitkin Ave., Palisade Water Treatment Plant.

Rifle, 144 3rd St. (5/14/09 – 12/31/09)

5. Results through the Year

In the previous sections, summary data has been presented to give an overall picture of the progress of air quality through the years and to compare measured concentrations against NAAQS, in Sections 2 and 4 respectively. However, the APCD collects data on hourly averages (which are themselves the result of even more brief intervals being averaged together) for select criteria pollutants at each site. In this section, monthly averages will be presented, and compared against the state-wide range of averages at each site.

In some sense, there is little interpretation to be done concerning the air quality information presented in this section. It is not intended to compare Colorado's air quality against the standards, other states, or past air quality. This section is only to suggest a more detailed picture of the air quality in our state throughout the year.

In all of the graphs in this section, the minimum and maximum average ranges are illustrated as blue shading in the background. This is the range for the entire state. The sites are not grouped in a geographic fashion, rather they are presented in order of their Air Quality Site ID, which is an EPA designated code derived from the state, county, and city (if appropriate) where the site is located. Each graph has been limited in the number of sites it presents for clarity sake, but for each pollutant set, the minimum and maximum state-wide range is the same.

5.1. Carbon Monoxide

Carbon monoxide can generally be considered an indicator of overall air quality. High CO concentrations indicate poor air quality, and low concentrations mean generally good air quality. CO is normally higher in the winter months and lower in the summer, for reasons discussed in Section 2 above. With the exception of a couple of extraordinarily high months at Auraria (June and September) this notion of low summer concentrations and higher winter concentrations holds true throughout Colorado. Figure 42 shows the monthly average concentrations for CO across the state.

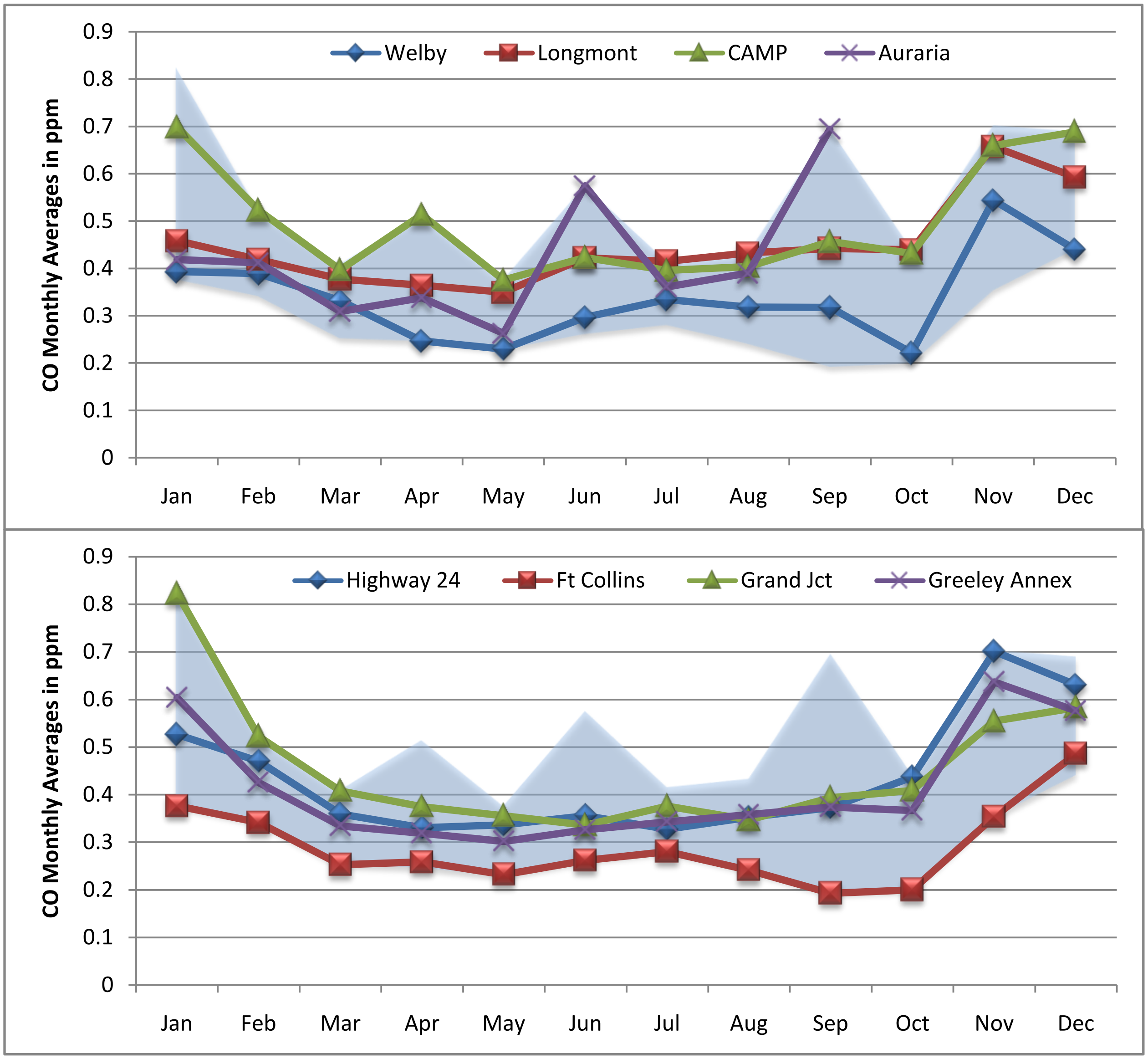


Figure 42. Monthly Carbon Monoxide Averages for 2009

5.2. Ozone

Ozone generally seems to follow an opposite pattern than that of carbon monoxide. The summer months see high ozone and the winter generally shows lower levels. Remember that ozone is indicative of ground-level smog or the "Denver Brown Cloud". Generally speaking, sites in the Northern Front Range counties fared worse than other areas, though sites outside the Front Range occasionally had the highest averages.

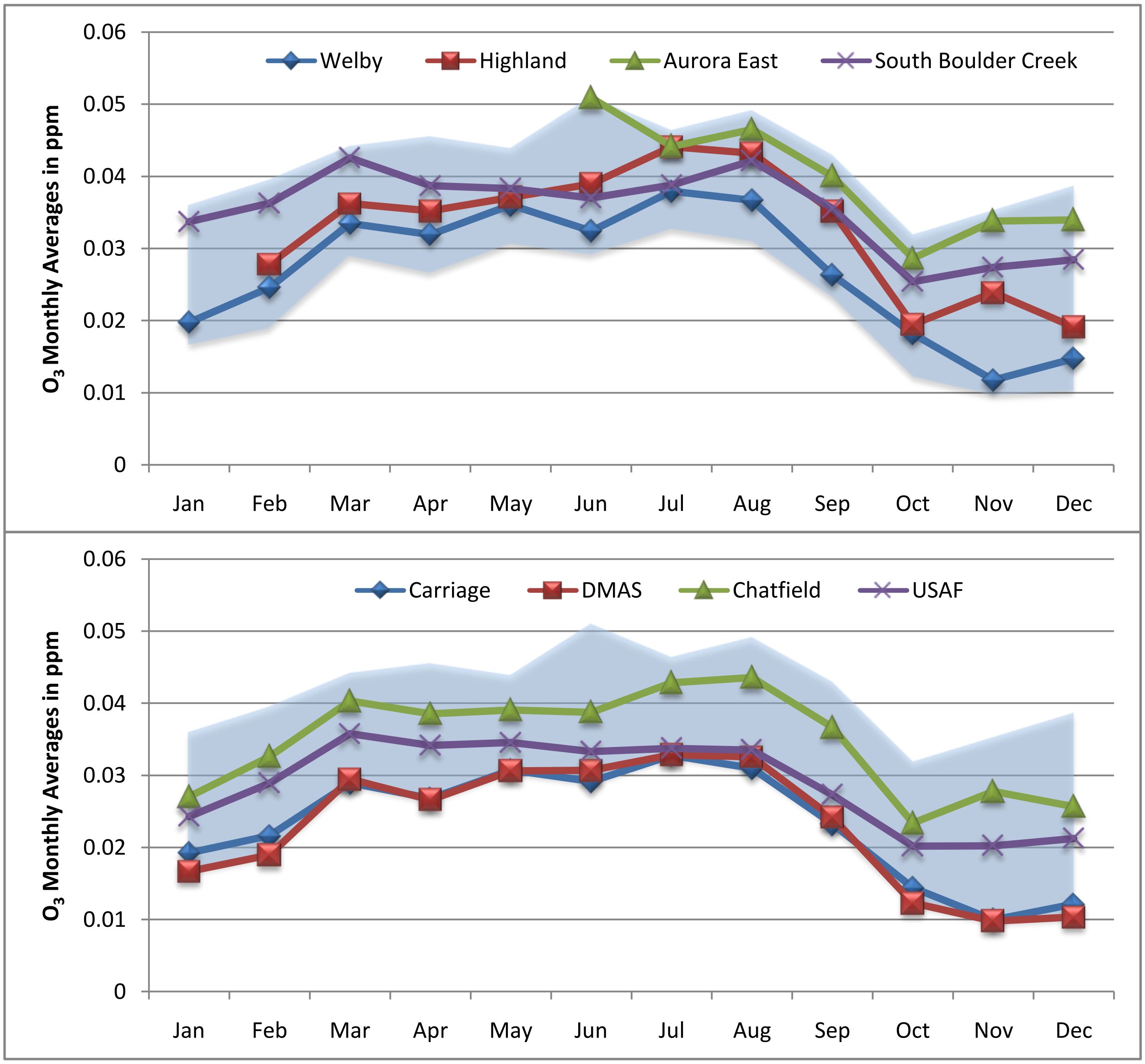


Figure 43. Monthly Ozone Averages for 2009

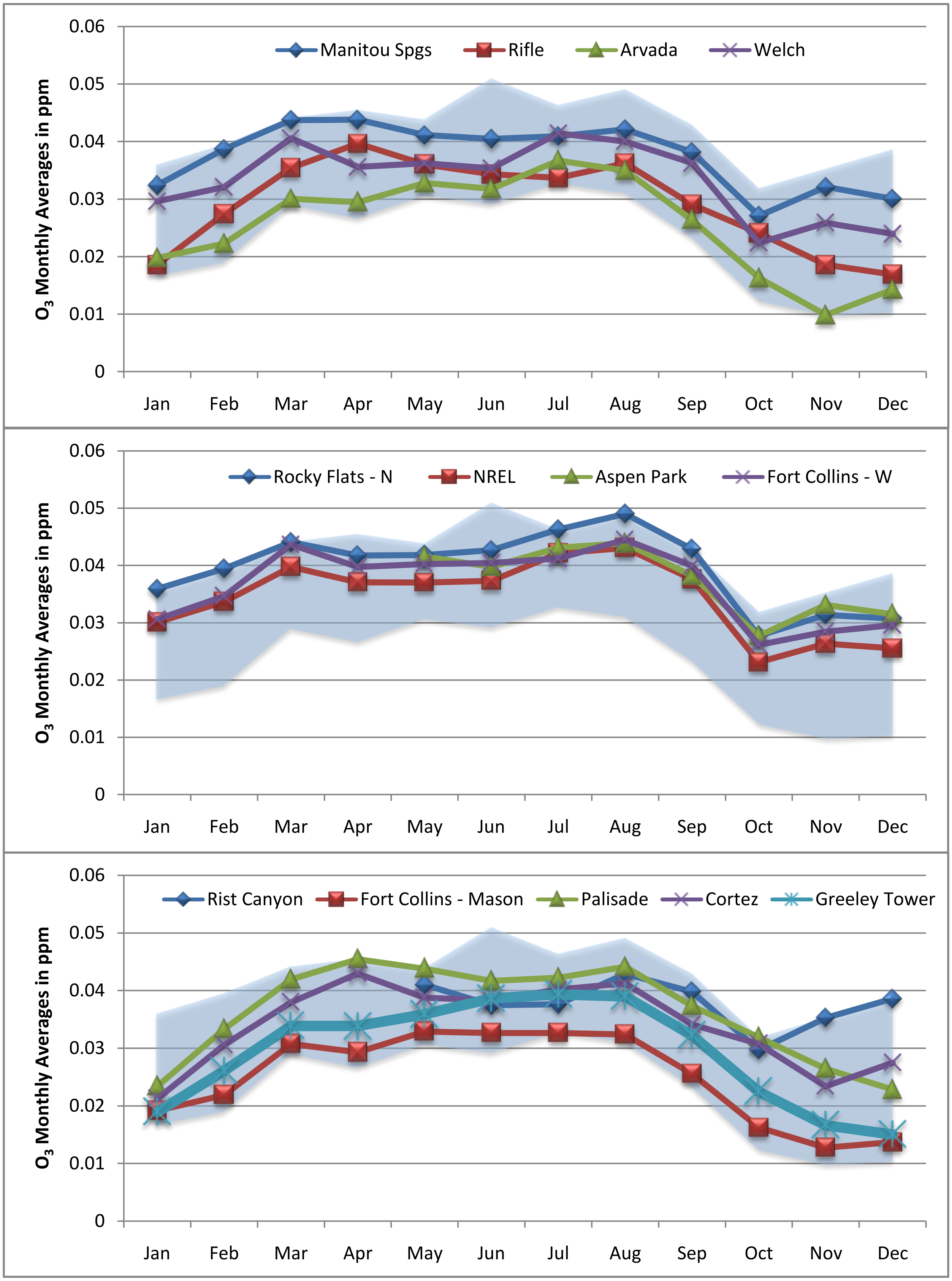


Figure 43. Monthly Ozone Averages for 2009 (Continued)

5.3. Sulfur Dioxide

Sulfur dioxide is measured at two stations in Colorado, Welby and CAMP, both in the metro Denver area. Sulfur dioxide measurements were lost at CAMP for the first half of the year, but between September and December, concentrations between the two stations appear to track well with each other. That is to say that when one site reads higher measurements the other site also reads higher measurements.

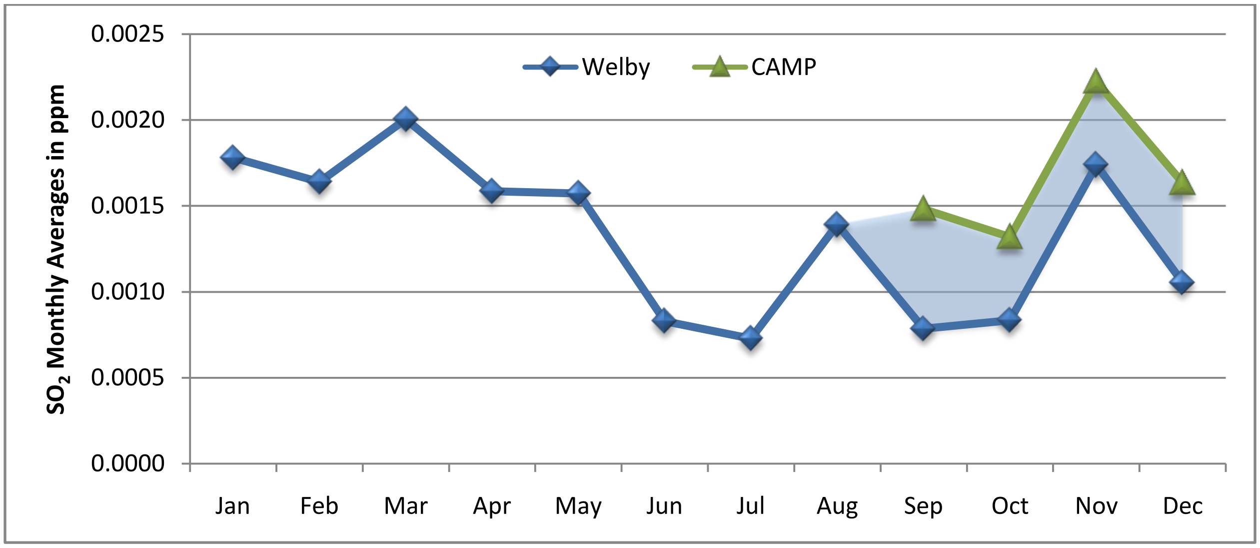


Figure 44. Monthly Sulfur Dioxide Averages for 2009

5.4. Nitrogen Dioxide

As with sulfur dioxide, data was lost for the first half of the year at CAMP. Additionally, some of the data in the second half of the year was also lost. Both sulfur dioxide and nitrogen dioxide seem to follow the same pattern of generally lower concentrations in the warmer months and higher in the colder months. This, in combination with the discussion about carbon monoxide above, indicates that colder months generally fair worse for air quality.

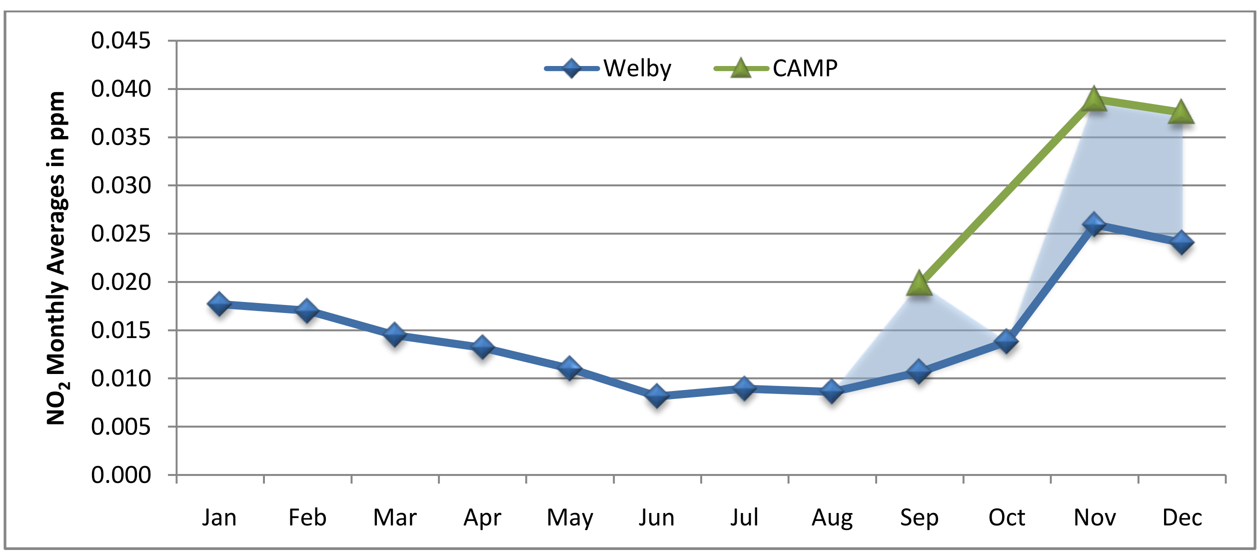


Figure 45. Monthly Nitrogen Dioxide Averages for 2009

5.5. Particulate Matter – PM_{10}

PM_{10} can be high for a variety of reasons including anthropogenic and natural occurrences. Higher PM_{10} concentrations might be expected during dry months, since the soil has a chance to dry out and be picked up by the winds. This can be somewhat seen in the range of PM_{10} concentrations found in the following graphs, especially early in the year, but the peaks in concentrations are often due to single-point high-concentration events. The data below may contain exceptional events. See Section 2.2.5.1.

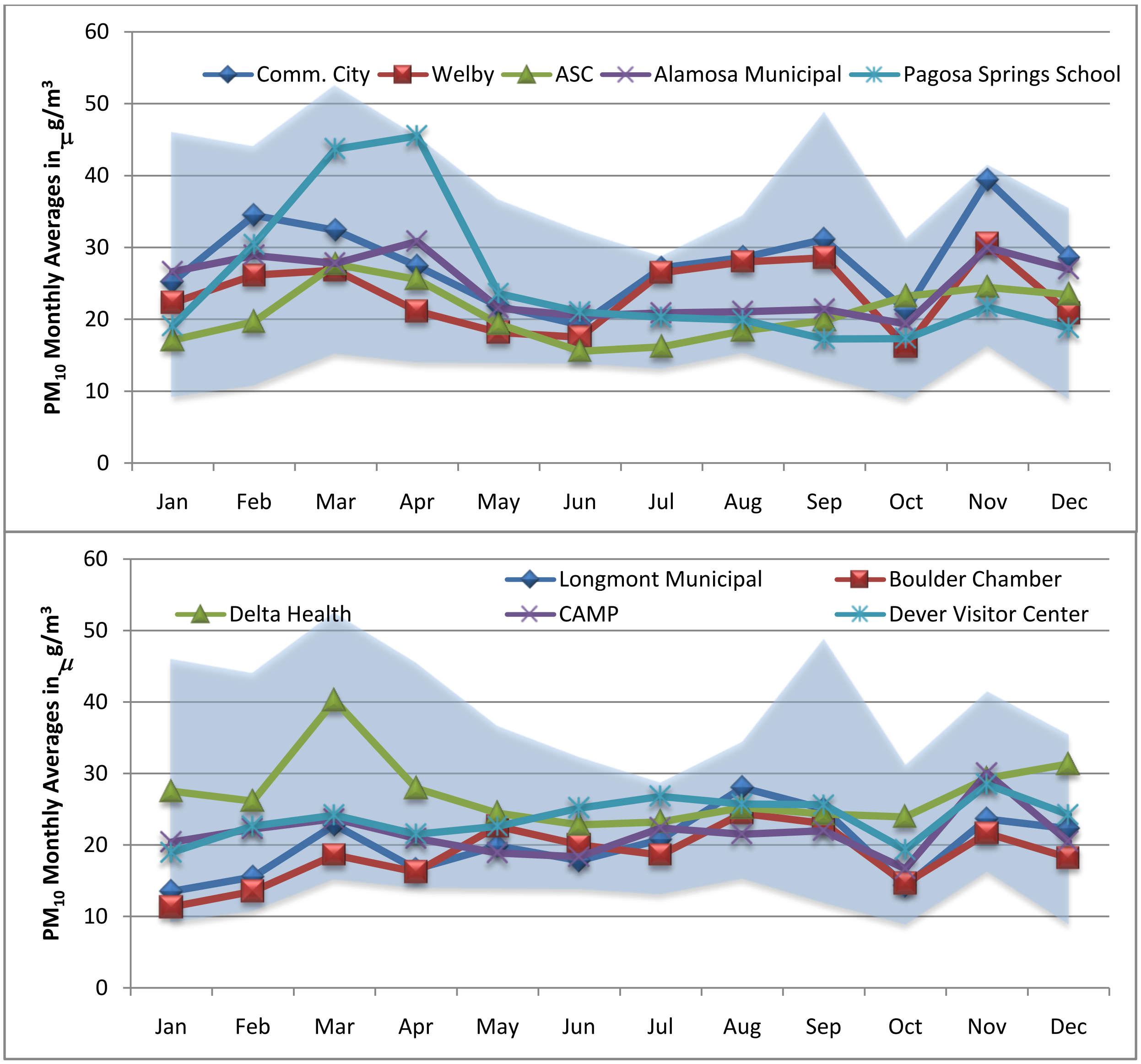


Figure 46. Monthly PM_{10} Averages for 2009

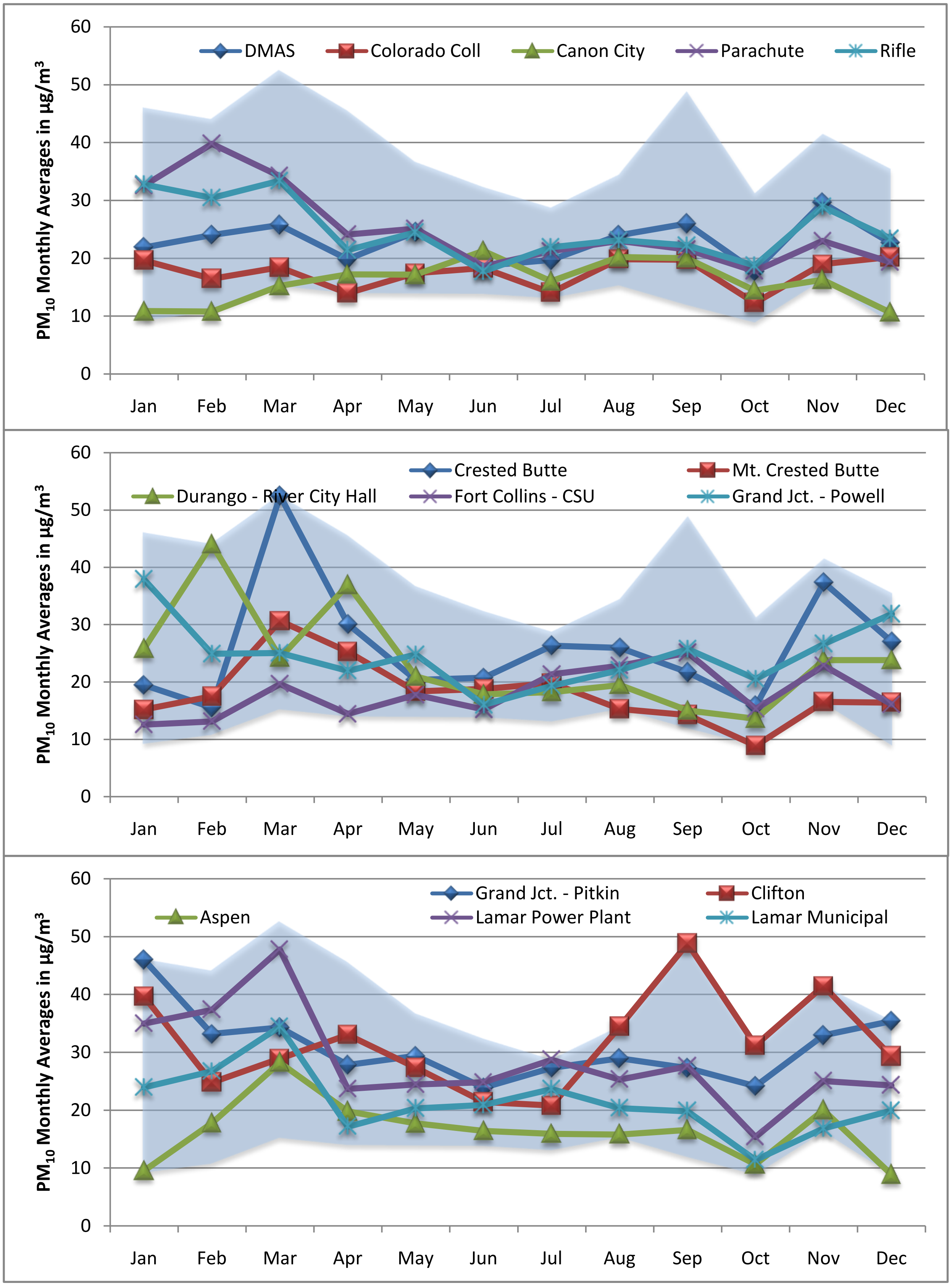


Figure 46. **Monthly PM_{10} Averages for 2009 (Continued)**

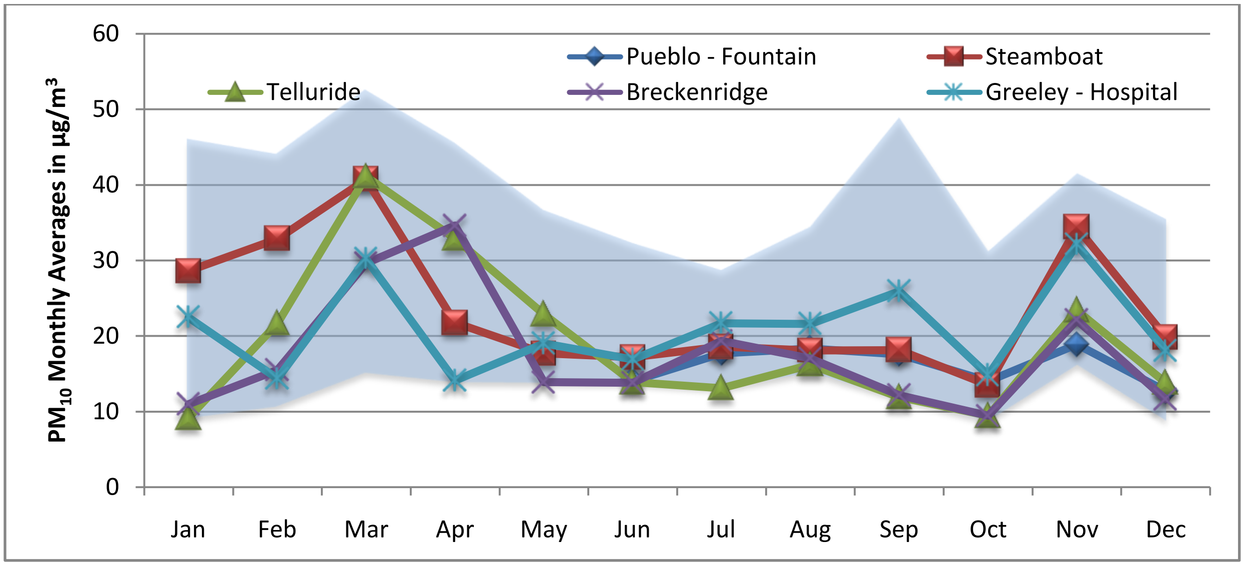


Figure 46. Monthly PM_{10} Averages for 2009 (Continued)

5.6. Particulate Matter – $PM_{2.5}$

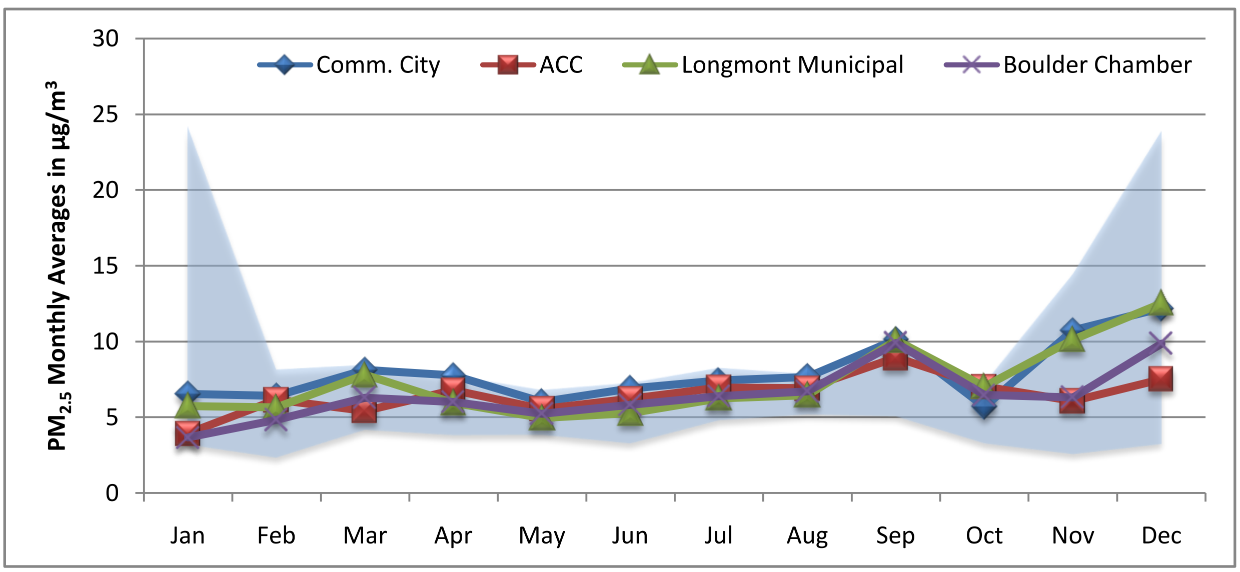


Figure 47. Monthly $PM_{2.5}$ Averages for 2009

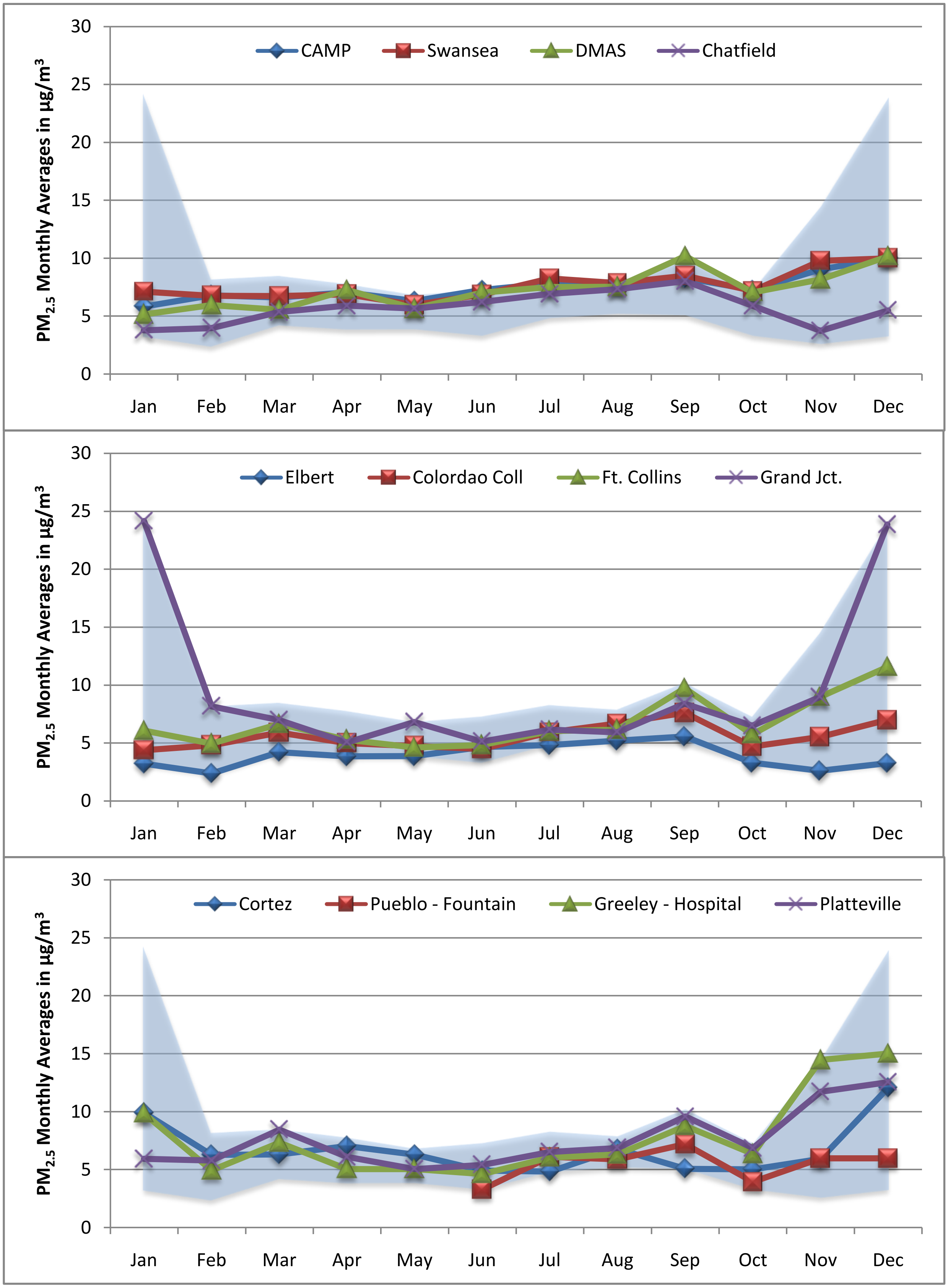


Figure 47. Monthly $PM_{2.5}$ Averages for 2009 (Continued)

5.7. Lead

Lead is sampled every 6 days, and each sample covers a 24-hour period. Lead concentrations are approximately flat throughout the year.

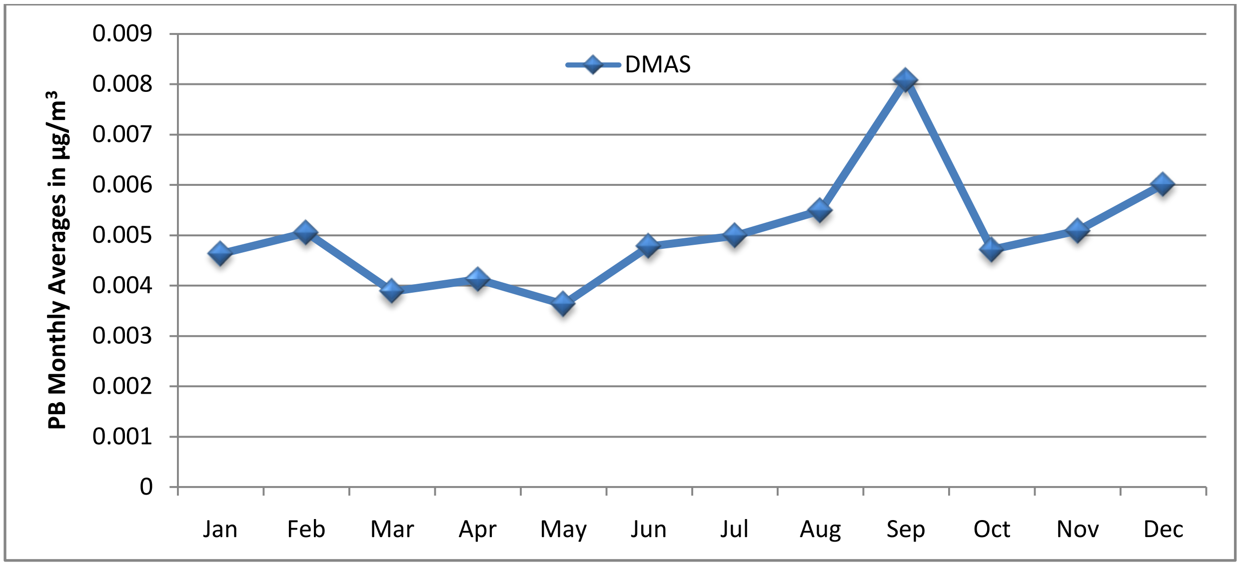


Figure 48. Monthly Lead Averages for 2009

6. Data Quality Assurance

6.1. Quality Assurance Checks for Gaseous Monitors

The APCD staff performs two types of gaseous analyzer performance checks: precision checks and accuracy audits. These audits/calibrations challenge the analyzer with pollutant gases of known concentration within the range of the analyzer. The following table shows the number of these audits conducted on the carbon monoxide analyzers for 2009. The APCD Quality Assurance staff conducts accuracy audits on all of the carbon monoxide instruments at least twice per year. The APCD Field staff conducts precision checks nominally once every two weeks, and assessment audits once every calendar quarter. The details and minimum standards for this program are set out in the Code of Federal Regulations (Part 58 Ambient Air Quality Surveillance). A complete description of the procedures and the results are available from the APCD.

Table 41. Precision Checks and Accuracy Audits for Carbon Monoxide in 2009

Site	Precision				Accuracy			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
08-001-3001	6	8	7	6	0	1	0	1
08-013-0009	7	7	6	7	1	0	1	0
08-031-0002	7	7	7	6	1	0	1	0
08-031-0019	7	7	5	0	0	1	0	0
08-041-0015	6	6	7	7	0	1	0	1
08-069-1004	7	7	6	7	1	0	1	0
08-077-0018	6	7	6	5	0	1	0	1
08-123-0010	7	7	6	7	1	0	1	0

Table 42. Precision Checks and Accuracy Audits for Ozone in 2009

Site	Precision				Accuracy			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
08 001 3001	6	8	7	6	0	1	0	1
08 005 0002	5	6	7	7	0	1	0	1
08 005 0006	0	1	7	6	0	0	1	0
08 013 0011	7	7	6	7	1	0	1	0
08 031 0014	7	7	6	7	0	1	0	1
08 031 0025	7	6	7	7	0	0	1	0
08 035 0004	7	7	6	7	0	1	1	0
08 041 0013	6	6	7	7	0	1	0	1
08 041 0016	6	5	7	7	0	1	0	1
08 045 0012	7	6	7	8	0	1	1	1
08 059 0002	7	7	6	7	0	1	0	1
08 059 0005	6	7	6	7	1	0	1	0
08 059 0006	6	7	5	7	1	0	1	0
08 059 0011	6	6	6	7	0	1	0	1
08 059 0013	0	4	6	5	0	0	1	0
08 069 0011	7	7	6	6	1	0	1	0
08 069 0012	0	5	6	7	0	0	1	0
08 069 1004	7	7	6	7	1	0	1	0
08 077 0020	7	6	7	7	0	1	1	1
08 083 0006	7	6	7	7	0	1	1	1
08 123 0009	7	7	6	5	1	0	1	0

Table 43. Precision Checks and Accuracy Audits for Oxides of Nitrogen in 2009

Site	Precision				Accuracy			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
08 001 3001	6	7	3	2	0	1	0	1
08 031 0002	0	0	0	1	0	0	1	0

Table 44. Precision Checks and Accuracy Audits for Sulfur Dioxide Monitors in 2009

Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
08 001 3001	6	5	7	5	0	1	0	1
08 031 0002	0	0	2	6	0	0	1	0

6.2. Quality Assurance Checks for Particulate Monitors

The audit checks performed on the particulate monitors consist of calibrated flow checks. The precision checks that are made on particulate monitors consist of collocated samplers that operate side-by-side on the same operating schedule. The samples are then compared to ensure that the data are within federal limits.

Table 45. Precision Checks for PM_{10} Monitors in 2009

Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
PM_{10} High Volume				
08 031 0002	15	15	15	15
08 031 0025	15	15	15	15
08 051 0004	15	14	15	14
PM_{10} Low Volume				
08 077 0017	14	12	14	15
PM_{10} Continuous TEOM				
08 001 3001	13	14	12	12
08 031 0002	14	8	12	10
08 031 0025	12	8	12	12

Table 46. Accuracy Audits for PM_{10} Monitors in 2009

Site	POC	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
PM_{10} High Volume					
08 001 3001	2	1	1	2	1
08 003 0001	1	4	4	4	4
08 003 0003	1	4	4	4	4
08 007 0001	3	4	4	4	4
08 013 0003	2	1	1	1	1
08 013 0012	1	1	1	0	1
08 029 0004	1	2	2	2	2
08 031 0002	1	1	1	1	1
08 031 0002	2	1	1	1	1
08 031 0017	1	4	4	4	4
08 031 0025	1	1	1	1	1
08 031 0025	2	1	1	1	1
08 043 0003	1	1	1	1	1
08 045 0005	1	2	0	2	2
08 045 0007	1	2	2	2	2
08 051 0004	2	2	2	2	2
08 051 0004	3	1	1	1	1
08 051 0007	1	4	4	4	4
08 067 0004	1	2	2	2	2
08 069 0009	1	2	2	4	2
08 077 0019	1	2	2	2	2
08 097 0006	1	2	2	2	2
08 099 0001	2	4	4	4	4
08 099 0002	2	4	4	4	4
08 101 0012	1	2	2	0	0
08 101 0015	1	0	0	2	2
08 107 0003	2	4	4	4	4
08 113 0004	1	2	2	2	2
08 117 0002	1	4	4	4	4

08 123 0006	2	2	2	2	2
PM_{10} Low Volume					
08 001 0006	1	1	1	1	1
08 041 0017	1	1	1	2	1
08 077 0017	3	1	1	1	1
08 077 0017	4	1	1	1	1
PM_{10} Continuous TEOM					
08 001 3001	3	1	1	0	1
08 031 0002	3	1	1	1	1
08 031 0025	3	1	0	1	1

Table 47. Precision Checks for $PM_{2.5}$ Monitors in 2009

Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
$PM_{2.5}$ FRM				
08 001 0006	14	15	15	14
08 031 0002	15	16	15	14
08 041 0017	1	1	1	1
08 101 0012	1	0	0	0
08 101 0015	0	0	2	0
$PM_{2.5}$ TEOM w/FDMS				
08 013 1001	10	10	12	4
08 031 0002	14	12	12	14
08 031 0013	4	14	14	10
08 031 0025	10	12	8	4
08 035 0004	8	12	8	4
08 041 0017	10	12	12	5
$PM_{2.5}$ TEOM				
08 001 0006	14	13	12	14
08 013 0003	10	8	14	4
08 077 0017	7	5	10	11
08 123 0006	10	14	12	4

Table 48. Accuracy Audits for $PM_{2.5}$ Monitors in 2009

Site	POC	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
$PM_{2.5}$ FRM					
08 001 0006	1	1	1	1	1
08 001 0006	2	1	1	1	1
08 005 0005	1	1	1	1	1
08 013 0003	1	1	1	2	1
08 013 0012	1	1	1	2	1
08 031 0002	1	1	0	1	1
08 031 0002	2	1	0	1	1
08 031 0023	1	1	1	1	1
08 031 0025	1	1	1	1	1
08 035 0004	1	1	1	1	1
08 039 0001	1	1	1	2	1

08 041 0017	1	1	1	2	1
08 069 0009	1	1	1	2	1
08 077 0017	1	1	1	1	1
08 083 0006	1	0	0	1	0
08 101 0012	1	1	1	0	0
08 101 0015	1	0	0	1	1
08 123 0006	1	1	1	1	1
08 123 0008	1	1	1	2	1
$PM_{2.5}$ TEOM w/FDMS					
08 013 1001	3	1	1	1	1
08 031 0002	3	1	1	1	1
08 031 0013	3	1	1	1	1
08 031 0025	3	1	1	1	1
08 035 0004	3	1	1	1	1
08 041 0017	3	1	1	1	1
$PM_{2.5}$ TEOM					
08 001 0006	3	1	1	1	1
08 013 0003	3	1	1	1	1
08 077 0017	3	1	1	1	1
08 123 0006	3	1	1	0	1

6.3. Quality Assurance Checks for TSP/Pb Monitors

The audit checks performed on the particulate monitors consist of calibrated flow checks. The precision checks that are made on particulate monitors consist of collocated samplers that operate side-by-side on the same operating schedule. The samples are then compared to ensure that the data are within federal limits.

Table 49. Precision Checks for TSP Monitors in 2009

Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
08 031 0025	12	15	15	15

Table 50. Precision Checks and Accuracy Audits for Pb Monitors in 2009

	Precision				Accuracy			
Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
08 031 0025	12	13	15	15	2	2	2	2

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