2001
Quality Assurance Report

April 2003

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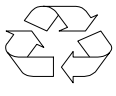


TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Gaseous Monitoring Network

The APCD routinely monitors four gaseous pollutants: carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), and oxides of nitrogen (NO_x). Fifty-eight accuracy audits were conducted in 2001. All but three of these audits were within the 10% full-scale analyzer response error considered acceptable by the APCD.

EPA interlaboratory comparisons were conducted during 2001 for carbon monoxide, ozone, sulfur dioxide, and nitrogen dioxide. The ozone comparisons were invalidated due to faulty NPAP equipment. Interlab comparisons are included for 18 gaseous analyzers. All interlab results were within the acceptable EPA performance criterion of 15% error, except one. It was determined that the instrument in question was in need of repair and recalibration.

Overall data recovery for the gaseous monitoring network was 92% in 2001. During this time only one of the analyzers in the APCD network failed to meet the EPA 75% data completeness criterion.

Particulate Monitoring Network

The APCD routinely monitors three size classes of particulate matter: total suspended particulate (TSP), inhalable particulate matter (PM_{10}), and respirable particulate matter ($PM_{2.5}$). Ambient lead concentrations are determined from analysis of TSP filters collected at selected sites. Field audits were performed at least semi-annually at all particulate monitoring sites in Colorado. A total of 606 particulate audits were conducted in 2001. Ninety-four percent of these audits passed both accuracy and design flow criteria. Only two audits during 2001 failed to meet the EPA accuracy criterium.

Ninety-two PM_{10} samplers and one TSP sampler were audited under the EPA NPAP interlaboratory program in 2001. All but 2 of these interlaboratory audits showed flow errors within EPA's acceptable criteria. Four $PM_{2.5}$ sites were audited under the EPA FRM PEP audit program to determine network bias. The bias of the $PM_{2.5}$ network was determined to be (-)2.5% in 2001.

Overall APCD particulate network data recovery in 2001 was 93% for TSP, 85% for lead, 88% for PM_{10}, and 93% for $PM_{2.5}$.

Meteorological Monitoring Network

Audits of the meteorological monitoring network were conducted at 13 of the 19 meteorological sites during 2001.

INTRODUCTION

The Colorado Department of Public Health & Environment (CDPHE) Air Pollution Control Division (APCD) operates a statewide system of air pollution monitors to characterize air quality in Colorado. Colorado is required to monitor air pollutants for which National Ambient Air Quality Standards (NAAQS) have been established. These NAAQS air pollutants include four gaseous pollutants; carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2), and three particulate pollutants; respirable particulate ($PM_{2.5}$), inhalable particulate (PM_{10}), and lead (Pb). In addition, a total suspended particulate (TSP) sampling network and several meteorological monitoring stations are also operated by the APCD in a number of Colorado communities. The gaseous pollutant networks, particulate pollutant networks, and meteorological monitoring program are maintained and operated by the APCD Technical Services Program.

The data collected by this network provide valuable information used in the protection of public health and welfare. Analysis of ambient data collected by this air monitoring network serves as the basis for determination of air pollutant trends, aids in identification of NAAQS pollutant attainment and nonattainment areas, aids in review of the air quality impacts of new and existing sources, and is used in the validation of air quality models used in the development of pollution control strategies.

The Air Pollution Control Division is required to develop and implement a quality assurance program consisting of policies, procedures, specifications, standards, and documentation necessary to; 1) provide data of adequate quality to meet monitoring objectives, and 2) minimize loss of air quality data due to sampler malfunctions or out-of-control situations. Minimum standards for air quality monitoring programs are detailed in the Code of Federal Regulations (*Part 58 Ambient Air Quality Surveillance*). More detailed information about APCD's network is provided in the *APCD Annual Network Review*. More specific information regarding quality assurance and monitoring operations is available in the *Quality Assurance Project Plan* and the associated *Standard Operating Procedures* found in its appendices. The Technical Services Program has a Quality Assurance group charged with performing or coordinating quality control efforts to meet the objectives of this monitoring effort.

The *2001 Quality Assurance Report* is part of an annual assessment of quality assurance activities conducted by the APCD and is used to inform federal regulators, APCD management and staff, and the general public of those activities. Minimum EPA Requirements for Data Quality and APCD's Data Quality Goals are summarized in the following tables:

Table 1 - EPA Minimum Requirements for Data Quality

Parameter	Method	Minimum Requirements			
		Precision	Accuracy	Flow Accuracy	Completeness
Carbon Monoxide (CO)	Automated	±15%	±15%		≥75% Quarterly
Ozone ($O_{3)}$	Automated	±15%	±15%		≥75% Seasonally
Nitrogen Oxides ($NO_{X)}$	Automated	±15%	±15%		≥75% Quarterly
Sulfur Dioxide ($SO_{2)}$	Automated	±15%	±15%		≥75% Quarterly
Total Suspended Particulate (TSP)	Manual	20-80 ug/m^3 ±5 ug/m^3 >80 ug/m^3 ±7%		±10%	≥75% Quarterly
Inhalable Particulate (PM_{10})	Manual	20-80 ug/m^3 ±5 ug/m^3 >80 ug/m^3 ±7%		±7%	≥75% Quarterly
PM_{10}	Automated	N/A		±7%	≥75% Quarterly
Respirable Particulate ($PM_{2.5}$)	Manual	± 10%		± 4%	≥75% Quarterly
$PM_{2.5}$	Automated	N/A		N/A	≥75% Quarterly
Lead	Manual	± 10%	±10%	±10%	≥75% Quarterly

Table 2 - APCD Data Quality Objectives

Parameter	Method	Objectives			
		Precision	Accuracy	Flow Accuracy	Completeness
Carbon Monoxide (CO)	Automated	±10%	±10%		≥90% / annually
Ozone (0_3)	Automated	±10%	±10%		≥90% / seasonally
Nitrogen Oxides (NO_x)	Automated	±10%	±10%		≥90% / annually
Sulfur Dioxide (SO_2)	Automated	±10%	±10%		≥90% / annually
Total Suspended Particulate (TSP)	Manual	20-80 ug/m^3 ±5 >80 ug/m^3 ±7%		±10%	≥75% / quarterly
Inhalable Particulate (PM_{10})	Manual	20-80 ug/m^3 ±5 >80 ug/m^3 ±7%		±7%	≥75% / quarterly
	Automated	N/A		±4% total ±6% main	≥90% / quarterly
Respirable Particulate ($PM_{2.5}$)	Manual	±10%		±4%	≥90% / quarterly
	Automated	N/A		±4% total ±6% main	≥90% / quarterly
Lead (Pb)	Manual	±10%	±10%	`	≥90% / quarterly
Wind Speed	Automated	N/A	±0.2 m/s and ±5%		≥90% / annually
Wind Direction	Automated	N/A	±5°		≥90% / annually
Temperature	Automated	N/A	±0.5° C		≥90% / annually
Gravimetric	Manual	0.2 mg	0.2 mg		≥90% / annually

1.0 STATUS OF THE MONITORING NETWORK

Most of the tables in this document have abbreviated site information. More detail about sites, such as site I.D., county, and address can be found in Appendix A. If more specific information is desired, complete and detailed site information can be found in the *APCD Annual Network Review*.

An important quality assurance concern is the degree of completeness of the data collected by the monitoring network. In order for ambient monitoring data to be considered representative, EPA requires that valid data must be available for at least 75% of the averaging period. The APCD has an internal goal of 90% data capture rate for each automated analyzer and 75% for each manual sampler. For automated sampling systems, gaseous pollutant and meteorological monitors, these data capture values are calculated by dividing the number of valid hourly samples by the total number of hours in the sampling period (generally a day, a quarter or a year). This is a conservative estimate of data completeness, since it does not take into consideration times when the sampler is disabled for routine maintenance, calibration, and audits. For manual methods the data completeness is calculated by dividing the number of valid daily samples at a site by the number of days that site is scheduled to sample during a period of time (generally a quarter or a year).

Table 3 presents the data recovery for all gaseous pollutant monitors in the APCD network. The overall average data recovery for gaseous pollutants during 2001 was 92%. This data recovery rate is excellent and is similar to the recovery rate calculated for the past few years. 26 of 32 gaseous sites met the APCD 90% data capture goal.

The data capture rates for the particulate monitoring networks and the lead network are presented in Tables 4a and 4b. The TSP network had an overall data recovery of 93% and the lead network had an overall recovery of 85%. The PM_{10} network had an average annual data recovery of 88%, and the $PM_{2.5}$ network was at 93% data completeness. The sites with these manual samplers operate every day, once every other day, once ever third day, or once every six days depending on the site. For more specific information on sampling frequency of the particulate networks, please refer to the *APCD Annual Network Review*.

All but one TSP site achieved the minimum 75% data completeness in 2001.

More than half of the PM_{10} sites obtained data recovery above 90% for 2001. Most of the PM_{10} sites complied with the 75% EPA data completeness requirement in 2001. The following sites did not meet the minimum criteria: Castlerock, Vail, Colorado Springs-Meadowland, Rifle, Ft. Collins-courthous, Montrose, Aspen, and Breckenridge.

In 2001 all but six of the 23 monitors achieved the desired 90% data recovery rate in the $PM_{2.5}$ network and all achieved the minimum EPA acceptance criteria of 75%.

Data capture rates for all parameters of the 19 APCD meteorological monitoring sites were above 90% in 2001 with the following exceptions:

Lamar	due to power failure and communications problems.
Telluride	due to power failure and communications problems.

Table 3 - 2001 Gaseous Data Recovery

SITE / STATION NAME	CO	O_3	SO_2	NO_X
Arvada	95%	99%		
Boulder - S. Boulder Creek		97%		
Boulder - YMCA	98%			
Chatfield Reservoir *		98%		
Colorado Springs - GLEN	88%			
Colorado Springs - Hwy 24	99%			
C.S. - US Air Force Academy		99%		
Denver - CAMP	98%		92%	87%
Denver - Carriage	99%	96%		
Denver - NJH	95%			
Denver Firehouse #6	99%			
Ft. Collins	98%	88%		
Grand Junction - Stocker	88%			
Greeley	97%	99%		
Highlands		92%		
Longmont	91%			
NREL		98%		
Rocky Flats X-1 (N)		98%		
Rocky Flats X-3 (SE)				93%
Rocky Flats X-5 (W)				70%
South Adams Pump Station			92%	
Welby	98%	95%	94%	86%
Welch		97%		
Parameter Average Data Recovery	**96%**	**96%**	**93%**	**84%**

NOTES: All monitors run continuosly for 2001, with following exceptions:

(*1) = Seasonal only

(*2) = New Site

(*3) = Site Discontinued

Table 4A – 2001 Particulate and Lead Data Recovery

SITE / STATION NAME	$PM_{2.5}$	PM_{10}	TSP	Pb
Adams City (primary) (*1)	94%	95%	83%	80%
Adams City (collocated) (*1)	100%			
Globeville Clinicare			94%	78%
Commerce City (primary) (*3)	93%	97%	72%	72%
Commerce City (collocated) (*3)	93%			
Brighton (*2)		83%		
Welby		90%		
Alamosa		86%		
Arapahoe Community College	96%			
Pagosa Springs - Middle School (*3)	100%	96%		
Pagosa Springs (*1)	96%	96%		
Longmont (particulate)	95%	96%		
Boulder Chamber of Commerce	94%	98%		
Hygiene		96%		
Delta	84%	87%		
Paonia (*1)				
Hotchkiss (*1)				
Denver - CAMP (primary)	96%	98%	97%	97%
Denver - CAMP (collocated)	94%	92%		
Denver - NJH	89%	96%		
Denver - Gates (primary)		84%	98%	85%
Denver - Gates (collocated)		97%	97%	80%
Denver Visitor Center (*2)		95%		
Denver - LARS		93%		
Castle Rock (*1)		73%		
Parker (*1)	97%			
Vail - WSD (*1)		73%		
Elbert	84%			
Colorado Springs - Meadowlands	98%	70%		
Colorado Springs - RBD (primary)	93%	89%	98%	95%
Colorado Springs - RBD (collocated)	97%	97%		
Canon City		97%		
Parachute		83%		
Rifle (*1)		70%		
Glenwood Springs (*1)		100%		
Crested Butte		93%		
Mt. Crested Butte	95%	95%		
Gunnison		81%		
Rocky Flats X-1 (N) (primary) (*1)		97%	97%	
Rocky Flats X-1 (N) (collocated) (*1)			97%	

SITE / STATION NAME	$PM_{2.5}$	PM_{10}	TSP	Pb
Rocky Flats X-2 (NE) (primary) (*1)		97%	97%	
Rocky Flats X-2 (NE) (collocated) (*1)		93%		
Rocky Flats X-3 (SE) (*1)		100%	97%	
Rocky Flats X-4 (S) (*1)		97%	90%	
Rocky Flats X-5 (W) (*1)		83%	83%	
Leadville			90%	90%
Durango - Platform		88%		
Durango - Park School	77%	80%		
Durango - Courthouse		87%		
Ft Collins - Courthouse (*1)		58%		
Ft. Collins - CSU	97%	88%		
Grand Junction - Health Dept. (primary)	86%	97%	100%	
Grand Junction - Health Dept. (collocated)	97%			
Grand Junction - Stocker (*1)		87%		
Montrose (*1)		64%		
Olathe (*1)		79%		
Aspen		73%		
Lamar Power Plant		89%		
Lamar Municipal Bldg		85%		
Pueblo Public Works	98%	82%		
Steamboat Springs	79%	95%		
Telluride	89%	93%		
Breckenridge		64%		
Silverthorne Rec Center		76%		
Cripple Creek		79%		
Greeley	91%	94%		
Platteville	95%			
Parameter Average Data Recovery	**93%**	**88%**	**93%**	**85%**

NOTES: Specific site sampling schedules can be found in Appendix A

(*1) = Site removed during 2001

(*2) = Shut down part of year for site maintenance

(*3) = New Site

Table 4B – Data Recovery for Continuous Patuculate Samplers

Site/Station Name	Responsible Organization	Instrument	Analysis	% Data Completeness	NOTES
Welby	CDPHE	TEOM	PM_{10}	96%	New Sampler
Denver - CAMP	CDPHE	TEOM	PM_{10}	98%	
Denver - CAMP	CDPHE	TEOM	$PM_{2.5}$	92%	New Sampler
Grand Junction	Mesa County Health Dept.	Beta Gauge	PM_{10}	91%	
Aspen	Pitkin County Health Dept.	TEOM	PM_{10} (daily)	97%	
Aspen	Pitkin County Health Dept.	same as above	PM_{10} (hourly))	96%	
Telluride	San Miguel Cnty. Hlth. Dept.	Beta Guage	PM_{10}	53%	APCD not responsible for operation of this sampler - only for data reporting

2.0 GASEOUS MONITORING NETWORK QUALITY ASSURANCE

The Air Pollution Control Division routinely monitors four gaseous pollutants; carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2). Quality assurance of this gaseous monitoring network involves a series of daily tests, maintenance activities, and record keeping, as well as several external assessment and control functions not performed on a daily basis.

In 2001, the gaseous monitoring network was involved in three non-daily programs; (1) regularly scheduled assessments and calibrations, (2) the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) precision and accuracy program, and (3) EPA NPAP interlaboratory comparison studies. The Quality Assurance Unit is responsible for recommending corrective actions when monitoring problems are discovered through these programs. It is the responsibility of the Continuous Monitoring Data Support Services (CMDSS) Unit to repair the monitors and perform the necessary corrective actions.

2.1 Assessment and Accuracy Audits

APCD staff perform two types of gaseous analyzer performance audits; assessment audits and accuracy audits. These audits challenge the analyzer with pollutant gases of known concentration within the range of the analyzer.

The APCD CMDSS Unit conducts frequent, regularly scheduled assessment audits. These assessment audits provide a means of gauging the response of an analyzer before calibration, adjustments, or repairs are made. Immediately before analyzer calibration, a CMDSS Unit staff person introduces a known gas concentration near the full-scale response of the instrument. If the instrument response shows an error greater than $\pm$ 10%, a full multi-point assessment audit is conducted prior to any analyzer adjustment. Assessment audits are also conducted when problems with the monitors are known or suspected. Personnel and equipment used in assessment audits are the same as those used for calibrations.

Accuracy audits are conducted with equipment independent of that used for calibration by the APCD Quality Assurance (QA) Unit. These randomly scheduled audits, using equipment and personnel different than those used in instrument calibration, meet EPA's definition of an accuracy audit. The results of accuracy audits are submitted to the EPA's national air quality database, the Aerometric Information Retrieval System - Air Quality Subsystem (AIRS-AQS).

Because both types of audits use gas standards of very high quality, APCD management considers these assessment and accuracy audits to be equivalent. In the event of an audit failure, data validation procedures are identical, regardless of whether the CMDSS Unit or QA Unit staff discovered the problem.

Table 5 show the number of Quality Assurance Unit accuracy audits and CMDSS Unit assessment audits or calibrations conducted in 2001 at each of the APCD monitoring sites. Of the 194 accuracy and assessment audits conducted by APCD staff during 2001, 22 audits showed unacceptable errors at full scale. The APCD acceptance criterion for both accuracy and assessment audits is an instrument response less than ±10% error at analyzer full scale. In those instances where a relative error greater than ±10% at full scale was discovered, a brief description of corrective actions taken to remedy the situation can be found in the right hand column. A more detailed overview of all audit failures and the corrective actions taken can be found is Section 6 of this *QA Report*.

Table 5 - 2001 Gaseous Internal Audits Summary

SITE / STATION NAME	Parameter	Assessment	Accuracy	Failed	Corrective Actions
Adams City - Nigra Station (*2)	SO_2	1	0		
Arvada	O_3	5	2		
	CO	5	2		
Boulder - S. Boulder Creek	O_3	5	1		
Boulder - YMCA	CO	4	2		
Chatfield Reservoir (*1)	O_3	2	2		
Colorado Springs - GLEN	CO	3	2		Maintenance and Calibration
Colorado Springs - Highway 24	CO	3	2		
C.S. - US Air Force Academy	O_3	4	2		
Denver - CAMP	CO	5	2		
	SO_2	5	2		
	NO_x	7	2	4	Maintenance and Calibration
Denver - Carriage	O_3	5	2		
	CO	5	2		
Denver - NJH	CO	3	1		
Denver Firehouse #6	CO	2	2		
Ft. Collins	O_3	5	2		
	CO	4	2		
Grand Junction - Stocker	CO	3	2		
Greely	O_3	4	2		
	CO	3	2		
Highlands	O_3	6	2		
Longmont	CO	3	2		
NREL	O_3	5	2	1	Maintenance and Calibration
Rocky Flats X-1 (N)	O_3	5	2		
Rocky Flats X-3 (SE) (*3)	NO_x	4	1	3	Maintenance and Calibration
Rocky Flats X-5 (W) (*3)	NO_x	6	1	5	Maintenance and Calibration
Welby	O_3	8	2	2	Maintenance and Calibration
	CO	3	2		
	SO_2	4	2	1	Maintenance and Calibration
	NO_x	5	2	4	Maintenance and Calibration
Welch	O_3	5	2	2	
TOTAL GASEOUS AUDITS	**32 Analyzers**	**136**	**58**	**22**	**4% Failure Rate**
SUBTOTALS:					
O_3 Audits	**12 Analyzers**	**50**	**24**	**5**	**7% Failure Rate**
CO Audits	**13 Analyzers**	**54**	**24**	**0**	**0% Failure Rate**
SO_2 Audits	**3 Analyzers**	**10**	**4**	**1**	**7% Failure Rate**
NO_x Audits	**4 Analyzers**	**22**	**6**	**16**	**57% Failure Rate**

NOTES:

(*1) = Seasonal only

(*2) = New Site

(3) = Site closed in 2001

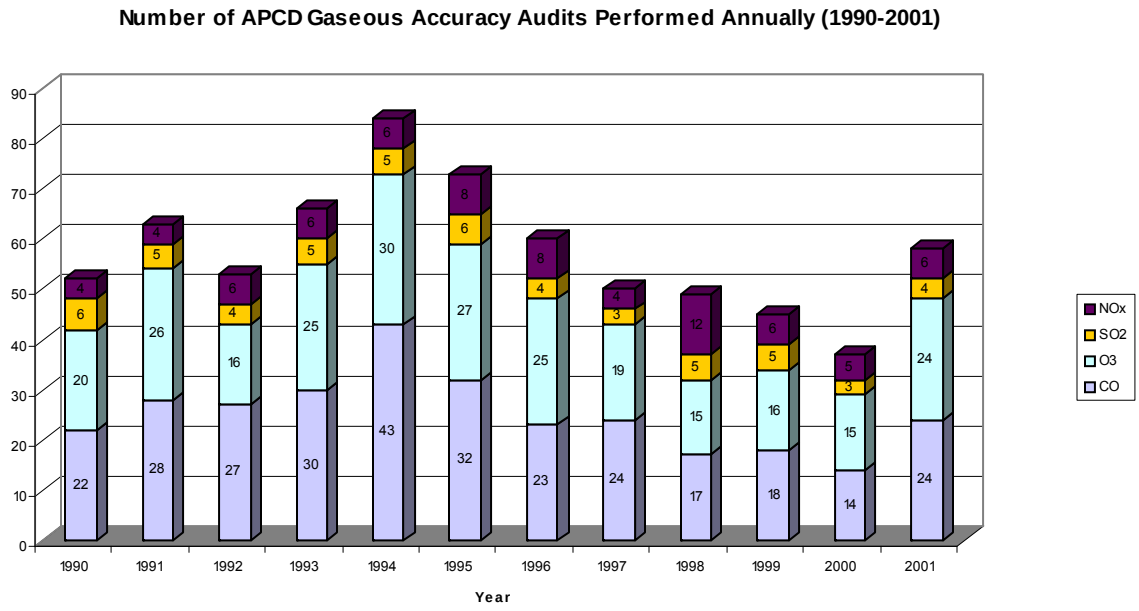
The Quality Assurance Unit completed 58 gaseous accuracy audits in 2001. APCD QA Unit maintained compliance with the EPA requirement of auditing each SLAMS and NAMS analyzer a minimum of once per year, with a minimum of 25% of each type of analyzer to audited each quarter.

During 2001 there were 13 continuously operated carbon monoxide monitoring sites in the APCD network. There were no audit failures of a CO analyzer. There were 12 continuously operated ozone monitoring sites in the APCD network. There were 5 assessment or accuracy audit failures of an O_3 analyzer in 2001. There were two continuously operated SO_2 analyzers with one audit failure.

Nitrogen dioxide monitoring was conducted at four sites in 2001. There were sixteen assessment or accuracy audit failures. This high number of failures is consistent with previous years. The Nitrogen dioxide measurement principle is highly sensitive to small flow and vacuum changes. The failures are usually found, as expected, soon after routine maintenance has occurred. The high number of these failures is a reflection of the CMDSS staff keeping tight controls on these instruments, and a reflection of their quick response time when a problem is suspected. Additional tests and comparisons were performed on the NO_x network and NO_x equipment and the APCD TSP group concluded that all converters should be replaced in these analyzers.

Table 6 summarizes the total number of QA gaseous accuracy audits performed annually since 1990.

Figure 1 - Number of Gaseous APCD Accuracy Audits (1990-2001)



2.2 Data Validation

APCD staff perform a number of routine data validation procedures to ensure the quality of the ambient data collected by the APCD's monitoring network. Site operators regularly perform diagnostic checks on monitors, and compare the monitor data logger and chart recorder response. Ambient data are telemetered to APCD offices and are reviewed daily for high values or anomalous readings. Daily span and zero tests are plotted in control chart format and reviewed. The control chart limits for span readings are consistent with the error calculations used to assess analyzer performance. Rather than setting individual analyzer action and warning limits, a warning limit of 7% error and an action limit of 10% error is used for all gaseous analyzers in the network. The CMDSS Unit updates these control charts daily in order to identify problem situations and to initiate a prompt response when monitors begin to drift out of acceptable performance range.

The ambient data are also reviewed in response to failed accuracy or assessment audits. In response to an audit error greater than ±15%, a data quality assessment is conducted including review of operator logs, maintenance records, and analyzer control charts to identify the cause of the audit failure. Current APCD policy is to invalidate all ambient data from the last analyzer calibration, valid QC check, or known failure point up to the date that corrective action (usually analyzer maintenance and recalibration) is completed.

2.3 EPA Interlaboratory Studies

In 2001 the APCD took part in national interlaboratory studies for carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), and nitrogen oxide (NO_2). The interlaboratory comparisons are part of the National Performance Audit Program (NPAP) operated by the EPA. Unfortunately, the NPA program invalidated all ozone audits due to problems with their auditing equipment. These interlaboratory studies are designed to assess the compliance of agencies operating monitors in the State and Local Air Monitoring System (SLAMS) network. This program provides a means of comparing the APCD's monitoring performance with that of other participating agencies. Although an organization can use the interlaboratory program to identify out-of-control situations, the interlaboratory results cannot be used to adjust or invalidate data.

The interlaboratory studies involved challenging analyzers with audit concentrations generated from EPA equipment. These audit concentrations or "assigned values" are unknown to the APCD personnel conducting the assessment. The EPA target criterion for acceptable audit performance is that the participant's value for each concentration be within ±15% of the assigned value. Participants reporting values outside these limits are urged to determine the cause for their poor performance and to take corrective action. Participants reporting results within ±10 -15% of the assigned value are encouraged to evaluate their measurement systems in order to reduce the size of the

difference.

The interlaboratory kit used in 2001 consisted of a multi-blend gas cylinder (CO, SO_2, and NO), clean air scrubbers, and a critical orifice dilution kit to regulate pollutant gas flow, and an ozone generating ultraviolet light source. The NPAP interlaboratory audits were conducted during the first quarter of 2001. Table 7 summarizes the 2001 NPAP audit results. This table shows EPA values, each individual APCD analyzer's response values, and the percent difference between the EPA "true" and the APCD "indicated" value for each of the three audit levels. The chart also has regression values generated from these data, the EPA's calculated "mean absolute % error", and APCD's calculated % analyzer full-scale error. All the ozone and SO_2 results were within the APCD's 10% full scale error and the EPA $\pm$15% mean error criteria. It was later determined that a problem existed with our NO_x analyzers. The problem was identified and corrected.

Table 6 - NPAP Interlaboratory Gaseous Audit Results

te / Station Name	Parameter (reporting units)	Date of Audit	NPAP Actual Value	APCD Indicated Value	NPAP Actual Value	APCD Indicated Value	% Error on High Level	NPAP Actual Value	APCD Indicated Value	% Error Middle Level	NPAP Actual Value	APCD Indicated Value	% Error on Low Level	S
Collins	CO (ppm)	3/20/2001	0.00	0.10	43.05	42.9	-0.3%	16.91	16.3	-3.6%	6.95	6.5	-6.5%	0
D Springs - Hwy 24	CO (ppm)	3/27/2001	0.00	0.30	43.05	44.2	2.7%	16.91	17.1	1.1%	6.95	6.9	-0.7%	1
AMP	CO (ppm)	3/22/2001	0.00	0.00	43.05	42.5	-1.3%	16.91	16.3	-3.6%	6.95	6.6	-5.0%	0
enver Firehouse #6	CO (ppm)	3/27/2001	0.00	0.40	43.05	43.9	2.0%	16.91	16.9	-0.1%	6.95	6.9	-0.7%	1
AMP	SO_2 (ppb)	3/22/2001	0.00	1.00	412.07	429	4.1%	161.86	162	0.1%	66.57	65	-2.4%	1
AMP	NO_2 (ppb)	3/22/2001	1.00	-2.00	377.70	395.0	4.6%	177.70	185.0	4.1%	73.00	73.0	0.0%	1
ocky Flats W (X-5)	NO_2 (ppb)	3/15/2001	1.00	-0.50	377.70	293.7	-22.2%	177.70	140.3	-21.0%	73.00	58.4	-20.0%	0
ocky Flats SE (X-3)	NO_2 (ppb)	3/16/2001	1.00	5.50	377.70	308.9	-18.2%	177.70	153.5	-13.6%	73.00	64.4	-11.7%	0

OTES: All Ozone audits were invalidated by ManTech due to a faulty ozone generator in the NPAP auditing device.

should also be noted that all NO_2 audits were conducted with the same fauly auditing device, but ManTech didn't feel it was necessary to invalidate these audits.

2.4 Precision and Accuracy Program

The APCD is required to conduct a one-point precision test every two weeks for each NAMS and SLAMS continuous monitor. This precision test involves introducing an analyte gas of known concentration, the "actual value," and determining an analyzer response or "indicated value." During this precision test, the analyte gas must pass through all of the filters and components of the ambient sampling system. The actual value of the analyte gas is determined shortly after the analyzer calibration. This value must fall within the range of 8-10 ppm for CO, and 0.080-0.100 ppm for O_3, SO_2, and NO_2.

Current APCD practice is to perform these precision tests weekly, using the automated system developed for span gas delivery and diluting the span gas to the appropriate precision test value. In addition to these automated precision tests, station operators, calibration personnel and audit personnel perform manually initiated tests to assess the ability of an analyzer to repeatedly measure a known analyte gas at relatively low concentration, typical of what may be found in ambient air. This testing provides an assessment of the repeatability of a measurement system. The values determined for this precision test system are sent to the EPA Aerometric Information Retrieval System (AIRS) database within 90 days of the end of each calendar quarter.

The EPA goal for single analyzer precision is ±15%. The APCD goal is to have all precision within ±10%. The weekly-automated precision checks are reviewed frequently, and a CMDSS staff member is sent out to any site where the precision values exceed the ±7% warning limits to investigate the problem.

The results of the accuracy audits performed by the APCD's Quality Assurance group are submitted to AIRS at the end of each calendar quarter. As in the precision test program, "actual" and "indicated" values are reported. The accuracy results are reported at up to four concentration levels. Level 1 "actual values" must fall within the range of 3-8 ppm for CO, and 0.030-0.080 ppm for O_3, SO_2, and NO_2. Level 2 values are 15-20 ppm and 0.150-0.200 ppm, and Level 3 values are 35-45 ppm and 0.350-0.450 ppm.

The results of this precision and accuracy program provide information about the ability of the APCD's network to accurately measure ambient pollutant concentrations at various levels. The precision and accuracy data submitted to AIRS are used to calculate precision probability limits, and accuracy probability limits at three audit levels. These calculated probability values are presented in Tables 7 - 10. The upper and lower probability limits indicate the range of percent difference from the "actual value" that would include 95% of the "indicated values." About 5% of the results of an individual precision or accuracy test would exceed these limits. Ideally, the probability ranges would be very small, and would be centered at zero. This indicates that the ambient data collected by the analyzer are both precise and accurate.

Shown in Tables 7 – 10 are quarterly precision probability limits by site and by reporting organization (CDPHE), and annual precision summaries by site and reporting organization. They also show quarterly and annual accuracy probability limits by reporting organization, but only for quarters where more than one audit was performed of that gaseous type.

Table 7 - Carbon Monoxide Precision and Accuracy Probability Limits (95% Confidence Interval)

Site/Station Name	Quarter	Precision Probability		Audit Probability Limits					
		Lower Limit	Upper Limit	Level 1		Level 2		Level 3	
				Lower	Upper	Lower	Upper	Lower	Upper
2001									
Arvada	1	-1%	2%						
	2	-4%	3%						
	3	-2%	2%						
	4	-5%	-2%						
	Annual	**-4%**	**3%**						
Boulder - YMCA	1	-1%	2%						
	2	-6%	8%						
	3	-1%	2%						
	4	0%	0%						
	Annual	**-3%**	**4%**						
CAMP	1	-1%	3%						
	2	-4%	-1%						
	3	-3%	7%						
	4	-2%	3%						
	Annual	**-4%**	**5%**						
Colo. Spr. - GLEN	1	-3%	2%						
	2	-2%	1%						
	3	-6%	6%						
	4	-1%	11%						
	Annual	**-5%**	**7%**						
Colo. Spr. - Hwy 24	1	-1%	1%						
	2	-6%	9%						
	3	-3%	2%						
	4	-2%	1%						
	Annual	**-4%**	**5%**						
Denver - Carriage	1	-8%	9%						
	2	-5%	2%						
	3	-2%	2%						
	4	0%	3%						
	Annual	**-5%**	**5%**						
Denver - Firehouse #6	1	-2%	3%						
	2	1%	4%						
	3	-1%	6%						
	4	-4%	5%						
	Annual	**-2%**	**5%**						
Denver - NJH	1	-3%	9%						
	2	-6%	4%						
	3	-5%	5%						
	4	-2%	0%						

Site/Station Name	Quarter	Precision Probability		Audit Probability Limits					
		Lower Limit	Upper Limit	Level 1		Level 2		Level 3	
				Lower	Upper	Lower	Upper	Lower	Upper
2001									
	Annual	**-5%**	**6%**						
Ft. Collins	1	-5%	3%						
	2	-6%	2%						
	3	-4%	0%						
	4	-7%	5%						
	Annual	**-6%**	**3%**						
Grand Junction	1	-4%	2%						
	2	-9%	4%						
	3	-7%	2%						
	4	-3%	0%						
	Annual	**-6%**	**3%**						
Greeley	1	-2%	2%						
	2	-7%	5%						
	3	-9%	4%						
	4	-6%	4%						
	Annual	**-6%**	**4%**						
Longmont	1	-7%	4%						
	2	-2%	2%						
	3	-5%	4%						
	4	-1%	2%						
	Annual	**-4%**	**3%**						
Welby	1	-3%	1%						
	2	-3%	0%						
	3	-2%	1%						
	4	-1%	2%						
	Annual	**-3%**	**1%**						
CDPHE	**1**	**-4%**	**4%**	**-4%**	**2%**	**1%**	**4%**	**1%**	**7%**
2001 Summary	**2**	**-6%**	**5%**	**-6%**	**1%**	**-3%**	**1%**	**-2%**	**2%**
	3	**-5%**	**5%**	**-15%**	**8%**	**-7%**	**0%**	**-6%**	**4%**
	4	**-5%**	**5%**	**-10%**	**5%**	**-5%**	**6%**	**-3%**	**9%**
	Annual	**-5%**	**5%**	**-9%**	**5%**	**-5%**	**5%**	**-4%**	**8%**

Table 8 - Ozone Precision and Accuracy Probability Limits (95% Confidence Interval)

Site/Station Name	Quarter	Precision Probability		Audit Probability Limits					
		Lower Limit	Upper Limit	Level 1		Level 2		Level 3	
				Lower	Upper	Lower	Upper	Lower	Upper
2001									
Arvada	1	-5%	4%						
	2	-2%	3%						
	3	-5%	5%						
	4	-10%	10%						
	Annual	**-6%**	**6%**						
Chatfield Res.	2	-5%	6%						
	3	-1%	4%						
	Annual	**-3%**	**5%**						
Co. Spr. - USAFA	1	-5%	6%						
	2	-4%	2%						
	3	-8%	5%						
	4	-4%	1%						
	Annual	**-5%**	**4%**						
Denver - Carriage	1	-7%	5%						
	2	-7%	4%						
	3	-9%	7%						
	4	-4%	3%						
	Annual	**-7%**	**5%**						
Ft. Collins	1	-4%	16%						
	2	-4%	5%						
	3	-7%	8%						
	4	-7%	9%						
	Annual	**-7%**	**10%**						
Greeley	1	-8%	11%						
	2	-5%	9%						
	3	-1%	5%						
	4	-22%	26%						
	Annual	**-11%**	**15%**						
Highlands	1	-6%	5%						
	2	-4%	-1%						
	3	-10%	14%						
	4	-8%	8%						
	Annual	**-8%**	**8%**						
NREL	1	1%	6%						
	2	2%	9%						
	3	-6%	5%						
	4	-3%	2%						
	Annual	**-4%**	**8%**						

Site/Station Name	Quarter	Precision Probability		Audit Probability Limits					
		Lower Limit	Upper Limit	Level 1		Level 2		Level 3	
				Lower	Upper	Lower	Upper	Lower	Upper
2001									
R.F. North	1	-6%	4%						
	2	-3%	8%						
	3	1%	10%						
	4	1%	7%						
	Annual	**-4%**	**9%**						
S. Boulder Creek	1	-2%	4%						
	2	-1%	1%						
	3	-5%	4%						
	4	-5%	7%						
	Annual	**-3%**	**4%**						
Welby	1	-19%	6%						
	2	-2%	8%						
	3	-13%	9%						
	4	-21%	11%						
	Annual	**-16%**	**10%**						
Welch	1	1%	14%						
	2	-2%	15%						
	3	-3%	10%						
	4	-5%	18%						
	Annual	**-2%**	**14%**						
CDPHE	**1**	**-9%**	**11%**	**-9%**	**2%**	**-5%**	**4%**	**-7%**	**6%**
2001									
Summary	**2**	**-5%**	**8%**	**-5%**	**3%**	**-1%**	**7%**	**0%**	**8%**
	3	**-7%**	**8%**	**-9%**	**5%**	**-6%**	**7%**	**-4%**	**7%**
	4	**-11%**	**12%**	**-17%**	**11%**	**-2%**	**10%**	**-5%**	**6%**
	Annual	**-8%**	**10%**	**-11%**	**6%**	**-4%**	**8%**	**-4%**	**7%**

Table 9 - Sulfur Dioxide Precision and Accuracy Probability Limits (95% Confidence Interval)

Site/Station Name	Quarter	Precision Probability		Audit Probability Limits					
		Lower Limit	Upper Limit	Level 1		Level 2		Level 3	
				Lower	Upper	Lower	Upper	Lower	Upper
2001									
CAMP	1	-5%	2%						
	2	-6%	1%						
	3	-12%	6%						
	4	-6%	-2%						
	Annual	**-8%**	**3%**						
S. Adams - Niagra	2	-2%	9%						
	3	-9%	10%						
	4	-6%	16%						
	Annual	**-6%**	**12%**						
Welby	1	-9%	5%						
	2	-4%	2%						
	3	-4%	2%						
	4	-13%	4%						
	Annual	**-8%**	**4%**						
CDPHE	**1**	**-7%**	**4%**						
2001 Summary	**2**	**-7%**	**7%**						
	3	**-9%**	**6%**						
	4	**-13%**	**11%**						
	Annual	**-9%**	**7%**	**-6%**	**4%**	**-5%**	**6%**	**-2%**	**8%**

Note: Quarterly accuracy probability limits are not available since only one audit was performed each quarter.

Table 10 - Nitrogen Dioxide Precision and Accuracy Probability Limits (95% Confidence Interval)

Site/Station Name	Quarter	Precision Probability		Audit Probability Limits					
		Lower Limit	Upper Limit	Level 1		Level 2		Level 3	
				Lower	Upper	Lower	Upper	Lower	Upper
2001									
CAMP	1	-7%	14%						
	2	-29%	17%						
	3	-8%	6%						
	4	-5%	6%						
	Annual	**-15%**	**13%**						
R. F. SouthEast	1	-8%	4%						
	2	-13%	11%						
	Annual	**-10%**	**7%**						
R. F. West	1	-23%	-29%						
	2	-12%	0%						
	Annual	**-22%**	**-21%**						
Welby	1	-14%	15%						
	2	-14%	3%						
	3	-7%	5%						
	4	-8%	7%						
	Annual	**-12%**	**9%**						
CDPHE	**1**	**-15%**	**17%**	**-17%**	**27%**	**-20%**	**29%**	**-18%**	**28%**
2001 Summary	**2**	**-18%**	**9%**						
	3	**-8%**	**5%**						
	4	**-6%**	**6%**						
	Annual	**-15%**	**12%**	**-33%**	**22%**	**-24%**	**19%**	**-25%**	**17%**

Note: Accuracy probability limits available only if more than one audit was performed during the quarter.

The annual CDPHE precision results for CO, O_3, SO_2, and NO_x are graphed in Figures 2 – 5 along with the last 10 years of precision results so that so that network trends can be observed.

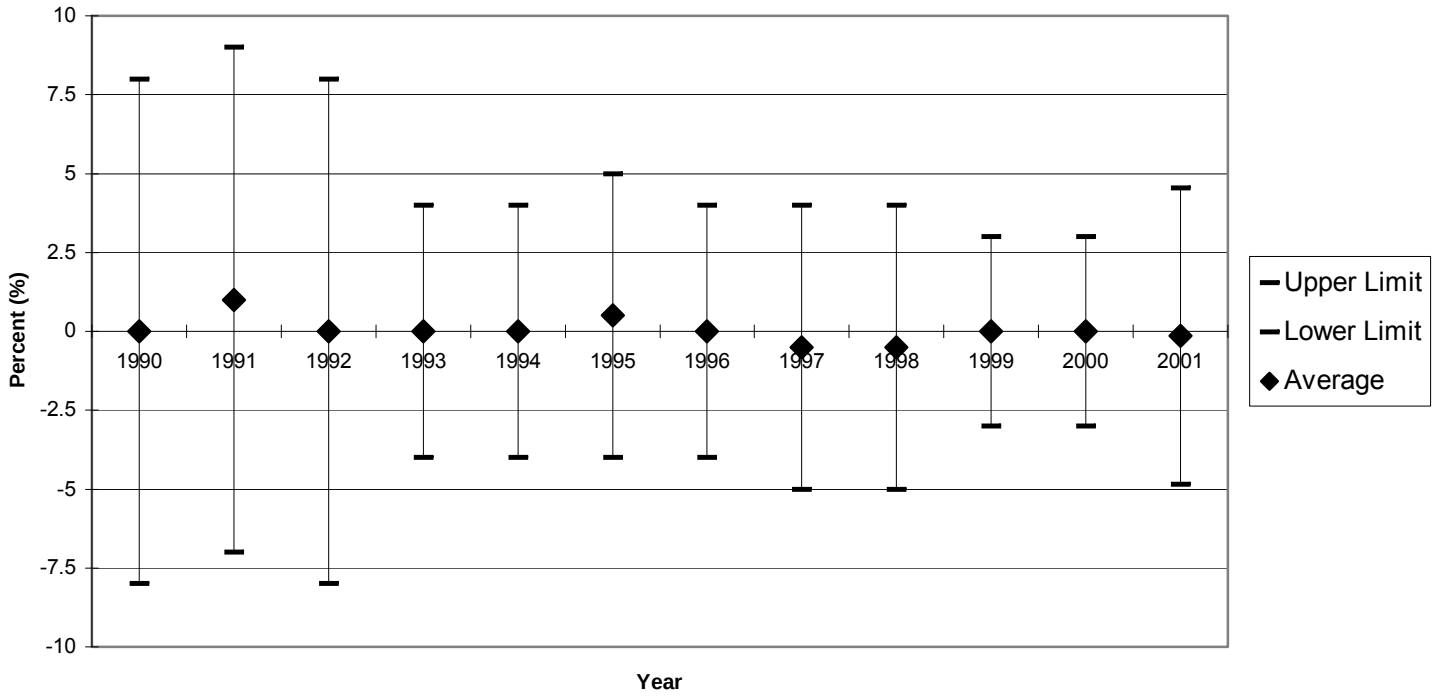


Figure 2 - APCD Annual Comparison of Carbon Monoxide Precision Probability Limits (1990 - 2001) (95 % Confidence Interval)

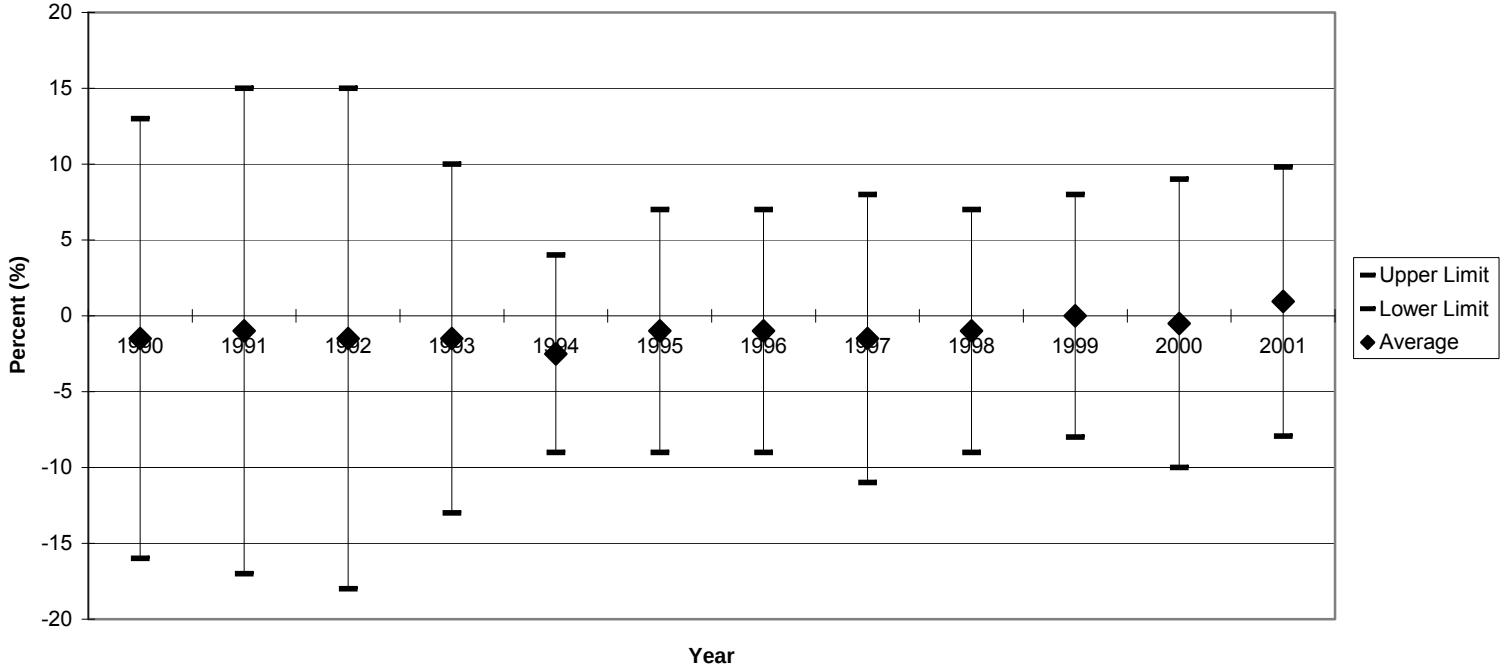


Figure 3 - Figure 3 - APCD Annual Comparison of Ozone Precision Probability Limits (1990 - 2001) (95% Confidence Interval)

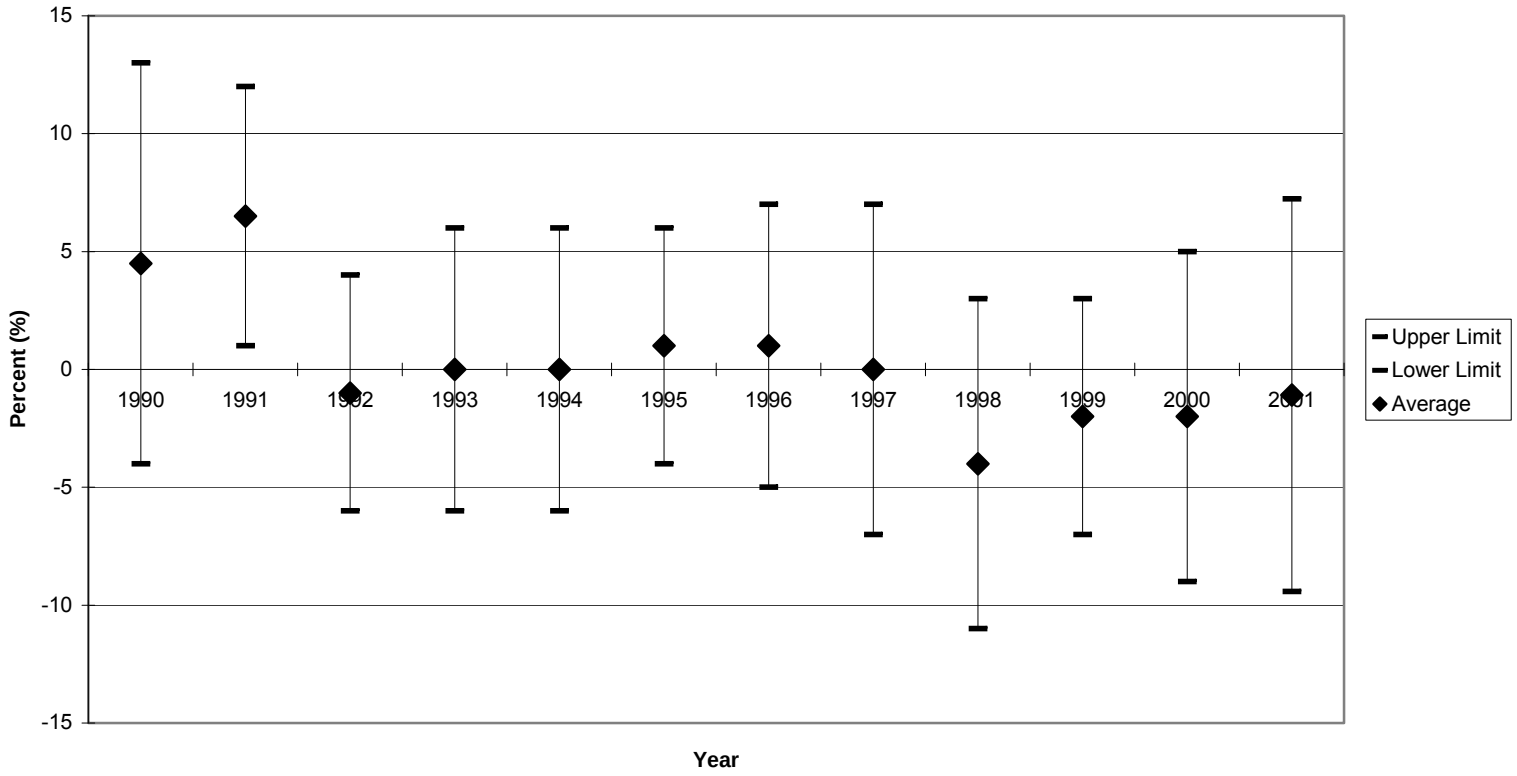


Figure 4 - Figure 4 - APCD Annual Comparison of Sulfur Dioxide Precision Probability Limits (1990-2001) (95% Confidence Interval)

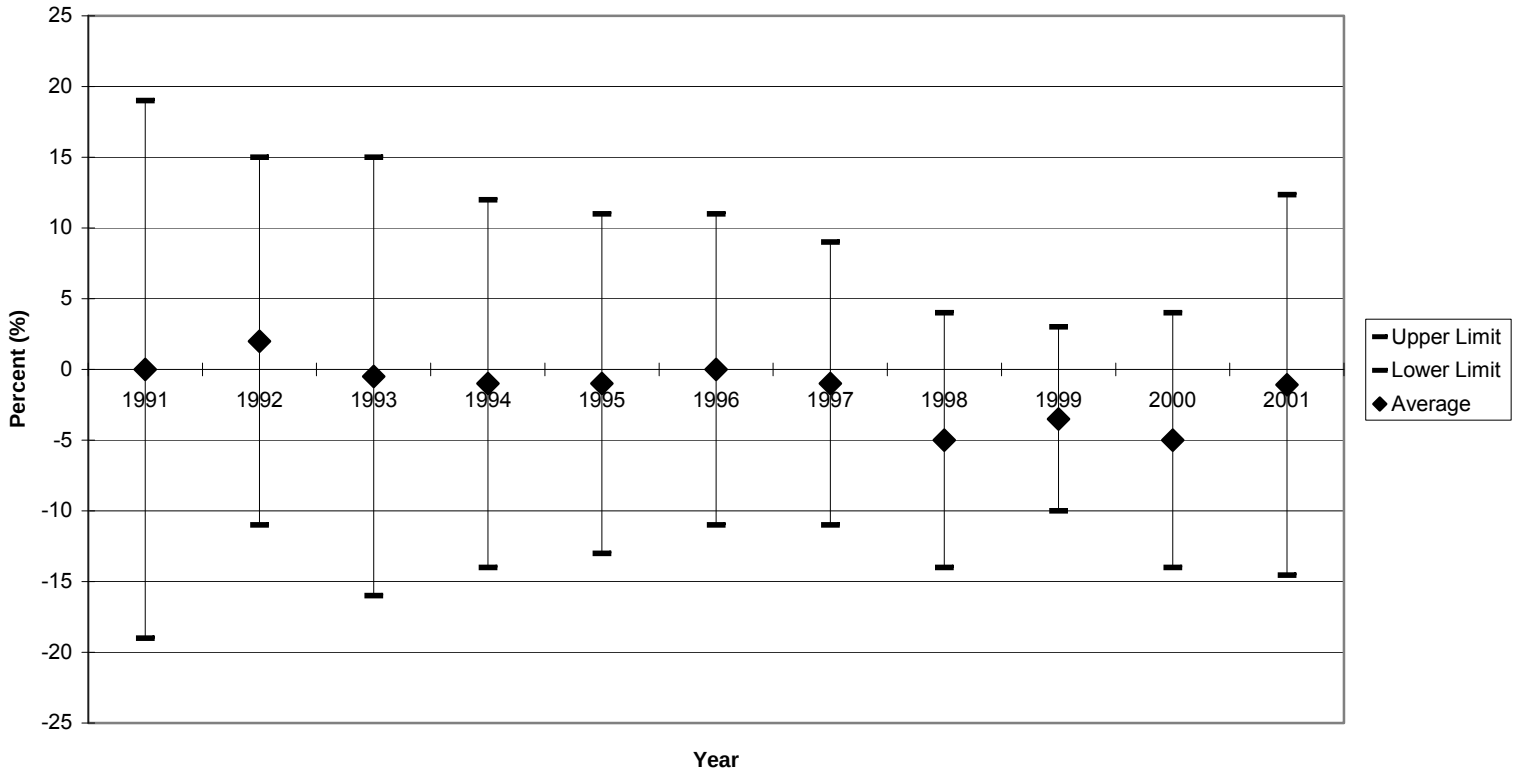


Figure 5 - Figure 5 - APCD Annual Comparison of Nitrogen Dioxide Precision Probability Limits (1991 - 2001) (95% Confidence Interval)

2.5 System Audits

A system audit is a qualitative inspection and review of a measurement system. For the APCD's gas monitoring network, these audits offer an assessment of field operations at a given site. Emphasis in these system audits is placed on safety and security at the site, and the adequacy of field procedures and record keeping. APCD's gaseous monitoring stations received system audits in 2001. The system audits revealed thorough maintenance and record keeping at all of the stations. Very few problems were noted. The APCD goal of conducting system audits at each of the gaseous monitoring stations was not met in 2001. Eleven gaseous sites were audited.

2.6 Additional Audits

The APCD occasionally performs audits of gas monitoring networks operated by other public and private entities in Colorado. Although not part of the APCD's monitoring network, the APCD has an interest in the quality of these data since they may be used in the determination of ambient background concentrations in Colorado. Ozone audits were conducted at Rocky Mountain National Park and Mesa Verde National Park. An SO2 audit was conducted at Buffalo Pass.

2.7 Certification of Audit Standards

For CO, NO_2, and SO_2 audits and calibrations, the APCD uses compressed gas cylinders whose accuracy is certified by the manufacturer. These certifications are updated approximately every 18 months, and are conducted by the vendor using the *Revised EPA Protocol For Assay and Certification of Compressed Gas Calibration Standards*. For SO_2 and NO_2 audit flow rates, the state uses NIST-traceable electronic flowmeters to measure dilution air flow.

The traceability of APCD ozone calibration and audit standards is maintained through the use of certified transfer standards. The ozone audit device is certified regularly against the state's laboratory standard. This standard is also employed in certifying the state's gaseous ozone calibrators, so that a common traceability is maintained for the APCD ozone monitoring network. The laboratory standard is compared annually to a Standard Reference Photometer (SRP) operated by the EPA.

EPA Region VIII closed their Air Quality Assurance Laboratory in 1992. The APCD was able to make arrangements to compare this laboratory standard against standard reference photometer located at the EPA Region VII office in Kansas City, Missouri. Results of SRP comparisons made since 1992 are shown below.

Acceptable comparison results are a regression slope of 1.00 ±0.03 and a regression intercept of less than 5 ppb. The APCD's laboratory standard has consistently met these criteria.

Date	Equation
February 18, 2000	State Standard = 0.995 * SRP + 1.0 ppb (EPA VII)
March 13, 1997	State Standard = 1.022 * SRP + 1.4 ppb (EPA VII)
March 13, 1996	State Standard = 1.008 * SRP + 0.7 ppb (EPA VII)
March 16, 1995	State Standard = 0.999 * SRP + 3.1 ppb (EPA VII)
March 17, 1994	State Standard = 1.011 * SRP + 3.5 ppb (EPA VII)
March 17, 1993	State Standard = 0.990 * SRP + 1.5 ppb (EPA VII)
Sept. 29, 1992	State Standard = 0.978 * SRP + 2.0 ppb (EPA VII)

3.0 PARTICULATE MONITORING NETWORK QUALITY ASSURANCE

The Air Pollution Control Division (APCD) routinely monitors three size classes of particulate matter. Total suspended particulates (TSP) includes particulate matter with a diameter of about 30 microns or less. Inhalable particulate matter (PM_{10}) includes all particulate matter with a diameter of 10 microns or smaller. Respirable particulate matter ($PM_{2.5}$)includes all particulate matter with a diameter of 2.5 microns or less. Filters collected at some sites in the TSP network are also chemically analyzed for lead (Pb), arsenic (As), cadmium (Cd), and sulfate ($SO_4^=$).

The particulate networks quality assurance functions are centered around three activities; (1) routine field audits, (2) the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) precision and accuracy program, and (3) EPA national NPAP and PEP programs.

3.1 Accuracy Audits

The particulate sampler flow audits conducted by the APCD are evaluated using two criteria. The first criteria is that sampler flow at the current operating set point, measured using an independent flow standard, must be within ±7% of the flow determined at the time of calibration for PM_{10} and TSP samplers. For a $PM_{2.5}$ sampler, the instrument flow rate at the time of audit, measured using an independent flow transfer standard, must be within ±4%. The second criteria has to do with instrument design flow rate. For PM_{10} samplers, the sampler flow rate (corrected to conditions of standard temperature and pressure) must also be within ±10% of the nominal sampler design flow air rate of 1.132 cubic meters per minute. For $PM_{2.5}$ instruments, the actual sampling flow rate must be within ±5% of the optimal instrument design flow conditions of 16.67L/min calculated in using actual local conditions.

Field audits of sampler flow rates were performed at all operating TSP, PM_{10}, and $PM_{2.5}$ sites in Colorado during 2001. $PM_{2.5}$ sites were audited quarterly. PM_{10} and TSP sites were audited at least semi-annually at all sites, and quarterly at most of the sites. Audit results for all particulate sites are summarized in Table 11. Corrective actions (which included sampler maintenance, recalibration, and data invalidation) were performed after analyzing the results of the out-of-specification audits. Summaries of these corrective actions can be found in Section 6 of this 2001 QA Report.

According to the *1997 revised CFR Part 58 Appendix A* additional calculations to determine bias of the $PM_{2.5}$ independent accuracy audits are required. Table 12 summarizes the bias on $PM_{2.5}$ QA accuracy audits.

Table 11 - 2001 Particulate Internal Audits Summary

	Number of Audits				
Site / Station Name	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**Failures**	**Corrective Actions**
Adams City (primary) (*1)	2	2	8		
Adams City (collocated) (*1)	2				
Commerce City (primary) (*4)	4	4	16	3	$PM_{2.5}$, TSP, see CORR ACT chart
Commerce City (collocated) (*4)	3				
Globeville Clinicare		6			
Brighton (*2)			6		
Welby			4		
Alamosa			24	2	MFC adjustment
Arapahoe Community College	5				
Pagosa Springs (*1)	2		12	2	MFC adjustment
Pagosa Spr. Middle School (*4)	2		12		
Longmont	4		8		
Boulder Chamber of Commerce	4		4		
Hygiene			16	2	Warnings
Delta	5		6		
Paonia (*1)			1		
Hotchkiss (*1)			1		
Denver - CAMP (primary)	6	4	5	2	Warnings
Denver - CAMP (collocated) (*3)	2		4		
Denver - Gates (primary)		4	4		
Denver - Gates (collocated)		4	4		
Denver Visitor Center			16	2	Warnings
Denver - LARS			6		
Castle Rock (*1)			2		
Parker (*1)	5			1	Partial/seals replaced/press fail
Vail - WSD (*1)			2		
Elbert	4				
Colorado Springs - Meadowlands	4		8		
Colorado Springs - RBD (primary)	4	4	4		
Co. Springs - RBD (collocated) (*5)	3		4	1	Warning
Canon City			4		
Parachute			6		
Rifle (*1)			2		
Glenwood Springs (*1)			2		
Crested Butte			8		
Mt. Crested Butte	4		16		
Gunnison			8		
Rocky Flats X-1 (N) (primary) (*1)		2	2		
Rocky Flats X-1 (N) (collocated) (*1)		2			

	Number of Audits				
Site / Station Name	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**Failures**	**Corrective Actions**
Rocky Flats X-2 (NE) (primary) (*1)		2	2		
Rocky Flats X-2 (NE)(collocated) (*1)			2		
Rocky Flats X-3 (SE) (*1)		2	2		
Rocky Flats X-4 (S) (*1)		2	2		
Rocky Flats X-5 (W) (*1)		2	2		
Leadville		4			
Durango - Platform			24	3	MFC adjustment
Durango - Park School	4		12	4	$PM_{2.5,}$ PM_{10}, see CORR ACT chart
Durango - Courthouse			12	3	Warning/MFC adjustment
Ft Collins - Courthouse			6	1	Delete data/replace motor/calibrate
Ft. Collins - CSU	4		8	1	Warning
G.J. - Health Dept.(primary) (*6)	4	4	4		
G.J. - Health Dept.(collocated)	4				
Grand Junction - Stocker (*1)			2		
Grand Junction - Traffic (*4)		8		2	Warnings
Montrose			5		
Olathe			8		
Aspen			8		
Lamar Power Plant			24	1	MFC adjustment
Lamar Municipal Bldg			24	2	MFC adjustment
Pueblo Public Works	4		8		
Steamboat Springs	4		20		
Telluride	4		12		
Breckenridge			10	1	MFC adjustment
Silverthorne			3		
Cripple Creek			16	3	Warning
Greeley	4		8		
Platteville	4			1	Partial /temperature probe calibrated
Total Particulate Audits	**101**	**56**	**449**	**37**	**See Corrective Action (Section 6)**
# of Failures	**4 partial**	**5**	**28**		
% Failure Rate	**4%**	**9%**	**6%**		
Number of Analyzers in Network	**26**	**17**	**115**		

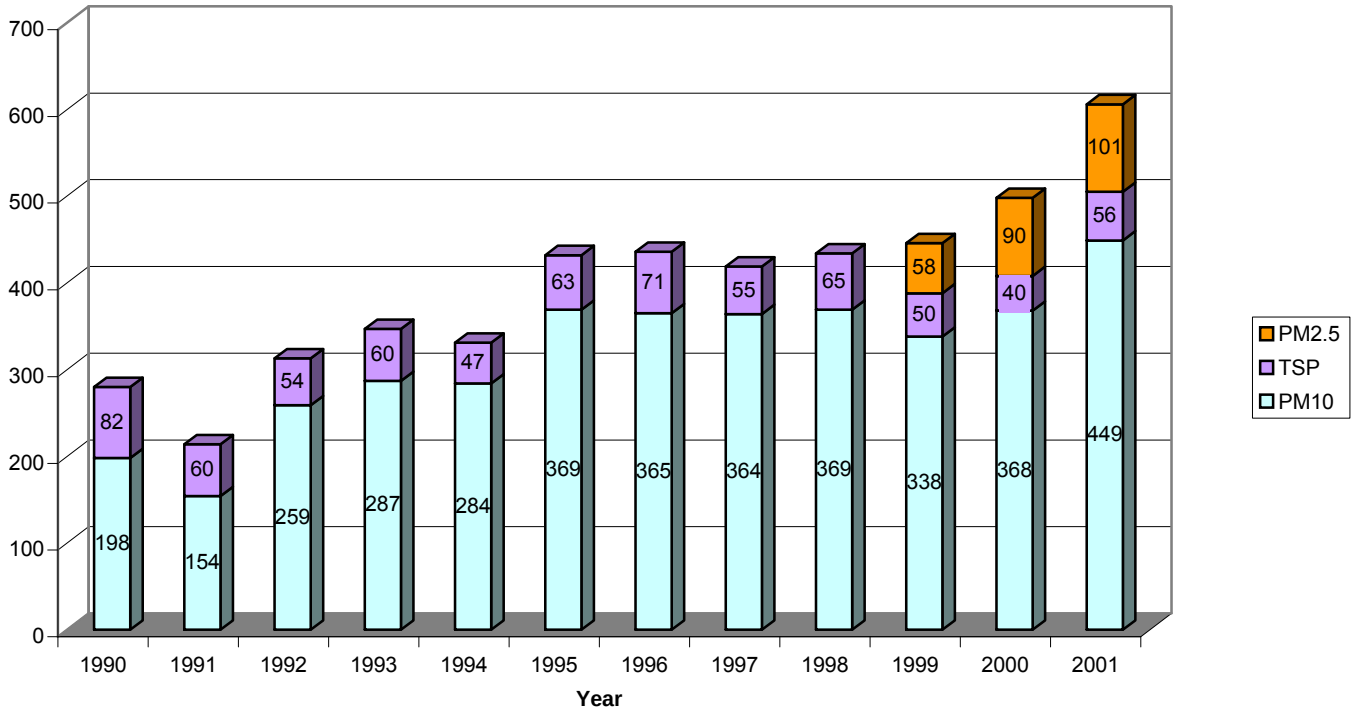
NOTES: Sampling schedule summaries can be found in Table 1
More detailed site, monitor, and sampling schedule information can be found in the Annual Network Review.
Complete CORRECTIVE ACTION list can be found in Table 21
(*1) Discontinued operation during 2001
(*2) Site shut down part of year for site maintenance
(*3) $PM_{2.5}$ monitor started operation during 2001
(*4) New Site
(*5) Collocated $PM_{2.5}$ instrument removed
(*6) New TSP site

Table 12 – Bias on Accuracy Audits for $PM_{2.5}$

Site/ Station Name	Method Code	QUARTER	Accuracy Bias
Adams City Primary	118	Annual	-1.23%
Adams City Collocated	118	Annual	-0.65%
Commerce City Primary	118	Annual	0.91%
Commerce City Collocated	118	Annual	0.15%
Arapahoe Community College	118	Annual	-1.03%
Pagosa Springs	117	Annual	0.26%
Pagosa Springs School	117	Annual	-0.51%
Longmont	118	Annual	1.86%
Boulder	118	Annual	0.10%
Delta	117	Annual	-1.00%
CAMP	118	Annual	-0.08%
Parker	118	Annual	0.83%
Elbert County	118	Annual	0.42%
Meadowlands	118	Annual	-0.05%
RBD Primary	118	Annual	0.26%
RBD Collocated	118	Annual	-1.04%
Mt. Crested Butte	117	Annual	-1.65%
Durango	117	Annual	-0.38%
Ft. Collins	118	Annual	-0.68%
Grand Junction Primary	118	Annual	-0.93%
Grand Junction Collocated	118	Annual	0.03%
Pueblo	118	Annual	0.02%
Steamboat Springs	117	Annual	0.26%
Telluride	117	Annual	-1.08%
Greeley	118	Annual	-0.57%
Platteville	118	Annual	0.09%
CDPHE	117	1	-0.97%
2001 Summary	117	2	-0.67%
	117	3	-1.07%
	117	4	-0.02%
	117	Annual	-0.68%
	118	1	0.15%
	118	2	-0.96%
	118	3	-1.46%
	118	4	1.89%
	118	Annual	-0.14%
	Both	1	-0.14%
	Both	2	-0.89%
	Both	3	-1.37%
	Both	4	1.41%
	Both	Annual	-0.27%

Figure 6 shows trends in the number of QA particulate accuracy audits performed by APCD QA staff over the past 12 years. Typically, well over 400 particulate audits are performed each year. In 2001, over 600 particulate audits were performed.

Figure 6 - Number of APCD Particulate Accuracy Audits Performed Annually (1990 - 2001)



3.2 Data Validation

The APCD performs a number of routine data validation procedures to ensure the quality of the ambient data collected by the particulate monitoring network. Site operators regularly perform flow checks on monitors before and after each sampling interval to ensure that they are operating within acceptable limits. During data processing, the CDPHE Laboratory Division ensures that indicated sampler flow rates are within range, if the flow is out of range the sample is voided. Ambient data are also reviewed in response to failed accuracy audits > ± 10%.

3.3 EPA Interlaboratory Studies

In 2001, the APCD participated in the national interlaboratory comparison study for PM_{10} and TSP measurements. These interlaboratory comparisons are part of the National Performance Audit Program (NPAP) operated by the EPA. This program provides a means of comparing the APCD's monitoring performance with that of other agencies. Although an organization can use the interlaboratory program to identify out-of-control situations, the interlaboratory results cannot be used to adjust or invalidate data.

The interlaboratory kit used in 2001consisted of a series of six orifice plates. Five of the plates are used with TSP sampler audits, a single orifice plate is used for PM_{10} audits. The current sampler flow rate, as determined from the most recent calibration, is compared with a flow rate determined using the EPA audit orifice. The EPA target criterion for acceptable audit performance is that the flow difference be within ±15% of the EPA value. Participants reporting values outside these limits are urged to determine the cause for their poor performance and to take corrective action. Participants reporting results within ±10 -15% of the assigned value are encouraged to evaluate their measurement systems in order to reduce the size of the difference.

In 1993 the NPAP program requested that the APCD and other reporting organizations target specific sampling sites which had monitored PM_{10} concentrations approaching or exceeding that of the National Ambient Air Quality Standard. In order to comply with this request, APCD performed 92 PM_{10} interlaboratory comparisons in 2001. This large number of audits occurred because the agency responsible for sending out the auditing devices did not send out the 2000 kit until the first quarter of 2001. Therefore, there were no audits in 2000. One TSP interlaboratory comparison was completed in 2001. The results of the 2001 comparisons are presented in Table 13. This table shows that all but two of the APCD samplers met the EPA target for flow differences. The average of the absolute flow differences of all the PM_{10} audits was within 3% of EPA's "true" value.

Table 13 - NPAP Interlab TSP and PM_{10} Audit Results

Audit Parameter	Audit Date	Site Name	Instrument Identification	Plate Number	Reported Value	Actual Value	% Difference
PM_{10}	11/20/2001	Commerce City	21972	88	1.103	1.091	1.1%
PM_{10}	11/20/2001	Commerce City	31963	88	1.188	1.166	1.9%
PM_{10}	11/20/2001	Commerce City	11975	88	1.158	1.141	1.5%
PM_{10}	11/20/2001	Commerce City	17406	88	1.159	1.141	1.6%
PM_{10}	3/15/2001	Alamosa	1	88	1.130	1.144	-1.2%
PM_{10}	3/15/2001	Alamosa	2	88	1.179	1.200	-1.7%
PM_{10}	3/15/2001	Alamosa	3	88	1.167	1.119	4.3%
PM_{10}	3/15/2001	Alamosa	4	88	1.165	1.124	3.7%
PM_{10}	11/27/2001	Alamosa	6000	88	1.139	1.160	-1.8%
PM_{10}	11/27/2001	Alamosa	4975	88	1.150	1.173	-2.0%
PM_{10}	11/27/2001	Alamosa	4070	88	0.888	0.914	-2.8%
PM_{10}	11/27/2001	Alamosa	12770	88	1.244	1.246	-2.0%
PM_{10}	3/15/2001	Pagosa Springs	1	88	1.201	1.056	13.7%
PM_{10}	3/15/2001	Pagosa Springs	2	88	1.101	1.043	5.6%
PM_{10}	3/15/2001	Pagosa Springs	3	88	1.127	1.005	12.1%
PM_{10}	3/15/2001	Pagosa Springs	4	88	1.096	1.064	3.0%
PM_{10}	11/28/2001	Pagosa Springs	5034	88	1.101	1.099	0.2%
PM_{10}	11/28/2001	Pagosa Springs	6020	88	1.141	1.160	-1.7%
PM_{10}	11/28/2001	Pagosa Springs	17370	88	1.176	1.177	-0.1%
PM_{10}	11/28/2001	Pagosa Springs	5033	88	1.100	1.118	-1.7%
PM_{10}	3/8/2001	Delta	1	88	1.119	1.059	5.6%
PM_{10}	11/8/2001	Delta	1	88	1.104	1.092	1.1%
PM_{10}	3/12/2001	Canon City	1	88	1.184	1.144	3.5%
PM_{10}	11/27/2001	Canon City	1	88	1.113	1.151	-3.3%
PM_{10}	3/13/2001	Crested Butte	1	88	1.110	1.141	-2.8%
PM_{10}	3/13/2001	Crested Butte	2	88	1.114	1.126	-1.1%
PM_{10}	11/5/2001	Crested Butte	5031	88	1.163	1.196	-2.7%
PM_{10}	11/5/2001	Crested Butte	15861	88	1.153	1.144	0.8%
PM_{10}	3/14/2001	Mt. Crested Butte	1	88	1.122	1.132	-0.9%
PM_{10}	3/14/2001	Mt. Crested Butte	2	88	1.160	1.195	-2.9%
PM_{10}	3/14/2001	Mt. Crested Butte	3	88	1.159	1.159	0.0%
PM_{10}	3/14/2001	Mt. Crested Butte	4	88	1.159	1.189	-2.5%
PM_{10}	11/5/2001	Mt. Crested Butte	2570	88	1.154	1.172	-1.5%
PM_{10}	11/5/2001	Mt. Crested Butte	5040	88	1.139	1.151	-1.0%
PM_{10}	11/5/2001	Mt. Crested Butte	6070	88	1.179	1.190	-0.9%
PM_{10}	11/5/2001	Mt. Crested Butte	17762	88	1.116	1.146	-2.6%

Audit Parameter	Audit Date	Site Name	Instrument Identification	Plate Number	Reported Value	Actual Value	% Difference
PM_{10}	3/14/2001	Durango Platform	4	88	1.133	1.162	-2.5%
PM_{10}	3/14/2001	Durango Platform	3	88	1.157	1.195	-3.2%
PM_{10}	3/14/2001	Durango Platform	2	88	1.104	1.178	-6.3%
PM_{10}	3/14/2001	Durango Platform	1	88	1.190	1.220	-2.5%
PM_{10}	11/29/2001	Durango Platform	17475	88	1.126	1.130	-0.4%
PM_{10}	11/29/2001	Durango Platform	16126	88	1.122	1.122	0.0%
PM_{10}	11/29/2001	Durango Platform	17358	88	1.166	1.159	0.6%
PM_{10}	11/29/2001	Durango Platform	5036	88	1.126	1.179	-4.5%
PM_{10}	3/14/2001	Durango School	2	88	1.244	1.274	-2.4%
PM_{10}	3/14/2001	Durango School	1	88	1.154	1.171	-1.5%
PM_{10}	11/28/2001	Durango School	31605	88	1.148	1.156	-0.7%
PM_{10}	11/28/2001	Durango School	8856	88	1.001	1.006	-0.5%
PM_{10}	3/14/2001	Durango Courthouse	2	88	1.094	1.009	8.4%
PM_{10}	3/14/2001	Durango Courthouse	1	88	1.118	1.133	-1.3%
PM_{10}	11/28/2001	Durango Courthouse	10905	88	1.023	1.029	-0.6%
PM_{10}	11/28/2001	Durango Courthouse	17352	88	1.105	1.119	-1.2%
PM_{10}	**3/8/2001**	**Montrose**	**1**	**88**	**1.011**	**0.861**	**17.4%**
PM_{10}	11/8/2001	Montrose	1	88	1.110	1.118	-0.7%
PM_{10}	3/5/2001	Lamar Power Plant	1	88	1.155	1.181	-2.2%
PM_{10}	3/5/2001	Lamar Power Plant	2	88	1.204	1.232	-2.2%
PM_{10}	3/5/2001	Lamar Power Plant	3	88	1.186	1.222	-3.0%
PM_{10}	3/5/2001	Lamar Power Plant	4	88	1.193	1.230	-3.0%
PM_{10}	10/30/2001	Lamar Power Plant	2069	88	1.157	1.162	-0.4%
PM_{10}	10/30/2001	Lamar Power Plant	11870	88	1.216	1.219	-0.3%
PM_{10}	10/30/2001	Lamar Power Plant	19142	88	1.238	1.244	-0.5%
PM_{10}	3/5/2001	Lamar Muni Blgd	4	88	1.173	1.204	-2.6%
PM_{10}	3/5/2001	Lamar Muni Blgd	3	88	1.144	1.177	-2.8%
PM_{10}	3/5/2001	Lamar Muni Blgd	2	88	1.136	1.182	-3.9%
PM_{10}	3/5/2001	Lamar Muni Blgd	1	88	1.204	1.242	-3.0%
PM_{10}	10/30/2001	Lamar Muni Blgd	21277	88	1.081	1.073	0.7%
PM_{10}	10/30/2001	Lamar Muni Blgd	6030	88	1.141	1.136	0.5%
PM_{10}	10/30/2001	Lamar Muni Blgd	6050	88	1.121	1.116	0.4%
PM_{10}	10/30/2001	Lamar Muni Blgd	17386	88	1.095	1.087	0.7%
PM_{10}	3/19/2001	Steamboat Springs	1	88	1.163	1.190	-2.2%
PM_{10}	3/19/2001	Steamboat Springs	2	88	1.189	1.220	-2.5%
PM_{10}	3/19/2001	Steamboat Springs	3	88	1.142	1.187	-3.8%
PM_{10}	3/19/2001	Steamboat Springs	4	88	1.183	1.218	-2.9%

Audit Parameter	Audit Date	Site Name	Instrument Identification	Plate Number	Reported Value	Actual Value	% Difference
PM_{10}	11/13/2001	Steamboat Springs	11222	88	1.127	1.154	-2.4%
PM_{10}	11/13/2001	Steamboat Springs	6080	88	1.165	1.186	-1.8%
PM_{10}	11/13/2001	Steamboat Springs	14384	88	1.137	1.161	-2.0%
PM_{10}	11/13/2001	Steamboat Springs	19035	88	1.097	1.107	-0.9%
PM_{10}	3/13/2001	Telluride	2	88	1.145	1.177	-2.7%
PM_{10}	3/13/2001	Telluride	1	88	1.092	1.129	-3.3%
PM_{10}	11/8/2001	Telluride	17320	88	1.125	1.119	0.6%
PM_{10}	11/8/2001	Telluride	21953	88	1.167	1.147	1.7%
PM_{10}	3/26/2001	CAMP	primary	88	1.129	1.091	3.5%
PM_{10}	3/26/2001	CAMP	collocated	88	1.119	1.163	-3.8%
PM_{10}	3/9/2001	Vail	1	88	1.139	1.216	-6.3%
PM_{10}	3/8/2001	Stocker - GJ	1	88	1.009	1.037	-2.7%
PM_{10}	3/8/2001	Grand Junction - Health	1	88	1.150	1.162	-1.0%
PM_{10}	3/9/2001	Glenwood	1	88	1.131	1.168	-3.2%
PM_{10}	3/9/2001	Aspen	1	88	1.173	1.176	-0.2%
PM_{10}	**3/9/2001**	**Aspen**	**2**	**88**	**0.971**	**0.614**	**58.1%**
PM_{10}	3/9/2001	Rifle	1	88	1.131	1.154	-2.0%
PM_{10}	3/8/2001	Olathe	1	88	1.131	1.117	1.3%
PM_{10}	3/8/2001	Olathe	2	88	1.156	1.107	4.4%
Average % Difference							0.3%
Average Absolute % Difference							3.2%
Range							-6.3% to 58.1%
TSP	11/20/2001	Commerce City	primary	5	0.524	0.579	-12.3%
TSP	11/20/2001	Commerce City	primary	7	0.641	0.716	-10.5%
TSP	11/20/2001	Commerce City	primary	10	0.778	0.822	-5.4%
TSP	11/20/2001	Commerce City	primary	13	0.838	0.880	-4.8%
TSP	11/20/2001	Commerce City	primary	18	0.910	0.946	-3.8%
Average % Difference							-7.4%
Average Absolute % Difference							7.4%
Range							-12.3% to -3.8%

Each Year the EPA Interlaboratory Performance Evaluation Program (PEP) Audit program selects 25% of our SLAMS and NAMS sites to use in their Performance Evaluation Program in order to establish a basis for determining bias of our network. Once per quarter the PEP auditor installs a portable $PM_{2.5}$ sampler within 4 feet of our site sampler at each of these selected sites, and they take a side-by-side 24 hour sample. It is desirable to have the concentration values of our 24 hour sample within 10% of the independent PEP audit concentration value. However, given the nature of the low concentration values we are recovering and the number of APCD/PEP concentration pairs that are not valid because they are below 6 $\mu g/m^3$, this is quite difficult. The differences between our values and the independent PEP auditor values averaged over a year give us an indication of instrument bias for a specific site. All sites averaged over the year gives us an indication of our network bias. Table 14 summarizes these bias results.

Table 14 - PM 2.5 Interlab Performance Evaluation Program Audit Results

Site and ID	Quarter	Date	APCD Station Results ($\mu g/m^3$)	PEP Audit Results ($\mu g/m^3$)	Difference in ($\mu g/m^3$)	BIAS	Temperature (deg C)	Pressure (mmHg)
Longmont	1	1/16/2001	9	8.07	0.93	11.5%	-6.1	639
080130003	2	5/22/2001	4.5	3.79	0.72	N/A	16.1	637
	3	9/19/2001	7.6	6.20	1.40	22.6%	16.8	638
	4	10/31/2001	4.6	4.91	-0.31	N/A	15.9	629
Longmont Annual						**17.0%**		
Elbert	1	1/10/2001	2.6	1.83	0.77	N/A	3.2	589
080390001	2	3/29/2001	4.4	4.95	-0.55	N/A	1.2	584
	3	5/16/2001	3.5	3.83	-0.33	N/A	15.9	589
	4	9/25/2001	5.6	5.20	0.40	N/A	17.1	594
Elbert Annual								
Co. Springs - Meadowland	1	1/10/2001	6.8	6.20	0.60	9.7%	4.5	598
080410008	2	5/16/2001	6	6.95	-0.95	-13.6%	18	600
	3	9/25/2001	7.7	8.11	-0.41	-5.1%	28.3	605
	4	12/6/2001	3.3	3.08	0.22	N/A	5.5	601
Meadowland Annual						**-3.0%**		
Greeley	1	1/16/2001	9.8	7.41	2.39	32.3%	-6	635
081230008	2	5/22/2001	3.8	3.66	0.14	N/A	14.8	640
	3	9/19/2001	8.4	6.91	1.49	21.6%	29.7	638
	4	10/31/2001	9.3	8.24	1.07	12.9%	18.6	632
Greeley Annual						**22.3%**		
CDPHE Annual BIAS						**12.10%**		

3.4 Precision and Accuracy Program

The APCD is required to conduct a precision and accuracy assessment program for the particulate and lead monitoring networks. As with the gaseous monitoring network, the accuracy audit program requires that at least 25% of the samplers are audited each quarter and that each monitor be audited at least once per year.

The precision testing program, for manual samplers, is different from that used for automated samplers. The automated systems compare a known analyte concentration (actual value) with an analyzer response (indicated value) on a biweekly schedule. There are no particulate concentration standards that can be used as "actual values," so the manual sampler precision program relies on comparison of collocated instruments. Identical collocated instruments are operated at several sites (3 $PM_{2.5}$, 2 TSP, 4 PM_{10}, and 1 lead site), on an every sixth day sample schedule, and the resulting measurements are used as precision checks. A sampler is selected as the primary sampler to represent the "actual values" and a collocated sampler provides the "indicated values."

The atmospheric concentration ($\mu g/m^3$) values determined in this precision test program are submitted to the EPA Aerometric Information Retrieval System (AIRS) database within 90 days of the end of each calendar quarter. The results of accuracy audits are also submitted to AIRS at the end of each calendar quarter. As in the precision test program, "actual" and "indicated" values, in this case sampler flow rates (m^3/minute), are reported. The precision and accuracy data submitted to AIRS are used to calculate precision probability limits, and accuracy probability limits.

The 2001 precision and accuracy probability limits for TSP and PM_{10} are presented in Table 15. Precision confidence limits for $PM_{2.5}$ are summarized in Table 16. Note the series of calculations prescribed by the *EPA in CFR Part 58 Appendix A revision 1997* for $PM_{2.5}$ confidence limits is a different set of calculations than those used to establish probability limits for automated and other particulate methods. Trends in APCD precision probability limits for PM_{10} and TSP pollutants over the past 11 years are presented graphically in Figures 7 and 8, and the past three years of $PM_{2.5}$ data in Figure 9. For PM_{10} and TSP the upper and lower 95% probability limits indicate the range of percent difference from the "actual value" that would include 95% of the "indicated values". About 5% of the results of an individual precision or accuracy test would exceed these limits. Ideally, the probability ranges would be very small, and centered around zero. This indicates that the ambient data collected by the analyzer are both precise and accurate. For $PM_{2.5}$ the upper and lower 90% confidence interval limits represent the chi - squared distribution range where 90% of the calculated Coefficient of Variation values for individual precision tests would be found. 10% of the calculated Coefficient of Variation values would not fall within this range. Ideally this range would be very small and aggregated around a very small number.

A significant increase in the limits of PM_{10} and TSP can be seen graphically for 2001 data in Figures 7 and 8. This is not a reflection of our program. This apparent increase

in limits is due to a calculation change instituted in the 1997 CFR that we are now incorporating into our data assessment review.

No precision probability data was available for lead since none of the collocated values were at a high enough concentration to qualify as a valid precision pair. Lead accuracy is a two-fold determination of TSP sampler flow rate accuracy and lab analytical accuracy. The flow rates of TSP lead samplers are regularly audited as part of the particulate network operations. The laboratory QA/QC program is discussed in section 4 of this *2001 QA Report*.

Table 15 -2001 PM_{10} and TSP Precision and Accuracy Probability Limits (95% Confidence Interval)

		Precision Probability Limits			Accuracy Probability Limits		
	Quarter	**# Valid Pairs**	**Lower PL**	**Upper PL**	**# of Audits**	**Lower PL**	**Upper PL**
PM_{10}	1	33	-18%	26%	139	-6%	6%
	2	41	-15%	16%	102	-4%	4%
	3	29	-18%	19%	84	-5%	5%
	4	33	-11%	18%	123	-4%	5%
	Annual	**136**	**-16%**	**20%**	**448**	**-5%**	**5%**
TSP	1	25	-21%	30%	15	-9%	11%
	2	33	-12%	21%	18	-10%	3%
	3	21	-13%	22%	10	-9%	7%
	4	21	-25%	18%	10	-4%	4%
	Annual	**100**	**-18%**	**24%**	**53**	**-10%**	**7%**

Table 16 – $PM_{2.5}$ Precision Data Confidence Limits

Site/Station Name	Quarter	Precision(CV)	Lower CL	Upper CL
2001 Precision				
Adams City	1	8.2	6.1	16.8
Colorado Springs	1	8.5	6.5	15.7
Grand Junction	1	6.7	5.0	14.4
CDPHE	**1**	**7.9**	**6.6**	**11.3**
Adams City	2	3.1	1.9	19.8
Commerce City	2	6.7	5.1	12.4
Colorado Springs	2	10.6	6.9	46.2
Grand Junction	2	4.1	2.7	14.2
CDPHE	**2**	**6.8**	**5.5**	**10.3**
Commerce City	3	4.3	3.1	9.7
Colorado Springs	3	4.8	3.6	9.8
Grand Junction	3	3.7	2.5	10.9
CDPHE	**3**	**4.4**	**3.6**	**6.6**
Commerce City	4	5.7	4.4	10.6
CAMP	4	3.2	2.5	5.4
Grand Junction	4	7.9	5.9	16.3
CDPHE	**4**	**5.6**	**4.9**	**8.0**
Adams City	**Annual**	**7.4**	**5.7**	**13.7**
Commerce City	**Annual**	**5.8**	**5.0**	**8.5**
CAMP	**Annual**	**3.2**	**2.5**	**5.4**
Colorado Springs	**Annual**	**7.7**	**6.3**	**11.4**
Grand Junction	**Annual**	**6.4**	**5.4**	**9.7**
CDPHE	**Annual**	**6.3**	**5.7**	**7.1**

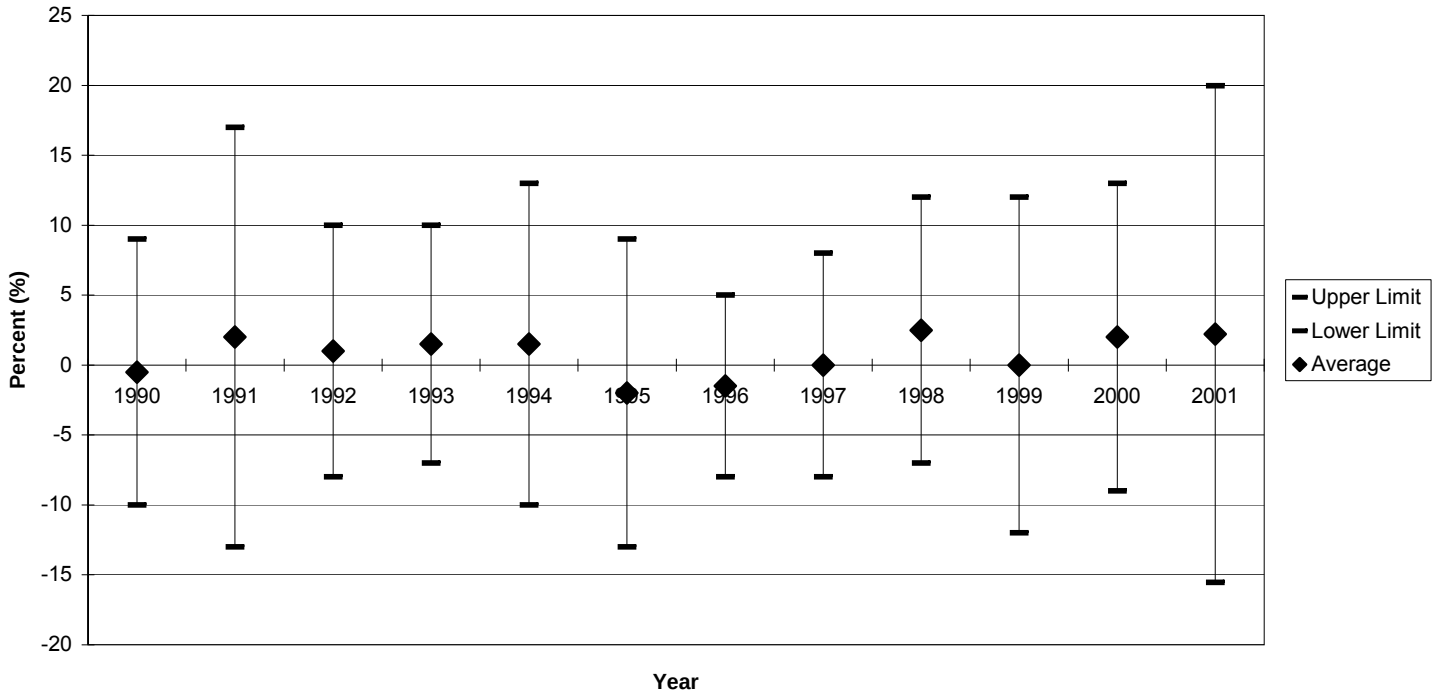


Figure 7 - APCD Annual Comparison of PM_{10} Precision Probability Limits (1990-2001) (95% Confidence Interval)

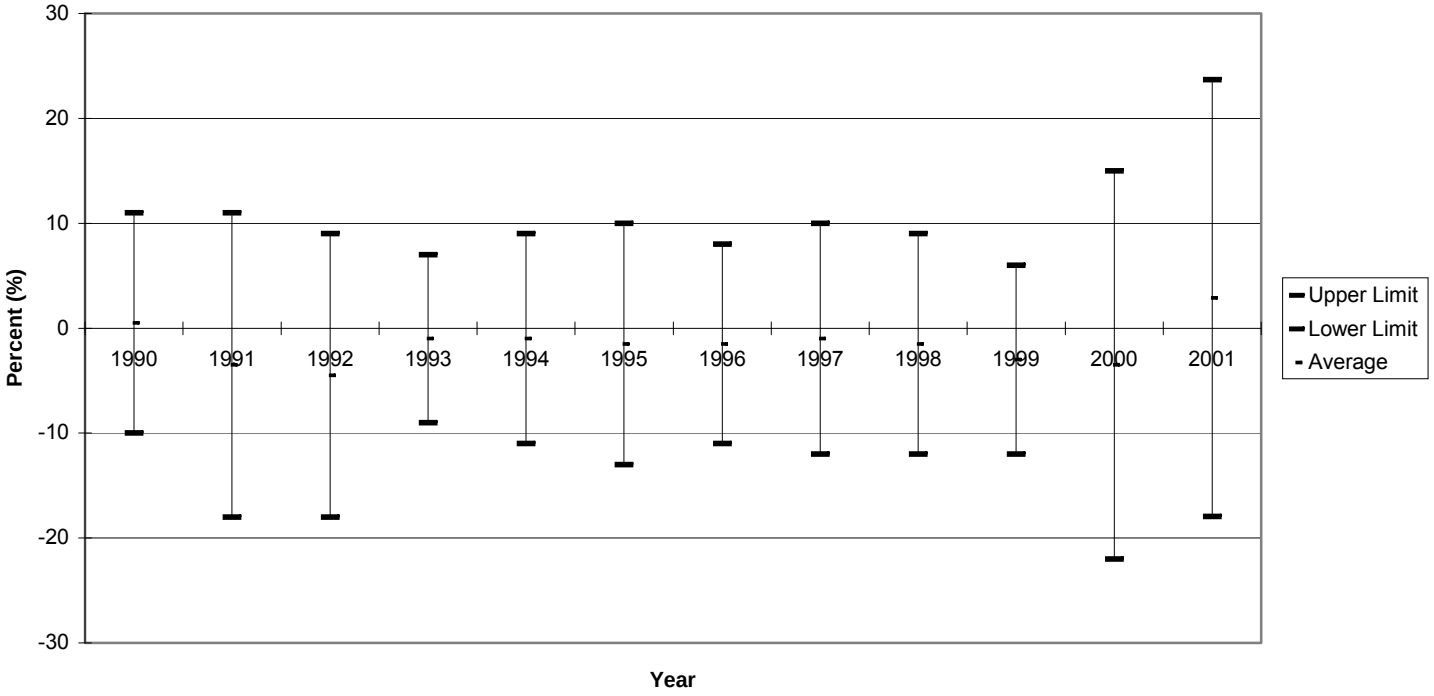


Figure 8 - APCD Annual Comparison of TSP Precision Probability Limits (1990-2001) (95% Confidence Interval)

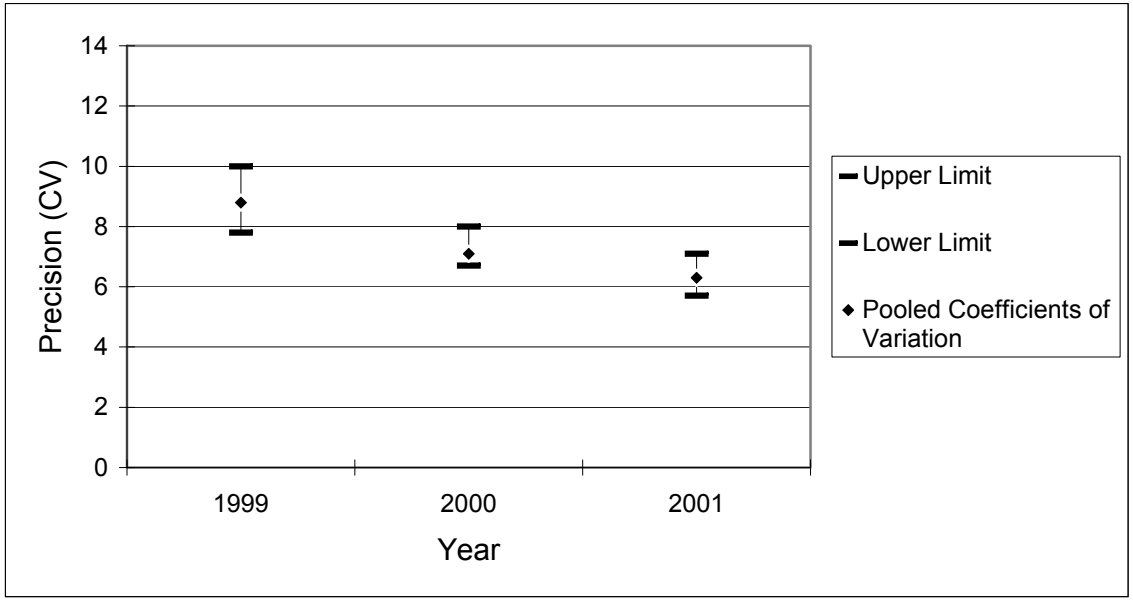


Figure 9 - APCD $PM_{2.5}$ Precision Confidence Intervals (1999-2001) (90% Confidence Interval)

3.5 Special Study Audits

The APCD often conducts short-term studies of particulate pollution in Colorado communities. Special studies have been conducted during the past two winter seasons at Denver National Jewish Hospital. These PM_{10} and $PM_{2.5}$ samplers were audited several times over the duration of the study. All audits conducted at this site passed EPA criteria. Some short-term studies were conducted for EPA in Grand Junction.

3.6 Additional Audits

APCD will occasionally perform audits on particulate monitoring networks operated by other public and private entities in Colorado. Although not part of the APCD's monitoring network, the APCD has an interest in the quality of these data. TSP audits were conducted at Cotter Corporation's Canon City site.

3.7 Certification of Audit Standards

The TSP and PM_{10} audits and calibrations performed by APCD Technical Services staff are done using one of nine fixed or variable resistance orifices. Until early 1992, the variable resistance orifices were certified at two-year intervals on a ROOTS meter having NIST (National Institute for Standards and Technology) traceability residing with EPA Region VIII offices in the Denver Federal Center. EPA Region VIII closed their Air Quality Assurance Laboratory in 1992. In early 1993, a ROOTS meter was donated to the APCD by a private monitoring company. This meter is certified against a NIST traceable standard at least every three years. APCD orifices are certified on an annual schedule using this meter. In addition to these certifications, the APCD performs frequent certifications for private groups doing particulate monitoring in Colorado.

The $PM_{2.5}$ audits and calibrations performed by APCD Technical Services staff are done with a flow transfer standard. APCD should have a NIST traceable flow verification system in house to certify these instruments by the early part of 2002. Currently we are sending these flow transfer standards to CEESI for NIST traceable verifications.

4.0 AIR POLLUTION LABORATORY QUALITY ASSURANCE

The Colorado Department of Public Health and Environment (CDPHE) Laboratory Division provides a number of analytical services to support the air monitoring work conducted by the Air Pollution Control Division. These support services include gravimetric analysis of air filters used for particulate monitoring, and analysis of selected filters for several elemental and ionic species. In 2001, analyses were conducted for lead (Pb), sulfate ($SO_4^=$), arsenic (As), and cadmium (Cd) in support of APCD monitoring programs.

The quality assurance program in the air pollution laboratory is comprised of a number of internal quality control checks and external audits. Laboratory instrumentation undergoes routine checks and calibrations in accordance with the *CDPHE Laboratory and Radiation Services (LARS) Quality Assurance Policy Manual and LARS Standard Operating Procedures (SOPs).*

Internal quality control checks are performed for the gravimetric determination of particulate as well as the analytical determinations of metals and sulfates. One important quality control check for gravimetric analysis of particulate filters involves having an independent analyst reweigh a randomly selected subset of 10% of each batch of filters. If the indicated gross or tare weight varies from the previous weight by more than 0.2 mg on any sample the entire batch of filters is re-weighed.

Analytical quality control checks for lead and sulfate include duplicate analyses, spiked samples, spiked blanks, and the analysis of filter strips provided by the EPA as part of the National Performance Audit Program (NPAP). These quality control checks are briefly summarized in Table 17.

Table 17 -Laboratory Quality Control Checks

Quality Control Check	Procedure
Duplicates	A duplicate filter strip is cut from the exposed filter and run through the analysis with the 'official' filter strips.
Spikes	A strip cut from an exposed filter is analyzed, then treated with a known amount of pollutant and reanalyzed.
NPAP Interlabs	Filter strips provided by EPA are analyzed as unknowns for a single point assessment per batch of filters processed.

4.1 Duplicate Samples

Laboratory precision estimates for lead and sulfate are derived from analysis of duplicate strips cut from the same TSP filter. Duplicate strips are cut from every tenth filter and dissolved into an aqueous solution. A percent difference is calculated as the absolute value of the difference (in micrograms per milliliter of filter extract) divided by the mean concentration of the two samples. This percent difference is calculated for samples that contain the analyte above the practical quantitation level (PQL). For lead, the PQL is 0.05 µg/ml of sample extract, and for sulfate the PQL is 0.5 µg/ml of sample extract. The results of the duplicate analyses performed during 2001 are presented in Tables 19 and 20. Analysis of these duplicate samples is an internal quality control check. The results of these duplicate analyses are reported annually to the APCD, but are not submitted to the EPA AIRS database.

4.2 Spiked Samples

The CDPHE laboratory routinely performs analysis of spiked filter samples and filter blanks. After the initial round of analysis, every tenth filter sample is spiked with a known amount of analyte and then reanalyzed. The results of these spiked sample analyses are recorded on control charts. Spiked sample analyte recoveries must fall within the laboratory control chart acceptance limits. The results of these internal quality control checks are reported to the APCD annually.

In addition to the spiked sample analyses conducted on exposed filters, the CDPHE laboratory also prepares laboratory fortified blanks (or spiked blanks) by spiking clean filter strips with known amounts of analyte. These audit sample strips are used to provide an assessment of analytical accuracy. The laboratory currently analyzes filter strips at two lead concentrations: 40 µg/strip and 160 µg/strip. The laboratory is required to audit at least three samples each calendar quarter at each of the two concentration ranges. A summary of lead sample and blank spike results can be found in Table 18.

The analytical accuracy results for lead are reported by the APCD to the AIRS-AQS air quality database. The analytical accuracy probability limits calculated from these lead analyses were presented in Table 15 of this report.

Although there is no federal requirement for analyzing sulfate strips, the laboratory also conducts monthly analyses of a 500 µg/strip sulfate fortified blank. The results of the lead and sulfate spiked sample analyses performed by the CDPHE Laboratory and Radiation Services Division during 1999 and 2000 are presented in Table 20. There is currently no provision to report the results of these sulfate analyses to the AIRS-AQS database.

4.3 EPA Interlaboratory Audits

The CDPHE Inorganic Laboratory participates in the EPA NPAP Interlaboratory audit program for lead. In 1996, the EPA discontinued NPAP interlaboratory audits for sulfate. Lead interlaboratory results are available for 3 quarters of 2001. The EPA requests that laboratories with results exceeding ±10% difference examine their measurement systems in order to reduce the size of the difference. Laboratories with results exceeding ±15% difference are asked to determine the cause and report any corrective actions to the NPAP Program Manager. Results for the lead interlaboratory audits are presented in Table 19. The results of all the lead NPAP audits are within the ±10% EPA criterion.

Table 18 - Laboratory Spike Recoveries for Lead

2001	% Sample Spike Recovery					% Blank Spike Recovery		Average % Recovery
January	91%	98%	90%			95%	102%	95%
February	95%	91%	99%	96%		95%	99%	96%
March	97%	96%	86%	93%		91%	94%	93%
April	102%	101%	103%			91%	96%	99%
May	92%	94%	107%	109%		98%	100%	100%
June	117%	98%				98%	100%	103%
July	121%	99%				97%	99%	104%
August	95%	101%				97%	99%	98%
September	107%	97%	112%			100%	100%	103%
October	93%	92%	96%			99%	99%	96%
November	94%	90%				99%	99%	96%
December	89%	104%	98%	95%		104%	103%	99%
Summary								**98%**

Table 19 - Laboratory Duplicate Analyses and NPAP Results for Lead

	% Absolute Difference on Duplicate Analyses									NPAP Results	
2001											
Q1	0.1%	0.2%	0.8%	8.1%	3.8%	12.9%				-10.8%	-6.7%
Q2	8.7%	6.5%	3.9%	2.1%						1.4%	0.6%
Q3	1.9%	6.0%								3.9%	6.9%
Q4	5.8%	0.3%	9.5%	1.7%	12.7%	9.1%	10.4%	9.9%	0.6%	-13.5%	-12.8%

Table 20 - Laboratory Quality Control for Sulfate

	Sample Spikes % Recovery	Blank Spikes % Recovery	Duplicates % Difference
2001 Results			
	99%	95%	0%
	105%	96%	0%
	98%	94%	1%
	100%	103%	1%
	99%	94%	1%
	97%	101%	1%
	104%	95%	0%
	90%	95%	0%
	103%	93%	2%
	97%		2%
	98%		1%
	94%		
2001 Averages	**99%**	**96%**	**1%**

5.0 METEOROLOGICAL MONITORING QUALITY ASSURANCE

The Air Pollution Control Division operates a meteorological monitoring network which is used to provide information to support air quality modeling and air pollution episode forecasting. These monitoring sites measure ambient temperature, wind speed, and wind direction at an elevation of 10 meters above the surrounding terrain. During 2001 there were 19 permanent meteorological monitoring sites in the APCD network.

The APCD CMDSS unit is responsible for meteorological sensor calibrations and the data acquisition and telemetry systems at these sites. The Quality Assurance Unit has been performing independent audits of the meteorological network since 1990. Performance audit equipment and personnel are different than those used during calibration. The results of these audits are reported to APCD management and staff, but there is currently no provision to submit these audit results to the AIRS-AQS database.

The audit procedures include an overall review of station operation, and an assessment of tower cross arm orientation using a surveyor's transit. The wind direction sensor is audited by rotating the sensor to a known orientation. Wind speed is audited by using a series of three synchronous motors to rotate the anemometer shaft. The temperature sensor is audited by comparing the current station temperature with that measured using a NIST-traceable thermometer. Data quality objectives for the APCD meteorological monitoring network include tower orientation within ±5° C wind direction measurements within ±5° checked at 9 positions, wind speed measurements within 5% of actual values checked at 5 speeds, and ambient temperature measurements within ±2° C.

The APCD goal is to audit each site annually. During 2001 thirteen accuracy audits were performed at the nineteen meteorological monitoring sites. All parameters for these audits met APCD Data Quality Objectives with the following exceptions:

Temperature at Cripple Creek (3.2° C out)

Channel 11 (upper) temperature at Auraria (2.5° C out)

Temperature at Carriage (2.2° C out)

6.0 CORRECTIVE ACTION SUMMARY

This section summarizes all problems encountered within the APCD air pollutant monitoring programs over 2001 as well as all corrective actions that were taken to remedy these situations.

Parameter	Date	Site / Station Name	Corrective Action	QC/QA Action Performed	% Full Scale Error	Date of Last Valid QC, flow or Calibration
O_3	1/8/2001	NREL	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	variable	1/8/2001
O_3	1/19/2001	Welby	Maintenance / Calibration	Assessment	variable	N/A
O_3	12/27/2001	Welby	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	-14.9%	12/21/2001
O_3	5/21/2001	Welch	Maintenance / Calibration	Assessment	11.9%	<15%
O_3	10/9/2001	Welch	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	-27.7%	10/7/2001
SO_2	4/20/2001	Welby	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	-11.0%	<15%
$PM_{2.5}$	2/2/2001	Commerce City	Immediate Calibration of Pressure/Recalculation of Data	Pressure	-12mm Hg	N/A
$PM_{2.5}$	2/13/2001	Durango	Seals Replaced	External Leak	Fail	N/A
$PM_{2.5}$	3/30/2001	Platteville	Immediate Calibration of Filter Temperature Probe	Temperature	3.0 deg C	N/A
$PM_{2.5}$	6/29/2001	Parker	Seals replaced	Int/Ext Leaks	Fail	N/A
NO_x	1/25/2001	CAMP	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	off scale	1/11/2001
NO_x	5/24/2001	CAMP	Calibration / Data deleted back to last valid QC check point	Assessment	19.9%	5/21/2001
NO_x	8/6/2001	CAMP	Immediate Calibration	Assessment	-11.2%	<15%
NO_x	9/4/2001	CAMP	Calibration	Accuracy Audit	11.0%	<15%
NO_x	3/19/2001	Rocky Flats SE	Calibration / Data deleted back to last valid QC check point	Accuracy Audit	-12.0%	<15%
NO_x	3/21/2001	Rocky Flats SE	Calibration / Data deleted back to last valid QC check point	Assessment	-17.5%	3/21/2001
NO_x	6/28/2001	Rocky Flats SE	Close out audit - instrument removed	Assessment	-13.4%	<15%

Parameter	Date	Site / Station Name	Corrective Action	QC/QA Action Performed	% Full Scale Error	Date of Last Valid QC, flow or Calibration
NO_x	3/15/2001	Rocky Flats West	Maintenance / Calibration / Data deleted back to last valid QC check point	Accuracy Audit	14.0%	3/4/2001
NO_x	3/16/2001	Rocky Flats West	Immediate Calibration	Assessment	-14.7%	3/4/2001
NO_x	3/22/2001	Rocky Flats West	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	-81.0%	3/4/2001
NO_x	4/19/2001	Rocky Flats West	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	13.7%	3/4/2001
NO_x	7/2/2001	Rocky Flats West	Close out audit - instrument removed / data deleted back to last valid QC	Assessment	-16.8%	6/30/2001
NO_x	3/8/2001	Welby	Calibration / Data deleted back to last valid QC check point	Assessment	-21.6%	3/7/2001
NO_x	6/22/2001	Welby	Immediate Calibration	Assessment	-10.7%	<15%
NO_x	9/14/2001	Welby	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	70.0%	9/10/2001
NO_x	11/9/2001	Welby	Maintenance / Calibration / Data deleted back to last valid QC check point	Assessment	21.8%	10/18/2001
PM_{10}	11/27/2001	Alamosa #3	Mass Flow Controller Adjusted	Design Flow	-17.0%	N/A
PM_{10}	11/27/2001	Alamosa #4	Mass Flow Controller Adjsuted	Design Flow	11.0%	N/A
PM_{10}	12/13/2001	Breckenridge	Mass Flow Controller Adjsuted	Design Flow	11.0%	N/A
PM_{10}	2/6/2001	CO Springs - RBD (collocated)	Motor Replacement / Claibration	Accuracy Audit	9.0%	<10%
PM_{10}	2/2/2001	Commerce City	Mass Flow Controller Adjsuted	Design Flow	9.0%	<10%
PM_{10}	3/12/2001	Criple Creek #1	Motor Replacement / Claibration	Accuracy Audit	9.0%	<10%
PM_{10}	6/19/2001	Criplpe Creek #1	Calibration	Accuracy Audit	-8.0%	<10%
PM_{10}	3/12/2001	Cripple Creek #4	Motor Replacement / Claibration	Accuracy Audit	8.0%	<10%
PM_{10}	8/30/2001	Denver Visitor Center	Mass Flow Controller Adjsuted	Design Flow	-10.0%	<10%
PM_{10}	12/5/2001	Denver Visitor Center	Calibration	Accuracy Audit	-9.0%	<10%
PM_{10}	11/28/2001	Durango Courthouse #1	Mass Flow Controller Adjsuted	Design Flow	-11.0%	N/A
PM_{10}	2/13/2001	Durango Courthouse #2	Incorrect Cassette Installation by Operator	Design Flow	-13.0%	N/A
PM_{10}	3/14/2001	Durango Courthouse #2	Mass Flow Controller Adjsuted	Design Flow	27.0%	N/A
PM_{10}	2/13/2001	Durango Platform #2	Mass Flow Controller Adjsuted	Design Flow	24.0%	N/A
PM_{10}	3/14/2001	Durango Platform #2	Mass Flow Controller Adjsuted	Design Flow	13.0%	N/A
PM_{10}	5/22/2001	Durango Platform #3	Mass Flow Controller Adjsuted	Design Flow	11.0%	N/A

Parameter	Date	Site / Station Name	Corrective Action	QC/QA Action Performed	% Full Scale Error	Date of Last Valid QC, flow or Calibration
PM_{10}	3/14/2001	Durango School #1	Mass Flow Controller Adjsuted	Design Flow	-11.0%	N/A
PM_{10}	5/22/2001	Durango School #1	Incorrect Cassette Installation by Operator	Design Flow	-29.0%	N/A
PM_{10}	3/14/2001	Durango School #2	Mass Flow Controller Adjsuted	Design Flow	-14.0%	N/A
PM_{10}	**8/7/2001**	**Ft. Collins - Courthouse**	**Maintenance / Calibration/ Data deleted back to last valid Calibration**	**Accuracy Audit**	**100.0%**	**3/30/2001**
PM_{10}	3/6/2001	Ft. Collins - School	Calibration	Accuracy Audit	-9.0%	<10%
PM_{10}	6/22/2001	Hygiene #2	Calibration	Accuracy Audit	-8.0%	<10%
PM_{10}	3/6/2001	Hygiene #3	Calibration	Accuracy Audit	8.0%	<10%
PM_{10}	6/18/2001	Lamar Municipal Blgd #1	Mass Flow Controller Adjsuted	Design Flow	14.0%	N/A
PM_{10}	10/15/2001	Lamar Municipal Blgd #1	Mass Flow Controller Adjsuted	Design Flow	-12.0%	N/A
PM_{10}	6/18/2001	Lamar Power Plant #3	Mass Flow Controller Adjsuted	Design Flow	11.0%	N/A
PM_{10}	5/21/2001	Pagosa #1	Mass Flow Controller Adjsuted	Design Flow	13.0%	N/A
PM_{10}	5/21/2001	Pagosa #3	Mass Flow Controller Adjsuted	Design Flow	12.0%	N/A
TSP	8/3/2001	CAMP	Outside Warning Ranges	Design Flow	-11.0%	N/A
TSP	10/1/2001	CAMP	Outside Warning Ranges	Design Flow	-11.0%	N/A
TSP	8/15/2001	Grand Junction Traffic (collocated)	Outside Warning Ranges	Design Flow	11.0%	N/A
TSP	11/12/2001	Grand Junction Traffic (primary)	Outside Warning Ranges	Design Flow	-14.0%	N/A
TSP	**4/18/2001**	**Commerce City**	**Motor Replaced/Calibrated/Data deleted back to last valid Calibration**	**Accuracy Audit**	**-13.0%**	**1/9/2001**

APPENDIX A - 2001 Site List

2001 Site List

SITE / STATION NAME	ADDRESS	COUNTY	AIRS CODE	O_3	CO	SO_2	NO_X	PM_{10}	TSP	Pb	$PM_{2.5}$	Met	Other
Adams City (primary)	4301 E. 72nd Ave.	Adams	08-001-0001					1/1	P	S	S		
Adams City (colocated)	4301 E. 72nd Ave.	Adams	08-001-0001								1/6		
Globeville Clinicare	5400 Washington St.	Adams	08-001-0005						1/3-1/6	P			
Commerce City (primary)	7101 Birch St.	Adams	08-001-0006					1/1	P	S	S		x
Commerce City (colocated)	7101 Birch St.	Adams	08-001-0006								1/6		
South Adams Pump Station	5580 Niagra St.	Adams	08-001-0007			S							
Brighton	22 S. 4th Ave.	Adams	08-001-2002					1/3-1/6					
Welby	78th Ave. & Steele St.	Adams	08-001-3001	S	S	N	N	1/6				x	x
Alamosa	369 Richardson Ave.	Alamosa	08-003-0001					1/1					
Highlands	8100 S. University	Arapahoe	08-005-0002	S								x	
Arapahoe Community College	6190 S. Santa Fe Dr.	Arapahoe	08-005-0005								S		
Pagosa Springs	Middle School	Archuleta	08-007-0001					1/1			P		
Pagosa Springs	486 San Juan Ave.	Archuleta	08-007-0002					1/1			P		
Longmont (particulate)	3rd Ave. & Kimbark St.	Boulder	08-013-0003					1/3			S		
Longmont (gaseous)	440 Main St.	Boulder	08-013-0009		S								
Boulder - YMCA	2150 28th St.	Boulder	08-013-0010		S								
Boulder - S. Boulder Creek	1405 1/2 S. Foothills Hwy.	Boulder	08-013-0011	S									
Boulder Chamber of Commerce	2440 Pearl St.	Boulder	08-013-0012					1/6			S		
Hygiene	7024 Colorado Hwy 66	Boulder	08-013-0013					1/1					
Delta	560 Dodge St.	Delta	08-029-0004					1/6					
Paonia	Middle School	Delta	08-029-0005					1/6					
Hotchkiss	222 W. Bridge St.	Delta	08-029-0006					1/6					
Denver - CAMP (primary)	2105 Broadway	Denver	08-031-0002		S	N	N	1/6	P	N	S1/1	x	x
Denver - CAMP (collocated)	2105 Broadway	Denver	08-031-0002					1/6			1/6		
Denver - NJH	14th Ave. & Albion St.	Denver	08-031-0013		S								
Denver - Carriage	23rd Ave. & Julian St.	Denver	08-031-0014	S	S							x	
Denver Gates (primary)	1050 S. Broadway	Denver	08-031-0015					1/6	P	N			x
Denver Gates (collocated)	1050 S. Broadway	Denver	08-031-0015					1/6	P	N			
Denver Visitor Center	225 W Colfax Ave.	Denver	08-031-0017					1/1					
Denver Firehouse #6	1300 Blake St.	Denver	08-031-0019		S								
Auraria Met	Auraria Campus Parking Lot	Denver	08-031-0021									x	
Denver - LARS	8100 Lorwy Blvd.	Denver	08-031-0022					1/3					
Castle Rock	310 3rd St.	Douglas	08-035-0001					1/6					

SITE / STATION NAME	ADDRESS	COUNTY	AIRS CODE	O_3	CO	SO_2	NO_X	PM_{10}	TSP	Pb	$PM_{2.5}$	Met	Other
Chatfield Reservoir	Roxborough Park Rd.	Douglas	08-035-0002	S									
Parker	Library	Douglas	08-035-0003								P		
Vail - WSD	846 Forest Rd.	Eagle	08-037-0007					1/6					
Elbert	Ben Kelly Rd. & Colo 5 & 98	Elbert	08-039-0001								S		
Colorado Springs - GLEN	I-25 & Uintah Ave.	El Paso	08-041-0006		S								
Colorado Springs - Meadowlands	3730 Meadowlands Blvd.	El Paso	08-041-0008					1/3			S		
Colorado Springs-RBD (primary)	101 Costillia	El Paso	08-041-0011					1/6	P	S	S		
Colorado Springs-RBD(collocated)	101 Costillia	El Paso	08-041-0011					1/6			1/6		
C.S. - US Air Force Academy	Road 640, USAF Academy	El Paso	08-041-0013	N									
Colorado Springs - Highway 24	69 W. U.S. Hwy 24	El Paso	08-041-0015		S								
Canon City	7th Ave. & Macon St.	Freemont	08-043-0001					1/6					
Parachute	100 E. 2nd Ave.	Garfield	08-045-0005					1/3					
Rifle	200 W. 3rd St.	Garfield	08-045-0006					1/6					
Glenwood Springs	806 Cooper Ave	Garfield	08-045-1002					1/6					
Crested Butte	Colo. Hwy 135 & Whiterock	Gunnison	08-051-0004					1/3					
Mt. Crested Butte	Town Center	Gunnison	08-051-0005					1/1			P		
Gunnison	221 N. Wisconsin	Gunnison	08-051-0006					1/3					
Arvada	57th Ave & Garrison St.	Jefferson	08-059-0002	N	S							x	
Welch	12400 W. U.S. Hwy 285	Jefferson	08-059-0005	S								x	
Rocky Flats X-1 (N) (primary)	16600 Colo 128	Jefferson	08-059-0006	P				1/6	P			x	
Rocky Flats X-1 (N) (collocated)	16600 Colo 128	Jefferson	08-059-0006						P				
Rocky Flats X-2 (NE) (primary)	11501 Indiana St.	Jefferson	08-059-0007					1/6	P			x	
Rocky Flats X-2 (NE) (collocated)	11501 Indiana St.	Jefferson	08-059-0007					1/6					
Rocky Flats X-3 (SE)	9901 Indiana St.	Jefferson	08-059-0008				P	1/6	P			x	
Rocky Flats X-4 (S)	18000 W. Hwy 72	Jefferson	08-059-0009					1/6	P			x	
Rocky Flats X-5 (W)	11190 N Hwy 93	Jefferson	08-059-0010				P	1/6	P			x	
NREL	20th Ave. & Quaker St.	Jefferson	08-059-0011	S									
Leadville	510 Harrison St.	Lake	08-065-0001						P	S			
Durango - Platform	277 3rd Ave.	La Platta	08-067-0007					1/1					
Durango - Park School	623 E. 5th Ave.	La Platta	08-067-0008					1/2			P		x
Durango - Courthouse	1060 E. 2nd Ave.	La Platta	08-067-1001					1/2					
Ft Collins - Courthouse	200 W. Oak St.	Larimer	08-069-0001					1/3					
Ft. Collins - CSU	251 Edison Dr.	Larimer	08-069-0009					1/3			S		
Ft. Collins (gaseous)	708 S. Mason St.	Larimer	08-069-1004	S	S							x	

SITE / STATION NAME	ADDRESS	COUNTY	AIRS CODE	O_3	CO	SO_2	NO_X	PM_{10}	TSP	Pb	$PM_{2.5}$	Met	Other
Grand Junct - Health Dpt.(primary)	515 Paterson Rd.	Mesa	08-077-0003					1/6	P		S		
Grand Junct - Health Dpt.(colloc)	515 Paterson Rd.	Mesa	08-077-0003								1/6		
Grand Junction - Stocker	12th St. & North Ave.	Mesa	08-077-0014		S			1/6				x	x
Grand Junction - Traffic	924 4th Ave.	Mesa	08-077-0016						P				
Montrose	125 S. Townsand Ave.	Montrose	08-085-0003					1/6					
Olathe	327 4th St.	Montrose	08-085-0004					1/3					
Aspen	420 Main St.	Pitkin	08-097-0004					1/3					x
Lamar Power Plant	100 2nd Ave.	Prowers	08-099-0001					1/1					
Lamar Municipal Bldg	104 E. Parmenter St.	Prowers	08-099-0002					1/1				x	
Pueblo Public Works	211 D St.	Pueblo	08-101-0012					1/3			S		
Steamboat Springs	136 6th St.	Routt	08-107-0003					1/1			P		
Steamboat Springs Met	137 10th St.	Routt	08-107-0008									x	
Telluride	333 W. Colorado Ave.	San Miguel	08-113-0004					1/3			P		x
Telluride Met	Coonskin Parking Lot	San Miguel	08-113-0005									x	
Breckenridge	County Justice Cntr	Summit	08-117-0002					1/3-1/1					
Silverthorne	151 4th St.	Summit	08-117-0003					1/6					
Silverthorne Rec Center	430 Rainbow Dr.	Summit	08-117-0004					1/6					
Cripple Creek	Bennet Ave. & 2nd St.	Teller	08-119-0001					1/1					
Cripple Creek Met	S. 2nd St. & Warren Ave.	Teller	08-119-0002									x	
Greeley (particulate)	1516 Hospital Rd.	Weld	08-123-0006					1/3			S		
Greely (gaseous)	811 15th St.	Weld	08-123-0007	S	S								
Platteville	Valley Middle School	Weld	08-123-0008								S		

NOTES:

S = SLAMS site

N = NAMS site

P = Special Purpose Monitoring site

1/1, 1/2, 1/3, 1/6 refers to sampling frequency

All TSP Sites are 1/6 with the exception of Globeville

All $PM_{2.5}$ SPM sites are 1/6 and all $PM_{2.5}$ SLAMS sites are 1/3 with the exception of CAMP

OTHER samplers include TEOMs, Beta Gauges, and Speciation Samplers

For more detailed information about specific monitoring sites, please refer to the APCD ***Annual Network Review***.


STATE · OF · COLORADO
NIL SINE NUMINE
1876
Colorado Department
of Public Health
and Environment