Technical Support Document
For the March 31, 1999
High Wind Event

Colorado Department
of Public Health
and Environment

Prepared by the Technical Services Program
Air Pollution Control Division
September 28, 1999

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Sheila Burns, Program Manager
Technical Services Program
Air Pollution Control Division

1.0 Introduction

PM_{10} Standards

In July 1987, EPA promulgated National Ambient Air Quality Standards for Particulates with an aerodynamic diameter of 10 microns or less (PM_{10}). This is a size that can be inhaled into the alveolar regions of the lungs. The standard has two forms, a 24-hour standard of 150 ug/m^3 and an annual arithmetic mean standard of 50 ug/m^3. The 24-hour standard is attained when the expected number of exceedances for each calendar year, averaged over three years, is less than or equal to one. The estimated number of exceedances is computed quarterly using available data and adjusting for missing sample days. The annual arithmetic mean standard is attained when the annual mean, averaged over three years is less than or equal to the level of the standard. Each annual mean is computed from the average of each quarter in the year, with adjustments made for missing sample days. In both cases, a data recovery of 75 percent is needed for each calendar quarter to be considered a valid quarter of data. This standard was modified in by EPA in July 1997, but was subsequently nullified back to this form in May 1999.

Elevated PM_{10} levels were monitored on March 31, 1999, throughout western Colorado. The elevated levels coincided with widespread high winds and gusty conditions.

EPA's Natural Events Policy enables states to demonstrate that PM_{10} exceedances were caused by natural events (volcanic and seismic activities, wildland fires, or high winds) and therefore are not to be taken into account in determining compliance with National Ambient Air Quality Standards (NAAQS). The Natural Events Policy requires that sufficient documentation be submitted to EPA to demonstrate:

1. That an event occurred that meets the definition of a natural event. This can include monitored particulate data, videos and photographs of the event, eyewitness accounts, and news accounts.
2. That there is a cause and effect relationship between the event and the exceedance. This can include meteorological data, receptor analyses, dispersion modeling, etc.

In this report, the Air Pollution Control Division (APCD) provides documentation to support that PM_{10} exceedances monitored on March 31st were caused by a natural event.

2.0 Ambient Particulate Data

Elevated PM_{10} levels were monitored throughout western Colorado on March 31, 1999. The draft values reported during initial notification to the EPA are listed below, by site. In most cases, this value is also the highest PM_{10} reading ever recorded for the area.

Table 1

SITE	SITE NO.	PM_{10} CONCENTRATION ($\mu g/m^3$)
Alamosa	08-003-0001	263
Crested Butte	08-051-0004	161
Delta	08-029-0004	444
Durango Courthouse	08-067-0001	168
Durango Platform	08-067-0007	209
Durango School	08-067-0008	177
Glenwood Springs	08-045-0002	358
Hotchkiss	08-029-0006	470
Montrose	08-085-0003	491
Mt. Crested Butte	08-051-0005	155
Olathe	08-085-0004	496
Paonia	08-029-0005	467
Rifle	08-045-0006	205
Telluride	08-113-0004	224

Since initial reporting, these data have been validated. As part of the validation process, the value for Montrose was deleted in accordance with the State's Quality Assurance Project Plan (QAPP)[1]. This was due to a failed audit. In addition, one data anomaly was identified. The value for Pagosa Springs, a site clearly in the region impacted by the high wind event (see Figure 2a), was 17 $\mu g/m^3$. The sample from the previous day was 138 $\mu g/m^3$. The sample data sheets for Pagosa Springs have been examined and seem to be in order. However, judging

from the fact that the March 30 concentration was unusually high, (the highest level monitored since 1994) and the March 31 concentration was so low, especially in light of other concentrations in the region (see Figure 1) it is likely that an incorrect date was entered on the field data sheet.

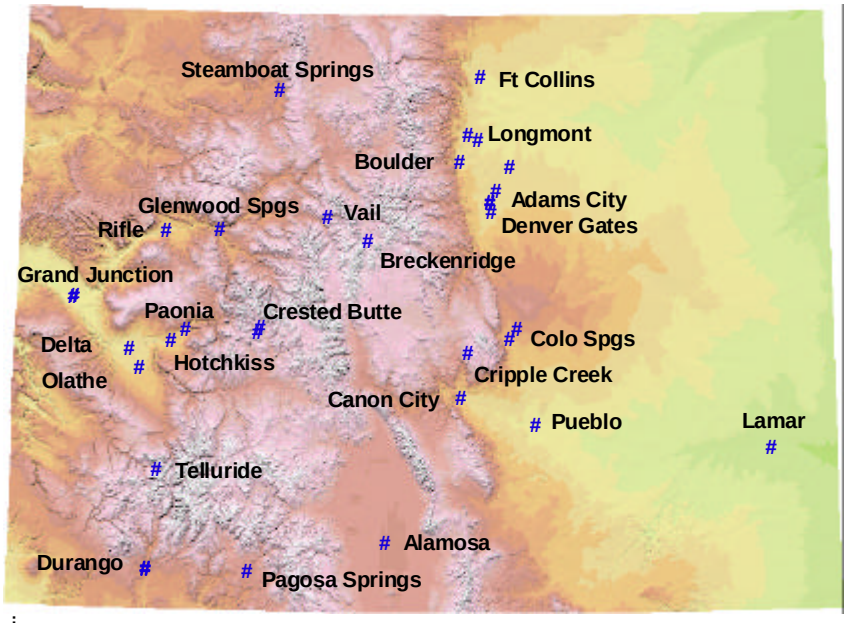
Monitored PM_{10} levels before and after the March 31st episode were low to moderate for all west/southwest sites, as summarized in Figure 2. Continuous PM_{10} data from those sites that monitor continuously show a similar pattern (see Figure 3, 4, 5). While Steamboat Springs did not exceed the PM_{10} standard on the 31st (with a value of 148 $\mu g/m^3$) it is included in this discussion for purposes of examining the geographic extent of the wind event.

While it is clear that the March 31st episode represents a very significant increase in PM_{10} levels relative to surrounding days, the relationship to average APCD wind speed data, where available, is less straight forward. As shown in 6, 7, and 8, PM_{10} levels generally were low with low to moderate hourly wind speeds. However, there are instances where PM_{10} levels remained low even with increased wind speeds. This may be due to local soil moisture or snow cover conditions. It is likely also indicative that hourly average wind speed data does not sufficiently characterize the wind conditions most likely to entrain and transport dust, such as gusts. A more detailed discussion of the meteorological conditions that occurred on March 31st appears in Section 3.0 of this report.

Only a minimal amount of PM10 data are available from surrounding states. In New Mexico, a PM10 level of 94 $\mu g/m^3$ was recorded in Farmington (35-045-0006) on March 31. While not an exceedance, this is the highest level recorded at this site since it began operation in 1989, the next highest being 72 $\mu g/m^3$ in 1991. So far, the second maximum PM_{10} level for 1999 at this site on AIRS is 28 $\mu g/m^3$.

A second site in Questa, New Mexico (35-055-0004) appears to be east of the dust event area and recorded a PM_{10} level of 23 on March 31, which is still the maximum PM_{10} level for 1999 at this site on AIRS.

No monitoring in Arizona is close to Colorado. In Utah, there is a PM_{10} site in Moab (49-019-0006), but the site failed to sample March 31.



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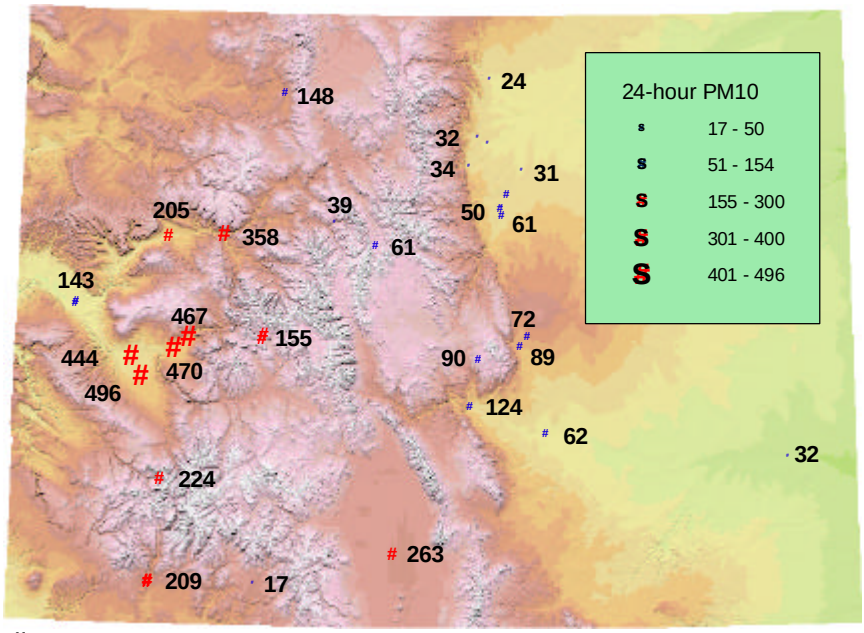


ii

Figure 1. Map of Colorado with (i) monitoring sites and (ii) 24-hour average PM10 concentrations in ug/m3 for select sites on March 31, 1999.

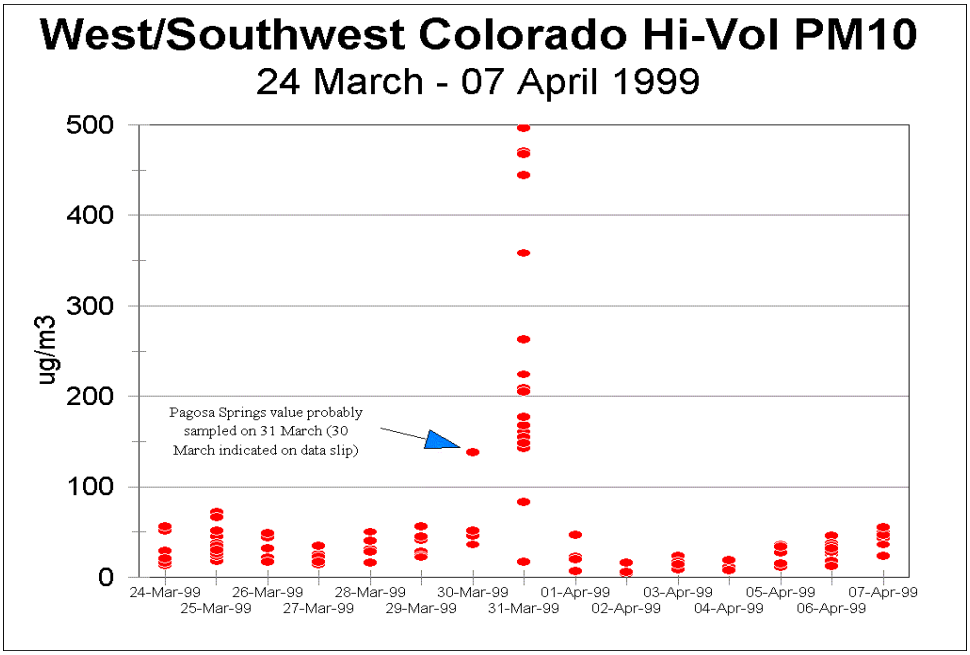


Figure 2

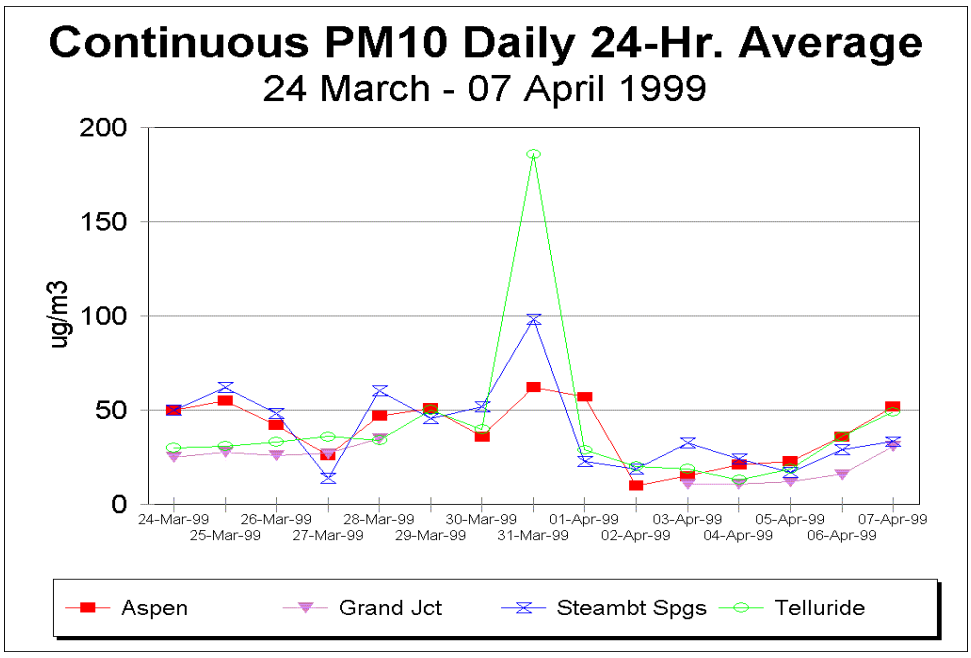


Figure 3

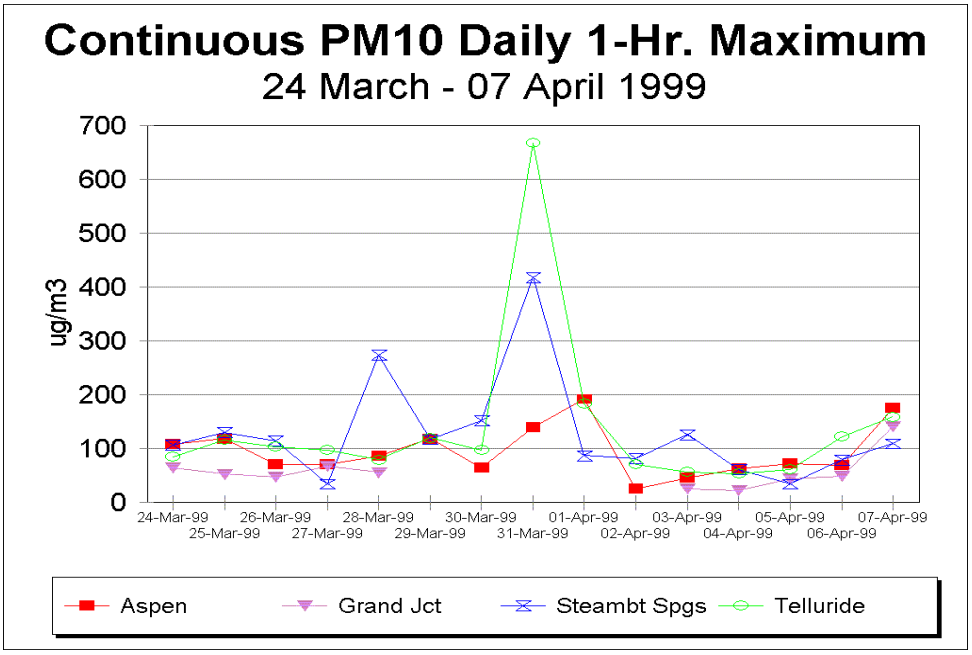


Figure 4

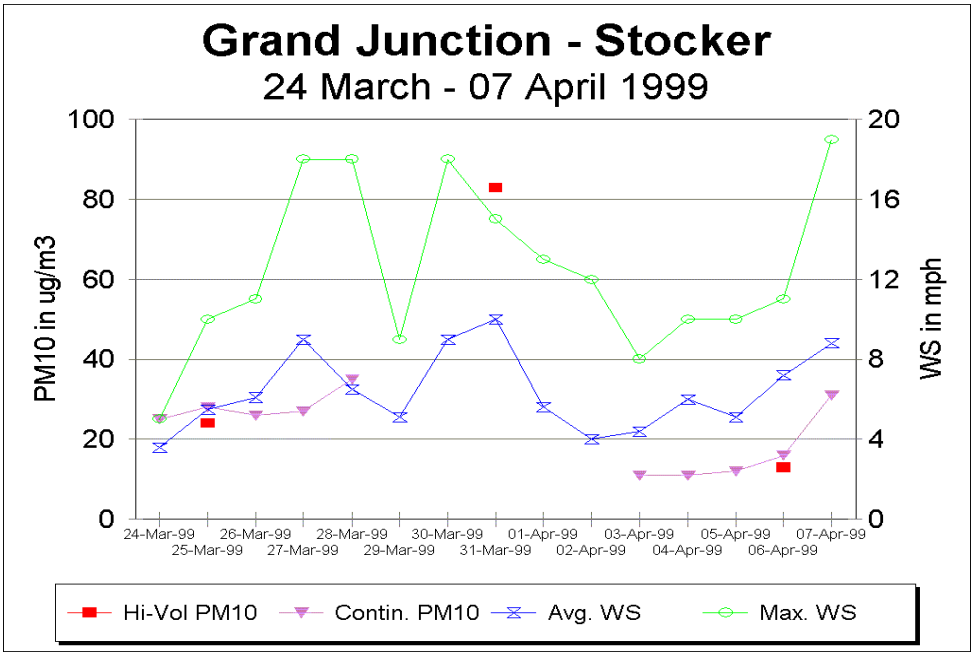


Figure 5

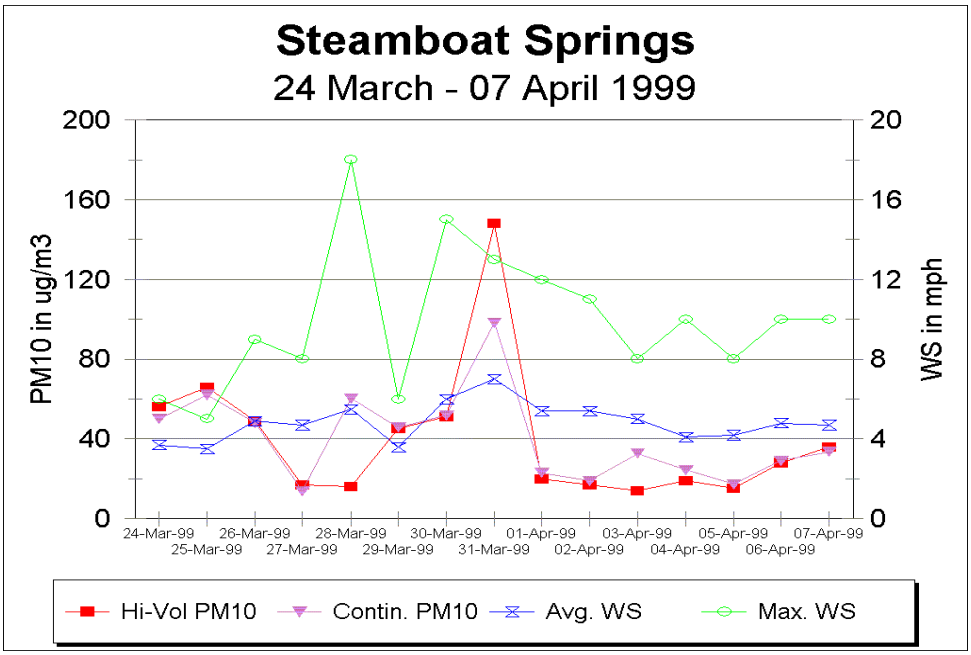


Figure 6

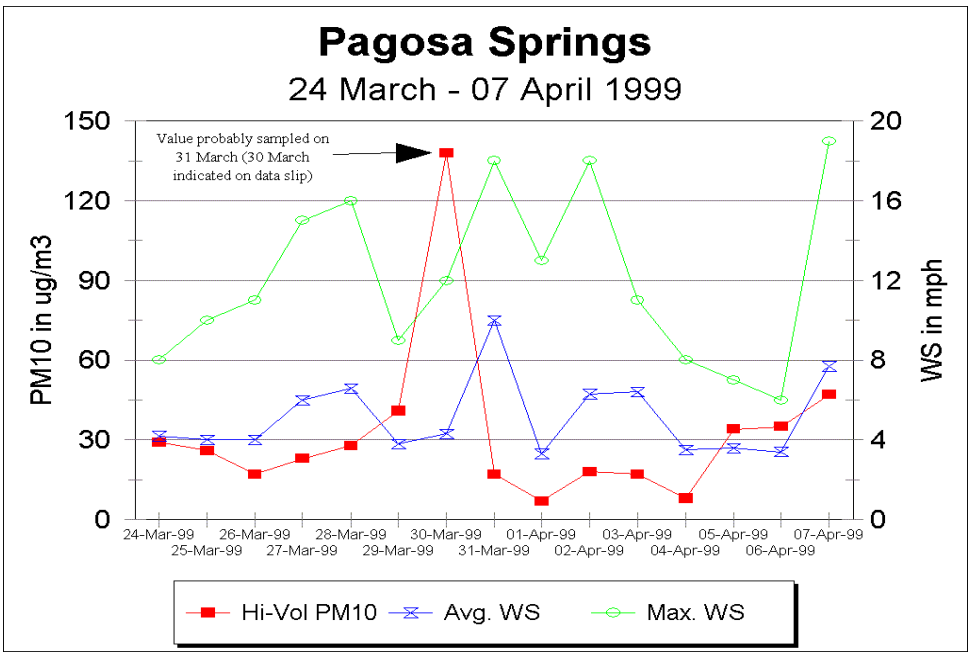


Figure 7

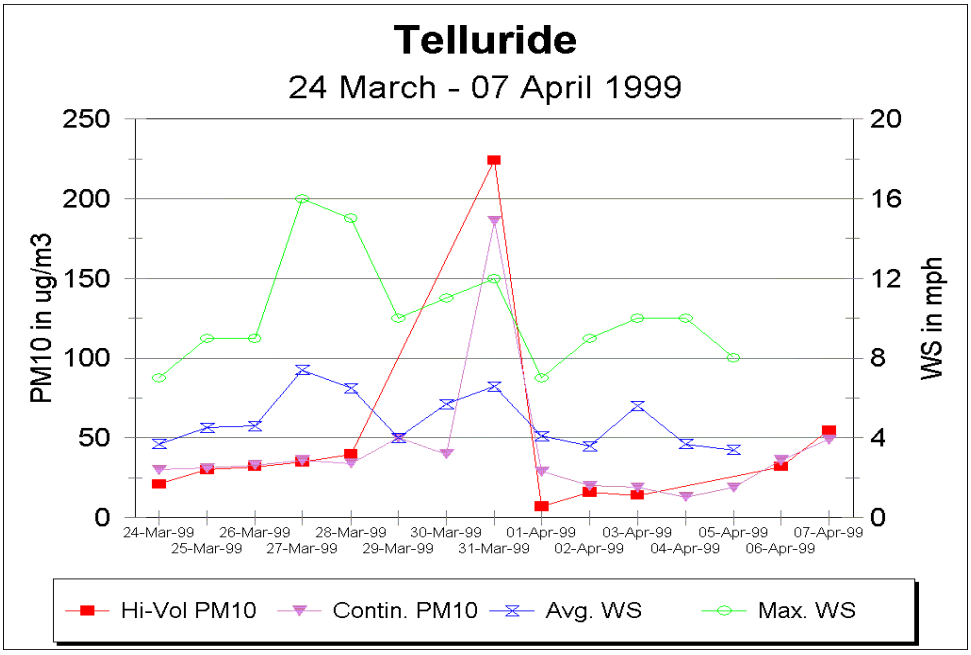

Telluride
24 March - 07 April 1999
PM10 in ug/m3
WS in mph
250
200
150
100
50
0
20
16
12
8
4
0
24-Mar-99
25-Mar-99
26-Mar-99
27-Mar-99
28-Mar-99
29-Mar-99
30-Mar-99
31-Mar-99
01-Apr-99
02-Apr-99
03-Apr-99
04-Apr-99
05-Apr-99
06-Apr-99
07-Apr-99
Hi-Vol PM10
Contin. PM10
Avg. WS
Max. WS

Figure 8

3.0 Meteorological Data

A deep surface low pressure system moved through Colorado on March 31, 1999. It is apparent from regional data and observations that gusty winds and dry surface soils resulted in widespread blowing dust in Colorado. A surface weather map in Figure 9 for 00Z April 1 (5 PM, March 31) shows a low pressure system with centers in western and northeastern Colorado. The central pressure of the western Colorado portion of the storm was about 990 mb. This is significant since storms of this strength were identified as a typical precondition for blowing dust in eastern Colorado when soils are dry (see reference for the *Natural Events Action Plan for High Wind Events* ***B*** *Lamar, Colorado* at the end of this document)[2].

Although there are no formal Air Pollution Control Division wind speed criteria for blowing dust events in western Colorado, wind gusts at Western Slope Bureau of Land Management Remote Automatic Weather Stations (BLM RAWS) sites exceeded the criteria developed for southeastern Colorado. The APCD reviewed meteorological data for about 9 BLM RAWS sites in western and southwestern Colorado, eastern Utah, and southeastern Arizona. All of these sites showed wind gusts in excess of 40 miles per hour (mph). This is the gust threshold for blowing dust that applies in *southeastern* Colorado when surface soils are dry. Table 2 below lists the number of hours with peak gusts of 40 mph or more and the range of gust speeds at each of the 9 RAWS sites considered - for March 31, 1999. Although hourly wind speeds were in most cases below the blowing dust thresholds derived for southeastern Colorado, the gusts are considered powerful enough and frequent enough to entrain large amounts of soil material.

Table 2 – Wind gust data for nine BLM RAWS sites for March 31, 1999.

RAWS Site	Number of Hours with Gusts of 40 mph or Higher	Range of Peak Gusts in mph
Big Indian Valley, Utah	9	40 to 56
Rifle, Colorado	7	41 to 50
Demaree, Colorado	2	41
Little Delores, Colorado	1	42
Nucla, Colorado	11	42 to 52
Kane Gulch, Utah	3	41 to 43
Greer, Arizona	20	40 to 60
Pine Ridge, Colorado	9	41 to 54
Hunter Creek, Colorado	2	45 to 46
Salter, Colorado	13	40 to 45

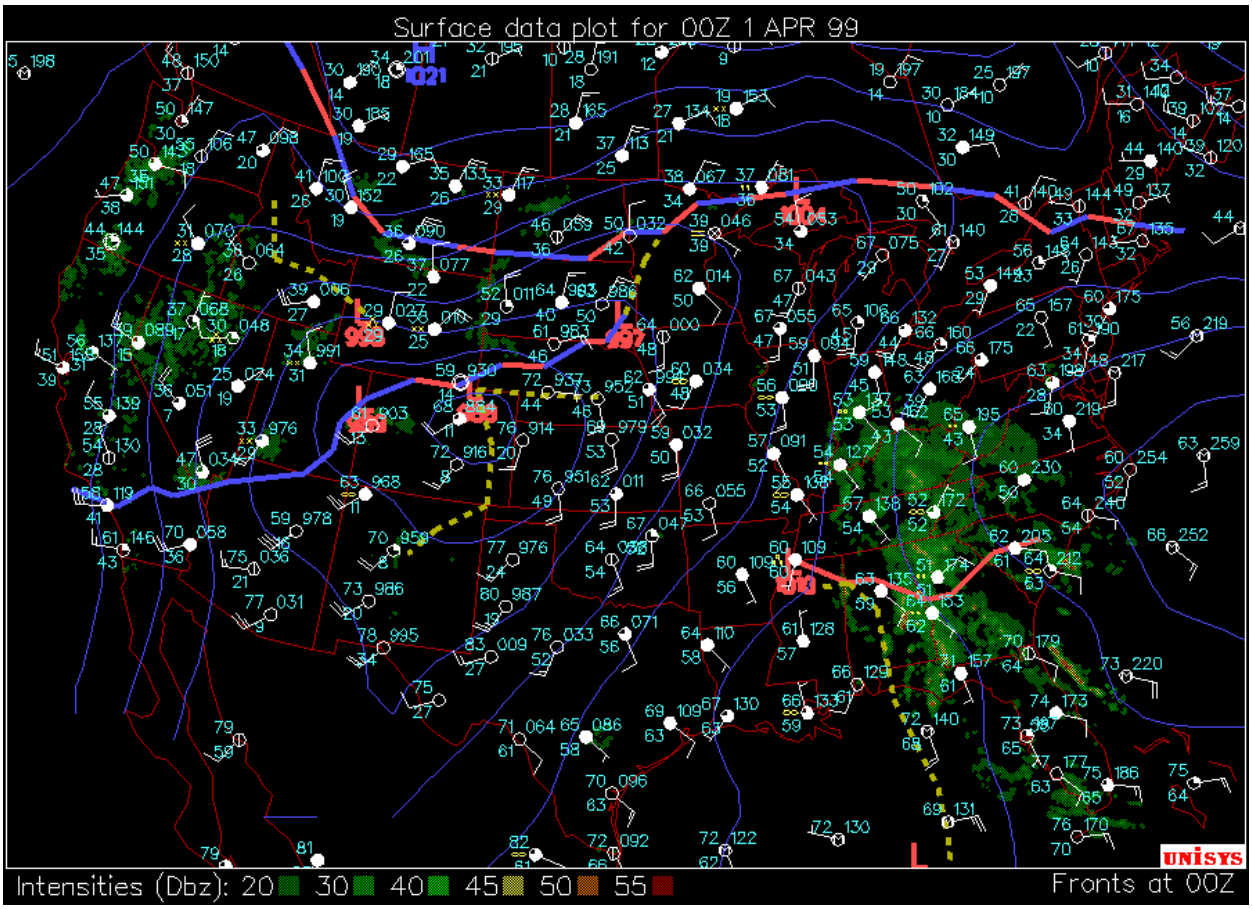


Figure 9. Surface weather map for 00Z or 5 PM MST, March 31, 1999.

A map of the seven western Colorado RAWS sites from Table 2 is shown in Figure 10. These stations are scattered within the region with the highest measured PM_{10} concentrations on March 31, 1999. The Big Indian Valley RAWS site in Utah is located just south of the La Sal mountains near Moab and the Kane Gulch RAWS station is located near Blanding, Utah. The Greer, Arizona, RAWS station is along the Mogollon Rim in east central Arizona near the New Mexico border.

Table 3 lists Pennsylvania State University (PSU) cooperative observer surface observations in universal time for Colorado on March 31, 1999. These were obtained from a PSU Web site (**http://www.ems.psu.edu/wx/usstats/uswxstats.html**). These observations show winds gusting from 40 to 60 mph in Colorado Springs, several hours of haze with visibility as low as 6 miles in Steamboat Springs, haze in Colorado Springs at 00:16Z or 5:16 PM MST, and a dust storm in Grand Junction at 01:28Z or 6:28 PM MST. The haze report at Colorado Springs at 5:26 PM also mentioned fog but the observer probably mistook blowing dust for fog in the early evening lighting. The dewpoints before and after this observation were entirely too low to allow fog to occur (8 to 9 degrees F with ambient temperatures of about 55 to 66 F).

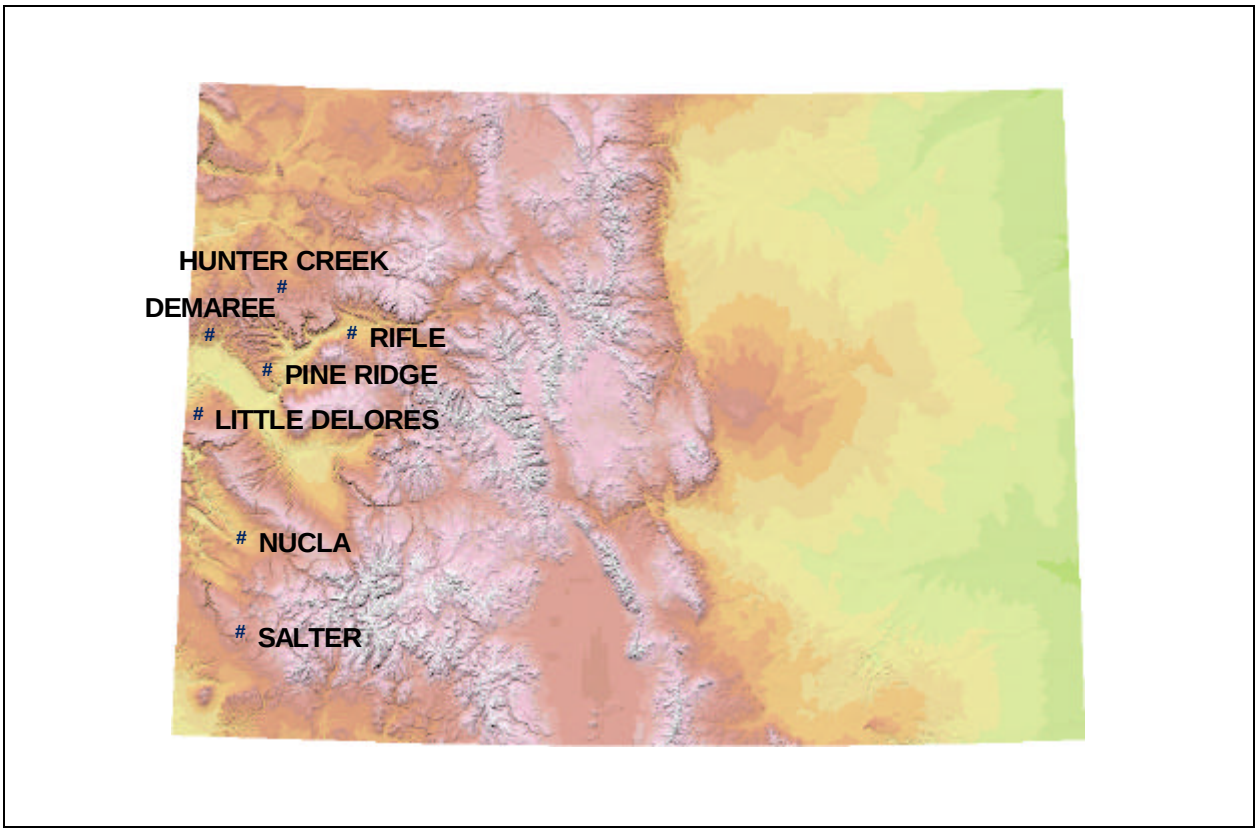


Figure 10. Locations of western Colorado RAWS stations cited in Table 2.

Table 3. Select Colorado PSU cooperative observer surface weather observations on March 31, 1999.

Time in MST	Monitoring Site	Temperature in Degree F	Dewpoint in Degree F	Wind Direction and Speed (mph)	Gust Speed (mph)	Mean Sea Level Pressure in mb	Weather	Comments
9:00 PM	Steamboat Springs	39		Southerly 11		999	Haze	
7:54 PM	Steamboat Springs	40		Southerly 12		999	Haze	
7:05 PM	Steamboat Springs	43		Southerly 6		998	Haze	Visibility 6 miles in smoke and haze
6:28 PM	Grand Junction	62	11	Southerly 20	30	994	***Blowing Dust***	Dust storm right now, hopefully some rain out of this
6:24 PM	Colorado Springs	55	8	Southerly 20	30	998		Cloud bank over mountains. Still windy. Low barometer. Weather change moving into area!
6:06 PM	Steamboat Springs	47		Southwesterly 4		997		Visibility 8 miles in smoke and haze
5:16 PM	Colorado Springs	63	8	Southwesterly 30	50	998	Fog Haze	Weather rolling into area from mountains. Mountains are just about hazed and fogged in right now[1]
3:52 PM	Colorado Springs	70	6	Southwesterly 20	30	998		Very windy with clouds moving over mountains into area!
3:35 PM	Aurora	68	10	Westerly 10	28	995		Peak wind 33 mph.
2:29 PM	Colorado Springs	73	5	Southwesterly 35	60	998		
1:49 PM	Steamboat Springs	52		Southerly 14		999		
1:48 PM	Colorado Springs	71	7	Southeasterly 35	50	998		
1:19 PM	Colorado Springs	71	4	Southwesterly 20	35	1000		
11:16 AM	Colorado Springs	66	3	Southerly 35	50	1002		
10:39 AM	Colorado Springs	64	2	Southwesterly 25	40	1001		
9:59 AM	Steamboat Springs	51		Southerly 12	18	1002		
9:27 AM	Colorado Springs	62	2	Northeasterly 12	20	1001		
6:28 AM	Grand Junction	53	11	Southerly 10	20	1002		

1 Amateur weather observer probably mistook blowing dust for fog in the early evening lighting. Temperatures in the 60's, a dewpoint of 8 degrees Fahrenheit , and winds gusting to 50 mph are not consistent with fog.

Table 4 presents maximum gusts and observed weather for Grand Junction and Alamosa on March 31, 1999. These data were obtained from the National Climatic Data Center Daily U.S. Surface Data product. The five-second gusts were well above the blowing dust thresholds identified for southeast Colorado. Both stations reported blowing dust on March 31. Neither station reported blowing dust on any other day in March of 1999.

Table 4 - Meteorological conditions on March 31, 1999, for select sites from the National Climatic Data Center Daily U.S. Surface Data product.

Station	**Highest 2-minute wind**	**Highest 5-second wind**	**Observed weather**
Alamosa	49 mph	60 mph	Blowing Dust
Grand Junction	39 mph	46 mph	Dust and Blowing Dust

Preliminary climate data for March and the winter of 1998/1999 show that the entire Southwest was experiencing drought or near-drought conditions. This was especially true for Colorado, Arizona, New Mexico, and Utah. Figure 11 shows Standardized Precipitation Index levels for the U.S. in March of 1999. The western third of Colorado was rated severely dry during March, while the surrounding Four Corners region was rated moderately to extremely dry. Figures 12 and 13 show total March precipitation and the percent of normal for the month, respectively. Much of Colorado received less than 0.50 inches of water during the month, with only 25 to 50% of the normal total for the month. Figure 14 presents the 3-month Standardized Precipitation Index for January through March 1999. Once again, moderately to extremely dry conditions prevailed throughout most of the Southwest region (NCDC climatologists have determined that Colorado, Utah, Arizona, and New Mexico can be considered a single climatically consistent region, which they call the Southwest). Figures 15 and 16 show the total January through March precipitation and the percent of normal for the three-month period, respectively. Much of Colorado received less than 1.0 to 2.0 inches of water and was at 25 to 50% of normal for the period.

Based on preliminary data, the NCDC has determined that the Southwest had the ***ninth*** driest March since 1895 and the ***third*** driest February-March since 1895 (this information was taken from an April 14, 1999, report at: http://www.ncdc.noaa.gov/ol/climate/research/1999/mar/us_regional.html). Colorado had the ***sixth*** driest March since 1895, and Utah had the ***seventh*** driest March since 1895. Colorado also had the ***sixth*** driest January through March period since 1895.

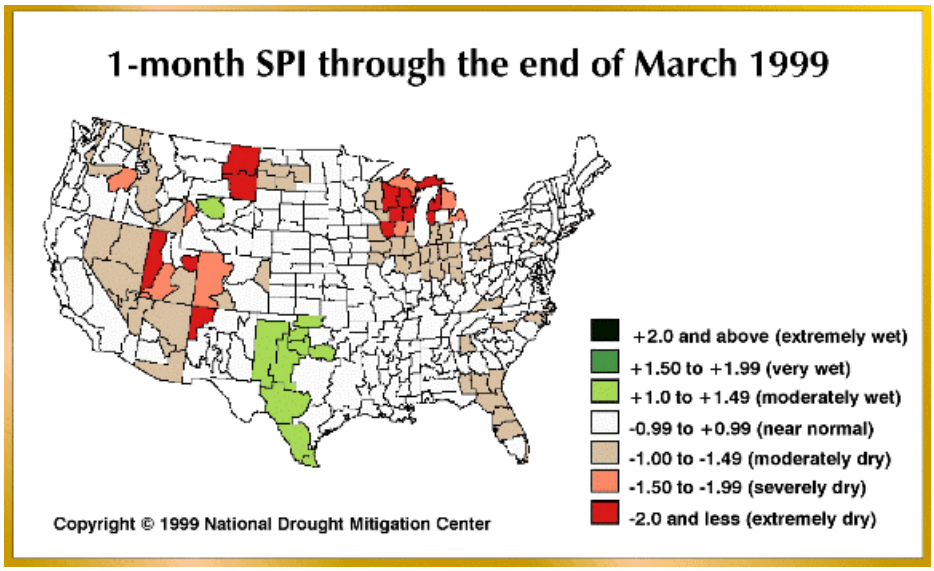


Figure 11. Standardized Precipitation Index for the U.S. for March 1999.

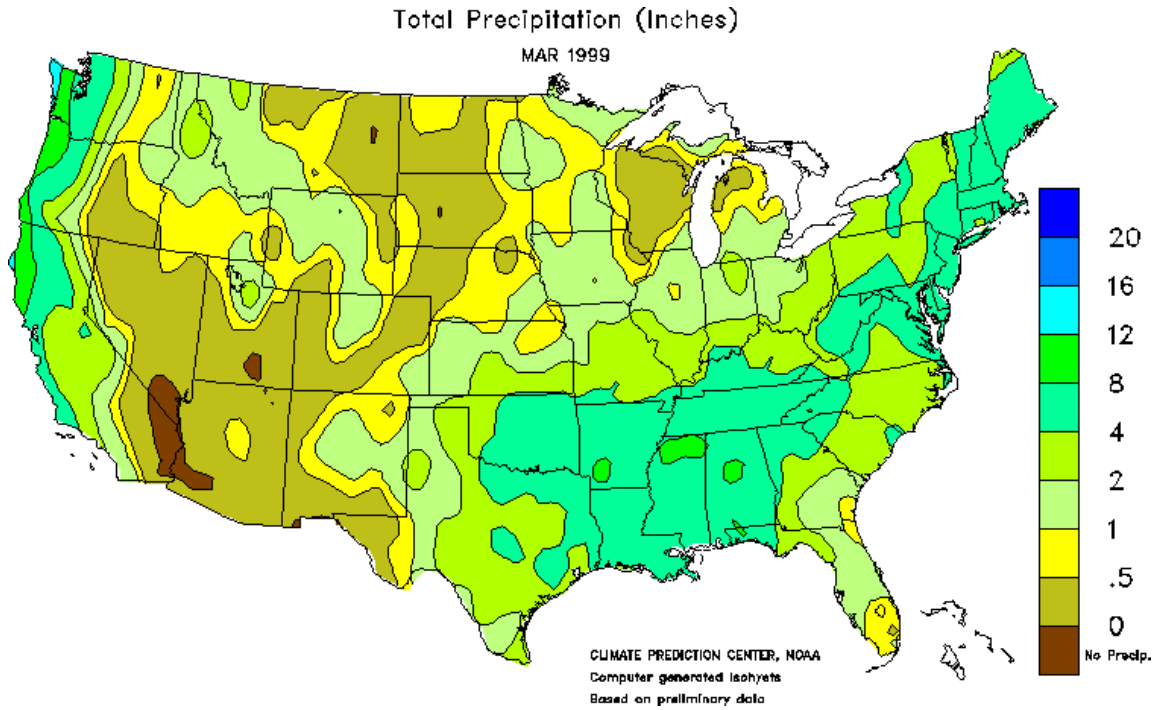


Figure 12. Total March precipitation for the U.S.

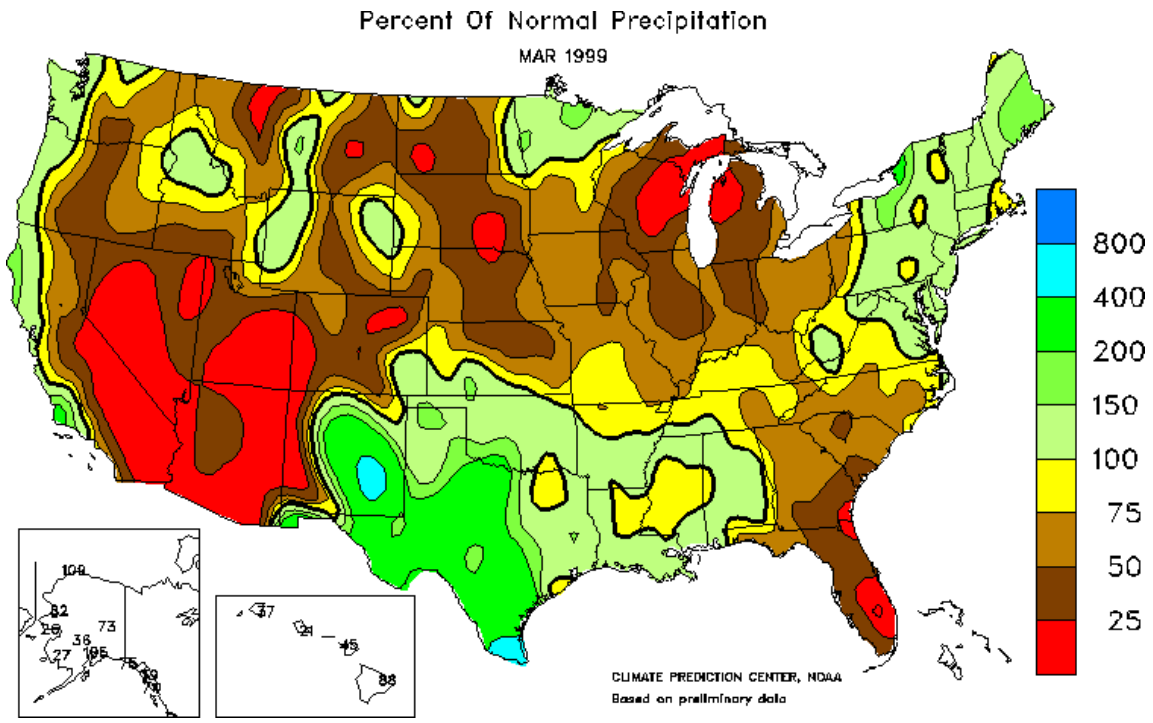


Figure 13. Percent of normal March precipitation for the U.S.

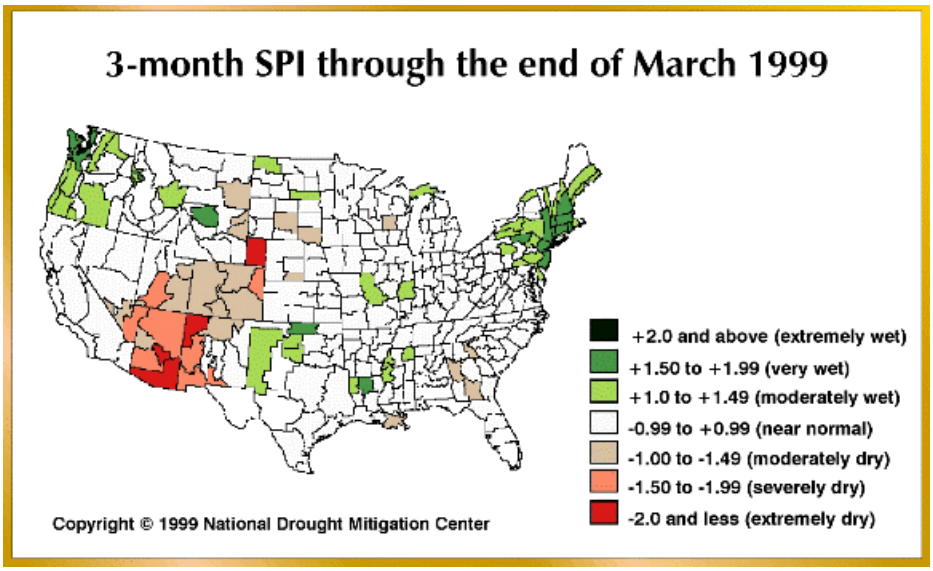


Figure 14. Standardized Precipitation Index for the U.S. for January through March, 1999.

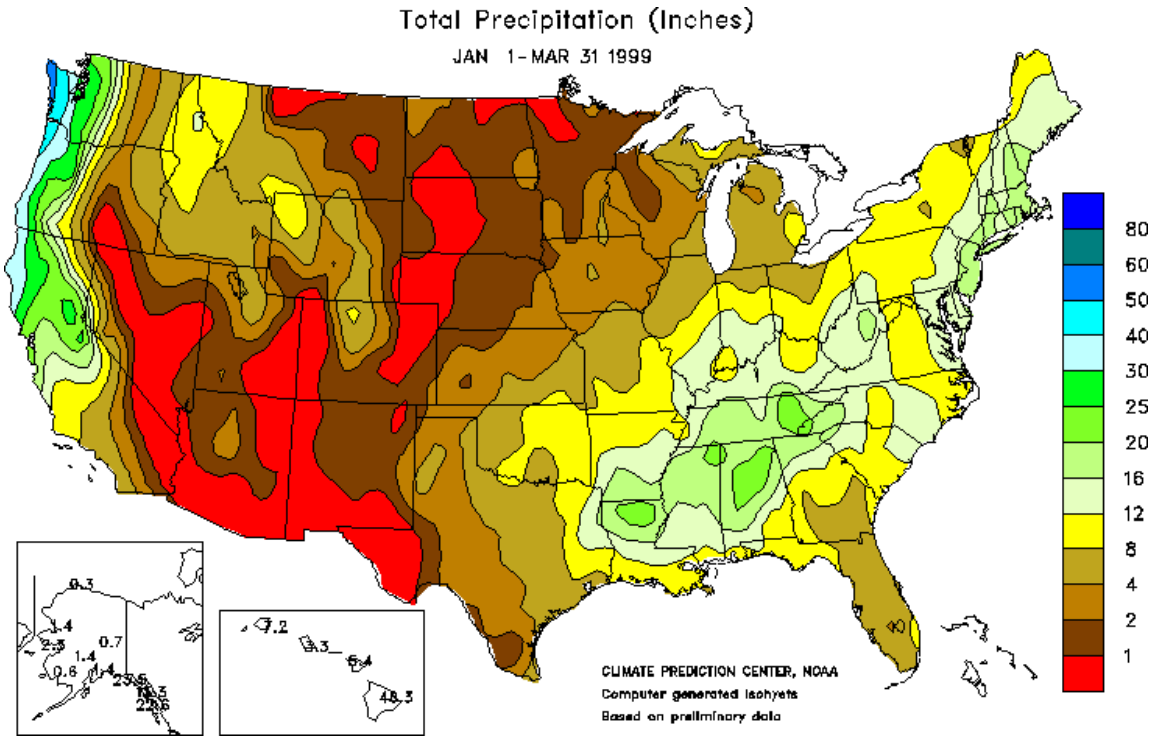


Figure 15. Total U.S. precipitation for January through March, 1999.

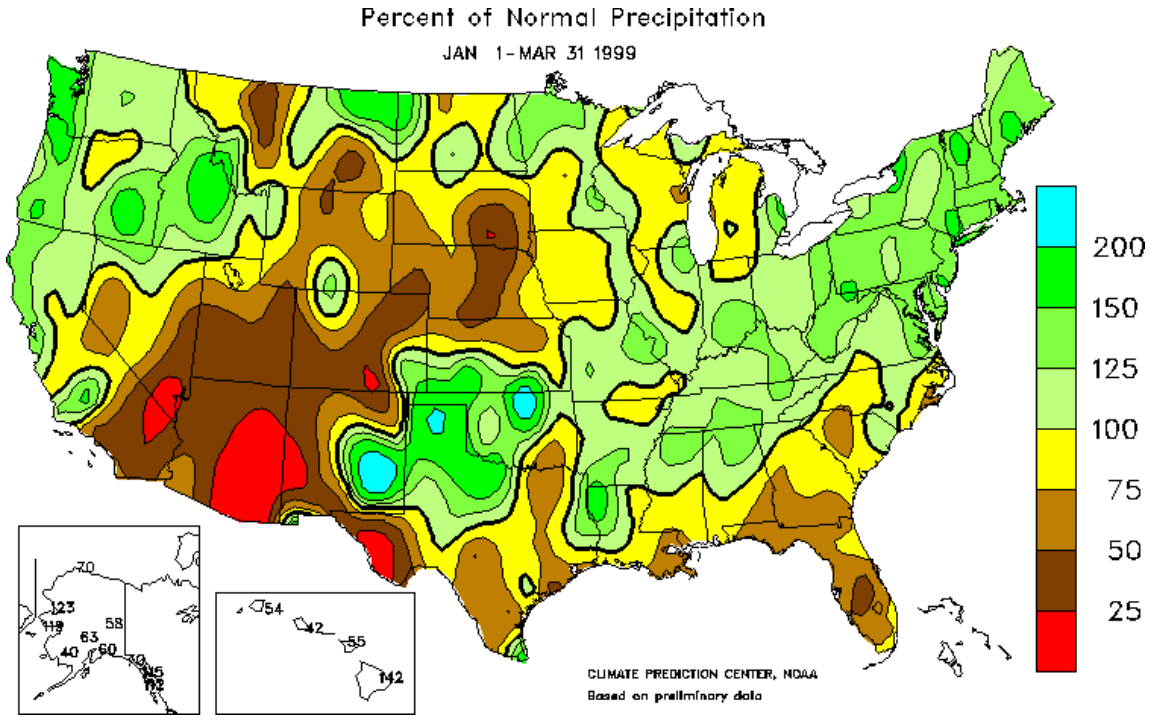


Figure 16. Percent of normal U.S. precipitation for January through March, 1999.

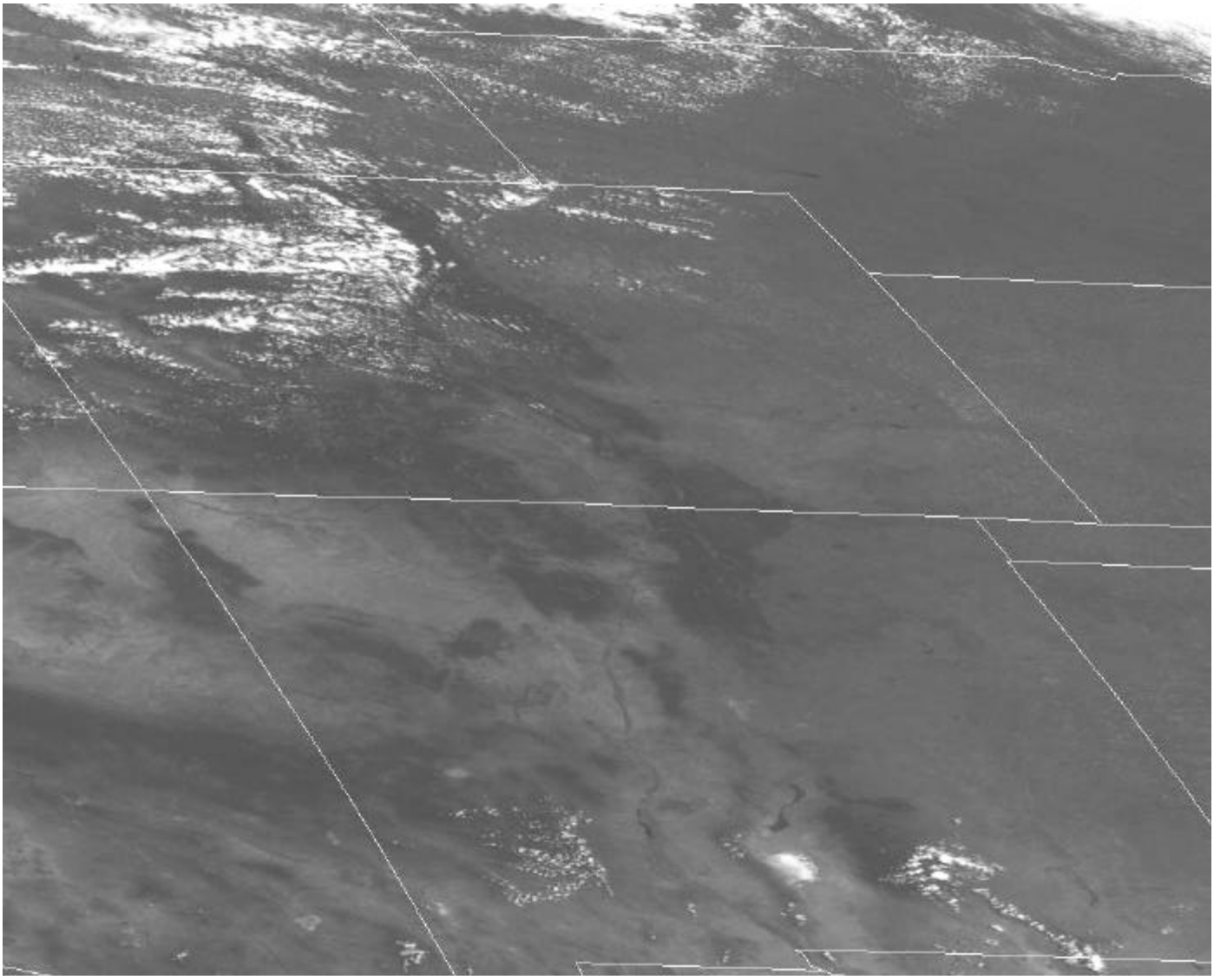


Figure 17. GOES 10 visible satellite image for 1800 Z (noon MDT) on August 12, 1999 – image contrast enhanced 5 st
web page).

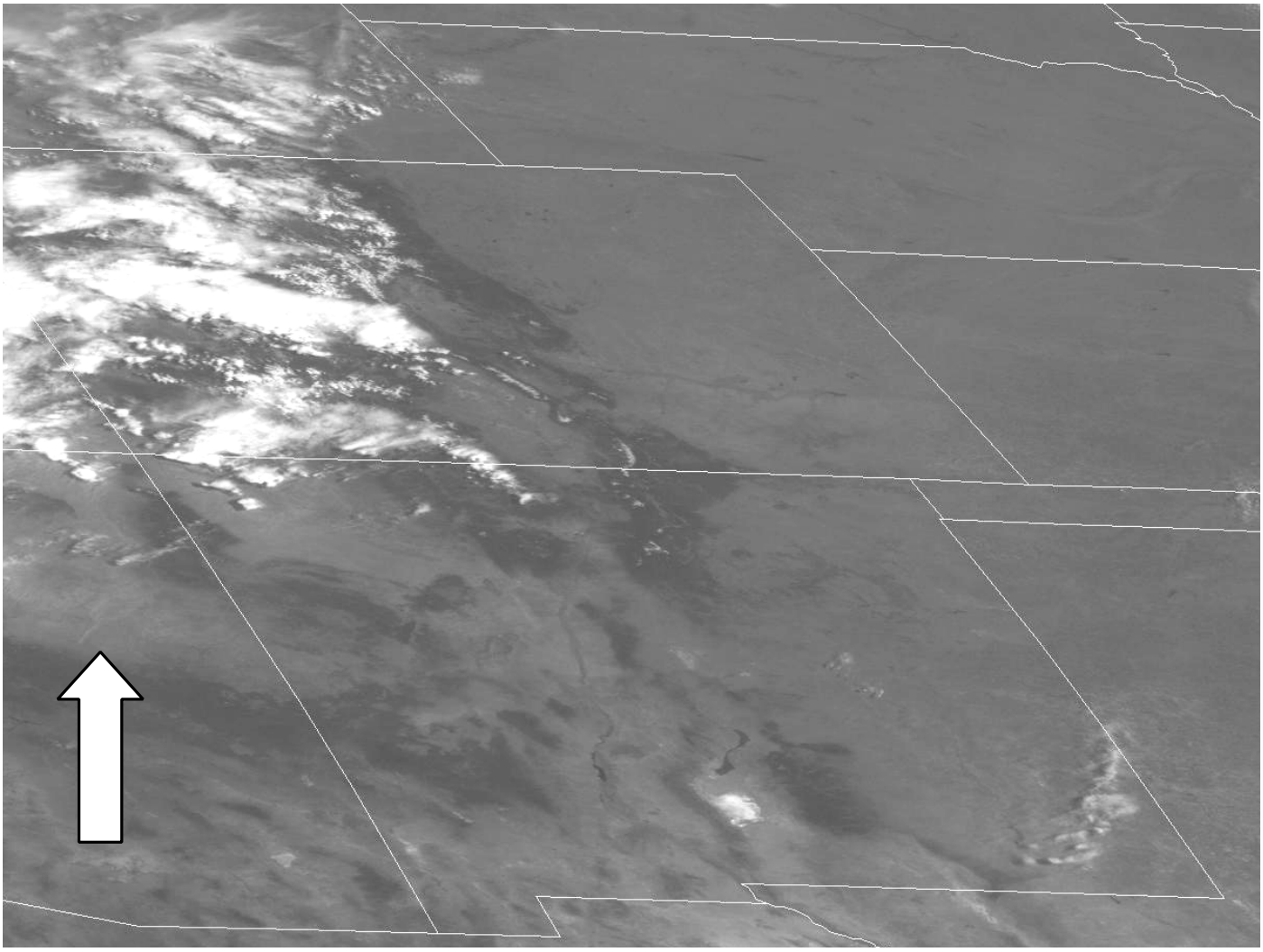


Figure 18. GOES 10 visible satellite image for 1800 Z (noon MST) on March 31, 1999 – image contrast enhanced 5 ste
web page). Arrow points to possible dust plumes.

GOES 10 visible satellite images of the Four Corners region are shown in Figures 17 and 18. The image in Figure 17 was taken at noon (MDT) on August 12, 1999, a day with clear dry weather throughout the Southwest. Figure 18 shows the same region of the U.S. at noon (MST) on March 31, the day of the dust storm. A comparison of surface details in the two images suggests that there were lower visibilities in the Four Corners region on March 31. The arrow in Figure 18 points to an area of possible dust plumes with a southwest to northeast orientation in the desert north of the Mogollon Rim.

4.0 Photo Documentation of the Event

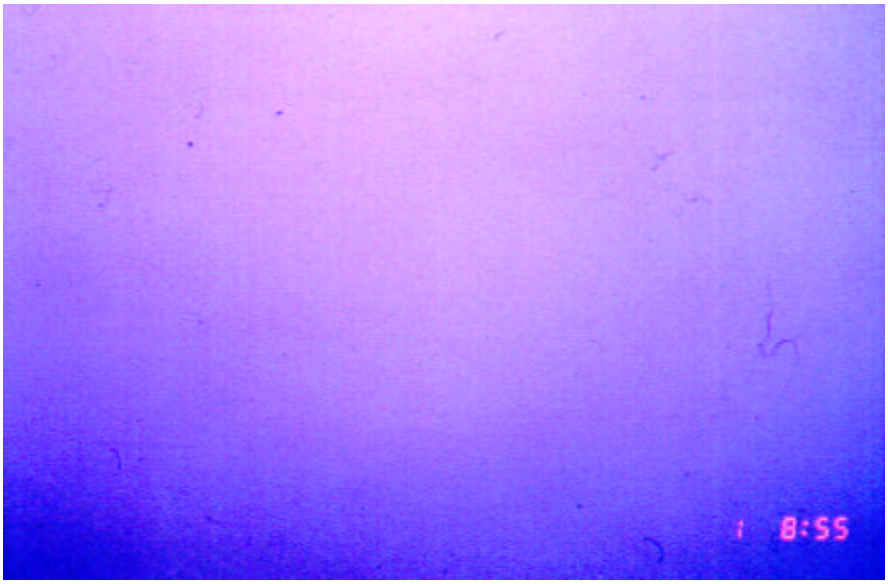
March 30, 5:00 pm

March 31, 9:00 am

March 31, Noon

March 31, 5:00 pm

.



April 1, 9:00 am

April 1, Noon

The Delta County Environmental Health office operates a 35 mm camera that takes slides three times daily, at 9am, noon, and 5 pm. The camera is located on top of a mesa seven miles northwest of the town of Delta and points southeast toward the town

The first image in the series of slides presented here was taken at 5:00 pm on March 30 and represents somewhat typical visibility conditions, as do the morning and noon shots on March 31st. While some haze and cloud cover is present, features in the valley and the opposing mesa are discernable. However, the view at 5 pm on the 31st is almost totally blocked by what appears to be reddish-brown material. Other photographic images of the event appeared in news articles (see Section 5)

5.0 News Accounts of the Event

News accounts of high winds and the March 31st dust storm appeared in the Montrose Daily Press (April 1, 1999), the Glenwood Post (April 2, 1999) and the Durango Herald (April 1, 1999). Photocopies of these articles follow and highlights from each are summarized below. As shown, the press coverage indicates that the wind event both was widespread and unusual.

Montrose Daily Press
Wind speed monitored at the local airport gusted to 52 mph; the National Weather Service office in Grand Junction indicated that visibility was down to two to five miles over most of the southwestern portion of the State and that high wind advisories were issued for southwest Utah; an area resident recalled a similar storm in the mid 1960s.

Glenwood Post
Wind speed of 50 mph was monitored at the airport; a National Weather Service technician reported that this was only the second time in twenty years that he had seen such a dust storm; at Sunlight Ski Area accompanying snow trapped the dust layer and it was visible to area users the next day.

Durango Herald
The National Weather Service in Grand Junction reported that "…a lack of moisture across the southwest allowed high winds to carry the dust from Arizona and New Mexico".

6.0 Credible Eyewitness Accounts

A number of eyewitness accounts of the high wind event from several Western Slope communities have been documented. These are summarized below by location. All are from March 31, 1999.

Steamboat Springs

Two staff of the Routt County Environmental Health Department observed that a dust storm moved through the area at about 5:00 pm and that the PM_{10} samples from that day had very heavy loadings and were light tan in color.

Grand Junction

A citizen related extremely dusty conditions during the evening and that “it seemed as if all of Utah and New Mexico (dirt) were in their air”.

Paonia

A citizen related that on that evening their vehicle was covered with red dust.

Dotsero

The deputy sheriff for Garfield County observed very hazy conditions at about 7:00 pm on March 31st and difficulty seeing on I-70. He had to use washer fluid with his wiper blades to see and his vehicle was covered with a powdery substance.

Edwards

The Garfield County sheriff observed dirt on his windshield followed by light rain with mud that required him to use washer fluid also.

Durango

A hydrologist with San Juan National Forest observed that the sky was pink and that haze extended from Durango to Cortez and the state line. They though “the Navajo Nation was blowing away”. A front moved through and snow trapped a layer of red dust on surfaces

Telluride

Staff of the San Miguel County Environmental Health Department said that it was like driving through a dust fog on his way home and that it was very windy. He also mentioned that the deck on his house was covered in red dust.

7.0 References

[1] The Colorado Quality Assurance Project Plan, revised September 25, 1998.
[2] Colorado Department of Public Health and Environment, City of Lamar, Prowers County Commissioners, *Natural events action plan for high wind events B Lamar, Colorado*, April 1998.