Technical Support Document For The May 2, 2008 Exceptional Event

Prepared by the Technical Services Program
Air Pollution Control Division
June 9, 2009

Table of Contents:

Tables:

Figures:

1.0 Introduction

In July 1987, EPA promulgated National Ambient Air Quality Standards for Particulates (NAAQS) 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 had 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. A data recovery of 75 percent is needed for each calendar quarter to be considered a valid quarter of data. The annual standard was revoked in December 2006.

A PM_{10} exceedance of 367 ug/m^3 was monitored in Lamar at the Power Plant site (100 N. 2nd Avenue) on May 2, 2008. The PM_{10} concentration at the Lamar Municipal Complex site (104 E. Parmenter St.) on May 2, 2008, while not an exceedance at 90 ug/m^3, was clearly elevated relative to PM_{10} concentrations on May 1, 2008 (55 ug/m^3) and May 3, 2008 (21 ug/m^3). The elevated levels at both sites coincided with successive low pressure systems creating widespread high winds and gusty conditions that brought blowing dust to the area.

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 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.
3. Should a PM_{10} NAAQS violation occur due to a natural event, a Natural Events Action Plan (NEAP) should be implemented.

In this report, the Air Pollution Control Division (APCD) provides documentation to support that the PM_{10} exceedance monitored in Lamar on May 2, 2008 was caused by a natural event. It should be noted that a NEAP has been in place for Lamar since 1998.

2.0 Ambient Particulate and Meteorological Data

On Friday May 2, 2008, Lamar recorded an exceedance of the twenty-four-hour PM10 standard with a reading of 367 ug/m3 at the Power Plant site. A concentration of 90 ug/m3, which is below the exceedance threshold, was recorded at the Lamar Municipal Building site. A large, deep, upper-level low-pressure system moved from western Colorado into Nebraska on May 1 and May 2. On May 2, the 700-millibar low was centered over Nebraska with strong northwesterly flow across eastern Colorado (Figure 1). A 991-millibar surface low was located over Iowa (Figure 2). Strong surface pressure gradients in Colorado and Kansas and perhaps a secondary surge of colder air behind the low-pressure system created very high winds across the region. Snow and snow showers were common in eastern Colorado on May 2 from about Limon northward, but significant precipitation did not extend into the Lamar area (see Figure 3). Based on the available regional data, it is evident that strong winds and sufficiently dry surface soils resulted in areas of blowing dust in portions of southeastern Colorado and western Kansas.

Wind speeds and gust speeds in Lamar exceeded blowing dust criteria, with speeds of 38 to 45 mph and gusts of at 47 to 60 mph for the two-hour period with greatly reduced visibilities during the late morning and early afternoon of May 2. Many other regional sites showed wind speeds well in excess of 30 miles per hour (mph) and gusts in excess of 40 mph. These are the speed and gust thresholds for blowing dust that apply in southeastern Colorado when surface soils are dry (see reference for the *Natural Events Action Plan for High Wind Events – Lamar, Colorado* at the end of this document). Table 1 below lists wind speeds and gusts for Lamar, Colorado, during the period with the highest winds on May 2. The 30 mph blowing dust threshold applies to hourly average winds. In most cases, these recorded speeds are not hourly average speeds but represent an instantaneous reading or several-minute average. If these spot observations show that speeds are above the 30 mph threshold for successive hours, then it can be reasonably assumed that hourly average winds are also above 30 mph. In this case, Lamar's wind and gust speeds were above these thresholds for two consecutive hours. During this two-hour period, visibilities at Lamar were reduced to 1.5 to 5 miles.

Figure 4 provides a snapshot of wind directions and gust speeds in eastern Colorado for 2 PM MST, with northerly winds in Lamar and gusts of 36 to 61 mph throughout the region. Tables 2 through 6 list wind and weather observations for Seibert, Colorado; La Junta, Colorado; Garden City, Kansas; Burlington, Colorado; and Ulysses, Kansas, respectively, for the period with strongest winds. Each of these sites experienced wind speeds or gusts well above the blowing dust thresholds for at least several hours during the day. During this high wind event, Seibert reported gusts as high as 63 mph. La Junta reported a maximum gust of 59 mph and visibility as low as 2.5 miles. Garden City reported a peak gust of 64 mph and visibility as low as 3 miles in blowing dust. Burlington recorded a peak gust of 71 mph and a minimum visibility of 1.5 miles. Ulysses recorded a peak gust of 61 mph and a lowest visibility of 2 miles.

Figure 5 shows that abnormally dry to moderate drought conditions prevailed in eastern and southeastern Colorado on May 6, 2008. Lamar recorded just 0.36 inches of precipitation in April of 2008 with 0.30 inches of this falling before April 16. No precipitation was recorded for Lamar for the first several days of May 2008. Figure 6 shows that there was a significant soil moisture deficit in southeastern Colorado in April of 2008.

While strong winds hit northeastern Colorado on May 2, including portions of the Front Range, Denver metro PM10 concentrations were only between 19 and 27 ug/m3. Front Range concentrations during high wind events rarely approach those from Lamar. Land use, surface roughness, soil conditions, and vegetative cover are significantly different in these two regions of the state. Figure 7 presents NOAA HYSPLIT back trajectories for the period of the day with highest winds at Lamar. These trajectories, the concentrations in the Denver metro area, and the observations for Burlington suggest that much of the dust probably came from the far eastern plains of Colorado.

Figures 8 and 9 show the relationship between all 24-hour PM10 concentrations at the Lamar Power Plant and Municipal Building, respectively, and the daily maximum 2-minute wind gust for the period from January 1, 2004, though February 2009. Figure 10 shows the frequency of occurrence of days with 2-minute gusts at specific speeds. These figures clearly show that PM10 exceedance concentrations of 150 ug/m3 or greater have only occurred when wind gusts were in excess of 40 mph, and gusts above this speed occur on less than 5% of the days in the period. The linear regression lines show that PM10 concentrations across the range increase in a statistically significant manner with increasing wind gust speeds. This is a signature of a region under the influence of blowing dust, and it is not surprising for an area that was at the heart of the great Dust Bowl of the 1930s. In contrast, anthropogenic pollutants from combustions sources and secondary particulate processes tend to decrease in concentration with increasing wind speeds.

K-means Cluster Analysis has been applied to Lamar Power and Municipal PM10 concentrations, Lamar 30-day total precipitation for each PM10 monitoring day, and Lamar daily maximum 5-second wind gust speeds for each monitoring day (see Table 7). K-means cluster analysis is a statistical method for identifying clusters or groupings of values for many variables. For environmental variables, these clusters often represent distinct processes, conditions, or events. In this case, cluster analysis differentiates PM10 concentrations associated with strong winds, low soil moistures, and blowing dust by providing mean values for these 4 variables for 5 distinct categories of PM10 events. The period of record considered was from January 2004 through March 2009. The 30-day total precipitation values appear to be a better metric for blowing dust conditions than shorter-term totals.

Clusters 1, 3, and 4 represent normal conditions with low PM10 and low winds and/or high 30-day precipitation, and these clusters represent the majority of days. Cluster 2 represents an intermediate blowing dust scenario with moderate gusts, moderate PM10, low precipitation, and a count of 198 days. Cluster 5 represents the significant blowing dust cases with high PM10, the lowest 30-day precipitation, and the highest wind gusts (with 15 days in the cluster). Figures 10 and 11 show Lamar Power and Municipal PM10, respectively, versus 30-day precipitation by cluster. Exceedances have only occurred with 30-day precipitation totals of 0.6 inches or less. Finally Figure 12 shows that high daily maximum wind gusts of 40 mph represent less than 5% of the days in the record. Without wind-driven dust, the exceedance of May 2, 2008, would not have occurred; and this is clearly a case of an exceptional event associated with blowing dust (windstorm-caused emissions from soil sources over a large area of eastern Colorado are not reasonably controllable or preventable.)

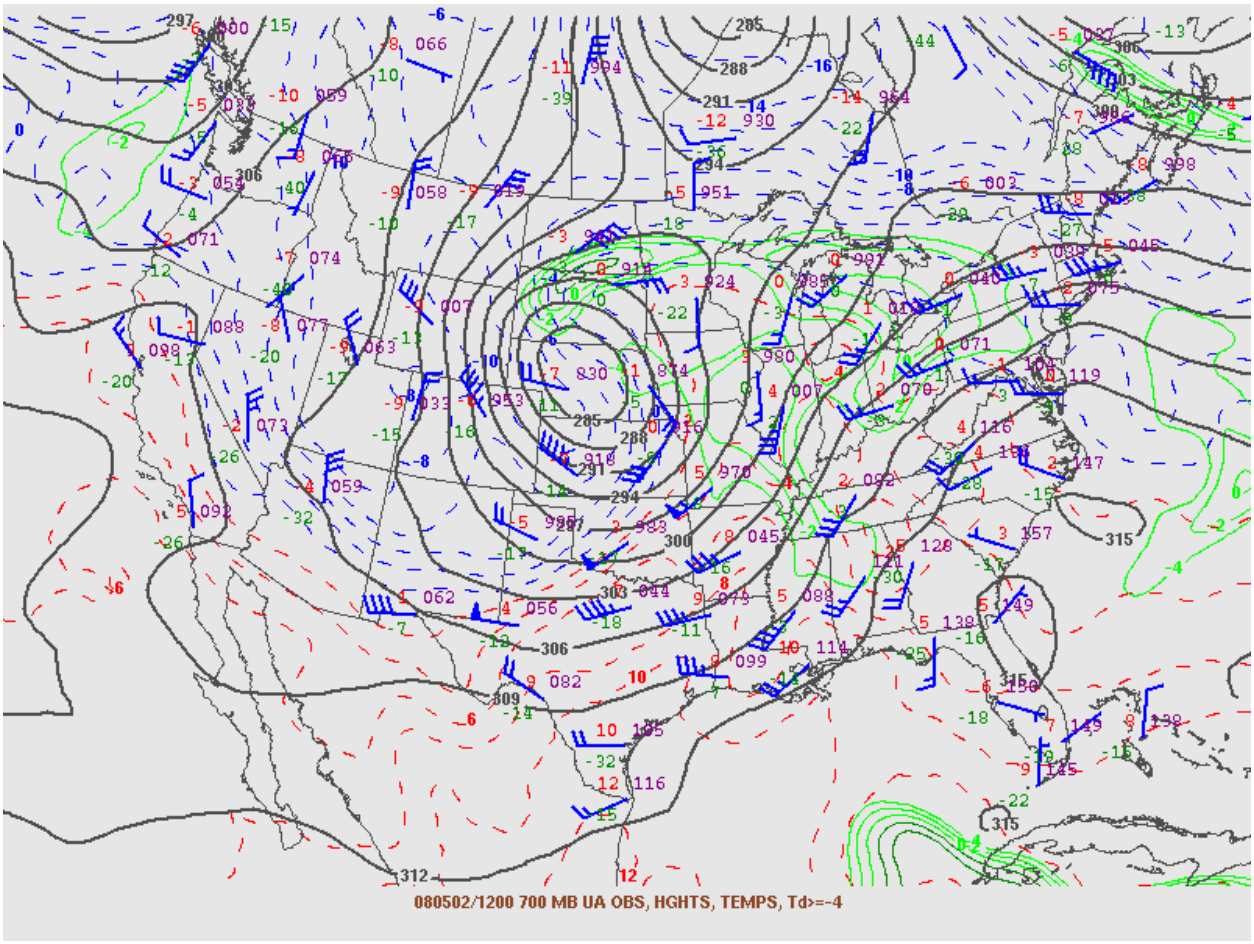


Figure 1. 700-millibar level weather map for 12Z May 2, 2009, or ***5 AM MST May 2***, 2008.

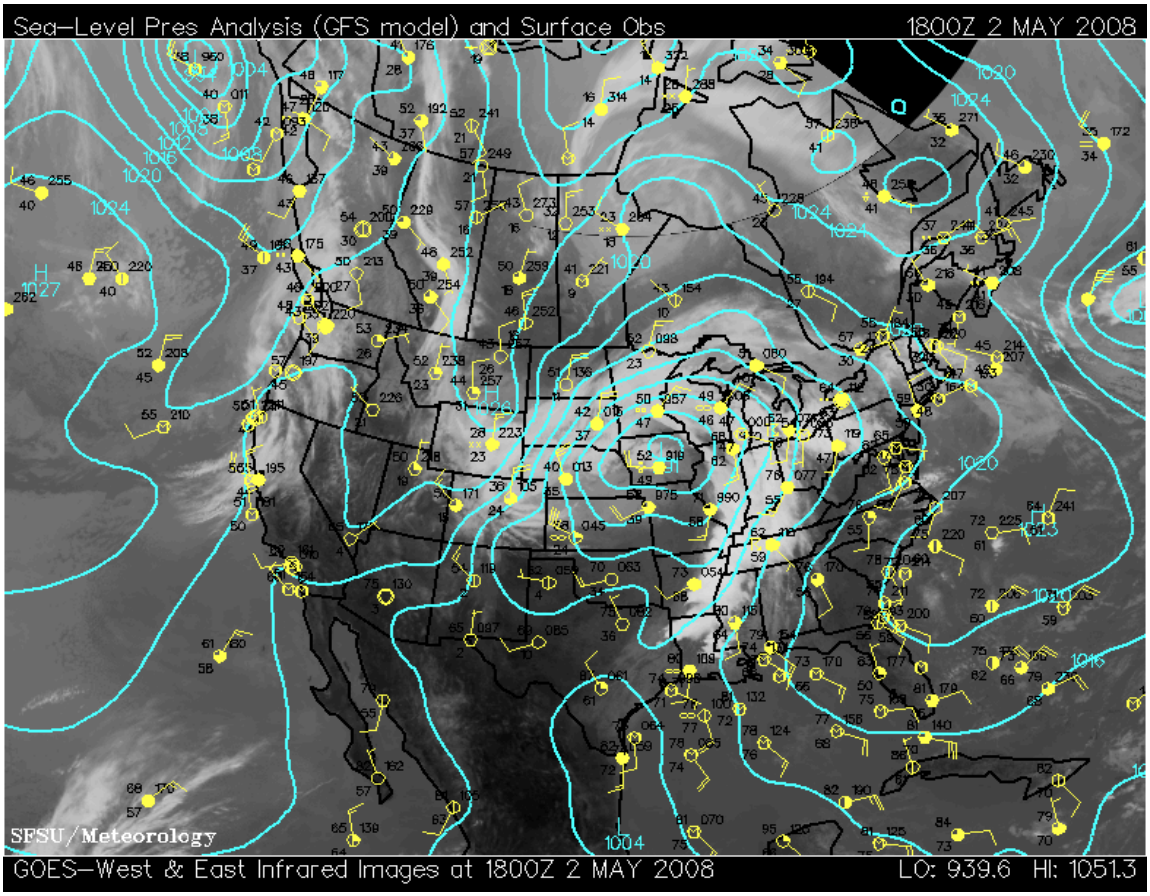


Figure 2. Surface weather and satellite cloud map for 18Z May 2, 2008, or ***11 AM MST May 2***, 2008.

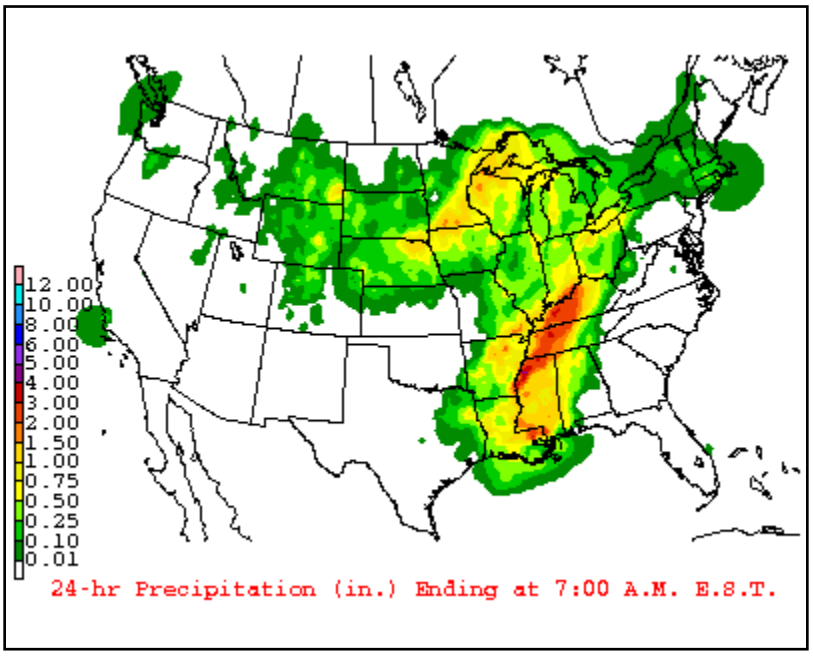


Figure 3. Total precipitation in inches between 7 AM May 2 and 7 AM May 3, 2008, showing no significant precipitation in southeast Colorado during the period.

Table 1. Wind and weather observations for Lamar, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 2, 2008.

Speeds at or above the blowing dust thresholds have been highlighted in yellow. Weather and visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
20:53	50	36	43	52	350	clear	9
20:23	46	42	45	53	350	haze	3
20:18	46	42	39	60	360	haze	1.5
20:10	46	42	45	60	360	haze	2.5
19:53	50	36	45	58	350	haze	4
18:53	51	35	38	47	350	haze	5
17:53	53	28	26	38	340	clear	10
16:53	55	26	30	36	350	clear	10
15:53	54	23	16	21	300	mostly cloudy	10
14:53	49	44	9		290	clear	10
13:53	41	57	14		290	clear	10

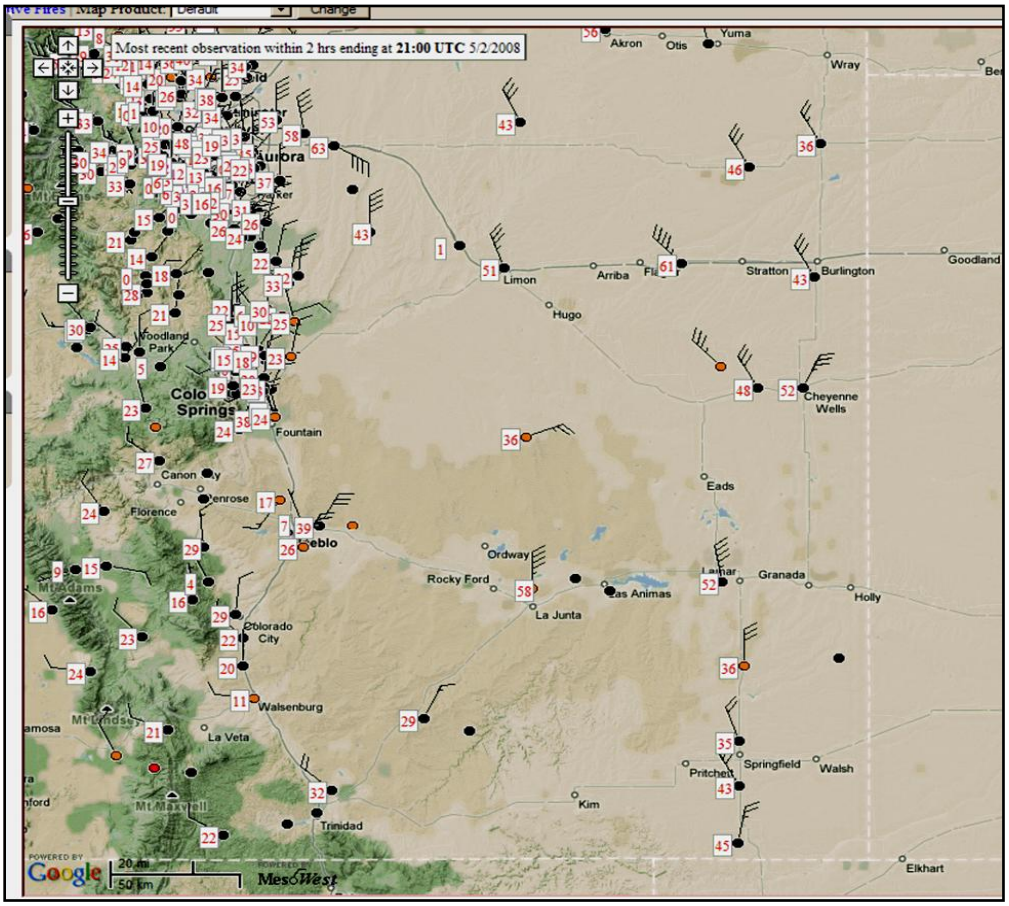


Figure 4. Wind directions and gust speeds in eastern Colorado at 2 PM MST on May 2, 2008.

Table 2. Wind and weather observations for Seibert, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 2, 2008.

Speeds at or above the blowing dust thresholds have been highlighted in yellow.

Time in GMT	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
20:22	35	55	47	61	315	NA	NA
20:05	35	54	44	63	315	NA	NA
19:25	35	55	46	60	320	NA	NA
18:44	35	63	49	62	320	NA	NA
18:06	33	67	38	58	315	NA	NA
17:26	33	72	35	47	315	NA	NA
17:05	34	67	31	43	320	NA	NA
16:45	34	63	35	57	315	NA	NA
16:25	37	54	34	50	320	NA	NA
15:42	37	49	40	59	320	NA	NA
15:22	37	47	37	53	310	NA	NA
15:06	36	56	28	48	320	NA	NA
14:41	38	54	29	52	310	NA	NA
14:26	35	59	35	48	315	NA	NA
13:41	36	56	29	40	320	NA	NA

Table 3. Wind and weather observations for La Junta, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 2, 2008.

Speeds at or above the blowing dust thresholds have been highlighted in yellow. Weather and visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
21:53	46	40	45	55	360	mostly clear	10
21:08	52	30	43	54	360	haze	6
20:53	50	30	43	58	360	haze	4
20:31	50	29	49	59	360	haze	4
20:20	48	34	46	56	350	haze	3
20:14	50	32	41	56	360	haze	2.5
19:53	50	39	39	49	360	haze	6
18:53	55	26	32	40	360	clear	10
17:53	56	28	25	35	360	clear	10
17:34	55	26	25	33	20	mostly clear	10
16:53	56	16	14	29	320	partly cloudy	10
15:53	56	16	18	28	310	clear	10
14:53	52	23	20	26	280	clear	10
13:53	41	48	15		270	clear	10

Table 4. Wind and weather observations for Garden City, Kansas, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 2, 2008.

Speeds at or above the blowing dust thresholds have been highlighted in yellow. Weather and visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:54	45	45	38	49	320	mostly clear	10
22:54	49	41	41	52	330	mostly clear	10
21:54	51	38	35	51	320	clear	10
20:54	51	38	48	60	320	blowing dust	3
20:17	52	35	48	60	320	blowing dust	3
19:54	53	33	43	58	320	blowing dust	4
19:23	54	32	47	56	320	blowing dust	4
18:54	53	29	51	64	320	blowing dust	3
18:00	55	28	40	52	310	dust	4
17:54	55	27	43	52	320	dust	4
16:54	56	30	44	58	310	clear	9
15:54	54	37	33	46	310	clear	10
14:54	53	36	35	46	310	clear	10

Table 5. Wind and weather observations for Burlington, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 2, 2008.

Speeds at or above the blowing dust thresholds have been highlighted in yellow. Weather and visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
19:53	34	82	36	51	330	light snow	0.75
19:49	36	75	35	51	330	light snow	1.5
19:24	39	60	38	61	330	haze	5
19:09	37	70	41	52	320	light snow	9
18:53	37	70	43	55	320	light snow	3
18:50	36	75	43	55	330	light snow	2
17:53	39	62	44	61	320	haze	4
17:31	39	56	49	60	330	haze	4
17:24	39	52	48	60	330	haze	5
16:53	39	55	49	58	320	mostly cloudy	8
16:35	37	60	47	64	320	haze	5
16:15	39	52	47	64	320	haze	5
16:08	39	52	55	64	320	haze	3
16:02	39	52	51	66	320	haze	1.5
15:53	40	46	49	71	330	haze	1.75
15:39	39	56	49	64	310	haze	4
15:28	41	45	53	71	310	haze	2.5
14:53	41	48	53	61	320	haze	4
13:53	38	62	40	58	310	mostly cloudy	10

Table 6. Wind and weather observations for Ulysses, Kansas, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 2, 2008.

Speeds at or above the blowing dust thresholds have been highlighted in yellow. Weather and visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:08	50	29	35	43	320	partly cloudy	10
23:03	50	29	36	48	320	mostly cloudy	7
22:58	52	28	38	51	320	mostly cloudy	7
22:53	52	30	37	51	320	haze	5
22:48	52	28	37	48	320	haze	5
22:43	54	28	36	48	310	haze	4
22:38	54	28	38	48	310	haze	4
22:33	54	26	39	52	310	haze	4
22:28	54	28	37	52	310	haze	5
22:23	52	28	39	55	330	haze	4
22:18	54	28	38	55	320	haze	4
22:13	54	26	38	54	320	haze	3
22:08	54	26	43	57	320	haze	2.5
22:03	54	26	46	57	320	haze	3
21:58	54	28	41	61	320	haze	4
21:53	54	28	39	61	320	haze	3
21:48	54	28	43	61	310	haze	2.5
21:43	54	28	47	57	320	haze	2.5
21:38	54	28	41	51	320	haze	3
21:33	52	28	39	48	320	haze	3
21:28	52	28	39	54	320	haze	3
21:23	54	26	44	54	320	haze	3
21:18	54	26	41	54	320	haze	2.5
21:13	52	28	38	56	320	haze	2
21:08	54	28	47	56	310	haze	2
21:03	54	28	38	53	320	haze	2.5
20:58	54	28	45	53	320	haze	3
20:53	54	28	43	53	320	haze	4
20:48	54	28	40	47	310	haze	5
20:43	54	28	40	47	310	haze	5
20:38	54	28	39	47	320	haze	5
20:33	54	28	35	47	310	haze	5
20:28	55	28	36	46	320	overcast	7
20:23	54	32	33	45	320	overcast	7
20:18	54	32	35	45	320	overcast	7
20:13	54	32	36	44	310	haze	5
20:08	54	30	36	49	310	haze	5
20:03	55	30	36	49	330	haze	5
19:58	55	28	36	48	320	haze	5
19:53	55	26	38	48	320	overcast	7
19:48	55	26	35	46	320	mostly cloudy	7

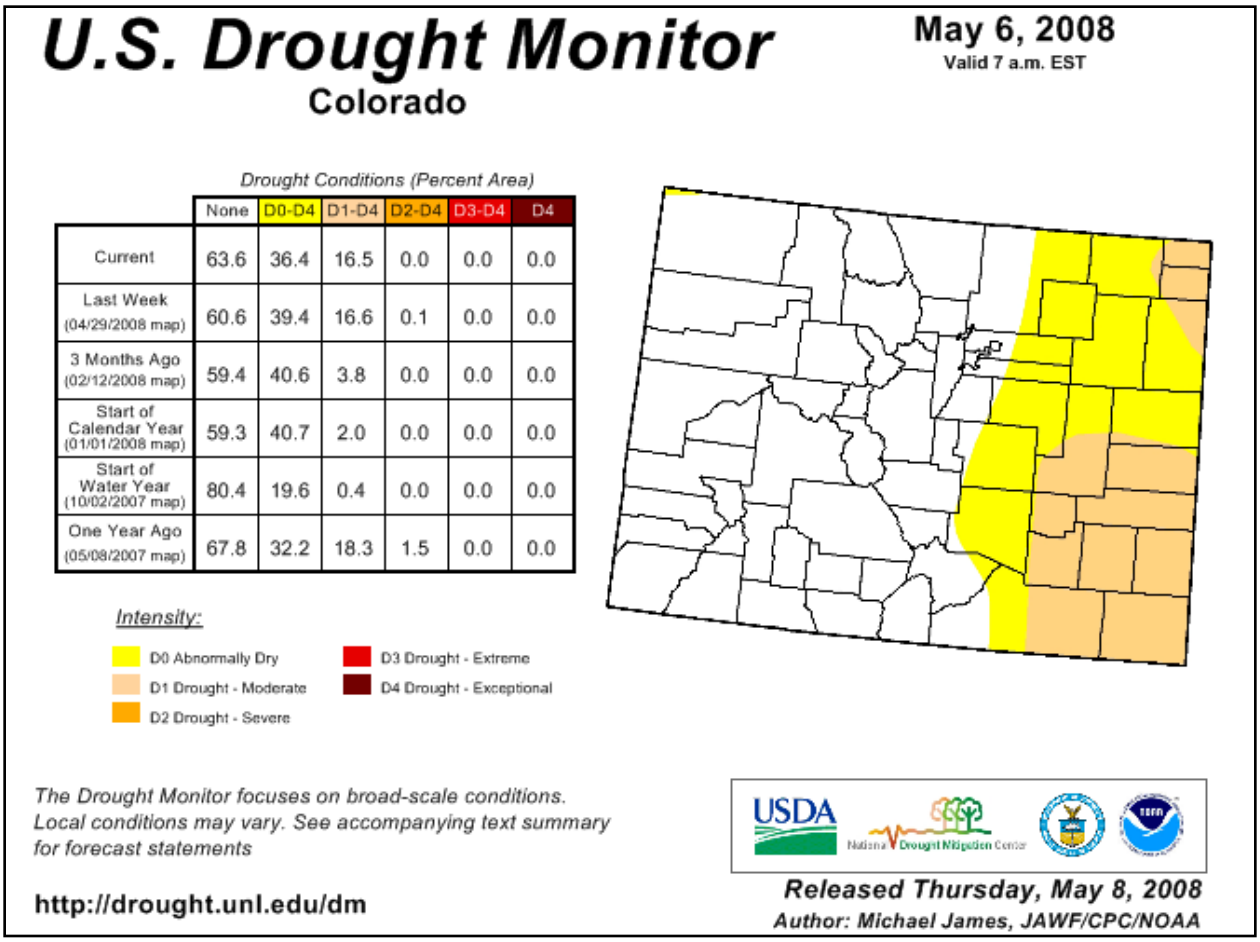


Figure 5. Drought status for the Colorado on May 6, 2008 (source: the USDA, NOAA, and the National Drought Mitigation Center at: http://drought.unl.edu/dm/archive.html).

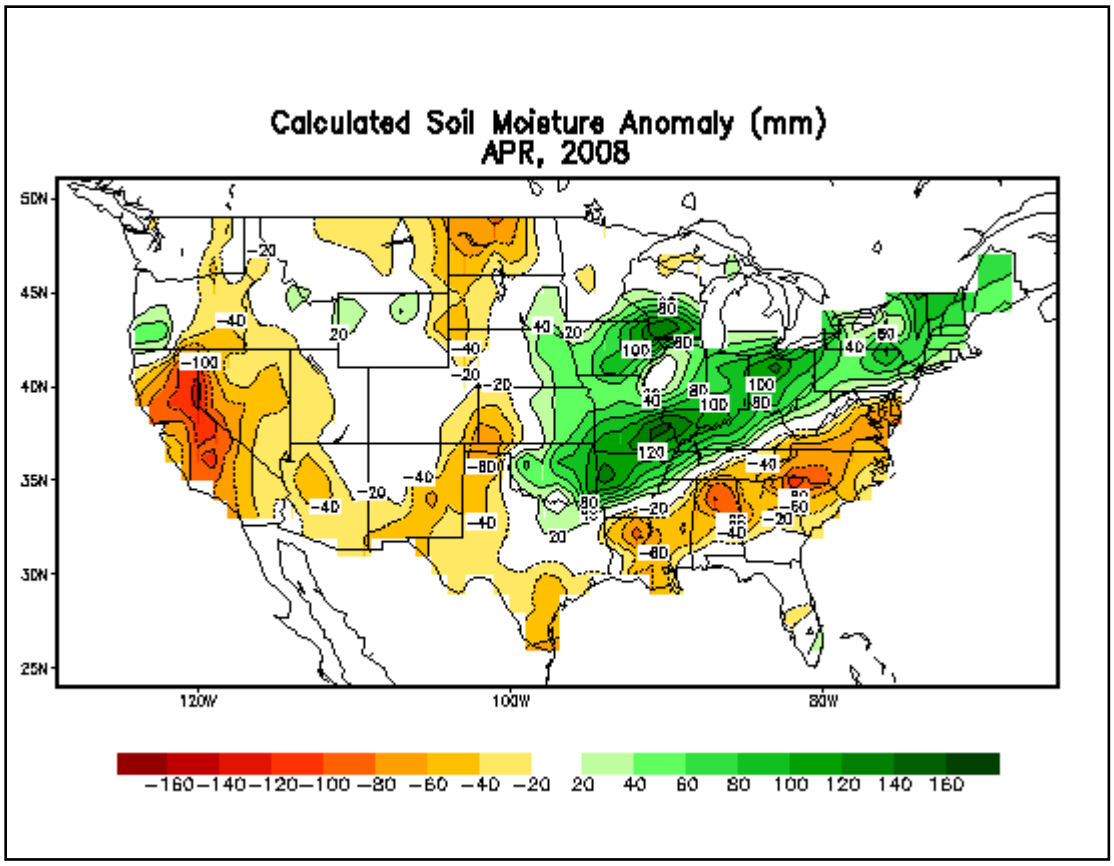


Figure 6. Calculated soil moisture anomalies for April 2008 showing a deficit in southeastern Colorado. (http://www.ncdc.noaa.gov/img/climate/research/2008/apr/cpc-soil-moist-anom-200805.gif)

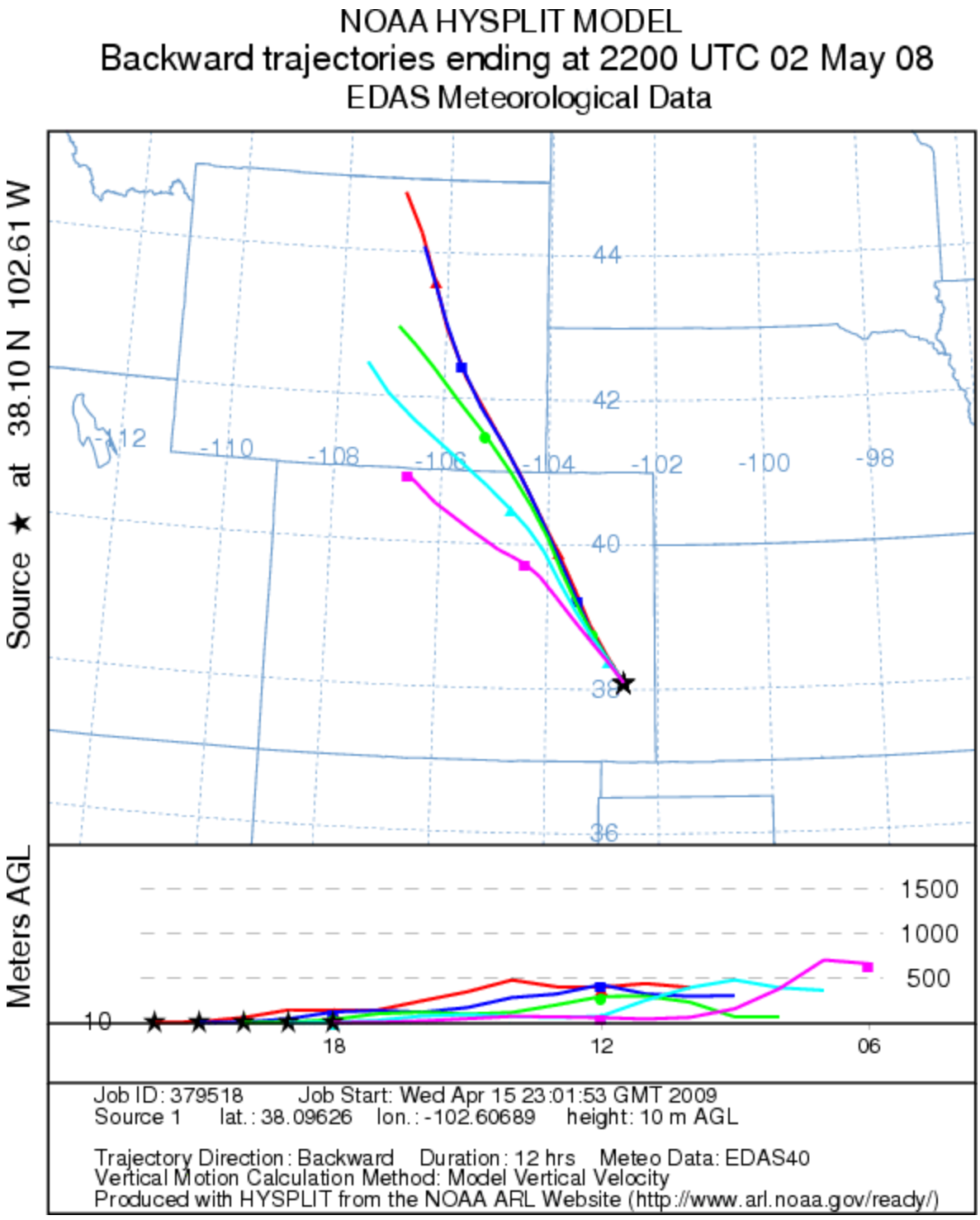


Figure 7. NOAA HYSPLIT 12-hour back trajectories for Lamar Colorado for each hour from 11 AM MST to 3 PM MST on May 2, 2008.

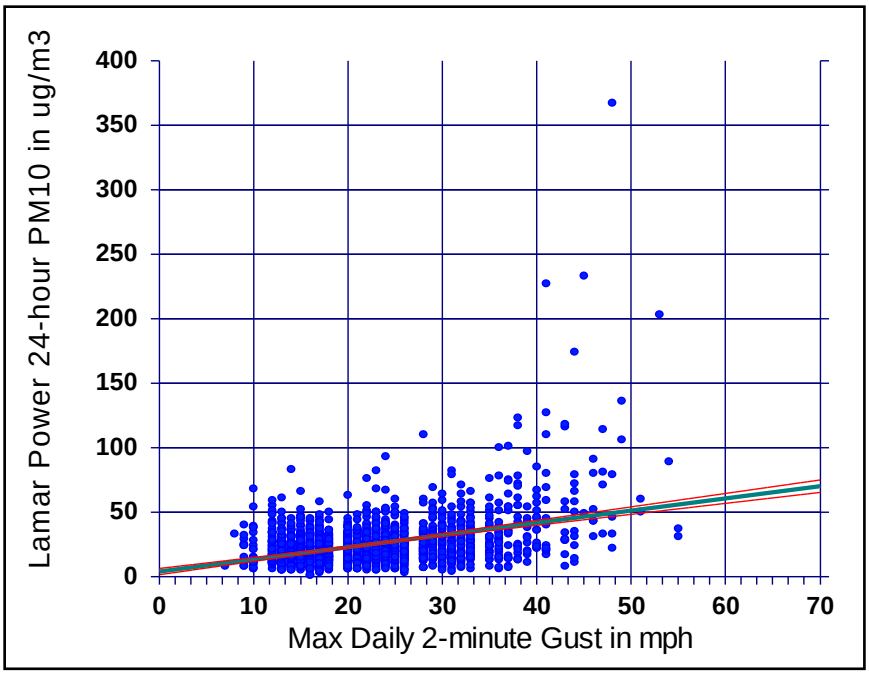


Figure 8. Lamar Power Plant 24-hour PM10 concentrations in ug/m3 versus Lamar daily maximum 2-minute wind speed in mph for January 2004 through February 2009 – with linear regression and regression confidence interval.

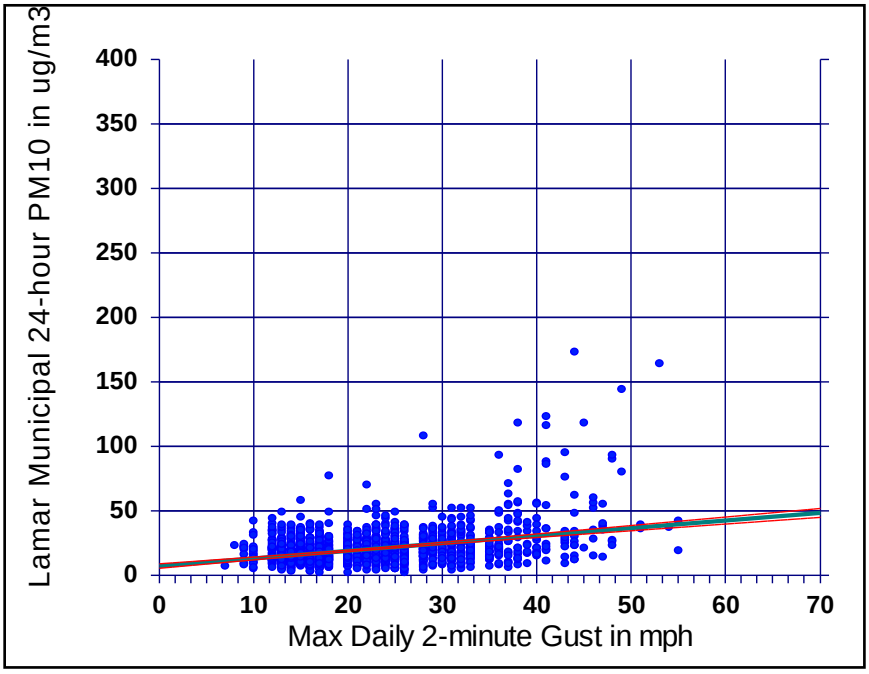


Figure 9. Lamar Municipal Building 24-hour PM10 concentrations in ug/m3 versus Lamar daily maximum 2-minute wind speed in mph for January 2004 through February 2009 – with linear regression and regression confidence interval.

Table 7. K-means cluster analysis means for Lamar PM10 and meteorological variables.

Cluster Variables	Cluster 1 Means	Cluster 2 Means	Cluster 3 Means	Cluster 4 Means	Cluster 5 Means
Lamar Power 24-hour PM10 in ug/m3	22.7	52.3	22.5	19.2	154.9
Lamar Municipal 24-hour PM10 in ug/m3	18.0	38.3	20.6	16.0	111.9
Lamar 5-second Wind Gust in mph	35.6	36.8	27.6	19.6	52.6
Lamar 30-day Precipitation	0.8	0.8	3.7	0.6	0.4
Count	535	198	298	798	15

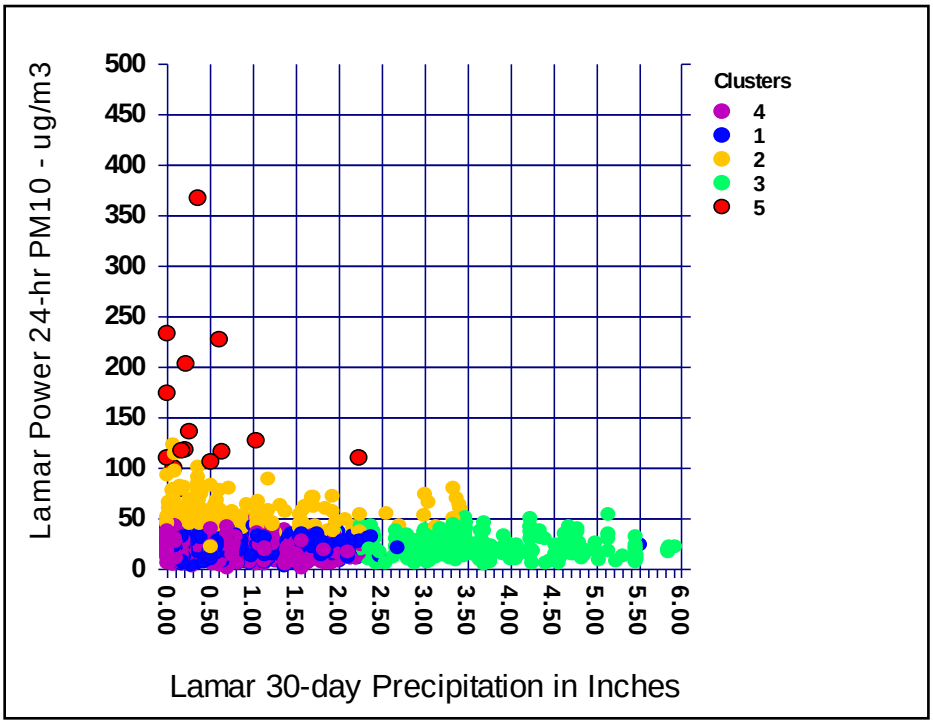


Figure 10. Lamar Power Plant 24-hour PM10 concentrations in ug/m3 versus Lamar 30-day total precipitation by cluster for 2004 through early 2009. Cluster 5 is the blowing dust cluster.

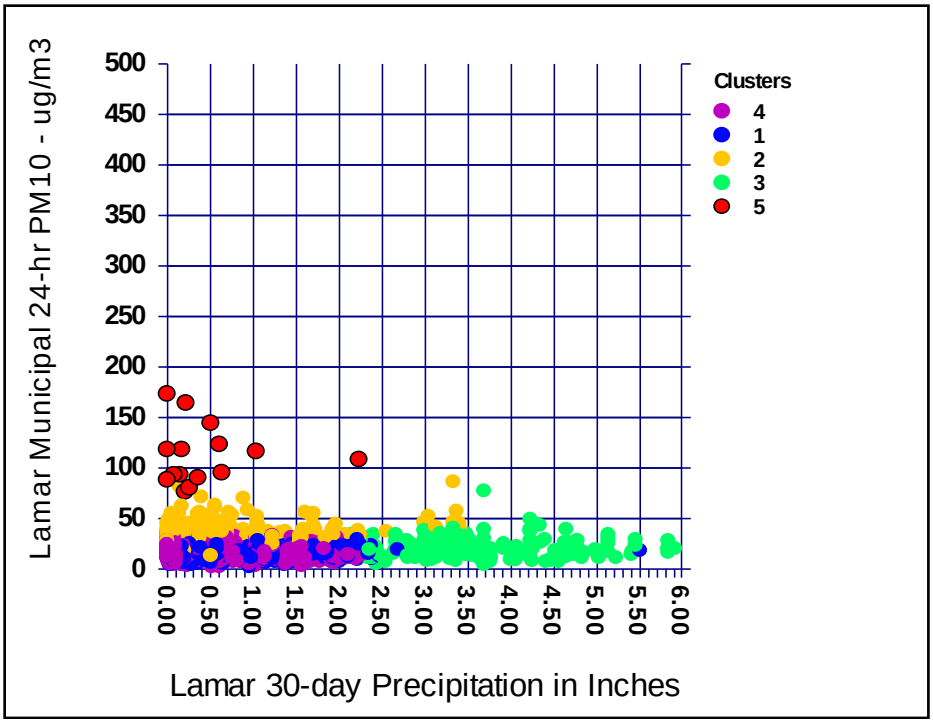


Figure 11. Lamar Municipal 24-hour PM10 concentrations in ug/m3 versus Lamar 30-day total precipitation by cluster for 2004 through early 2009. Cluster 5 is the blowing dust cluster.

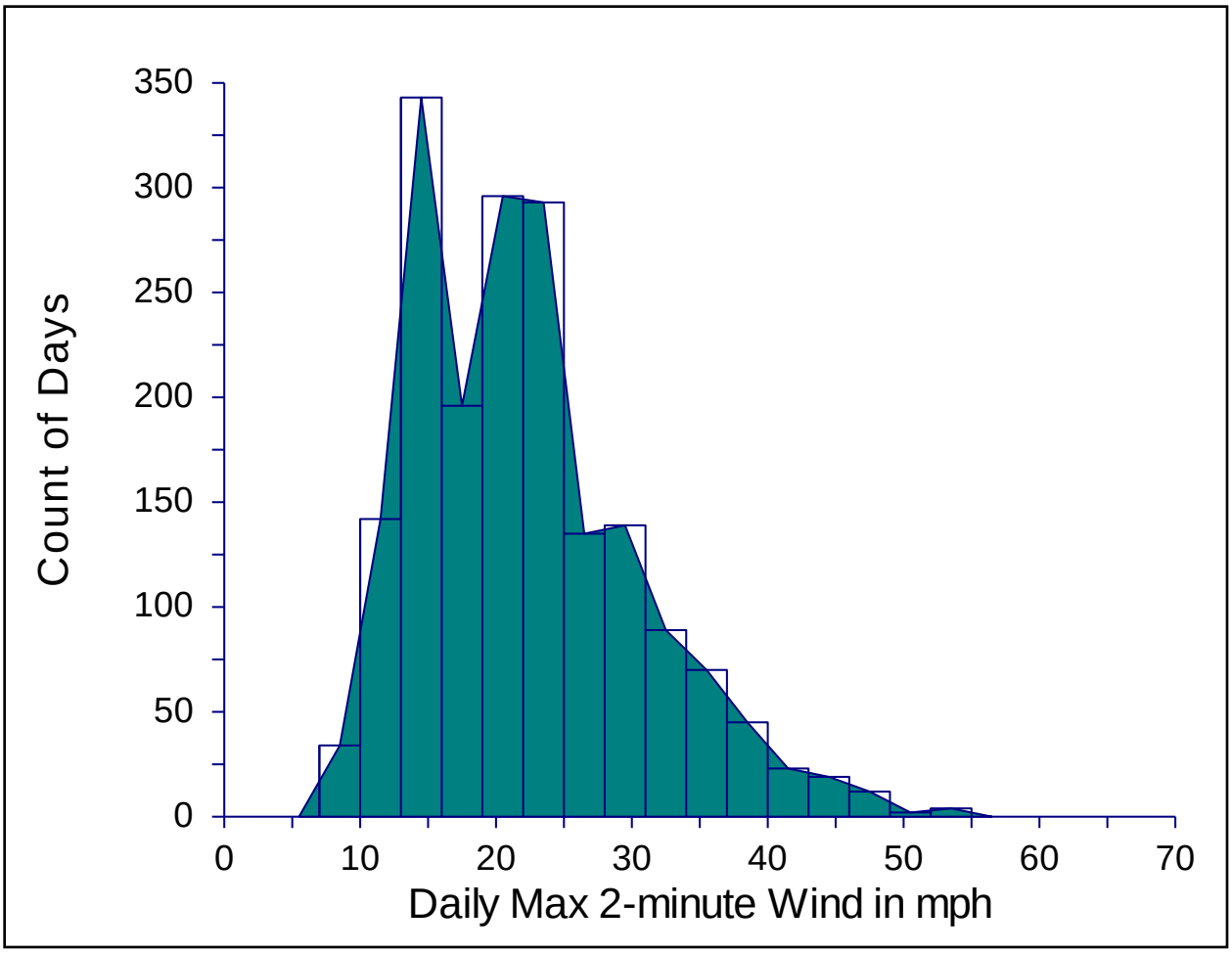


Figure 12. Histogram of the Lamar Airport daily maximum 2-minute wind speed in mph for January 2004 through February 2009 – gusts over 40 mph occur on fewer than 5% of the days in this period.

3.0 News Accounts

1. Photo by Mike Bowen

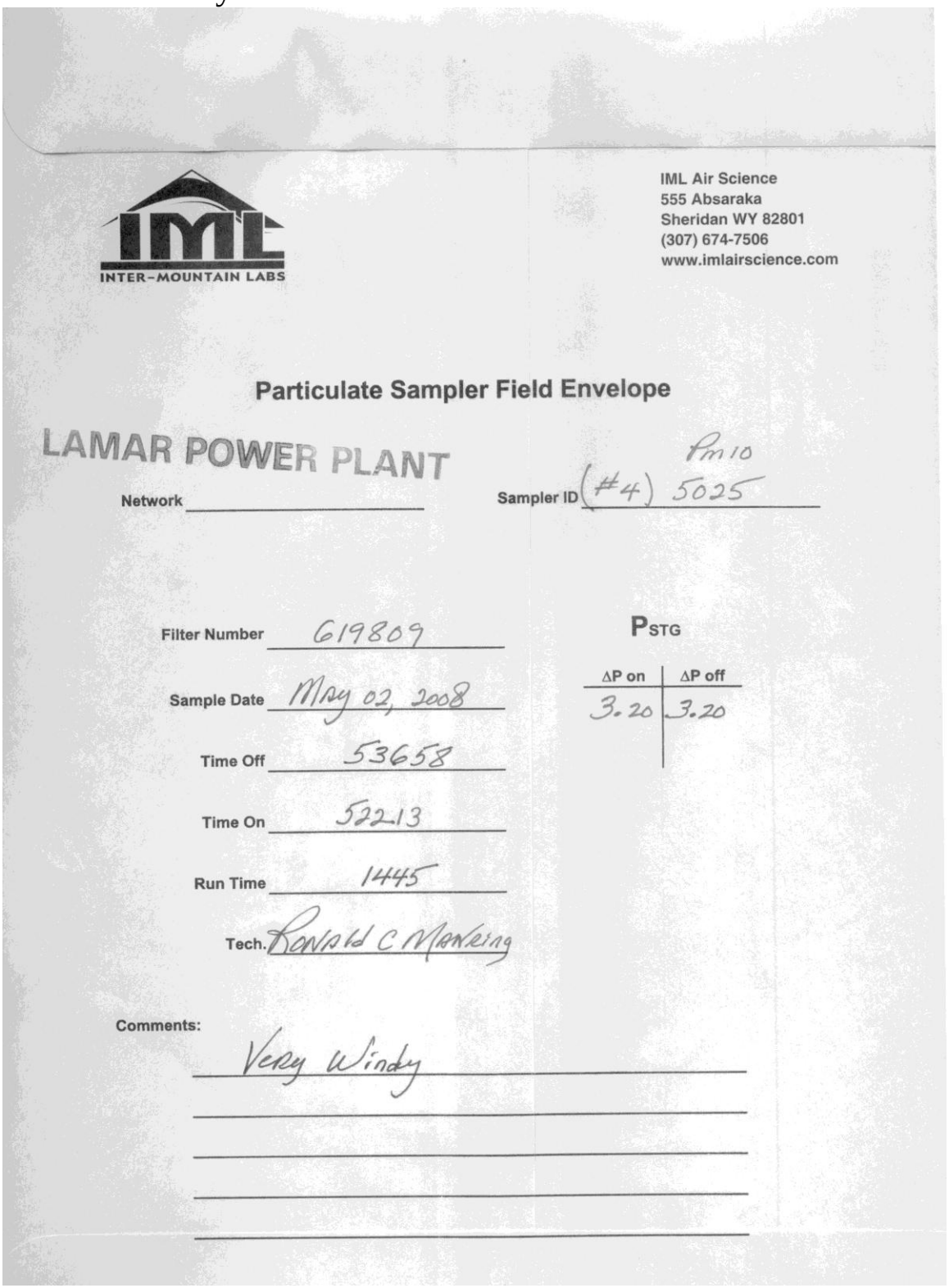
Last week's high winds were evidently too much for the flag over the Prowers County Courthouse Friday. By late afternoon it had been torn by the ferocious sustained winds that pummeled the region for over 24 hours. By Saturday, the winds were calm and on Monday morning an undamaged flag was flying at the courthouse.

1. Photo by Mike Bowen

Last week's high winds were evidently too much for the flag over the Prowers County Courthouse Friday. By late afternoon it had been torn by the ferocious sustained winds that pummeled the region for over 24 hours. By Saturday, the winds were calm and on Monday morning an undamaged flag was flying at the courthouse.

From the Lamar Ledger 5/6/08

4.0 Laboratory And Field Data



INTER-MOUNTAIN LABS

IML Air Science
555 Absaraka
Sheridan WY 82801
(307) 674-7506
www.imlairscience.com

Particulate Sampler Field Envelope

LAMAR POWER PLANT

Network _____

Sampler ID PM10 (#4) 5025

Filter Number 619809

Sample Date May 02, 2008

Time Off 53658

Time On 52213

Run Time 1445

Tech. Ronald C Mankering

PSTG

ΔP on	ΔP off
3.20	3.20

Comments:

Very Windy

IML Air Science
555 Absaraka
Sheridan WY 82801
(307) 674-7506
www.imlairscience.com

INTER-MOUNTAIN LABS

Particulate Sampler Field Envelope

AMAR MUNICIPAL COMPLEX

Network _____ Sampler ID PM10-3-4060

Filter Number 619449

Sample Date 5-2-08

Time Off 64558

Time On 63125

Run Time 1433

Tech. _____

PSTG

ΔP on	ΔP off
3.05	3.00

Comments:

_____

_____

_____

5.0 Reference

Colorado Department of Public Health and Environment, City of Lamar, Prowers County Commissioners, *Natural Events Action Plan for High Wind Events – Lamar, Colorado*, April 1998.