Technical Support Document For the May 11, 2010, Alamosa and Pagosa Springs Exceptional Event

Colorado Department of Public Health and Environment

Prepared by the Technical Services Program
Air Pollution Control Division
Colorado Department of Public Health and Environment

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Executive Summary

In 2005, Congress identified a need to account for events that result in exceedances of the National Ambient Air Quality Standards (NAAQS) that are exceptional in nature[1] (e.g., not expected to reoccur or caused by acts of nature beyond man-made controls). In response, EPA promulgated the Exceptional Events Rule (EER) to address exceptional events in 40 CFR Parts 50 and 51 on March 22, 2007 (72 FR 13560). On May 2, 2011, in an attempt to clarify this rule, EPA released draft guidance documents on the implementation of the EER to State, tribal and local air agencies for review. The EER allows for states and tribes to “flag” air quality monitoring data as an exceptional event and exclude those data from use in determinations with respect to exceedances or violations of the NAAQS, if EPA concurs with the demonstration submitted by the flagging agency.

Due to the semi-arid nature of parts of the state, Colorado is highly susceptible to windblown dust events. These events are often captured by various air quality monitoring equipment throughout the state, sometimes resulting in exceedances or violations of the 24-hour PM_{10} NAAQS. This document contains detailed information about the large regional windblown dust event that occurred on May 11, 2010. The Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) has prepared this report for the U.S. Environmental Protection Agency (EPA) to demonstrate that the elevated PM_{10} concentrations were caused by a natural event.

On May 11, 2011, PM_{10} sample values greater than the 24-hour NAAQS of 150 $\mu g/m^3$ were recorded at multiple sites across southwestern Colorado including Pagosa Springs School (08-007-0001) monitor (200 $\mu g/m^3$), the Alamosa Municipal Building (08-003-0003) monitor (161 $\mu g/m^3$) and the Adams State College (08-003-0001) monitor in Alamosa (160 $\mu g/m^3$). These exceedances and other concentrations across Colorado are plotted on the map for May 11, 2010, in Figure 1. This event exceeded the 98th% value of any evaluation criteria for all three monitoring sites. The statistical and meteorological data clearly shows that but for this high wind blowing dust event, Alamosa and Pagosa Springs would not have exceeded the 24-hour NAAQS on May 11, 2010. Since at least 2005, there has not been an exceedance that was not associated with high winds carrying PM_{10} dust from distant sources in these areas.

All of the noted May 11, 2010, twenty-four-hour PM_{10} concentrations were above the 90^{th} percentile concentrations for their locations (see Table 14). This event exceeded the 98th% value of any evaluation criteria for all three monitoring sites. The statistical data clearly shows that but for this high wind blowing dust event, Alamosa and Pagosa Springs would not have exceeded the 24-hour NAAQS on May 11, 2010. Since at least 2005, there has not been an exceedance that was not associated with high winds carrying PM_{10} dust from distant sources in these areas. This is evidence that the event was associated with a measured concentration in excess of normal historical fluctuations including background.

This large regional dust storm adversely affected the air quality exceeding the 24-hour PM_{10} NAAQS in these three areas and impacted PM_{10} concentrations at several other monitoring stations in southwestern Colorado. Since at least 2005, there has not been an exceedance that was not associated with high winds carrying PM_{10} dust from distant sources in these areas. APCD is

[1] Section 319 of the Clear Air Act (CAA), as amended by section 6013 of the Safe Accountable Flexible Efficient-Transportation Equity Act: A Legacy for Users (SAFE-TEA-LU of 2005, required EPA to propose the Federal Exceptional Events Rule (EER) no later than March 1, 2006.

requesting exclusion for each of the samples taken at the Adams State College monitor in Alamosa, the Alamosa Municipal Building monitor, and the Pagosa Springs School monitor.

Specifically, these high values taken on May 11, 2010, were the consequence of strong, pre-frontal southwesterly winds in combination with very dry conditions which caused significant blowing dust across northeastern Arizona, northwestern New Mexico, southeastern Utah and southwestern Colorado. The meteorological conditions that created the high winds included a vigorous trough of low pressure in the upper atmosphere that moved across the Great Basin combined with a surface cold front that swept across the Desert Southwest. This dust storm originated in the desert regions of northeastern Arizona and northwestern New Mexico. It transported PM_{10} dust into the southwestern portion of Colorado.

Widespread restrictions to visibility occurred in northeast Arizona, northwest New Mexico, and southwest Colorado. The weather system causing the winds affected southwestern Colorado during the afternoon and evening hours on May 11, 2010. These observations contribute to the body of evidence that shows that a regional dust storm caused the PM_{10} exceedances at the monitoring sites in question.

EPA's June 2012 draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule states "the EPA will accept a threshold of a sustained wind of 25 mph for areas in the west provided the agencies support this as the level at which they expect stable surfaces (i.e., controlled anthropogenic and undisturbed natural surfaces) to be overwhelmed..." In addition, in both eastern and western Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust (see reference for the Technical Support Document for the January 19, 2009 Lamar Exceptional Event and Attachment A - Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). For this blowing dust event, it has been assumed that sustained winds of 25 mph and higher or wind gusts of 40 mph and higher can cause blowing dust in Arizona, New Mexico, and Colorado.

The blowing dust climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Forecast products from the Navy Aerosol Analysis and Prediction System model provide evidence for a widespread blowing dust event in the Four Corners states, suggesting that significant source regions for dust transported into Colorado were located in arid regions of Arizona, Utah, and New Mexico. NOAA HYSPLIT forward and backward trajectories provide clear supporting evidence that dust from desert regions of northwest New Mexico and Arizona caused the PM10 exceedances measured across portions of southwest Colorado on May 11, 2010. Soils in the Four Corners area and in northeast Arizona and extreme northwestern New Mexico in particular were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.

The Drought Monitor map of the western U.S. for the month of April 2010 shows that southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico had less than 0.5 inches of precipitation in April. The Drought Monitor report for the western U.S. shows that northeast Arizona and much of northwest New Mexico were classified as "Abnormally Dry", with an area of "Moderate" to "Severe" drought in the Painted Desert region. Soils in the Four Corners area and in northeast Arizona and extreme northwestern New Mexico in particular were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.

Surface weather maps for the Four Corner States show evidence of widespread blowing dust and winds above the threshold speeds for blowing dust on May 11, 2010. Table 6 through Table 10 show that winds were as high as 43 mph and wind gusts were as high as 58 mph in areas south of the stationary front and surface low pressure complex. MODIS Terra satellite image shows that the Four Corners region including Utah, Arizona, New Mexico, and Colorado were sources regions for blowing dust on May 11, 2010. This is consistent with the climatology for many dust storms in Colorado as described in the Grand Junction, Colorado, Blowing Dust Climatology report contained in Appendix A of this document. The observations of winds above blowing dust thresholds and restricted visibilities in the areas of concern demonstrate that this is a natural event that cannot be reasonably controlled or prevented.

The Center for Snow and Avalanche Studies has been studying the effects of wind-blown desert dust from Arizona, New Mexico, and Utah on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. The Center for Snow and Avalanche Studies lists May 11, 2010, as one of nine Dust-on-Snow events for the 2009/2010 water year, and this provides clear supporting evidence that a regional blowing dust event with long-range transport caused the PM10 exceedances measured across portions of Colorado on May 11, 2010. Snow cover data provide strong evidence that a widespread, regional, blowing dust event caused exceedances at these locations.

The PM_{10} exceedances Alamosa and Pagosa Springs on May 11, 2010, would not have occurred if not for the following: (a) dry soil conditions over southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico; (b) a combination of strong surface low pressure and a cold front associated with an intense upper-level trough that was moving across the western United States that created conditions necessary for widespread strong gusty winds over the area of concern; and (c) elevated friction velocities and the deep mixing of the blowing dust from desert regions of Arizona, northwest New Mexico, and southeast Utah. These PM_{10} exceedances were due to an exceptional event associated with regional windstorm-caused emissions from erodible soil sources over a large area of southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico. These sources are not reasonably controllable during a significant windstorm under abnormally dry or moderate drought conditions.

APCD is requesting concurrence on exclusion of the PM_{10} values from Alamosa-Adams State College (08-003-0001), Alamosa-Municipal Building (08-003-0003), and Pagosa Springs-Middle School (08-007-0001) on May 11, 2010.

Table of Contents

Figures

Tables

List of Appendices

1.0 Exceptional Events Rule Requirements

In addition to the technical requirements that are contained within the EER, procedural requirements must also be met in order for EPA to concur with the flagged air quality monitoring data. This section of the report lays out the requirements of the EER and discusses how the APCD addressed those requirements.

1.1 Procedural Criteria

This section presents a review of the procedural requirements of the EER as required by 40 CFR 50.14 (Treatment of Air Quality Monitoring Data Influenced by Exceptional Events) and explains how APCD fulfills them.

The Federal EER requirements include public notification that an event was occurring, the placement of informational flags on data in EPA's Air Quality System (AQS), submission of initial event description, the documentation that the public comment process was followed, and the submittal of a demonstration supporting the exceptional events flag. ACPD has addressed all of these procedural and documentation requirements.

Public notification that event was occurring (40 CFR 50.14(c)(1)(i))
APCD issued Blowing Dust Advisories for Western and South Central Colorado advising citizens of the potential for high wind/dust events on May 11, 2010. This area includes: Grand Junction, Rifle, Cortez, Telluride, Alamosa, Durango, Aspen, and nearby towns (i.e. Pagosa Springs and Crested Butte). The advisories that were issued on May 11, 2010, can be viewed at: http://www.colorado.gov/airquality/forecast_archive.aspx?seeddate=05%2f11%2f2010 and are included in Appendix B.

Place informational flag on data in AQS (40 CFR 50.14(c)(2)(ii))
APCD and other applicable agencies in Colorado submit data into EPA's AQS. Data from both filter-based and continuous monitors operated in Colorado are submitted to AQS.

When APCD and/or another agency operating monitors in Colorado suspects that data may be influenced by an exceptional event, APCD and/or the other operating agency expedites analysis of the filters collected from the potentially-affected filter-based air monitoring instruments, quality assures the results and submits the data into AQS. APCD and/or other operating agencies also submit data from continuous monitors into AQS after quality assurance is complete.

If APCD and/or the applicable operating agency have determined a potential exists that the sample value has been influenced by an exceptional event, a preliminary flag is submitted for the measurement when the data is uploaded to AQS. The data are not official until they are certified by May 1st of the year following the calendar year in which the data were collected (40 CFR 58.15(a)(2)). The presence of the flag can be confirmed in AQS.

Notify EPA of intent to flag through submission of initial event description by July 1 of calendar year following event (40 CFR 50.14(c)(2)(iii))
In early 2011, APCD and EPA Region 8 staff agreed that the notification of the intent to flag data as an exceptional event would be done by submitting data to AQS with the proper flags and the initial event descriptions. This was deemed acceptable, since Region 8 staff routinely pull the data to review for completeness and other analyses.

On May 11, 2010, three sample values greater than 150 $\mu g/m^3$ were taken at multiple sites across southwestern Colorado during the high wind event that occurred that day. These were the monitors located in Pagosa Springs at the School (SLAMS) and in Alamosa at Adams State College (SLAMS) and the Municipal Building (SLAMS). All three of these monitors are operated by APCD in partnership with local operators.

Document that the public comment process was followed for event documentation (40 CFR 50.14(c)(3)(iv))
APCD posted this report on the Air Pollution Control Division's webpage for public review. APCD opened a 30-day public comment period on May 28, 2013. A copy of the public notice certification, along with any comments received, will be submitted to EPA, consistent with the requirements of 40 CFR 50.14(c)(3)(iv). See Appendix D for a copy of the affidavit of public notice.

Submit demonstration supporting exceptional event flag (40 CFR 50.14(a)(1-2))
At the close of the comment period, and after APCD has had the opportunity to consider any comments submitted on this document, APCD will submit this document, along with any comments received (if applicable), and APCD's responses to those comments, to EPA Region VIII headquarters in Denver, Colorado. The deadline for the submittal of this demonstration package is June 30, 2013.

1.2 Documentation Requirements

Section 50.14(c)(3)(iv) of the EER states that in order to justify excluding air quality monitoring data, evidence must be provided for the following elements:

a. The event satisfies the criteria set forth in 40 CFR 501(j) that:
    (1) the event affected air quality,
    (2) the event was not reasonably controllable or preventable, and
    (3) the event was caused by human activity unlikely to recur in a particular location or was a natural event;

b. There is a clear causal relationship between the measurement under consideration and the event;

c. The event is associated with a measured concentration in excess of normal historical fluctuations; and

d. There would have been no exceedance or violation but for the event.

2.0 Meteorological analysis of the May 11, 2010, blowing dust event and PM_{10} exceedance – Conceptual Model and Wind Statistics

On May 11, 2010, a strong spring storm system caused multiple exceedances of the twenty-four-hour PM_{10} standard in southwest Colorado. Exceedances were recorded at the Pagosa Springs School monitor with a concentration of 200 µg/m^3, the Alamosa Municipal Building monitor with a concentration of 161 µg/m^3 and the Adams State College monitor in Alamosa with a concentration of 160 µg/m^3. These exceedances and other PM_{10} concentrations across Colorado are plotted on the map for May 11, 2010, in Figure 1. These exceedances were the consequence of strong southwesterly prefrontal surface winds over dry soils which caused significant blowing dust across much of Arizona, northwest New Mexico, southeast Utah and southwest Colorado. These strong winds were the result of a strong surface low pressure and cold front associated with an intense upper-level trough that was moving across the western United States. This single storm system caused blowing dust during the afternoon and evening hours of May 11, 2010.

EPA's June 2012 draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule states "the EPA will accept a threshold of a sustained wind of 25 mph for areas in the west provided the agencies support this as the level at which they expect stable surfaces (i.e., controlled anthropogenic and undisturbed natural surfaces) to be overwhelmed..." In addition, in both eastern and western Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust (see reference for the Technical Support Document for the January 19, 2009 Lamar Exceptional Event and Appendix A – Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). For this blowing dust event, it has been assumed that sustained winds of 25 mph and higher or wind gusts of 40 mph and higher can cause blowing dust in northeast Arizona, northwest New Mexico and southwest Colorado.

The surface weather associated with this storm on May 11, 2010, is presented in Figure 2, Figure 3, Figure 4 and Figure 5; the surface analyses for 5 AM MST, 11 AM MST, 5 PM MST and 11 PM MST May 11, 2010 respectively. Significant surface features included a low pressure system that moved from Utah into Colorado, a cold front that traversed the Great Basin and Desert Southwest into the southern Rockies, and a semi-stationary front that drifted slowly southeastward across southern Colorado.

The upper-level trough associated with this storm is shown in Figure 6, Figure 7 and Figure 8. Figure 6 and Figure 7 show the 500-mb height analysis maps for 5 AM and 11 AM MST respectively on May 11, 2010. The 500 mb level is roughly 6 kilometers above mean sea level (MSL). These two maps show that a deep trough was located in the western United States. Figure 7 shows the jet stream maximum winds around the base of the trough from California through Colorado. Figure 8 shows the trough at the 700 mb level which is approximately 3 kilometers above MSL. Upper-level winds at the base of the trough ranged from 40 to 90 knots at 500 mb (Figure 7). Concurrently at the 700 mb level, peak winds approaching 60 knots could be found over the Painted Desert of east-central Arizona (Figure 8).

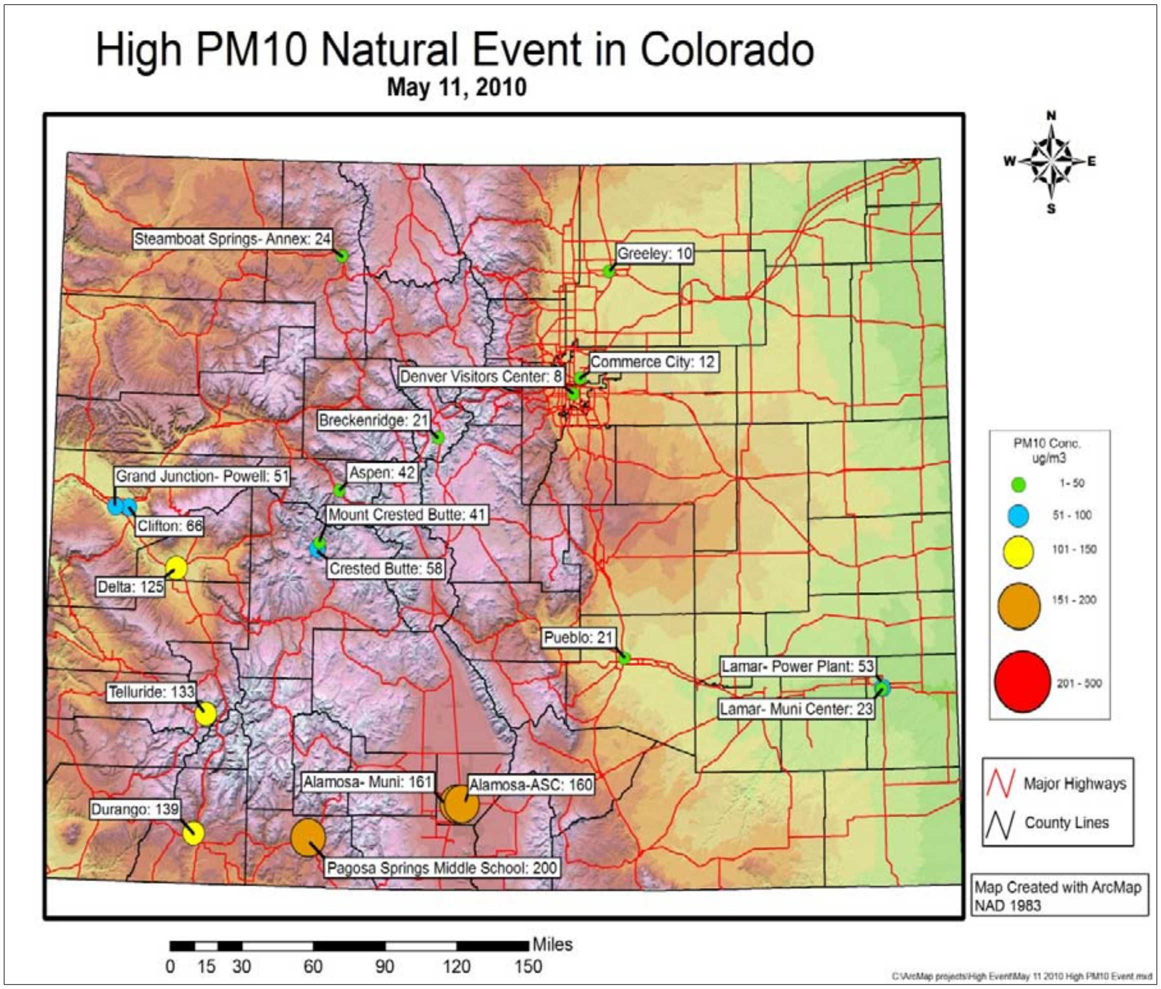

Figure 1: 24-hour PM_{10} concentrations for May 11, 2010.

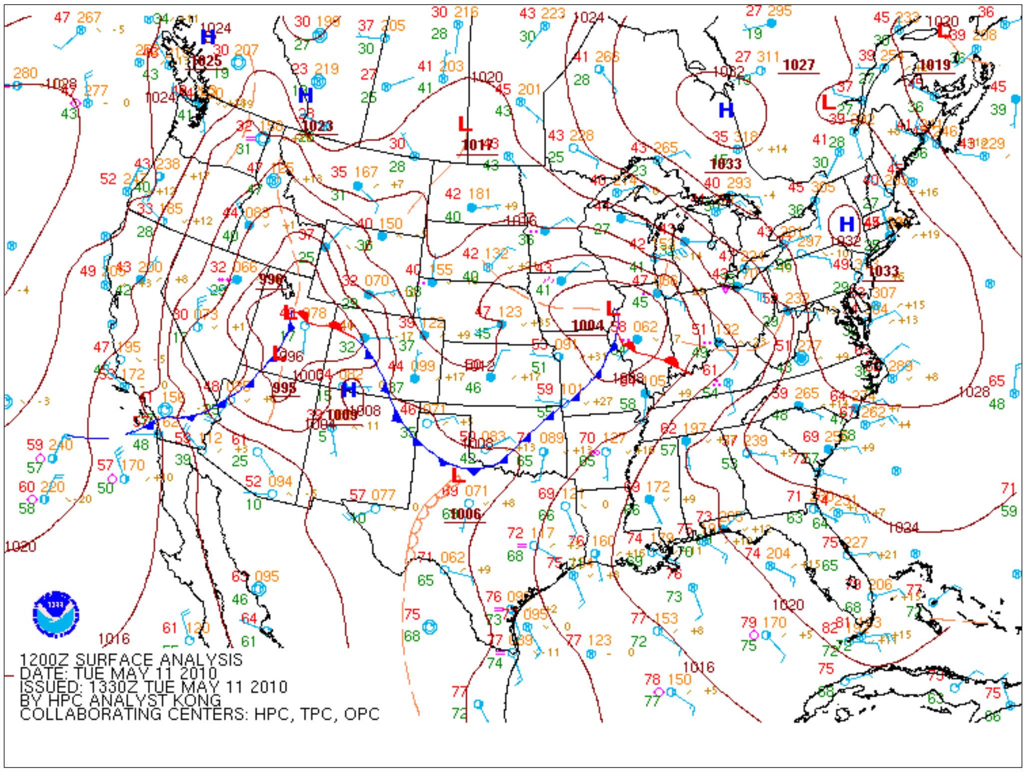

Figure 2: Surface analysis for 12Z May 11, 2010, or 5 AM MST May 11, 2010 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP).

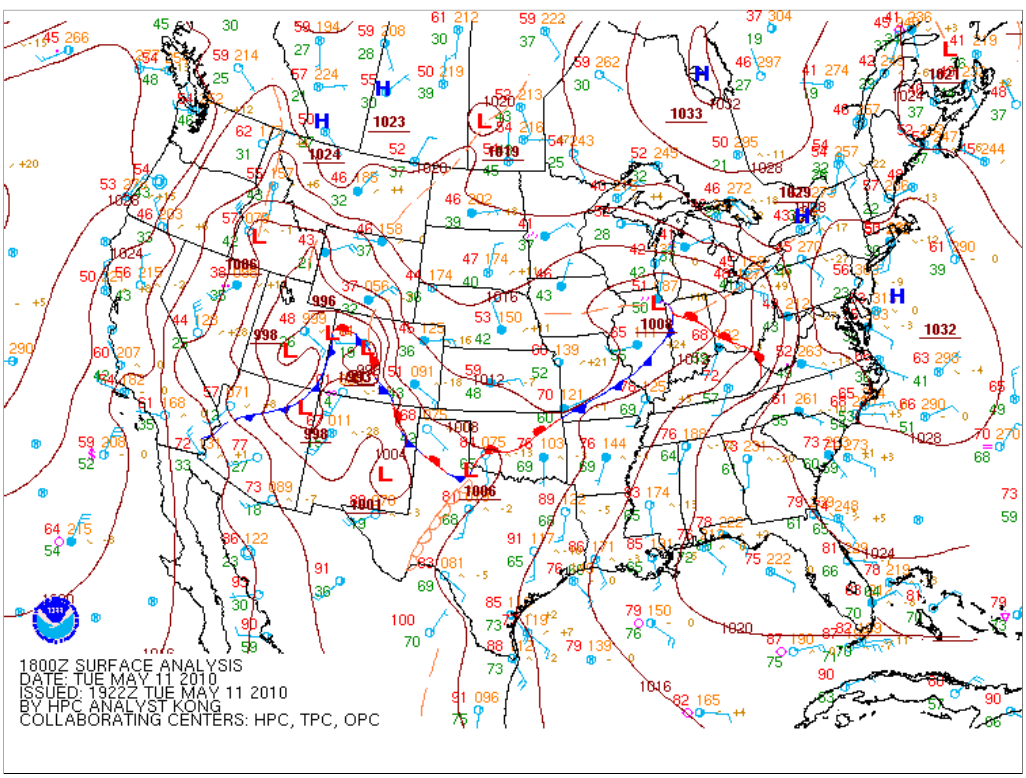

Figure 3: Surface analysis for 18Z May 11, 2010, or 11 AM MST May 11, 2010 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP).

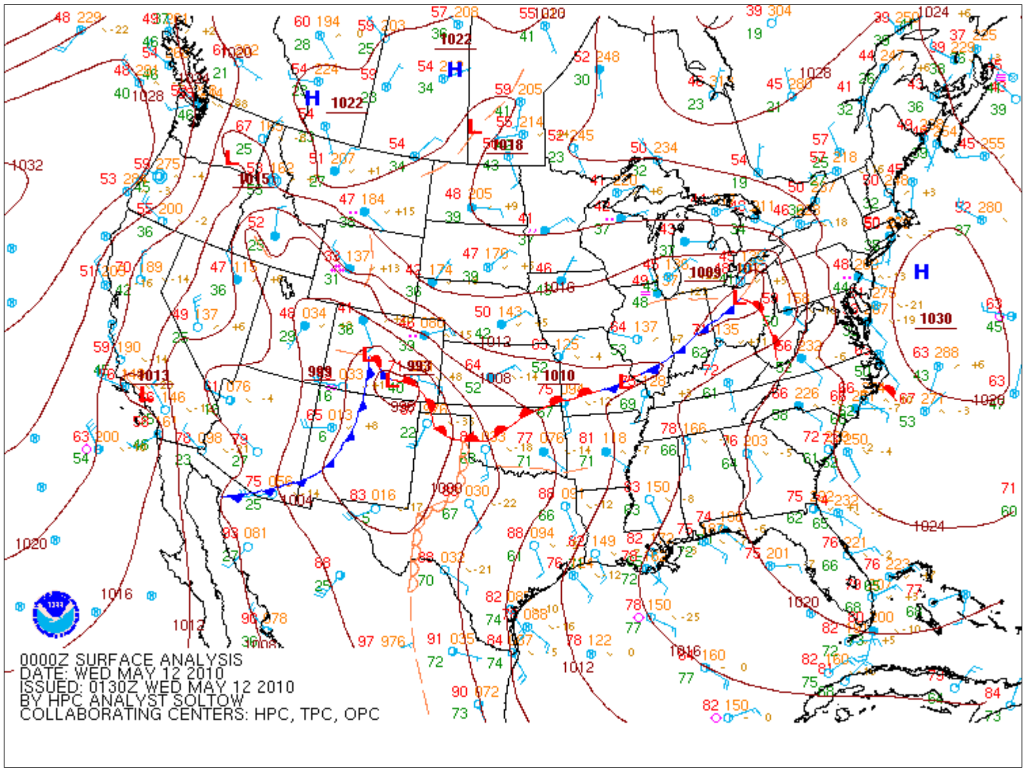

Figure 4: Surface analysis for 00Z May 12, 2010, or 5 PM MST May 11, 2010 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP).

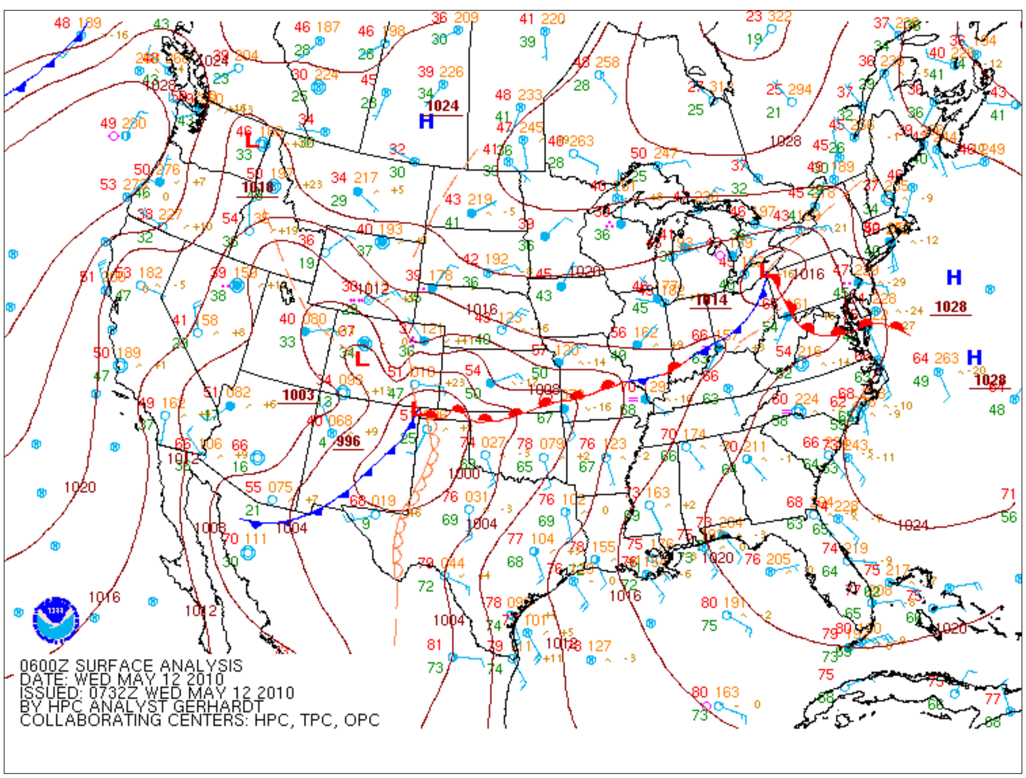

Figure 5: Surface analysis for 06Z May 12, 2010, or 11 PM MST May 11, 2010 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP).

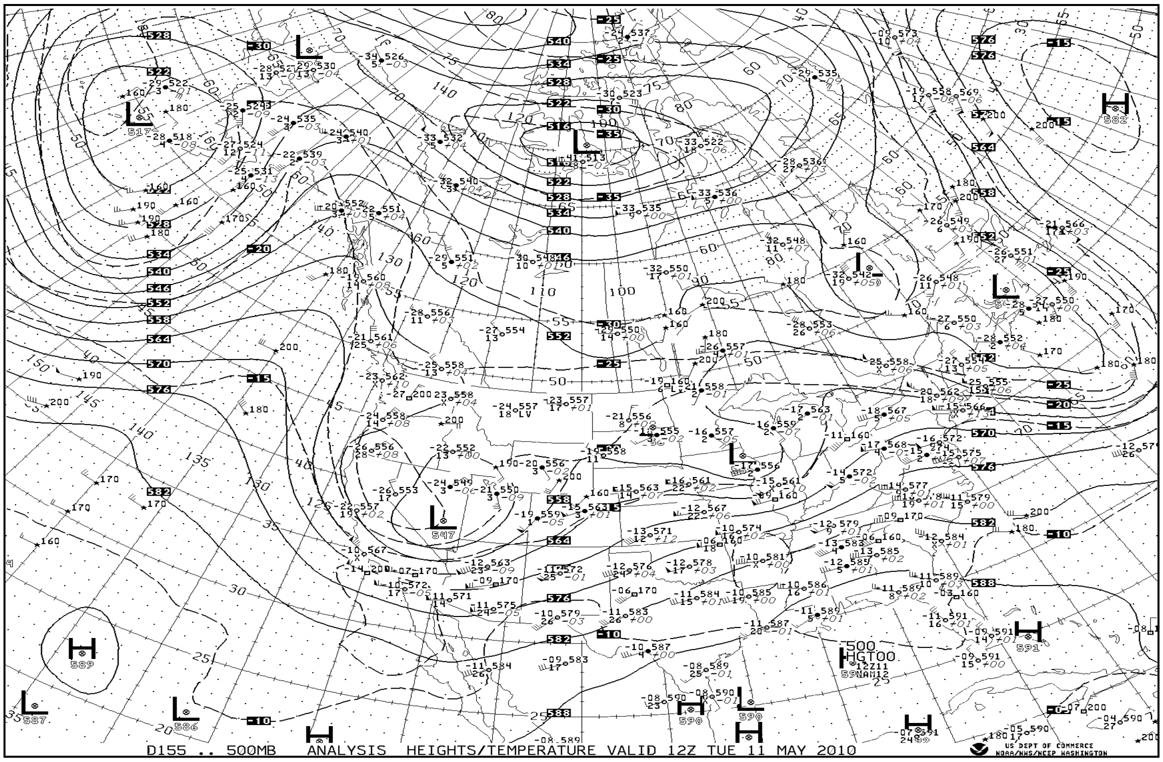

Figure 6: 500 mb (about 6 kilometers above sea level) analysis for 12Z May 11, 2010, or 5 AM MST May 11, 2010 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP).

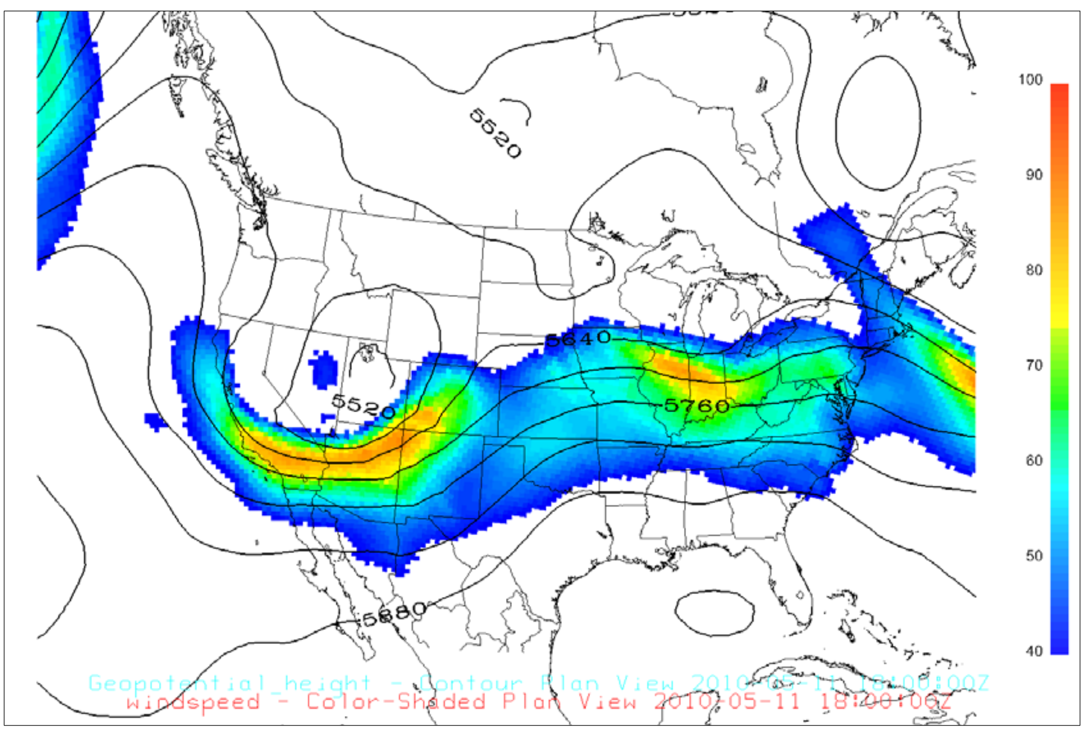

Figure 7: NARR (North American Regional Reanalysis) 500mb (about 6 kilometers above sea level) analysis for 18Z May 11, 2010, or 11 AM MST May 11, 2010, showing wind speeds in knots. Only speeds greater than 40 knots are plotted.

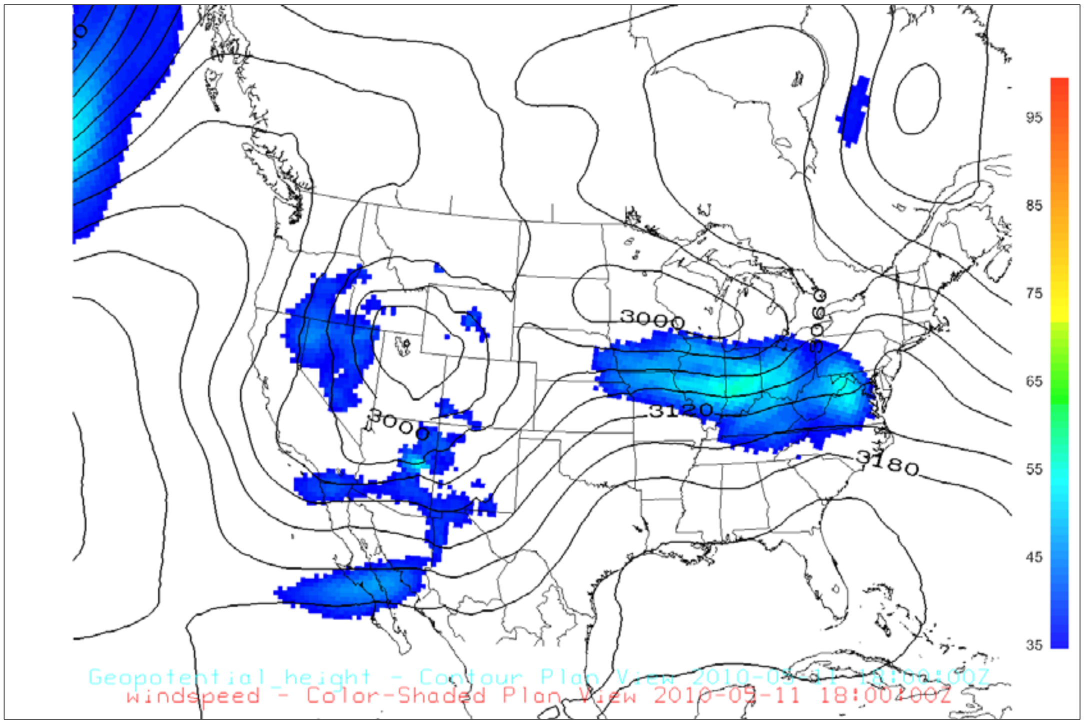

Figure 8: NARR (North American Regional Reanalysis) 700mb (about 3 kilometers above sea level) analysis for 18Z May 11, 2010, or 11 AM MST May 11, 2010, showing wind speeds in knots. Only speeds greater than 35 knots are plotted.

The upper level trough affected winds near the surface in two ways. First of all, the trough generated a surface low pressure system with tight pressure gradients that caused strong winds at the surface. Secondly, momentum associated with the strong winds aloft at the base of the trough was transferred to the surface because of deep vertical mixing in the area of the strong winds aloft. Figure 9 shows the height of the top of the mixed layer above MSL at 11 AM MST on May 11, 2010. Mixing as deep as 4 to 7 kilometers MSL would have been sufficient to transfer momentum to the surface from the zone of strong winds evident at 700 and 500 mb over the Four Corners region and southern Colorado. When blowing dust occurs with strong winds at the surface and aloft along with deep mixing, dust can be suspended for many hours and transported long distances. These conditions are the hallmarks of a regional dust transport event.

Figure 10 and Figure 11 show the winds at 700 mb and the height of the mixed layer respectively at 5 PM MST on May 11, 2010. Both the extent of the wind speed maximum and the depth of the mixing had increased since 11 AM MST, particularly in southern Colorado and northern New Mexico where Figure 10 displays an area of strong 700 mb winds of 35-50 knots. Figure 11 shows that the mixing was as deep as 5 to 10 kilometers above MSL from central Colorado southward into northern New Mexico. This combination of strong winds aloft and deep mixing would have enabled the transfer of momentum from the upper level winds to the surface in these areas.

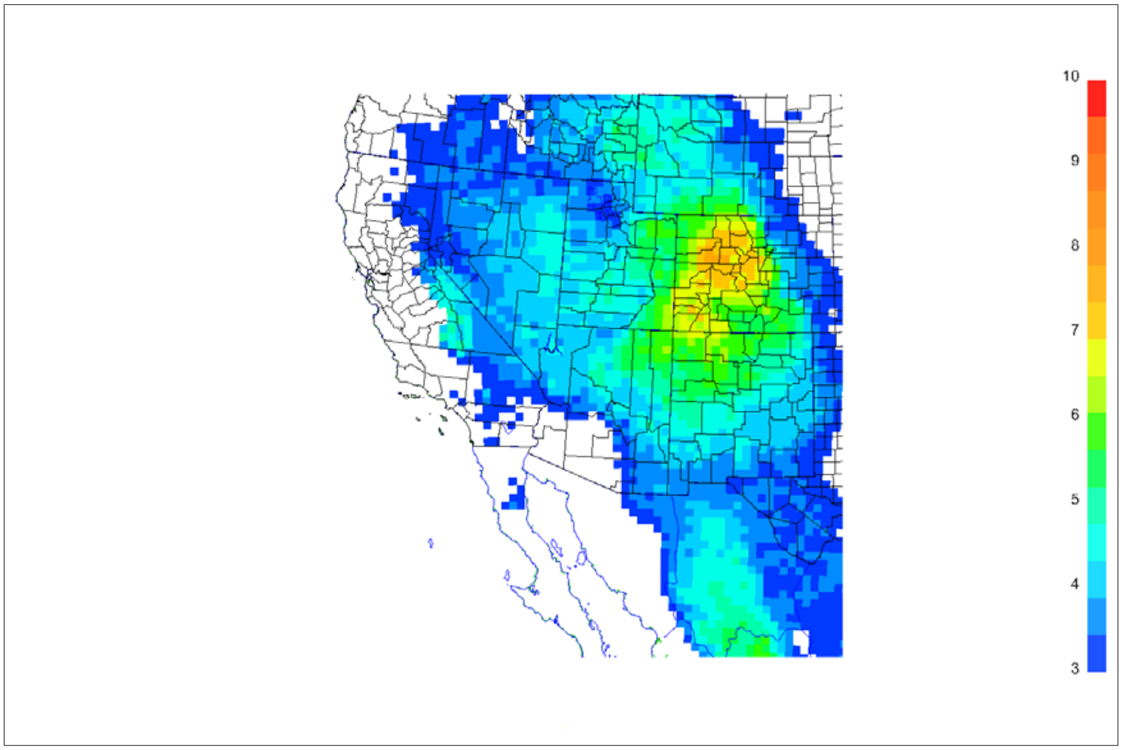

Figure 9: Height of the mixed layer in kilometers above sea level from the NARR analysis at 18Z May 11, 2010, or 11 AM MST May 11, 2010, showing mixing as deep as 4 to 7 kilometers above MSL in the Four Corners area.

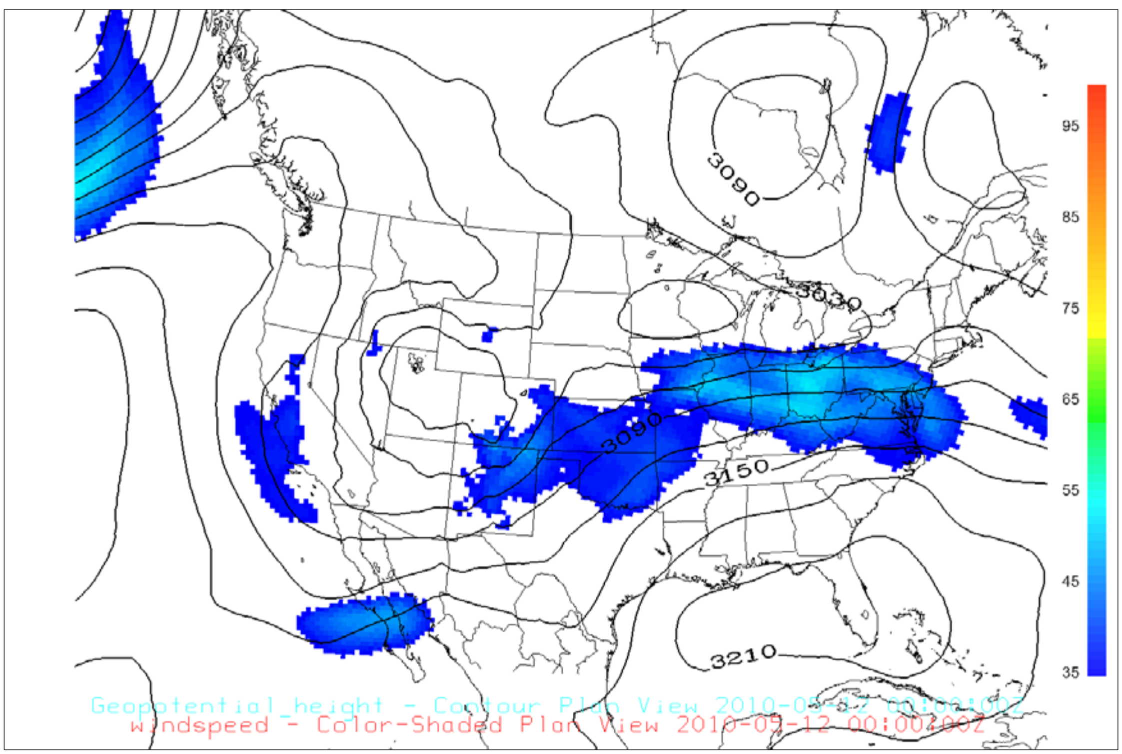

Figure 10: NARR (North American Regional Reanalysis) 700 mb (about 3 kilometers above sea level) analysis for 00Z May 12, 2010, or 5 PM MST May 11, 2010, showing wind speeds in knots. Only speeds greater than 35 knots are plotted.

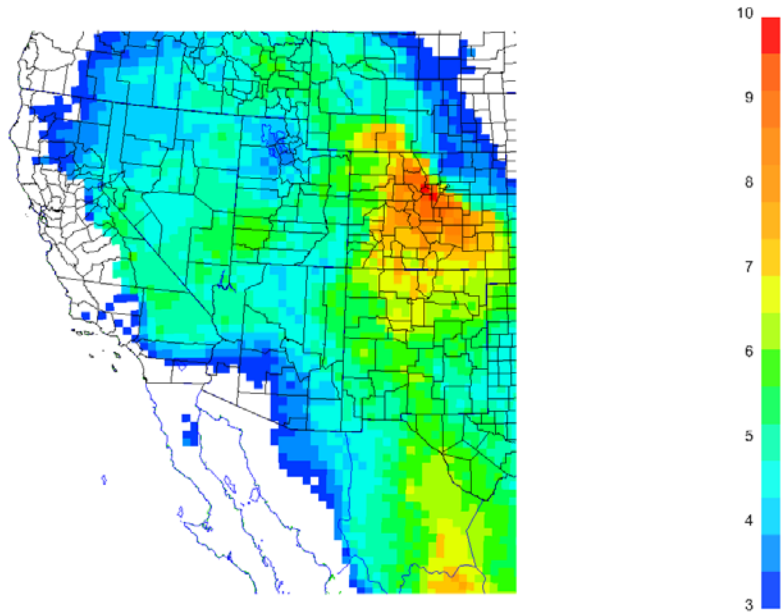

Figure 11: Height of the mixed layer in kilometers above sea level from the NARR analysis at 00Z May 11, 2010, or 5 PM MST May 11, 2010, showing mixing as deep as 4 to 10 kilometers above MSL in the Four Corners area and most of Colorado.

The combination of strong winds aloft, deep mixing and the tight surface pressure gradient associated with the surface low pressure system caused sustained surface winds of up to 43 mph with gusts to 58 mph. Winds of this strength will cause blowing dust if soils are dry. Recall that wind speeds of 30 mph or greater and/or gusts of 40 mph or higher have been shown to cause blowing dust in Colorado (see reference for the *Technical Support Document for the January 19, 2009, Lamar Exceptional Event* and Appendix A - Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). ***The synoptic weather conditions on May 11, 2010, (illustrated in Figures 2 through 11) show that the conditions necessary for widespread strong gusty winds and transport of blowing dust were in place over the area of concern.***

Figure 12, Figure 13 and Figure 14 show surface weather observations for 11:43 AM MST, 3:43 PM MST, and 7:43 MST May 11, 2010, respectively. These maps cover Colorado and the areas of Arizona and New Mexico that were upwind of the portions of Colorado that experienced exceedances of the PM_{10} standard. These surface analyses shows that winds above 30 mph with gusts above 40 mph occurred in areas south of the stationary front and surface low pressure complex shown on Figures 2-5. On the map in Figure 12, the station plot for Durango, CO (DRO) at 11:43 AM MST is accompanied by the infinity sign (∞) which is the weather symbol for haze. Haze is often reported during dust storms, and in dry and windy conditions haze typically refers to blowing dust. By 3:43 PM MST (Figure 13), the station observation for Chama, NM (E33) just a few miles south of the Colorado state line shows a dollar sign ($). The dollar sign is the weather symbol for dust or sand raised by wind at the time of the observation. It should also be noted from Figure 13 that haze had increased in southwest Colorado with haze reported in Montrose (MTJ) and Wolf Creek Pass at Pagosa Springs (CPW), while continuing in

Durango (DRO) with visibility reduced to 2 miles. Even as the event began to taper off during the evening hours of May 11, 2010, haze could be found in Alamosa, CO (ALS) at 7:43 MST (Figure 14). Additional surface weather maps not included here show that haze and blowing dust were reported in other parts of Arizona, New Mexico and southwest Colorado during the afternoon and evening hours of May 11, 2010. ***Surface weather maps for the Four Corners states show evidence of widespread blowing dust and winds above the threshold speeds for blowing dust on May 11, 2010.***

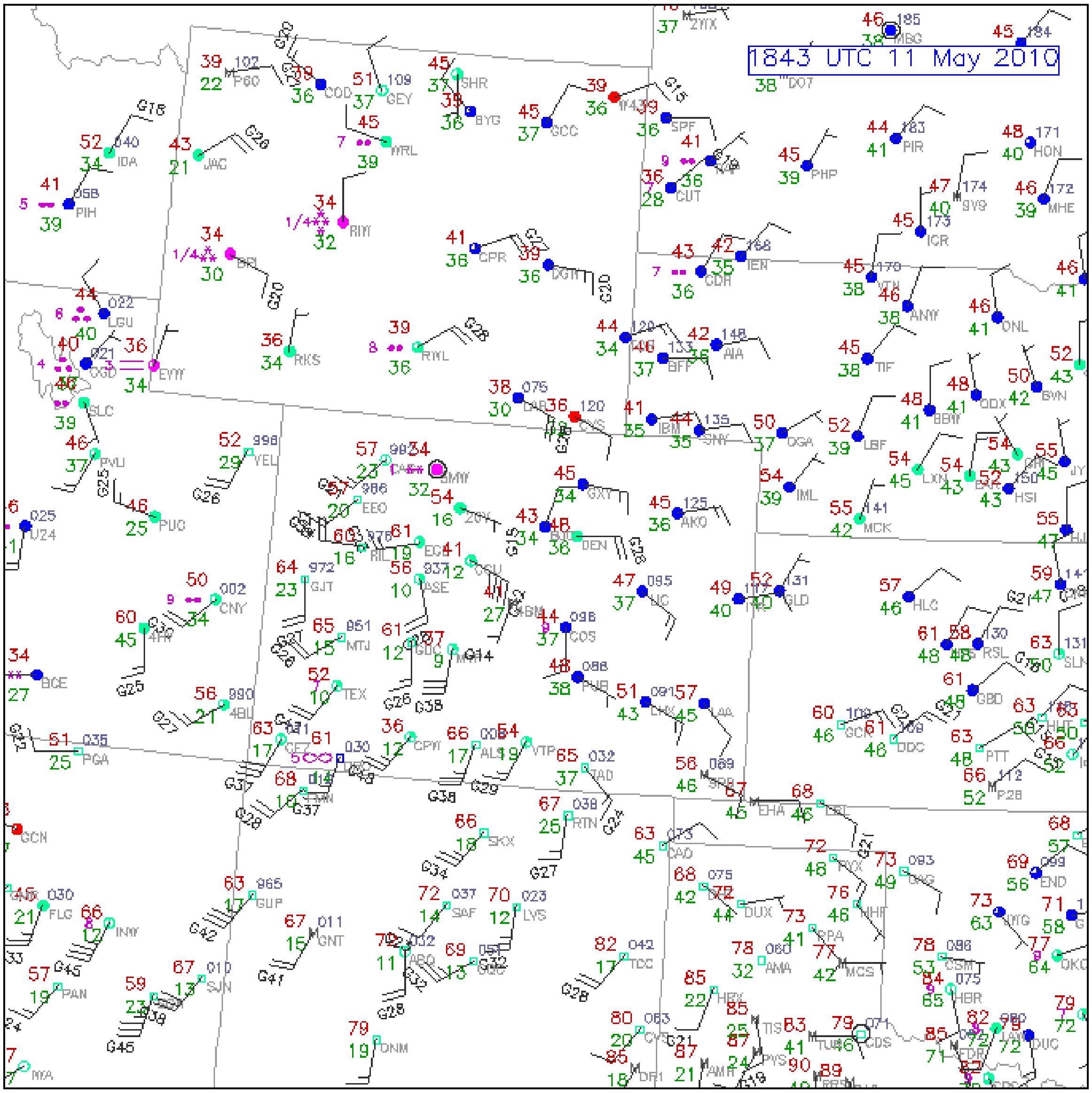

Figure 12: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 1843Z May 11, 2010, or 11:43 AM MST May 11, 2010 (source: http://www.rap.ucar.edu/weather/).

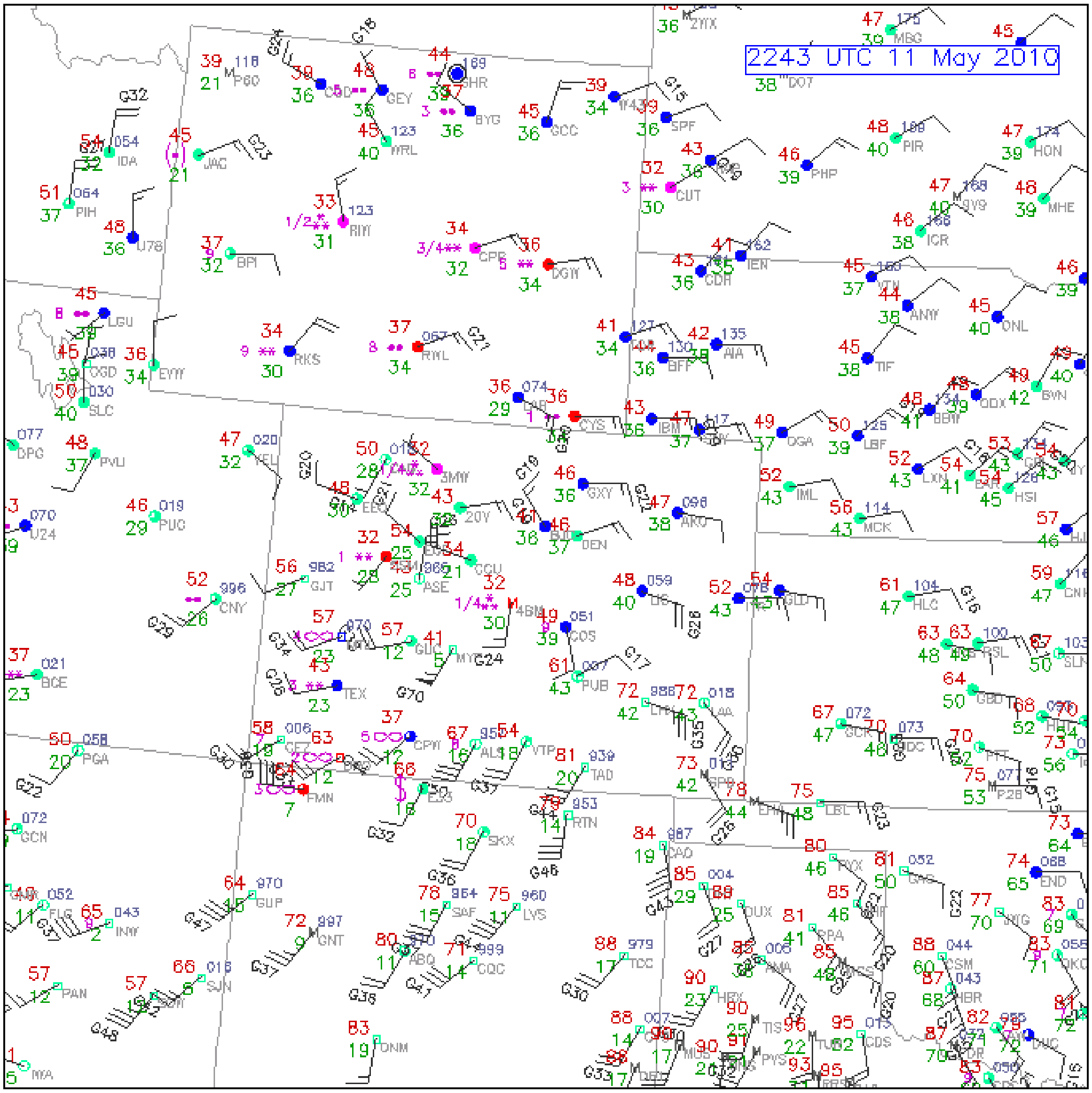

Figure 13: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 2243Z May 11, 2010, or 3:43 PM MST May 11, 2010 (source: http://www.rap.ucar.edu/weather/).

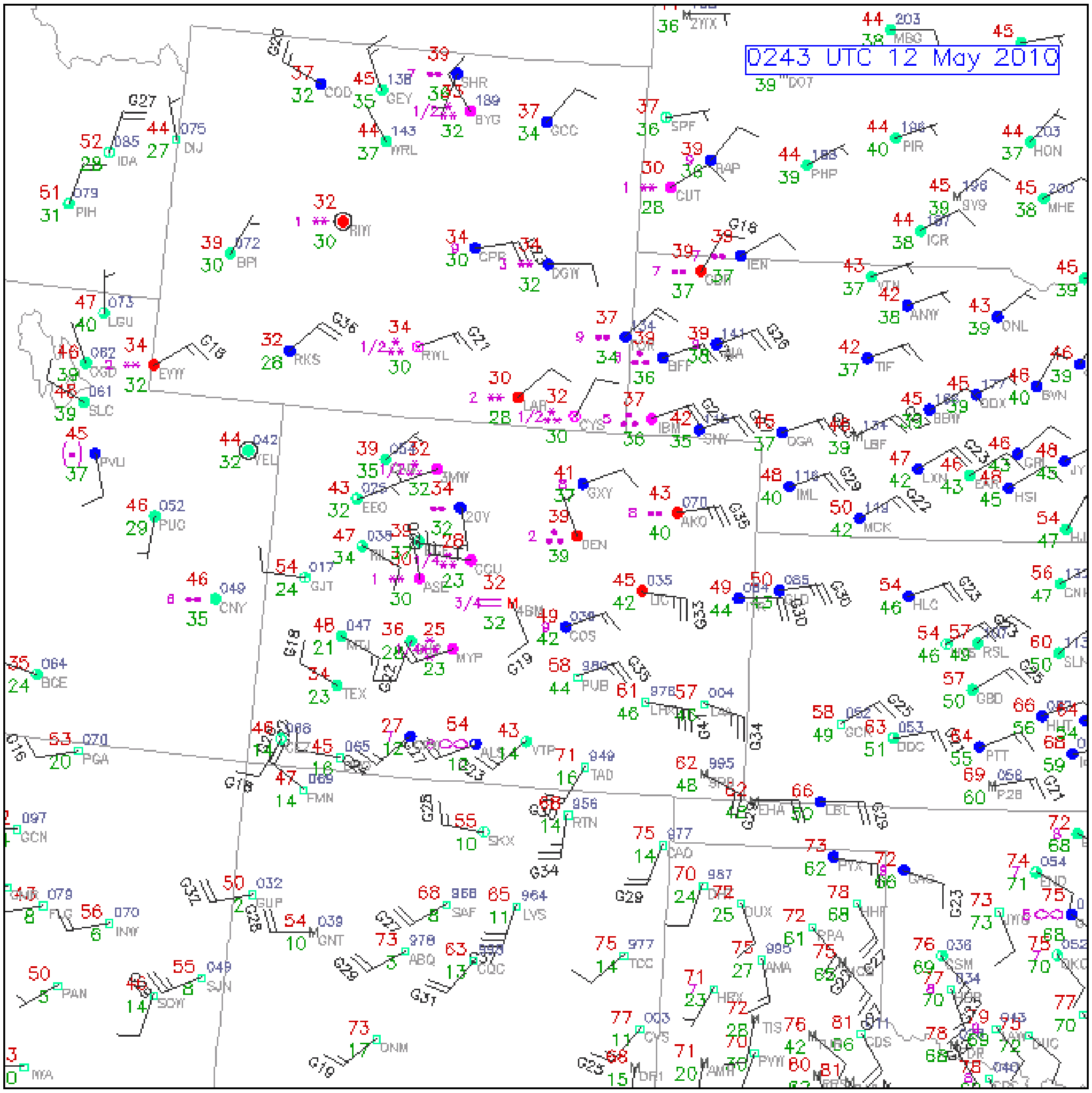

Figure 14: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 0243Z May 12, 2010, or 7:43 PM MST May 11, 2010 (source: http://www.rap.ucar.edu/weather/).

Tables 1 through 5 contain the surface weather observations for Winslow, Hopi, and Window Rock, Arizona, and Gallup and Farmington, New Mexico, for May 11, 2010. These locations are either in or near the areas in northeast Arizona and northwest New Mexico that are known sources for blowing dust as described in Appendix A (Grand Junction, Colorado, Blowing Dust Climatology - at the end of this document). At these locations wind speeds were as high as 43 mph and wind gusts were as high as 58 mph, and these are well above the blowing dust thresholds already identified. Tables 6 through 10 list observations for Cortez, Durango, Montrose, Alamosa, and Pagosa Springs, respectively. These are the National Weather Service sites in Colorado south of the stationary front in Figures 2-4. These sites also experienced many hours of reduced visibility along with wind speeds and gusts at or above the thresholds for blowing dust. ***Observations of wind speeds and gust speeds above the blowing dust thresholds and reduced visibilities on May 11, 2010, at weather stations in northeast Arizona, northwest***

New Mexico, and southwest Colorado show that a regional dust storm event occurred under southwesterly flow. The weather system causing the winds affected southwest Colorado during the afternoon and evening hours on May 11, 2010. These observations contribute to the body of evidence that shows that a regional dust storm caused the PM_{10} exceedances at the monitoring sites in question.

Table 1: Wind and weather observations for Winslow, Arizona, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:56	51	27	6		120		10
1:56	48	27	4		170		10
2:56	51	24	12		180		10
3:56	51	24	14		160		10
4:56	52	28	16		170		10
5:56	53	29	22	38	180		10
6:56	56	25	23	35	200		10
7:56	59	21	20	40	200		10
8:56	62	18	23	31	200		10
9:56	64	14	36	53	200	haze	5
10:56	66	11	28	52	220	haze	6
10:59	66	12	41	54	220	haze	2.5
11:25	66	12	38	52	210		8
11:56	66	12	29	45	220		10
12:17	64	12	43	58	230	haze	1.75
12:26	66	12	36	52	220	haze	3
12:56	66	10	33	46	210		10
13:56	65	10	31	51	230		9
14:56	65	8	35	43	250		9
15:56	63	7	33	47	240		8
16:56	61	10	29	40	240		10
17:56	60	11	20	30	260		10
18:56	56	13	16		260		10
19:56	51	17	10		250		10
20:56	47	19	10		270		10
21:56	45	22	9		280		10
22:56	40	26	4		230		10
23:56	38	30	9		250		10

Table 2: Wind and weather observations for Hopi, Arizona, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:13	47	26	15	20	194		
1:13	44	28	4	20	201		
2:13	46	29	10	15	204		
3:13	46	28	16	22	196		
4:13	45	29	17	23	179		
5:13	44	31	13	22	180		
6:13	47	30	16	23	186		
7:13	52	29	31	40	204		
8:13	55	24	33	44	208		
9:13	57	18	29	41	228		
10:13	59	15	29	42	238		
11:13	61	13	31	46	234		
12:13	58	16	27	45	277		
13:13	60	13	28	46	261		
14:13	56	18	31	46	279		
15:13	56	17	31	45	274		
16:13	54	14	29	47	286		
17:13	53	14	24	43	286		
18:13	53	15	17	32	291		
19:13	49	16	9	25	310		
20:13	43	20	6	13	327		
21:13	39	24	3	5	247		
22:13	34	27	4	5	66		
23:13	31	29	3	7	19		

Table 3: Wind and weather observations for Window Rock, Arizona, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	45	24	4				10
1:53	44	25	7		210		10
2:53	42	29	6		160		10
3:53	42	30	5		170		10
4:53	42	31	7		200		10
5:53	42	31	7	16	190		10
6:53	44	28	13	20	190		10
8:53	52	24	22	37	220		10
9:53	54	24	31	41	200		10
10:53	57	21	29	48	200		10
11:53	59	19	36	54	220		10
12:53	61	19	35	51	220		10
13:53	62	17	38	48	230		10
14:53	64	14	31	50	220		10
15:53	61	14	32	47	230		7
16:53	58	12	33	46	240		10
17:53	56	14	33	45	240		10
18:53	51	12	23	41	250	haze	6
19:53	47	17	17	27	290		10
20:53	43	19	8	17	280		10
21:53	39	24	0				10
22:53	35	29	4		20		10
23:53	33	31	5		360		10

Table 4: Wind and weather observations for Gallup, New Mexico, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	49	19	17	24	220		10
1:53	46	22	12		210		10
2:53	45	23	12		210		10
3:53	45	25	14		210		10
4:53	45	26	15		200		10
5:53	45	27	13		210		10
6:53	46	25	14	21	200		10
7:53	51	22	17	30	210		10
8:53	55	20	29	40	210		10
9:53	58	18	29	50	220		10
10:53	61	17	36	48	220		10
11:53	63	17	38	48	220		10
12:53	65	16	36	51	220		10
13:53	65	16	30	50	220		10
14:53	65	15	40	55	240		10
15:53	64	15	40	54	230		10
16:53	62	14	32	51	240		10
17:53	58	13	37	48	260		10
18:53	54	15	31	40	240		10
19:53	50	14	24	37	260		10
20:53	45	19	13		270		10
21:53	42	20	9		270		10
22:53	36	27	0				10
23:53	33	31	0				10

Table 5: Wind and weather observations for Farmington, New Mexico, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	51	20	6		240		10
1:53	46	25	5				10
2:53	55	13	4				10
3:53	42	27	8		30		10
4:53	48	21	4				10
5:44	50	20	9	21	160		10
5:53	50	20	8		180		10
6:53	52	20	25	33	170		10
7:53	55	16	23	31	170		10
8:53	58	15	22	29	190		10
9:53	61	14	22	35	180		10
10:53	65	14	22	30	180		10
11:53	68	10	22	32	230		10
12:53	70	10	20	29	230		10
13:53	71	10	25	32	200		10
14:53	72	9	31	44	230	haze	6
15:31	70	8	24	37	270	haze	3
15:34	70	8	23	37	280	haze	2.5
15:53	67	8	28	43	250	haze	2
16:31	64	10	32	44	280	haze	3
16:53	64	11	25	43	260	haze	5
17:53	54	20	31	43	300		7
18:53	51	24	18	33	300		9
19:53	47	26	22	30	310		10
20:53	45	26	8		300		10
21:53	42	29	5		300		10
22:53	41	29	0				10
23:53	34	38	0				10

Table 6: Wind and weather observations for Cortez, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	52	26	13		200		10
1:53	51	24	15		200		10
2:53	50	23	13	23	220		10
3:53	47	25	4		200		10
4:53	38	39	5		80		10
5:53	41	33	0				10
6:53	47	26	24	30	140		10
7:53	51	24	18	33	130		10
8:53	55	22	23	30	150		10
9:53	59	20	25	35	190		10
10:53	62	19	25	36	210		10
11:53	63	17	36	43	210		10
12:53	65	18	30	43	200		10
13:53	64	15	27	37	220	haze	5
14:13	63	17	22	36	250	haze	2.5
14:20	61	20	23	32	250	haze	3
14:53	60	22	21	32	240	haze	6
15:53	58	22	18	35	240		7
16:53	52	27	24	32	260		10
17:53	49	28	16	25	260		10
18:53	48	31	17	29	270		10
19:53	46	27	10	21	210		10
20:53	42	33	8		210		10
21:53	33	49	6		40		10
22:53	34	47	4				10
23:53	30	58	6		60		10

Table 7: Wind and weather observations for Durango, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	37	42	4.6				10
1:53	38	40	8		80		10
2:53	35	45	5		40		10
3:53	37	40	9		60		10
4:53	37	38	6		90		10
5:53	34	45	7		80		10
6:53	37	42	6		80		10
7:53	45	34	9		90		10
8:53	50	25	6		100		10
9:53	57	16	23	37	200		10
10:53	59	17	25	36	190		10
11:53	61	16	28	43	200	haze	5
12:53	62	14	25	45	200	haze	5
13:53	63	15	30	43	210		7
14:53	63	15	20	39	210		10
15:53	63	14	29	43	250	haze	3
16:01	63	14	27	38	240	haze	2
16:41	57	18	27	38	270	haze	4
16:53	56	19	22	35	260	haze	4
17:53	53	23	25	37	270	haze	6
18:53	49	26	23	30	260		9
19:53	45	31	14	25	280		10
20:53	42	34	9		290		10
21:53	39	39	0				10
22:53	36	42	4		220		10
23:53	34	41	0				10

Table 8: Wind and weather observations for Montrose, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	54	22	6		110		10
1:53	60	14	10	25	170		10
2:53	54	22	0				10
3:53	57	17	4		220		10
4:53	51	27	0				10
5:53	48	30	10		110		10
6:53	47	33	9		140		10
7:53	54	26	9		100		10
8:53	60	19	7				10
9:53	63	16	18	30	230		10
10:53	65	14	18	38	230		10
11:53	65	14	22	30	240		10
12:53	66	13	33	47	250		10
13:53	66	13	24	40	250		10
14:53	63	17	23	45	240		10
15:53	57	27	23	39	250	haze	4
16:53	49	48	10	25	250		10
17:53	52	36	12		160		10
18:53	52	26	17	29	250		10
19:29	48	32	12	24	200		10
19:53	48	34	15	25	120		10
20:53	46	37	14	25	170		10
21:53	46	30	17	38	200		9
22:53	43	30	9		180		10
23:53	42	30	7		190		10

Table 9: Wind and weather observations for Alamosa, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:52	37	40	8		120		10
1:52	33	51	0				10
2:52	35	49	9		140		10
3:52	42	29	16		200		10
4:52	42	25	13		190		10
5:52	37	37	12		140		10
6:52	42	30	8		180		10
7:52	50	17	16	23	190		10
8:52	55	17	21	29	200		10
9:52	59	17	22	37	210		10
10:52	62	17	23	39	210		10
11:52	66	15	29	44	200		10
12:52	67	14	36	50	210		10
13:52	68	10	32	51	230		8
14:52	69	11	37	54	210		10
15:35	70	12	41	58	200	haze	2.5
15:50	66	14	35	52	220		9
15:52	67	14	43	58	210		8
16:52	67	14	31	41	190		10
17:52	67	10	32	44	240		10
18:52	61	14	30	50	230		8
19:52	55	19	20	32	240		7
20:24	54	19	24	31	250	haze	6
20:52	51	21	23	31	250	haze	6
21:07	50	22	16	28	240		7
21:52	46	24	12		220		9
22:52	41	30	8		230		10
23:52	43	26	12	29	230		10

Table 10: Wind and weather observations for Pagosa Springs, Colorado, reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 11, 2010. Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time MST May 11	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
3:15	34	47	5		10		10
4:15	36	41	4		20		10
5:15	32	51	0				10
6:15	32	43	6		20		10
7:15	36	35	5		30		10
8:15	41	28	5		20		10
9:15	45	26	5		10		10
10:15	52	17	7	16	210		10
10:55	55	15	24	40	190		10
11:15	55	15	27	36	180		10
12:15	59	11	22	35	200		10
13:15	61	11	21	30	190		10
14:15	63	10	23	35	230		10
14:35	63	10	21	38	220		7
14:55	61	11	21	40	230	haze	5
15:15	61	11	18	41	220	haze	4
15:35	61	12	21	37	220	haze	4
15:55	61	11	29	45	230	haze	4
16:15	59	11	29	52	220	haze	4
16:35	61	11	24	43	220	haze	4
16:55	59	11	28	48	220	haze	5
17:15	57	14	30	45	210	haze	5
17:35	55	12	25	35	240	haze	2.5
17:55	54	14	23	30	250	haze	2.5
18:15	52	19	22	29	260	haze	3
18:35	50	20	17	25	250	haze	4
18:55	50	22	16	28	250	haze	4
19:15	50	22	17	28	240	haze	5
19:35	48	23	10		230	haze	5
19:55	46	25	14	20	220	haze	5
20:15	45	26	15	27	230	haze	5
20:35	43	26	14	23	230		7
20:55	43	28	10	20	230		7
21:15	43	28	12		240		10
22:15	39	35	9		220		10
23:15	37	35	8		200		10

The Albuquerque, Flagstaff, and Grand Junction National Weather Service Forecast Offices issue weather warnings and advisories for northeast Arizona, most of New Mexico, eastern Utah, and western and southwest Colorado. The weather warnings and advisories issued by theses offices for May 11, 2010, are presented in Appendix B. These warnings and advisories show that strong winds and areas of blowing dust were expected and experienced across this region on May 11, 2010.

Figure 15 shows the NOAA HYSPLIT 24-hour forward matrix trajectories (Draxler and Rolph, 2012) for northeast Arizona and northwest New Mexico starting at 5 PM MST May 10, 2010, (see the following link for more information on HYSPLIT: http://ready.arl.noaa.gov/HYSPLIT.php). This analysis shows transport of air from this region into Colorado on May 11, 2010. HYSPLIT 12-hour back trajectories for 2 PM MST May 11, 2010, for Alamosa and Pagosa Springs, are presented in Figure 16 and Figure 17, respectively. These figures also show that Arizona and northwest New Mexico were source regions for air transported into Colorado on May 11, 2010. ***NOAA HYSPLIT forward and backward trajectories provide clear supporting evidence that dust from desert regions of Arizona and northwest New Mexico caused the PM_{10} exceedances measured across portions of southwest Colorado on May 11, 2010.***

Figure 18 shows the output for blowing dust from the Navy Aerosol Analysis and Prediction System (NAAPS) Global Aerosol Model for 5 PM MST May 11, 2010, (00Z May 12), 2010 (source: http://www.nrlmry.navy.mil/aerosol-bin/aerosol/display_directory_all?DIR=/web/aerosol/public_html/globaer/ops_01/wus/). The NAAPS system models blowing dust emissions and transport based on soil moisture content, soil erodibility factors, and a variety of meteorological factors known to be conducive to blowing dust (for a description of NAAPS see: http://www.nrlmry.navy.mil/aerosol_web/Docs/globaer_model.html).

The forecast panel in the lower left of Figure 18 shows blowing dust generation over northeast Arizona, northwest New Mexico and portions of southeast Utah. The NAAPS model can overestimate dust emissions, and in this case it shows high concentrations of dust in southeast Colorado that were not actually observed. The model output, however, does suggest that the Four Corners areas of Arizona, New Mexico, and Utah were major source regions for blowing dust on May 11, 2010. ***Forecast products from the Navy Aerosol Analysis and Prediction System model provide evidence for a widespread blowing dust event in the Four Corners states, suggesting that significant source regions for dust in Colorado were located in arid regions of Arizona, Utah, and New Mexico.***

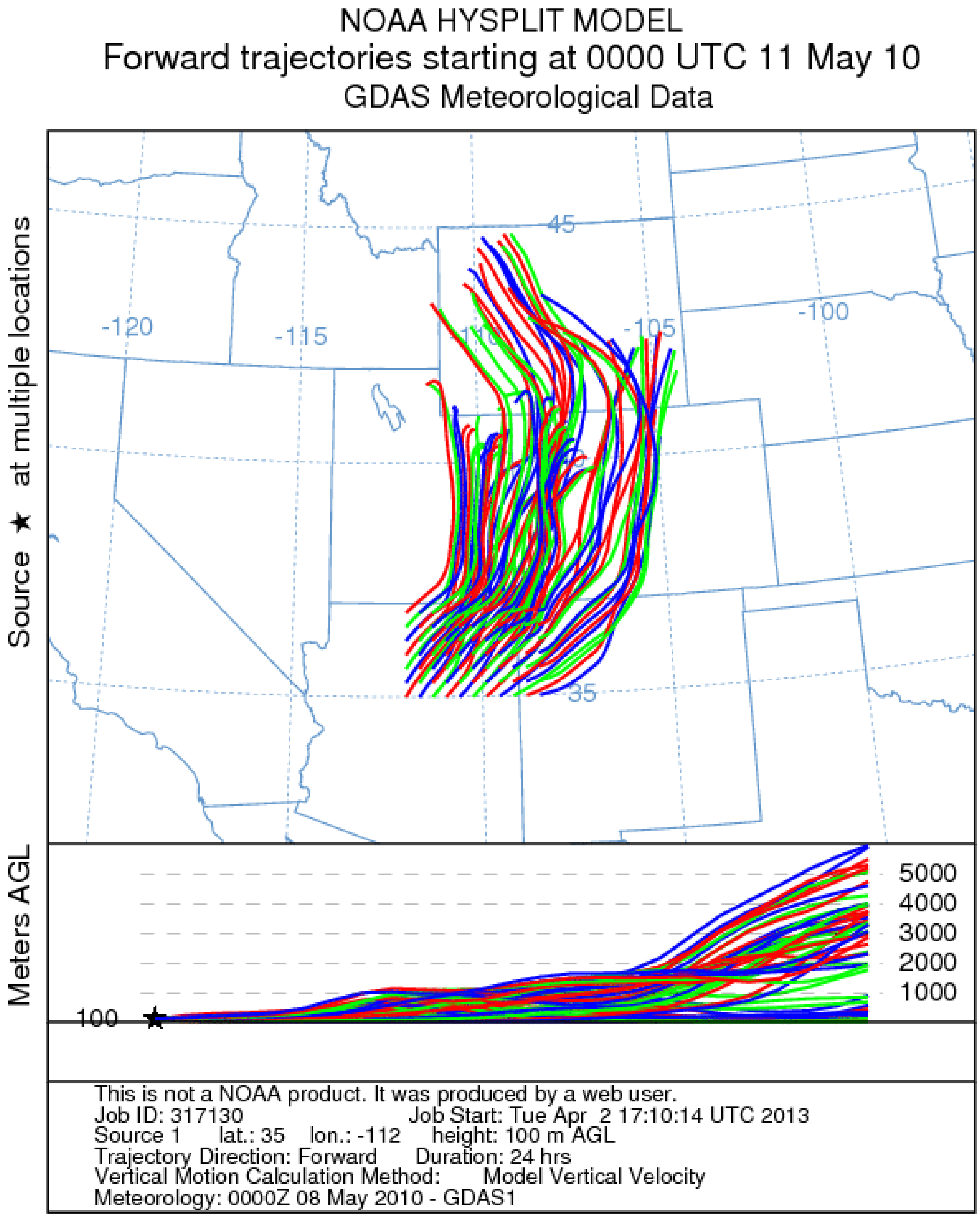

Figure 15: NOAA HYSPLIT 24-hour forward trajectories for northeast Arizona and northwest New Mexico for 5 PM MST May 10 (00Z May 11), 2010, (source: NOAA Air Resources Laboratory at: http://ready.arl.noaa.gov/HYSPLIT.php).

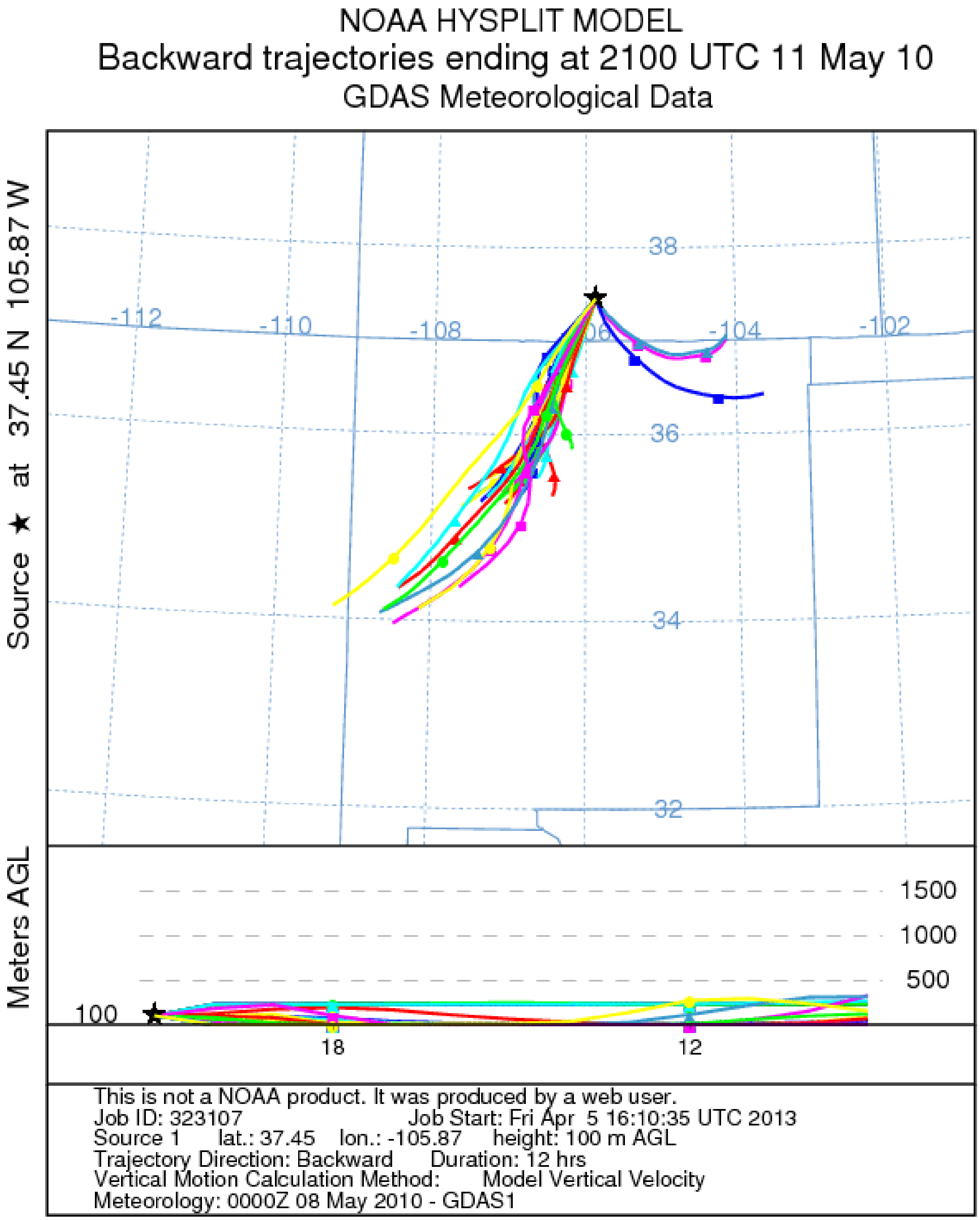

Figure 16: NOAA HYSPLIT 12-hour back trajectories for Alamosa, Colorado, for each hour from 2 AM MST May 11, 2010, to 2 PM MST May 11 (21Z May 11), 2010 (source: NOAA Air Resources Laboratory at: http://ready.arl.noaa.gov/HYSPLIT.php).

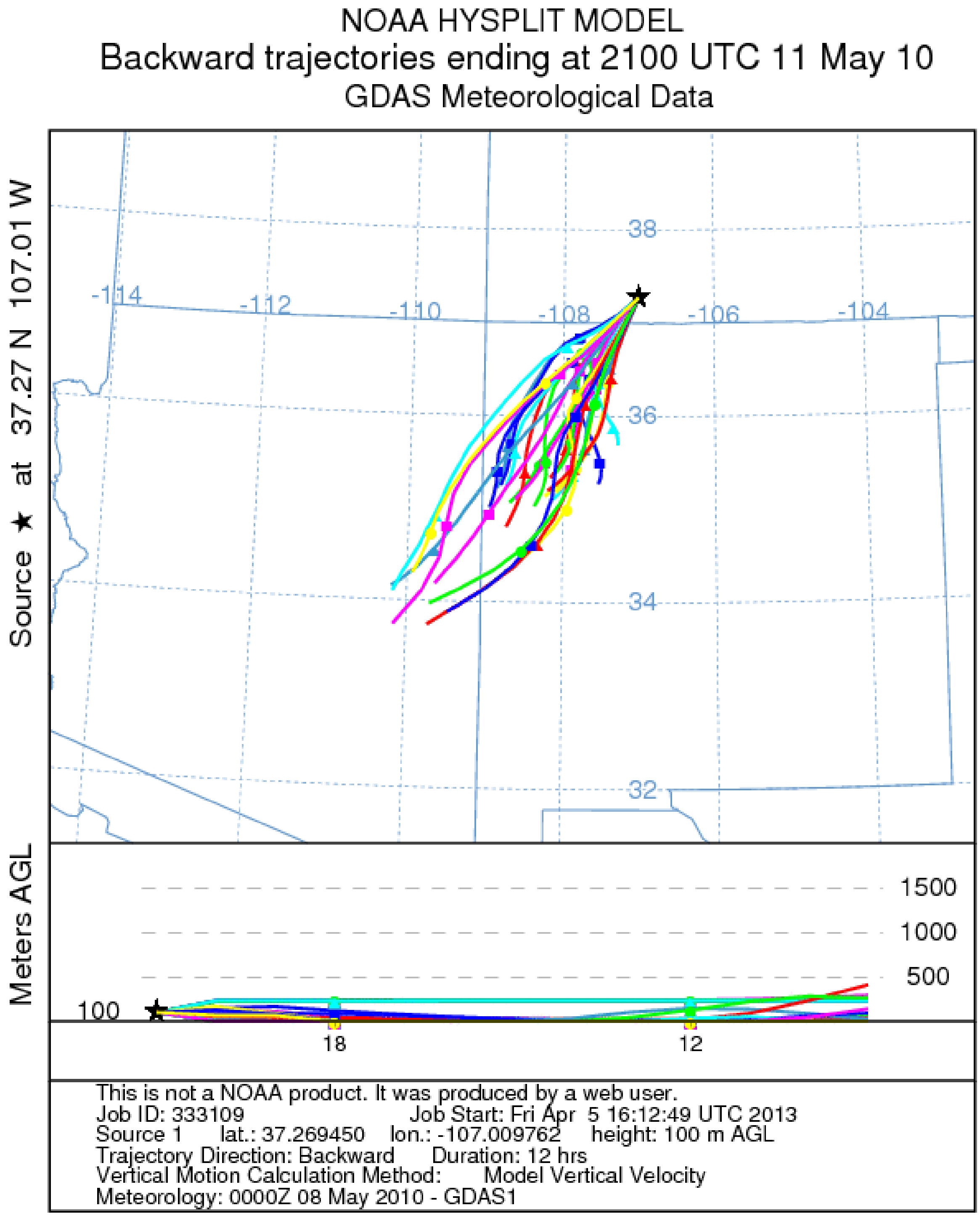

Figure 17: NOAA HYSPLIT 12-hour back trajectories for Pagosa Springs, Colorado, for each hour from 2 AM MST May 11, 2010, to 2PM MST May 11 (21Z May 11), 2010 (source: NOAA Air Resources Laboratory at: http://ready.arl.noaa.gov/HYSPLIT.php).

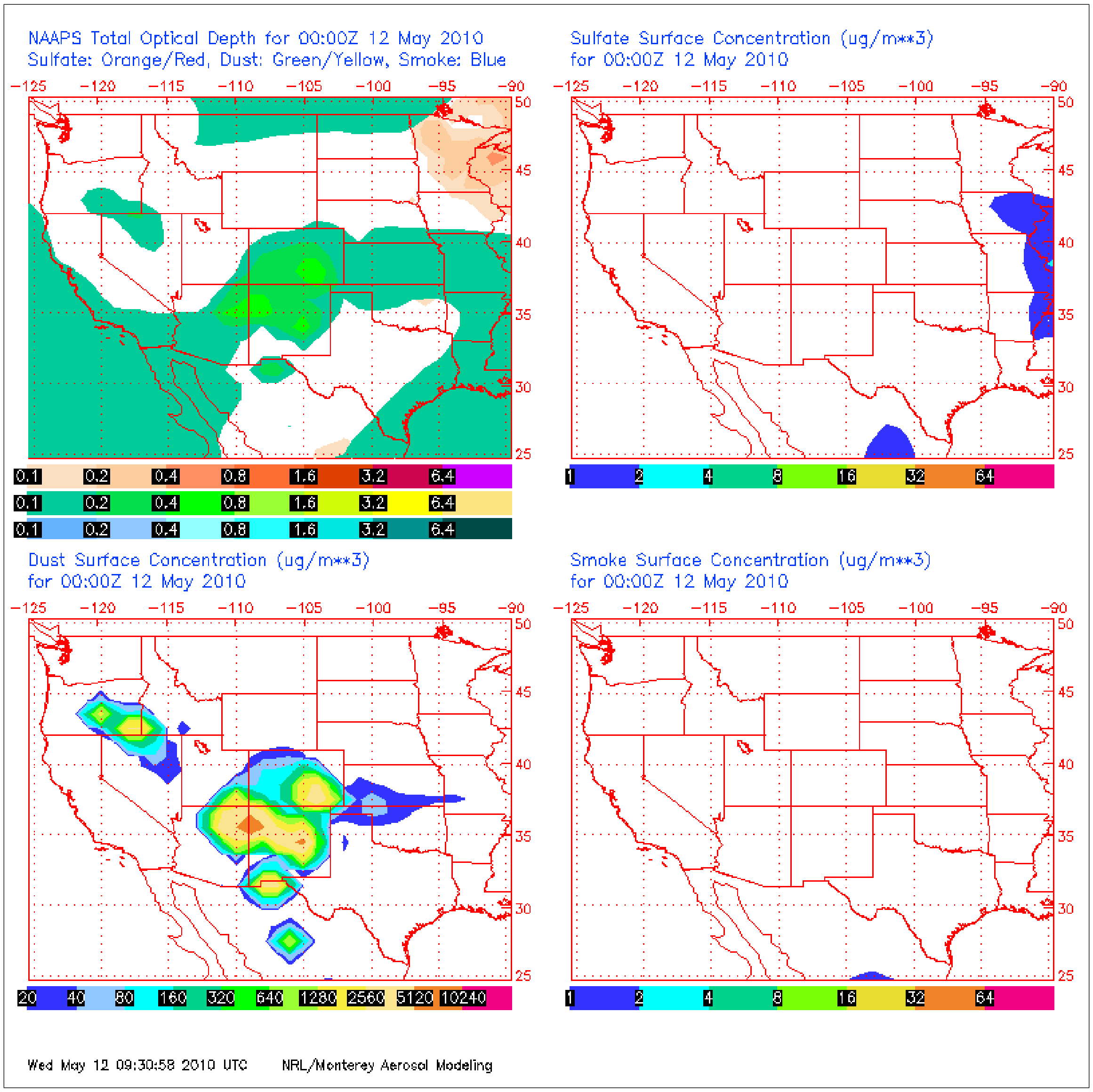

Figure 18: NAAPS forecasted dust concentrations for 5 PM MST May 11 (00Z May 12), 2010 (source: http://www.nrlmry.navy.mil/aerosol-bin/aerosol/display_directory_all?DIR=/web/aerosol/public_html/globaer/ops_01/wus/).

The Center for Snow and Avalanche Studies has been studying the effects of wind-blown desert dust from Arizona, New Mexico, and Utah on snowpack albedo and snowmelt in the San Juan Mountains of Colorado.

Colorado Dust-on-Snow (CODOS)

Dust-on-Snow Deposition Events Log

Thanks to our original National Science Foundation research grants for collaborative research (grants ATM-0432327 to Painter at National Snow and Ice Data Center and ATM-0431955 to Landry at Center for Snow and Avalanche Studies), and to the subsequent support of the Colorado Dust-on-Snow program by Colorado water districts the State of Colorado, the U.S. Bureau of Reclamation, and others, this program has accumulated several seasons of dust-on-snow observations at our Senator Beck Basin Study Area (SBBSA) at Red Mountain Pass, summarized in the table below. It is reasonable to assume that our skill at detecting dust-on-snow events has improved and that we may have failed to observe very small events during the early years of this work. Therefore the table represents an absence of events in grey for the first two years of observation but thereafter indicates an absence of observed events as “0” (zero).

Dust-on-Snow Events Documented per Month, by Winter
Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
2002/2003					2		1			**3**
2003/2004							2	1		**3**
2004/2005	0	0	0	0	0	1	2	1	0	**4**
2005/2006	0	0	1	0	1	1	3	2	0	**8**
2006/2007	0	0	1	0	1	1	3	1	1	**8**
2007/2008	0	0	0	0	0	3	3	1	0	**7**
2008/2009	1	0	1	0	1	4	5	0	0	**12**
2009/2010	1	0	0	0	0	1	4	3	0	**9**

Dates of the events, by winter/spring season, were as follows (WY = Water Year):

2002/2003 (WY2003): Feb 3, Feb 22, Apr 2-3

2003/2004 (WY 2004): Apr 17, Apr 28, May 11

2004/2005 (WY 2005): Mar 23, Apr 4, Apr 8, May 9

2005/2006 (WY 2006): Dec 23, Feb 15, Mar 26, Apr 5, Apr 15, Apr 17, May 22, May 27

2006/2007 (WY 2007): Dec 17, Feb 27, Mar 27, Apr 15, Apr 18, Apr 24, May 4, Jun 6

2007/2008 (WY 2008): Mar 16, Mar 26-27, Mar 30-31, Apr 15, Apr 21, Apr 30, May 12

2008/2009 (WY 2009): Oct 11, Dec 13, Feb 27, Mar 6, Mar 9, Mar 22, Mar 29, Apr 3, Apr 8, Apr 15, Apr 24, Apr 25

2009/2010 (WY 2010): Oct 27, March 30, April 3, April 5, April 12, April 28, May 9, May 11, May 22

is the Center’s log of events that are associated with deposits or layers of wind-blown dust on or within the snowpack of the San Juan Mountains. ***The Center for Snow and Avalanche Studies lists May 11, 2010, as one of nine Dust-on-Snow events for the 2009/2010 water year, and this provides clear supporting evidence that a regional blowing dust event with long-range transport caused the PM_{10} exceedances measured across portions of Colorado on May 11, 2010.***

Colorado Dust-on-Snow (CODOS)

Dust-on-Snow Deposition Events Log

Thanks to our original National Science Foundation research grants for collaborative research (grants ATM-0432327 to Painter at National Snow and Ice Data Center and ATM-0431955 to Landry at Center for Snow and Avalanche Studies), and to the subsequent support of the Colorado Dust-on-Snow program by Colorado water districts the State of Colorado, the U.S. Bureau of Reclamation, and others, this program has accumulated several seasons of dust-on-snow observations at our Senator Beck Basin Study Area (SBBSA) at Red Mountain Pass, summarized in the table below. It is reasonable to assume that our skill at detecting dust-on-snow events has improved and that we may have failed to observe very small events during the early years of this work. Therefore the table represents an absence of events in grey for the first two years of observation but thereafter indicates an absence of observed events as "0" (zero).

Dust-on-Snow Events Documented per Month, by Winter
Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
2002/2003					2		1			**3**
2003/2004							2	1		**3**
2004/2005	0	0	0	0	0	1	2	1	0	**4**
2005/2006	0	0	1	0	1	1	3	2	0	**8**
2006/2007	0	0	1	0	1	1	3	1	1	**8**
2007/2008	0	0	0	0	0	3	3	1	0	**7**
2008/2009	1	0	1	0	1	4	5	0	0	**12**
2009/2010	1	0	0	0	0	1	4	3	0	**9**

Dates of the events, by winter/spring season, were as follows (WY = Water Year):

2002/2003 (WY2003): Feb 3, Feb 22, Apr 2-3

2003/2004 (WY 2004): Apr 17, Apr 28, May 11

2004/2005 (WY 2005): Mar 23, Apr 4, Apr 8, May 9

2005/2006 (WY 2006): Dec 23, Feb 15, Mar 26, Apr 5, Apr 15, Apr 17, May 22, May 27

2006/2007 (WY 2007): Dec 17, Feb 27, Mar 27, Apr 15, Apr 18, Apr 24, May 4, Jun 6

2007/2008 (WY 2008): Mar 16, Mar 26-27, Mar 30-31, Apr 15, Apr 21, Apr 30, May 12

2008/2009 (WY 2009): Oct 11, Dec 13, Feb 27, Mar 6, Mar 9, Mar 22, Mar 29, Apr 3, Apr 8, Apr 15, Apr 24, Apr 25

2009/2010 (WY 2010): Oct 27, March 30, April 3, April 5, April 12, April 28, May 9, May 11, May 22

Figure 19: Dust-on-Snow Deposition Events Log at the Senator Beck Basin Study Area at Red Mountain Pass, Colorado. (source: Chris Landry, September 24, 2010).

Figure 20 shows the MODIS Terra satellite image for the Four Corners region including, Arizona, New Mexico, Utah and Colorado for May 11, 2010. Areas of blowing dust can be seen in Arizona and New Mexico. Plumes of blowing dust originating in the Painted Desert region of northeast Arizona and northwest New Mexico stretched across southwest Colorado and extreme southeast Utah. Also note the red discoloration of the cloud cover and snow pack in southwest Colorado from the blowing dust. Figure 21, Figure 22 and Figure 23 show the GOES 11 longwave split-window difference product for the same region for 9:30 AM MST, 11:30 AM MST and 3:30 PM MST, respectively. This product employs a special color enhancement to emphasize the negative temperature differences for select wavelengths associated with blowing dust. Blowing dust is generally noted by orange and red colors (see the following link for more information on the GOES-11 longwave split-window difference product: (http://rammb.cira.colostate.edu/ramsdis/online/goes-r.asp). Plumes of dust can clearly be seen developing in northeast Arizona and northwest New Mexico at 9:30 AM MST (Figure 21) which then spread into southwest Colorado by 11:30 AM MST (Figure 22) and continued to increase in intensity and coverage by 3:30 PM MST (Figure 23).

MODIS and GOES satellite imagery shows that the Painted Desert and Four Corners area in general were source regions for blowing dust May 11, 2010. This is consistent with the climatology for many dust storms in Colorado as described in the Grand Junction, Colorado, Blowing Dust Climatology report contained in Appendix A of this document.

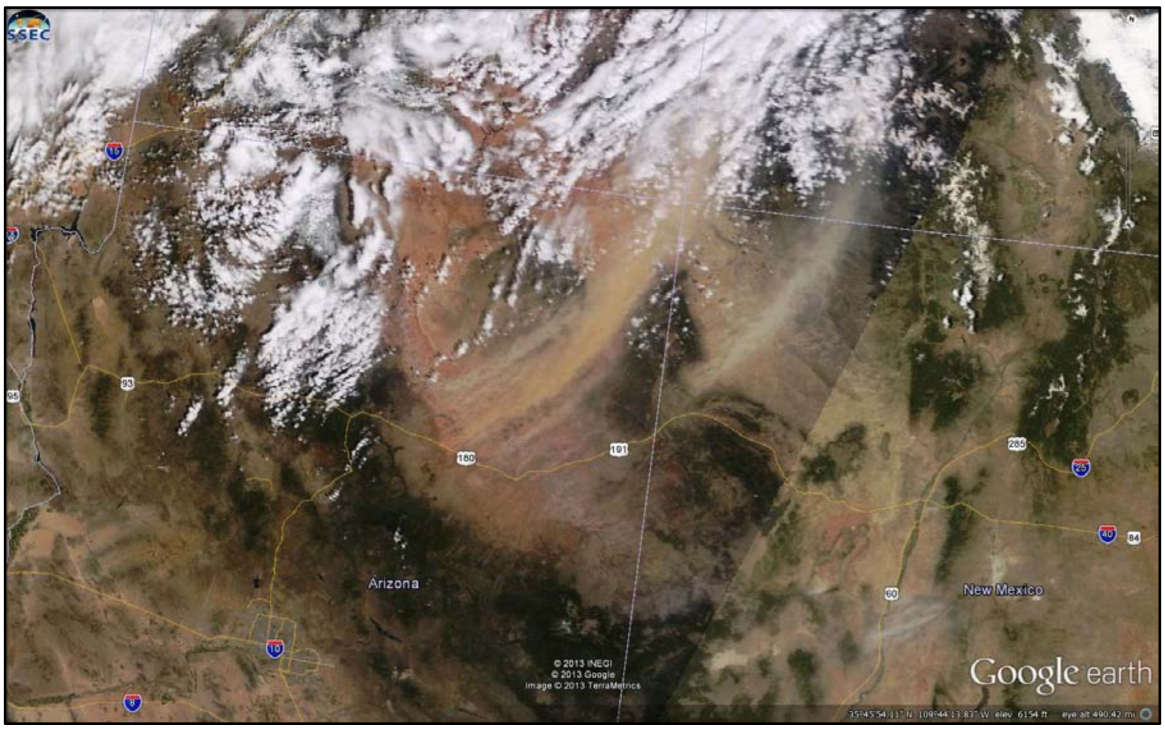

Figure 20: MODIS Terra satellite image of Arizona and northwest New Mexico on May 11, 2010 (source: http://ge.ssec.wisc.edu/modis-today/index.php).

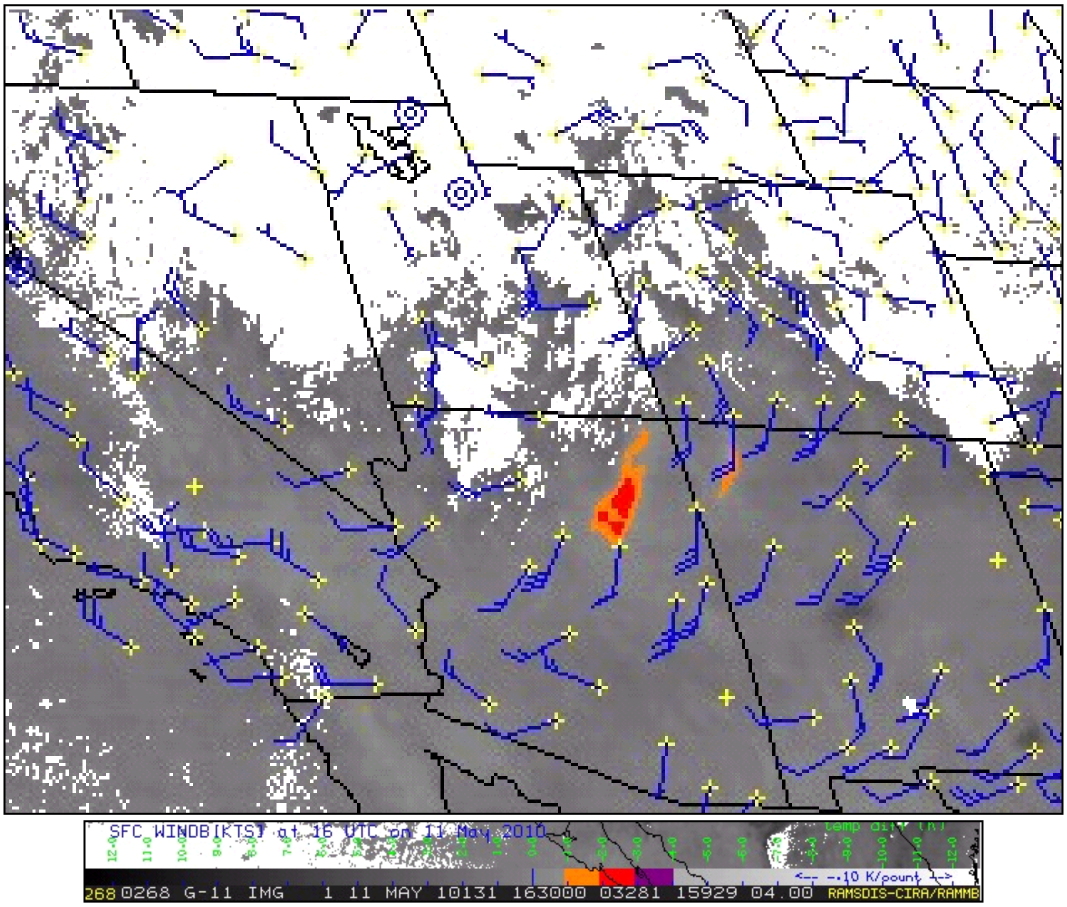

Figure 21: GOES-11 longwave split-window difference product for 9:30 AM MST May 11, 2010 (source: http://rammb.cira.colostate.edu/ramsdis/online/goes-r.asp).

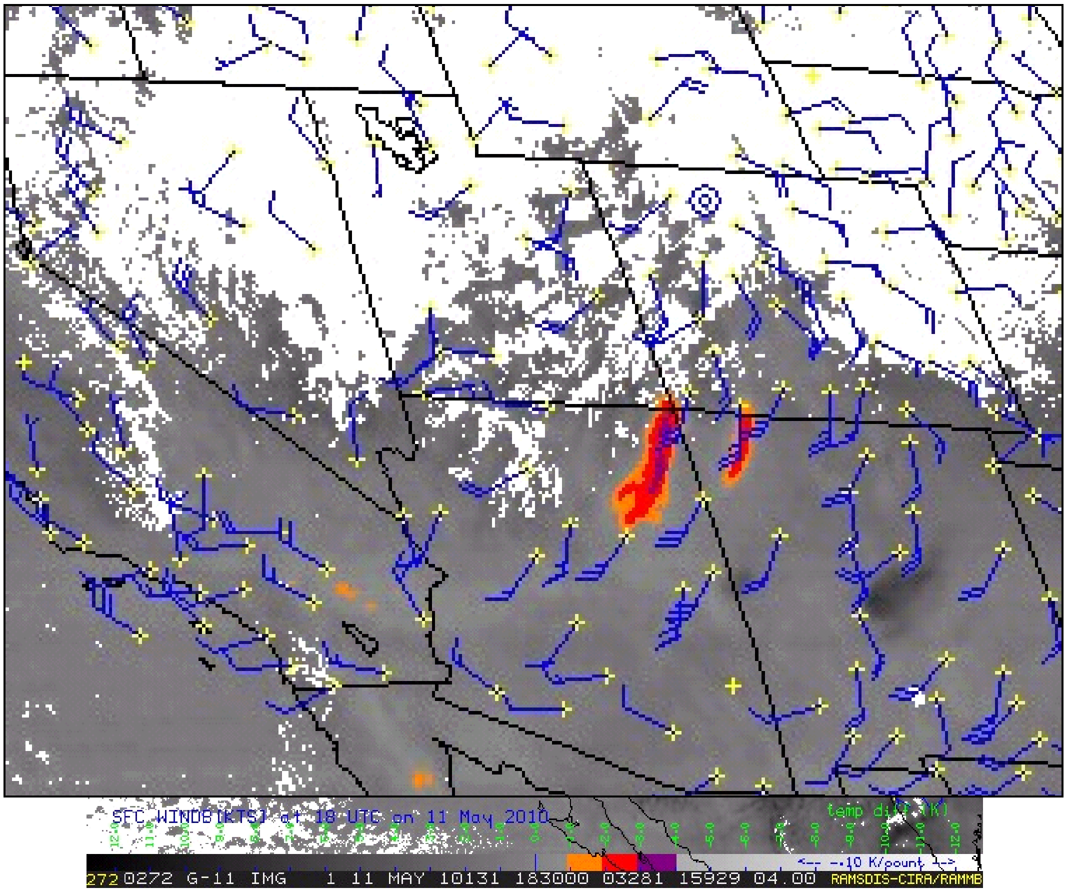

Figure 22: GOES-11 longwave split-window difference product for 11:30 AM MST May 11, 2010 (source: http://rammb.cira.colostate.edu/ramsdis/online/goes-r.asp).

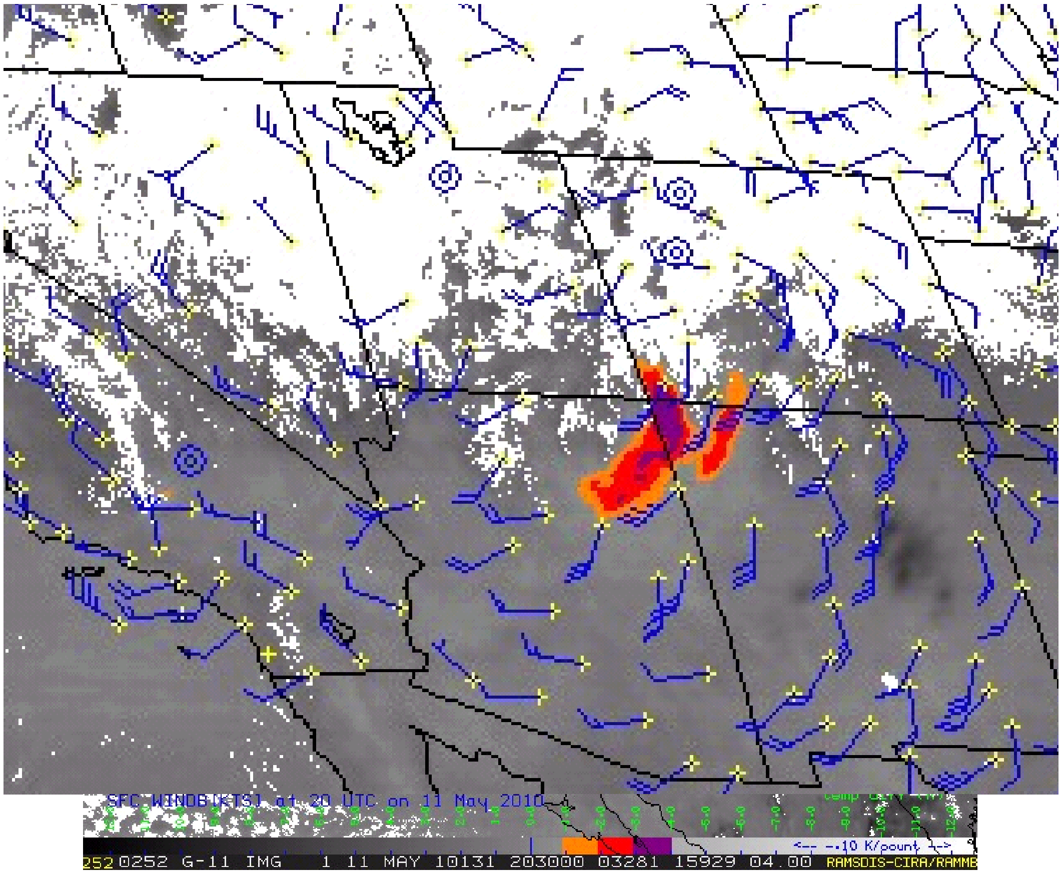

Figure 23: GOES-11 longwave split-window difference product for 3:30 PM MST May 11, 2010 (source: http://rammb.cira.colostate.edu/ramsdis/online/goes-r.asp).

The Smoke Text Product from the National Oceanic and Atmospheric Administration (NOAA) Satellite Services Division - Descriptive Text Narrative for Smoke/Dust Observed in Satellite Imagery through 0230Z May 12, 2010, (7:30 PM MST May 11) (http://www.ssd.noaa.gov/PS/FIRE/DATA/SMOKE/2010/2010E120243.html) - describes dust from Arizona and New Mexico moving into Colorado:

> "An area of moderately dense to locally dense blowing dust originating from point sources in northeastern Arizona and northwestern New Mexico moved northeastward across far southeastern Utah and southwestern Colorado toward central Colorado."

The U.S. Geological Survey (USGS) Southwest Geographic Science Team: Dust Monitoring web pages (http://sgst.wr.usgs.gov/dust_detection/dust-events/2010-2/may-11th-2010/) list May 11, 2010, as a dust event day. The web page for the May 11, 2010, event has various satellite pictures, videos and time lapse imagery of the dust storm. This web page provides the following characterization for this event:

> "A strong pacific storm front moved through the southwest today, bringing very strong winds but no precipitation. The dominant wind direction was out of the south-west. Severe dust was viewable from satellite by both visible band and thermal imaging in the Four Corners area. Activity was apparent from early morning on to well after sunset.

Interstate 40 in Arizona was closed from Winona to Winslow for most of the day. Peak gusts in the Winslow area at the heart of the western dust sources reached 77mph."

NOAA and USGS Scientists with expertise in the analysis of dust storms have indicated that a regional dust storm occurred in the Four Corners area on May 11, 2010.

Figure 24 shows the total precipitation in inches for the western U.S. for the month of April 2010. It shows that much of southeast Utah, northeast Arizona and portions of extreme northwest New Mexico had less than 0.5 inches of precipitation in April. This is an approximate threshold below which blowing dust can occur in the Painted Desert area when winds are above the blowing dust thresholds. The precipitation threshold is reported in Appendix A that shows that blowing dust occurs in northeastern Arizona source regions when soils are dry (typically less than 0.5 inches in a 30-day period at Hopi, Arizona) and winds are strong. Figure 25 shows that some light amounts of precipitation (mainly 0.5 inches or less) fell in the Four Corners region in the two weeks leading up to the May 11, 2010, event, but Figure 26 displays that the immediate week prior to the May 11, 2010, event brought little to no precipitation to the area. Figure 27 is the Drought Monitor report for the western U.S. It shows that northeast Arizona and much of northwest New Mexico were classified as "Abnormally Dry", with an area of "Moderate" to "Severe" drought in the Painted Desert region. ***Soils in the Four Corners area and in northeast Arizona and extreme northwest New Mexico in particular were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.***

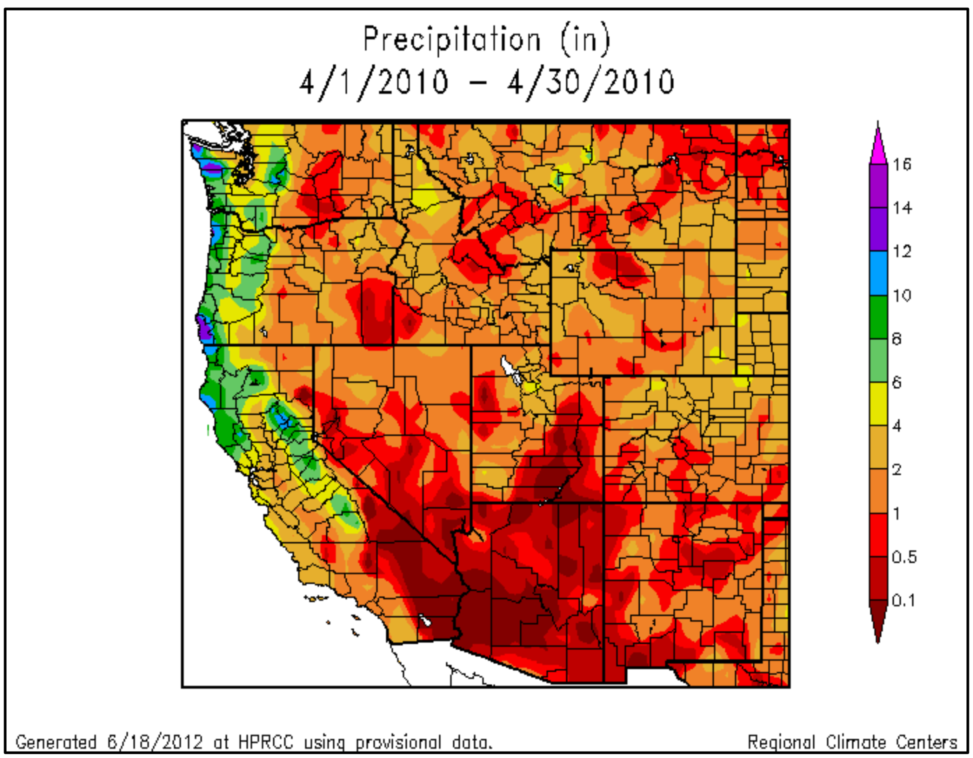

Figure 24: Total precipitation in inches for April 2010 (source: http://www.hprcc.unl.edu/maps/current/index.php?action=update_region&region=WRCC)

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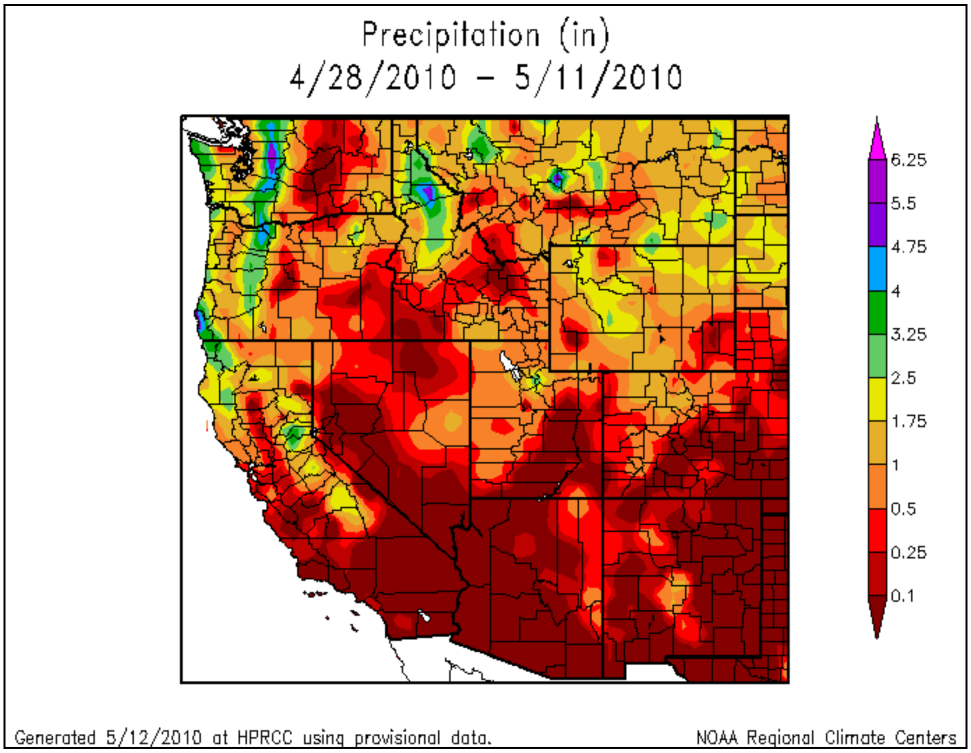


Figure 25: Total precipitation in inches for April 28-May 11, 2010 (source: http://hprcc.unl.edu/maps/current/index.php?action=update_region&region=WRCC).

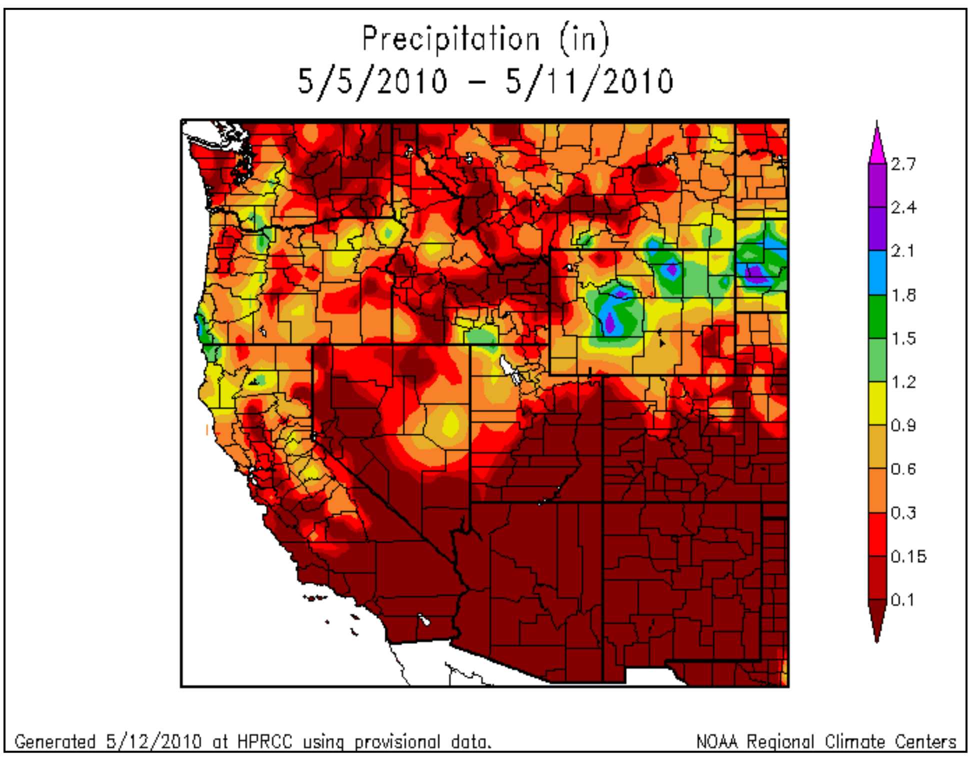


Figure 26: Total precipitation in inches for May 5-May 11, 2010 (source: http://www.hprcc.unl.edu/maps/current/index.php?action=update_region&region=WRCC)

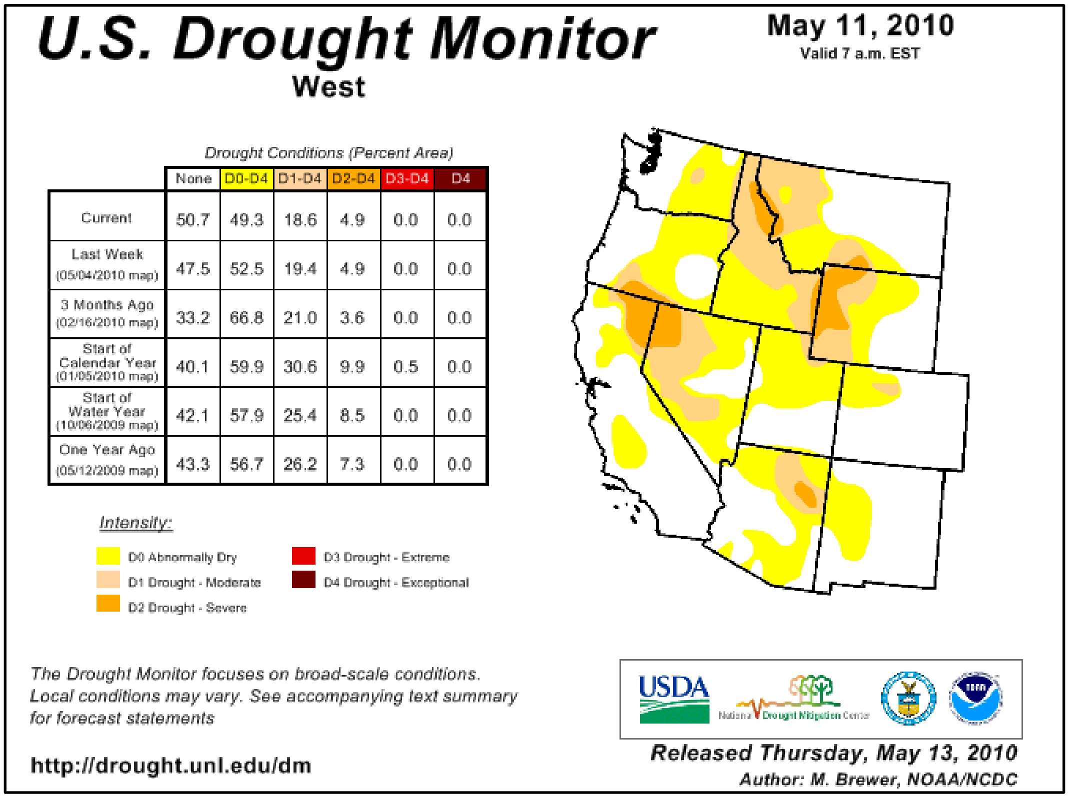


Figure 27: Drought status for the western United States on May 11, 2010 (source: the USDA, NOAA, and the National Drought Mitigation Center at: http://drought.unl.edu/dm/archive.html).

In a 1997 paper "Factors controlling threshold friction velocity in semiarid and arid areas of the United States" (Marticorena et al., 1997), the authors characterized the erodibility of both disturbed and undisturbed desert soil types. The threshold friction velocity, which is described in detail in this paper, is a measure for conditions necessary for blowing dust and is higher for undisturbed soils and lower for disturbed soils.

Friction velocities have been calculated for 11 AM MST and 5 PM MST May 11, 2010, using the NAM12 model (data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets). These friction velocities are shown in Figure 28 and Figure 29, respectively. According to Marticorena and coauthors (1997), even undisturbed desert soils normally resistant to wind erosion will be susceptible to emission of blowing dust when threshold friction velocities are greater than about 1.0 to 2.0 meters per second. These figures show that a wide area of northeast Arizona, northwest New Mexico, southeast Utah and southwest Colorado had friction velocities above 1.0 meters per second during the second half of the day on May 11, 2010. This includes portions of the arid San Luis Valley where Alamosa is located. High values were present within the Little Colorado River Valley and Painted Desert region of northeastern Arizona where satellite imagery shows the eruption of large plumes of blowing dust and where 30-day precipitation totals were near or below 0.5 inches. Note that blowing dust will typically only occur where friction velocities are high and the soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is why blowing dust occurred in the desert and more arid areas of northeastern Arizona, and northwestern New Mexico on May 11, 2010.

The elevated friction velocities shown in Figures 28 and 29, the data on soil moisture conditions presented elsewhere in this report, and the prevalence of winds above blowing dust thresholds (all occurring in traditional source regions in northeast Arizona and northwest New Mexico) prove that this dust storm was a natural event that was not reasonably controllable or preventable.

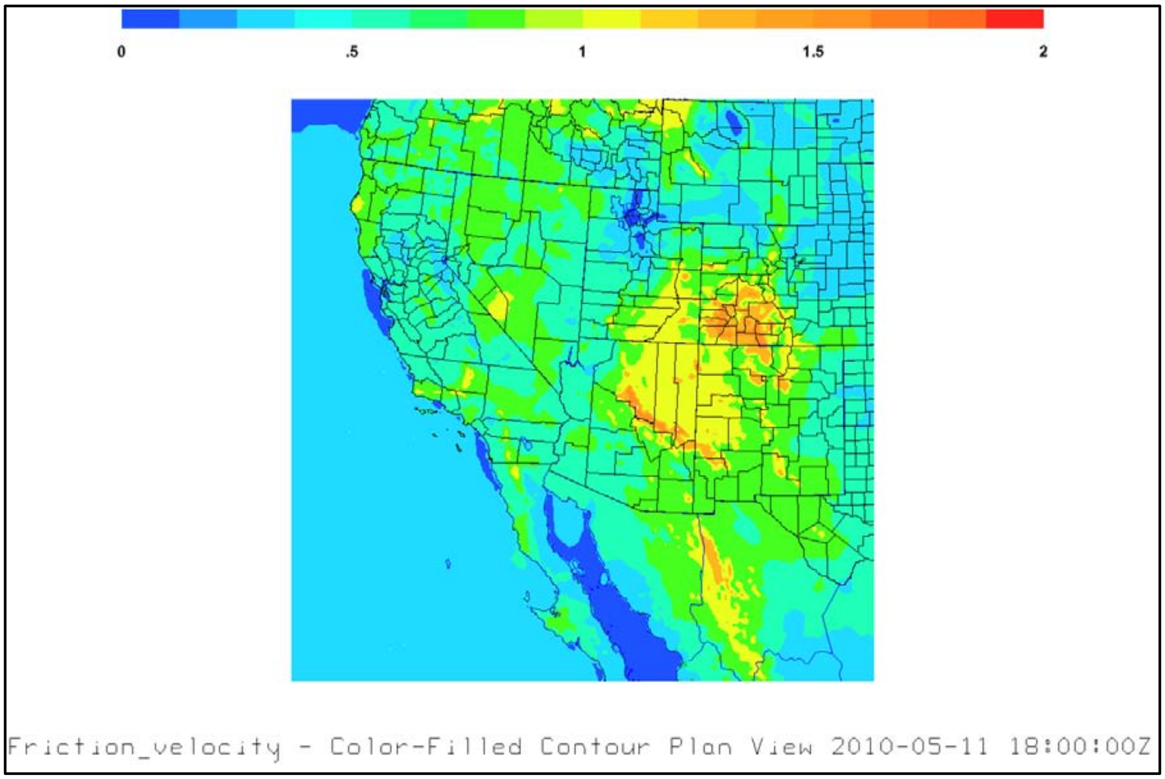


Figure 28: Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 18Z May 11, 2010 (11 AM MST May 11).

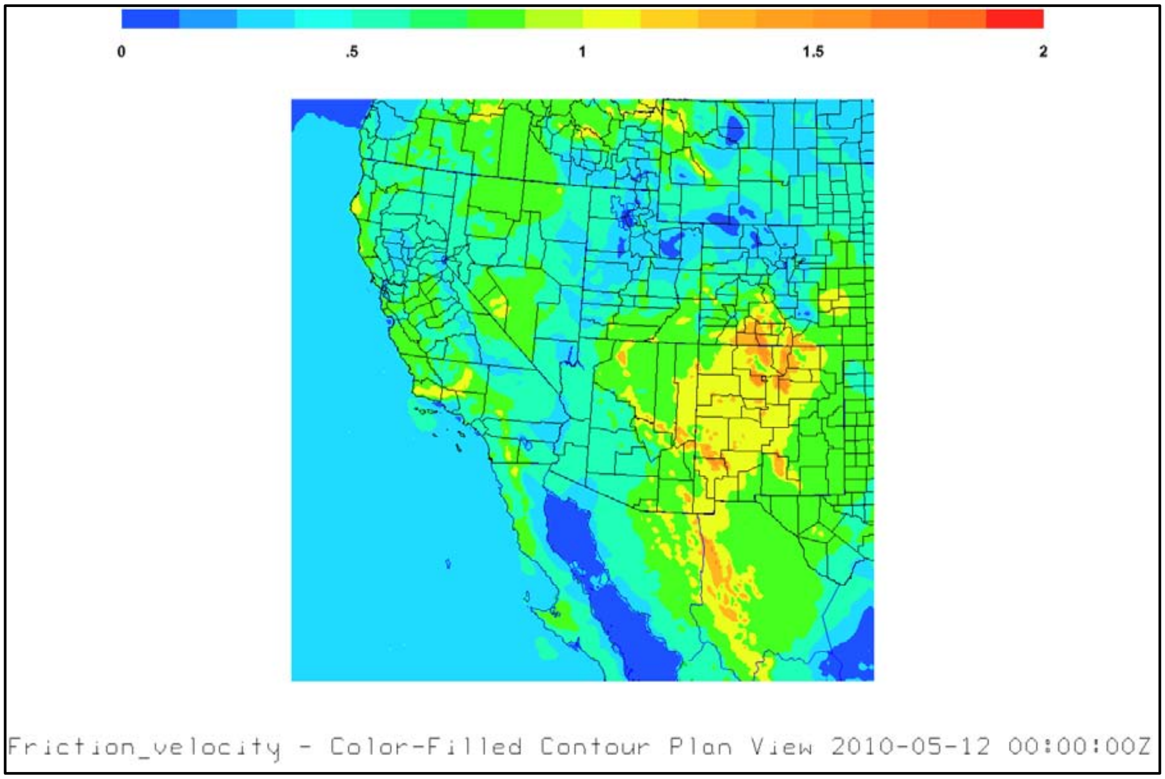


Figure 29: Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 00Z May 12, 2010 (5 PM MST May 11).

3.0 Evidence-Ambient Air Monitoring Data and Statistics

PM_{10} concentrations that exceeded the level of the twenty-four-hour PM_{10} NAAQS were monitored across western Colorado on May 11, 2010. Values in excess of the PM_{10} standard were taken using high volume samplers at Pagosa Springs School monitor (200 µg/m^3), the Alamosa Municipal Building monitor (161 µg/m^3) and the Adams State College monitor in Alamosa (160 µg/m^3). For a map of the Colorado PM_{10} monitoring sites and all valid PM_{10} concentrations on May 11, 2010, see Figure 1. The PM_{10} exceedances Alamosa and Pagosa Springs on May 11, 2010, would not have occurred if not for the following: (a) dry soil conditions over southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico; (b) a combination of strong surface low pressure and a cold front associated with an intense upper-level trough that was moving across the western United States that created conditions necessary for widespread strong gusty winds over the area of concern; and (c) elevated friction velocities and the deep mixing of the blowing dust from desert regions of Arizona, northwest New Mexico, and southeast Utah. This weather system adversely affected the air quality in much of western Colorado.

The APCD reviewed PM_{10} monitoring data in Western Colorado in the path of the dust storm (see Section 3.1). The PM_{10} concentrations at affected sites were compared using time series plots for a number of days pre and post event (see Figure 42). The time series graphs clearly show that the regional blowing dust storm adversely affected the air quality in Alamosa and Pagosa Springs on May 11, 2010. PM_{10} samples the day before and the day two days after the event were typical of samples at each affected site.

3.1 Historical Fluctuations of PM_{10} Concentrations in Alamosa, Pagosa Springs, and Durango

This evaluation of PM_{10} monitoring data for sites affected by the May 11, 2010, event was made using valid samples from hi-vol PM_{10} samplers in Alamosa, Pagosa Springs, and Durango from 2005 through 2011. APCD has been monitoring PM_{10} concentrations in these areas since 1985. On-going data collection at all the sites affected by the event began in 2005; therefore, the data in this analysis is from January 2005 through the end of 2011. The overall data summary for the affected sites is presented in Table 11, all data values are presented in µg/m^3:

Table 11: May 11, 2010, PM_{10} Monitoring Data Summary (Affected Sites)

Evaluation	Alam ASC	Alam Muni	Pag Spr	Delta	Durango	Telluride
5/11/2010	**160**	**161**	**200**	**125**	**139**	**133**
Mean	22.1	27.9	22.7	24.5	20.7	18.7
Median	18	23	20	23	18	15
Mode	16	20	16	24	16	12
St. Dev.	24.0	26.8	17.0	13.7	18.8	18.9
Variance	578.3	716.4	290.6	186.9	355.3	357.3
Minimum	1	1	2	3	3	1
Maximum	473	635	349	186	320	354
Count	2214	2168	2287	773	811	785

As Table 11 demonstrates the spatial scope of this event, addressed elsewhere in this document, was broad and had an impact on PM_{10} concentrations at multiple sites covering an extensive geographical area. Since the event will affect attainment status of only Alamosa and Pagosa Springs only these data sets will be discussed in detail. The attainment status of the other sites (Delta, Durango, and Telluride) will not be affected by this event. It is a certainty that the PM_{10} samples at these sites were affected by the event to the same extent as the samples in Alamosa and Pagosa Springs and so they are included here to help define the geographical extent of the affected area. A snapshot summary of data from all those sites affected by the event is presented in Table 12 along with the approximate percentile value that data point represents for each site for their unique historical data sets, for the month of the event (every sample in any May), and for the year of the event. All percentile calculations presented anywhere in this section were made using the entire dataset, including known high wind events. There is no difference between the two datasets (with and without high wind events) in regards to percentile calculations. All data sets were restricted to valid samples from the interval 2005 – 2011.

Table 12: May 11, 2010, Monitoring Data Percentiles (Affected Sites)

Evaluation	Alam ASC	Alam Muni	Pagosa Spr.	Delta	Durango	Telluride
5/11/2010	**160 µg/m^3**	**161 µg/m^3**	**200 µg/m^3**	**125 µg/m^3**	**139 µg/m^3**	**133 µg/m^3**
Overall	99.64%	99.58%	99.87%	99.87%	99.51%	99.87%
All May	99.46%	99.50%	Max Value	Max Value	Max Value	Max Value
2010	99.04%	99.30%	99.68%	Max Value	98.18%	99.13%

*The 'Max Value' notation refers to the May 11, 2010, sample value

This event produced the maximum value in four of the six datasets and exceeded the 98th% value of any evaluation criteria for the other two sites. The overall magnitude and broad geographical extent of affected sites suggests that there was a common contribution to each sample from other than local sources.

Those data sets for sites with samples greater than 150 µg/m^3 are further summarized by month. As with previous submittals these summaries present no obvious 'season'; PM_{10} levels at any particular site in Colorado do not necessarily fluctuate by season. Of greater importance affecting day-to-day, typical PM_{10} concentrations are local sources, e.g. road sanding and sweeping, local burning from agriculture and residential heating, vehicle contributions via road dust, unpaved lots or roads, etc. While the historic monthly mean values for the affected sites can be higher during the winter and spring months there is little month-to-month variation. Additionally, some of the sites exhibit monthly medians over this period (winter/spring) that are generally lower than other months of the year. This time frame (winter and early spring) is that which is most likely to experience the regional meteorological and dry soil conditions exhibited during this event and discussed elsewhere in this document. Although the maximum values for these months (winter/spring) are the highest in the data set the 'typical' data (i.e. day-to-day, reflective of local conditions) are similar or lower than the same 'typical' data for the rest of the year. The summary data for the month of May (all samples in any May) and for 2010 for Alamosa ASC, Alamosa Muni, and Pagosa Springs are presented in Table 13:

Table 13: Month and Year PM_{10} Monitoring Data Summary

	Alamosa ASC		Alamosa Muni		Pagosa Springs	
	May	2010	May	2010	May	2010
Mean	22.3	23.5	27.3	26.6	26.5	24.3
Median	17	19	22	22	21	18
Mode	15	20	25	19	20	18
St. Dev.	24.7	26.5	22.4	22.8	22.1	28.7
Variance	612.1	704.1	502.4	519.9	488.4	824.3
Minimum	3	2	1	5	6	4
Maximum	260	285	194	236	200	349
Count	187	314	203	285	201	310

Alamosa ASC – 080030001

The PM_{10} sample on May 11, 2010, at Alamosa ASC of 160 µg/m^3 exceeds the 99th percentile value for all May data, exceeds the 99th percentile value for all 2010 data, and is greater than the 99th percentile value (97 µg/m^3) for the entire dataset. Overall, this sample is the ninth highest sample in the entire data set and the 4th largest sample in 2010. The eight samples greater than the event sample are all associated with high wind events. There are 2214 samples in this dataset. The sample of May 11, 2010, clearly exceeds the typical samples for this site.

Figures 30 through 33 graphically characterize the Alamosa ASC PM_{10} data. The first is a simple time series; every sample in this dataset (2005 – 2011) greater than 150 µg/m^3 is identified. Note the overwhelming number of samples occupying the lower end of the graph; an interested reader can count the number of samples greater than 100 µg/m^3. Of the 2214 samples in this data set less than 1% are greater than 100 µg/m^3.

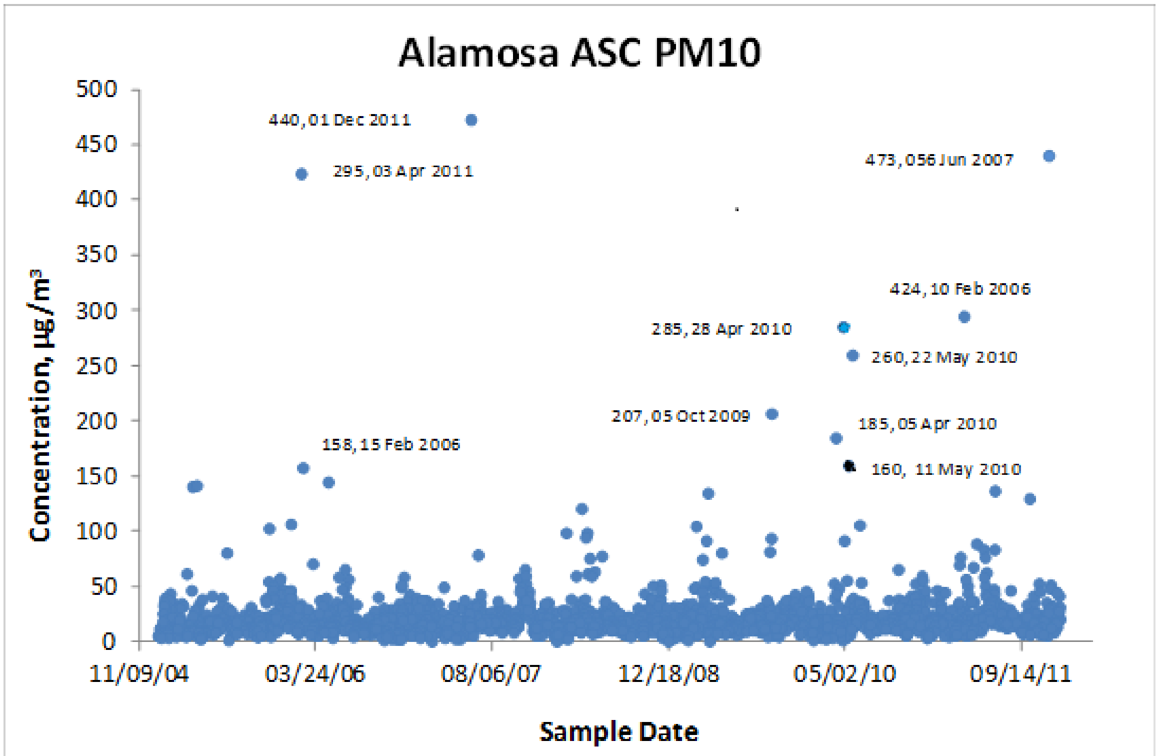


Figure 30: Alamosa ASC PM_{10} Time Series

Figure 31 is a simple histogram, demonstrating the overwhelming weight of samples on the low end of the curve. Over 60% of the samples in this data set are less than 20 µg/m^3. Of the 2214 samples in this data set only 10 exceed 150 µg/m^3. Clearly the sample of May 11, 2010, exceeds what is typical for this site.

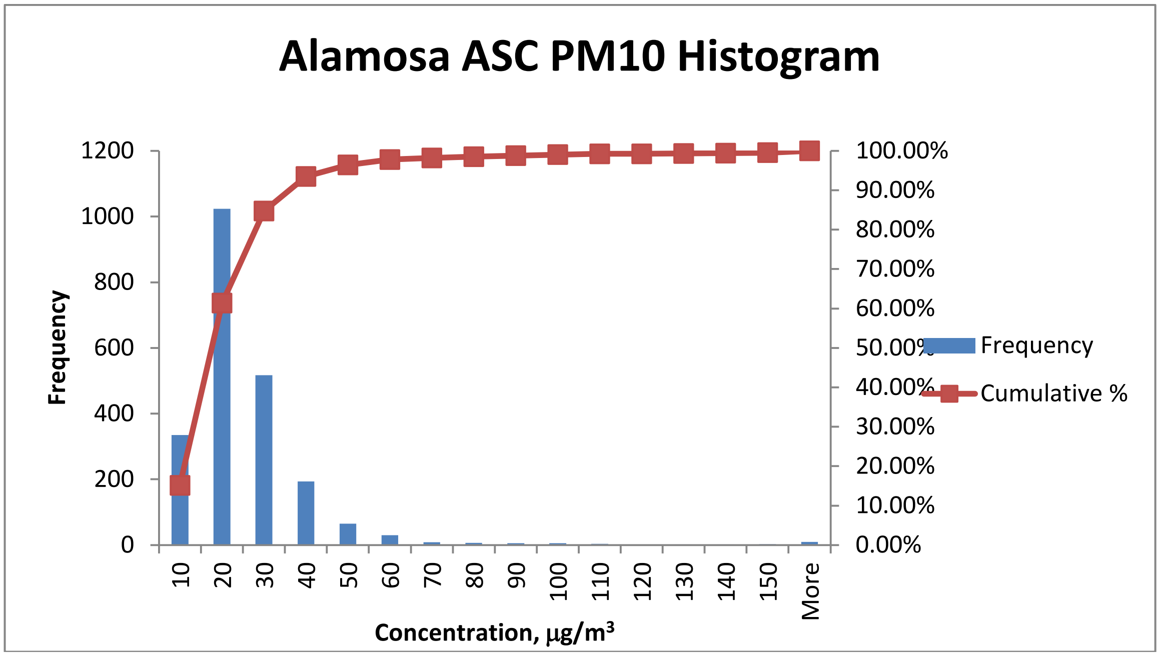


Figure 31: Alamosa ASC PM_{10} Histogram

The monthly box-whisker plot, **Error! Reference source not found.**, highlights the consistency of the majority of data from month to month. Note the greater variability (wider inner-quartile range) and greater range of the data through the winter and early spring months that's accompanied by typically greater monthly maxima. Recall, this time period experiences a greater number of days with meteorological conditions similar to those experienced on May 11, 2010. Although these high values affect the variability and central tendency (average) of the dataset they aren't representative of what is typical at the site.

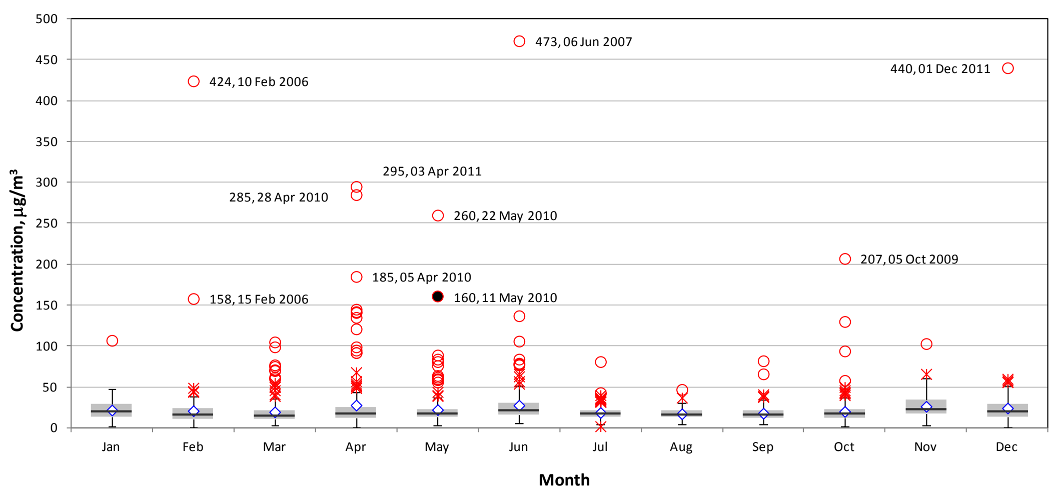


Figure 32: Alamosa ASC Monthly PM10 Box and Whisker Plot

The box and whisker plots graphically represent the overall distribution of each data set including the mean (◊), the inner quartile range (IQR, defined to be the distance between the 75th% and 25th%), the median (represented by the horizontal black line) and two types of outliers identifed in these plots: outliers greater than 75th% +1.5*IQR (✳)and outliers greater than 75th% + 3*IQR (○). The outliers that satisfy the last criteria and are greater than 150 µg/m^3 are labeled with sample value and sample date. Each of these outliers is associated with a known high-wind event similar to that of 05 April.

The presence of the extreme values distorts the graph, losing definition and distorting information presented across the range where the majority of data resides. The same plot graphed to 100 µg/m^3, which includes almost 99% of all the data, is presented in **Error! Reference source not found.**.

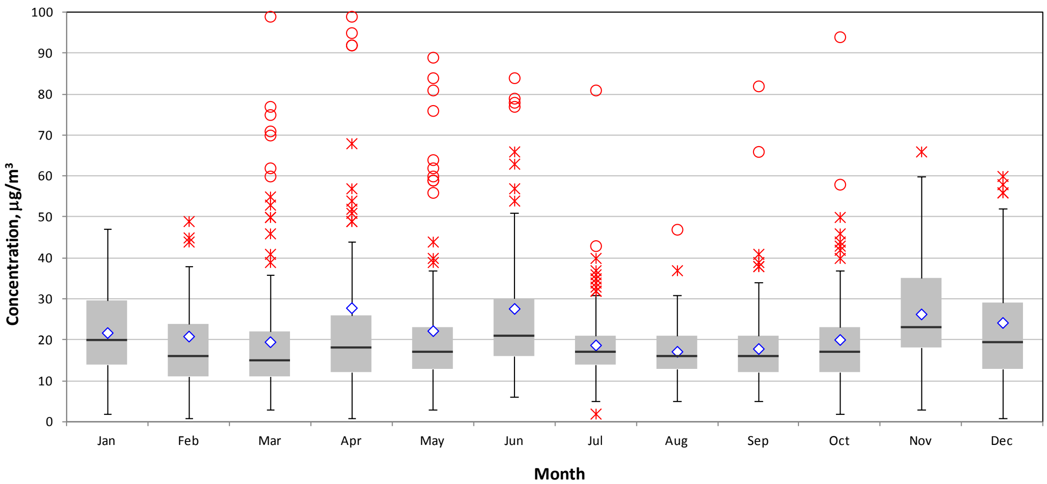


Figure 33: Alamosa ASC PM$_{10}$ Monthly Box and Whisker Plot (expanded view)

Note the degree to which the April and May (among other months) data is skewed. The May mean (22.3 µg/m^3) is nearly equal to the the 75th percentile value (23 µg/m^3). This is due to the presence of a handful of extreme values and can create the perception that those months experiencing these high wind events are somehow 'dirtier' than other months of the year. This data exposes that perception as flawed as the typical data is similar to every other month of the year. The sample of May 11, 2010, clearly exceeds the typical data at this site.

Alamosa Municipal – 080030003

The PM$_{10}$ sample on May 11, 2010, at Alamosa Muni of 236 µg/m^3 exceeds the 99th percentile value for all May data, is the maximum value for all 2010 data, and is greater than the 99th percentile value (110 µg/m^3) for the entire dataset. Overall, this sample is the 10th highest sample in the entire data set and the second largest in any May. The nine samples greater than the event sample are all associated with high wind events. There are 2168 samples in this dataset. The sample of May 11, 2010, clearly exceeds the typical samples for this site.

Figures 34 through 37 graphically characterize the Alamosa Muni PM$_{10}$ data. The first is a simple time series, the sample of May 11, 2010, is identified. Note the overwhelming number of samples occupying the lower end of the graph; an interested reader can count the number of samples greater than 100 µg/m^3. Of the 2168 samples in these data, only 27 are greater than 100 µg/m^3.

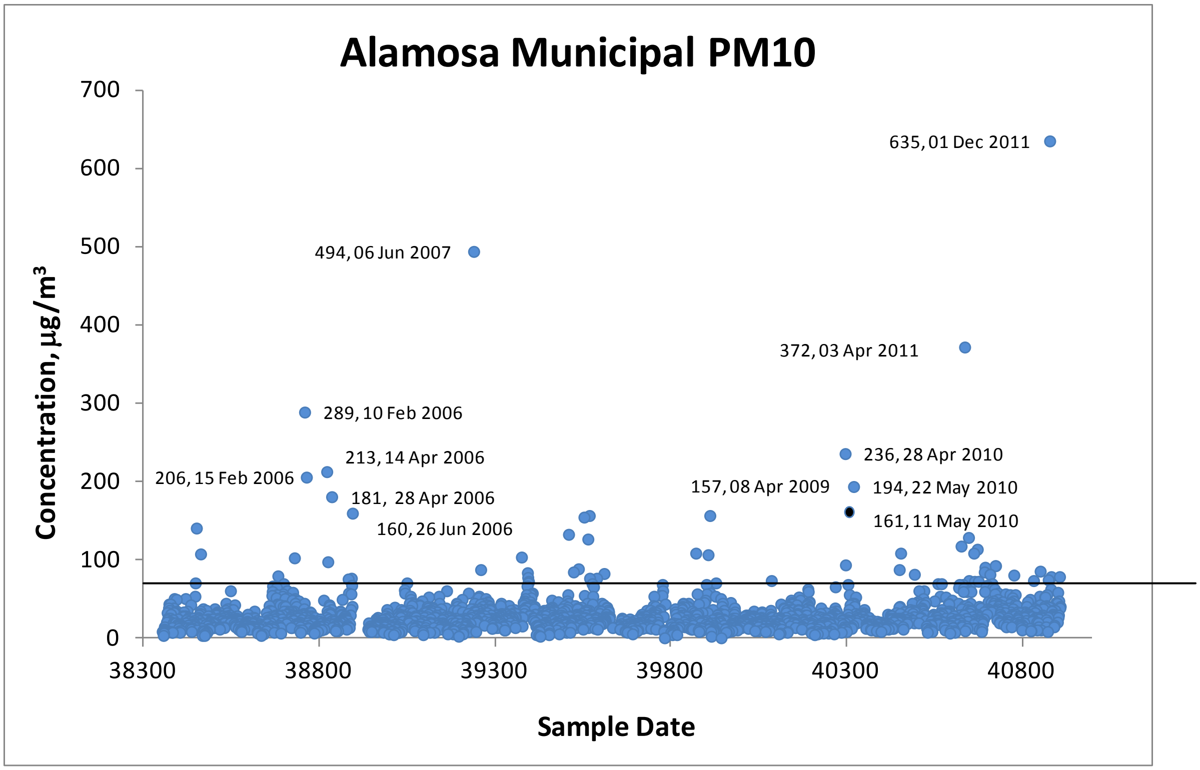


Figure 34: Alamosa Municipal PM_{10} Time Series

Figure 35 is a simple histogram, demonstrating the overwhelming weight of samples on the low end of the curve. Over 70% of the samples in this data set are less than 30 µg/m^3. Even in the highly variable month of May over 90% of the samples are less than 50 µg/m^3. Clearly the sample on May 11, 2010, exceed what is typical for this site.

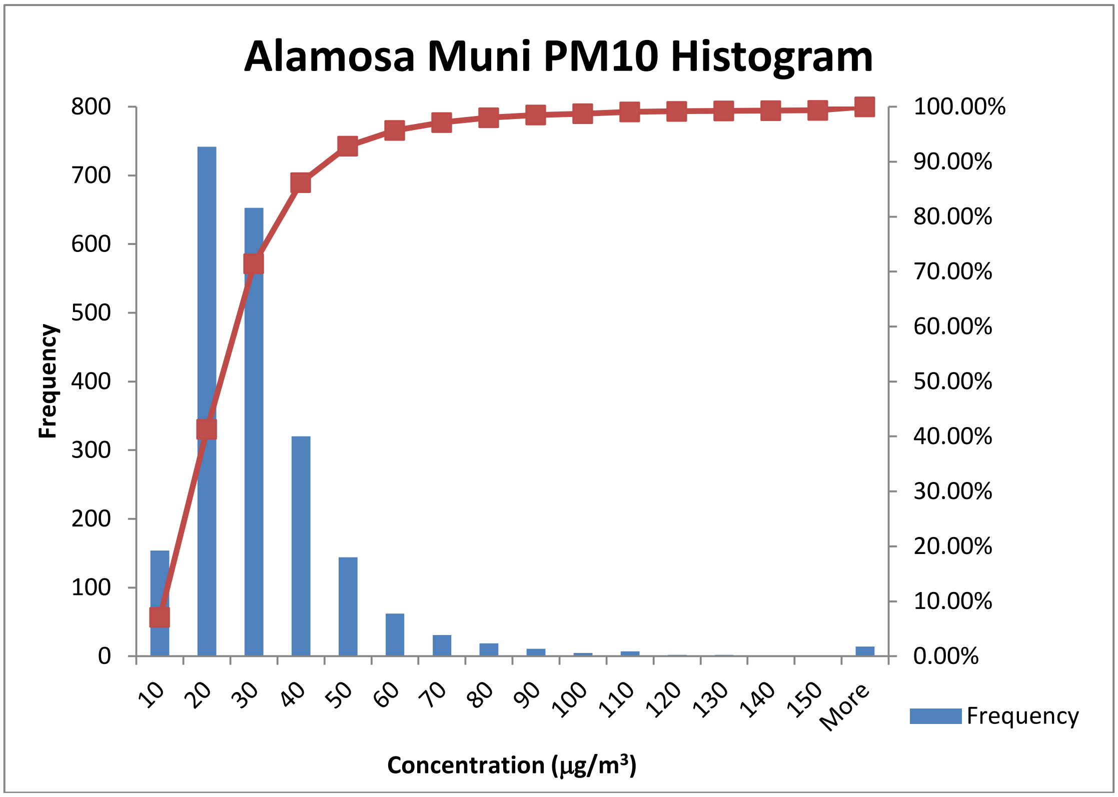


Figure 35: Alamosa Municipal PM_{10} Histogram

The monthly box-whisker plot in **Error! Reference source not found.** highlights the consistency of the majority of data from month to month. Note the greater variability (wider inner-quartile range) and greater range of the data through the winter and early spring months that's accompanied by typically greater monthly maxima. Recall, this time period experiences a greater number of days with meteorological conditions similar to those experienced on May 11, 2010. Although these high values affect the variability and central tendency (average) of the dataset they aren't representative of what is typical at the site.

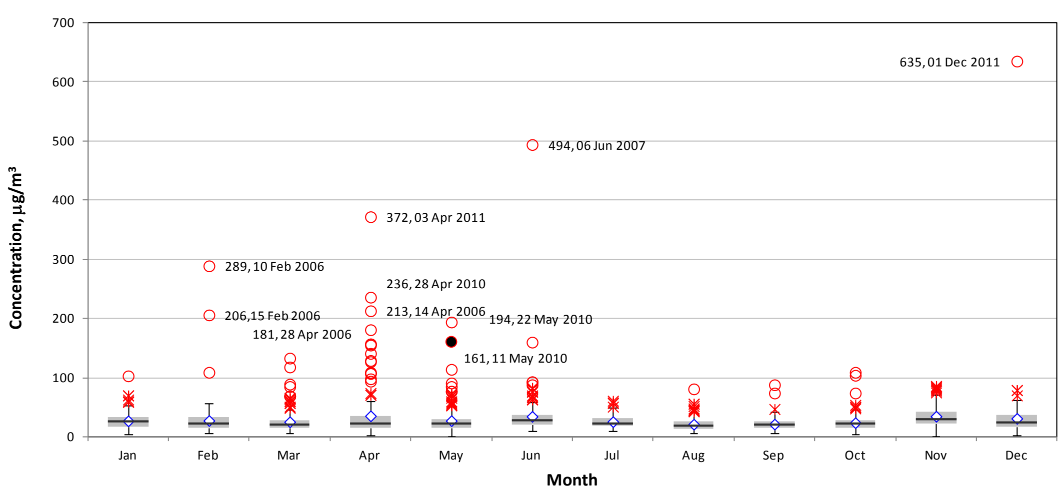


Figure 36: Alamosa Municipal PM_{10} Monthly Box and Whisker Plot

The presence of the extreme values distorts the graph, losing definition and distorting information presented across the range where the majority of data resides. The same plot graphed to 100 µg/m^3, which includes almost 99% of all the data, is presented in **Error! Reference source not found.**.

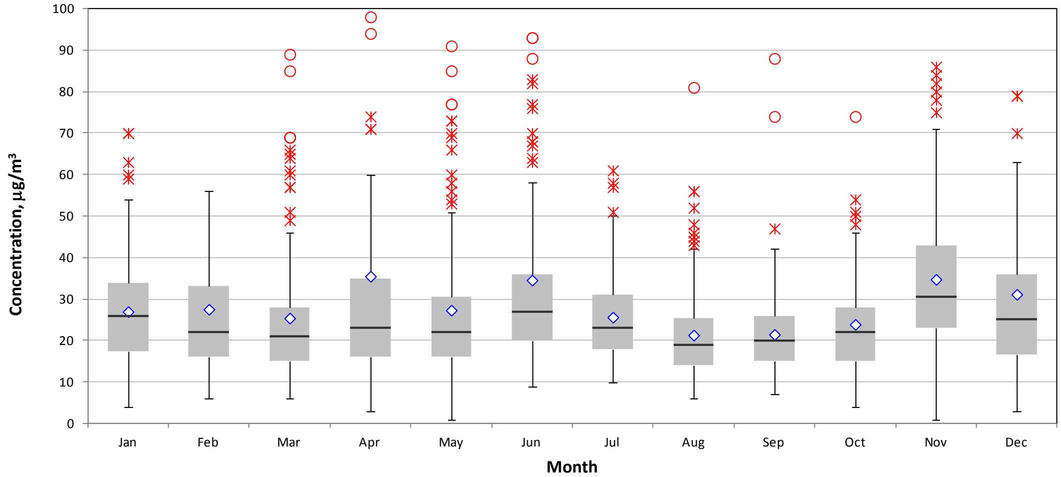


Figure 37: Monthly Alamosa Muni PM_{10} Box and Whisker Plot (expanded view)

While the May data isn't as skewed as April or June the mean is still significantly higher than the median. The mean (27.3 µg/m^3) is equivalent to the 70th percentile value. This is due to the presence of a handful of extreme values and can create the perception that those months experiencing these high wind events are somehow 'dirtier' than other months of the year. This data exposes that perception as flawed as the typical data is similar to every other month of the year. The sample of May 11, 2010, clearly exceeds the typical data at this site.

Pagosa Springs – 080070001

The PM_{10} samples on May 11, 2010, at Pagosa Springs of 200 µg/m^3 is the maximum value for any May, exceeds the 99th percentile value for any data in 2010, and exceed the 99th percentile value for all data in this data set. There are 2287 samples in this dataset. The sample of May 11, 2010, clearly exceeds the typical samples for this site.

Figures 38 through 41 graphically characterize the Pagosa Springs PM_{10} data. **Error! Reference source not found.** is a simple time series; the sample on May 11, 2010, has been identified. Note the overwhelming number of samples occupying the lower end of the graph; an interested reader can count the number of samples greater than 100 µg/m^3. Of the 2287 samples in this data set, only 14 samples are greater than 110 µg/m^3.

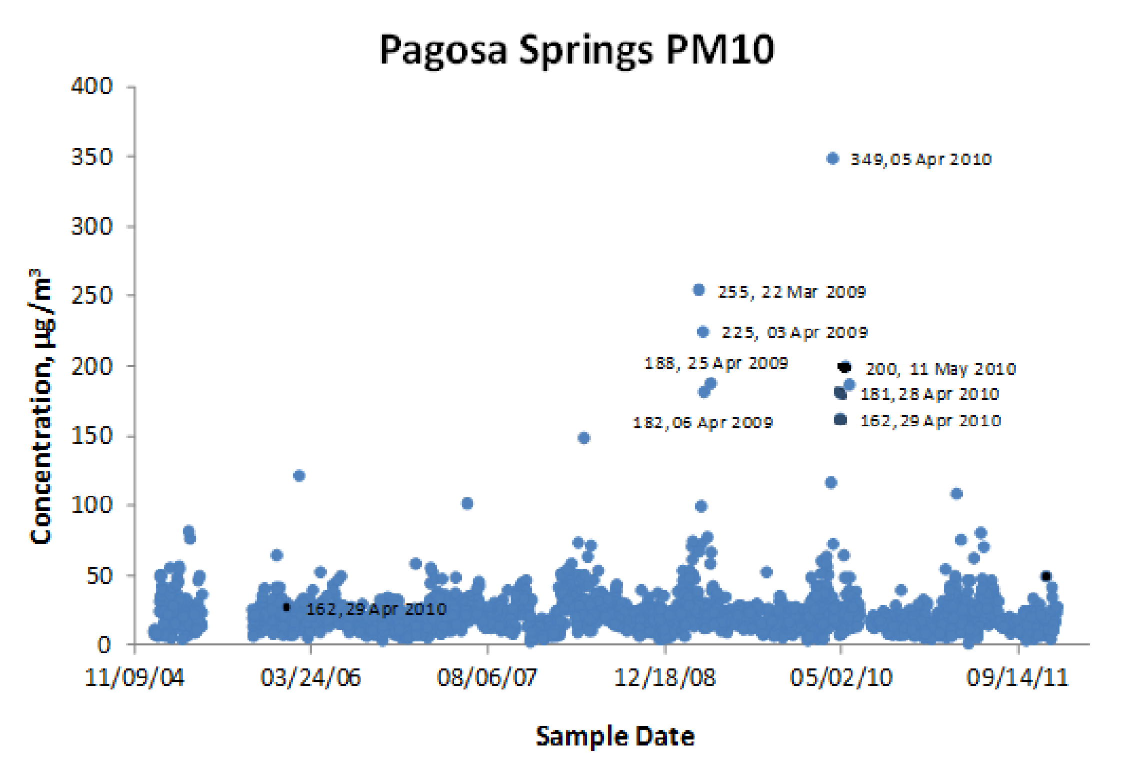


Figure 38: Pagosa Springs PM_{10} Time Series

Error! Reference source not found., is a simple histogram, demonstrating the overwhelming weight of samples on the low end of the curve. Over 50% of the samples in this data set are less than 20 µg/m^3. Of any sample in May 95% of the samples are less than 50 µg/m^3. Clearly the sample on May 11, 2010, exceed what is typical for this site.

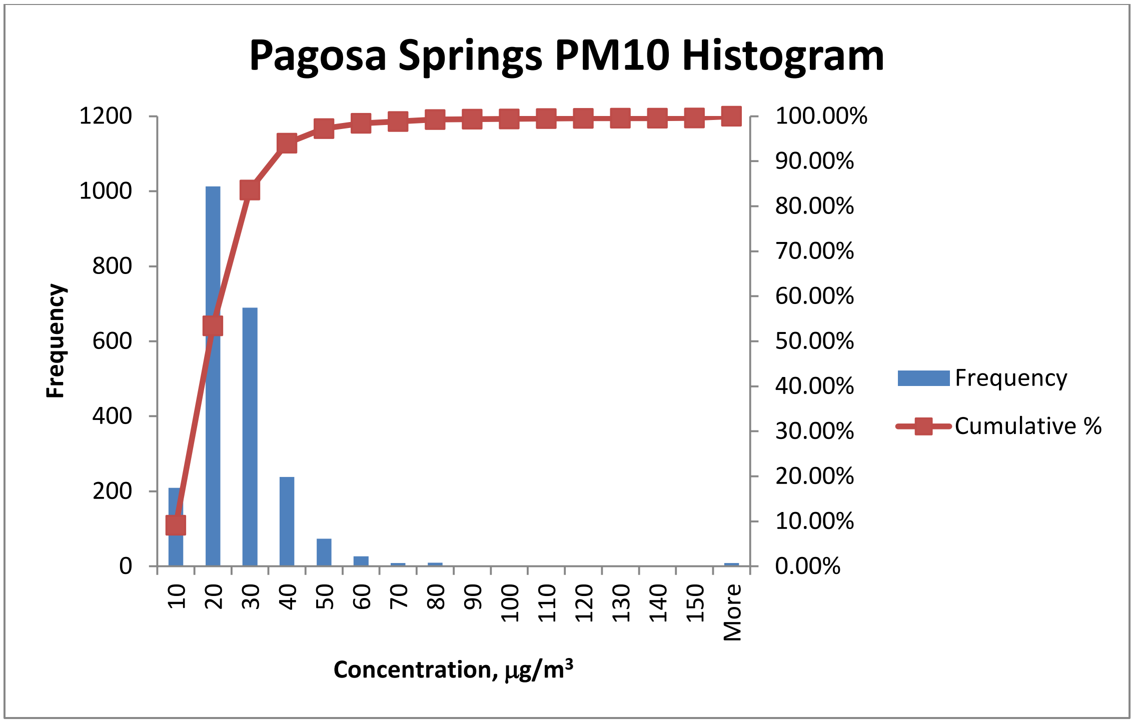


Figure 39: Pagosa Springs PM_{10} Histogram

The monthly box-whisker plot in Figure 40 highlights the consistency of the majority of data from month to month. Note the greater variability (wider inner-quartile range) and greater range of the data through the winter and early spring months that's accompanied by typically greater monthly maxima. Recall, this time period experiences a greater number of days with meteorological conditions similar to those experienced on May 11, 2010. Although these high values affect the variability and central tendency of the dataset they aren't representative of what is typical at the site.

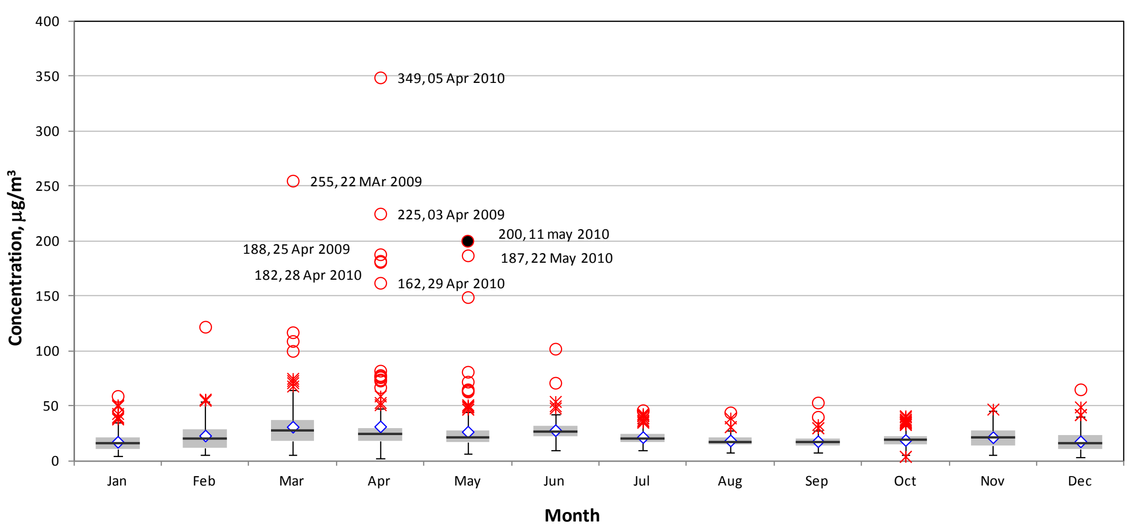


Figure 40: Pagosa Springs PM_{10} Monthly Box and Whisker Plot

As with the previous box and whisker plots outliers greater than 150 µg/m^3 are identified by concentration and date. Each of these outliers is associated with a known high-wind event similar to that of May 11, 2010. The presence of the extreme values distorts the graph, losing definition and distorting information presented across the range where the majority of data resides. The same plot graphed to 100 µg/m^3, which includes over 99% of all the data, is presented **Error! Reference source not found.**, here.

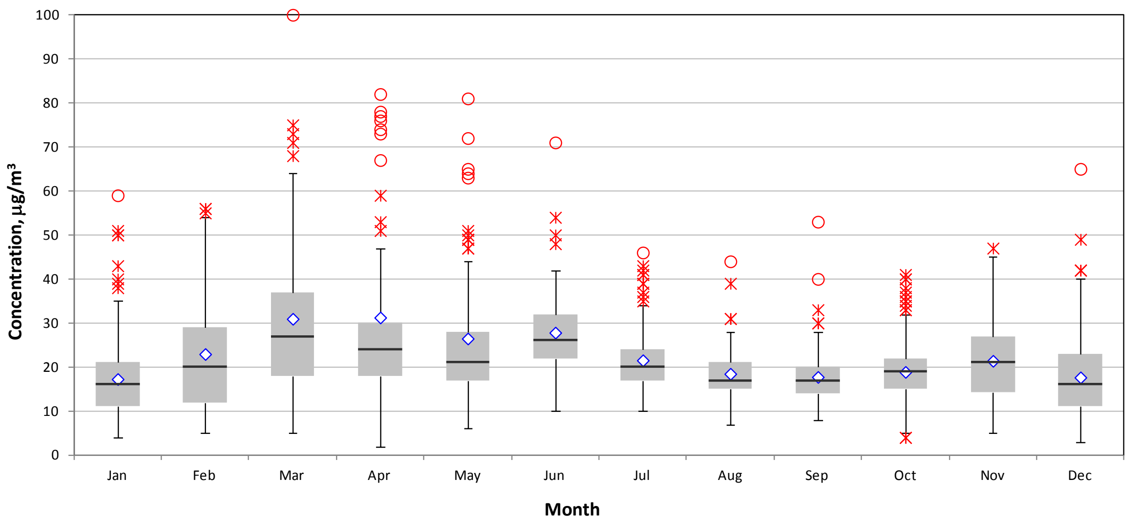
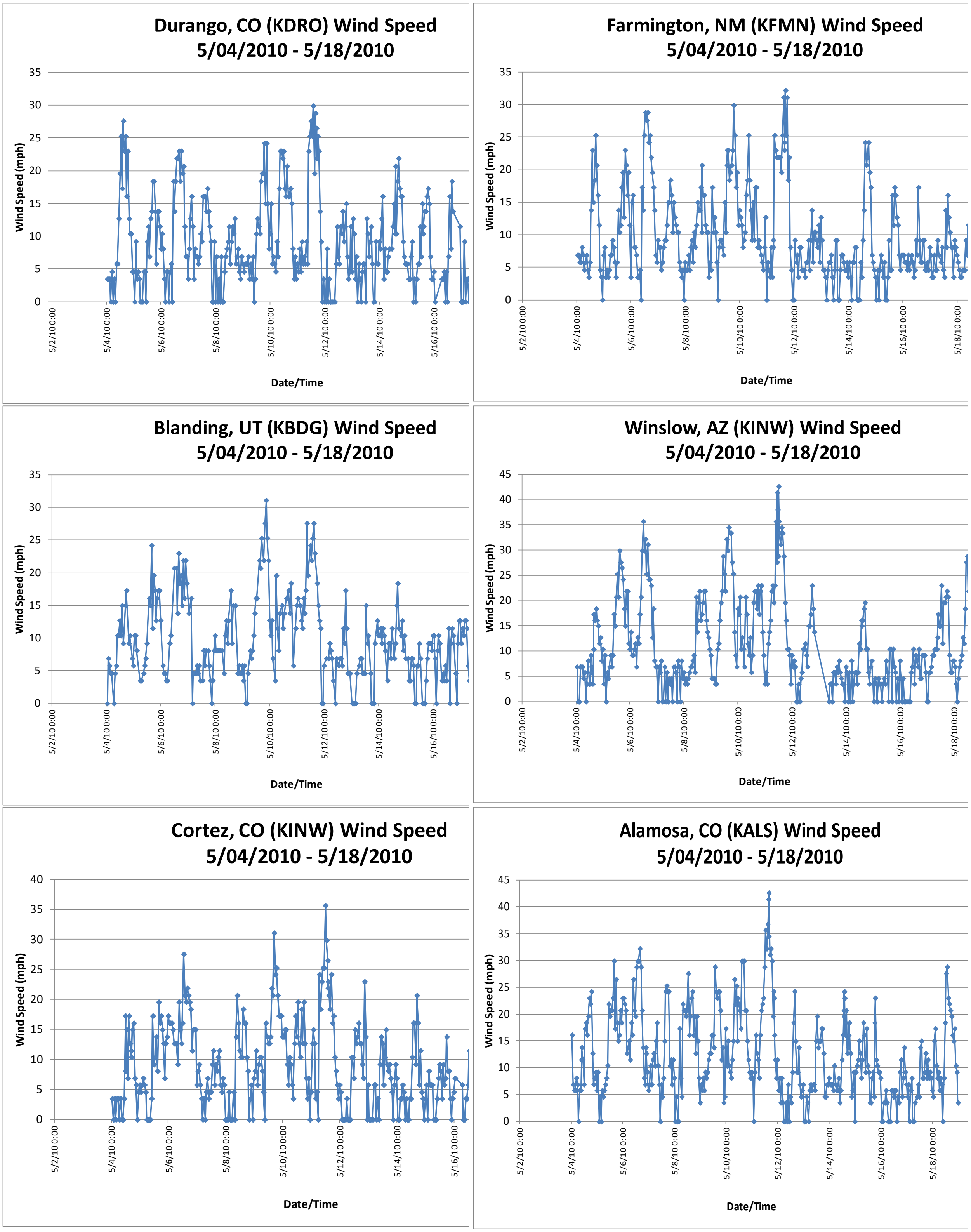


Figure 41: Pagosa Springs PM_{10} Monthly Box and Whisker Plot (expanded view)

3.2 Wind Speed Correlations

Wind speeds around the region (Southwest Colorado, Northeast Arizona, Northwest New Mexico) increased n the morning of May 11, 2010, peaking around noon and then declining through the early morning of the 12th; peak gusts in the afternoon of May 11, 2010, exceeded 50 mph at some stations. The following charts display wind speed (mph) as a function of date from six widely dispersed stations across the region. Every one of these stations, despite being in completely disparate locations, exhibits nearly the same behavior in regards to the sustained high winds from May 11, 2010.

Figure 42: Wind Speed (mph) Various Stations



(Wind Speed data courtesy of University of Utah, Mesowest)

Figure 43 plots PM_{10} concentrations from the affected sites for seven days prior to and following the sample of May 11, 2010.

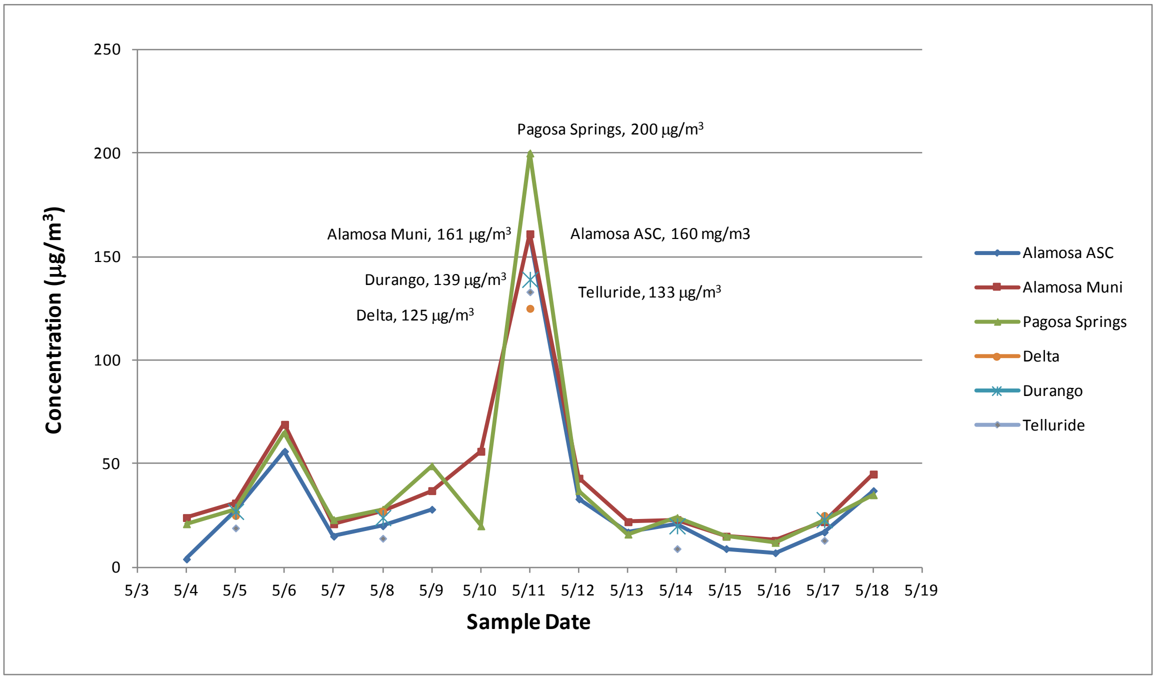


Figure 43: PM_{10} Concentrations Affected Sites 04 May - 18 May

The plot precisely mimics the plots for area wind speeds (Figure 42: Wind Speed (mph) Various Stations). Although not every sample from May 11, 2010, is in excess of 150 µg/m^3 the elevated concentrations are clearly associated with the elevated wind speeds. Given the spatial dislocation of the sites (meteorological and PM_{10}) the relationship between the two data sets would suggest that the regional high winds had a similar effect on PM_{10} samples in across a broad spatial region in Colorado from May 11, 2010.

3.3 Percentiles

Monthly percentile plots (Figure 44) for each site demonstrate a high degree of association between monthly median values and relatively high monthly percentile values, e.g. the r^2 value between the Alamosa ASC monthly 90th percentile and the Alamosa ASC monthly median is 0.699. The same value(s) for Pagosa Springs and Durango are 0.827 and 0.613, respectively. As the percentile value decreases (i.e. 85%, 75%, etc) the correlation between those values and the median increases sharply. The monthly percentile plots for the affected sites are presented in Figure 44: PM10 Monthly Percentile Plots Affected Sites (the black line is the 85th percentile):

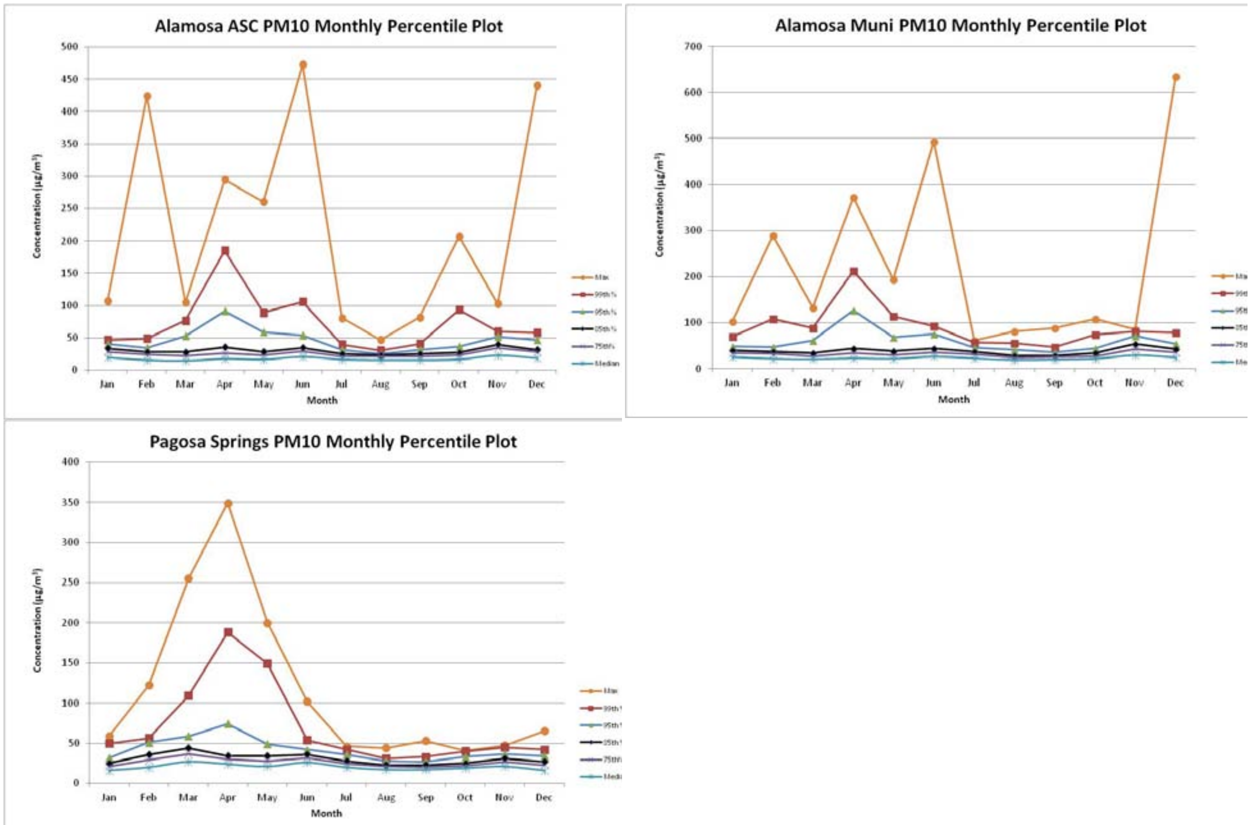


Figure 44: PM_{10} Monthly Percentile Plots
Affected Sites

It is certainly the case that monthly median values are indicative of typical, day to day concentrations. Additionally, there is a range of samples that are a product of normal variation subject to typical, day to day local effects. This range may be restricted to percentile values that are well correlated with the median. For these data sets a conservative estimate of the percentile value that is reflective of typical, day to day variation is the 90th percentile value. A different way to phrase this may be that most of the variability in the monthly 90th percentile values can be explained by the variation in monthly medians. If we take the 90th percentile as an estimate of the maximum contribution that could have come from local sources then the portion of the sample concentration remaining would be due to the event. Nearly all of the variation in the monthly 84th percentile values can be explained by the variation in monthly medians; for these five sites the correlation between the median and 84th percentile values vary from an $r^2 = 0.69$ (Mt. Crested Butte) to an $r^2 = 0.93$ (Alamosa Muni). The following tables identify various percentile values for each site from all April data for both sample dates. The range estimate in the 'Est. Conc. Above Typical' column is derived using the difference between the actual sample value and the 90th percentile as the minimum event contribution estimate and the difference between the actual sample value and the 84th percentile as the maximum event contribution estimate.

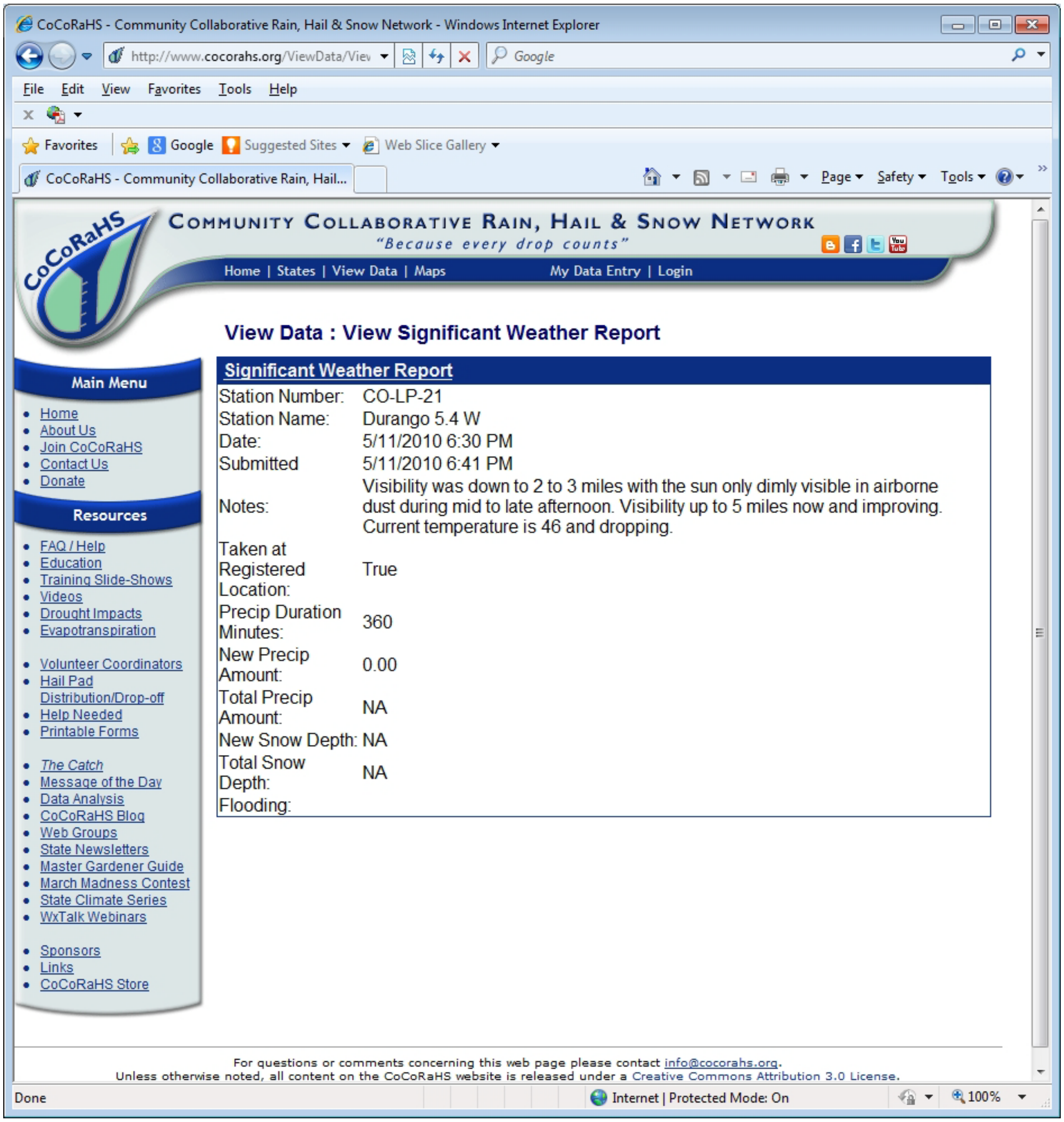
Table 14: Estimated Contribution to PM_{10} Concentrations from May 11, 2010, Event

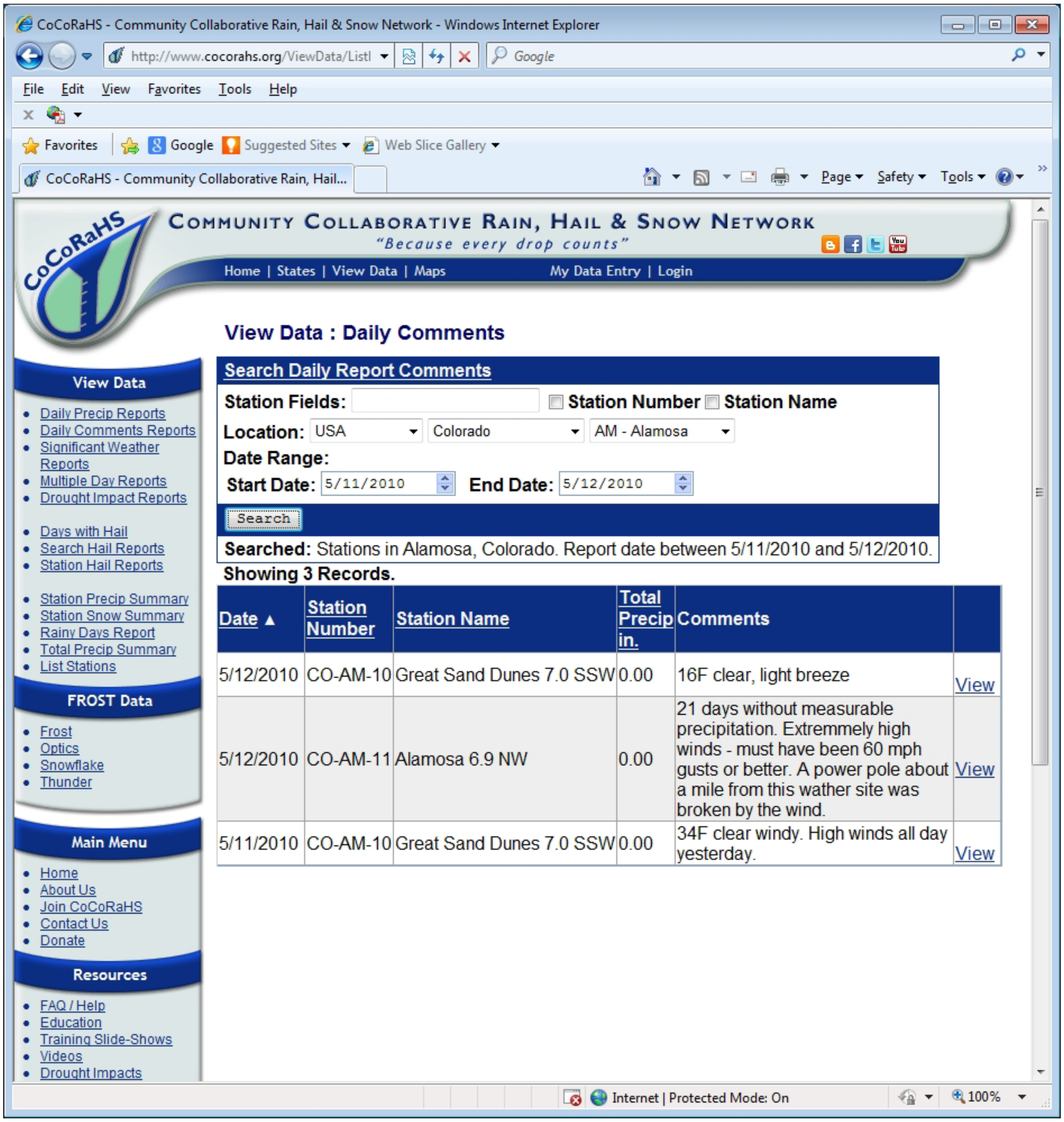
Site	Event Day Concentration (µg/m³)	May Median (µg/m³)	May Average (µg/m³)	May 75th % (µg/m³)	May 84th % (µg/m³)	May 90th % (µg/m³)	Est. Conc. Above Typical (µg/m³)
Alamosa ASC	**160**	17	22.3	23	**27**	**35**	**125 - 133**
Alamosa Muni	**161**	22	27.3	30	**38**	**45**	**116 - 123**
Pagosa Springs	**200**	21	26.5	28	**33**	**38**	**162 - 167**

Clearly, there would have been no exceedance but for the additional contribution provided by the event.

Since the local anthropogenic sources are well controlled in Alamosa and Pagosa Springs and the sustained surface wind speeds were above 30 mph in the region of the dust storm, it follows that the dust was transported into the region on May 11, 2010. This high wind blowing dust event affected the air quality in Alamosa, and Pagosa Springs in the state of Colorado on May 11, 2010. The size, extent, and origination of the blowing dust storm made the event not preventable and it could not be reasonably controlled. Statistical data clearly shows that but for this high wind blowing dust event Alamosa and Pagosa Springs would not have exceeded the 24-hour NAAQS on May 11, 2010.

4.0 News and Credible Evidence





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COMMUNITY COLLABORATIVE RAIN, HAIL & SNOW NETWORK

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Station Fields: Station Number Station Name

Location: USA Colorado AM - Alamosa

Date Range:

Start Date: 5/11/2010 **End Date:** 5/12/2010

Search

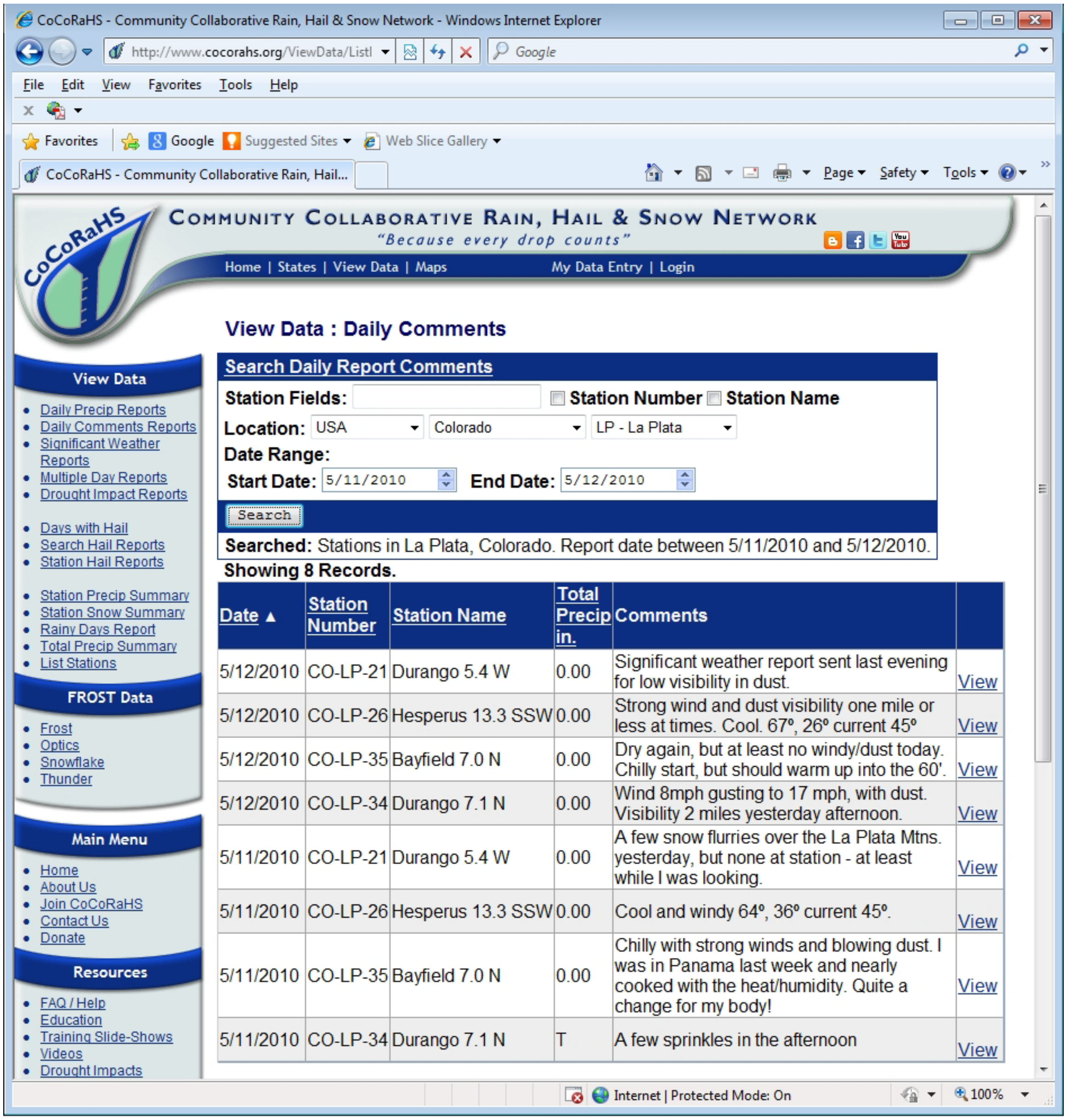
Searched: Stations in Alamosa, Colorado. Report date between 5/11/2010 and 5/12/2010.

Showing 3 Records.

Date ▲	Station Number	Station Name	Total Precip in.	Comments	
5/12/2010	CO-AM-10	Great Sand Dunes 7.0 SSW	0.00	16F clear, light breeze	View
5/12/2010	CO-AM-11	Alamosa 6.9 NW	0.00	21 days without measurable precipitation. Extremmely high winds - must have been 60 mph gusts or better. A power pole about a mile from this wather site was broken by the wind.	View
5/11/2010	CO-AM-10	Great Sand Dunes 7.0 SSW	0.00	34F clear windy. High winds all day yesterday.	View

Internet | Protected Mode: On 100%

(NOTE: CoCoRaHS "Daily Comments" reports are submitted at approx. 7:00 a.m.)



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Station Fields: ☐ **Station Number** ☐ **Station Name**

Location: USA | Colorado | LP - La Plata

Date Range:

Start Date: 5/11/2010 **End Date:** 5/12/2010

Search

Searched: Stations in La Plata, Colorado. Report date between 5/11/2010 and 5/12/2010.

Showing 8 Records.

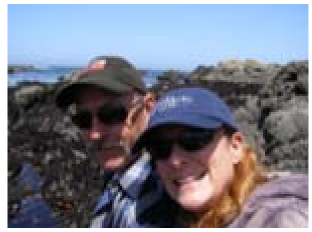
Date ▲	Station Number	Station Name	Total Precip in.	Comments	
5/12/2010	CO-LP-21	Durango 5.4 W	0.00	Significant weather report sent last evening for low visibility in dust.	View
5/12/2010	CO-LP-26	Hesperus 13.3 SSW	0.00	Strong wind and dust visibility one mile or less at times. Cool. 67º, 26º current 45º	View
5/12/2010	CO-LP-35	Bayfield 7.0 N	0.00	Dry again, but at least no windy/dust today. Chilly start, but should warm up into the 60'.	View
5/12/2010	CO-LP-34	Durango 7.1 N	0.00	Wind 8mph gusting to 17 mph, with dust. Visibility 2 miles yesterday afternoon.	View
5/11/2010	CO-LP-21	Durango 5.4 W	0.00	A few snow flurries over the La Plata Mtns. yesterday, but none at station - at least while I was looking.	View
5/11/2010	CO-LP-26	Hesperus 13.3 SSW	0.00	Cool and windy 64º, 36º current 45º.	View
5/11/2010	CO-LP-35	Bayfield 7.0 N	0.00	Chilly with strong winds and blowing dust. I was in Panama last week and nearly cooked with the heat/humidity. Quite a change for my body!	View
5/11/2010	CO-LP-34	Durango 7.1 N	T	A few sprinkles in the afternoon	View

Internet | Protected Mode: On   100%

(NOTE: CoCoRaHS "Daily Comments" reports are submitted at approx. 7:00 a.m.)

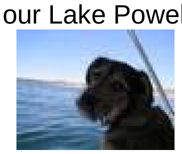
Wind, Sand And More Wind

May 11, 2010



Lake Powell

View from our Lake Powell Campsite



Heidi's first water adventure

Show all 16 photos

We've spent the last several days exploring the desert around the Utah/Arizona borders. We are getting our fill of warm, dry and bug-free weather before we head east.

We stayed a couple nights at Lake Powell – a man-made lake on the Colorado River, north of the Grand Canyon. Lake Powell was created when the Glen Canyon Dam was built managing the flow of the Colorado. It is a very scenic area with many natural geologic wonders. Lake Powell is part of the Glen Canyon National Recreation Area controlled by the National Park System.

We spent a day on the lake in our Achilles inflatable boat. This was Heidi's first experience on the water and we were thrilled with how calm and comfortable she was in the boat. She did not attempt to get into the water and we did not encourage it. The water was cold and neither Marty nor I wanted to get wet in case Heidi needed assistance. We will reserve that excitement for later in the summer.

We continued our journey just north of the Arizona border into Monument Valley. Monument Valley is part of the Navaho Nation Indian Reservation and not a National or State Park. It gained fame in the 1930's as a setting for many movie westerns and was favored by director John Ford and actor John Wayne (Stagecoach). We stayed at the only place around – Goulding's Resort – which provides camping and hotel lodging – along with a restaurant, gas station, grocery store, museum and gift shop.

Our stay at Monument Valley was frustrating. The wind was howling and tearing through the Valley, whipping up the sand and making being outside torture. According to the employees, sand storms are not uncommon. Dirt, grit and sand obliterated the Valley views and got into our eyes, ears and mouths. Cold and snow is much more acceptable than high winds and blowing sand. It was miserable.

We had one clear day and we took the Jeep out on the "17-mile" drive. It is a rough dirt road that traverses the valley. You can take one of the guided tours for $40+ a person – in a very uncomfortable looking, open air truck – or drive it yourself for $5 a person. The road was particularly bad in only a few spots and there were numerous Europeans driving their rental motorhomes down the road. This made for some additional entertainment and a reason not to rent out your RV.

While I found Monument Valley to be spectacular and beautiful, it is in an out of the way location, expensive and has limited things to do. I would not recommend it as a vacation destination unless you've already seen your fill of Bryce, Zion, Capital Reef and Arches National Parks. The National Parks offer so much more for a family to do, easier access and a better dollar value with similar stunning views.

The wicked winds appear to be following us as we continue our eastward travels, so I'll keep repeating…it is all part of the adventure!

http://www.mytripjournal.com/travel-516529-lake-powell-monument-valley-national-sand-canyon-part

5.0 Not Reasonably Controllable or Preventable: Local Particulate Matter Control Measures

While it is likely that some dust was generated within the local communities as gusts from the regional dust storm passed through the area, the amount of dust generated locally was easily overwhelmed by, and largely unnoticeable as compared to the dust transported in from the source regions of the dust storm. The following sections will describe in detail the regulations and programs in place designed to control PM_{10} in each affected community. These sections will demonstrate that the event was not reasonably controllable, as laid out in Section 50.1(j) of Title 40 CFR 50, within the context of reasonable local particulate matter control measures. As shown from the meteorological and monitoring analyses (Sections 2 and 3), the source region for the associated dust that occurred during the May 11, 2010, event originated outside of the monitored areas, primarily from southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico.

The Colorado Air Pollution Control Division (Division) conducted thorough analyses and outreach with local governments to confirm that no unusual anthropogenic PM10-producing activities occurred in these towns and that despite reasonable control measures in place, high wind conditions overwhelmed all reasonably available controls. The following subsections describe in detail Best Available Control Measures (BACM), other reasonable control measures, applicable federal, state, and local regulations, appropriate land use management, and an in-depth analysis of potential areas of local soil disturbance for each affected community during the May 11, 2010 event, as well as subsequent outreach designed to administer these activities. This information shall confirm that no unusual anthropogenic actions occurred in the local areas of Alamosa or Pagosa Springs during this time.

Regulatory Measures- State
The Division's regulations on PM_{10} emissions are summarized in Table 15.

Table 15: State Regulations Regulating Particulate Matter Emissions

Rule/Ordinance	Description
Colorado Department of Public Health and Environment Regulation 1- Emission Control For Particulate Matter, Smoke, Carbon Monoxide, And Sulfur Oxides	Applicable sections include but are not limited to: Everyone who manages a source or activity that is subject to controlling fugitive particulate emissions must employ such control measures and operating procedures through the use of all available practical methods which are technologically feasible and economically reasonable and which reduce, prevent and control emissions so as to facilitate the achievement of the maximum practical degree of air purity in every portion of the State. Section III.D.1.a) Anyone clearing or leveling of land greater than five acres in attainment areas or one acre in

	non-attainment areas from which fugitive particulate emissions will be emitted are required to use all available and practical methods which are technologically feasible and economically reasonable in order to minimize fugitive particulate emissions.(Section III.D.2.b) Control measures or operational procedures for fugitive particulate emissions to be employed may include planting vegetation cover, providing synthetic cover, watering, chemical stabilization, furrows, compacting, minimizing disturbed area in the winter, wind breaks and other methods or techniques approved by the Division. (Section III.D.2.b) Any owner or operator responsible for the construction or maintenance of any existing or new unpaved roadway which has vehicle traffic exceeding 200 vehicles per day in the attainment/maintenance area and surrounding areas must stabilize the roadway in order to minimize fugitive dust emissions (Section III.D.2.a.(i))
Colorado Department of Public Health and Environment Regulation 3- Stationary Source Permitting and Air Pollutant Emission Notice Requirements	Construction Permit required if a land development project exceeds 25 acres and spans longer than 6 months in duration (Section II.D.1.j)
Colorado Department of Public Health and Environment Regulation 6- Standards of Performance for New Stationary Sources	Implements federal standards of performance for new stationary sources including ones that have particulate matter emissions. (Section I)
Colorado Department of Public Health and Environment Regulation 9- Open Burning, Prescribed Fire, and Permitting	Prohibits open burning throughout the state unless a permit has been obtained from the appropriate air pollution control authority. In granting or denying any such permit, the authority will base its action on the potential contribution to air pollution in the area, climatic conditions on the day or days of such burning, and the authority's satisfaction that there is no practical alternate method for the disposal of the material to be burned. Among other permit conditions, the authority granting the permit may impose conditions on wind speed at the time of the burn to minimize smoke impacts on smoke-sensitive areas. (Section III)
Federal Motor Vehicle Emission Control	The federal motor vehicle emission control

Program	program has reduced PM_{10} emissions through a continuing process of requiring diesel engine manufacturers to produce new vehicles that meet tighter and tighter emission standards. As older, higher emitting diesel vehicles are replaced with newer vehicles; the PM_{10} emissions in areas will be reduced.

5.1 Alamosa

Natural Events Action Plan (NEAP)

The Final NEAP for High Wind Events in Alamosa, Colorado was completed in May 2003. The NEAP addresses public education programs, public notification and health advisory programs, and determines and implements Best Available Control Measures (BACM) for anthropogenic sources in the Alamosa area. The Division followed up with the City and County of Alamosa in January 2007 and in the spring of 2013 on whether the NEAP mitigation measures and commitments were satisfied, the results of which are detailed below. The City of Alamosa, Alamosa County, the Division, and participating federal agencies worked diligently to identify contributing sources and to develop appropriate BACM as required by the Natural Events Policy.

Regulatory Measures- City

The Division and the City of Alamosa are responsible for implementing regulatory measures to control emissions from agricultural sources, stationary sources, fugitive dust sources, and open burning within Alamosa. Alamosa's ordinances of PM_{10} emissions are summarized in Table 16.

Table 16: Rules and Ordinances Regulating Particulate Matter Emissions in Alamosa

Rule/Ordinance	Description
City of Alamosa Code of Ordinances Article VII of Section 21-140 (5)	Addresses dust control for home occupations
City of Alamosa Code of Ordinances Article V Sec. 17-87(3))	Requires all new roads and alleys to be paved
City of Alamosa Code of Ordinances (Article VI Sec. 21-119(g)(3)).	New large commercial/retail establishments must install underground automatic irrigation systems for all landscaped areas

<u>City of Alamosa</u>

The City of Alamosa has been active in addressing potential PM_{10} sources within the Alamosa area through various efforts. Some of these efforts, plus other potential future measures, include the adoption of local ordinances to reduce PM_{10}. Copies of current ordinances and any related commitments are included in the NEAP in Appendix C. According to the City's Public Works Director, as of 2013, the City is planning on adding additional dust control best management practices to the International Building Codes that are adopted by the city in the next update. The best management practices will include requiring a Dust Control Plan for any site that is issued a clearing permit for any site over 2 acres. The City is also currently (as of 2013) working on revising part of their landscaping ordinances to require mulch in areas that are not vegetated or covered by rock to help mitigate fugitive particulate emissions. These efforts have been stalled in the past due to employee turnover at City Manager's Office.

Street Sweeping
The City of Alamosa sweeps on an every 4-week schedule or as needed, as determined by local officials on a case by case situation (e.g., following each snowstorm and/or where sand was applied). Sweeping occurs on every single City street with an emphasis on the downtown corridor where public exposure is expected to be greatest. In fact as of Spring 2013, street sweeping in the downtown corridor currently takes place twice per week according to the City's Public Works Director.

According to the City's Public Works Director, the city currently (as of 2013) owns an Elgin Pelican (mobile mechanical sweeper) and a Tymko 600 (brush-assisted head) street sweeper. As of June 2013, the City will also own a new Elgin Broom Badger street sweeper at which time the Tymko 600 will be sent in for a re-build. The new Elgin Broom Badger street sweeper can be used in the winter months when the Tymko cannot due to freezing of the water delivery system.

Unpaved Roads within the City
The City of Alamosa (as of 2008) requires all new roads and alleys to be paved according to the Municipal Code (Article V Sec. 17-87(3)) and some existing unpaved roads are being treated with dust suppressants until all underground utilities are installed. No new development is allowed until paving is complete unless a performance bond is in place.

According to the City's Public Works Director, as of 2013, less than 3% of City roads are unpaved; most of these unpaved roads are legacy annexations. One of these unpaved roads is scheduled for paving this year (2013). The remaining unpaved roads are all low traffic (less than 100 ADT) and the City continues to seek funding sources for paving these streets.

Sod/Vegetative Cover Projects in the City of Alamosa
As of 2008, the City of Alamosa placed vegetative cover in all city parks and has installed irrigation systems to maintain the cover. As of 2013, the City has been emphasizing more low-water use landscaping with shrubs, mulch, etc. including both organic and rock. All turf areas do have irrigation systems which utilize drip systems for specimen plantings.

Alamosa County
Alamosa County has also been active in addressing blowing dust and is preparing a county ordinance as such.

Unpaved Roads
Alamosa County is presently addressing unpaved roads and lanes that are anticipated to contribute to PM_{10} emissions in the community. As of 2002, Alamosa County was nearing the end of its five-year road paving plan and was developing their next plan with the intention of paving on a yearly basis, based on traffic, community needs/priorities, and funding availability.

In 2002, Alamosa County addressed approximately ten (10) miles of unpaved roads. This includes the stabilization of approximately five section roads, the seal coating of two roads, and the overlay (repaving) of four (4) additional roads.

In 2003, approximately 14 miles of roads were paved. This includes the Seven Mile Road (three miles long), Road 109 (one mile long), and 10th Street (also one mile long). These roads are in close proximity to the City of Alamosa, are upwind (prevailing) from the city, and have heavy traffic. Paving is anticipated to greatly reduce blowing dust and impacts in the vicinity.

No paving projects took place between 2004 and 2010 due to lack of funding. Between 2010 and 2013 the County was able to get funding but only for maintenance paving on previously paved roads that needed repair. Now that the county is caught up on maintenance paving, it is focusing on paving the remaining unpaved roads. The County's goal is to pave about 2.5 miles of unpaved road per year depending on funding availability.

As of 2013, Alamosa County has funding to pave approximately 2.5 miles of the 106 North which is currently unpaved. After this paving project the County will only have 2.5 miles of unpaved road remaining on the 106 North which is anticipated to be paved in the summer of 2014.

In the summer time the County regularly hauls water and wets down the unpaved roads (mostly gravel, clay and sand) to reduce the fugitive particulate emissions. The County wets the unpaved roads on an as needed basis based on weather conditions and traffic volume. In addition, when it gets cold enough in the area, the County wets down some of the more sandy roads. Once the water soaks in and freezes, good dust suppression is seen. Road construction areas are being dampened with water for dust control. These practices reduce PM_{10} emissions in and near Alamosa. This control measure is balanced with the availability of water in the area.

Alamosa County used to assess the need to use $MgC1_2$ treatment on roads in front of residences that request such service. This practice stopped in 2004 when funding was lost. Assessments included the sensitivity to dust of residents, the materials of the road base for safety reasons, and possible environmental concerns of the neighborhood. Most requests for treatment are were granted. Other areas for treatment, such as commercial construction zones or gravel pits, are investigated on a case by case basis. The County hopes to be able to start offering this service again when funding is restored.

Dust Control Plans
Alamosa County may consider changes in local ordinances governing dust control plans at construction sites. This would be addressed through the revision of Alamosa County's Comprehensive Plan and supporting zoning codes. Alamosa County is reviewing language from other successful dust control programs for inclusion in their local ordinances.

The County may update the Comprehensive Plan to include a dust control plan. The Land Use Administrator is researching the potential for a dust control ordinance. This effort is anticipated to reduce PM_{10} emissions in Alamosa, especially as it relates to impacts on the community and high recorded PM_{10} values. At the time of this submittal (June 2013), this effort is still underway.

Wind Erosion of Open Areas
To reduce PM_{10} emissions from open areas outside of the City limits, low tilling and other soil conservation practices continue to be utilized in the community. In addition, the community is using in strategic areas the State of Colorado Agricultural Office's program to purchase and plant shelter trees to reduce wind erosion in open areas. These trees have a demonstrated advantage for the community and for air quality. Once the trees reach maturity, it is anticipated that the equivalent of 112 miles of double-rowed trees will be in place. The survival rate of the tree seedlings varies but according to the District Coordinator for the Seedling Tree Program, potted seedlings have about a 60% to 80% survival rate and the bare root seedlings have about a 40 to 60% survival rate. The Seedling Program recommends Siberian elm and Rocky Mountain juniper trees for low maintenance, drought resistance windbreaks in the valley. In addition, there is ongoing planting of trees (approximately 50) on newly developed Alamosa County property

south/southwest of Alamosa (prevailing winds from southwest) and the Airport south of Alamosa for added air quality improvement.

Windblown Dust from Disturbed Soils

Alamosa has a semi-arid climate with approximately 7.25 inches of precipitation annually. The San Luis Valley, as noted within 25 miles of the San Luis Valley Regional Airport in Alamosa, is primarily comprised of forests (43%) and shrublands (42%). Consequently, soils in all areas are typically a mixture of silt and sand with limited vegetation due to low precipitation. In winter and spring, windstorms are common, especially in drier years. It is due to these high velocity windstorms that Alamosa experiences most of the PM_{10} problems for the area.

Figure 1 illustrates potential areas of local soil disturbance that have been evaluated by the Division for the Alamosa Adams State PM_{10} monitor.

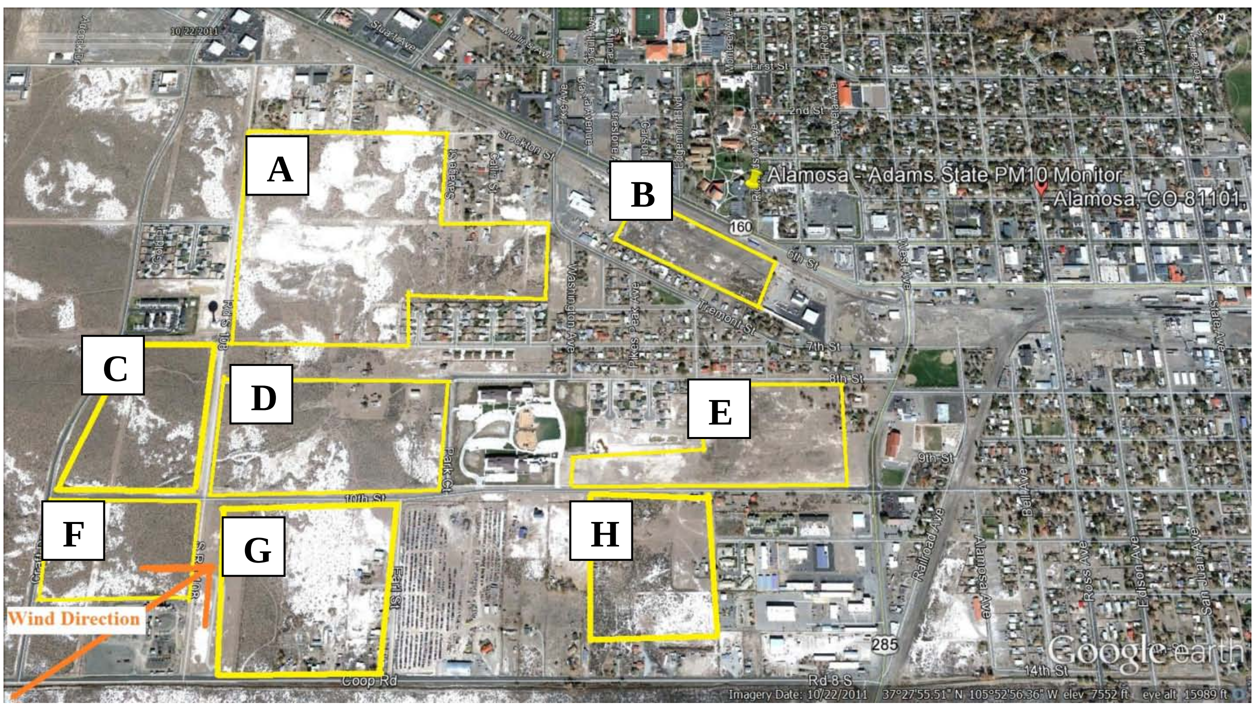


Figure 45: Relative positions of Adam's State College PM_{10} Monitor and potential disturbed soil. (Image from Google Earth 2007)

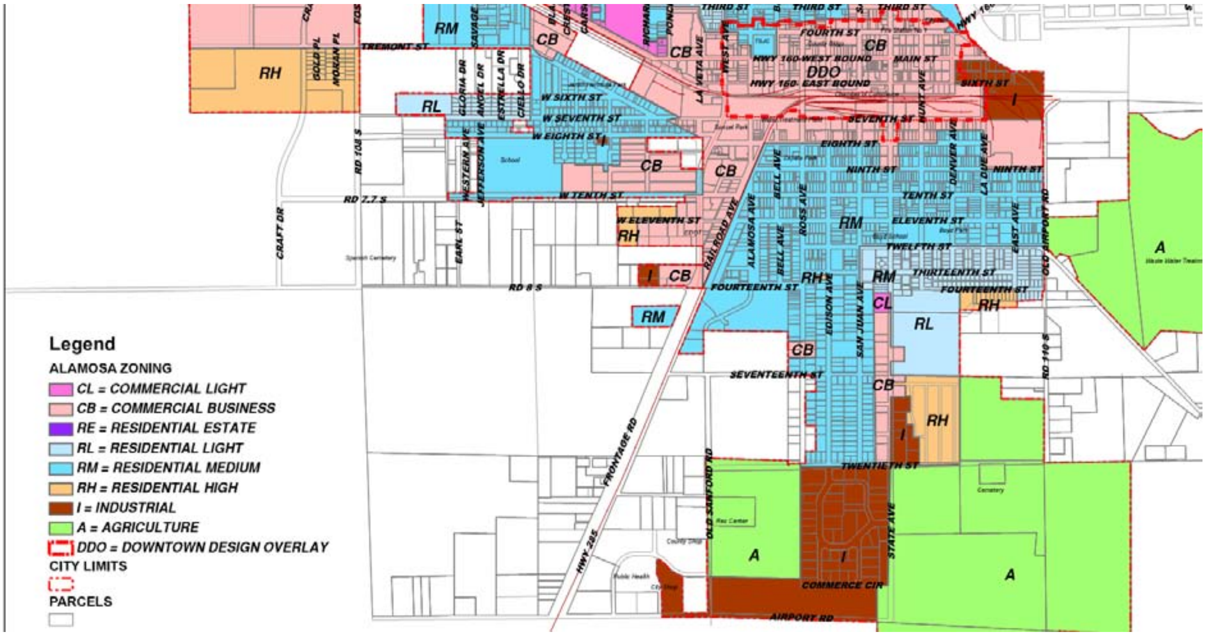


Figure 46: 2011 City of Alamosa Zoning Map (Provided by the Public Works Department)

Site A in Figure 45 (approximately 85 acres) is East of Rd S 108 and South of Chico St. It is zoned outside of the city's limits by the city as a "Parcel" as shown in Figure 46. The eastern portion of Area A is being considered for annexation into the City.

Site C in Figure 45 (approximately 25 acres) is north of 10th St, West of Road 108, and east of Craft St. It is zoned outside of the city's limits by the city as a "Parcel" as shown in Figure 46.

Site D in Figure 45 (approximately 34 acres)is north of 10th street, east of Rd S 108, west of Park Ct, and south of 8th St. It is zoned outside of the city's limits by the city as a "Parcel" as shown in Figure 46.

Site F in Figure 45 (approximately 31 acres)is south of 10th St, east of Craft Dr, west of S Rd 108, and North of Coop Rd. It is zoned outside of the city's limits by the city as a "Parcel" as shown in Figure 46.

Site G in Figure 45 (approximately 41 acres) is east of S Rd 108, north of Coop Rd, west of Earl St, and South of 10th St. It is zoned outside of the city's limits by the city as a "Parcel" as shown in Figure 46.

Sites A, C, D, F, and G are noted by the City of Alamosa's Public Works Director to be vacant land with natural vegetation (i.e. shrubland) with no artificial irrigation and no access restriction. The City emphasizes that the areas are not suited for motorized travel. These lots are not considered to be anthropogenically disturbed soils and should be considered to be natural sources at this time. If future high wind or other exceptional events occur, the Division will re-assess these lots to determine if they are still natural sources.

Site B in Figure 45 (approximately 22 acres) is south of Highway 160 and north east of Tremont St. It is zoned outside of the city's limits by the city as a "Parcel" as shown in Figure 46. Site E in Figure 45 (approximately 30 acres) is north of 10th St, south of 8th St, east of Park Ct, and west of West Ave. It is zoned mostly as a "Commercial Business" as shown in Figure 46. There is a small portion in the top right corner that is zoned outside of the city's limits by the city as a

"Parcel". Site H (approximately 23 acres) in Figure 45 is east of Earl St, south of 10th St, and north of Rd 8 S. It is zoned as "Commercial business", "Residential High" and a little "Industrial" as shown in Figure 46. Sites B, E, and H are naturally vegetated and potentially irrigated as shown in Figure 47. Figure 47 demonstrates that these sites are minimally (if at all) disturbed soil areas.

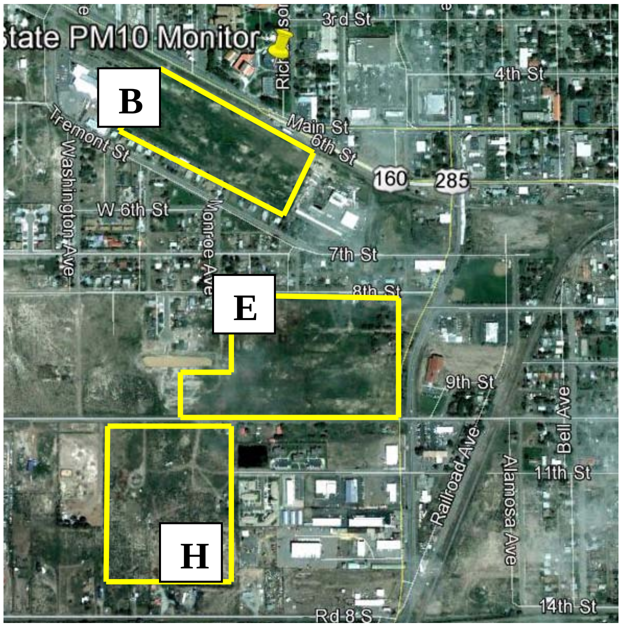


Figure 47: Sites B, E, and H with natural vegetation (Google Earth 2007)

The Division conducted thorough assessments to determine if the potential soil disturbances shown in Figure 45 were present during the 2010 exceedances. During the course of these assessments, the Division discovered that these sites were either reasonably controlled or considered to be natural sources during the May 11, 2010 high wind event. Therefore, these sites were not significant contributors to fugitive dust in the Alamosa area during the May 11, 2010 high wind event.

The Division is currently investigating the applicable area around the Alamosa Municipal Building (08-003-0003) PM_{10} monitor in coordination with the County and City of Alamosa, shown in Figure 1. The Division plans to submit an in-depth analysis similar to the analysis for the Alamosa Adams State PM_{10} monitor.Figure 48 illustrates potential areas of local soil disturbance that have been evaluated by the Division for the Alamosa Municipal Building (08-003-0003) PM_{10} monitor.

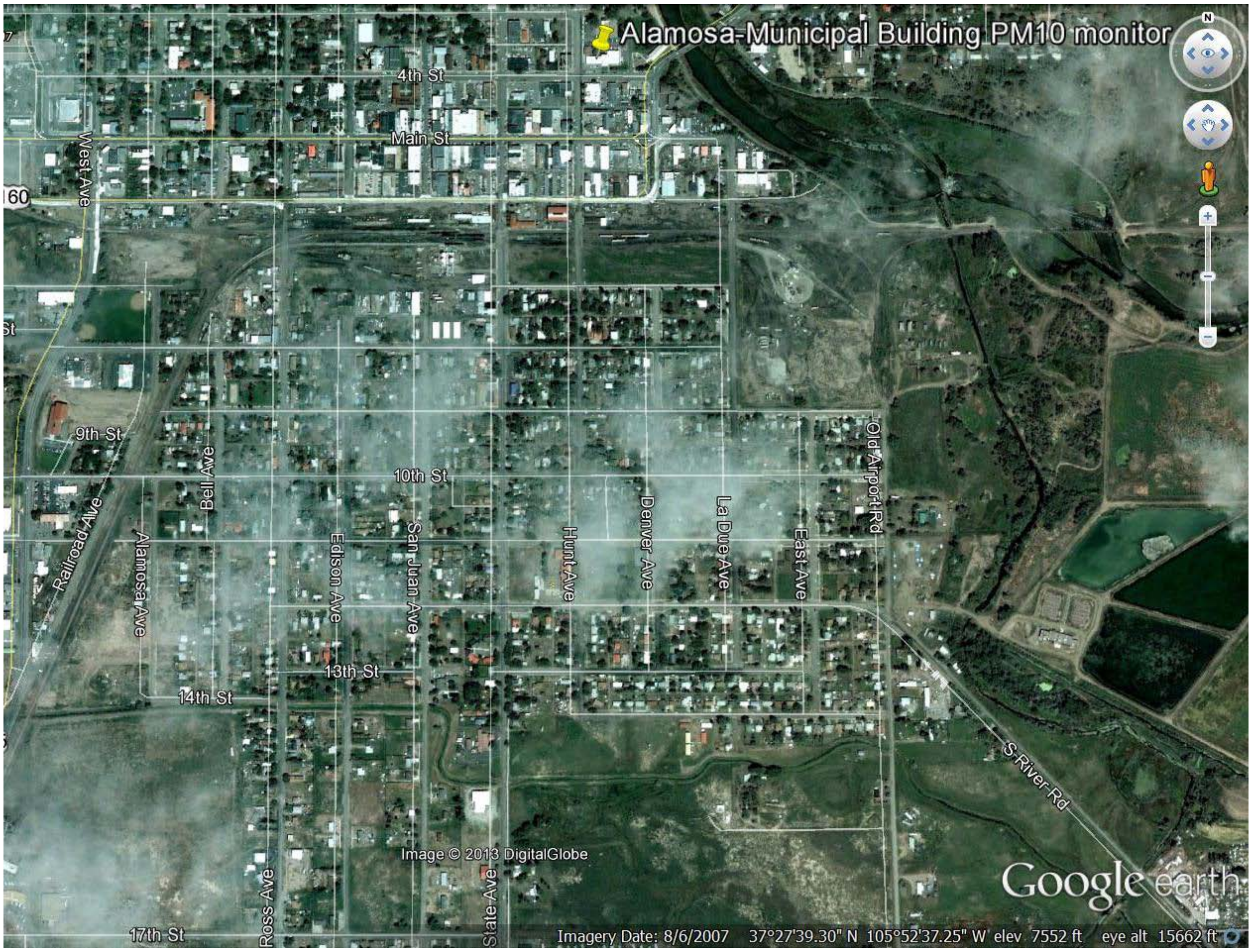


Figure 48: Relative positions of Municipal Building PM10 Monitor and potential disturbed soil. (Image from Google Earth 2007)

Sod and Vegetative Projects in the County

The development and construction of a local park, Eastside Park, is complete in Alamosa County. It has been completed with turf grass, shrubs, and landscape rock. No exposed soil remains. This park has reduced blowing dust from this previously undeveloped site.

Numerous other projects to reduce blowing dust and its impacts have happened or are happening at the County Airport. For example:

- Through additional grounds maintenance of the 40-acre Alamosa County airport south of the city, grass is being grown for aesthetics and dust control.
- Sodding and the placement of decorative rock and ground cover have been implemented in the landscaping of the Alamosa County property (2007-2012). These measures have directly abated blowing dust at the Airport.
- Also, the widening of the airport's safety areas (250 feet on either side of the runway) is now complete and seeding of natural grasses was incorporated in the project. Trees and grass were incorporated in the approaches to the airport and have provided additional wind-break advantages to South Alamosa.

In other areas where watering is a problem, xeriscape (the use of native drought resistant vegetation and/or rock cover) is being encouraged for County owned property and for all other property owners.

Colorado State University Co-Op Extension Office
In response to extremely dry conditions, the need to maintain area topsoil, and reduce impacts, the Colorado State University Co-Op Extension Office of Alamosa County provides the following outreach efforts and recommendations:

- Modification of grazing practices to improve protective crop cover
- Increasing crop residues left in the fields to reduce blowing dust
- Planting of Fall crops to maintain fields
- Application of manure to protect top soils from blowing away
- Staggering of the harvest to minimize blowing dust
- Outreach programs on soil conservation efforts
- Development of outreach/education materials (e.g., news articles, newsletters, fact sheets, etc.), and
- Attendance at Statewide workshop to educate other Co-Op offices to various practices to reduce blowing top soil and minimize impacts.

These control strategies are not meant to be enforceable. They are meant only to demonstrate the regional nature of cooperation in addressing blowing dust and its impacts on the community.

Natural Resources Conservation Service (NRCS)
Alamosa County is a predominately agricultural area where limited water, coupled with the frequent high winds experienced during late fall and early spring, can destroy crops, encourage pests, and damage soil surfaces lending them susceptible to wind erosion. Thus, activities that improve the topsoil and prevent its lifting during high wind events are encouraged. Some notable NRCS and agricultural examples include:

- Cover crops and perennial crops (e.g., alfalfa) are recommended to protect soils;
- NRCS works with area farmers in the development of conservation compliance plans to also protect topsoil;
- NRCS encourages the use of perennial crops or the leaving in place of weeds on the corners of area acreage (instead of tilling that might lead to open, barren lands) to reduce the lifting of topsoil;
- NRCS "cost shares" on conservation practices with local farmers to prevent soil erosion, and;
- The NRCS works with Colorado State University to identify other strategies that minimize blowing dust.

Other successful agricultural practices encouraged in the area include: timing of tillage, crop rotation, amount of crop residue left on the land, and proper water usage. These control strategies are not meant to be enforceable. They are meant only to demonstrate the regional nature of cooperation in addressing blowing dust and its impacts on the community.

Please refer to the Final NEAP in Appendix C for more detail if needed.

5.2 Pagosa Springs

Regulatory Measures- City and County

The Division and the Archuleta County Air Quality Department are responsible for implementing regulatory measures to control emissions from agricultural sources, stationary sources, fugitive dust sources, and open burning within Pagosa Springs. Archuleta County regulations of PM_{10} emissions are summarized in Table 17.

Table 17: Rules and Ordinances Regulating Particulate Matter Emissions in Archuleta County

Rule/Ordinance	Description
Pagosa Springs Land Use and Development Code 6.6.3(h)	Requires that all new developments have paved streets.
Pagosa Springs Land Use and Development Code 6.6.3(m)(i)	All new roads having a projected trip generation of 200 or greater ADT (average daily traffic) shall be paved.

The following control measures resulted in the area‘s attainment of the PM_{10} NAAQS, and these measures should ensure continued maintenance of the PM_{10} NAAQS through the year 2021, which is the duration of the maintenance period.

Control of Emissions through Road Paving

The Town of Pagosa Springs paved 6.5 miles of unpaved roads during 1992, 1993, and 1994 in order to reduce PM_{10} emissions. This strategy was adopted locally in 1991 and included in State regulation in 1992 (Section I.B. of the State Implementation Plan-Specific Regulations for Nonattainment - Attainment/Maintenance Areas (Local Elements)). The rule was approved by EPA in 1994 and was removed from the Colorado regulation in 2000 as the paving requirements had been completed.

Street Sanding Controls

There is a requirement that any user that applies street sanding material on Highway 160 and Highway 84 in the Pagosa Springs attainment/maintenance area must use materials containing less than one percent fines. Users of street sand on these highways must also use 15 percent less sand than an established base sanding amount. These strategies were adopted in 1992 and approved by EPA in 1994, and they are defined in detail in Sections I.B. and C., respectively, of the ―State Implementation Plan-Specific Regulations for Nonattainment - Attainment/Maintenance Areas (Local Elements) Regulations (5 CCR 1001-20).

Control of Emissions from Stationary Sources

Although there are no stationary sources located in the Pagosa Springs attainment/maintenance area, the State‘s comprehensive permit rules will limit emissions from any new source that may, in the future, locate in the area. These rules are outlined in Table 15.

As indicated above, emissions from new or modified major stationary sources emissions of PM10 are controlled under AQCC Regulation No. 3's nonattainment-area (NAA) new source review (NSR) permitting requirements. The NSR provisions require all new and modified major stationary sources to apply emission control equipment that achieves the "lowest achievable emission rate" (LAER) and to obtain emission offsets from other stationary sources of PM_{10}.

The EPA approval of the original PM_{10} Maintenance Plan, effective on 08/14/01, reinstates the prevention of significant deterioration (PSD) permitting requirements in the Pagosa Springs Attainment/Maintenance area. The federal PSD requirements are considered a relaxation from the

NAA NSR requirements, as LAER is no longer required and is replaced by the less stringent "best available control technology" (BACT), along with the removal of the requirement to offset PM_{10} emissions. The future reapplication of NAA NSR provisions appears unlikely in the Pagosa Springs Attainment/Maintenance area based on current PM_{10} monitoring trends.

Voluntary and State-Only Measures

In addition to the mandatory control measures discussed above, there are other activities that result in the reduction of PM_{10} emissions that are not classified as “federally enforceable control measures.” Some notable examples include:

The Town of Pagosa Springs has historically cleaned Highway 160 in town throughout the winter and spring using regenerative air vacuum sweepers. The frequency of this voluntary sweeping/cleaning has been about once after each street sanding deployment. The Town of Pagosa Springs is committed to regularly vacuum sweep/clean Highway 160 within four days of the roadway becoming free and clear of snow and ice following each street sanding deployment, as weather, temperature, and street conditions permit, between the intersections of Highway 84 to the east and 14th street to the west. The town also street sweeps regularly on the side streets.

The Town of Pagosa Springs encourages private businesses to properly clean/sweep private parking lots on a regular basis. These strategies are considered to be voluntary local initiatives intended to reduce PM10 emissions. These strategies are not intended to be federally enforceable.

The city of Pagosa Springs has completed the road paving (100% of total segment) of Hot Springs
Boulevard.

The city of Pagosa Springs is gradually paving Majestic Road (see Figure 49) depending on funding sources.

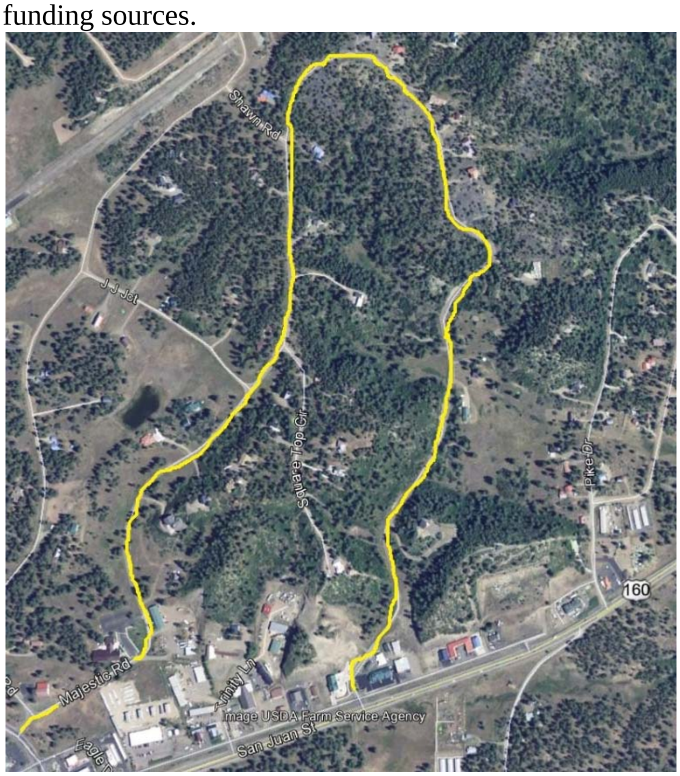


Figure 49: Majestic Road Highlighted in Yellow (Google Earth 2011)

Windblown Dust from Disturbed Soils

Pagosa Springs has a semi-arid climate with approximately 17 inches of precipitation annually. The town is located about 35 miles north of the New Mexico border at 7,000 feet. This area is considered a high desert plateau, creating an unusually mild climate. In winter and spring, regional windstorms are common, especially in drier years. It is during these high velocity windstorms that Pagosa Springs experiences PM_{10} issues. Figure 50 illustrates potential areas of local soil disturbance that have been evaluated by the Division.

Figure 50: Relative positions of Pagosa Springs PM_{10} monitor and known or potential disturbed soil. (Image from EPA)

Site A in Figure 50 shows a 1 acre vacant lot that previously contained a small convenience store which was torn down by the new owner between March and April of 2006. Division conversations with neighboring local business owners indicate the owner seeded the vacant lot (site A) with grass soon after demolishing the building. According to several nearby businesses and a court house clerk, the lot has been under continuous vegetative cover since the seeding in 2006. The grass is well maintained and is enclosed by a small fence (shown in Figure 51) to deter people from walking on the grass. Moreover, the lot is not used for parking or storage.

Figure 51: View of the fence surrounding the vacant lot (Site A)- Google Image 12-2007

Site B in Figure 50 (approximately 2 acres) shows The Springs Resort and Spa. The resort underwent an expansion; construction began in June 2008 and was completed in May 2009. By April 2009, the entire construction site was paved and the building was constructed; the interior was just being finished. Therefore, this project was completed and did not contribute to the May 11, 2010 exceptional event.

Site C in Figure 50 is a 35-acre area of vacant land. According to the Pagosa Springs Parks Department, the area is private property and is entirely naturally vegetated because of a continuous supply of ground water from the nearby stream. The Parks Department also indicates that off-road recreational vehicles are prohibited on the property. The Parks Department is very aware of dust prevention practices and does not believe that the area is a significant source of dust during high winds. With regard to AQCC Regulation 1 requirements (Section III.D.2.b), the Division considers the natural vegetation with regular ground water availability due to the low-lying terrain to be the appropriate available and practical method that is technologically feasible and economically reasonable in order to minimize fugitive particulate emissions for this lot at this time. Local sources, including the Pagosa Daily Post, cite the proposed future 35-acre hotel expansion (Site C) to be projected to occur in several phases over a 10-15 year time period.

The Division will conduct appropriate outreach and compliance assistance so the hotel is aware of potentially applicable AQCC Regulation 1 (Section III.D.2.b) and Regulation 3 (Construction Permit required if the project exceeds 25 acres and spans longer than 6 months in duration) requirements for future construction projects. The Division has specific Air Pollutant Emissions Notices (APENs) for land development and associated guidance documents posted on its website for these type of sources. Additionally, the Division has staff that conduct Small Business Assistance outreach as warranted. Compliance and enforcement inspectors from the Division are assigned regions throughout the state. As part of their workplans, they are required to be reasonably (within 1-2 business days) responsive to community and local government concerns and complaints regarding air quality issues, including fugitive dust.

Site D in Figure 50 is Yamaguchi Park, a 16-acre park consisting mostly of well-maintained turf and some stabilized clay associated with a baseball field. The entire park is irrigated on a regular basis to both maintain the vegetation and to mitigate dust. In the fall of 2008, Pagosa Springs hydro-seeded the park and vegetation emerged around April 2009 which was watered on a regular basis to help the vegetation grow. In Figure 52 below, it is apparent that the park has well maintained vegetation and a small amount of stabilized clay. With regard to AQCC Regulation 1 requirements (Section III.D.2.b), the Division considers hydro-seeding to be the appropriate available and practical method that is technologically feasible and economically reasonable in order to minimize fugitive particulate emissions for this magnitude of construction project.

Figure 52: Yamaguchi Park- Google Image from 10-2011

The Division conducted thorough assessments to determine if the potential soil disturbances shown in Figure 5 were present during the 2010 exceedances. During the course of these assessments, the Division discovered that these sites were reasonably controlled during the May 11, 2010 high wind event. Therefore, these sites were not significant contributors to fugitive dust in the Pagosa Springs area during the May 11, 2010 high wind event.

6.0 Summary and Conclusions

APCD is requesting concurrence on exclusion of the PM_{10} values from Alamosa-Adams State College (08-003-0001), Alamosa-Municipal Building (08-003-0003), and Pagosa Springs-Middle School (08-007-0001) on May 11, 2010.

Elevated 24-hour PM_{10} concentrations were recorded across Colorado on May 11, 2010. All of the noted May 11, 2010, twenty-four-hour PM_{10} concentrations were above the 90^{th} percentile concentrations for their locations (see Table 14). This event exceeded the 98th% value of any evaluation criteria for all three monitoring sites. The statistical and meteorological data clearly shows that but for this high wind blowing dust event, Alamosa and Pagosa Springs would not have exceeded the 24-hour NAAQS on May 11, 2010. Since at least 2005, there has not been an exceedance that was not associated with high winds carrying PM_{10} dust from distant sources in these areas. This is evidence that the event was associated with a measured concentration in excess of normal historical fluctuations including background.

The PM_{10} exceedances Alamosa and Pagosa Springs on May 11, 2010, would not have occurred if not for the following: (a) dry soil conditions over southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico; (b) a combination of strong surface low pressure and a cold front associated with an intense upper-level trough that was moving across the western United States that created conditions necessary for widespread strong gusty winds over the area of concern; and (c) elevated friction velocities and the deep mixing of the blowing dust from desert regions of Arizona, northwest New Mexico, and southeast Utah.

Surface weather maps for the Four Corner States show evidence of widespread blowing dust and winds above the threshold speeds for blowing dust on May 11, 2010. This surface analysis shows that winds were as high as 43 mph and wind gusts were as high as 58 mph in areas south of the stationary front and surface low pressure complex. These speeds are above the thresholds for blowing dust identified in EPA draft guidance and in detailed analyses completed by the State of Colorado. These PM_{10} exceedances were due to an exceptional event associated with regional windstorm-caused emissions from erodible soil sources over a large area of southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico. These sources are not reasonably controllable during a significant windstorm under abnormally dry or moderate drought conditions.

The blowing dust climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Forecast products from the Navy Aerosol Analysis and Prediction System model provide evidence for a widespread blowing dust event in the Four Corners states, suggesting that significant source regions for dust transported into Colorado were located in arid regions of Arizona, Utah, and New Mexico. NOAA HYSPLIT forward and backward trajectories provide clear supporting evidence that dust from desert regions of northwest New Mexico and Arizona caused the PM10 exceedances measured across portions of southwest Colorado on May 11, 2010. Soils in the Four Corners area and in northeast Arizona and extreme northwestern New Mexico in particular were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.

Both wind speeds and soil moisture in the Four Corners area and northeastern Arizona were conducive to the generation of significant blowing dust. Multiple sources of data for the event in question and analyses of past dust storms in this area prove that this was a natural event and, more specifically, a significant natural dust storm originating in northeastern Arizona and northwestern New Mexico and spreading into southwestern Colorado.

Friction velocities in a wide area of northeast Arizona, northwest New Mexico, southeast Utah, and southwest Colorado were above 1.0 meters per second on May 11, 2010. Even undisturbed desert soils normally resistant to wind erosion will be susceptible to blowing dust when friction velocities are greater than about 1.0 to 2.0 meters per second. Note that blowing dust will typically only occur where these values are high and the soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is why blowing dust occurred in the desert and more arid areas of northern Arizona, northwestern New Mexico, southeastern Utah, and southwestern Colorado on May 11, 2010. The elevated friction velocities shown in Figures 28 and 29, the data on soil moisture conditions presented elsewhere in this report, and the prevalence of winds above blowing dust thresholds (all occurring in traditional source regions in northeastern Arizona and northwestern New Mexico) prove that this dust storm was a natural event that was not reasonably controllable or preventable.

MODIS Terra satellite image shows that the Four Corners region including Utah, Arizona, New Mexico, and Colorado were sources regions for blowing dust on May 11, 2010. This is consistent with the climatology for many dust storms in Colorado as described in the Grand Junction, Colorado, Blowing Dust Climatology report contained in Appendix A of this document. The observations of winds above blowing dust thresholds and restricted visibilities in the areas of concern demonstrate that this is a natural event that cannot be reasonably controlled or prevented.

The Center for Snow and Avalanche Studies has been studying the effects of wind-blown desert dust from Arizona, New Mexico, and Utah on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. The Center for Snow and Avalanche Studies lists May 11, 2010, as one of nine Dust-on-Snow events for the 2009/2010 water year, and this provides clear supporting evidence that a regional blowing dust event with long-range transport caused the PM10 exceedances measured across portions of Colorado on May 11, 2010. Snow cover data provide strong evidence that a widespread, regional, blowing dust event caused exceedances at these locations.

But for the dust storm on May 11, 2010, this exceedance would not have occurred.

7.0 References

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.

Draxler, R.R. and Rolph, G.D., 2012. *HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://ready.arl.noaa.gov/HYSPLIT.php). NOAA Air Resources Laboratory, Silver Spring, MD.*

Marticorena, B., G. Bergametti, D. Gillette, and J. Belnap, 1997, Factors controlling threshold friction velocity in semiarid and arid areas of the United States, *Journal of Geophysical Research 102 D19*, 23,277-23, 287.

Technical Services Program, Air Pollution Control Division, Colorado Department of Public Health and Environment, November 22, 2011, *Technical Support Document for the January 19, 2009 Lamar Exceptional Event.*

United States Environmental Protection Agency, June 2012, draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule

Appendix A- Grand Junction, Colorado, Blowing Dust Climatology January 24, 2012

There can be significant transport of regional blowing dust into Grand Junction from source regions in Utah and Arizona. While there are sources for wind-blown dust within the Grand Valley and Grand Junction itself, there is evidence from the analysis of soil features, wind and precipitation climatology, and statistical analyses of Grand Junction exceedances of the PM10 standard that regional sources often play a significant role during these blowing dust events. This document provides a weight of evidence analysis for dust transport into Colorado.

Grand Junction, Colorado, is located in a part of the country that is largely arid to semi-arid. Figure A-1 through A-3 show the annual average precipitation for Colorado, Arizona, and Utah, respectively. Grand Junction is in the Grand Valley of Western Colorado where the annual precipitation is typically less than 10 inches. Northeastern Arizona, which is frequently upwind of Grand Junction during blowing dust events, receives between 5 and 15 inches of precipitation each year. The Colorado River Basin in eastern and southeastern Utah, which is also frequently upwind of Grand Junction during blowing dust events, also receives 5 to 10 inches per year.

Figure A-4 shows the 1971-2000 monthly normal precipitation amounts for Grand Junction, Colorado. The annual average for this time period is 8.99 inches. The wettest months are March through May and August through October. The driest months are January, February, June, July, November, and December. These months receive an average of 0.57 inches per month. The annual monthly average precipitation is 0.75 inches.

Arid to semi-arid soils make much of the region susceptible to blowing dust. The map in Figure A-5 shows that portion of the Colorado Plateau (circled in red) where modern wind erosion features are common and clearly visible in Google Earth images. These features include longitudinal dunes and other sand or soil erosion structures with a predominant southwest to northeast orientation. This orientation is the result of the predominant southwesterly flow that occurs during high wind and blowing dust events in the region. Figures A-6 through A-12 present aerial views of ubiquitous erosion features in northeastern Arizona and southeastern Utah. The Painted Desert of northeastern Arizona is frequently the source for much of the blowing dust in the Four Corners region. Figure A-13 provides a particularly good satellite image of a blowing dust event originating in the Painted Desert and extending northeastward across the junction of the Four Corners (source: NASA Tera satellite, http://earthobservatory.nasa.gov/IOTD/view.php?id=37791). Strong southwesterly winds caused this blowing dust event.

The text that accompanies this image on NASA's Earth Observatory 10th Anniversary page follows below:

> "A dust storm struck northeastern Arizona on April 3, 2009. With winds over 145 kilometers (90 miles) per hour reported near Meteor Crater, east of Flagstaff, the storm reduced visibility and forced the temporary closure of part of Interstate 40, according to *The Arizona Republic*.
>
> The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this image on April 3, 2009. Clear skies allow a view of multiple source points of this dust storm. The source points occur along an arc that runs from northwest to southeast.
>
> This dust storm occurred in the area known as Arizona's Painted Desert, and the dust plumes show why. Whereas many dust plumes are uniform in color, these plumes resemble a band of

multicolored ribbons, ranging from pale beige to red-brown, reflecting the varied soils from which the plumes arise. The landscapes of the Painted Desert are comprised mostly of Chinle Formation rocks—remains of sediments laid down during the time of the first dinosaurs, over 200 million years ago."

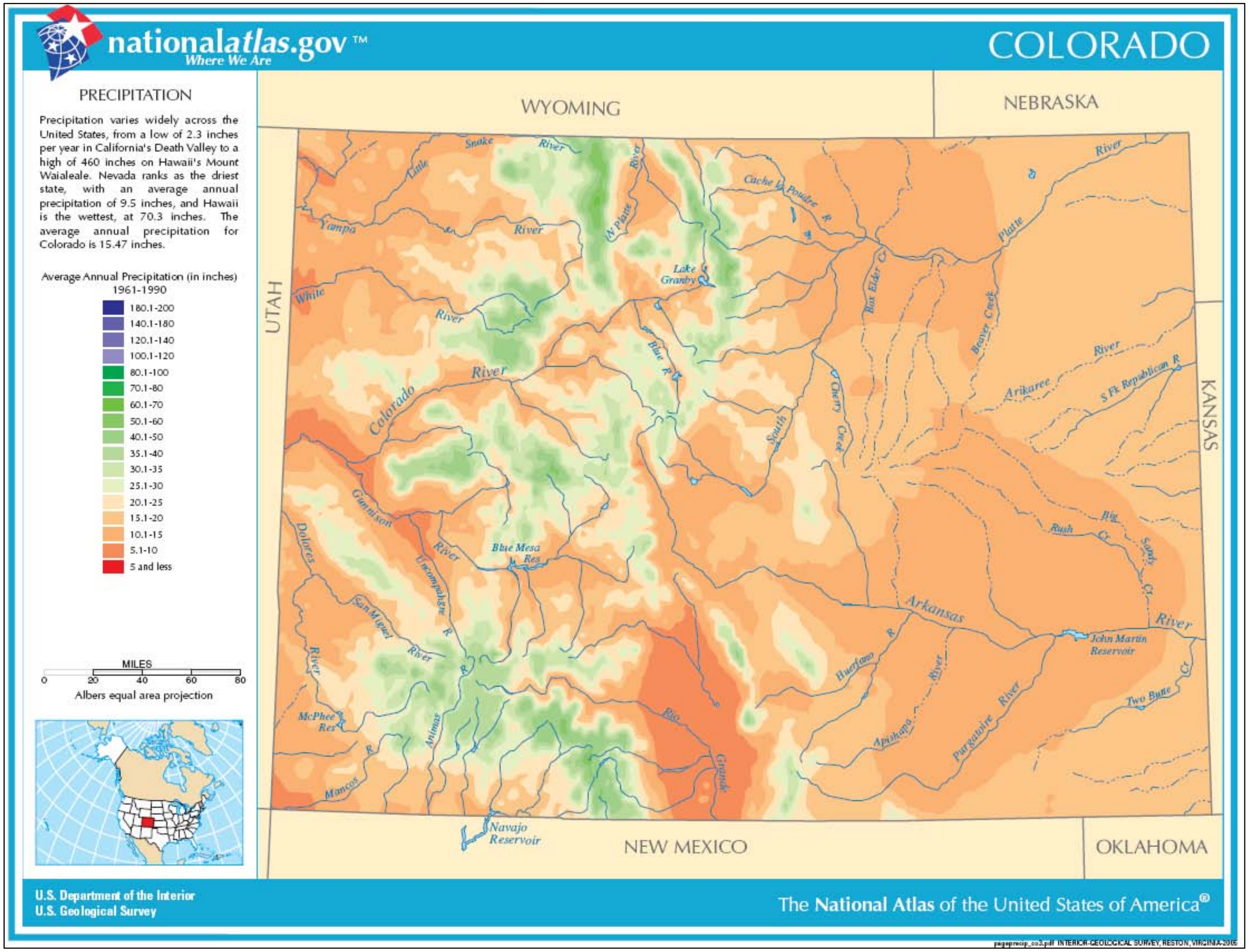


Figure A-1. Average annual precipitation in Colorado based on 1961-1990 normals.

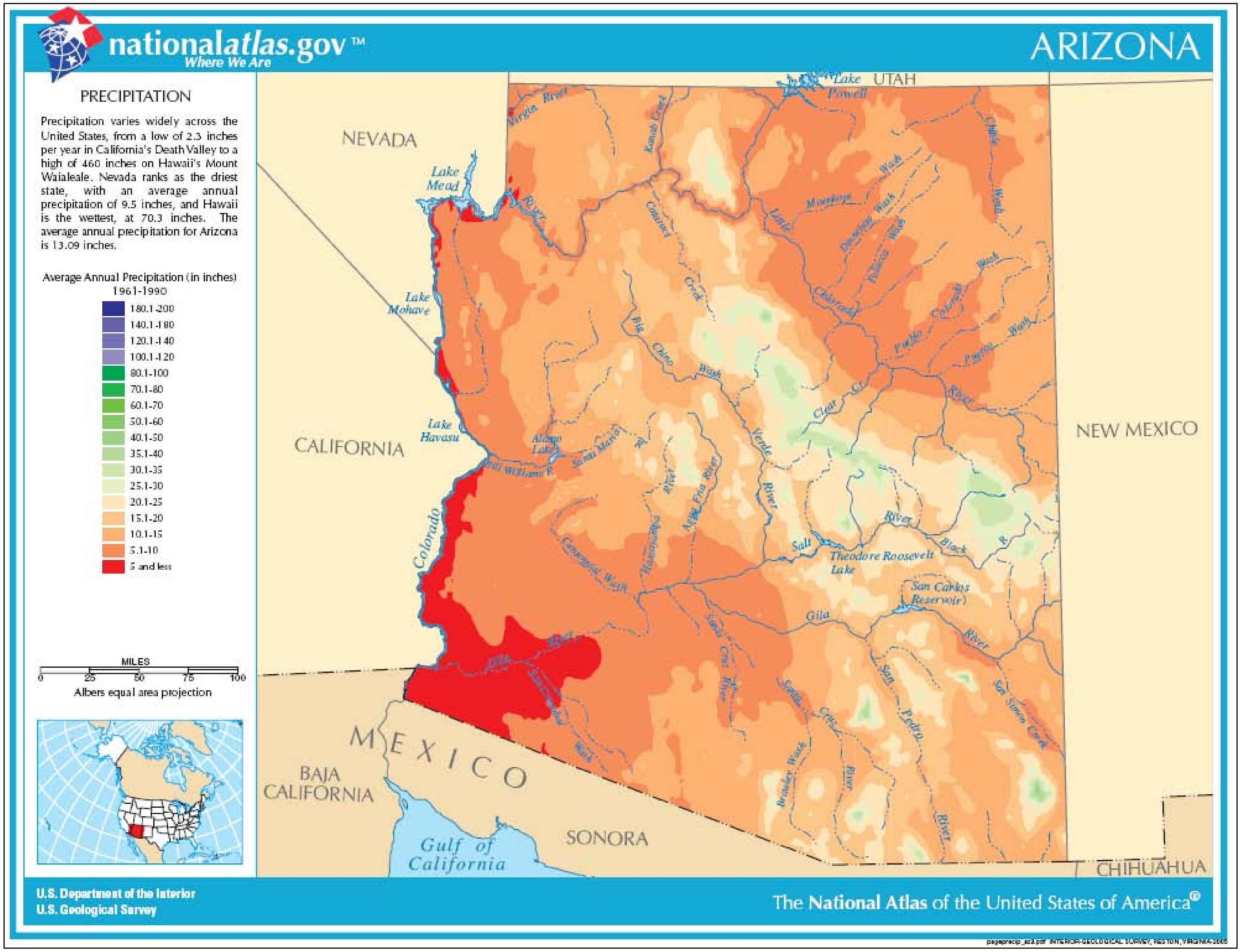


Figure A-2. Average annual precipitation in Arizona based on 1961-1990 normals.

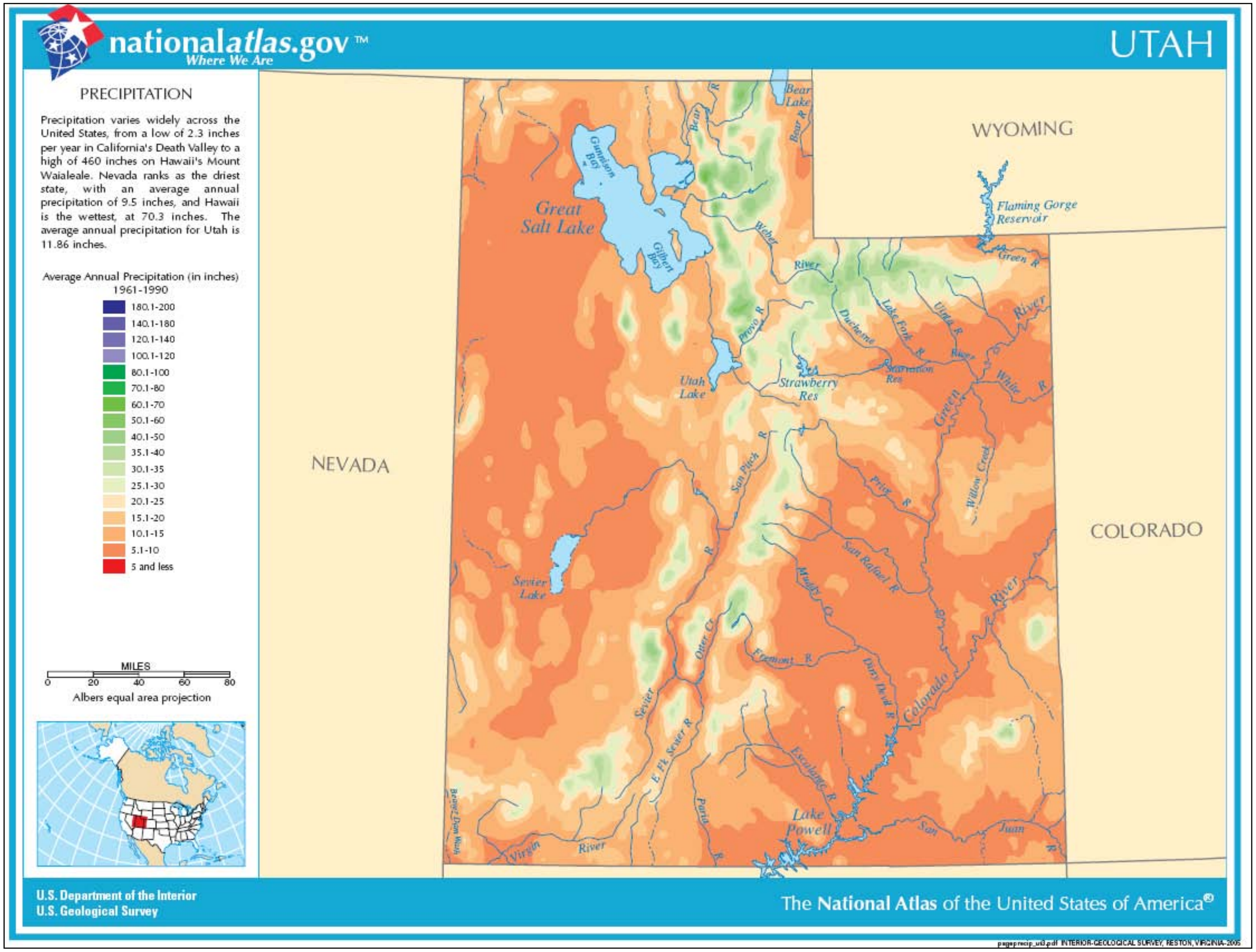


Figure A-3. Average annual precipitation in Utah based on 1961-1990 normals.

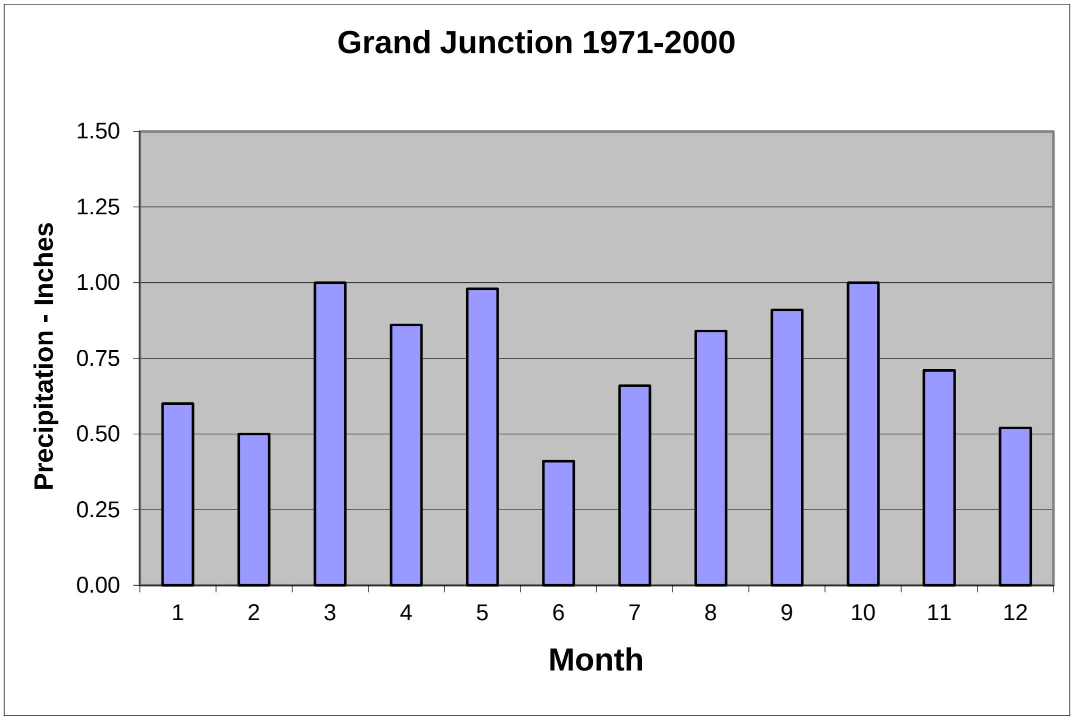


Figure A-4. 1971-2000 monthly normal precipitation in Grand Junction Colorado.

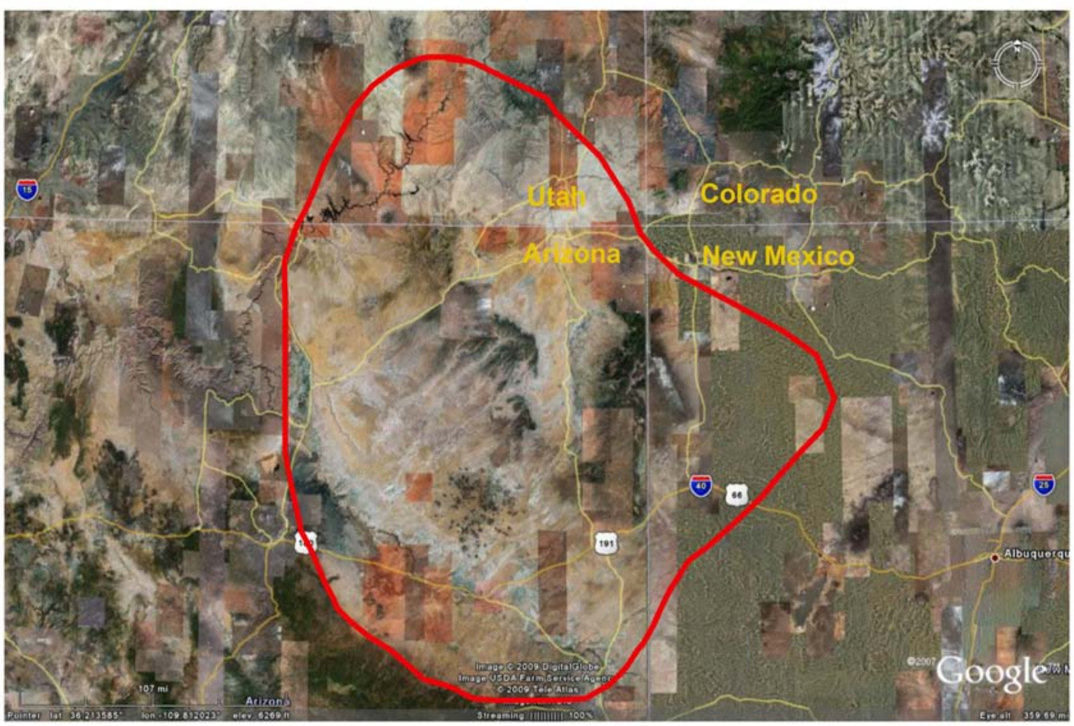


Figure A-5. The portion of the Colorado Plateau in Utah, Arizona, and New Mexico that exhibits widespread surface soil and sand erosion features in Google Earth imagery. Much of the highlighted area within Arizona is within the Painted Desert.

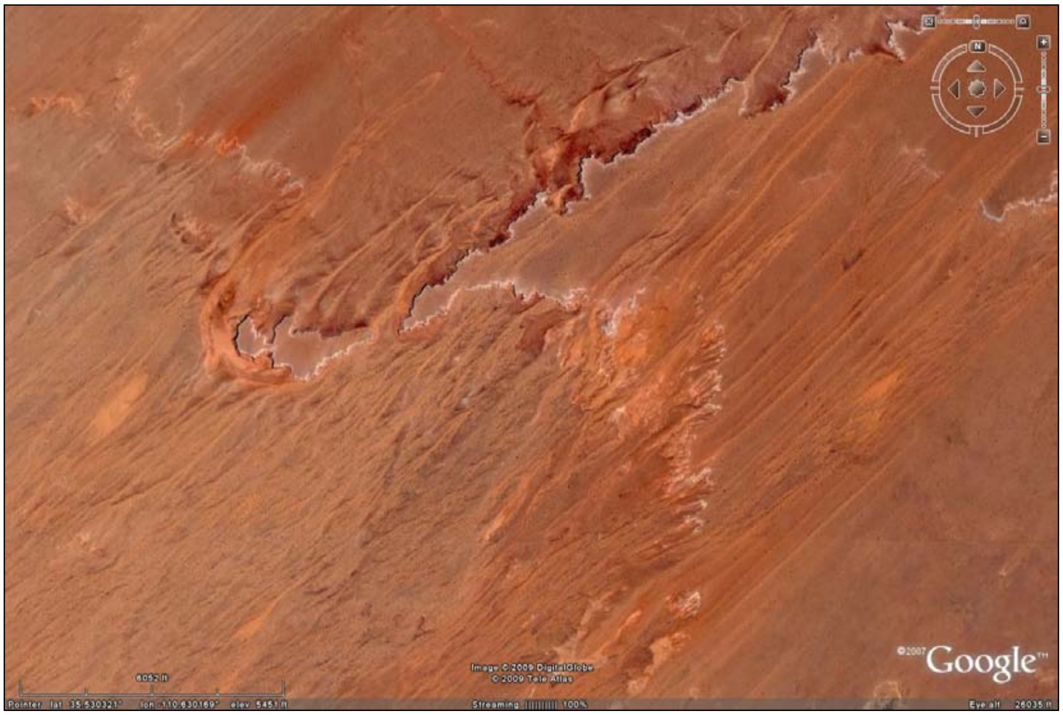


Figure A-6. Southwest to northeast soil and sand erosion structures in southeastern Utah.

Figure A-7. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

Figure A-8. Southwest to northeast soil and sand erosion structures in southeastern Utah.

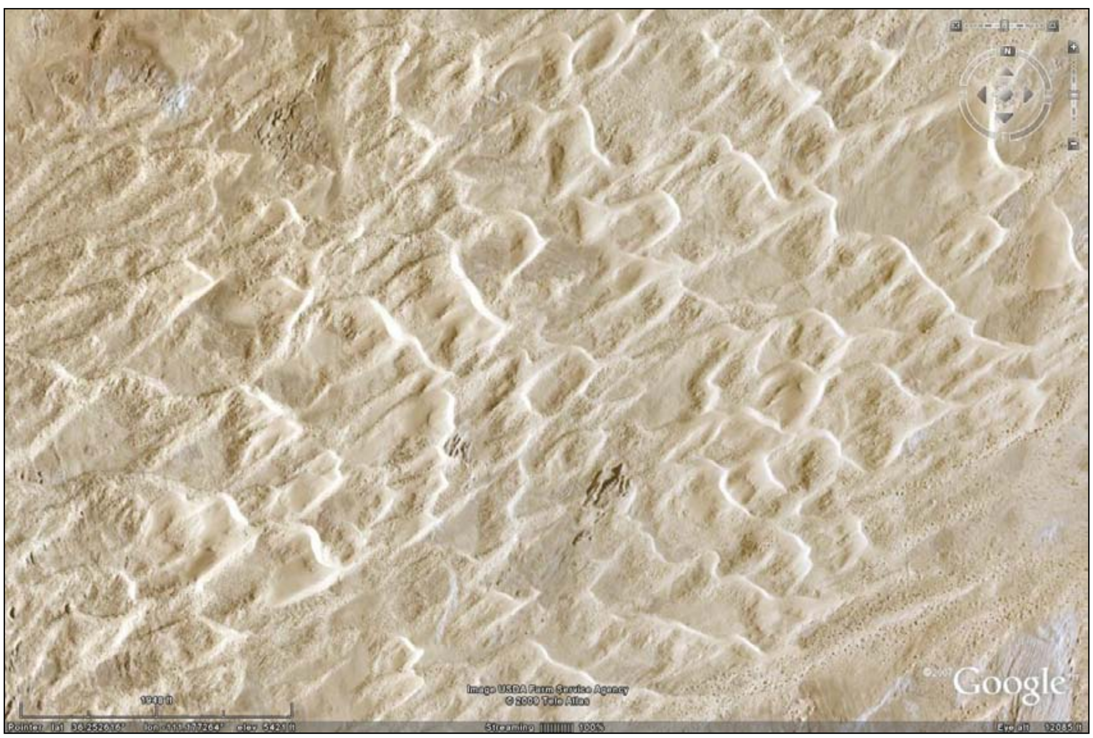


Figure A-9. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert). The slip faces of dunes (lighter bands) face in the direction of wind flow – toward the northeast.

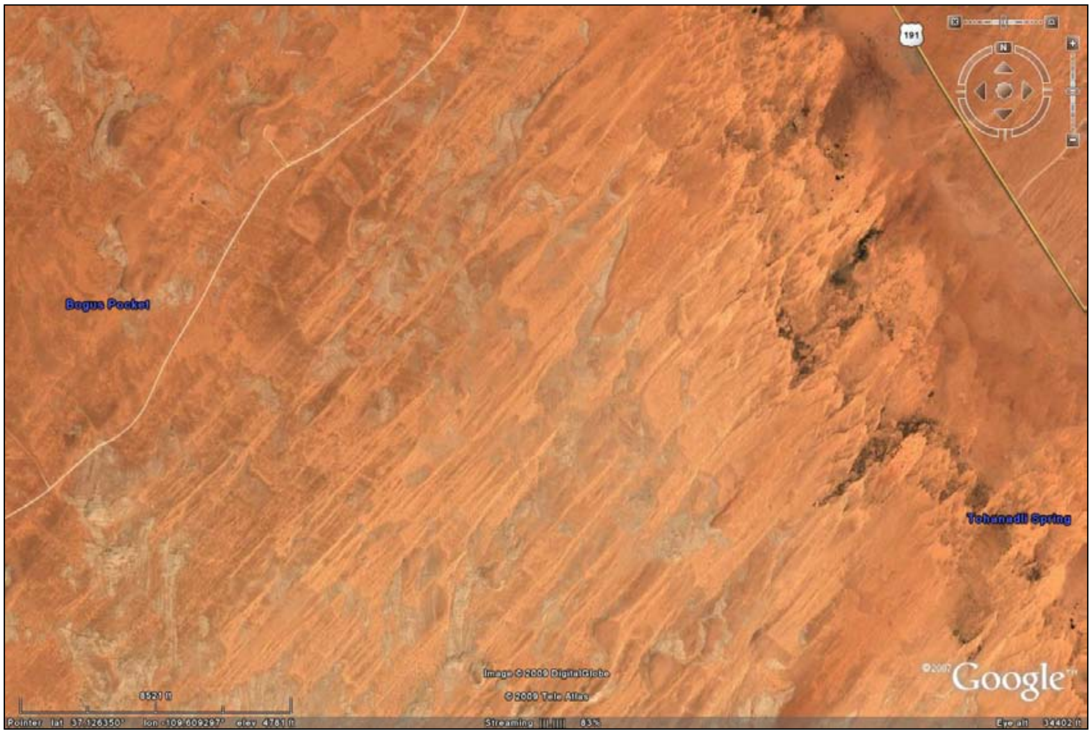


Figure A-10. Southwest to northeast soil and sand erosion structures in southeastern Utah.

Figure A-11. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

Figure A-12. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

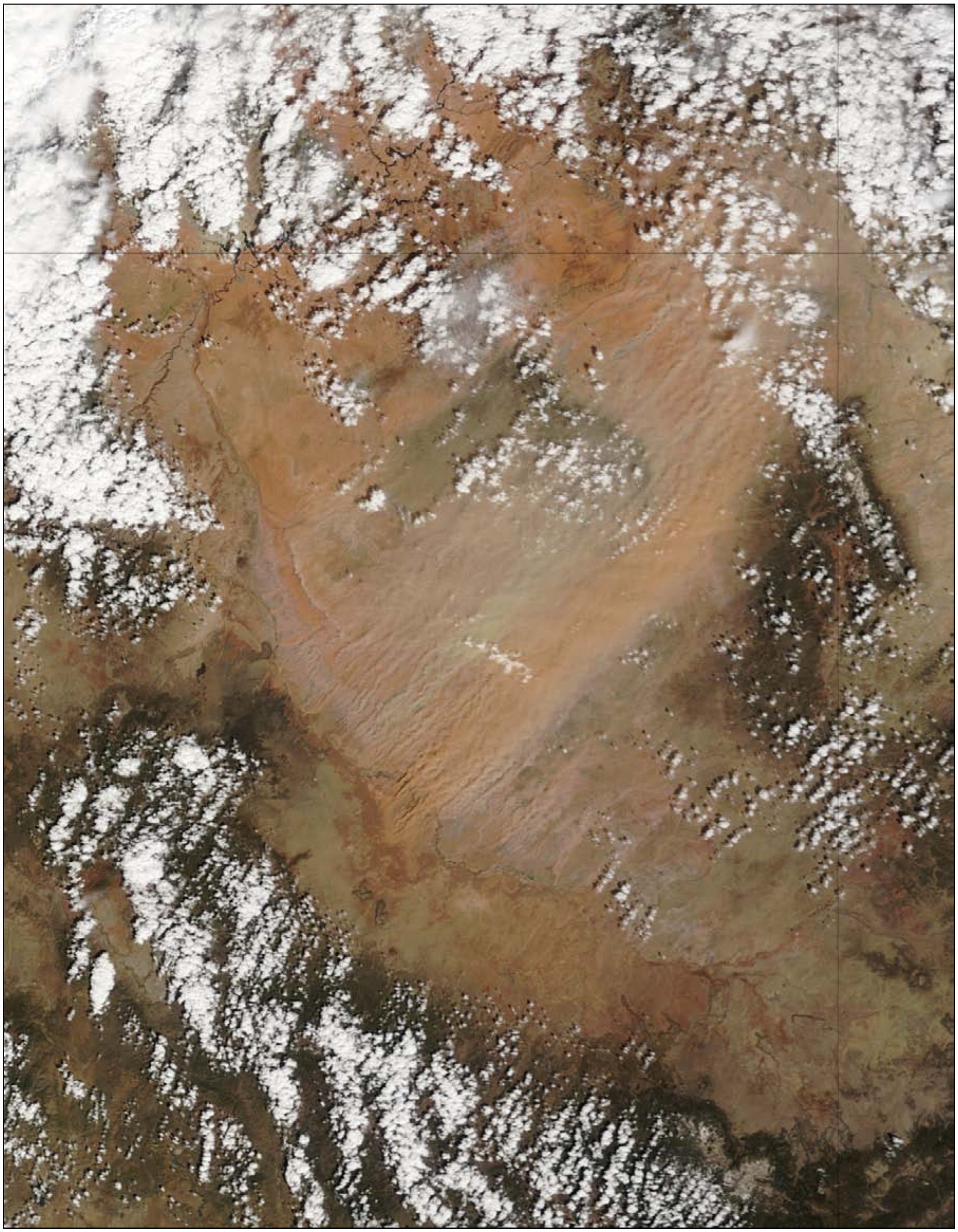


Figure A-13. NASA Tera satellite image of a dust storm on April 3, 2009, in southwesterly flow over the Painted Desert of northeastern Arizona (http://earthobservatory.nasa.gov/IOTD/view.php?id=37791).

Figure A-14 displays the surface weather map for this event (00Z April 4, 2009, or 5 PM MST April 3, 2009). A strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area, and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado) are evident in this map. Blowing dust in this region is frequently associated with southwesterly flow.

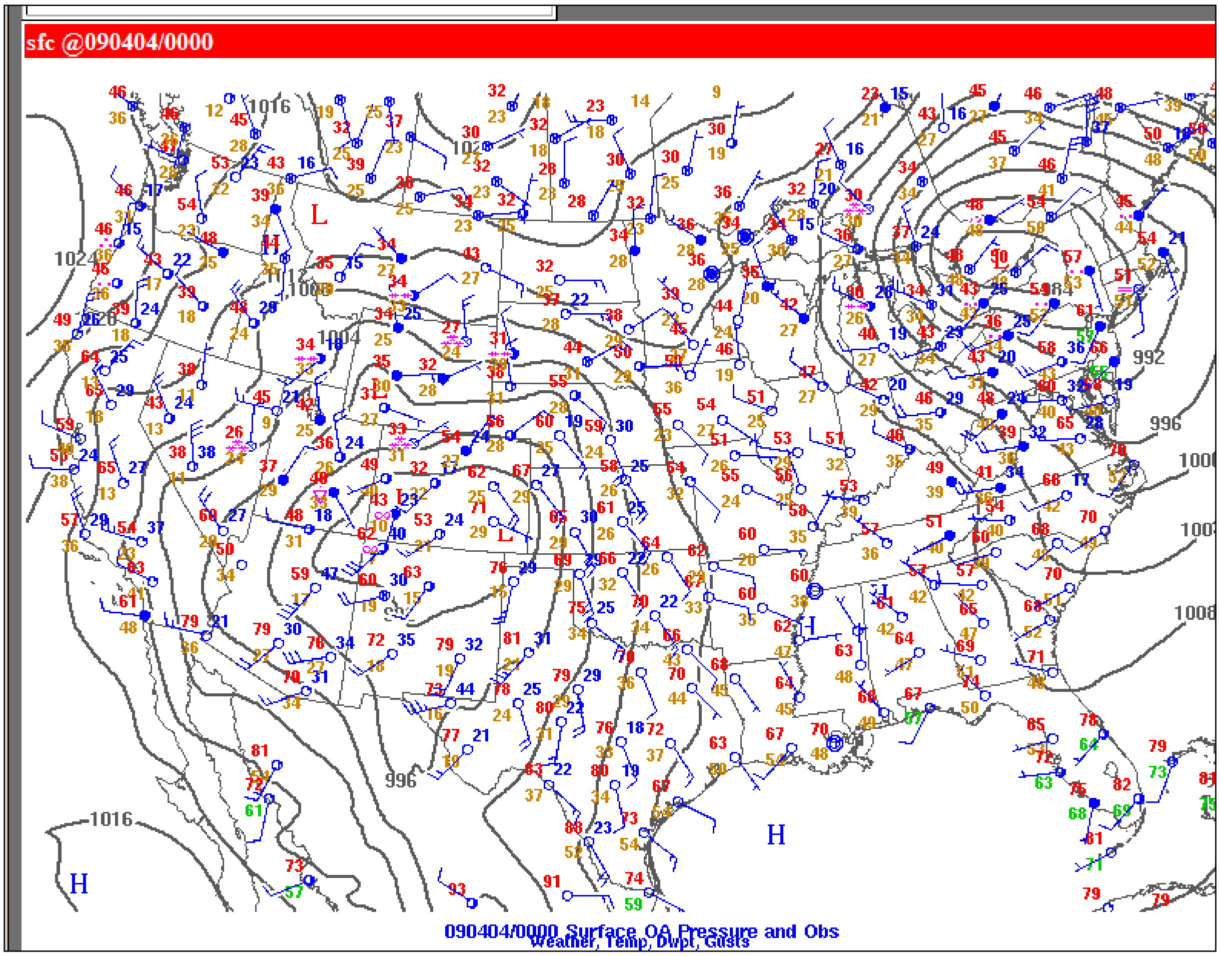


Figure A-14. Surface weather map for 00Z April 4, 2009, (5 PM MST April 3, 2009), showing a strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado).

A USGS map of the Colorado Plateau in Figure A-15 shows the prevalence of eolian or wind-blown sand deposits in southeastern Utah and northeastern Arizona. An analysis of the annual frequency of dust storms (Orgill and Sehmel, 1976) in the western half of the U.S. suggests that portions of eastern and western Utah and northeastern Arizona are source regions for blowing dust (see Figure A-16). Soil and sand structures point to the prevalence of southwesterly flow during blowing dust events, and precipitation climatology highlights the potential for blowing dust across much of the region. In addition, an analysis of back trajectories associated with high PM10 concentration events in Grand Junction discussed in the next section of this document supports the conclusion that soils in Arizona and

Utah are likely significant contributors to PM10 measured during many dust storms affecting Grand Junction.

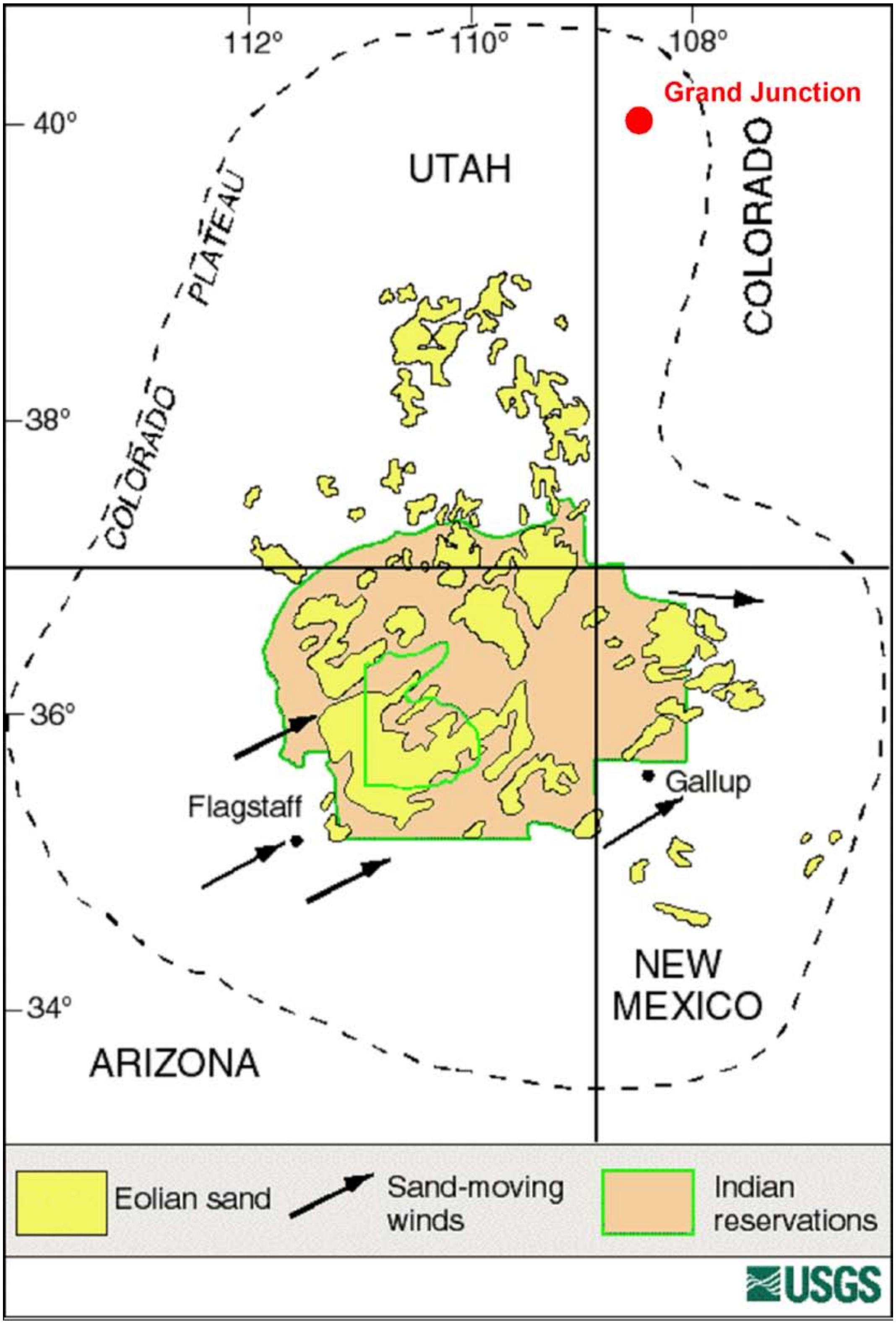


Figure A-15. USGS map of eolian sand features on the Colorado Plateau (http://geochange.er.usgs.gov/sw/impacts/geology/sand/).

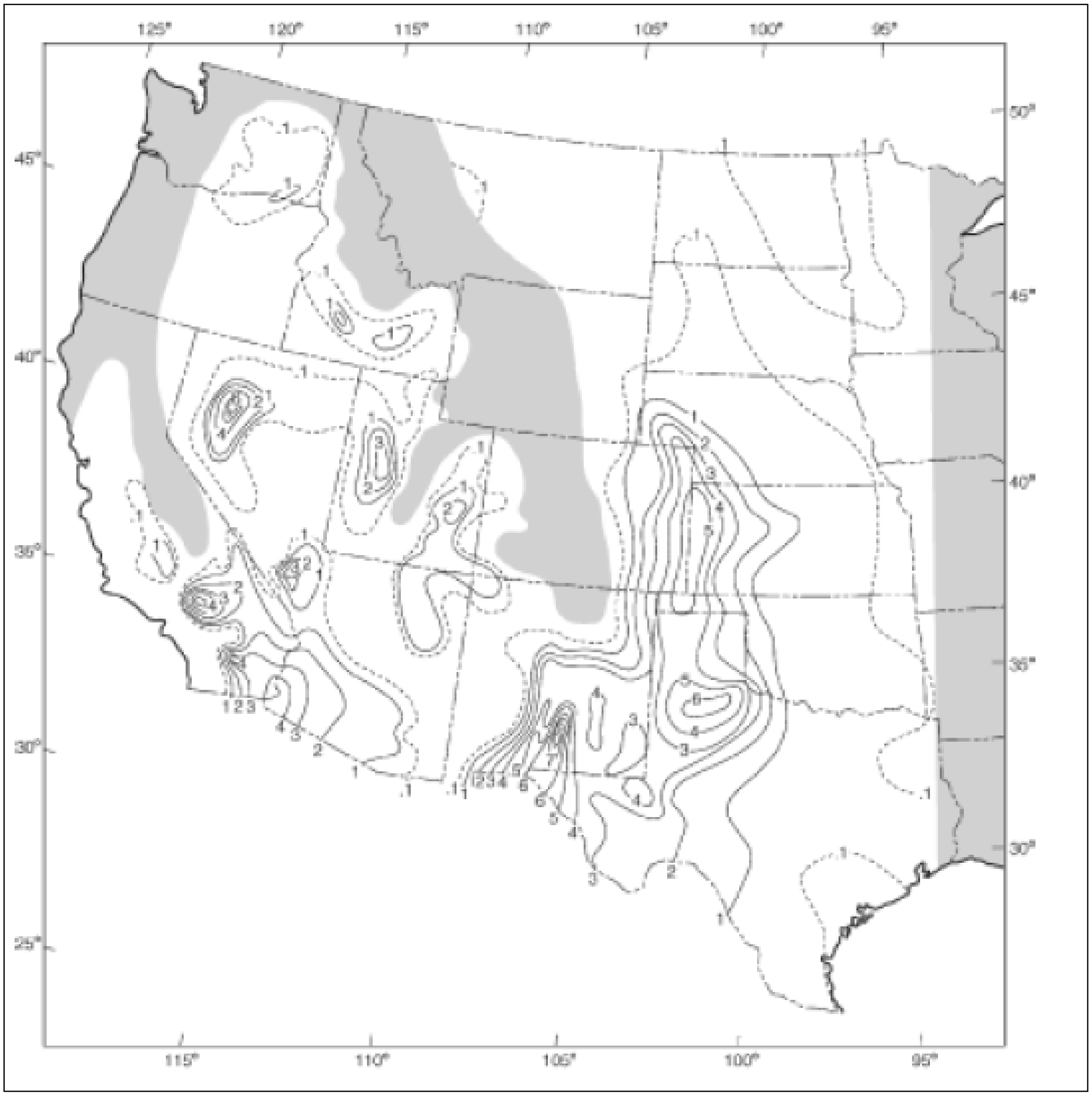


Figure A-16. Number of dust storms per year from: Orgill, M.M., Sehmel, G.A., 1976. Frequency and diurnal variation of dust storms in the contiguous USA. **Atmospheric Environment 10**, 813-825.

NOAA HYSPLIT 36-hour back trajectories were calculated for Grand Junction for the eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM10 concentrations in excess of 75 ug/m3, strong regional winds, and dry soils. Trajectories were modeled every 4 hours for each day. Data presented later in this document provides evidence that the moderate to high PM10 levels on these days were from blowing dust. The 6 back trajectories for each day were calculated for an arrival height of 500 meters using EDAS40 data and model vertical velocities (see: http://www.arl.noaa.gov/HYSPLIT.php). The eight days used in the analysis and the Powell monitor concentrations measured on these days are presented in Table A-1.

The back trajectories for these high-concentration days are shown in Figure A-17. Transport was generally from the west through southwest. A high density of trajectory points is found in northeast Arizona and southeast Utah. Most of these trajectories in Figure A-17 are also consistent with transport from or across suspected or known blowing dust source regions highlighted in Figures A-5, A-13, A-15, and A-16.

Table A-1. Grand Junction Powell monitor days with concentrations in excess of 75 ug/m3 and blowing dust conditions (from 2004 through early 2009).

Year	Month	Day	Powell 24-hour PM10 concentration in ug/m3
2005	4	19	197.8
2008	4	15	116.1
2008	4	21	103.6
2004	9	3	102
2006	3	3	98.3
2008	5	21	86.7
2008	4	30	83.5
2006	6	7	77.9

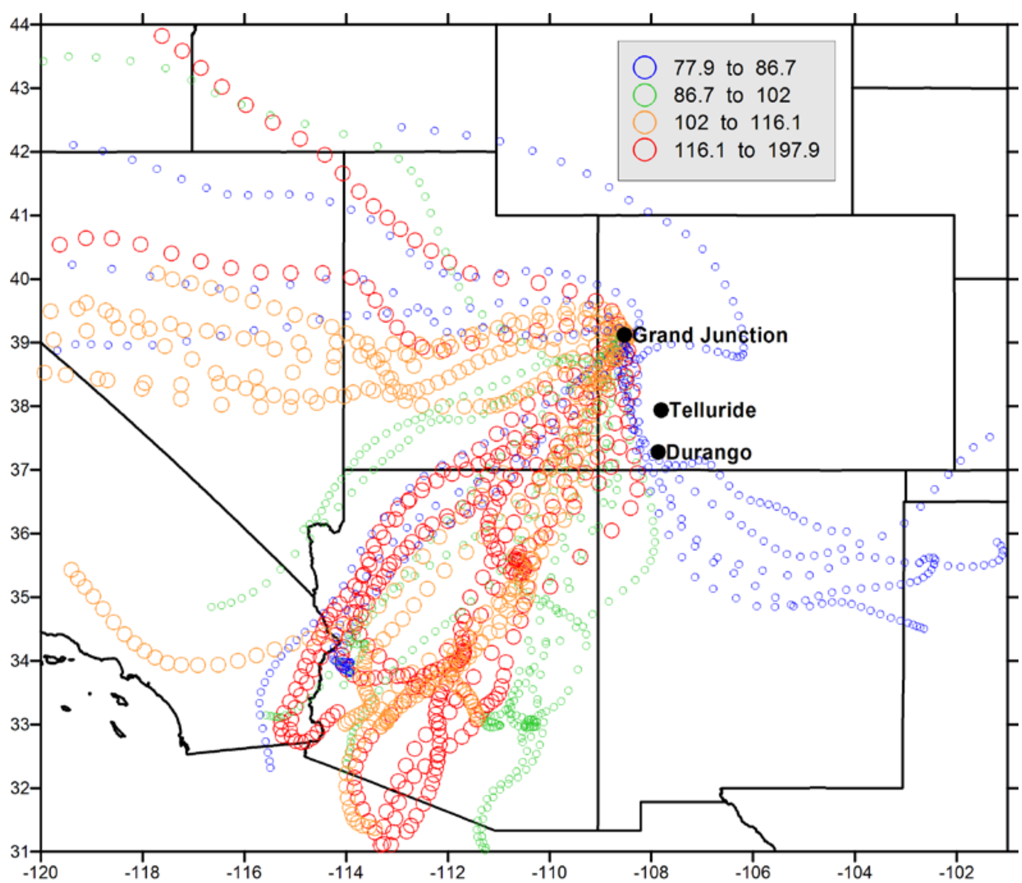


Figure A-17. NOAA HYSPLIT 36-hour back trajectories for Grand Junction for those eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM10 concentrations in excess of 75 ug/m3, strong regional winds, and dry soils. Trajectory points are sized and color-coded to reflect 24-hour PM10 concentrations in ug/m3. Trajectories were calculated every 4 hours for each day.

The trajectories in Figure A-17 point to the possibility that, at times, dust from Utah and Arizona can have a major impact on Grand Junction and less of an impact elsewhere in western Colorado. This non-homogeneity is possible given the fact that dust storms are frequently organized into discreet plumes from discreet areas that maintain their integrity for long distances. An example of this can be seen in Figure A-18 that shows plumes of dust in New Mexico during a windstorm on May 20, 2008.

Figure A-19 shows the NOAA HYSPLIT back trajectories for the highest concentration day during the 2004 through early 2009 period: April 19, 2005. Twenty-four hour back trajectories for each hour during the period with high winds (using EDAS40 data and 500-meter arrival heights) show that the back trajectories for Grand Junction were more likely to have crossed the Painted Desert and southeastern Utah than those for Telluride and Durango, which measured lower PM10 concentrations on this day.

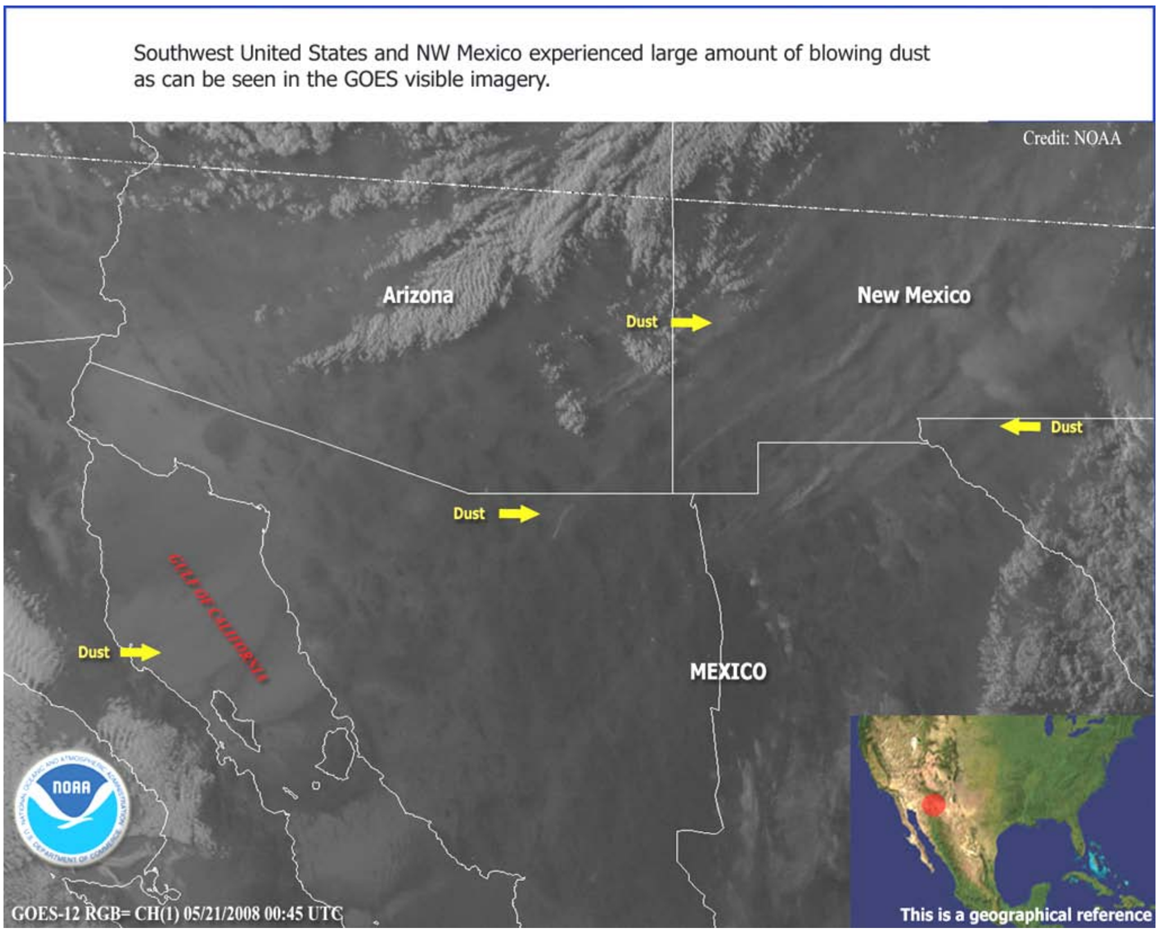


Figure A-18. Discreet plumes of blowing dust in New Mexico, Mexico, and Arizona visible in GOES satellite imagery for May 20, 2008 (http://www.osei.noaa.gov/Events/Dust/US_Southwest/2008/DSTusmx142_G12.jpg).

K-means cluster analysis has been applied to Grand Junction Powell PM10 concentrations, Grand Junction and

Painted Desert 30-day total precipitation for each PM10 monitoring day, and Grand Junction and Painted Desert daily maximum wind gust speeds for each monitoring day. 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 5 variables for 5 distinct categories of PM10 events. The period of record considered was from January 2004 through March 2009. The Hopi weather station located in the central portion of the Painted Desert was used to represent Painted Desert conditions in northeastern Arizona, and the Grand Junction National Weather Service station was used to represent Grand Junction conditions. The 30-day total precipitation values appear to be a better metric for blowing dust conditions than shorter-term totals.

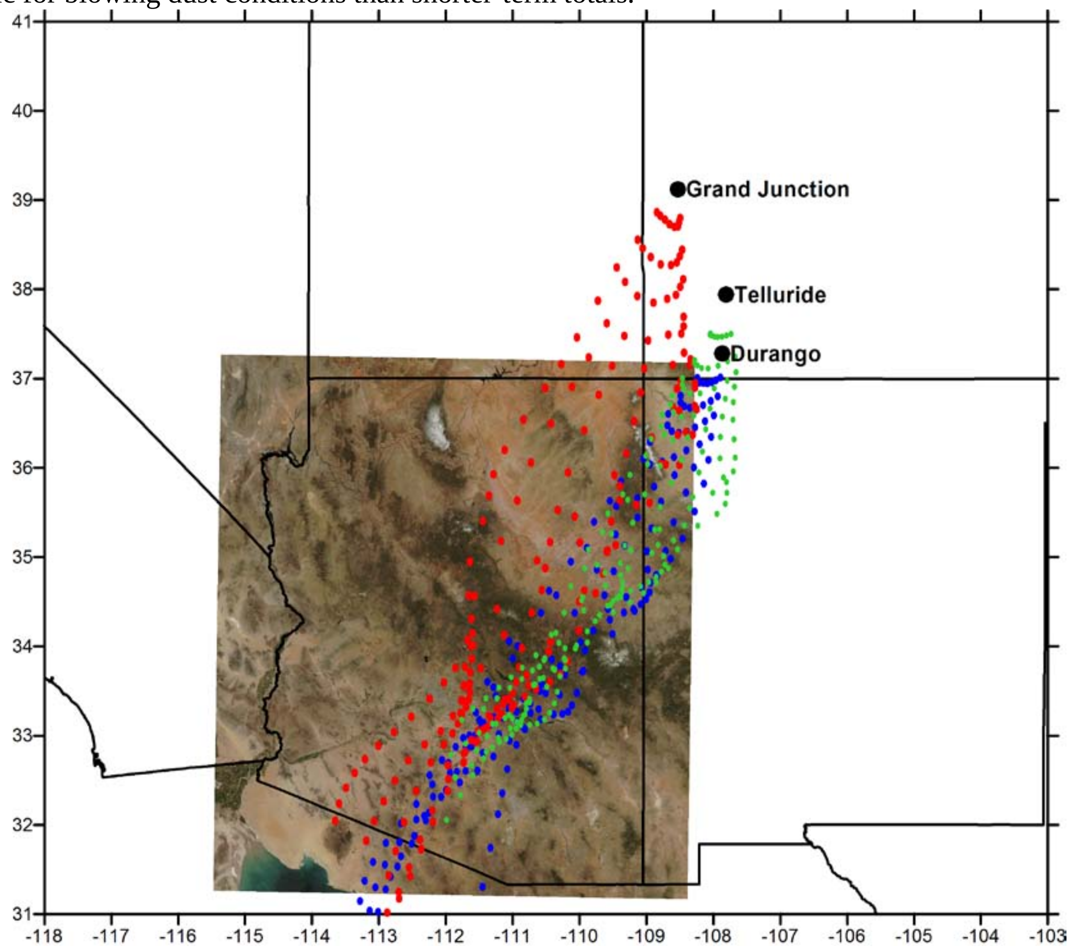


Figure A-19. 24-hour NOAA HYSPLIT back trajectories for every hour from 1500 MST to 2200 MST for Grand Junction (red), Telluride (green), and Durango (blue) for the dust storm of April 19, 2005.

The results of the cluster analysis are presented in Table A-2 below. Cluster 1 represents high soil moisture conditions, moderate gust speeds, and low PM10 concentrations. Cluster 2 represents very low soil moisture, moderate PM10, and low gust speeds. Cluster 3 represents low soil moisture, moderate gusts, and low PM10. Cluster 4 represents moderate soil moisture, low gusts, and low PM10. Finally, Cluster 5 represents high PM10, high gusts, and low soil moisture. Cluster numbers, Grand Junction Powell PM10 concentrations, and Grand Junction daily maximum gust speeds are plotted in Figure A-20.

The data in Figure A-20 clearly show that the highest PM10 concentrations tend to occur in Cluster 5 with gusts above 40 mph. The only exceedance in this period occurred on a day with a peak gust of 43 mph. Cluster 2 is likely to be indicative of wintertime inversion conditions with lighter winds and moderately elevated PM10. Figure A-21 shows the concentrations and cluster values associated with Hopi station daily maximum gust speeds. The overall pattern is similar. The highest concentration day is associated with a peak gust of 47 mph at Hopi. All of the days/events presented in Figure A-17, A-19, and Table A-1 were classified as Cluster 5.

Table A-2. K-means cluster analysis means for Grand Junction PM10 and meteorological variables.

Cluster Variables	**Cluster 1 Means**	**Cluster 2 Means**	**Cluster 3 Means**	**Cluster 4 Means**	**Cluster 5 Means**
Powell 24-hour PM10 in ug/m3	24.5	37.3	24.3	21.8	74.9
Hopi Wind Gust in mph	20.8	18.0	32.5	20.7	40.5
Grand Junction Wind Gust in mph	20.4	16.5	31.8	19.6	43.1
Grand Junction 30-day Precipitation	1.7	0.4	0.5	0.8	0.6
Hopi 30-day Precipitation	1.8	0.2	0.5	0.7	0.3
Count	85	120	170	147	24

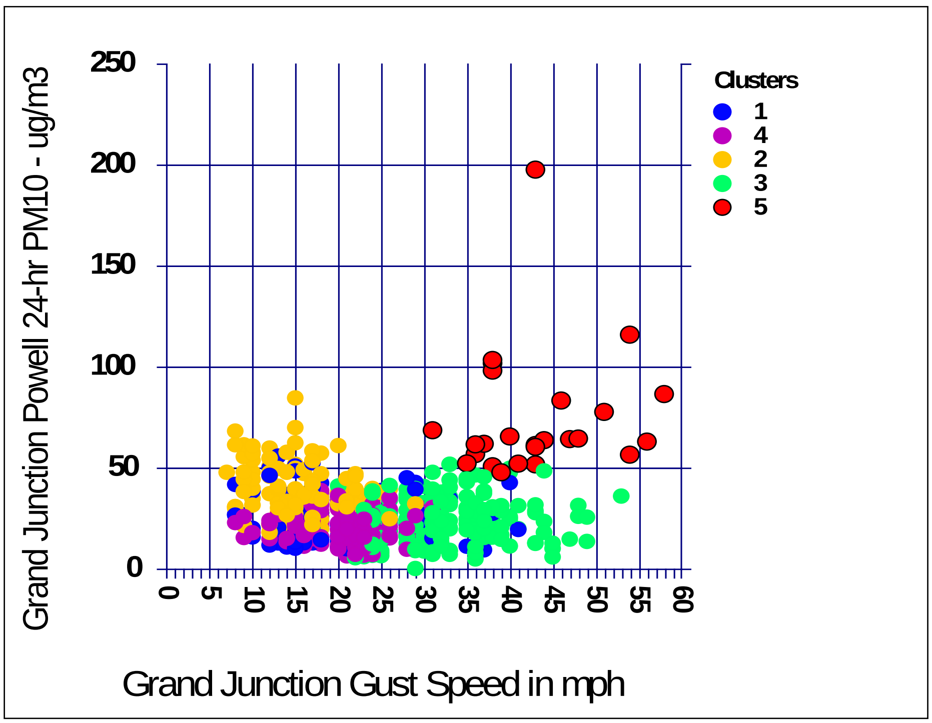


Figure A-20. Grand Junction Powell 24-hour PM10 concentrations versus Grand Junction gust speed by cluster.

Figures A-22 and A-23 show Powell PM10 concentrations versus Grand Junction and Hopi 30-day precipitation totals, respectively, by cluster. The blowing dust group, Cluster 5, is generally associated with 30-day precipitation totals of less than 1.00 inches at Grand Junction and less than 0.50 inches at Hopi. While this is not proof that the measured dust in Grand Junction is from Arizona, it adds to the weight of evidence that the Painted Desert makes a significant contribution to PM10 concentrations in Grand Junction during many blowing dust events. Of interest in this regard are the two high concentrations (greater than 100 ug/m3) that occurred when Grand Junction 30-day precipitation totals were greater than an inch (see Figure A-22). One of these occurred when transport was from the southwest. On this day (April 21, 2008) the NOAA Satellite Smoke Text Archive reported the following (see http://www.ssd.noaa.gov/PS/FIRE/smoke.html):

"Blowing dust is seen over most of Utah (and part of western Nevada) and the dust is moving toward the northeast, reaching into northwestern Colorado and southern Wyoming."

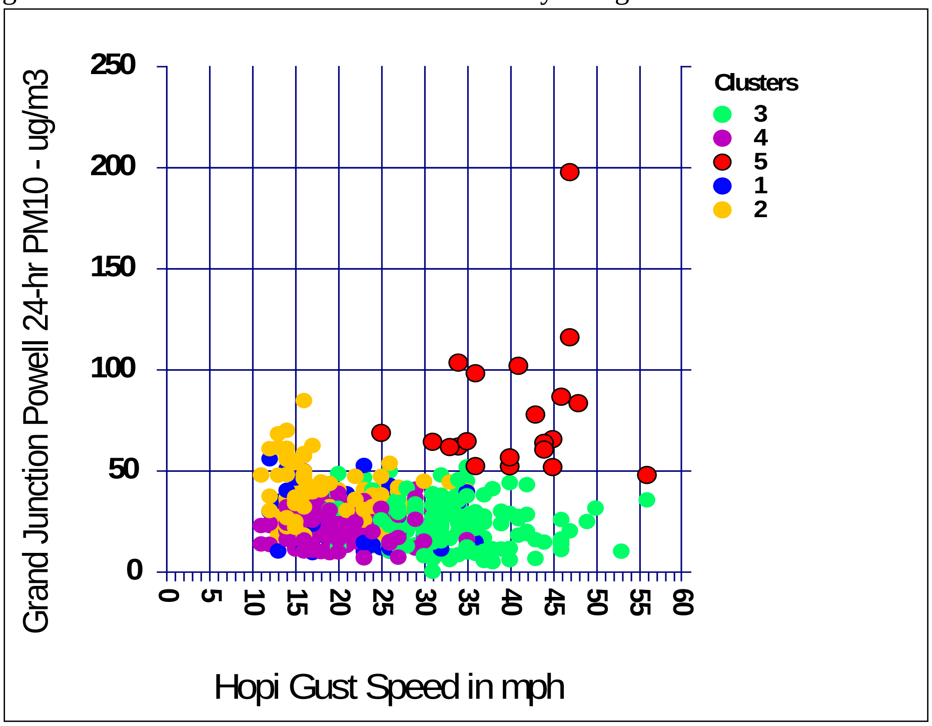


Figure A-21. Grand Junction Powell 24-hour PM10 concentrations versus Hopi gust speed by cluster.

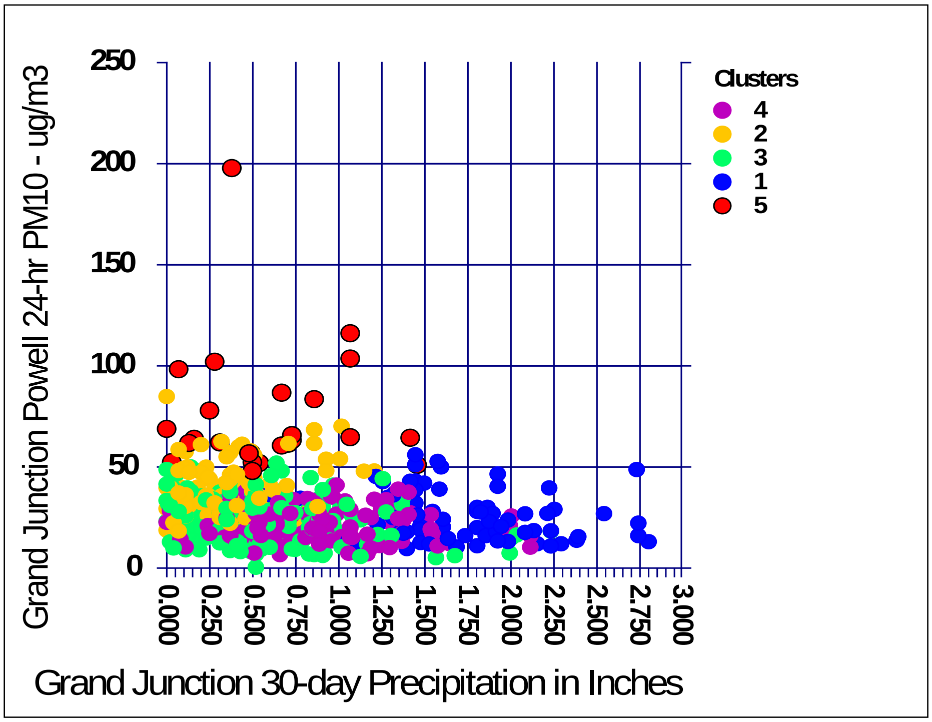


Figure A-22. Grand Junction Powell 24-hour PM10 concentrations versus Grand Junction 30-day total precipitation by cluster.

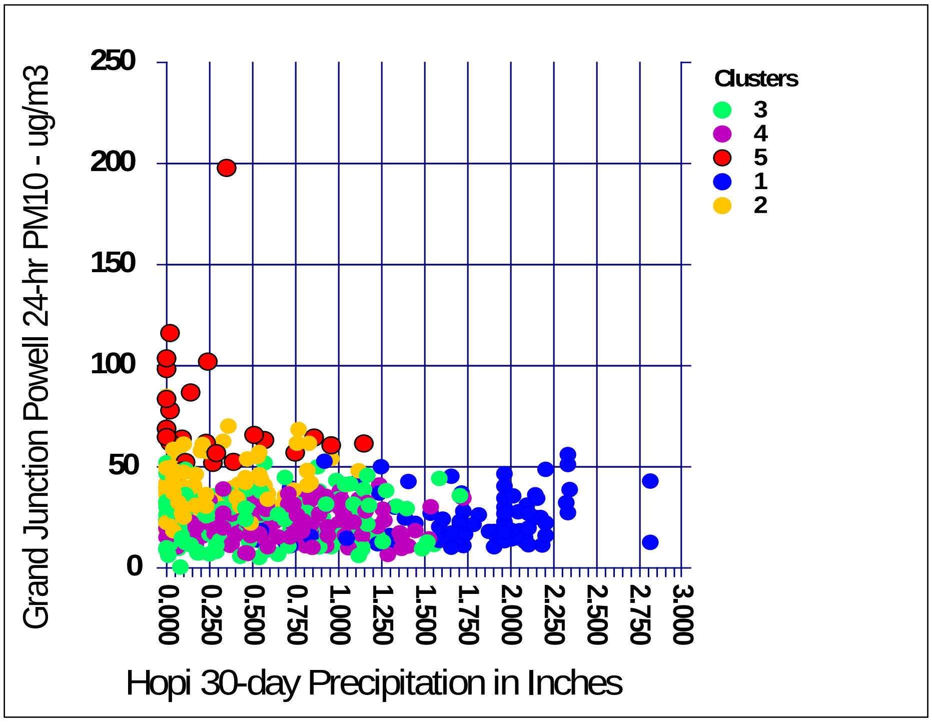


Figure A-23. Grand Junction Powell 24-hour PM10 concentrations versus Hopi 30-day total precipitation by cluster.

The other occurred on April 15, 2008, when the flow was from Arizona and southeast Utah. The transport conditions, the discrepancy between high recent precipitation in Grand Junction and low recent precipitation at Hopi for these two days, and, in one case, analyst discussion of what was visible in satellite images suggest that much of the dust might have originated from outside of the Grand Junction environment.

Figure A-24 shows Grand Junction Powell 24-hour PM10 concentrations versus peak gust wind directions at the Little Delores RAWS weather station about 25 miles west-southwest of Grand Junction. Grand Junction is situated on the floor of the Grand Valley, a major northwest to southeast trending basin than can force or channel synoptic scale flows. As a result, surface wind directions in Grand Junction may not be useful indicators of the direction of longer-range transport. Little Delores is on the Umcompahgre Plateau, and winds here are more likely to reflect the larger-scale transport directions for the region. This graph indicates that high PM10 at Grand Junction (Cluster 5) is associated with winds from the south-southeast to west-southwest at Little Delores. These directions point to dust sources in southeast Utah and northeastern Arizona. This is further evidence that dust from these areas may make a significant contribution to PM10 measured in Grand Junction during blowing dust events.

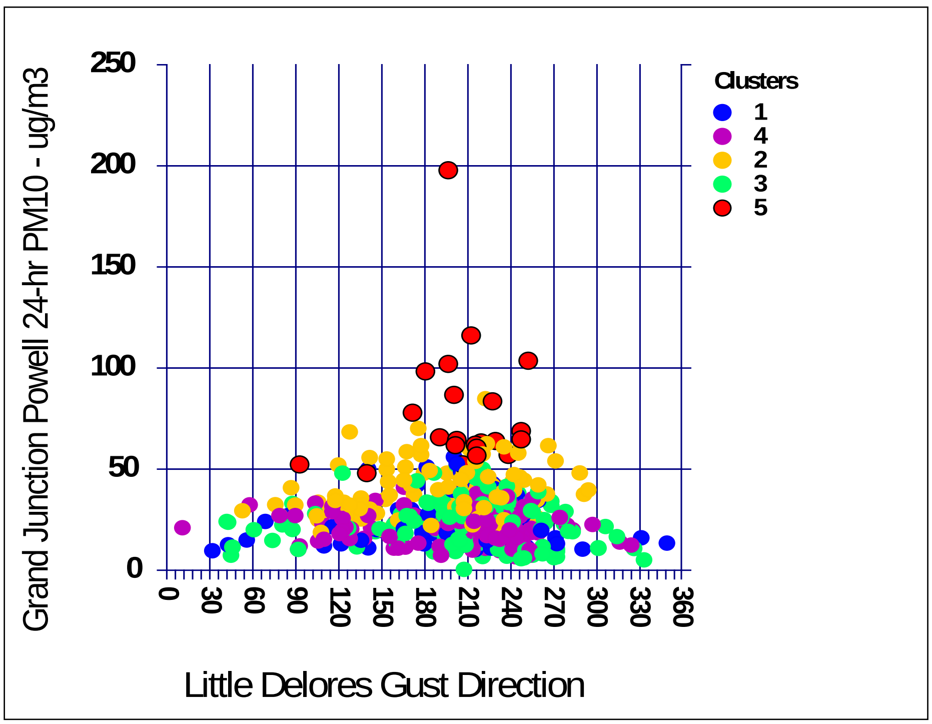


Figure A-24. Grand Junction Powell 24-hour PM10 concentrations versus peak gust wind directions at the Little Delores RAWS weather station, by cluster.

Figure A-25 presents monthly percentiles for Grand Junction gust speeds. Wind gusts generally considered to be high enough for significant blowing dusts (40 mph or higher) are within the upper 5 to 15 percent during each month of the year. Consequently, these events can be viewed as exceptional rather than normal. Gusts in this category can occur any month of the year, but are most likely in March, April, May and October. Figure A-4 shows that in Grand Junction these are typically among the wettest months of the year. It is in drier years, therefore, that blowing dust may be most prevalent during the spring and fall months. January, February, and

June are typically very dry, and might be expected to have a significant proportion of blowing dust events.

Figures A-26 and A-27 show histograms for Grand Junction and Hopi wind gusts, respectively. The 95th percentile gust speed for Grand Junction is 43 mph. For Hopi it is 41 mph. For both sites, it is clear that gusts in the range that is associated with blowing dust are the exception rather than the rule. Cluster analysis also shows that the blowing dust events represent only 4% of the PM10 sample days (from Table A-2, Cluster 5 had 24 cases out of a total of 546). The weight of evidence presented in this document clearly suggests that source regions in Arizona and Utah can have a significant impact on PM10 concentrations in Grand Junction during blowing dust events and that these events occur when dry soils are affected by winds of exceptional strength. Control of these sources, which are outside of Colorado, may not be reasonably achievable or possible.

The precipitation climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Back trajectories, case studies, satellite imagery, and statistical analyses have also shown that northeastern Arizona and southeastern Utah are a significant source for blowing dust transported into Colorado. Elevated PM10 in Grand Junction during windstorms is generally associated with wind gusts of 40 mph or higher at Grand Junction and Hopi in northeastern Arizona and southwesterly flow in Grand Junction. Elevated PM10 in Grand Junction is generally associated with 30-day precipitation totals of less than 1.00 inches at Grand Junction and less than 0.50 inches at Hopi.

Reference:

Orgill, M.M., Sehmel, G.A., 1976. Frequency and diurnal variation of dust storms in the contiguous USA. **Atmospheric Environment 10**, 813-825

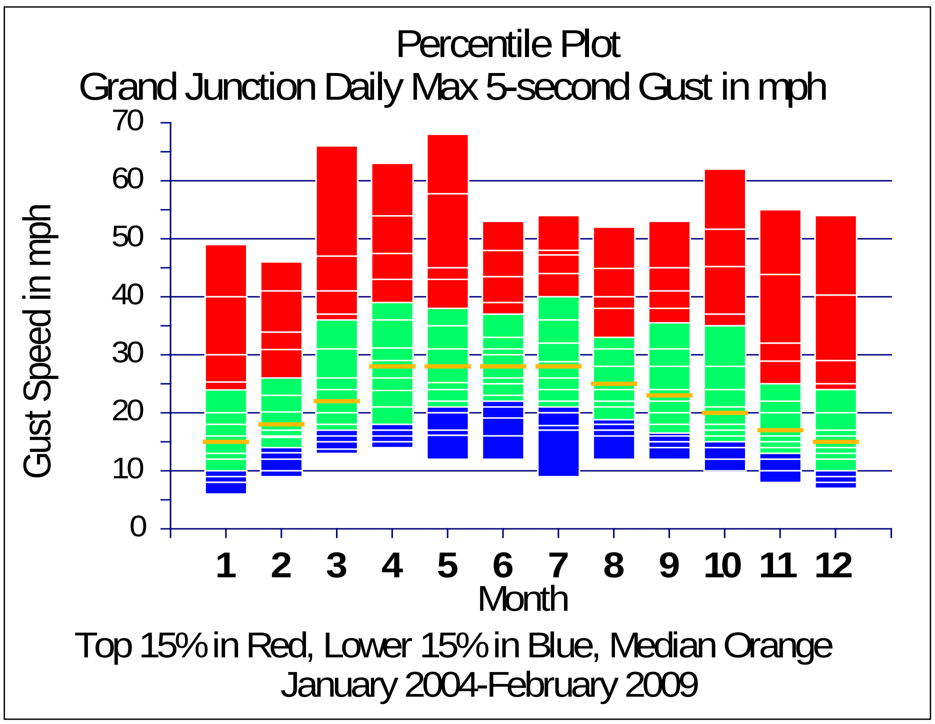


Figure A-25. Percentile plot of Grand Junction daily maximum 5-second gust speed in miles per hour showing that gusts of 40 mph or greater always occur within the top 15 percentile speeds for each month of the year.

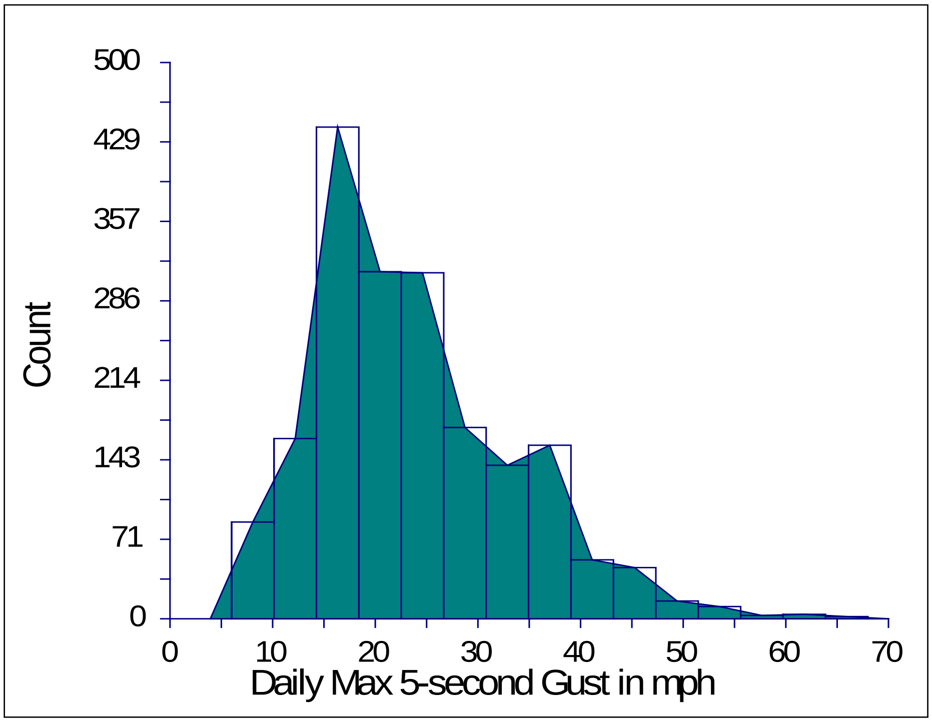


Figure A-26. Histogram of daily maximum 5-second wind gusts at Grand Junction based on January 2004 – February 2009.

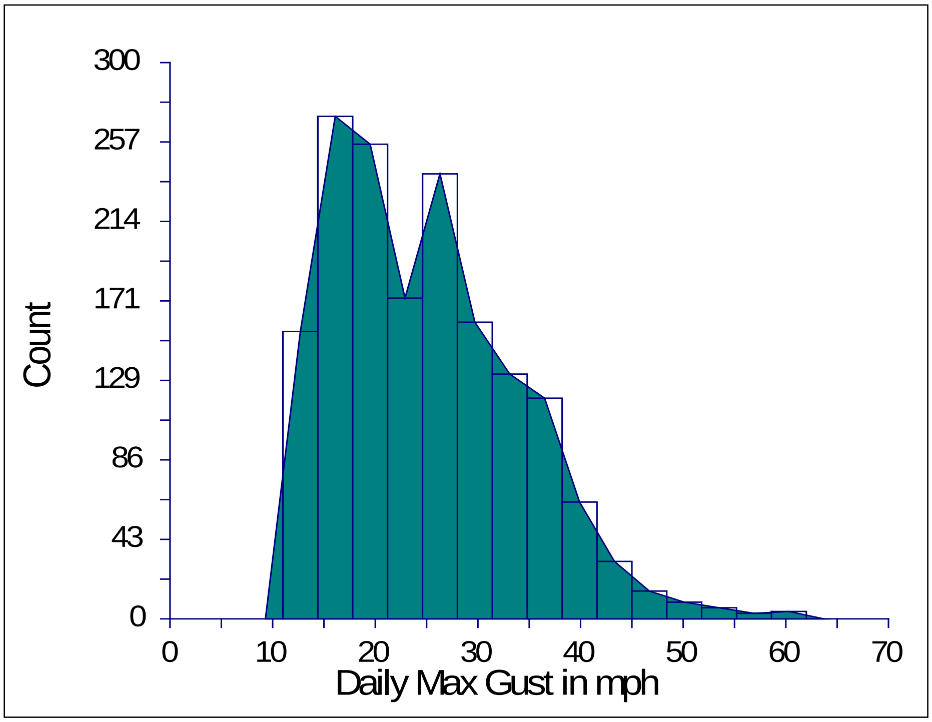


Figure A-27. Histogram of daily maximum 5-second wind gusts at Hopi based on January 2004 – February 2009.

Appendix B- Weather Warnings and Blowing Dust Advisories for May 11, 2010

WWUS75 KABQ 111751
NPWABQ

URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE ALBUQUERQUE NM
1151 AM MDT TUE MAY 11 2010

...STRONG WINDS ACROSS NEW MEXICO AGAIN TODAY...

.STRONG AND GUSTY WINDS ARE CURRENTLY REDEVELOPING AREA WIDE TODAY AS ANOTHER UPPER LEVEL LOW PRESSURE SYSTEM DIGS CLOSER TO THE FOUR CORNERS REGION. STRONG MID AND UPPER LEVEL WINDS MIXING DOWN TO THE SURFACE... COMBINED WITH A DEEPENING SURFACE LOW OVER FAR NORTHEAST NEW MEXICO WILL ALLOW WIND SPEEDS TO CONTINUE TO INCREASE ACROSS THE STATE THROUGH THE EARLY AFTERNOON. THE STRONGEST WINDS ARE EXPECTED ACROSS WEST CENTRAL NEW MEXICO AS WELL AS AROUND THE LAS VEGAS AND CLINES CORNERS AREAS WHERE WIND GUSTS MAY REACH 60 MPH. AREAS OF BLOWING DUST MAY OCCUR. WINDS ARE EXPECTED TO GRADUALLY DECREASE AROUND SUNSET.

NMZ502-505-506-120200-
/O.CON.KABQ.HW.W.0009.000000T0000Z-100512T0200Z/
CHUSKA MOUNTAINS-WEST CENTRAL PLATEAU-WEST CENTRAL MOUNTAINS-
1151 AM MDT TUE MAY 11 2010

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING.

* LOCATION...THIS INCLUDES THE CHUSKA AND WEST CENTRAL MOUNTAINS... AS WELL AS THE WEST CENTRAL PLATEAU.

* WINDS...SOUTHWEST 35 TO 45 MPH WITH GUSTS AROUND 60 MPH.

* TIMING...WINDS WILL CONTINUE TO STRENGTHEN THROUGH THE MID AFTERNOON HOURS BEFORE GRADUALLY DECREASING THIS EVENING.

* VISIBILITY...AREAS OF BLOWING DUST MAY LOCALLY REDUCE VISIBILITY.

* LOCAL IMPACTS...DANGEROUS CROSS WINDS WILL IMPACT NORTHWEST TO SOUTHEAST ORIENTED ROADS...INCLUDING PORTIONS OF INTERSTATE 40 BETWEEN GALLUP AND THOREAU. LOOSE OBJECTS MAY BECOME AIRBORNE. POWER INTERRUPTIONS WILL BE POSSIBLE.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WARNING MEANS DAMAGING WINDS ARE IMMINENT

OR HIGHLY LIKELY. SUSTAINED WIND SPEEDS OF AT LEAST 40 MPH OR
GUSTS OF 58 MPH OR MORE CAN LEAD TO PROPERTY DAMAGE.

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NMZ523-529-120200-
/O.CON.KABQ.HW.W.0009.000000T0000Z-100512T0200Z/
CENTRAL HIGHLANDS-NORTHEAST HIGHLANDS-
1151 AM MDT TUE MAY 11 2010

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 8 PM MDT THIS
EVENING...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL 8 PM MDT THIS
EVENING.

* LOCATION...THIS INCLUDES THE CENTRAL AND NORTHEAST HIGHLANDS...
  INCLUDING LAS VEGAS AND CLINES CORNERS.

* WINDS...SOUTHWEST 35 TO 45 MPH WITH GUSTS NEAR 60 MPH.

* TIMING...WINDS WILL CONTINUE TO INCREASE THROUGH MID DAY. THE
  STRONGEST WINDS ARE EXPECTED DURING THE MID TO LATE AFTERNOON
  HOURS BEFORE DECREASING AROUND SUNSET.

* VISIBILITY...EXPECT LOCAL VISIBILITY REDUCTIONS IN BLOWING
  DUST.

* LOCAL IMPACTS...HAZARDOUS WINDS WILL IMPACT NORTHWEST TO
  SOUTHEAST ORIENTED ROADS INCLUDING U.S. HIGHWAYS 285 AND 84.
  LOOSE OBJECTS MAY BECOME AIRBORNE.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WARNING MEANS DAMAGING WINDS ARE IMMINENT
OR HIGHLY LIKELY. SUSTAINED WIND SPEEDS OF AT LEAST 40 MPH OR
GUSTS OF 58 MPH OR MORE CAN LEAD TO PROPERTY DAMAGE.

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NMZ501-503-504-508-509-120200-
/O.CON.KABQ.WI.Y.0027.000000T0000Z-100512T0200Z/
NORTHWEST PLATEAU-FAR NORTHWEST HIGHLANDS-NORTHWEST HIGHLANDS-
SOUTHWEST MOUNTAINS-SAN FRANCISCO RIVER VALLEY-
1151 AM MDT TUE MAY 11 2010

...WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING...

A WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING.

* LOCATION...THIS INCLUDES MUCH OF NORTHWEST NEW MEXICO AS WELL
  AS THE SAN FRANCISCO RIVER VALLEY IN SOUTHWEST NEW MEXICO.

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS FROM 50 TO 55 MPH.

* TIMING...WIND WILL CONTINUE TO INCREASE THROUGH THE MID
  AFTERNOON...BEFORE DECREASING AROUND SUNSET.

* VISIBILITY...EXPECT LOCAL VISIBILITY REDUCTIONS IN BLOWING
  DUST.

* LOCAL IMPACTS...STRONG CROSS WINDS WILL IMPACT HIGH PROFILE
  VEHICLES ALONG NORTHWEST TO SOUTHEAST ORIENTED ROADWAYS.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE TRAVELLING. SUDDEN GUSTS
OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA
ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ507-510>522-524>528-532-533-537>540-120200-
/O.CON.KABQ.WI.Y.0027.000000T0000Z-100512T0200Z/
WEST CENTRAL HIGHLANDS-SAN JUAN MOUNTAINS-JEMEZ MOUNTAINS-
WEST SLOPES SANGRE DE CRISTO MOUNTAINS-
NORTHERN SANGRE DE CRISTO MOUNTAINS ABOVE 9500 FEET/RED RIVER-
SOUTHERN SANGRE DE CRISTO MOUNTAINS ABOVE 9500 FEET-
EAST SLOPES SANGRE DE CRISTO MOUNTAINS-UPPER RIO GRANDE VALLEY-
LOWER CHAMA RIVER VALLEY-SANTA FE METRO AREA-
ALBUQUERQUE METRO AREA-LOWER RIO GRANDE VALLEY-
SANDIA/MANZANO MOUNTAINS-ESTANCIA VALLEY-SOUTH CENTRAL HIGHLANDS-
UPPER TULAROSA VALLEY-SOUTH CENTRAL MOUNTAINS-
RATON RIDGE/JOHNSON MESA-FAR NORTHEAST HIGHLANDS-
EASTERN SAN MIGUEL COUNTY-GUADALUPE COUNTY-DE BACA COUNTY-
CHAVES COUNTY PLAINS-EASTERN LINCOLN COUNTY-
SOUTHWEST CHAVES COUNTY-
1151 AM MDT TUE MAY 11 2010

...WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING...

A WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING.

* LOCATION...THIS INCLUDES CENTRAL AND MUCH OF EASTERN NEW
  MEXICO.

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS FROM 50 TO 55 MPH.

* TIMING...WINDS WILL CONTINUE TO INCREASE IN SPEED THROUGH THE EARLY
  AFTERNOON HOURS. WIND SPEEDS WILL BEGIN TO DECREASE BELOW
  HAZARDOUS LEVELS TOWARD SUNSET.

* VISIBILITY...EXPECT LOCAL VISIBILITY REDUCTIONS IN BLOWING DUST.

* LOCAL IMPACTS...STRONG WINDS WILL IMPACT NORTHWEST TO SOUTHEAST ORIENTED ROADS SUCH AS U.S. HIGHWAYS 285 AND 84. LOOSE OBJECTS MAY BECOME AIRBORNE.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE TRAVELLING. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ530-531-534>536-120200-
/O.CON.KABQ.WI.Y.0027.000000T0000Z-100512T0200Z/
UNION COUNTY-HARDING COUNTY-QUAY COUNTY-CURRY COUNTY-
ROOSEVELT COUNTY-
1151 AM MDT TUE MAY 11 2010

...WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING...

A WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING.

* LOCATION...THIS INCLUDES FAR EASTERN NEW MEXICO ALONG THE TEXAS BORDER.

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS NEAR 50 MPH.

* TIMING...STRONG WINDS ARE EXPECTED DURING THE AFTERNOON HOURS BEFORE DECREASING AROUND SUNSET.

* VISIBILITY...EXPECT LOCAL VISIBILITY REDUCTIONS IN BLOWING DUST.

* LOCAL IMPACTS...HAZARDOUS WINDS WILL IMPACT HIGH PROFILE VEHICLES ALONG NORTHWEST TO SOUTHEAST ORIENTED ROADS SUCH AS U.S. HIGHWAY 87. LOOSE OBJECTS MAY BECOME AIRBORNE.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE TRAVELLING. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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WWUS75 KFGZ 110527
NPWFGZ

URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE FLAGSTAFF AZ
1027 PM MST MON MAY 10 2010

AZZ012-013-040-111430-
/O.UPG.KFGZ.WI.Y.0012.100511T1500Z-100512T0200Z/
/O.NEW.KFGZ.HW.W.0007.100511T1500Z-100512T0200Z/
/O.NEW.KFGZ.DS.W.0001.100511T1500Z-100512T0200Z/
LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-
LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-
NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-
INCLUDING THE CITIES OF...WINSLOW...HOLBROOK...SNOWFLAKE...DILKON
1027 PM MST MON MAY 10 2010

...DUST STORM WARNING IN EFFECT FROM 8 AM TO 7 PM MST TUESDAY...
...HIGH WIND WARNING IN EFFECT FROM 8 AM TO 7 PM MST TUESDAY...

THE NATIONAL WEATHER SERVICE IN FLAGSTAFF HAS ISSUED A DUST STORM WARNING...WHICH IS IN EFFECT FROM 8 AM TO 7 PM MST TUESDAY. A HIGH WIND WARNING HAS ALSO BEEN ISSUED. THIS HIGH WIND WARNING IS IN EFFECT FROM 8 AM TO 7 PM MST TUESDAY. THE WIND ADVISORY IS NO LONGER IN EFFECT.

* TIMING: SOUTHWEST WINDS WILL INCREASE EARLY TUESDAY MORNING AND WILL LAST MUCH OF THE DAY TUESDAY...BEFORE DECREASING TUESDAY EVENING.

* WINDS: EXPECT SOUTHWEST WINDS OF 30 TO 40 MPH WITH GUSTS FROM 45 TO 55 MPH.

* IMPACTS: DANGEROUS CROSS WINDS...ESPECIALLY IF YOU ARE DRIVING A HIGH PROFILE VEHICLE. IN ADDITION...SOME AREAS WILL EXPERIENCE BLOWING DUST WITH GREATLY REDUCED VISIBILITY. SOME LOCATIONS THAT WILL LIKELY BE IMPACTED BY BLOWING DUST INCLUDE... INTERSTATE 40 BETWEEN TWO GUNS AND WINSLOW NORTH TO HIGHWAY 15 FROM LEUPP TO DILKON...AND STATE ROUTE 87 FROM INTERSTATE 40 TO SECOND MESA.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A DUST STORM WARNING MEANS AREAS WITH VISIBILITIES LESS THAN ONE QUARTER MILE ARE EXPECTED DUE TO BLOWING DUST. TRAVEL COULD BECOME EXTREMELY DANGEROUS. PERSONS WITH RESPIRATORY PROBLEMS SHOULD MAKE PREPARATIONS TO STAY INDOORS UNTIL THE STORM PASSES.

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

&&

WWUS75 KGJT 280842
NPWGJT

URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE GRAND JUNCTION CO
242 AM MDT WED APR 28 2010

...VERY STRONG WINDS WILL BLOW ACROSS EASTERN UTAH AND WESTERN COLORADO TODAY...

.WINDS WILL CONTINUE TO STRENGTHEN TODAY WITH HIGH WIND GUSTS TO OVER 60 MPH EXPECTED BY THIS AFTERNOON AND EVENING. THESE HIGH WINDS WILL DEVELOP IN ADVANCE OF A VIGOROUS COLD FRONT MOVING ACROSS UTAH. THE STRONGEST WINDS WILL OCCUR LATE IN THE AFTERNOON AS THE FRONT MOVES INTO SOUTHEAST UTAH AND APPROACHES WESTERN COLORADO. FOR THE LATEST UPDATES...VISIT THE NATIONAL WEATHER SERVICE GRAND JUNCTION WEB PAGE AT WEATHER.GOV/GJT.

COZ002-003-006-007-009-011-017>021-UTZ022-025-027>029-282130-
/O.EXT.KGJT.HW.W.0001.100428T0842Z-100429T0300Z/
CENTRAL YAMPA RIVER BASIN-ROAN AND TAVAPUTS PLATEAUS-GRAND VALLEY-
DEBEQUE TO SILT CORRIDOR-GRAND AND BATTLEMENT MESAS-
CENTRAL GUNNISON AND UNCOMPAHGRE RIVER BASIN-
UNCOMPAHGRE PLATEAU AND DALLAS DIVIDE-
NORTHWEST SAN JUAN MOUNTAINS-SOUTHWEST SAN JUAN MOUNTAINS-
PARADOX VALLEY/LOWER DOLORES RIVER-
FOUR CORNERS/UPPER DOLORES RIVER-SOUTHEAST UTAH-TAVAPUTS PLATEAU-
ARCHES/GRAND FLAT-LA SAL AND ABAJO MOUNTAINS-
CANYONLANDS/NATURAL BRIDGES-
INCLUDING THE CITIES OF...CRAIG...HAYDEN...MEEKER...RIO BLANCO...
GRAND JUNCTION...FRUITA...PALISADE...RIFLE...SILT...PARACHUTE...
MESA...SKYWAY...CEDAREDGE...DELTA...HOTCHKISS...MONTROSE...
RIDGWAY...GLADE PARK...OURAY...TELLURIDE...LAKE CITY...
SILVERTON...RICO...HESPERUS...GATEWAY...NUCLA...CORTEZ...
DOVE CREEK...MANCOS...BLANDING...BLUFF...MEXICAN HAT...MOAB...
CASTLE VALLEY...THOMPSON SPRINGS...MONTICELLO AND VICINITY
242 AM MDT WED APR 28 2010

...HIGH WIND WARNING NOW IN EFFECT UNTIL 9 PM MDT THIS EVENING...

THE HIGH WIND WARNING IS NOW IN EFFECT UNTIL 9 PM MDT THIS EVENING.

* TIMING...HIGH WINDS EXPECTED THROUGH 9 PM MDT THIS EVENING.

* WINDS...SUSTAINED STRONG WINDS FROM THE SOUTHWEST OF 20 TO 40 MPH WILL BE COMMON. HIGH WIND GUSTS TO 60 MPH FOR THE VALLEYS AND 75 MPH IN THE MOUNTAINS WILL BE POSSIBLE.

* VISIBILITY...VISIBILITY WILL BE SIGNIFICANTLY REDUCED FROM BLOWING DUST...ESPECIALLY ALONG INTERSTATE 70 FROM GREEN RIVER

TO FRUITA.

* IMPACTS...BUFFETING WINDS WILL CREATE HAZARDOUS DRIVING CONDITIONS FOR HIGH PROFILE VEHICLES.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING. SUSTAINED WIND SPEEDS OF AT LEAST 40 MPH OR GUSTS OF 58 MPH OR MORE CAN LEAD TO PROPERTY DAMAGE.

PEOPLE...ESPECIALLY THOSE WITH RESPIRATORY ILLNESSES...HEART DISEASE...THE ELDERLY...AND CHILDREN ARE RECOMMENDED TO STAY INDOORS AND AVOID PROLONGED OUTDOOR EXERCISE OR HEAVY EXERTION DUE TO WIND-BLOWN DUST.

&&

NOUS45 KFGZ 120312
PNSFGZ

PUBLIC INFORMATION STATEMENT
NATIONAL WEATHER SERVICE FLAGSTAFF AZ
812 PM MST TUE MAY 11 2010

...STRONG WINDS ACROSS NORTHERN ARIZONA ON TUESDAY...

A LOW PRESSURE SYSTEM MOVING THROUGH THE REGION PRODUCED ANOTHER DAY OF WINDY CONDITIONS ACROSS PORTIONS OF NORTHERN ARIZONA. A HIGH WIND WARNING AND DUST STORM WARNING WERE ISSUED FOR EAST CENTRAL ARIZONA INCLUDING INTERSTATE 40 NEAR WINSLOW. WIND ADVISORIES WERE IN EFFECT FOR MUCH OF THE REMAINDER OF NORTHERN ARIZONA. NEAR ZERO VISIBILITY WAS REPORTED AT TIMES TUESDAY FROM WEST OF WINSLOW...NORTHEAST TO CHINLE...RESULTING IN A CLOSURE OF I-40 FOR MUCH OF THE DAY.

SOME PEAK WIND GUSTS REPORTED TODAY INCLUDE:

TWO GUNS .... 77 MPH.
10 S HOLBROOK .... 66 MPH.
LUPTON .... 62 MPH.
SHOW LOW .... 60 MPH.
FLAGSTAFF .... 59 MPH.
PETRIFIED FOREST ..... 59 MPH.
WINDOW ROCK .... 58 MPH.
WINSLOW .... 58 MPH.
ST. JOHNS .... 55 MPH.
GREER .... 52 MPH.
WUPATKI NATL MONUMENT 50 MPH.
GRAND CANYON .... 43 MPH.
PRESCOTT .... 37 MPH.

MUCH LIGHTER WINDS ARE EXPECTED OVERNIGHT INTO WEDNESDAY.

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WWUS75 KGJT 111825
NPWGJT

URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE GRAND JUNCTION CO
1225 PM MDT TUE MAY 11 2010

COZ006-011-020>023-UTZ022-027-029-120200-
/O.CON.KGJT.WI.Y.0009.000000T0000Z-100512T0200Z/
GRAND VALLEY-CENTRAL GUNNISON AND UNCOMPAHGRE RIVER BASIN-
PARADOX VALLEY/LOWER DOLORES RIVER-
FOUR CORNERS/UPPER DOLORES RIVER-ANIMAS RIVER BASIN-
SAN JUAN RIVER BASIN-SOUTHEAST UTAH-ARCHES/GRAND FLAT-
CANYONLANDS/NATURAL BRIDGES-
INCLUDING THE CITIES OF...GRAND JUNCTION...FRUITA...PALISADE...
CEDAREDGE...DELTA...HOTCHKISS...MONTROSE...GATEWAY...NUCLA...
CORTEZ...DOVE CREEK...MANCOS...DURANGO...BAYFIELD...IGNACIO...
PAGOSA SPRINGS AND VICINITY...BLANDING...BLUFF...MEXICAN HAT...
MOAB...CASTLE VALLEY...THOMPSON SPRINGS
1225 PM MDT TUE MAY 11 2010

...WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING...

A WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM MDT THIS EVENING.

* TIMING...WIND ADVISORY IN EFFECT UNTIL 8 PM THIS EVENING.

* WINDS...SOUTH TO SOUTHWEST WINDS OF 20 TO 35 MPH WITH OCCASIONAL GUSTS TO 45 MPH. WINDS WILL BE ERRATIC WITH GUSTY OUTFLOWS IN THE PROXIMITY OF SHOWERS AND THUNDERSTORMS.

* VISIBILITY...AREAS OF BLOWING DUST WILL DROP VISIBILITIES FROM TIME TO TIME...ESPECIALLY ACROSS INTERSTATE 70 FROM GREEN RIVER UTAH TO FRUITA COLORADO.

* IMPACTS...STRONG CROSSWINDS WILL BE POSSIBLE ACROSS SOUTHEAST UTAH AND SOUTHWEST COLORADO...MAKING FOR HAZARDOUS DRIVING CONDITIONS FOR HIGH PROFILE VEHICLES.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT A SIGNIFICANT WIND EVENT IS EXPECTED OR OCCURRING. WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT. USE EXTRA CAUTION.

PEOPLE...ESPECIALLY THOSE WITH RESPIRATORY ILLNESSES... HEART DISEASE...THE ELDERLY...AND CHILDREN ARE RECOMMENDED TO STAY INDOORS AND AVOID PROLONGED OUTDOOR EXERCISE OR HEAVY EXERTION DUE TO WIND-BLOWN DUST.

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Appendix C- Final Natural Events Action Plan For High Wind Events, Alamosa, Colorado

FINAL NATURAL EVENTS ACTION PLAN

FOR

HIGH WIND EVENTS

ALAMOSA,

COLORADO

Colorado Department
of Public Health
and Environment

CITY OF ALAMOSA,
ALAMOSA COUNTY,
and
COLORADO AIR POLLUTION CONTROL DIVISION
4300 Cherry Creek Drive South
Denver, Colorado 80222-1530
(303) 692-3100

May 2003

I. EXECUTIVE SUMMARY

On March 31 and April 9, 1999 and again on April 18 and December 17, 2000, the monitor located in Alamosa, Colorado recorded exceedances of the 24-hour National Ambient Air Quality Standard (NAAQS) for PM10 (particulate matter having a nominal aerodynamic diameter equal to or less than 10 microns). Each of these exceedances was associated with high winds and blowing dust in the Alamosa area.

Recognizing that certain uncontrollable natural events, such as high winds, wildfires, and volcanic/seismic activity can have on the NAAQS, the Environmental Protection Agency (EPA) issued a Natural Events Policy (NEP) on May 30, 1996. The NEP sets forth procedures through the development of a Natural Events Action Plan (NEAP) for protecting public health in areas where the PM10 standard may be violated due to these uncontrollable natural events. The guiding principles of the policy are:

1. Federal, State, and local air quality agencies must protect public health;

2. The public must be informed whenever air quality is unhealthy;

3. All valid ambient air quality data should be submitted to the EPA Aerometric Information Retrieval System (AIRS) and made available for public access;

4. Reasonable measures safeguarding public health must be taken regardless of the source of PM10 emissions; and,

5. Emission controls should be applied to sources that contribute to exceedances of the PM10 NAAQS when those controls will result in fewer violations of the standards.

In response to Alamosa's four exceedances of the PM10 NAAQS in 1999 and 2000, the Colorado Department of Public Health and Environment's Air Pollution Control Division (Division), in conjunction with the City of Alamosa, Alamosa County, and other agencies developed a NEAP for the Alamosa area. The referenced NEAP was developed based on Natural Events Policy that calls for states to "develop a NEAP for any area where natural events cause or have caused a PM10 NAAQS to be violated within eighteen (18) months of the date of the violation." April 18, 2000 was the triggering event for the development of the NEAP. The referenced NEAP was developed and submitted to EPA in October 2001. A revised version of the NEAP (including U.S. EPA recommendations) was submitted February 2002. A copy of the letter of concurrence for these submittals is available in the Appendix.

The Natural Events Policy also indicates that in attainment areas (such as Alamosa), best available control measures (BACM) must be implemented within three (3) years after the triggering event. With that, this *Final Natural Events Action Plan for Alamosa, Colorado* includes BACM not identified in the February 2002 submittal and includes additional efforts in the community to limit blowing dust and its impacts on public health.

The *Final Natural Events Action Plan* also addresses PM10 exceedances experienced in the area that have occurred since the December 17, 2000 event.

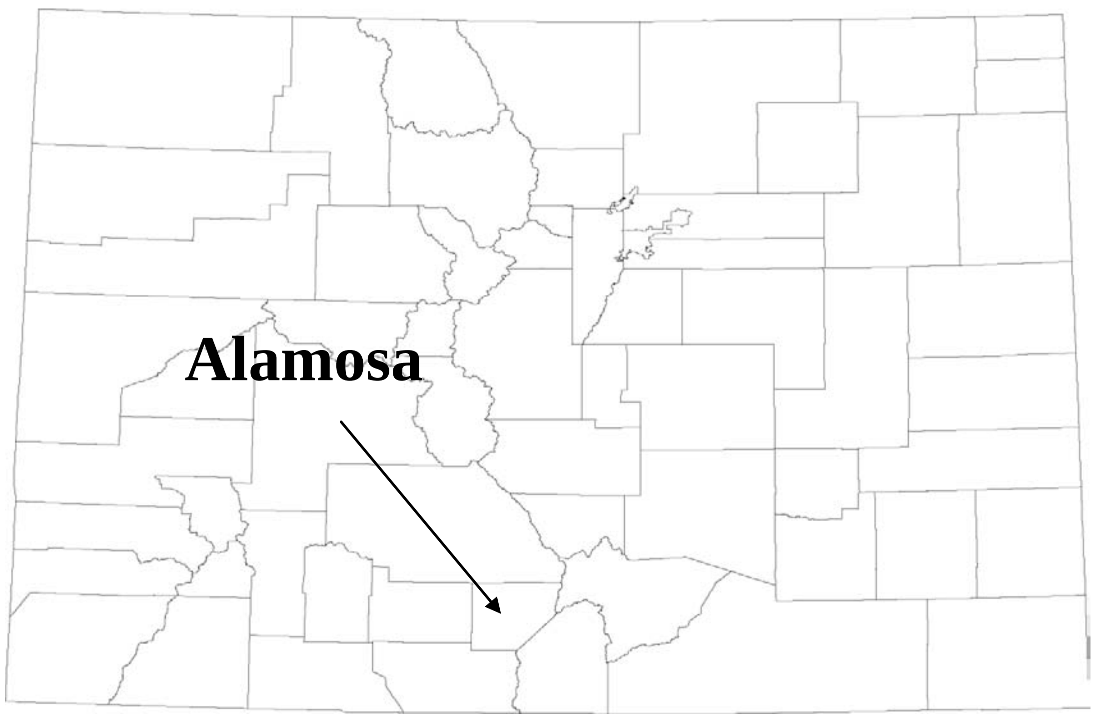
The plan provides analysis and documentation of the exceedances as attributable to uncontrollable natural events due to unusually high winds. In addition, the NEAP is designed to protect public health, educate the public about high wind events; mitigate health impacts on the community during future events; and, identify and implement Best Available Control Measures (BACM) for anthropogenic sources of windblown dust.

TABLE OF CONTENTS

II. INTRODUCTION

The City of Alamosa is located in Alamosa County in south central Colorado. Situated in the San Luis Valley, Alamosa serves as one of the largest cities and the agricultural center for south central Colorado. The area surrounding Alamosa consists of gently rolling to nearly level uplands where the dominant slopes are less than 3 percent. The climate is generally mild and semiarid. Annual precipitation is about 7.5 inches. Summers are considered short and cool, with winters long and cold. In winter and spring, windstorms are common, especially in drier years. It is due to these high velocity windstorms that Alamosa experiences most of the PM10 problems for the area.

Area Map



On March 31 and April 9, 1999 and again on April 18 and December 17, 2000 the PM10 monitor located on the roof of Alamosa's Adams State College recorded exceedances of the primary 24-hour NAAQS for PM10. The PM10 concentrations of 263 $\mu g/m^3$, 190 $\mu g/m^3$, 238 $\mu g/m^3$, and 217 $\mu g/m^3$ respectively, were recorded on these days - as were unusually high wind speeds and little or no precipitation. The circumstances surrounding the Alamosa exceedances has provided adequate reason for the Division to believe the high wind events and blowing dust have caused exceedances of the NAAQS that otherwise would not have occurred.

As required by the NEP, each of the exceedances was flagged by the Division's Technical Services Program in the AIRS system. The flags appear after the recorded values in AIRS with the descriptor code "A" for high winds. According to EPA guidance the type and amount of documentation provided for each event should be sufficient to demonstrate that the natural event occurred, and that it impacted a particular monitoring site in such a way as to cause the PM10 concentrations measured. This documentation has been previously submitted to EPA.

Recognizing the need to protect public health in areas where PM10 exceeds the NAAQS due to natural events such as the unusually high winds, a Natural Events Action Plan has been developed for the Alamosa area based on the NEP guidance. This plan outlines specific procedures to be taken in response to future high wind events. In short, the purpose of the plan is to:

1. Educate the public about the problem;
2. Mitigate health impacts on exposed populations during future events; and
3. Identify and implement Best Available Control Measures (BACM) for anthropogenic sources of windblown dust.

A. Background

High winds are common to the southern region of Colorado. Under some conditions, these winds are strong enough to lift particulate matter into the air and cause elevated levels of PM10 above the Federal and State standards. Due to observed problems in Alamosa, particulate monitoring of total suspended particulate pollution was instituted at the Adams State College monitoring site in 1970. In 1989, monitoring for PM10 began.

More recently, an additional monitoring site has been established in the Alamosa area. Specifically, a second PM10 monitor was established at the Alamosa Municipal Building to ensure adequate coverage of local air quality monitoring and to ensure protection of public health. This monitor, like the first PM10 monitor at Adams State College, operates on an everyday sampling protocol.

Alamosa's monitoring history shows that the annual PM10 standard of 50 $\mu g/m^3$ (averaged over an annual period) has never been exceeded. The 24-hour PM10 standard of 150 $\mu g/m^3$ has been exceeded on a number of occasions. However, all exceedances have been due to natural events. The associated weather conditions on each of the exceedance days conform to a repeated pattern of regional high winds and blowing dust. In each case an intense, fast-moving, surface low-pressure system tracked through Colorado. Typically these systems had surface lows that were not collocated with a closed upper low or nearly-closed upper level trough. This distinction is important because the collocated or vertically "coupled" systems usually bring significant up slope snow or rain to the region. The intensity of the lows associated with the PM10 exceedances is evident in the average central pressure of 990 mb (corrected to sea level). This value is typical of a deep, well-organized system. Such well-organized systems usually generate high winds in the vicinity of the low center.

The NEP applies only to emissions caused by natural events that have occurred since January 1, 1994. Only those high wind events experienced since that time are addressed by this NEAP. This submittal includes those exceedances occurring since the previous NEAP submittal as well. See table on page 6 for more details of all area exceedances.

B. The Natural Events Policy

1. Background

On May 30, 1996, EPA issued the Natural Events Policy in a memorandum from Mary D. Nichols, Assistant Administrator for Air and Radiation. In this memorandum EPA announced its new policy for protecting public health when the PM10 NAAQS are violated due to natural events. Under this policy three categories of natural events are identified as affecting the PM10 NAAQS: (1) volcanic and seismic activity; (2) wildland fires; and, (3) high wind events. Only high wind events will be addressed in this NEAP.

Based on EPA's natural events policy high winds are defined as uncontrollable natural events under the following conditions: (1) the dust originated from non-anthropogenic sources; or, (2) the dust originated from anthropogenic sources controlled with best available control measures (BACM). Furthermore, the conditions that create high wind events vary from area to area with soil type, precipitation, and the speed of wind gusts.

2. Content

In order for exceedances of the NAAQS to be considered as due to a natural event, a Natural Events Action Plan must be developed to address future events. The following is a summary of the specific EPA guidance regarding development of a NEAP.

1. Analysis and documentation of the event should show a clear causal relationship between the measured exceedance and the natural event. The type and amount of documentation provided should be sufficient to demonstrate that the natural event occurred, and that it

impacted a particular monitoring site in such a way as to cause the PM10 concentrations measured.

2. Establish education programs. Such programs may be designed to educate the public about the short-term and long-term harmful effects that high concentrations of PM10 could have on their health and inform them that: (a) certain types of natural events affect the air quality of the area periodically, (b) a natural event is imminent, and (c) specific actions are being taken to minimize the health impacts of events.

3. Minimize public exposure to high concentrations of PM10 through a public notification and health advisory program. Programs to minimize public exposure should (a) identify the people most at risk, (b) notify the at-risk population that a natural event is imminent or currently taking place, (c) suggest actions to be taken by the public to minimize their exposure to high concentrations of PM10, and (d) suggest precautions to take if exposure cannot be avoided.

4. Abate or minimize appropriate contributing controllable sources of PM10. Programs to minimize PM10 emissions for high winds may include: the application of BACM to any sources of soil that have been disturbed by anthropogenic activities. The BACM application criteria require analysis of the technological and economic feasibility of individual control measures on a case-by-case basis. The NEAP should include analyses of BACM for contributing sources. If BACM are not defined for the anthropogenic sources in question, step 5 listed below is required.

5. Identify, study, and implement practical mitigating measures as necessary. The NEAP may include commitments to conduct pilot tests of new emission reduction techniques. For example, it may be desirable to test the feasibility and effectiveness of new strategies for minimizing sources of windblown dust through pilot programs. The plan must include a timely schedule for conducting such studies and implementing measures that are technologically and economically feasible.

6. Periodically reevaluate: (a) the conditions causing violations of a PM10 NAAQS in the area, (b) the status of implementation of the NEAP, and (c) the adequacy of the actions being implemented. The State should reevaluate the NEAP for an area every 5 years at a minimum and make appropriate changes to the plan.

7. The NEAP should be developed by the State in conjunction with the stakeholders affected by the plan.

8. The NEAP should be made available for public review and comment and may, but is not required, to be adopted as a revision to the State Implementation Plan (SIP) if current SIP

rules are not revised.

9. The NEAP should be submitted to the EPA for review and comment.

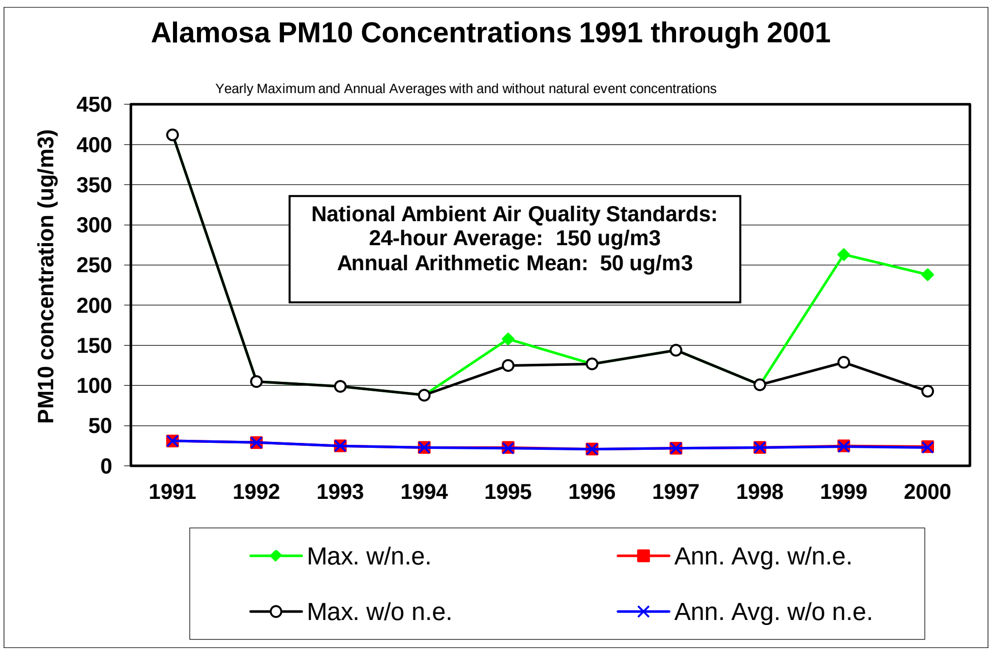
The following text describes the Alamosa NEAP and its conformance with the above-described EPA guidance on natural events.

III. NATURAL EVENTS ACTION PLAN

A. Element 1: Documentation & Analysis

On March 31 and April 9, 1999 and again on April 18 and December 17, 2000, the air quality monitor located in Alamosa, Colorado recorded exceedances of the 24-hour National Ambient Air Quality Standard (NAAQS) for PM10 (Figure 1). Each of these exceedances was associated with unusually high winds in the Alamosa area (Table 1).

Figure 1. Recent Alamosa PM10 Concentrations



n.e.- Natural Event

On October 29, 1999 and again on March 30, 2000 the Division submitted documentation to EPA Region VIII in support of Alamosa's most recent exceedances of the PM10 NAAQS due to natural events. The documentation contained monitoring data, meteorological data, PM10 filter analysis and receptor model results, maps of the area, news accounts of the events and other miscellaneous supporting material. On July 3, 2001, EPA concurred that the aforementioned natural events were, in fact, high wind events (Table 1). The EPA letter of concurrence can be found in the Appendix of this NEAP.

More recently (since the February 2002 submittal), several additional exceedances of the PM10 NAAQS have been experienced in the community. These exceedances were recorded at the Adams State site only; none have been seen at the recently sited PM10 monitor at the Municipal Complex. Details are included in the table below and documentation for these events is on file with EPA.

Table 1. Recent 24 Hour PM-10 Values in Alamosa Colorado

EVENT Date	**PM-10 Concentration**	***Details***
3/31/99	263 µg/m^3	Natural Event- EPA concurrence on July 3, 2001
4/9/99	190 µg/m^3	Natural Event- EPA concurrence on July 3, 2001
4/18/00	238 µg/m^3	Natural Event- EPA concurrence on July 3, 2001
12/17/00	217 µg/m^3	Natural Event- EPA concurrence on July 3, 2001
2/8/02	215 µg/m^3	Natural Event Under EPA consideration
2/25/02	182 µg/m^3	Natural Event Under EPA consideration
3/23/02	164 µg/m^3	Natural Event Under EPA consideration
5/21/02	160 µg/m^3	*Natural Event Under EPA consideration*

Taken together, the supporting documentation establishes a clear, casual relationship between the measured exceedances and the natural events as required by the NEP. On the days of Alamosa's PM10 exceedances, unusually high winds and/or wind gusts were experienced over a prolonged period of time. For example, meteorological data in and around the area (Trinidad, Colorado) demonstrate that on April 18, 2000, maximum wind speeds were over 41 miles per hour and gust speeds were as high as nearly 59 miles per hour. Meterological data for the December 18, 2000 event indicate that gusts were as high as 49 miles per hour in the Alamosa area. Both events were coupled with dry periods of weather.

According to the Natural Events Policy, "the conditions that create high wind events vary from area to area with soil type, precipitation and the speed of wind gusts." Thus, states are to determine the conditions that define high winds in an area. Making a precise determination, however, is a complex task that requires detailed information on soil moisture, daily wind speeds, temperature, and a number of other variables that are not readily available at this time.

Until such research and/or guidance is available, the Division will use the definition of high winds included in the *Guideline on the Identification and Use of Air Quality Data Affected by Exceptional Events* for the Alamosa area. According to this guidance, high winds are defined as: "An hourly wind speed of greater than or equal to 30 mph or gusts equal to or greater than 40 mph, with no precipitation or only a trace of precipitation." In all these high wind events, hourly wind speeds and/or wind gust data coupled with low precipitation levels meet this high wind definition.

The analysis and documentation of the natural high wind events fulfill Element 1 as described on page 3 of this NEAP.

B. Element 2: Public Education Programs

The purpose of this program is to inform and educate the public about the problem. The Division has worked with the City of Alamosa, Alamosa County Commissioners, and interested stakeholders to educate the public about the problems associated with elevated levels of PM10 in the Alamosa area. Several meetings have taken place with the City and County governments to discuss these issues and to develop a plan to address future high wind events in Alamosa. Elements of the public education program include: informing the public when air quality in the area is unhealthy; explaining what the public can expect when high wind events occur; what steps will be taken to control dust emissions during future high wind events; and, how to minimize the public's exposure to high concentrations of PM10 during high wind conditions. The public notification and education programs will include but are not limited to:

- An informational and health-related brochure has been and will continue to be distributed by the local governments, the Alamosa County Health Nurses, and Alamosa County conservation and agricultural extension agencies to sensitive populations (elderly and local school districts) as well as the general public. Distribution of the *Blowing Dust Health Advisory Brochure* began in March 2000. A copy of this brochure is available in the Appendix. More recent (since the February 2002 submittal of the NEAP) activities include: 1) the revision of the area brochure to highlight additional activities in the community and make the document more reader friendly; 2) a review of the effectiveness of the brochure distribution in the community. The brochure is now available at additional sites in the community (e.g., County Land Use office), and; 3) the development of a Spanish version of the brochure.

- Beginning in February 2002, blowing dust watches and health advisories are being issued by the Alamosa County Public Health Nursing office during the high wind season (see Appendix for details). More recent (since the February 2002 submittal of the NEAP) activities include: 1) expanding the public education effort to include staff from the

County Land Use office; 2) meetings with city, county, and local public health nurse to devise improved ways to educate/reach the community regarding blowing dust and its impacts.

- Media press releases for both the print and local radio will be issued in the community as needed. More recent (since the February 2002 submittal of the NEAP) activities include: 1) newspaper articles highlighting the significant impacts of the drought on blowing dust in the Alamosa area (e.g., “Biblical Level Help Needed for Drought,” *The Denver Post*, April 22, 2002. This referenced article also highlighted some of the mitigation strategies underway to limit impacts), and; 2) identifying possible Public Service Announcement outlets for additional outreach into the community and the ongoing development of an area press release on the NEAP development and control strategies.

- Meetings have been held to review the requirements of and local involvement in the NEAP. Other meetings will be convened as deemed necessary by State and/or local agencies.

- Advertising at local meetings (e.g. Sunshine Festival - Summer 2003) of ongoing efforts to reduce blowing dust and its impacts. This is new effort not part of the February 2002 submittal.

- Development of a logo/brand to better familiarize area residents to the NEAP and components of that plan including the blowing dust advisory. An example of that logo can be found on the revised *Blowing Dust Health Advisory Brochure*, located in the Appendix. This is new effort not part of the February 2002 submittal.

- Ongoing development of educational materials to be made available through the County’s tax announcement (2004). These educational materials will be distributed in the mail alongside tax announcements and are expected to go to all area residents (approximately 13,000 notices). Materials are likely to be in both English and Spanish. This is new effort not part of the February 2002 submittal.

- The Division in conjunction with the area County Public Health Nurse is revising the blowing dust education/notification procedure to highlight public health issues associated with blowing dust.

- Finally, County building inspectors will also educate citizens (home owners and contractors) about blowing dust issues and strategies to minimize such. This will be done in all construction zones in the county and documented as an item on the inspector’s checklist of building issues covered during the permitting process. This is new effort not part of the February 2002 submittal.

This section fulfills the requirement of Element 2 as described on page 4.

C. Element 3: <u>Public Notification Program and Health Advisory Program</u>

The Blowing Dust Health Advisory program will notify the public that a high wind/blowing dust event is imminent or currently taking place, and will include an advisory suggesting what actions can be taken to minimize PM10 emissions and exposure to high concentrations of particulate matter.

Advisories are issued by the Alamosa area Public Health Nursing office, with forecasting assistance provided by the National Weather Service (Pueblo) and the Colorado Air Pollution Control Division. Since 2002, five (5) advisories have been issued locally. The forecasting methodology, the public education brochure, and a copy of the text of blowing dust forecasts and health advisories are provided in the Appendix.

Alamosa County will be investigating, during 2003, the possibility of modifying the 911 data base for reverse notification of sensitive populations during high wind events. This is new activity not included in the February 2002 submittal.

Finally, high winds are currently being documented to determine if the Division and the local agencies can better address these issues. For example, the Alamosa County Public Health Nursing office maintains records of all blowing wind events and the associated notifications. Included in this analysis is a rudimentary review of the high wind data to identify patterns of events and possible solutions to minimize public exposure. Given the drought conditions affecting the Alamosa area over the past several years, no consistent pattern (outside of extremely dry conditions and lack of rainfall) has been noted. Nonetheless, the Division is committed to continually investigating this issue and improving the advisory as possible. Ongoing review of those records will continue to investigate patterns of the exceedances and the notifications. This is a new activity that was not part of the February 2002 submittal and demonstrates additional efforts by the Division and the local agencies to minimize blowing dust and protect public health.

This section fulfills the requirement of Element 3 as described on page 4.

D. Element 4: Determination and Implementation of BACM

1. BACM Determination

According to the NEP, Best Available Control Measures (BACM) must be implemented for anthropogenic sources contributing to NAAQS exceedances in attainment and unclassifiable areas, like Alamosa. BACM must be in place for those contributing sources within *three years* after the first NAAQS violation attributed to high wind event(s) for sources in the Alamosa area. BACM must be in place no later than April 18, 2003. BACM for PM10 are defined (in 59 F.R. 42010, August 16, 1994) as techniques that achieve the maximum degree of emissions reduction from a source as determined on a case-by-case basis considering technological and economic feasibility.

On September 2, 1999 the Division attended several meetings in Alamosa with officials representing the City of Alamosa and Alamosa County Commissioners. Discussed were the monitoring data, meteorological data, potential contributing sources to the high wind events, the development of a NEAP, and possible control measures. In addition, meetings in December 2001 and February 2002 and numerous correspondences at other times have covered the same. The meetings, coupled with the analyses of the supporting documentation, identified two distinct sets of circumstances that lead to Alamosa's high wind/blowing dust exceedances of the PM10 NAAQS:

10. High concentrations of PM10 caused by a mixture of anthropogenic and non-anthropogenic sources coming largely from outside the area under high wind conditions; and,

2. Prolonged climatic conditions of low precipitation over an extended period of time that act to dry area soils, making them more susceptible to airborne activity under high wind conditions.

Discussions with the community stakeholders also covered local agricultural practices. Alamosa County is a predominately agricultural area where a lack of water, coupled with the frequent high winds experienced during late fall and early spring, can destroy crops, encourage pests, and damage soil surfaces lending them susceptible to wind erosion.

Other potential contributing sources may include construction sites, wind erosion of open areas, paved and unpaved roads, residential wood burning, and/or open burning. See below for more details on each of these potentially contributing sources and their consideration for BACM.

2. BACM Options Considered

Based on the contributing source analysis and/or in review with community stakeholders, the following BACM options were considered as possible PM10 control measures for the community:

a) Street Sweeping Activities- community street sweeping programs have demonstrated effectiveness in other communities. Such activities were considered as a local control measure. Expanding the current street sweeping program was also reviewed.

b) Construction/Demolition Activity – local ordinances to control emissions from construction and demolition sites have been implemented in other parts of the state with good success.

c) Wind Erosion of Open Areas – several practices were reviewed regarding the wind erosion of open areas, including both local and regional efforts.

d) Control of Stationary Source Emissions- as identified elsewhere in this NEAP, a review of stationary sources and their relative contribution to overall PM concentrations was completed. It was determined that six PM-10 sources exist in the area, appearing to contribute a small amount of particulate matter to the overall inventory.

e) Road Stabilization- In a effort to better understand the effects of road stabilization, several options were reviewed including the use of chemical stabilizers and water as a stabilizing measure.

Also, periodic assessments to determine if traffic levels on unpaved roads surpass Colorado Regulation No. 1 limits were considered. If daily traffic counts exceed 200 trips per day on unpaved roads, state regulations apply that reduce PM-10 emissions from those roads. Specifically, periodic assessments of traffic levels on unpaved roads within the city limits and within one mile of the city limits were considered. State regulation calls for a road traffic count and dust control plan for roads that exceed the 200 trips threshold.

In addition, Alamosa currently suggests that drivers maintain their vehicles at a slow speed on unpaved roads and other dirt surfaces to reduce dust emissions.

f) Woodburning Curtailment Programs- the possibility of instituting a citywide curtailment program was reviewed and considered. This consideration includes discouraging wood burning on high wind days.

g) Open Burning- The usefulness of imposing and maintaining an open burning curtailment program during high wind events was reviewed. Current state air pollution control laws and regulations provide some guidance on the effort.

h) Avoidance of Dust Producing Equipment- The effectiveness of avoiding the use of dust producing equipment has also been considered. Currently Alamosa discourages the use of dust-producing equipment (e.g., leaf blowers) in an effort to reduce PM10 emissions and does so through public education and outreach efforts.

(i) Reducing or Postponing Tilling and Plowing or Other Agricultural Practices that Contribute to PM10 Emissions- It is well recognized that dust-producing activities such as tilling, plowing, and other agricultural practices increase the amount of PM10 released. As such, these control measures were discussed as part of the effort to reduce PM10 impacts on Alamosa. Review of existing and potentially future control practices were considered at the local, regional, state, and federal (e.g., Natural Resources Conservation Service) level.

j) Wind Break- Various trees are found throughout Alamosa. However, the placement of one row of barrier trees (e.g., Russian Olives) would block potential contributing sources. The Russian Olive is a quick growing large shrub/small tree will do well given the windy climate of Alamosa. According to section 3.5.2.1 of EPA guidance entitled Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures, dated September 1992, one-row of trees is considered an effective windbreak.

k) Vegetative Cover/Sod- Efforts elsewhere in the State have demonstrated the usefulness of using a vegetative cover at sites where dust is known to blow. Efforts to use this control measure were reviewed for applicability and effectiveness.

Alamosa PM10 Stationary Source Emissions

To ensure that PM10 emissions from local stationary sources are not a significant contributing factor to area exceedances, an emission inventory was prepared and reviewed. Identified stationary sources are as follows: Public Service Company (natural gas/fuel oil plant), Rakhra Mushroom Farm Corporation (coal-fired boilers and one natural gas fired boiler), Rocky Mountain Soils (fugitive dust emissions), Rogers Family Mortuary (crematorium), San Luis Valley Regional Medical Center (biomedical waste incinerator), and Southwest Ready Mix (concrete batch plant). While no emission inventory of natural sources was prepared as part of this NEAP, appreciation for the significant sand dunes at Great Sand Dunes National Monument highlights that these few and limited stationary sources have very little effect on the total PM10 emission inventory for the Alamosa area. The following table demonstrates their limited impacts on the total emission estimation.

Alamosa PM10 Emission Inventory (circa 2003)

Source	Emissions in lbs/day
Public Service Company of Colorado	44.4
Southwest Ready Mix	4.4
San Luis Valley Regional Medical Center	0.1
Rakhra Mushroom Farm Corp.	11.1
Rocky Mountain Soils, Inc.	11.5
Rogers Family Mortuary	0.5
TOTAL EMISSIONS	***72.1***

Limited Stationary Source Impacts

The largest of these stationary sources, Public Service Company of Alamosa (PSC), is 44.4 pounds per day of particulate matter (as reported to the Colorado APCD). At PSC, the site consists of two turbines that can run on natural gas, #1 fuel oil, #2 fuel oil, or a combination thereof. PSC must stay in compliance with Colorado Air Quality Regulation No. 1 particulate standard. PSC must also meet the state 20% opacity standard.

Other Alamosa area stationary sources have considerably smaller particulate matter emissions than PSC and their own existing control measures in place. For example:

Southwest Ready-Mix has a concrete batch plant in the City of Alamosa. Southwest Ready-Mix has several outside storage piles for their raw materials (sand & aggregate). There exists a sprinkler system at the facility to keep these piles watered. Cement and fly ash are stored in silos, each controlled with a baghouse to capture particulate when the silos are being loaded. When all of the raw materials are loaded into the concrete trucks, 25% of the total water is loaded first, followed by rock, sand, cement, and then the remaining water. This helps to minimize the particulate emissions from the truck during loading. The baghouses are part of the Southwest Ready-Mix permit, and as such are required. This source is also subject to the 20% opacity standard. Finally, Southwest Ready-Mix may be upgrading their baghouses.

San Luis Valley Regional Medical Center has a permit for a biomedical waste incinerator, which is natural gas fired. The incinerator is subject to New Source Performance Standards which limit opacity to 10% and also has a particulate standard. Ash removal from the incinerator must be done in an enclosed area to limit particulate emissions. Ash must be completely enclosed during transport as well.

3. BACM Options Discounted

Several BACM options were discounted from further consideration based on meteorological analysis, on-site inspections, and discussions with local government officials and sources.

Woodburning curtailment was discounted because high wind events are actually beneficial to good atmospheric clearing of particulate matter. In addition, woodburning curtailment was not recognized as an effective control measure on high wind days. Lastly, many of the community citizens rely on woodburning as their sole source of home heating- reducing or eliminating wood burning is thus not an option.

BACM of stationary sources at great distances from the City were discounted as their impacts would be negligible, if seen at all.

Finally, for this revised NEAP (since the February 2002 submittal), the community remains committed to meet BACM in all instances, as feasible. For example, meetings with local officials indicate that the ongoing regional drought may significantly impact the amount of water available as a control measure (e.g., watering of roads to reduce PM10). With that, water restrictions (and related economic impacts of the drought) will likely dictate the utility of this control measure.

4. BACM Implemented

Refer to the stakeholder agreements for details of selected BACM.

IV. STAKEHOLDER AGREEMENTS

The City of Alamosa, Alamosa County, the Division, and participating federal agencies have been working diligently to identify contributing sources and to develop appropriate BACM as required by the Natural Events Policy. A copy of relevant agreements and supplemental information are included in the Appendix**.** This section fulfills the requirements of Element 4 as described on page 4.

City of Alamosa
The City of Alamosa has been active in addressing potential PM10 sources within the Alamosa area through various efforts. Some of these efforts, plus other potential future measures, include the adoption of local ordinances to reduce PM10. Copies of current ordinances and any related commitments are included in the Appendix.

Street Sweeping
Currently, the City of Alamosa sweeps on an every 6-week schedule or as needed, as determined by local officials on a case by case situation (e.g., following each snowstorm and/or where sand was applied). Sweeping occurs on every single City street with an emphasis on the downtown corridor where public exposure is expected to be greatest. In fact, street sweeping in the downtown corridor currently takes place three times per week.

In addition, the City recently agreed to lease/own a new TYMCO 600 (brush-assisted head) sweeper. Efforts are underway to get this effective piece of equipment into place immediately. This new sweeper will complement a mobile mechanical sweeper already in use.

Unpaved Roads within the City
While very few unpaved roads exist in the City of Alamosa, the city did recently annex new land. This annexation includes roadways not currently paved. The City of Alamosa is discussing the paving of these annexed roads. At a minimum, the City of Alamosa commits to continually provide in-kind engineering services for the development of the annexed lands.

Sod/Vegetative Cover Projects in the City of Alamosa
The development and construction of a local park, Eastside Park, is underway in Alamosa. It is anticipated that sodding at the park will take place this year. This commitment is anticipated to reduce blowing dust from this previously undeveloped site.

Alamosa County

Alamosa County has also been active in addressing blowing dust and is preparing county ordinance as such. Examples can be found below and available supporting documents in the Appendix.

Unpaved Roads
Alamosa County is presently addressing unpaved roads and lanes that are anticipated to contribute to PM10 emissions in the community. As of 2002, Alamosa County was nearing the end of its five-year road paving plan and was developing their next plan with the intention of paving on a yearly basis, based on traffic and community needs/priorities.

In 2002, Alamosa County addressed approximately ten (10) miles of unpaved roads. This includes the stabilization of approximately five section roads, the seal coating of two roads, and the overlay (repaving) of four (4) additional roads.

For 2003, approximately 14 miles of roads are scheduled for paving. This includes the Seven Mile Road (three miles long), Road 109 (one mile long), and 10^{th} Street (also one mile long). These roads are in close proximity to the City of Alamosa, are upwind (prevailing) from the city, and have heavy traffic. Paving is anticipated to greatly reduce blowing dust and impacts in the vicinity.

In addition, once it gets cold enough in the area, the County will wet down some of the more sandy roads. Once the water soaks in and freezes, it is anticipated that good dust suppression will be seen. These commitments are anticipated to reduce PM10 emissions in and near Alamosa. This control measure will be balanced with the availability of water in the area.

Finally, Alamosa County assesses the need to use $MgC1_2$ treatment on roads in front of residences that request such service. Assessments include the sensitivity to dust of residents, the materials of the road base for safety reasons, and possible environmental concerns of the neighborhood. Most requests for treatment are granted. Road construction areas are being dampened with water for dust control. Other areas for treatment, such as commercial construction zones or gravel pits, are investigated on a case by case basis.

Dust Control Plans

Alamosa County is considering changes in local ordinances governing dust control plans at construction sites. This will be addressed through the revision of Alamosa County’s Comprehensive Plan and supporting zoning codes. Alamosa County is currently reviewing language from other successful dust control programs for inclusion in their local ordinances. The process is due for completion in December 2003 or early 2004 and will specifically include dust control language. This effort is anticipated to reduce PM10 emissions in Alamosa, especially as it relates to impacts on the community and high recorded PM10 values. The Division commits to providing copies of this language to EPA upon finalization and availability.

Wind Erosion of Open Areas

To reduce PM10 emissions from open areas outside of the City limits, low tilling and other soil conservation practices will continue to be utilized in the community. In addition, the community is using in strategic areas the State of Colorado Agricultural Office’s program to purchase and plant shelter trees to reduce wind erosion in open areas. These trees have a demonstrated advantage for the community and for air quality. Once the trees reach maturity, it is anticipated that the equivalent of 112 miles of double-rowed trees will be in place.

In addition, there is ongoing planting of trees (approximately 50) on newly developed Alamosa County property south/southwest of Alamosa (prevailing winds from southwest) and the Airport south of Alamosa for added air quality improvement.

These commitments are anticipated to further reduce the PM-10 emissions in Alamosa.

Sod and Vegetative Projects in the County

Numerous projects to reduce blowing dust and its impacts have happened or are happening at the County Airport. For example:

- Through additional grounds maintenance of the 40-acre Alamosa County airport south of the city, grass is being grown for aesthetics and dust control.

- Sodding and the placement of decorative rock and ground cover will be implemented in the landscaping of the Alamosa County property, as well. These measures will directly abate blowing dust at the Airport.

- Also, the widening of the airport's safety areas (250 feet on either side of the runway) is now complete and seeding of natural grasses was incorporated in the project. Trees and grass were incorporated in the approaches to the airport and have provided additional wind-break advantages to South Alamosa.

In other areas where watering is a problem, xeriscape (the use of native drought resistant vegetation and/or rock cover) is being encouraged for County owned property and for all other property owners.

These efforts are anticipated to further reduce PM10 emissions in Alamosa.

Open Burning Issues at the County

The Colorado air pollution control laws and regulations prohibit open burning throughout the state unless a permit has been obtained from the appropriate air pollution control authority. In granting or denying any such permit, the authority will base its action on the potential contribution to air pollution in the area, climatic conditions on the day or days of such burning, and the authority's satisfaction that there is no practical alternate method for the disposal of the material to be burned. No open burning is allowed when local wind speeds exceed 5 miles per hour.

Colorado State University Co-Op Extension Office

In response to extremely dry conditions, the need to maintain area topsoil, and reduce impacts, the Colorado State University Co-Op Extension Office of Alamosa County provides the following outreach efforts and recommendations:

- Modification of grazing practices to improve protective crop cover
- Increasing crop residues left in the fields to reduce blowing dust
- Planting of Fall crops to maintain fields
- Application of manure to protect top soils from blowing away
- Staggering of the harvest to minimize blowing dust

- Outreach programs on soil conservation efforts
- Development of outreach/education materials (e.g., news articles, newsletters, fact sheets, etc.), and
- Attendance at Statewide workshop to educate other Co-Op offices to various practices to reduce blowing top soil and minimize impacts

These control strategies are not meant to be enforceable. They are meant only to demonstrate the regional nature of cooperation in addressing blowing dust and its impacts on the community.

Natural Resources Conservation Service

As stated elsewhere in this NEAP, Alamosa County is a predominately agricultural area where limited water, coupled with the frequent high winds experienced during late fall and early spring, can destroy crops, encourage pests, and damage soil surfaces lending them susceptible to wind erosion. Thus, activities that improve the topsoil and prevent its lifting during high wind events are encouraged. Some notable NRCS and agricultural examples include:

- Cover crops and perennial crops (e.g., alfalfa) are recommended to protect soils;
- NRCS works with area farmers in the development of conservation compliance plans to also protect topsoil;
- NRCS encourages the use of perennial crops or the leaving in place of weeds on the corners of area acreage (instead of tilling that might lead to open, barren lands) to reduce the lifting of topsoil;
- NRCS "cost shares" on conservation practices with local farmers to prevent soil erosion, and;
- The NRCS works with Colorado State University to identify other strategies that minimize blowing dust.

Other successful agricultural practices encouraged in the area include: timing of tillage, crop rotation, amount of crop residue left on the land, and proper water usage.

These control strategies are not meant to be enforceable. They are meant only to demonstrate the regional nature of cooperation in addressing blowing dust and its impacts on the community.

Natural Events Policy guidance indicates that control options must be implemented within three years of the exceedance in question. For Alamosa, BACM must be in place no later than April 18, 2003. This submittal is meant to meet that three year commitment.

This section fulfills the requirement of Element 4.

V. PUBLIC REVIEW AND PERIODIC EVALUATION

This section describes the public process used to develop this NEAP and the commitment made to periodically evaluate the plan.

Stakeholder Involvement
The EPA's NEAP development guidance states that the NEAP should be developed by the State in conjunction with the stakeholders affected by the Plan. The Colorado APCD worked with stakeholders mentioned throughout this document. Numerous meetings and telephone conversations occurred with stakeholders, and the final agreement here reflects control measures offered as part of the NEAP.

Public Review
The Division made this documentation available for and presented the NEAP and its strategies to the public to ensure public review and comment. Examples of these efforts in Alamosa, beginning with the earliest community involvement, include:

- Briefing of the San Luis Valley County Commissioners, "Air Quality Briefing," San Luis Valley County Commissioners' Association Meeting, September 1999.
- "Control Alamosa's Dust? Lots of Luck." Newspaper article appearing in *Pueblo Chieftan* indicating the area is developing a plan (NEAP) to address blowing dust – November 1, 2001.
- Briefing of the Alamosa City Council, "Alamosa Air Quality and the Development of a Local Natural Events Action Plan," a meeting to reintroduce the NEAP to City Council staff, February 6, 2002.
- Placement of *Natural Events Action Plan for Alamosa, Colorado* at the area library (Southern Peaks Public Library) for public review, February 2002.
- "Odd Issues Keep Alamosa Busy." Newspaper article appearing in *Valley Courier* indicating NEAP being developed and available for public review at the Southern Peaks Public Library, February 2002.
- Briefing of the Alamosa City Council, "Alamosa Natural Events Action Plan," a meeting to incorporate comments from the City Council, local stakeholders, and the public, February 20, 2002.
- Briefing of the Colorado Air Quality Control Commission, "Natural Events Action Plan for Alamosa, Colorado," May 2002.
- Briefing of the Colorado Air Quality Control Commission, "Alamosa Natural Events Action Plan – Final Activities," January 2003.
- Public Notice, "Natural Events Action Plan for Alamosa, Colorado" Available for Public Review and Comment at the Public Library, April 2003.
- "Media Advisory" notifying public of upcoming Alamosa City Council meeting to

discuss the NEAP, monthly city council meeting agenda published in the area newspaper, May 2003.

- "Media Advisory" notifying public of City Council meeting to discuss the NEAP, Channel Ten Cable Access Channel Public Service Announcement, May 2003.
- Briefing of the Alamosa City Council, "Final Alamosa Natural Events Action Plan," May 2003.

Periodic Evaluation

EPA's Natural Events Policy guidance requires the state to periodically reevaluate: 1) the conditions causing violations of the PM10 NAAQS in the area, 2) the status of implementation of the NEAP, and 3) the adequacy of the actions being implemented. The State will reevaluate the NEAP for Alamosa at a minimum of every 5 years and make appropriate changes to the plan accordingly.

Evaluation of the effectiveness of the NEAP included several key strategies to ensure protection of public health and a robust plan. Strategies included: review of Natural Events Policy in specific relation to the Alamosa community, review of the effectiveness/appropriateness of ongoing control strategies, consideration of new/additional control options, review of meteorological and climatological conditions leading to blowing dust, review of local and regional PM10 monitoring data, discussions with other States (e.g., South Dakota, Washington) and Federal (US EPA) personnel regarding NEAP updates and protocols, review of the established emission inventory and identification of any new emission sources, review of the blowing dust advisory protocol and notification records, public/stakeholder meetings and community outreach/education efforts, etc.

The Division commits to continually review the effectiveness of the Alamosa Natural Events Action Plan and improve the effort, where feasible.

The Division commits to evaluate the NEAP at a minimum of every five years.

Submittal to EPA

The NEAP was submitted in its initial form to EPA in October 2001. Following EPA comment and input from stakeholders, appropriate changes were made to the NEAP. The Alamosa City Council heard and approved the NEAP in February 2002. Since that period, meetings with local agencies and stakeholders have led to finalization of stakeholder agreements (found elsewhere in the NEAP). The *Final Natural Events Action Plan for Alamosa, Colorado* and its Best Available Control Measures, where feasible, are presented here as required under the Natural Events Policy.

This section fulfills the requirements of Elements 6, 7, 8, and 9 as described on page 4 and 5.

Appendix D – Copy of Affidavit of Public Notice