Technical Support Document
For the December 1, 2011,
Alamosa Exceptional Event

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

October 28, 2014

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 On May 2, 2011, in an attempt to clarify this rule, EPA released draft guidance documents on the implementation of the EER to State, tribal and local air agencies for review.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.

EPA's June 2012, Draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule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 Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust. For this blowing dust event, it has been assumed that sustained winds of 30 mph and higher or wind gusts of 40 mph and higher can cause blowing dust in the San Luis Valley of south-central Colorado.

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 December 1, 2011. 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 December 1 of 2011, a powerful late autumn storm system caused an exceedance of the twenty-four hour PM_{10} standard at both sampling stations in Alamosa, Colorado. The Alamosa Municipal Building monitor recorded a concentration of 635 $\mu g/m^3$ while the Adams State College monitor reported a concentration of 440 $\mu g/m^3$. These elevated readings and the locations of the two monitors are plotted on a map of the Greater Alamosa area in Figure 1. The exceedances in Alamosa were the result of intense surface winds produced by a very tight pressure gradient in the wake of a passing cold front. The surface winds were predominantly out of an easterly direction and moved over the dry soils of the eastern San Luis Valley producing significant blowing dust.

A summary of data from all those sites affected by the event is presented in Table 4 of the report. The approximate percentile value that the December 1, 2011, sample represents for each site for their unique historical data sets, for the month of the event (every sample in any December), and for the year of the event. All percentile calculations presented 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. Percentile calculations for both sites affected by the event are 99.9 percentile and are presented in Table 5 of the report.

[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.

Observations of sustained wind speeds and gust speeds at or above the blowing dust thresholds and reduced visibilities on December 1, 2011, at weather stations in the San Luis Valley of south-central Colorado show that a dust storm event occurred under northeast to easterly flow in the wake of a cold front. The observations contribute to the body of evidence that shows that dust originating to the northeast and east of Alamosa 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 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 the San Luis Valley.

The Pueblo National Weather Service (NWS) forecast office issues weather information and alerts for south-central Colorado, including the San Luis Valley. The Area Forecast Discussion from the evening before the blowing dust event is presented in Appendix B. The highlighted text from this product clearly states that winds well in excess of the blowing dust criteria (established earlier in this paper) would be a threat to the San Luis Valley on December 1, 2011. Additionally, the Colorado Department of Public Health and Environment (CDPHE) issued a Blowing Dust Advisory for the San Luis Valley on December 1. This advisory can also be found in Appendix B. Text products and advisories issued by the NWS and CDPHE show that very strong winds and areas of blowing dust were anticipated in the San Luis Valley on December 1.

Figure 11 shows the total precipitation in inches for Colorado during November 2011. Notice that south-central parts of the state, particularly the San Luis Valley where Alamosa is centrally located, generally received less than 0.4 inches of precipitation in the 30 days prior to December 1, 2011. Based on previous research 0.5 to 0.6 inches of precipitation has been found to be the approximate threshold, below which, blowing dust exceedances in Colorado are more likely to occur when combined with high winds.

Furthermore, the Drought Monitor report for Colorado as of 5:00 AM MST November 29, 2011 (Figure 12) reveals that severe drought conditions were being experienced in south-central Colorado before and during the dust event described here. This report included the San Luis Valley counties of Costilla, Alamosa and southern parts of Saguache. According to the National Drought Mitigation Center, the definition of a severe drought includes, "Crop or pasture losses likely", which would imply high rates of erosion and an increase in vulnerability to particulate suspension (see the following link for more information on drought severity classification from the National Drought Mitigation Center: http://droughtmonitor.unl.edu/AboutUs/ClassificationScheme.aspx). 30-day precipitation and Drought Monitor reports indicate that soils in the San Luis Valley of south-central Colorado were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.

GASP and MODIS satellite imagery reveal that a dust storm was taking place in the San Luis Valley of south-central Colorado during the morning of December 1, 2011. The drought-stricken and largely undeveloped eastern half of the San Luis Valley was the source region for the blowing dust that produced the PM_{10} exceedance in Alamosa.

NOAA HYSPLIT backward trajectories in tandem with MODIS imagery provide clear supporting evidence that air transported from the arid, dust-prone sections of the eastern San Luis Valley caused or significantly contributed to the PM_{10} exceedances measured in Alamosa on December 1, 2011.

This part of the eastern San Luis Valley with enhanced frictional velocity values is also the same area where 30-day precipitation totals were below 0.5 inches (Figure 11) and which back trajectories from Figure 16 identify as a source region for air transported into Alamosa. Blowing dust will typically only occur where friction velocities are high and soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is an accurate description of much of the terrain in the eastern San Luis Valley as shown in Figure 19. Therefore, it appears very likely that undisturbed soils in the arid eastern San Luis Valley were a large contributor to the blowing dust that occurred in Alamosa.

The elevated friction velocities shown in Figure 20 and Figure 21, the data on soil moisture conditions presented elsewhere in this report and the prevalence of winds above blowing dust thresholds prove that this dust storm was a natural event that was not reasonably controllable or preventable.

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) on December 1, 2011.

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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. APCD 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 the San Luis Valley advising citizens of the potential for high wind/dust events on December 1, 2011. The advisory that was issued on December 1, 2011, can be viewed at : http://www.colorado.gov/airquality/forecast_archive.aspx?seeddate=12%2f01%2f2011 and is 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 December 1, 2011 two sample values greater than 150 $\mu g/m^3$ were taken at the two sites in Alamosa, Colorado during the high wind event that occurred that day. These were the monitors located in Alamosa at Adams State College (SLAMS), Alamosa at the Municipal Building (SLAMS). All 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 October 29, 2014. 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 December 31, 2014.

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 December 1, 2011, blowing dust event and PM_{10} exceedance – Conceptual Model and Wind Statistics

On December 1 of 2011, a powerful late autumn storm system caused an exceedance of the twenty-four hour PM_{10} standard in Alamosa, Colorado. The Alamosa Municipal Building monitor recorded a concentration of 635 $\mu g/m^3$ while the Adams State College monitor reported a concentration of 440 $\mu g/m^3$. These elevated readings and the locations of the two monitors are plotted on a map of the Greater Alamosa area in Figure 1. The exceedances in Alamosa were the result of intense surface winds produced by a very tight pressure gradient in the wake of a passing cold front. The surface winds were predominantly out of an easterly direction and moved over the dry soils of the eastern San Luis Valley producing significant blowing dust.

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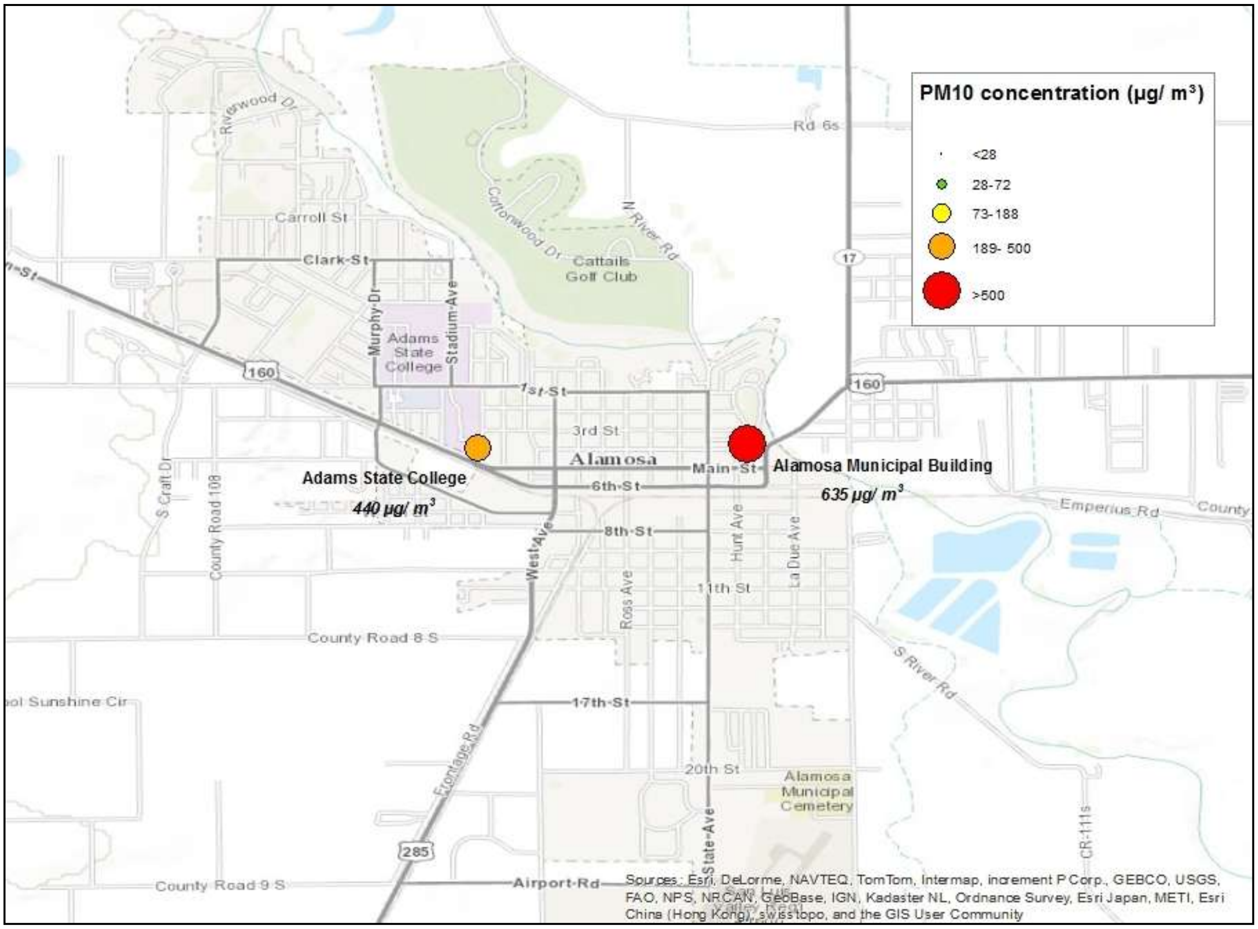

Figure 1: 24-hour PM_{10} concentrations for December 1, 2011
(data source: http://webapps.datafed.net/datafed.aspx?dataset=AQS_D&parameter=pm10**)**

The surface weather associated with the storm system of December 1, 2011, is presented in Figure 2 through Figure 5; the surface analyses for 11 PM MST November 30 and 5 AM, 11 AM and 5 PM MST December 1, respectively. Significant surface features during this period of time included a cold front that swept across south-central Colorado. Additionally, an intense area of surface low pressure was located in western Colorado along this cold front. Simultaneously a strong high pressure system was building into the Western High Plains of eastern Montana and Wyoming along with the western Dakotas. This caused a surface ridge to strengthen over eastern Colorado. The interaction between the intense low pressure in western Colorado and building high pressure in eastern Colorado produced a very tight pressure gradient in central parts of the state. This tight pressure gradient spawned the high winds which produced blowing dust in the San Luis Valley of south-central Colorado.

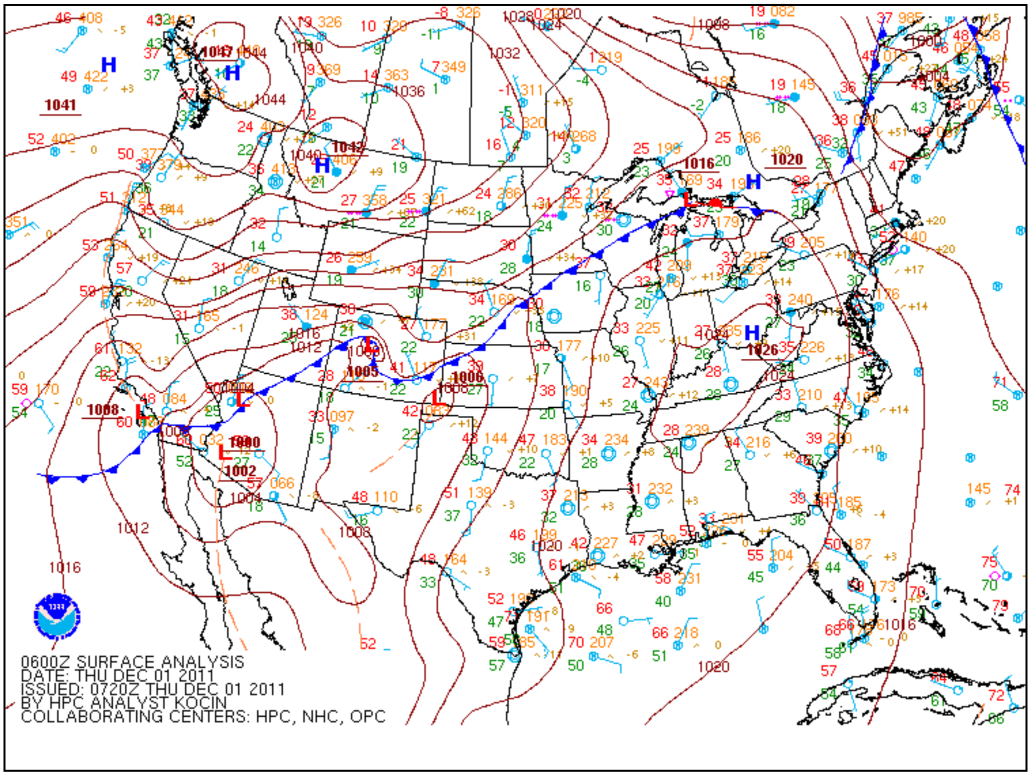

Figure 2: Surface Analysis for 06Z December 1, 2011, or 11 PM MST November 30, 2011 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

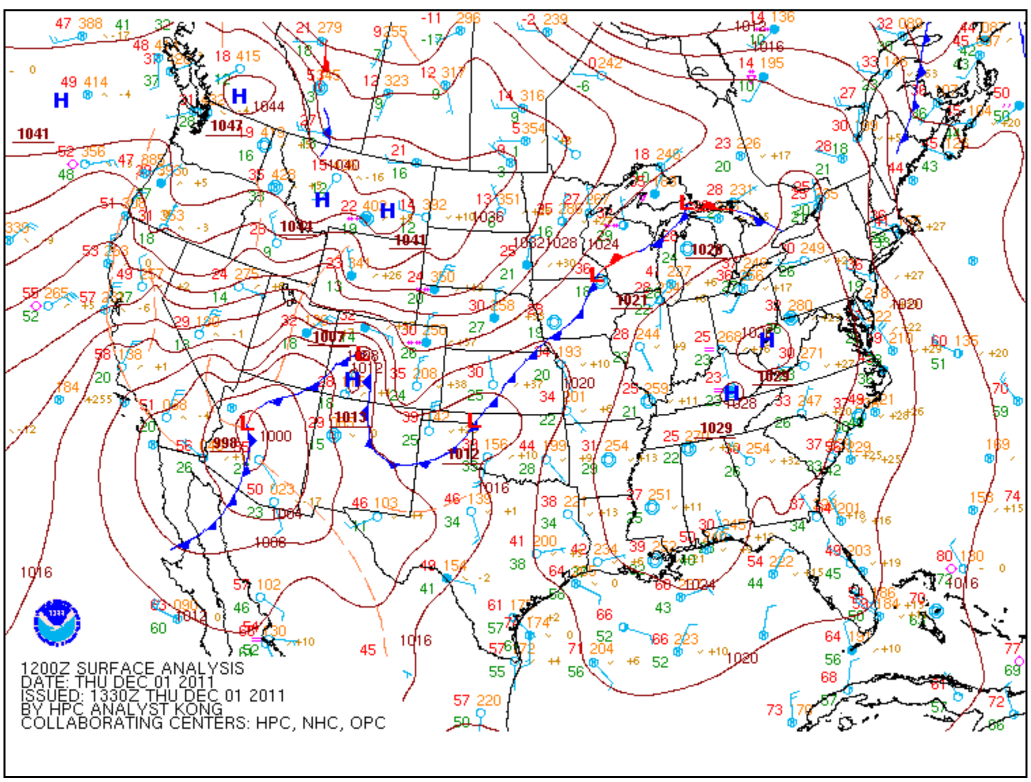

Figure 3: Surface Analysis for 12Z December 1, 2011, or 5 AM MST December 1, 2011 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

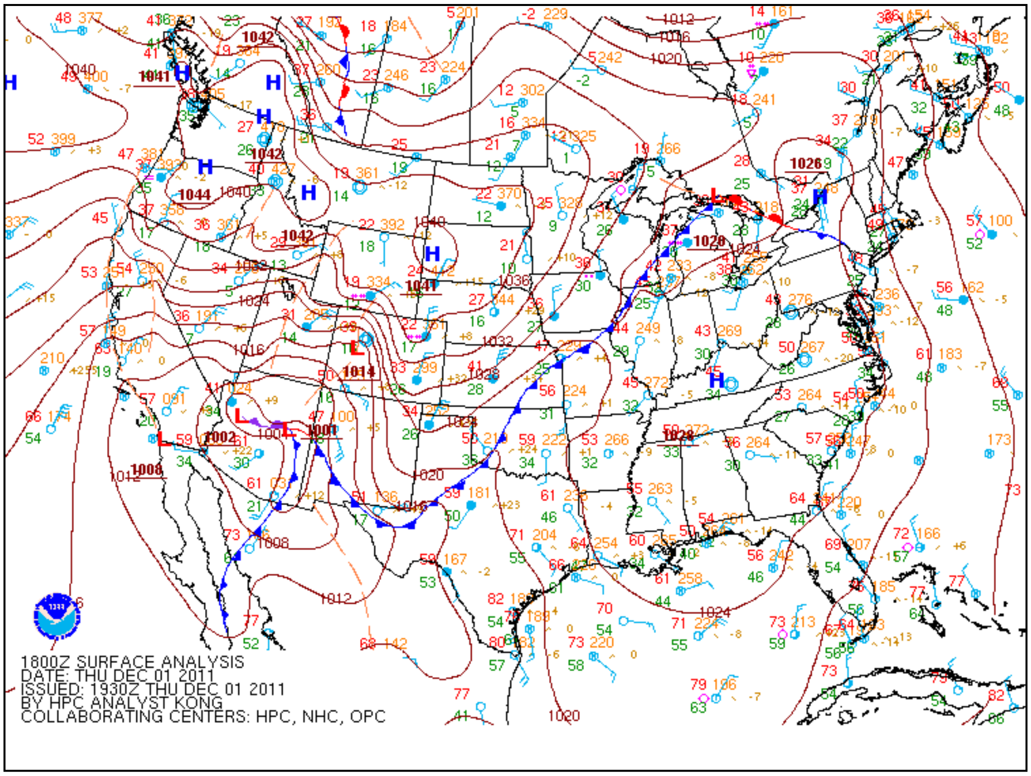

Figure 4: Surface Analysis for 18Z December 1, 2011, or 11 AM MST December 1, 2011 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

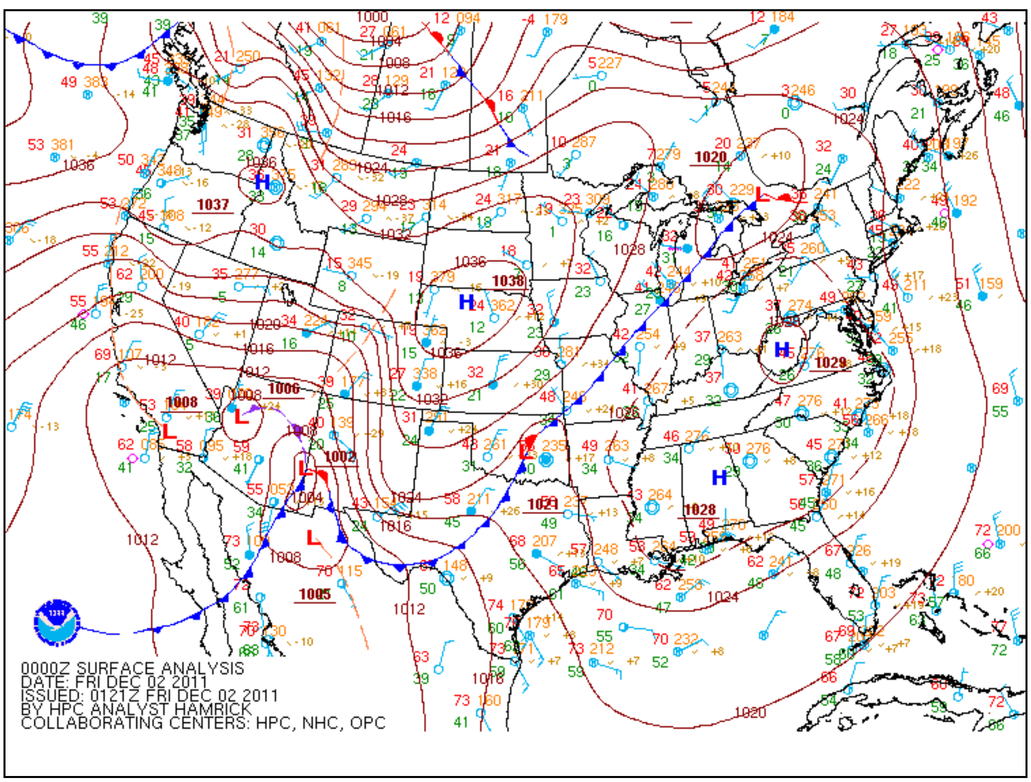

Figure 5: Surface Analysis for 00Z December 2, 2011, or 5 PM MST December 1, 2011 (source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

Figure 6 through Figure 9 present regional surface maps for 11 PM MST November 30 and 5 AM, 11 AM and 2 PM MST December 1, 2011, respectively. These maps provide a more detailed view of synoptic weather conditions in the San Luis Valley before and during the blowing dust episode. They also display individual station observations which greatly aid in reconstructing the events that led to the PM_{10} exceedances recorded in Alamosa.

On the map in Figure 6, a cold front can be observed approaching south-central Colorado from the north and northeast. This cold front passes through the region by 5 AM MST as shown in Figure 7. Note from Figure 7 the atmospheric pressure readings for La Junta in southeast Colorado and Farmington in northeast New Mexico (both circled in red). In La Junta, the barometric pressure displays as 208. This converts to 1020.8 millibars (mb). Meanwhile in Farmington the barometric pressure reads 085, or 1008.5 mb, producing a pressure gradient between the two stations of 12.3 mb. Wind speed is directly proportional to the pressure gradient. Hence, a higher pressure gradient will produce stronger winds (see the following link for additional information on pressure gradient and its relationship to wind speed from the National Oceanic and Atmospheric Administration (NOAA): http://www.srh.noaa.gov/jetstream/synoptic/wind.htm).

Six hours later at 11 AM MST (Figure 8) the pressure gradient had increased significantly to 20.4 mb between La Junta and Farmington. This was due to high pressure strengthening over eastern Colorado while a deep area of low pressure remained firmly entrenched across western Colorado and the Desert Southwest. This building pressure gradient is plainly evident by the tightening of isobars located in south-central Colorado. Correspondingly the winds increased across the San Luis Valley. The Alamosa observation station (circled in red) can be observed in Figure 8 reporting a sustained wind speed of 30 knots (with each barb denoting 10 knots) and the weather symbol of infinity (∞) colored pink. The infinity sign 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 (see the following link for the description of haze published by the National Oceanic and Atmospheric Administration (NOAA): http://www.crh.noaa.gov/lmk/?n=general_glossary). The tight surface pressure gradient, very gusty winds and the observation of haze would persist for Alamosa three hours later at 2 PM MST (Figure 9) before conditions gradually improved during the mid afternoon hours.

These regional surface weather maps show evidence of blowing dust and winds above the threshold speeds for blowing dust in the San Luis Valley of south-central Colorado on December 1, 2011.

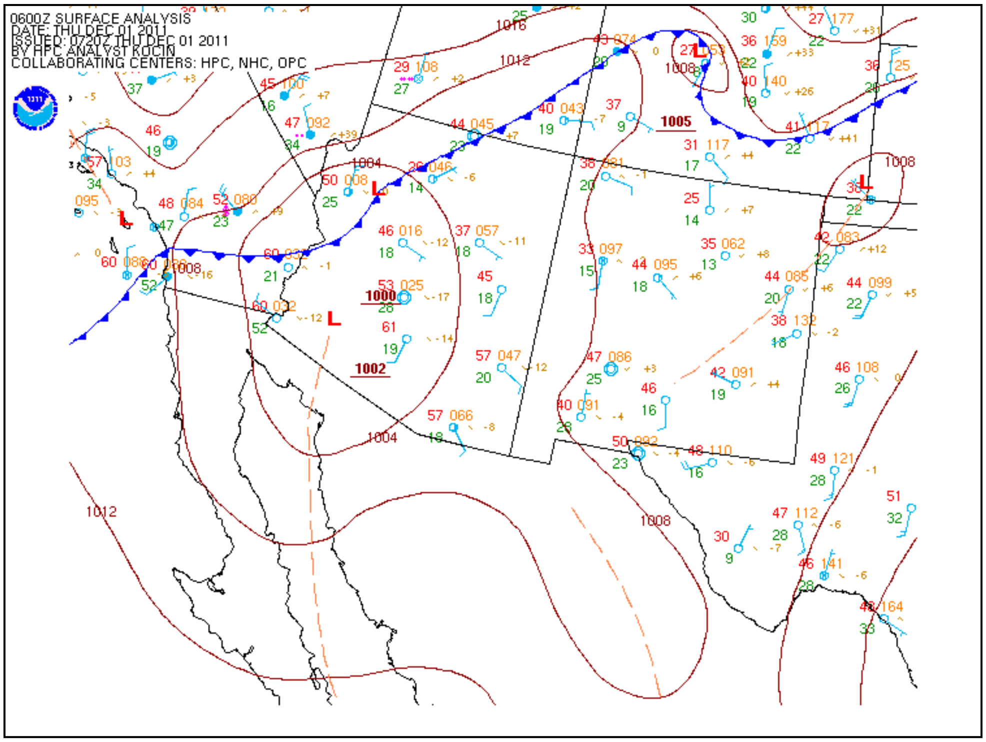

Figure 6: Southwest U.S. Regional Surface Analysis for 06Z December 1, 2011, or 11 PM MST November 30, 2011
(data source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

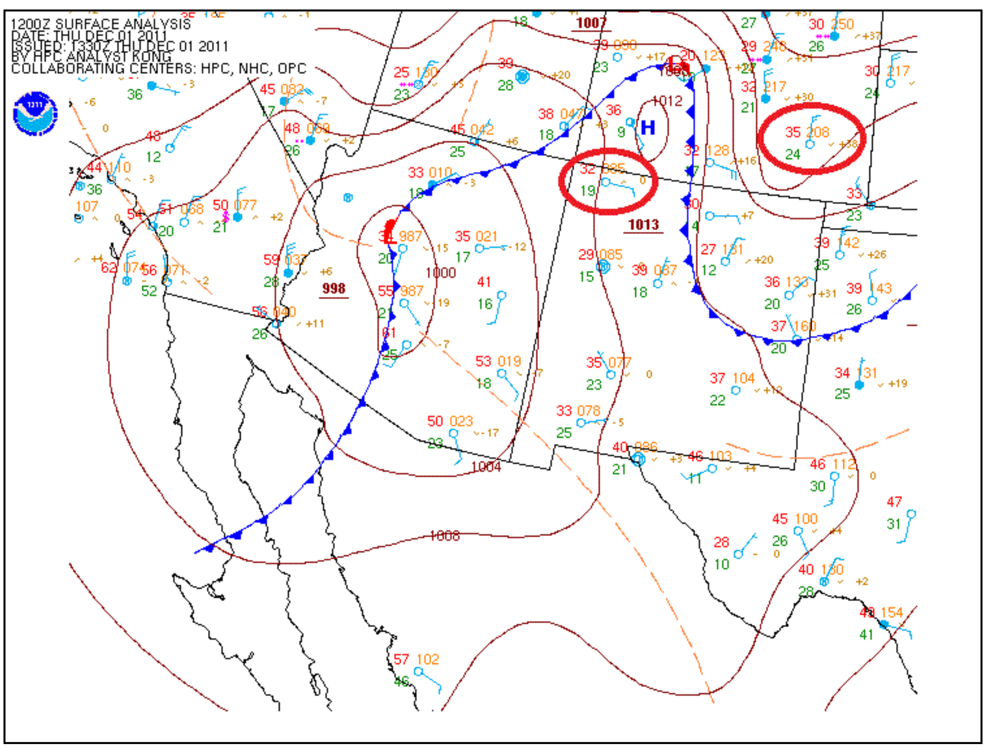

Figure 7: Southwest U.S. Regional Surface Analysis for 12Z December 1, 2011, or 5 AM MST December 1, 2011
(data source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

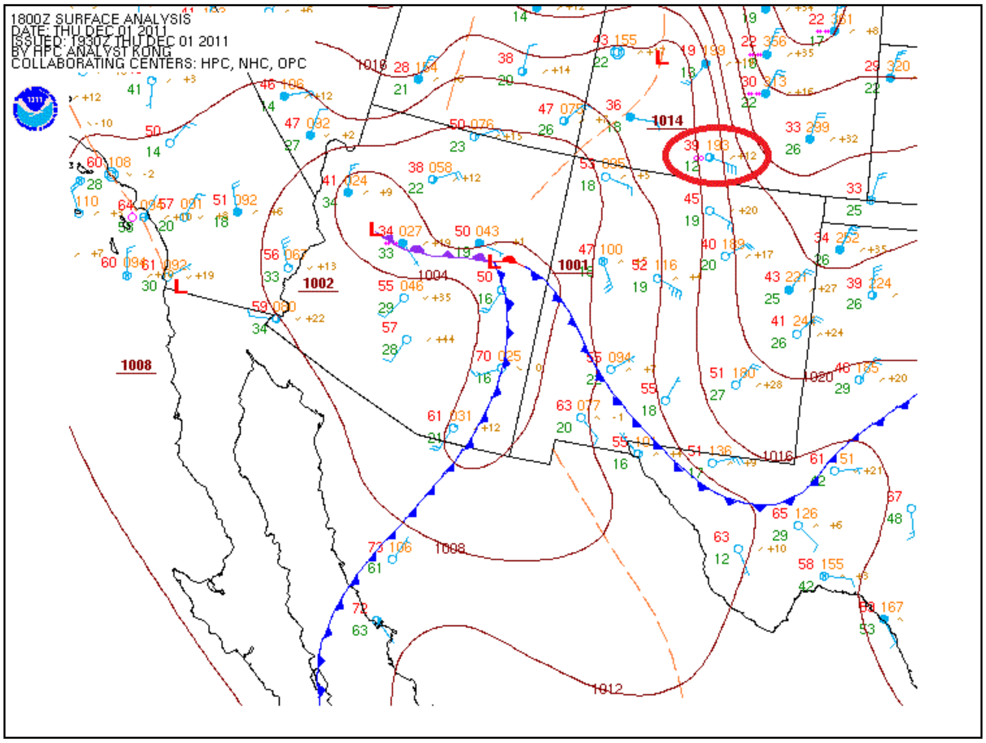

Figure 8: Southwest U.S. Regional Surface Analysis for 18Z December 1, 2011, or 11 AM MST December 1, 2011
(data source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

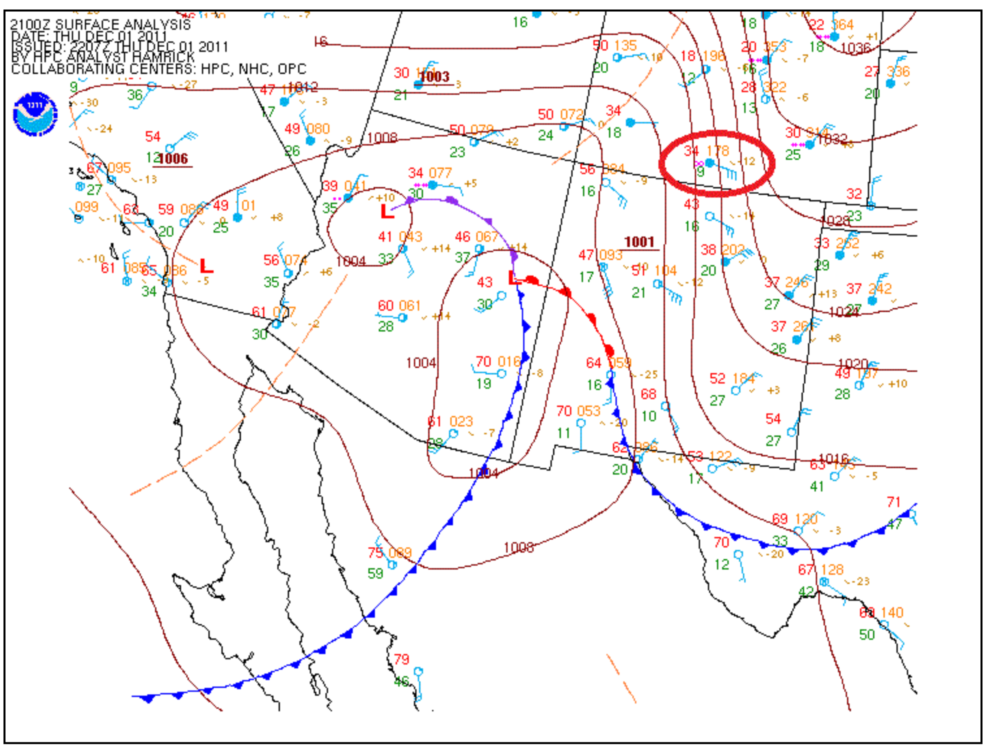

Figure 9: Southwest U.S. Regional Surface Analysis for 21Z December 1, 2011, or 2 PM MST December 1, 2011

(data source: http://nomads.ncdc.noaa.gov/ncep/NCEP**)**
To expand on the data from these regional weather maps, hourly surface observations were gathered from each of the reporting stations within the San Luis Valley. Figure 10 provides a reference map containing the location of each station utilized for this analysis along with the local topography. Table 1 lists weather observations for the PM_{10} exceedance location of Alamosa. Observations that are climatologically consistent with blowing dust conditions are highlighted in yellow. Table 2 and Table 3 contain the surface observations from the other two weather stations in the San Luis Valley that logged observations on December 1, 2011. These two stations are Sand Dunes and Hooper, respectively.

The tables reveal that Alamosa experienced several hours of reduced visibility along with sustained wind speeds and gusts at or above the thresholds for blowing dust established earlier in this paper. Meanwhile Sand Dunes reported many hours of wind gusts above the threshold for blowing dust and sustained wind speeds slightly below the threshold. It should be noted that the complete lack of haze and reduced visibility observations at Sand Dunes and Hooper can be attributed to the fact that the Sand Dunes station is a RAWS (Remote Automatic Weather Station) while the Hooper station is a CWOP (Citizen Weather Observer Program). Consequently, neither station consistently reports observable weather or visibility.

Observations of sustained wind speeds and gust speeds at or above the blowing dust thresholds and reduced visibilities on December 1, 2011, at weather stations in the San Luis Valley of south-central Colorado show that a dust storm event occurred under northeast to easterly flow in the wake of a cold front. The observations contribute to the body of evidence that shows that dust originating to the northeast and east of Alamosa caused the PM_{10} exceedances at the monitoring sites in question.

Figure 10: San Luis Valley weather observation stations

Table 1: Weather observations for Alamosa, Colorado, on December 1, 2011
(data source: http://www.met.utah.edu/mesowest/)

Time MST December 1	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:52	36	38	17	24	110		10
1:52	36	40	21	27	110		10
2:52	35	43	15		110		10
3:52	33	49	13		90		10
4:52	32	54	23	32	100		10
5:52	31	58	22	35	110		10
6:52	30	55	29	37	110		9
7:52	31	53	10	20	50		9
8:08	32	51	15	25	70	haze	2
8:16	32	47	15	28	60	haze	1.25
8:33	34	44	23	32	70	haze	1.25
8:47	34	44	23	35	70	haze	3
8:52	35	41	27	36	80	haze	3
9:09	36	41	25	38	100	haze	5
9:26	34	51	10	22	280		7
9:52	35	47	12	18	290		10
10:08	37	44	10		310		10
10:47	39	33	14	35	90	haze	5
10:52	39	32	32	37	100	haze	6
11:52	38	32	33	46	100	haze	4
12:04	39	30	30	47	100	haze	4
12:24	39	30	32	46	100	haze	3
12:52	36	34	36	53	100	haze	4
13:38	34	37	31	51	100	haze	5
13:52	34	35	32	47	100	haze	6
14:52	32	37	35	44	110		8
15:52	30	41	28	36	100		10
16:52	27	48	23	35	110		10
17:52	27	46	13		70		10
18:52	24	54	8		280		10
19:52	22	60	9		320		10
20:52	22	60	8		330		10
21:52	20	67	12		330		10
22:52	16	73	6		310		10
23:52	15	73	4		310		10

Table 2: Weather observations for Sand Dunes, Colorado, on December 1, 2011 (data source: http://www.met.utah.edu/mesowest/)

Time MST December 1	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:44	34	31	14	25	95		
1:44	33	37	16	30	95		
2:44	32	35	14	34	103		
3:44	28	50	17	32	89		
4:44	30	51	19	37	100		
5:44	29	55	22	39	103		
6:44	26	59	20	45	97		
7:44	25	57	22	45	105		
8:44	25	58	26	45	116		
9:44	25	61	24	44	119		
10:44	26	59	22	47	106		
11:44	27	57	23	43	111		
12:44	26	54	27	46	115		
13:44	26	51	22	48	111		
14:44	24	53	23	48	113		
15:44	23	50	22	46	106		
16:44	21	52	18	46	102		
17:44	21	54	18	41	99		
18:44	19	57	15	40	86		
19:44	18	61	18	38	90		
20:44	18	57	13	31	59		
21:44	18	56	10	29	87		
22:44	18	55	6	26	86		

Table 3: Weather observations for Hooper, Colorado, on December 1, 2011 (data source: http://www.met.utah.edu/mesowest/)

Time MST December 1	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
8:52	30	60	24	34	84		
9:52	30	59	22	34	82		
10:52	32	54	21	30	80		
11:52	35	48	24	34	84		
12:52	32	50	23	34	78		
13:52	31	49	22	35	78		
14:52	30	50	20	30	92		
15:52	27	52	21	29	83		
16:52	24	58	18	28	62		
17:52	24	59	16	26	73		
18:52	24	57	14	23	73		
19:52	20	67	7	10	39		
20:52	18	72	5	8	23		
21:52	16	76	1	4	33		
22:52	13	75	0	1	33		
23:52	10	82	0	0			

The Pueblo National Weather Service (NWS) forecast office issues weather information and alerts for south-central Colorado, including the San Luis Valley. The Area Forecast Discussion from the evening before the blowing dust event is presented in Appendix B. The highlighted text from this product clearly states that winds well in excess of the blowing dust criteria (established earlier in this paper) would be a threat to the San Luis Valley on December 1, 2011. Additionally, the Colorado Department of Public Health and Environment (CDPHE) issued a Blowing Dust Advisory for the San Luis Valley on December 1, 2011. This advisory can also be found in Appendix B.

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Figure 11 shows the total precipitation in inches for Colorado during November 2011. Notice that south-central parts of the state, particularly the San Luis Valley where Alamosa is centrally located, generally received less than 0.4 inches of precipitation in the 30 days prior to December 1, 2011. Based on previous research 0.5 to 0.6 inches of precipitation has been found to be the approximate threshold, below which, blowing dust exceedances in Colorado are more likely to occur when combined with high winds.

Furthermore, the Drought Monitor report for Colorado as of 5:00 AM MST November 29, 2011 (Figure 12) reveals that severe drought conditions were being experienced in south-central Colorado two days before the December 1 dust event. This included the San Luis Valley counties of Costilla, Alamosa and southern parts of Saguache. According to the National Drought Mitigation Center, the definition of a severe drought includes, "Crop or pasture losses likely", which would imply high rates of erosion and an increase in vulnerability to particulate suspension (see the following link for more information on drought severity classification from the National Drought Mitigation Center: http://droughtmonitor.unl.edu/AboutUs/ClassificationScheme.aspx).

30-day precipitation and Drought Monitor reports indicate that soils in the San Luis Valley of south-central Colorado were dry enough to produce blowing dust when winds were above the thresholds for blowing dust on December 1, 2011.

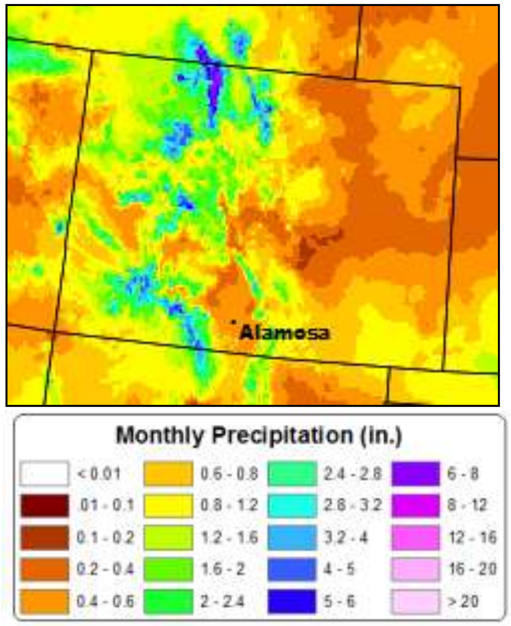


Figure 11: Total precipitation in inches for Colorado, November 2011 (source: http://prism.nacse.org/recent/).

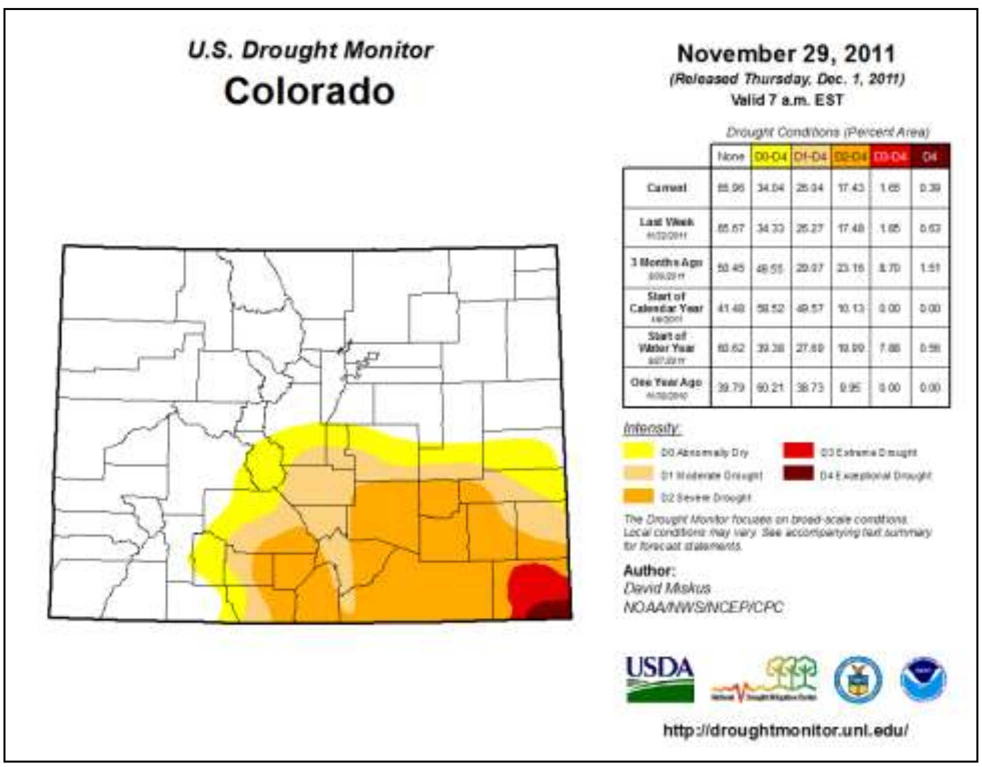


Figure 12: Drought conditions for Colorado at 5 AM MST November 29, 2011 (source: http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx)

Figure 13 and Figure 14 show the GASP (GOES Aerosol Smoke Product) West Aerosol Optical Depth image at 7:45 AM and 8:00 AM MST respectively on December 1, 2011. Aerosol Optical Depth (AOD) is a measure of the degree to which aerosols prevent the transmission of light (see the following link for additional information on GASP: http://www.star.nesdis.noaa.gov/smcd/emb/aerosols/products_geo.php). In Figure 13, a cluster of moderate to high-moderate AOD values of 0.4 - 0.7 can be observed in south-central Colorado. Fifteen minutes later these elevated AOD values spread northward in Figure 14 to the approximate location of Alamosa. This corresponds in both location and time to observations of deteriorating visibility and haze in Alamosa between 7:52 and 8:08 AM MST (Table 1).

Approximately four hours later at 11:50 AM MST (1850Z), the MODIS Terra satellite image (Figure 15) zoomed on south-central Colorado reveals plumes of dust stretching from northeast to southwest in Costilla and Conejos counties located in the southern part of the San Luis Valley. Unfortunately the northern half of the valley, including Alamosa, is obscured by cloud cover. However it should be noted that at the approximate time of this image, Alamosa was reporting sustained winds out of an easterly direction of 33 mph with gusts to 46 mph and visibility reduced to 4 miles due to haze (11:52 AM MST, Table 1). This lends support to the argument that dust was being transported from eastern parts of the San Luis Valley westward into Alamosa on December 1, 2011.

GASP and MODIS satellite imagery reveal that a dust storm was taking place in the San Luis Valley of south-central Colorado during the morning of December 1, 2011. The drought-stricken and largely undeveloped eastern half of the San Luis Valley was the source region for the blowing dust that produced the PM_{10} exceedance in Alamosa.

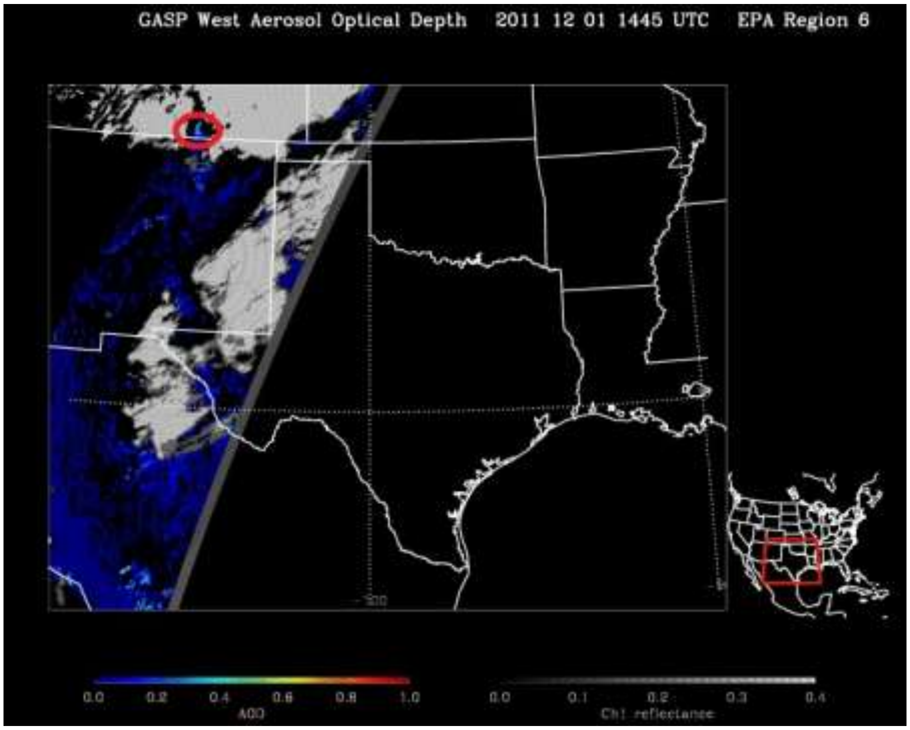


Figure 13: GASP West Aerosol Optical Depth image, EPA Region 6 at 7:45 AM MST December 1 (1445 Z December 1), 2011
(source: http://www.star.nesdis.noaa.gov/smcd/spb/aq/index.php?product_id=2)

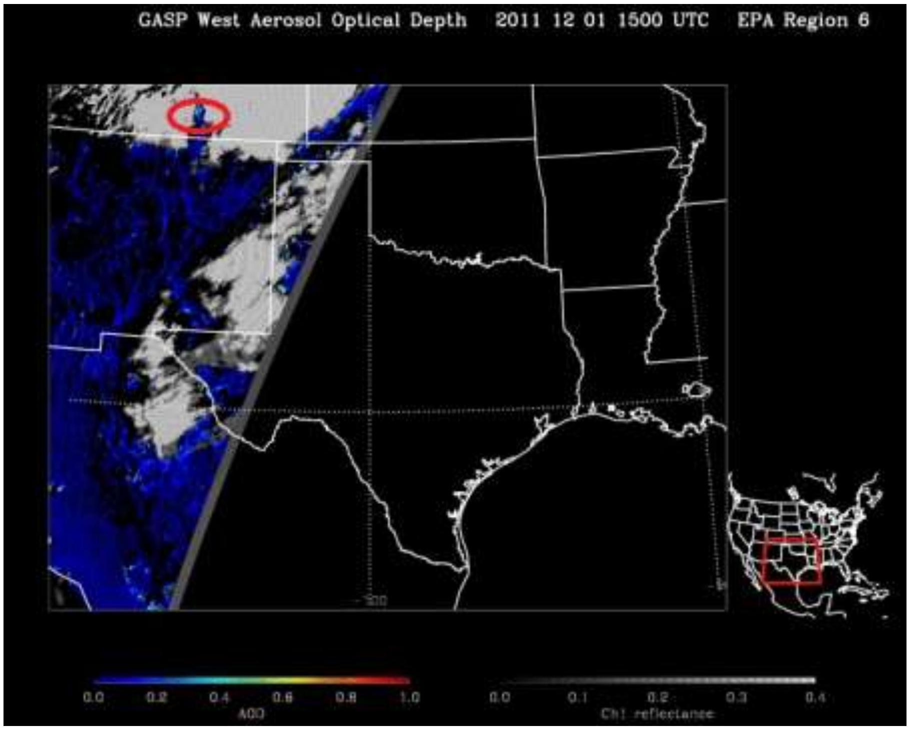


Figure 14: GASP West Aerosol Optical Depth image, EPA Region 6 at 8:00 AM MST December 1 (1500Z December 1), 2011
(source: http://www.star.nesdis.noaa.gov/smcd/spb/aq/index.php?product_id=2)

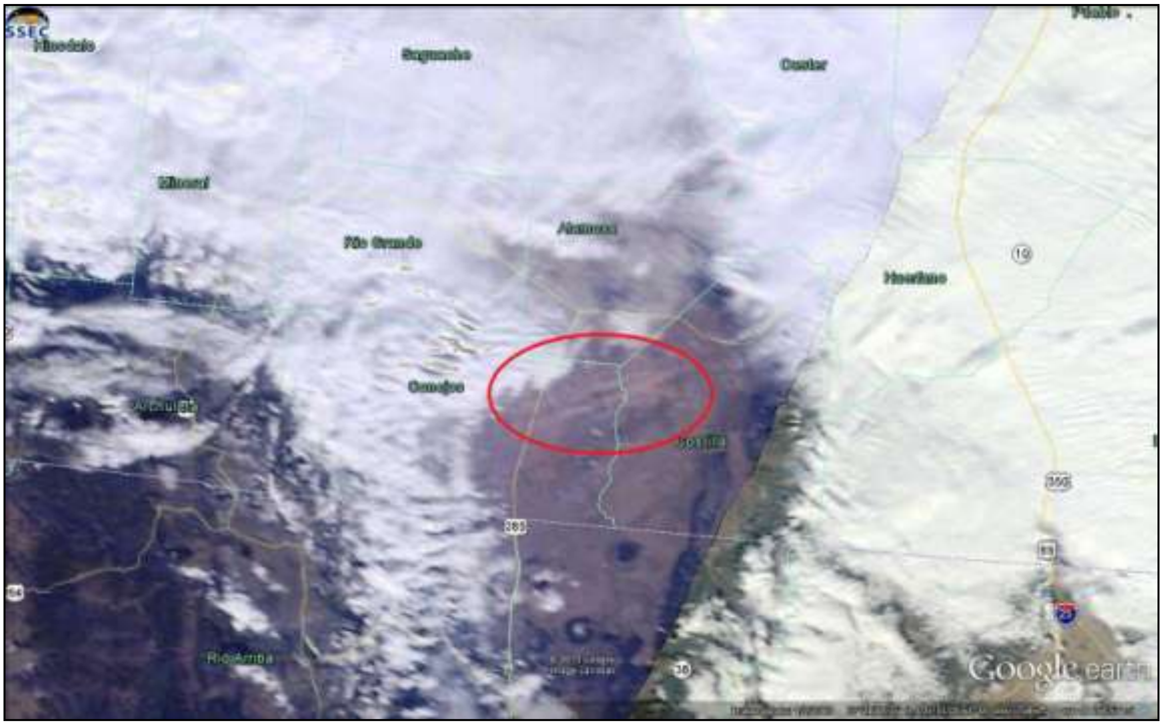


Figure 15: MODIS Terra satellite image of south-central Colorado at approximately 11:50 AM MST (1850Z) on December 1, 2011
(source: http://ge.ssec.wisc.edu/modis-today/index.php**).**

Figure 16 shows the NOAA HYSPLIT 1-hour backward trajectories (Draxler and Rolph, 2012) for Alamosa for a duration of 6 hours (8 AM MST to 2 PM MST December 1, 2011. See the following link for more information on HYSPLIT from the NOAA Air Resources Laboratory: http://ready.arl.noaa.gov/HYSPLIT.php). This time period encompasses the vast majority of reduced visibility observations in Alamosa from Table 1. The trajectory analysis clearly shows the transport of air nearly unidirectional from areas on the eastern side of the San Luis Valley where “Severe” drought conditions were being experienced, according to Figure 12.

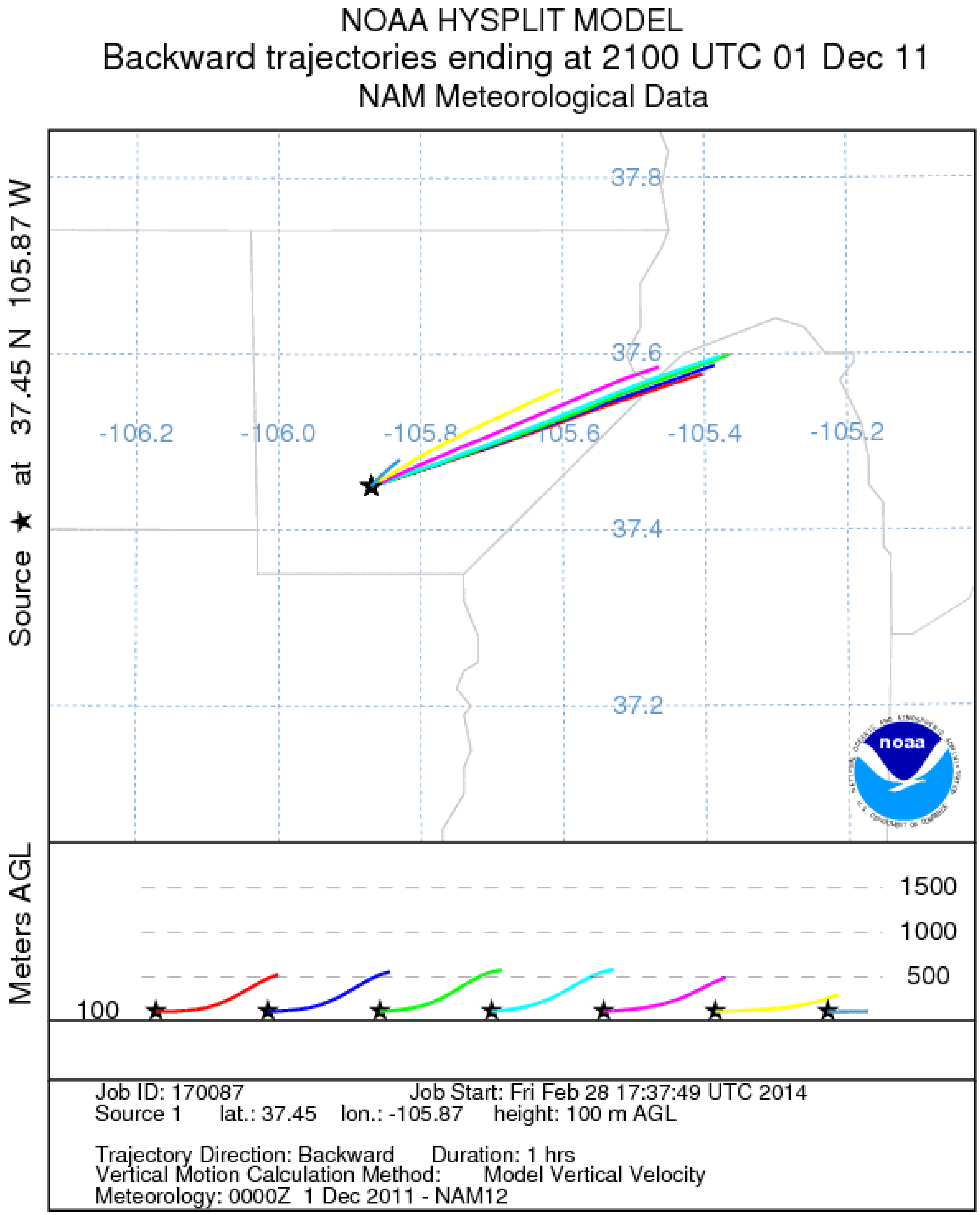


Figure 16: NOAA HYSPLIT NAM12 1-hour back trajectories for Alamosa, CO for 8 AM MST (15 Z) December 1, 2011, to 2 PM MST (21Z) December 1, 2011
(source: http://ready.arl.noaa.gov/HYSPLIT.php**)**

By overlaying these backward trajectories on MODIS imagery, we can get a better sense of the source area of the air transported into Alamosa on December 1. Figure 17 shows the MODIS aqua image of November 30, 2011 at 12:45 PM MST (one day before the dust event of December 1) with overlain trajectories from Figure 16. Many of the 1-hour trajectories originate near the top of Blanca Peak, suggesting the possibility that a Bora wind may have locally enhanced the winds in the San Luis Valley (for more information on Bora winds in Colorado: http://www.crh.noaa.gov/bou/?n=winterwxwinds).

Figure 18 is the same MODIS aqua image as Figure 17, but in False Color. This image reveals several distinct areas of a brown to reddish hue to the east and northeast of Alamosa in eastern parts of the San Luis Valley; the same areas that Figure 17 identifies as a major source of the air that was transported into Alamosa the following day. The MODIS imagery of Figure 18 is also consistent with land cover classifications of the San Luis Valley as shown in Figure 19 where widespread areas of bare rock/sand/clay are found in the eastern half of the valley. Blowing dust is more likely to originate in areas of exposed soil or sand without vegetation cover, which is clearly an accurate description of the source area of the air transported into Alamosa on December 1, 2011.

NOAA HYSPLIT backward trajectories in tandem with MODIS imagery provide clear supporting evidence that air transported from the arid, dust-prone sections of the eastern San Luis Valley caused or significantly contributed to the PM_{10} exceedances measured in Alamosa on December 1, 2011.

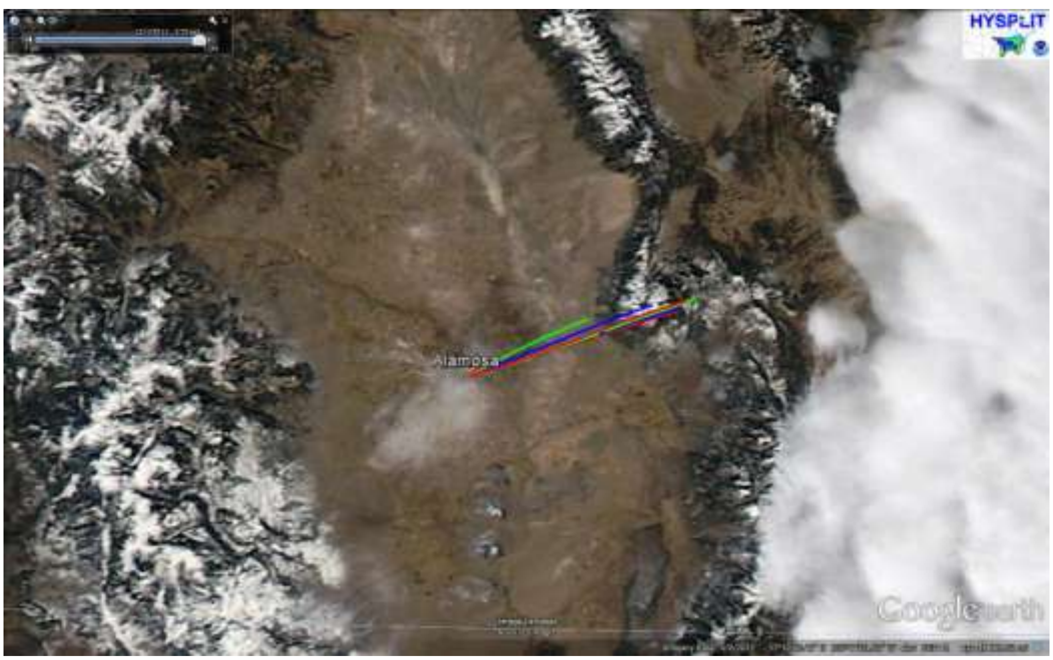


Figure 17: NOAA HYSPLIT 2-hour back trajectories for Alamosa, CO for 6 AM MST December 1, 2011, to 8 AM MST (15Z) December 1, 2011, overlain on the MODIS Aqua satellite image of south-central Colorado on November 30, 2011 at approximately 12:45 PM MST (1945Z) (sources: http://ready.arl.noaa.gov/HYSPLIT.php and http://ge.ssec.wisc.edu/modis-today/index.php)

Figure 18: MODIS Aqua false color satellite image of south-central Colorado at approximately 12:45 PM MST (1945Z) on November 30, 2011
(source: http://ge.ssec.wisc.edu/modis-today/index.php**)**

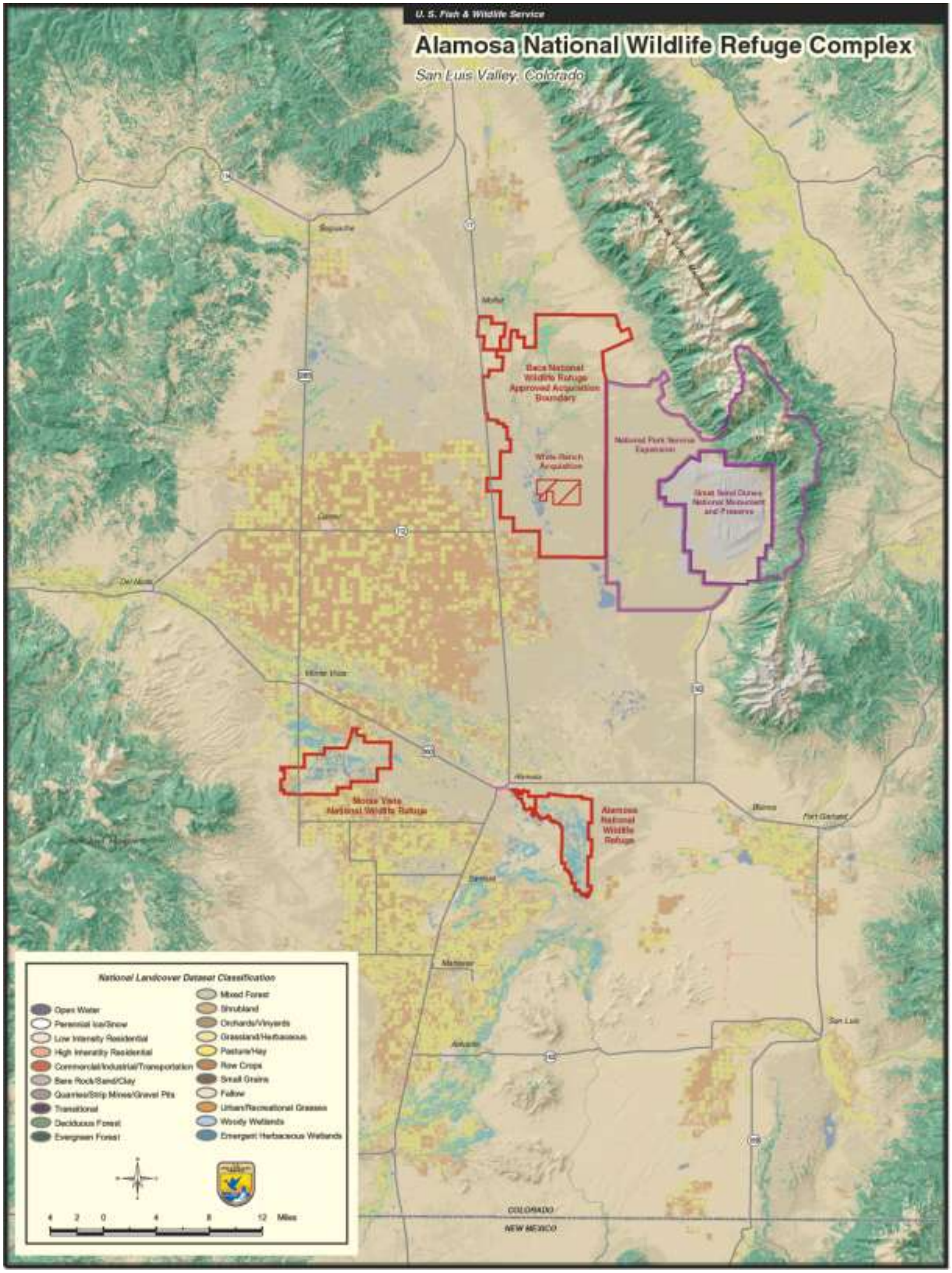


Figure 19: San Luis Valley land cover classification map (source: http://www.fws.gov/alamosa/SLV.html)

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 the Marticorena paper, is a measure for conditions necessary for blowing dust. This value is higher for undisturbed soils and lower for disturbed soils.

Friction velocities have been calculated for 8 AM and 11 AM MST December 1, 2011, using the 12 km NAM (North American Mesoscale Model). These friction velocities are presented in Figure 20 and Figure 21, respectively. According to data presented by Marticorena et al. (1997), even undisturbed desert soils normally resistant to wind erosion will be susceptible to emission of blowing dust when threshold friction velocities are in the 1.0 to 2.0 meters per second range. In Figure 20 a distinct section of the eastern San Luis Valley shows friction velocities of 1.00 to 1.25 meters per second just minutes before Alamosa reported haze and highly obscured visibilities of 1.25 to 2.00 statute miles (Table 1). Three hours later in Figure 21 parts of the eastern San Luis Valley upwind of Alamosa saw an increase in frictional velocity to nearly 1.50 meters per second.

This part of the eastern San Luis Valley with enhanced frictional velocity values is also the same area where 30-day precipitation totals were below 0.5 inches (Figure 11) and which back trajectories from Figure 16 identify as a source region for air transported into Alamosa. Note that blowing dust will typically only occur where friction velocities are high and soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is an accurate description of much of the terrain in the eastern San Luis Valley as shown in Figure 19. Therefore, it appears very likely that undisturbed soils in the arid eastern San Luis Valley were a large contributor to the blowing dust that occurred in Alamosa.

The elevated friction velocities shown in Figure 20 and Figure 21, the data on soil moisture conditions presented elsewhere in this report and the prevalence of winds above blowing dust thresholds prove that this dust storm on December 1, 2011, was a natural event that was not reasonably controllable or preventable.

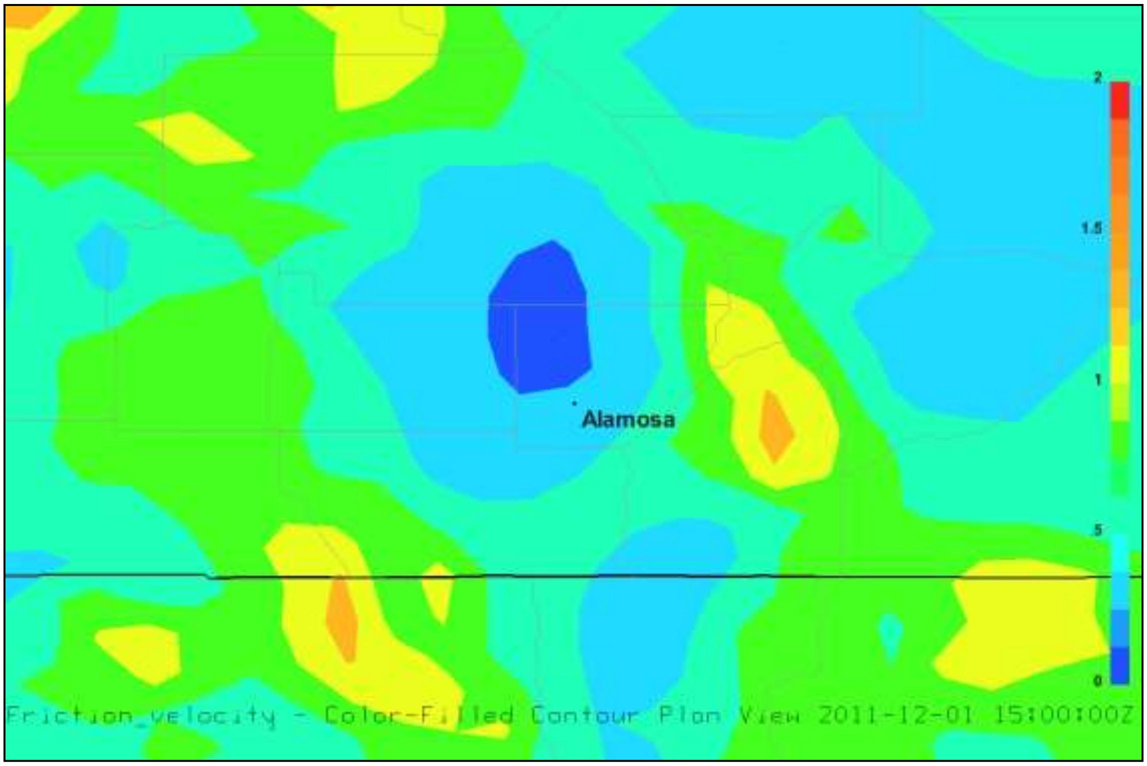


Figure 20: 12 km NAM friction velocities in meters/second at 8 AM MST (15Z) December 1, 2011. (data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets**)**

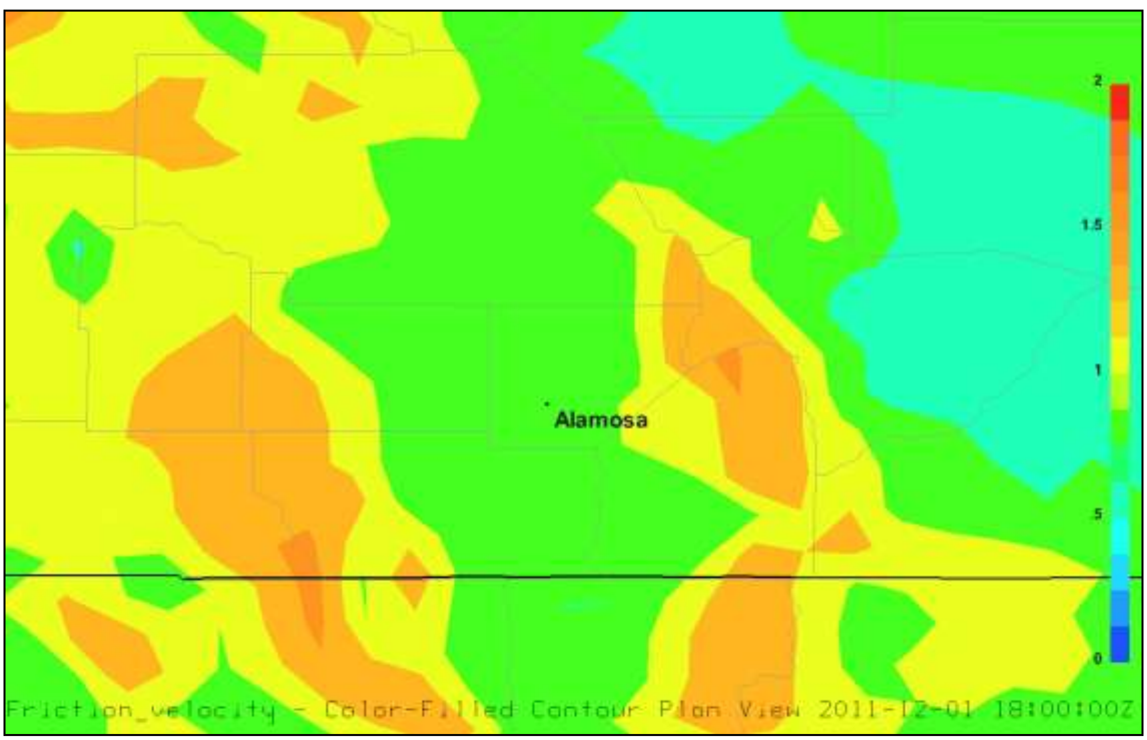


Figure 21: 12 km NAM friction velocities in meters/second at 11 AM MST (18Z) December 1, 2011 (data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets**)**

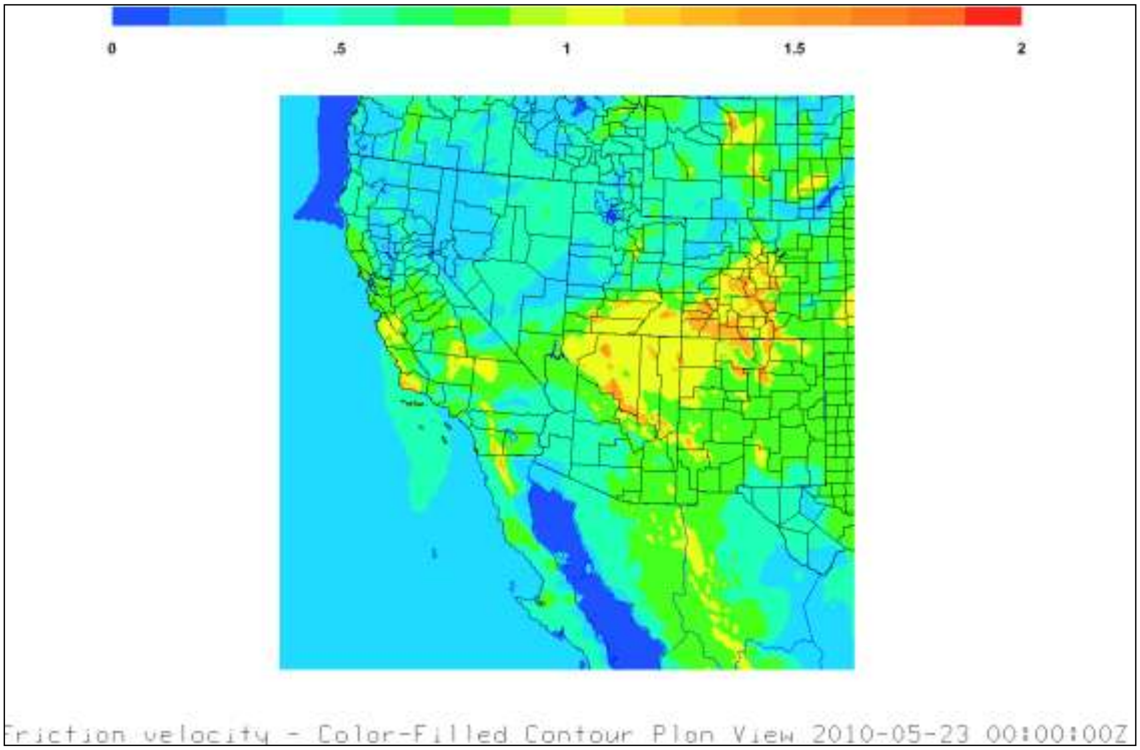


Figure 22: Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 00Z May 23, 2010 (5 PM MST May 22, 2010)

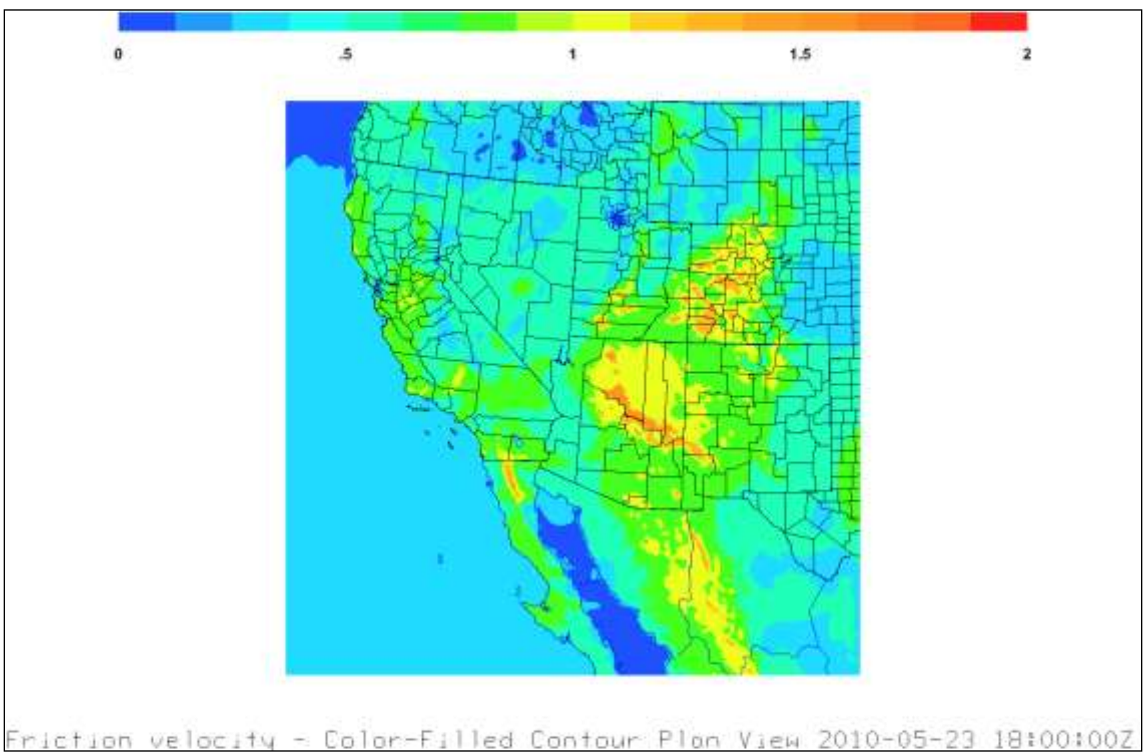


Figure 23: Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 18Z May 23, 2010 (11 AM MST May 23, 2010)

3.0 Evidence-Ambient Air Monitoring Data and Statistics

On December 1, 2011, a strong cold front moved across Colorado. During this event, samples in excess of 150 µg/m^3 NAAQS for PM_{10} were recorded at Alamosa - Adams State College (Alamosa ASC, 440 µg/m^3) and Alamosa Municipal (Alamosa Muni, 635 µg/m^3). The elevated PM_{10} readings in Alamosa resulted from blowing dust associated with strong, gusty winds behind the passage of the front. The winds transported blowing dust into Alamosa from eastern parts of the San Luis Valley.

3.1 Historical Fluctuations of PM_{10} Concentrations in Alamosa and Lamar

This evaluation of PM_{10} monitoring data for sites affected by the December 1, 2011, event was made using valid samples from PM_{10} samplers in Alamosa from 2006 through 2011, APCD has been monitoring PM_{10} concentrations in these areas since 1985. The overall data summary for the affected sites is presented in Table 4, with all data values being presented in µg/m^3.

Table 4: December 1, 2011, Event Data Summary

Evaluation	*Alamosa ASC*	*Alamosa Muni*
12/01/2011	**440**	**635**
Mean	22.3	28.6
Median	18	23.5
Mode	14	19
St. Dev.	25.2	28.4
Variance	633.1	807.7
Minimum	1	1
Maximum	473	635
Count	1904	1824

A snapshot summary of data from all those sites affected by the event is presented in Table 4. The approximate percentile value that the December 1, 2011, sample represents for each site for their unique historical data sets, for the month of the event (every sample in any December), and for the year of the event. All percentile calculations presented 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. Percentile calculations for both sites affected by the event are presented in Table 5.

Table 5: December 1, 2011, Site Percentile (All Affected Sites)

Evaluation	Alamosa ASC	Alamosa Muni
12/1/2011	**440**	**635**
Overall	99.9%	Max Value
All December	Max Value	Max Value
2011	Max Value	Max Value

Of those samples in excess of 150 µg/m^3 both are the maximum value from either site for any December, the largest sample at both sites in 2011, and is the largest sample in this dataset for Alamosa Muni. The overall magnitude of the samples suggests that there was a common contribution to each sample from other than local sources.

Those data sets for sites with samples for which exclusion is being requested are further summarized by month. As with previous exceptional events submittals from the state, these summaries the data presents 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 these periods (winter and early 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 meteorological and dry soil conditions necessary for this type of event and are discussed elsewhere in this document. Although the maximum values for these months (winter and early 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 December (all samples in any December from 2006-2011) and for 2011 for Alamosa ASC and Alamosa Muni are presented in Table 6**.**

Table 6: December 1, 2011, PM_{10} Evaluation by Month and Year

	Alamosa ASC		Alamosa Muni	
	December	2011	December	2011
Mean	25.6	25.5	34.9	37.9
Median	23	20	31	30
Mode	18	17	27	20
St. Dev.	13	31.6	17.3	44.1
Variance	169.3	999.7	298.9	1947.6
Minimum	3	5	1	7
Maximum	66	440	86	635
Count	153	327	140	303

Alamosa ASC – 08-003-0001

The PM_{10} sample on December 1, 2011, at Alamosa ASC of 440 $\mu g/m^3$ is the largest sample recorded among all December samples, is the largest sample of all 2011 data, and is greater than the 99th percentile value (97 $\mu g/m^3$) for the entire dataset. Overall, this sample is the second largest sample in the entire data set. The single sample greater than the event sample is associated with a high wind event. There are 1904 samples in this dataset. The sample of December 1, 2011, clearly exceeds the typical samples for this site.

Figure 24 through Figure 27 graphically characterize the Alamosa ASC PM_{10} data. The first, Figure 24, is a simple time series; every sample in this dataset (2006 – 2011) greater than 150 $\mu g/m^3$ 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 $\mu g/m^3$. Of the 1904 samples in this data set less than 1% are greater than 100 $\mu g/m^3$.

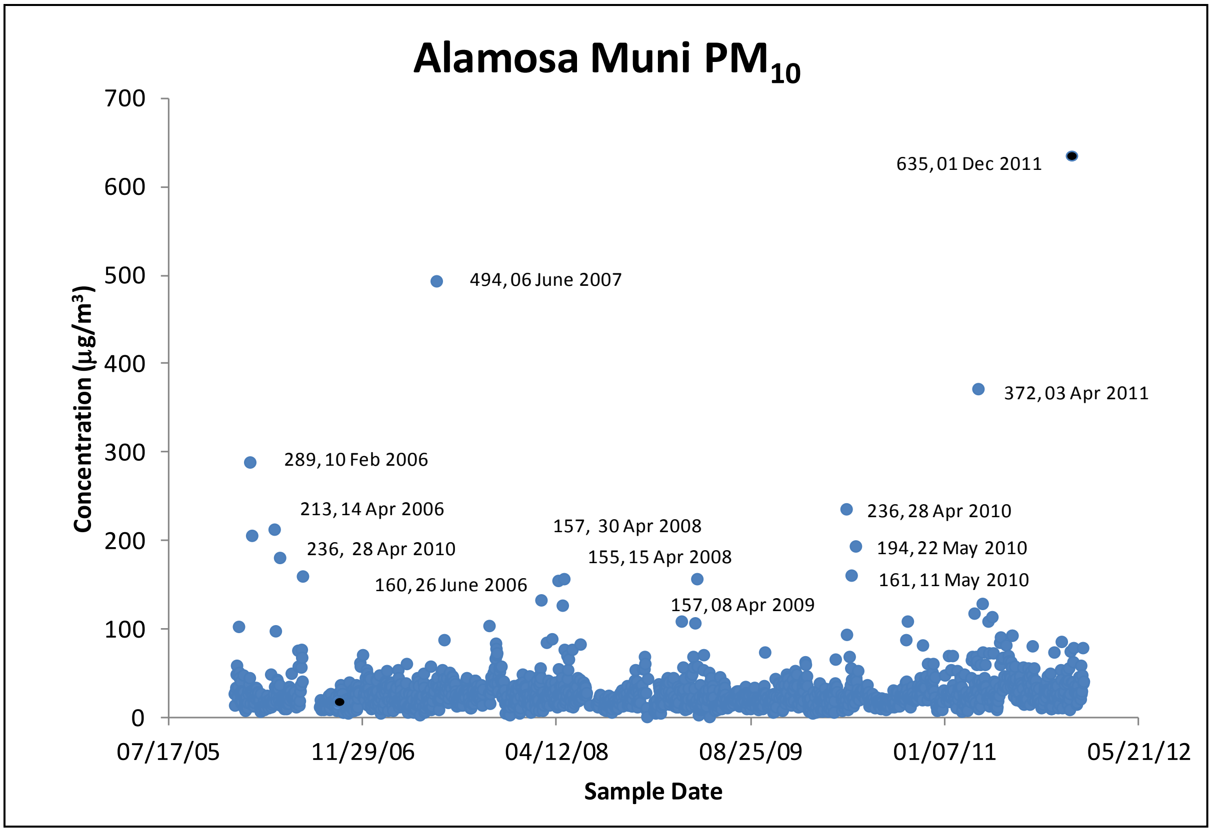


Figure 24: Alamosa Adams State College PM_{10} Time Series

Figure 25 is a simple histogram, demonstrating the overwhelming weight of samples on the low end of the curve. This range of data can be considered typical, representing contributions from local sources. Over 60% of the samples in this data set are less than 20 µg/m^3. Even in the highly variable month of winter and early spring over 90% of the samples are less than 50 µg/m^3. Clearly the sample of December 1, 2011, exceeds what is typical for this site.

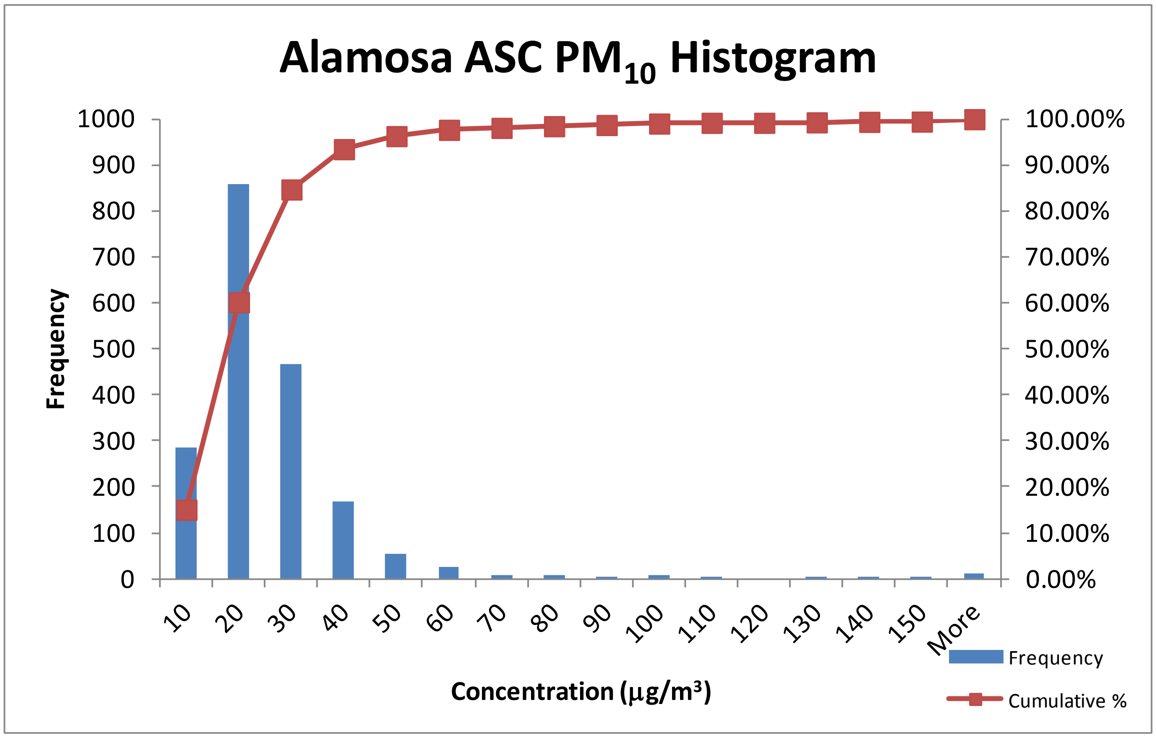


Figure 25: Alamosa Adams State College PM_{10} Histogram

The monthly box-whisker plot in Figure 26 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 December 1, 2011. 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.

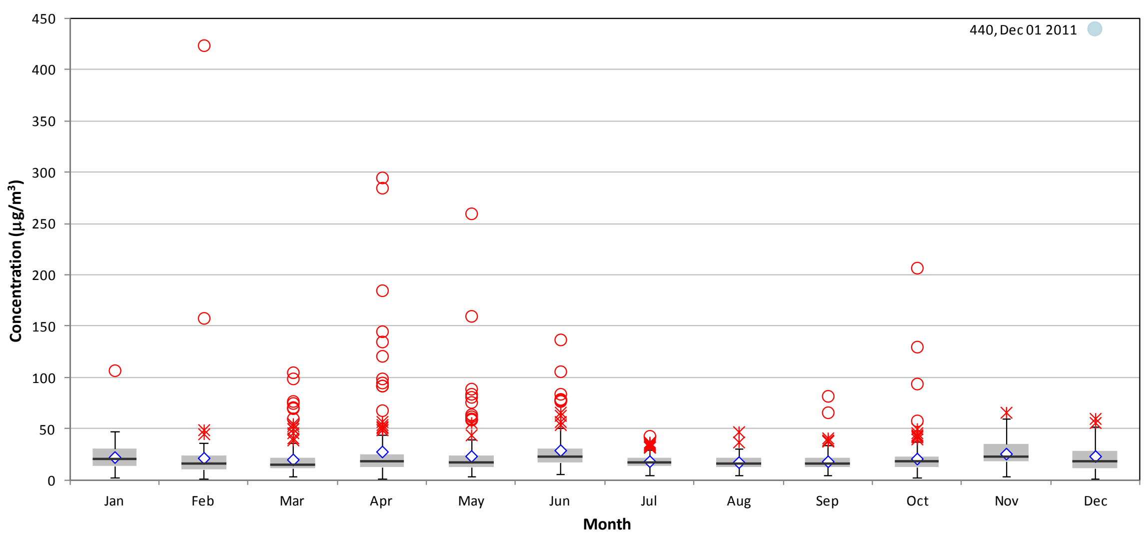


Figure 26: Alamosa Adams State College PM_{10} Box-whisper Plot

The box-whisper 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 75^{th}% and 25^{th}%), 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 December 1, 2011.

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 Figure 27. This expanded plot demonstrates that December is a month where contributions from local sources are similar to other months of the year but with a broad interquartile range – indicating a large amount of variation in samples.

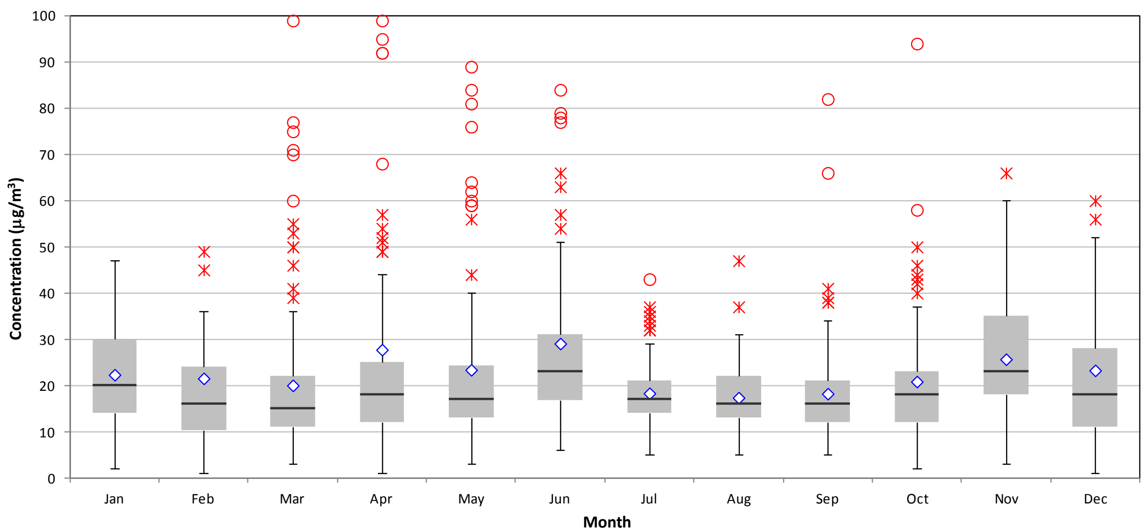


Figure 27: Alamosa Adams State College PM_{10} Box-whisper Plot, Reduced Scale

Note the degree to which the data in the months of winter and spring, including December, is skewed. The December mean (23.2 μg/m^3) is greater than the December median value (18 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 December 1, 2011, clearly exceeds the typical data at this site.

Alamosa Municipal – 080030003

The PM_{10} sample on December 1, 2011, at Alamosa Municipal of 635 μg/m^3 is the maximum value for any criteria. Overall, this sample is the largest sample in the entire data set; there are 1824 samples in this dataset. The sample of December 1, 2011, clearly exceeds the typical samples for this site.

Figure 28 through Figure 31graphically characterize the Alamosa Muni PM_{10} data. The first is a simple time series; the sample of December 1 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 1824 samples in this data set less than 1% are greater than 80 μg/m^3.

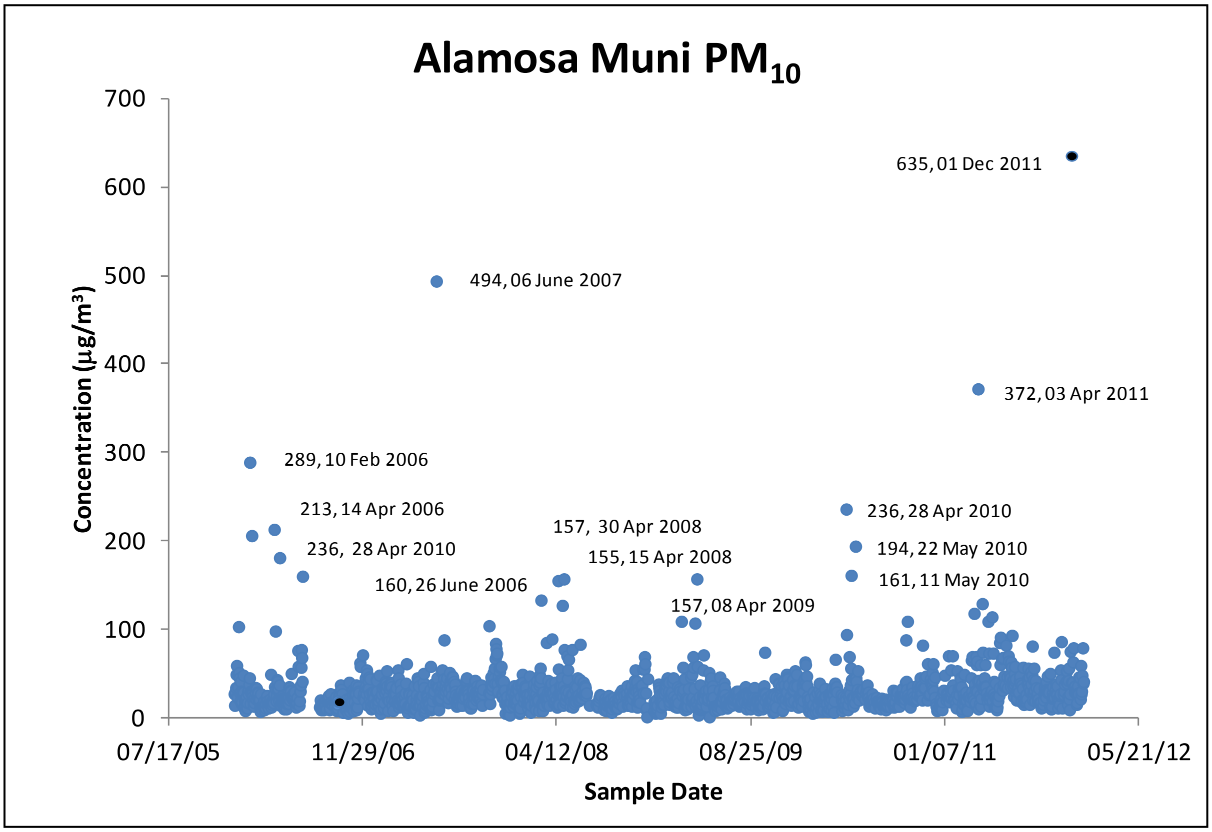


Figure 28: Alamosa Municipal PM_{10} Time Series

Figure 29 is a simple histogram, demonstrating the overwhelming weight of samples on the low end of the curve. Over 80% of the samples in this data set are less than 30 $\mu g/m^3$. Even in the highly variable months subject to similar conditions typified by this event over 90% of the samples are less than 40 $\mu g/m^3$. Clearly, the sample on December 1, 2011, exceeds what is typical for this site.

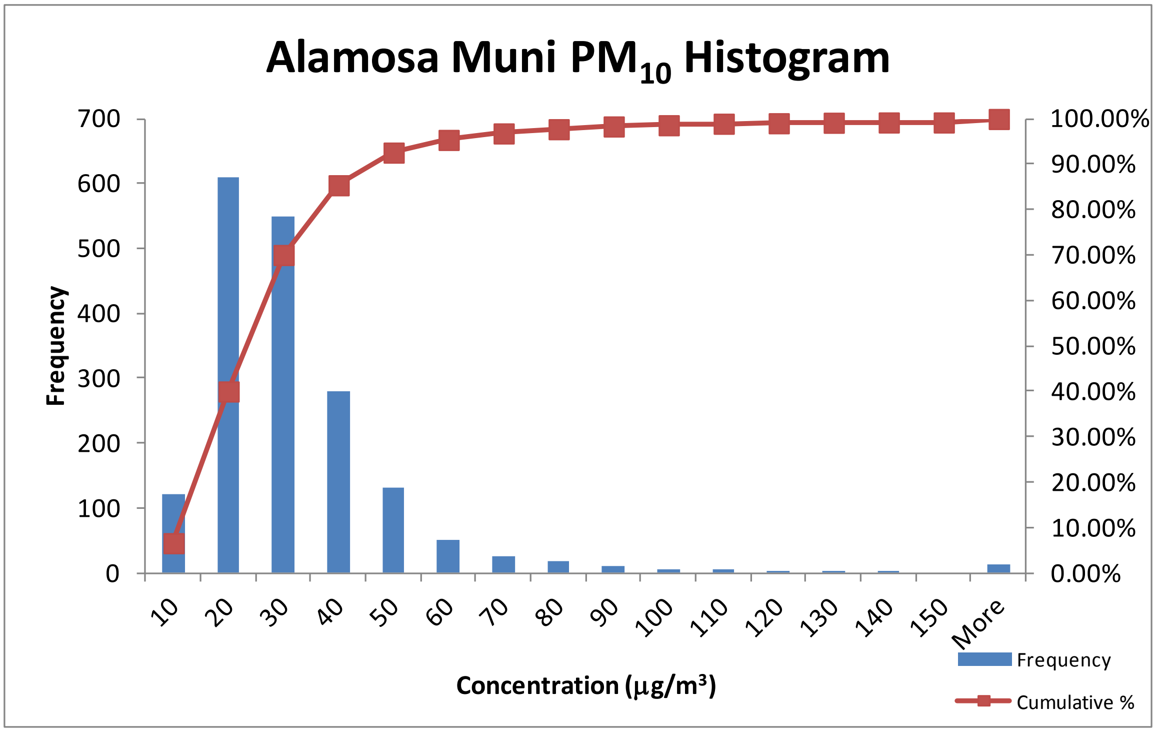


Figure 29: Alamosa Municipal PM_{10} Histogram

The monthly box-whisker plot in Figure 30 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 December 1, 2011. 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.

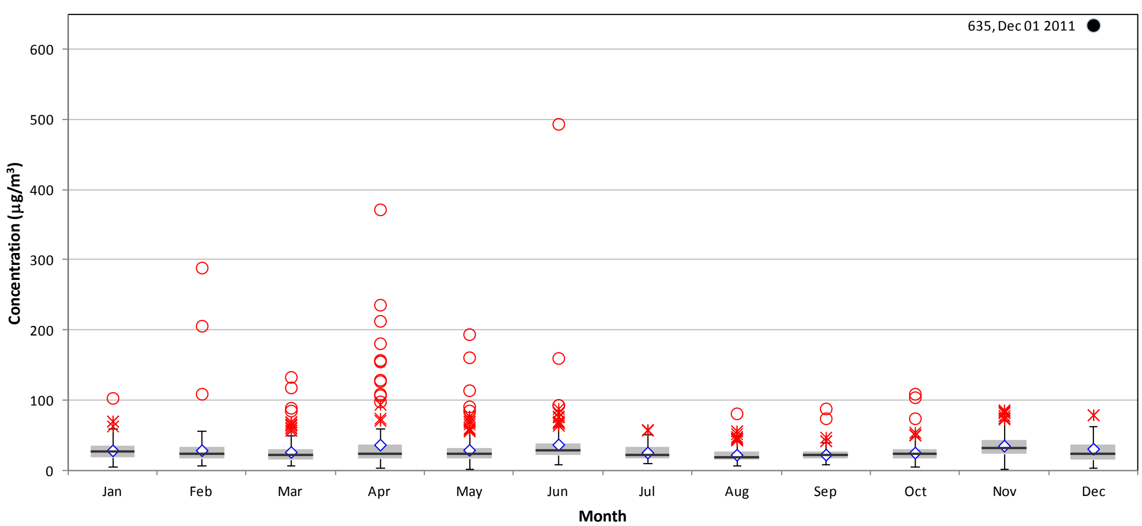


Figure 30: Alamosa Municipal PM_{10} Box-whisper Plot

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 Figure 31. As with Figure 27, this expanded plot demonstrates that December is the month where contributions from local sources are amont the highest of the year.

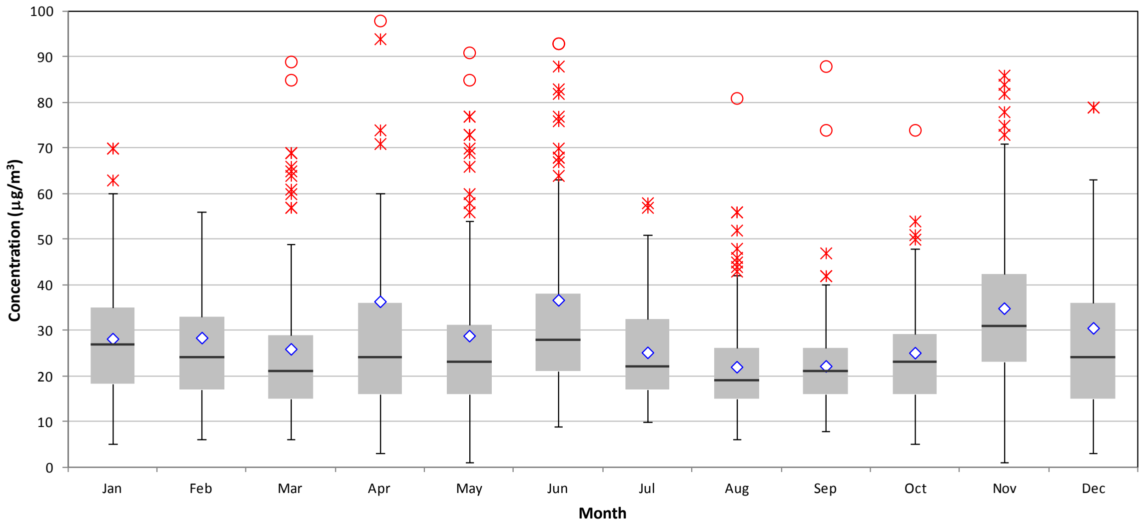


Figure 31: Alamosa Municipal PM_{10} Box-whisper Plot, Reduced Scale

Note the degree to which the data from the months of winter/spring, including December, are skewed. The December mean (30.5 µg/m^3) is much greater than the sample median (24 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 December 1, 2011, clearly exceeds the typical data at this site.

<u>Clear Causal Relationship</u>

Wind speeds around San Luis Valley increased early in the morning December 1, 2011 and stayed elevated throughout the day, gusting to speeds in excess of 40 mph. Figure 32 displays wind speed (mph) as a function of date from the Alamosa Airport (KALS) for a number of days before and after the event.

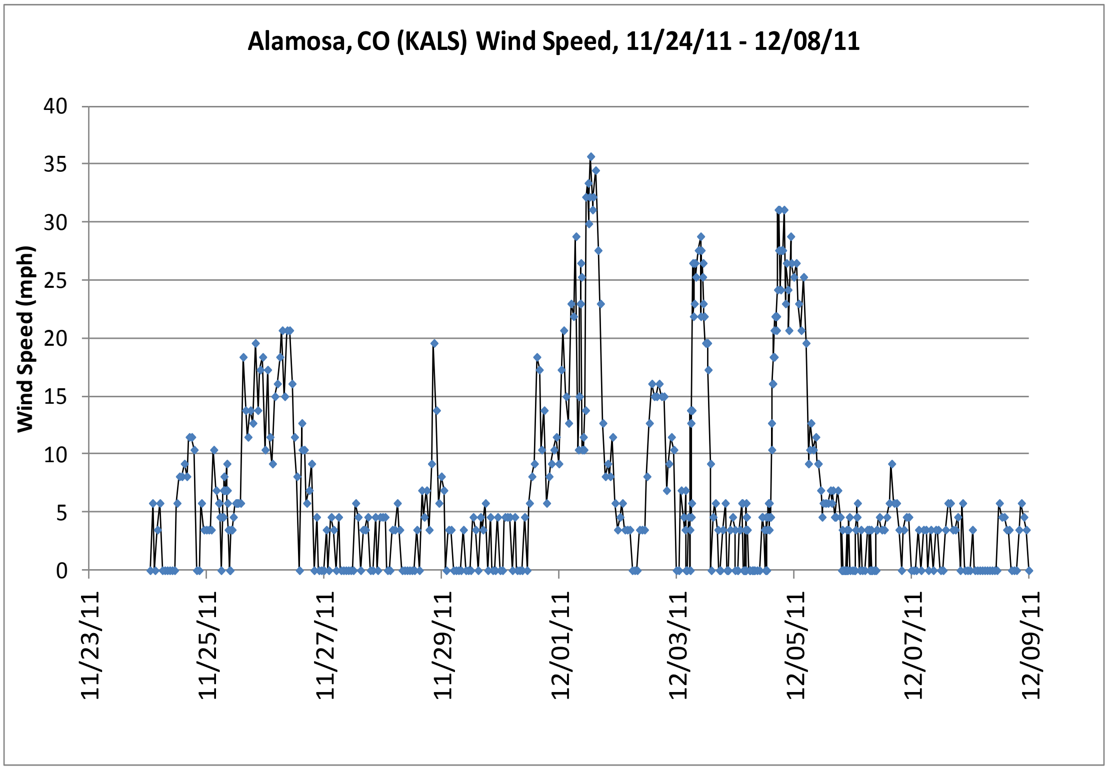


Figure 32: Wind Speed (mph) Various Stations, 11/04/2011 – 12/08/2011

Figure 33 plots PM_{10} concentrations from the affected sites in Alamosa for the period for seven days prior to and following the samples of December 1, 2011.

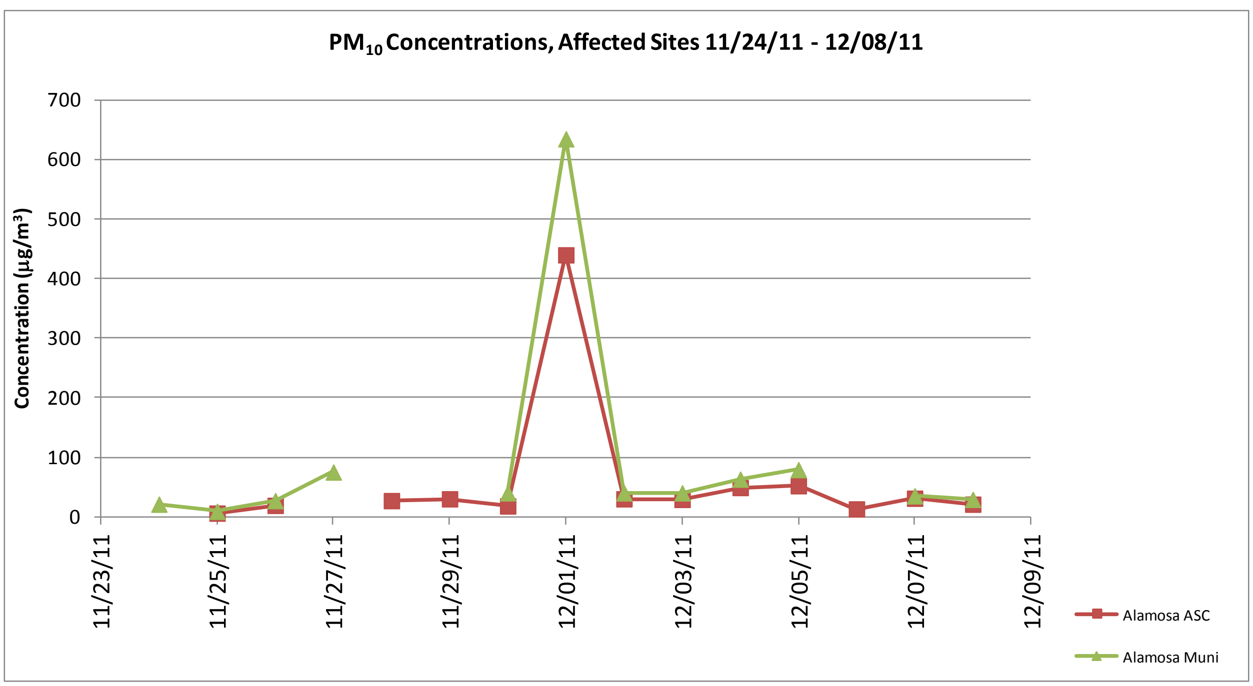


Figure 33: PM_{10} Concentrations, Affected Sites, 03/26/2011 – 04/11/2011

Figure 33 mimics the plots for wind speed, suggesting an association between the regional high winds and PM_{10} concentrations at the samplers in Alamosa. Although both samples were affected to differing degrees by the high winds 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 an effect on PM_{10} samples in Alamosa on December 1, 2011.

<u>No Exceedance But For the Event</u>

Monthly percentile plots in Figure 34 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 90^{th} percentile value and the Alamosa ASC monthly median is 0.63, the same value(s) for Alamosa Muni is 0.72. 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 each site are presented in Figure 34.

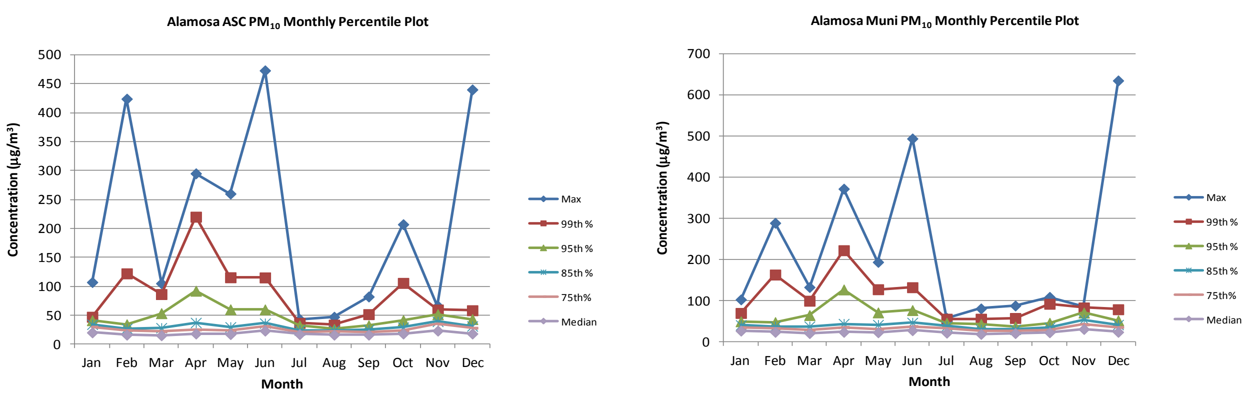


Figure 34: Monthly PM_{10} Percentile Plots

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 the data sets of concern (Alamosa ASC and Alamosa Muni) a conservative estimate of the percentile value that is reflective of typical, day to day variation is the 75^{th} percentile value. Nearly all of the variation in the monthly 75^{th} percentile values of these data sets can be explained by the variation in monthly medians; for the Alamosa sites the correlation between the median and monthly 75^{th} percentile values vary little with an $r^2 = 0.91$ (Alamosa ASC) and $r^2 = 0.92$ (Alamosa Muni). A less conservative estimate of the contribution to the event from local sources for these data sets may be the monthly 85^{th} percentile values; for these three sites the correlation between the median and the monthly 85^{th} percentile values vary from an $r^2 = 0.82$ (Alamosa ASC) to an $r^2 = 0.89$ (Alamosa Muni). The portion of the sample concentration greater than these monthly percentile values would be the sample contribution due to the event.

Table 7 identifies various percentile values that are representative of the maximum contribution due to local sources for each site from all December data for both sample dates. In Table 7 the range estimate in the 'Est. PM_{10} Contribution' column is derived using the difference between the actual sample value and the 85^{th} percentile as the minimum (reasonable) event contribution estimate and the difference between the actual sample value and the 75^{th} percentile as the maximum (conservative) event contribution estimate. The last column represents the range of estimated contribution to the December 1, 2011, sample from the high wind event.

Table 7: Estimated Maximum Event PM_{10} Contribution - Alamosa ASC and Alamosa Muni

Site	Event Day Concentration ($\mu g/m^3$)	December Median ($\mu g/m^3$)	December Average ($\mu g/m^3$)	December 70th % (mg/m3)	December 85th % (mg/m3)	Est. Conc. Above Typical ($\mu g/m^3$)
Alamosa ASC	440	18	23.2	26	31	**409 - 414**
Alamosa Muni	635	24	30.5	33	42	**593 - 602**

Clearly, there would have been no exceedance on December 1, 2011, but for the additional contribution to the PM_{10} samples provided by the event.

4.0 News and Credible Evidence

Windstorm Whips across the West

by Tim Ballisty, Editorial Meteorologist

Updated: November 30, 2011 4:40 pm ET

Video: Dr. Forbes Dissects the Windstorm

Play Video

This isn't just a California thing. A major windstorm will not only blow through California during the latter half of this workweek but will also whip across the majority of the interior West.

Although high wind events are fairly common across the region, this wind event has the potential to produce scattered areas of property damage, widespread areas of blowing dust/sand, tree and power line damage among several other impacts.

Weather.com November 30, 2011

Wild wind storm blasts California and Colorado, knocking down trees and power lines

By The Associated Press
on December 02, 2011 at 2:06 AM
0

Mark Boster/Los Angeles Times/MCTTree trimmer Alfredo Cardona carefully scrambles up the broken tree trunk of a sycamore that fell across the roof of a $2.2 million home that had just closed escrow in Pasadena, California on Thursday. The tree fell around midnight during a major windstorm that swept through southern California.

PASADENA, Calif. — The most powerful winds to tear across California in years kept 9-year-old Dalen Guyton up late into the night. Then, around midnight, came the boom.

The great yawning tree that stood next to his grandmother's house, the one with the rope swing he and his sisters played on, had toppled, coming within inches of their one-story home.

On Thursday, the siblings stood out front surveying the damage, like thousands across the West where high winds toppled countless trees, knocked out power to hundreds of thousands and brought gusts as high as 123 mph.

"If she pays someone to clean it up, it's not going to be a good Christmas," said the boy, who was wearing a Santa hat. "She's not going to be able to get any presents."

The National Weather Service called Southern California's winds Wednesday night a once-in-a-decade event, and it's not over. Winds were expected to pick up again Thursday night, though they won't be as fierce.

In the mountains, winds were expected to gust up to 65 mph into Friday morning and 50 mph in the valleys.

High wind warnings and advisories were also issued for Utah, Nevada, Wyoming, Arizona and New Mexico. The blustery weather is expected to eventually hit Oklahoma, Missouri and Indiana.

The storms were the result of a dramatic difference in pressure between a strong, high-pressure system and a cold, low-pressure system, meteorologists said. This funnels strong winds down mountain canyons and slopes.

The winds reached 123 mph at a ski resort northwest of Denver and topped 102 mph in Utah.


View full sizePaul Buck/EPAA crucifix, erected in 1935, is knocked from its perch and has its arms severed, after high winds broke a eucalyptus tree at the trunk in the courtyard of the San Gabriel Mission in San Gabriel, California, on Thursday.

California, however, was the hardest hit, with more than 330,000 utility customers still without power late Thursday. The gusts were blamed for toppling semitrailers and causing trees to fall on homes, apartment complexes and cars.

A state of emergency was declared in Los Angeles County, where schools in a dozen communities were closed.

In some neighborhoods, concrete light poles cracked in half. Darkened traffic signals and fallen palm tree fronds and branches snarled traffic. At a Shell station, the roof collapsed into a heap of twisted metal.

"It was a terrifying ride for me, coming here in pitch dark ... and watching motorists take no notice of lights being out," said Bob Spencer, a spokesman for the Los Angeles County Department of Public Works.

The last time that Southern California was battered by such intense winds was in January 2007, when similarly high gusts toppled trees and made a mess.

Bill Patzert, a climate expert with NASA's Jet Propulsion Laboratory, lives in Sierra Madre and, like hundreds of thousands of people across the region, lost power at his home. A heavy tree limb blocked his driveway.

He estimated winds peaked between 80 to 90 mph in his neighborhood overnight.

"It was like being in a hurricane. I thought I was going to blow away," he said.

In heavily damaged Pasadena, schools and libraries closed and a local emergency, the first since 2004, was declared. Officials said 40 people were evacuated from an apartment building after a tree smashed part of the roof.

View full sizeDavid McNew/Getty ImagesA gas station sits damaged under the weight of a fallen tree Thursday after strong Santa Ana winds caused the worst wind damage in decades in Pasadena, California.

Pasadena is known for its historic homes and wide oak-lined streets that are frequently depicted in films.

Many residents Thursday blamed the city for protecting its old trees from over-trimming to such an extent that they have now become a public safety hazard.

Vince Mehrabian, the general manager at A&B Motor Cars, estimated eight Lexus, Cadillac and other luxury cars had been destroyed by fallen limbs. He said he'd been asking the city for four years to trim the trees more.

On a street around the corner, almost every tree was either cracked in half or missing limbs.

Elsewhere, Daphne Bell, a 30-year Pasadena resident, said she was kept awake by howling wind. "This is the worst, the absolute worst. There were times it sounded like a freight train was roaring down my driveway," she said.

Similar stories of downed trees and power lines echoed across the West, where winds in some areas ripped storefront awnings, filled gutters with debris and forced school closures.

High winds ripped through Utah, overturning several semi-trucks on or near Interstate 15. About 50,000 customers lost power along the state's 120-mile Wasatch Front as high winds took down power lines, but service was restored to more than half of them by Thursday night.

Police asked schools to close in Centerville, where a 102-mph gust was reported. Mail delivery and trash pickup were canceled.

In Nevada, weather officials warned that blowing dust was creating visibility problems on a highway between Reno and Las Vegas.

In Steamboat Springs, Colo., the roof of a four-story condominium complex was blown off and about 100 trees were knocked over, some landing on homes. A ski area shut down its lifts after a gust of 123 mph.

Even some weather experts were surprised by the wind's force.

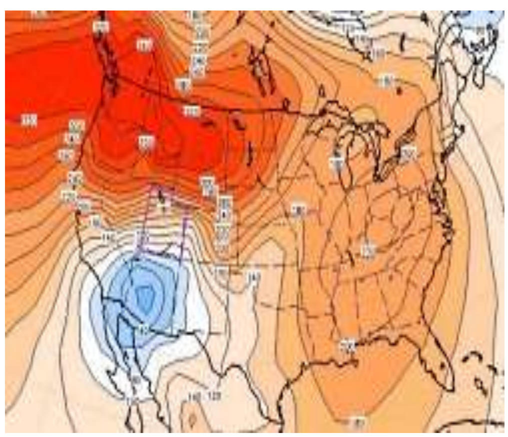
"It's one of the strongest events that I can remember," said Brian Edwards, a meteorologist with Accuweather. "It's rather rare."

Those Howling East Winds

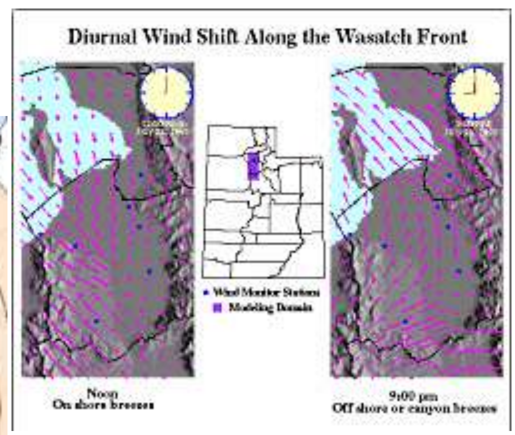
Audio: mp3

Courtesy Utah Division of Air Quality

Air Pressure at the Surface, 1 Dec 2011 Blue=Low Pressure, Red=High Pressure The spacing of the lines is a measure of the pressure gradient: the closer the lines, the higher the pressure gradient.
Courtesy Utah



Normal Diurnal Wind Shift Along the Wasatch Front



Read: A Bit of a Blow… Climate Center, Utah State University

Wind is inevitable on a spinning planet with an atmosphere and a sun. At our latitude, westerlies prevail, but east winds do occur now and then. Locally, canyons daily exhale denser, cooler mountain air that drains into valleys. In Logan, trees blown by these canyon winds tilt westward. Occasionally, though, the whole Wasatch front is whipped by howling gales from the east, leaving behind shredded shingles, snapped tree limbs and rolled tractor-trailers. These forceful east wind events have a regional weather origin that is intensified by local topography.

It begins with a strong high-pressure cell parked over southwestern Wyoming. It's descending dry air circulates clockwise. Somewhere to the south or southwest, a low-pressure cell is needed. The strong air pressure gradient between high and low generates a wind that raceswestward from Wyoming. The surging wind pours over the entire Wasatch front like water over a flat boulder in rapids. These winds then plunge down slope, blowing quickest where the descent is long, steep, and unobstructed. The down rushing air slams onto the flat benches and valley floors. In November 2011, such winds ripped Centerville with 100 MPH gusts.

Where these so-called mountain wave events blow regularly they often have names. The mistral and foehn winds howl down from the Alps, chinooks race down the Rocky Mountain Front Range, and the Santa Anas blast Southern California. The steep altitudinal descent of these parched winds compressively heats the air. A spark or flame soon transforms to a raging wildfire when fanned by a drying foehn or Santa Ana wind. Europe's foehns are also known to spark short tempers and stress.

Perhaps the sporadic easterly gales that lash the Wasatch Front and Cache Valley deserve an evocative name too. For now, you at least know the answer to what's blowin' in the east wind.

Thanks to Martin Schroeder at the Utah Climate Center for insights and the stream boulder analogy

This is Linda Kervin for Bridgerland Audubon Society.

Credits:
Diurnal Utah Winds Image: Courtesy Utah Division of Air Quality
Surface Air Pressure 1 Dec 2011 Image: Courtesy Utah Climate Center, USU
Text: Jim Cane

WildAboutUtah.com

Strong Santa Ana Winds

Posted on December 3, 2011

Earlier this week, the southwestern region of the US experienced one of its worst wind storms in over a decade. The winds that swept through the area were not a typical Santa Ana event.

The Santa Ana is usually a robust easterly wind that blows dry air across southern California in the late fall. It is formed by a large pressure difference that builds up between the inland Mojave Desert and the LA Basin. The steep pressure gradient between the two areas funnels air downhill through the canyons and passes of the San Gabriel and San Bernardino mountains toward the Pacific. Winds speeds generally reach somewhere between 40 and 60 mph.

This week's event was unusual, because it followed a cold front and had a powerful northerly wind component with exceptionally strong gusts. The NWS is reported to have measured wind gusts up to 140 mph along the Sierra Crest mountain ridge. This fierce wind storm uprooted trees and knocked out power to over 300,000 people across the Los Angeles area. Even LAX lost power and had to shut down briefly.

Another unusual aspect of this epic wind event was its wide reach across the region. Damage has been reported across the west from California to Colorado. Some places in Utah experienced wind gusts over 100 mph and saw tractor-trailers flipped over like toys.

The tight pressure gradient that caused the storm has now weakened and the winds have subsided. The forecast, however, is calling for blustery conditions to return to the southwest in the next few days.

Posted in weather | Tagged storms, wind

Weathergamut.com

Excerpt:

> High winds preceded and accompanied the Western temperature transition. On November 30, Bishop, CA, noted a monthly record wind gust to 60 mph, topping the record of 59 mph that had just been set on November 18. In Los Angeles County, CA, a northwesterly gust to 97 mph was clocked on the 30th on Whitaker Peak. The first day of December featured gusts to 102 mph in Centerville, UT; 94 mph in Cedar Ridge, CA; and 69 mph in Albuquerque, NM. The storm responsible for the Western winds triggered late-week rain and snow from the Southwest to the Midwest. December 1-3 snowfall totaled 13.1 inches in Flagstaff, AZ.

From The **Weekly Weather and Crop Bulletin**, December 6, 2011. USDA Cornell

From clip description:

Uploaded on Dec 4, 2011

The wind blew in one hell of a snowstorm. Winds were gusting up to 45 MPH and the windchill was well below zero.

Gotta love the Valley!

You Tube Clip, 12/04/2011

Search Daily Report Comments

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

Location: USA ▼ Colorado ▼ AM - Alamosa ▼

Date Range:

Start Date: 11/30/2011 **End Date:** 12/2/2011

Search

Searched: Stations in Alamosa, Colorado. Report date between 11/30/2011 and 12/2/2011.

Showing 5 Records.

Date ▲	Station Number	Station Name	Total Precip in.	Comments	
12/2/2011	CO-AM-10	Great Sand Dunes 7.0 SSW	T	High winds, horizontal snow - what little there was.	View
12/2/2011	CO-AM-11	Alamosa 6.9 NW	0.00	24 days without measurable precipitation	View
12/1/2011	CO-AM-10	Great Sand Dunes 7.0 SSW	0.00	Wind!	View
12/1/2011	CO-AM-11	Alamosa 6.9 NW	0.00	23 days without measurable precipitation	View
11/30/2011	CO-AM-11	Alamosa 6.9 NW	0.00	22 days without measurable precipitation	View

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 Arizona, northwest New Mexico, and southeast Utah. 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 December 1, 2011 event originated outside of the monitored areas, primarily from the desert regions of Arizona, northwest New Mexico, and southeast Utah.

The APCD conducted thorough analyses and outreach with local governments to confirm that no unusual anthropogenic PM_{10}-producing activities occurred in these areas 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 December 1, 2011, event. This information shall confirm that no unusual anthropogenic actions occurred in the local areas of Alamosa and Lamar during this time.

Regulatory Measures - State

The APCDs regulations on PM_{10} emissions are summarized in Table 8.

Table 8: 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 APCD (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). All sources with uncontrolled actual PM_{10} emissions equal to or exceeding five (5) tons per year, must obtain a permit. The new source review provisions require all new and modified major stationary sources in non-attainment areas to apply emission control equipment that achieves the "lowest achievable emission rate" and to obtain emission offsets from other stationary sources of PM_{10}.
Colorado Department of Public Health and Environment Regulation 4- New Wood Stoves and the Use of Certain Woodburning Appliances During High Pollution Days	Regulates wood stoves, conventional fireplaces and woodburning on high pollution days. Prohibits the sale and installation a wood-burning stove in Colorado unless it has been tested, certified, and labeled for emission performance in accordance with criteria and procedures specified in the Federal Regulations and meets emission standards. (Section II). Section III regulates pellet stoves. Section IV regulates masonry heaters. Section VII limits the use of stoves on high pollution days.
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).
Colorado Department of Public Health and Environment- Common Provisions Regulation	Applies to all emissions sources in Colorado. When emissions generated from sources in Colorado cross the state boundary line, such emissions shall not cause the air quality standards of the receiving state to be exceeded, provided reciprocal action is taken by the receiving state. (Section II A).
Federal Motor Vehicle Emission Control Program	The federal motor vehicle emission control 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 Regulatory Measures and Other Programs

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 APCD 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 APCD, 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 and County

The APCD, the City of Alamosa, and Alamosa County 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 9.

Table 9: 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
Alamosa County Land Use and Development Code (1.4.2)	Agriculture an important part of the economy and adds intrinsic value to life in Alamosa County. Agriculture, as a business, brings dust and other inconveniences. To maintain this way of life, Alamosa County intends to protect agricultural operators from unnecessary, intrusive litigation. Therefore, no inconvenience shall be considered a nuisance so long as it occurs as a part of non-negligent and legal agricultural practice, as stated in C.R.S. 35-3.5-101, 102 and 103.
Alamosa County Land Use and Development Code (3.5.2(A)(8))	For Feed lot, animal waste treatment, or animal waste collection facilities fugitive dust shall be confined on the property
Alamosa County Land Use and Development Code (3.5.6(D)(2))	For a proposed oil and gas well installation, any interior transportation network shall be paved, or the company shall undertake appropriate dust abatement measures
Alamosa County Land Use and Development Code (3.5.7(G))	All roads, driveways, parking lots and loading and unloading areas within 500 feet of any lot line shall be graded and paved with an approved concrete or asphalt/concrete surface as to limit adjoining lots and public roads the nuisance caused by wind-borne dust.
Alamosa County Land Use and Development Code (4.2.3(C)(2))	Where off-street facilities are provided for parking or any other vehicular use area, they shall be surfaced with asphalt bituminous, concrete or other dustless material approved by the administrator and shall be maintained in a smooth, well-graded condition.

City of Alamosa's Control Measures

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. 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 (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.

<u>Alamosa County's Control Measures</u>

Alamosa County has also been active in addressing blowing dust as detailed below.

Unpaved Roads
Alamosa County continues to address 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 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.

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 County Road 106 North (located north of Alamosa off of Highway 17) 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 requires dust control plans for selected construction/developments. The dust control plans are typically done through a negotiated agreement by the Alamosa Land Use Department and is supported by zoning codes.

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 (December 2014), 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. The Mosca-Hooper Conservation District and Natural Resources Conservation Service is working on education efforts to promote cover crops and no-till agriculture. In addition, the community is using in strategic areas the Colorado State Forest Service's program to purchase and plant shelter trees to reduce wind erosion in open areas. Nursery seedlings from the program have been sold in Alamosa County since 1956. The number of seedlings sold has varied over the last few years as illustrated in Table 10.

Table 10: Number of Seedlings Sold in Alamosa per Year.

Year:	2008	2009	2010	2011	2012	2013
Seedlings Sold:	7,432	5,963	2,805	4,197	3,327	4,231

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, but offers over 40 varieties to suit specific site conditions. The Colorado State Forest Service and the Mosca-Hooper Conservation District promote the windbreak program through workshops and consulting landowners.

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. Also, The Bureau of Reclamation has an ongoing project to plant windbreaks along their Closed-Basin Canal.

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. The City zoning map in Figure 35 which was provided by the City of Alamosa, depicts various areas of possible soil disturbance. These were evaluated by Air Division staff in conjunction with local input from the City and County staff for the Alamosa Adams State PM_{10} monitor and Municipal monitors over the past years. The area zoned agricultural remains mostly natural grassland and “Chico” shrubs.

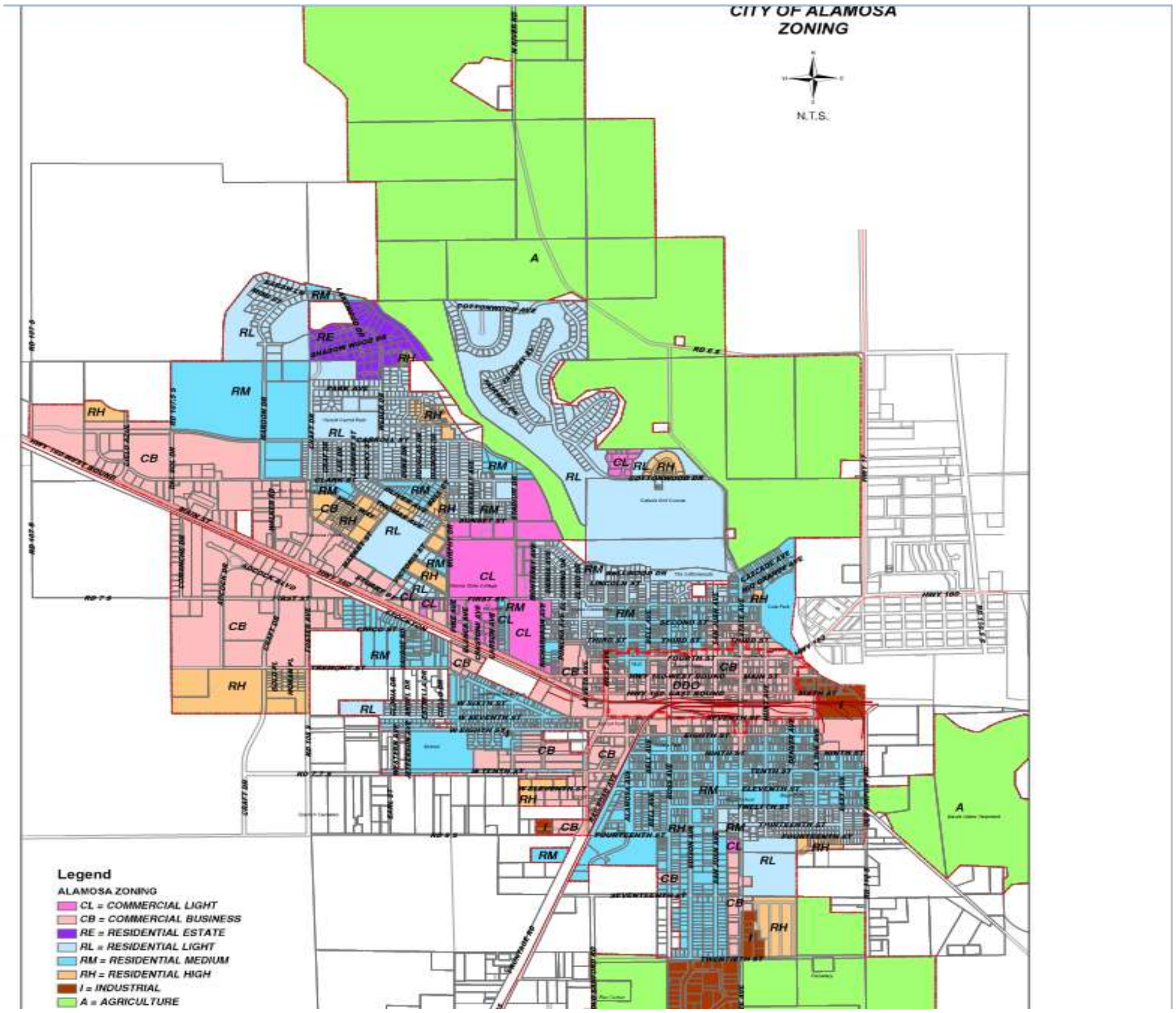


Figure 35: 2011 City of Alamosa Zoning Map (Provided by the Public Works Department)

The Division also conducted thorough assessments in 2012 to determine if the potential soil disturbances shown in Figure 36 were present during the 2011 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 December 1, 2011 high wind event. Therefore, these sites were not significant contributors to fugitive dust in the Alamosa area during the December 1, 2011 high wind event.

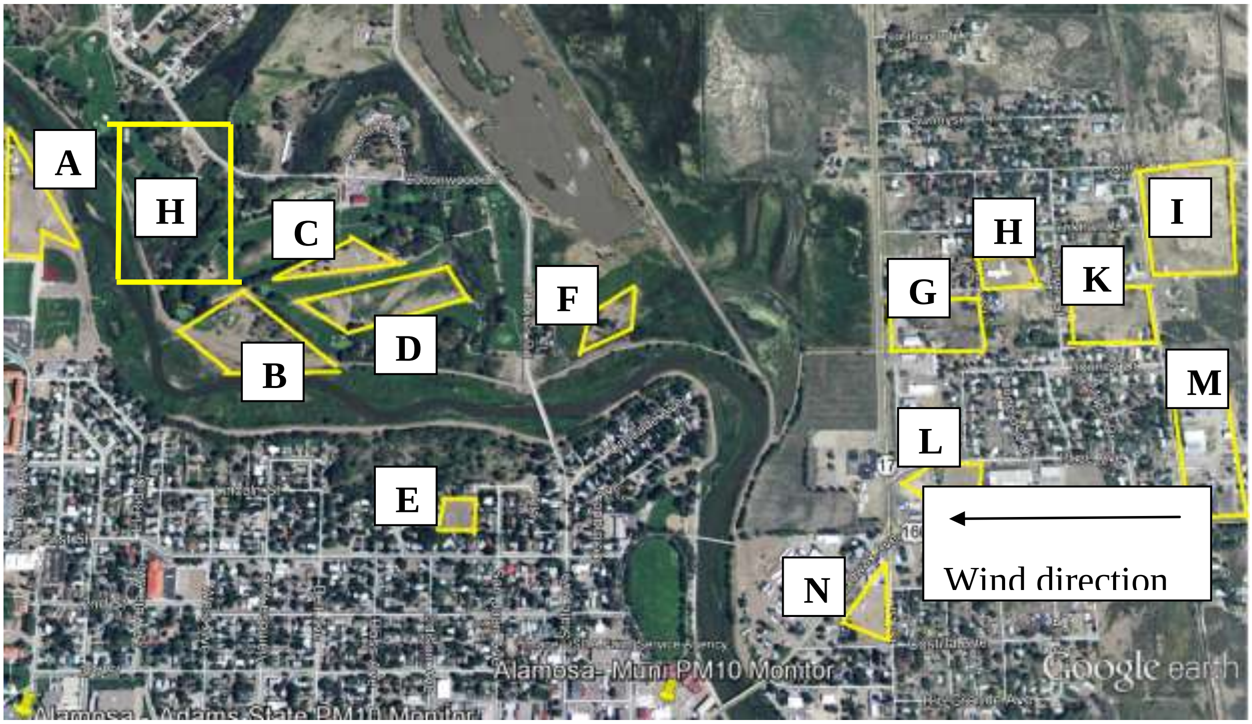


Figure 36: North and east of the Alamosa Municipal Building PM_{10} Monitor (Google Image 2011)

Site A in Figure 36 is an Astroturf baseball field located to the north of the Adams State College softball field. The baseball field was constructed in 2012.


Figure 37: Site A as of August 2013

Site B, C, and D in Figure 36 are located on a golf course. These areas of the golf course are natural, undisturbed, and unmaintained. These areas receive some of the irrigation sprinkling from the golf course but are not irrigated themselves. The golf carts use the designated paths and park on the greenways; they do not disturb these natural areas.

Figure 38: Representative of Site B, C and D as of August 2013 (also showing golf cart path)

Site E in Figure 36 is a private vacant lot in a residential area. The area is covered in gravel and weeds as shown in Figure 39**Error! Reference source not found.**. The land is used to store farm equipment in-between harvest seasons.

Figure 39: Site E as of August 2013

Site F in Figure 36 is a public green space and gravel walking path maintained by the City of Alamosa. Motor vehicles are not permitted on the path. Adjacent to the path is private property that is fenced in with barbed wire. All the private land is irrigated and maintained by the owner Figure 40 shows site F as of August 2013.

Figure 40: Site F as of August 2013

Site G in Figure 36 is a vacant lot in a residential neighborhood. The vacant lot is for sale as of August 2013. The soil is hard packed with a crust. The lot is covered in natural vegetation and is undisturbed as shown in Figure 41.

Figure 41: Site G as of August 2013

Site H in Figure 36 is a church parking lot. The lot is well maintained gravel that is watered on an as needed basis as shown in **Error! Reference source not found.**. The lot is only used for church events.

Figure 42: Site H as of August 2013

Site I in Figure 36 is private property with a fence that restricts access. The land is irrigated and is covered with vegetation as shown in **Error! Reference source not found.**.

Figure 43: Site I as of August 2013

Site K in Figure 36 is a vacant lot in a residential area. As of August 2013, the lot is for sale. The vacant lot has natural dense vegetation as shown in Figure 44.

Figure 44: Site K as of August 2013

Site L in Figure 36 is a well maintained gravel parking lot for the Day's Inn hotel as shown in Figure 45. The parking lot is graded and watered on an as needed basis to mitigate blowing dust.


Figure 45: Site L as of August 2013

Site M in Figure 36 is owned by the Southway Construction Company. The land is large gravel parking lot that is used to store construction equipment as shown in Figure 46. Local government employees reported that the gravel is graded several times per year and is watered on an as needed basis. Also, vehicle speed is restricted to 5 mph on site.

Figure 46: Site M as of August 2013

Site N in Figure 36 is a gravel parking lot for a semi-truck service station as shown in Figure 47. The gravel is graded and watered on an as needed basis.

Figure 47: Site N as of August 2013

Additionally, there were several other areas that were identified by Air Division staff, as shown in Figure 48. Similar to the sites described earlier these sites were also either reasonably controlled or considered to be natural sources during the December 1, 2011 high wind event. Therefore, these sites were not significant contributors to fugitive dust in the Alamosa area during the December 1, 2011 high wind event.

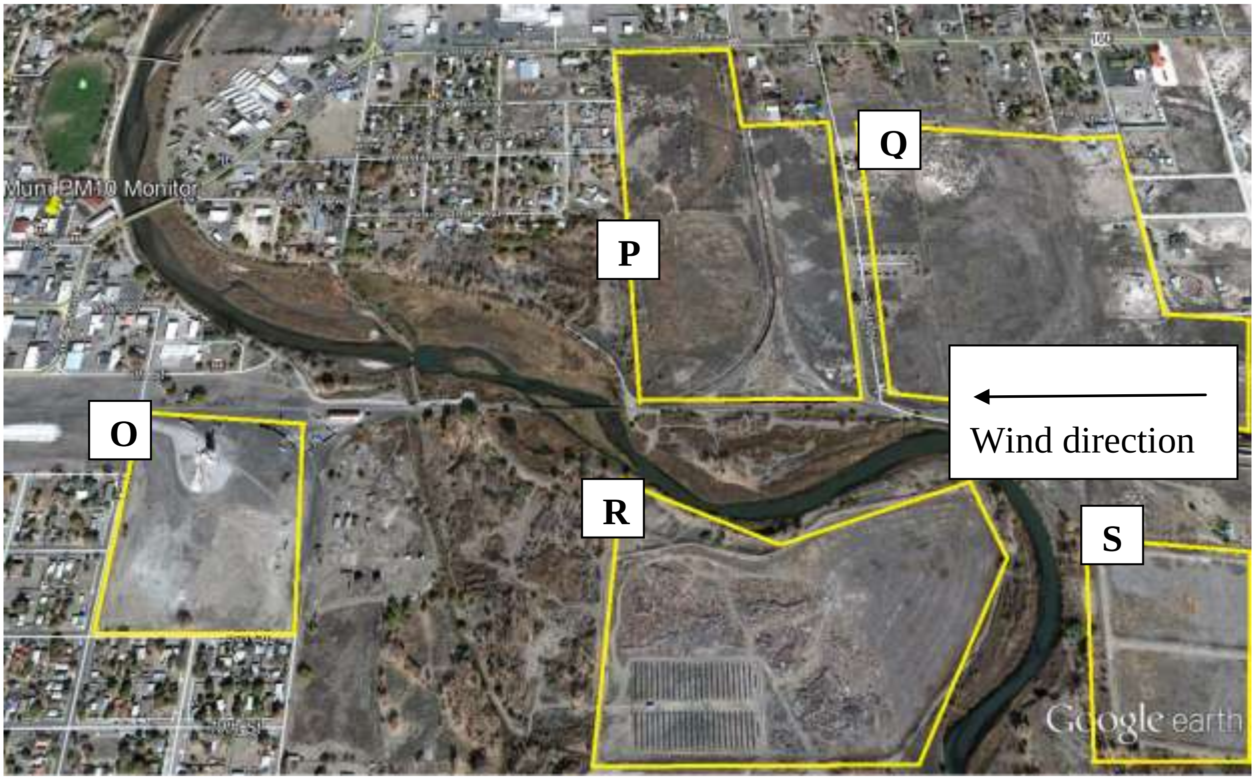


Figure 48: Southeast of the Alamosa Municipal PM_{10} Monitor (Google 2011)

Site O in Figure 48 (approximately 22 acres) is east of La Due Ave, south of 6th St, north of 9th St, and west of Old Airport Rd. It is zoned by the city as "Commercial Business" and "Industrial". Site O is private property with restricted access located just south of the rail yard. The land is naturally vegetated and undisturbed as shown in Figure 49.

Figure 49: Site O as of August 2013

Site P in Figure 48 (approximately 20 acres) is a vacant lot that is for sale as of August 2013. The undisturbed land is fenced in with barbed wire. The land is in a heavily wooded area and has dense natural vegetation as shown in Figure 50.

Figure 50: Site P as of August 2013

Site Q in Figure 48 is all private undisturbed land (multiple owners) that is fenced in with barbed wire. The land has dense natural vegetation as shown in Figure 51.

Figure 51: Site R as of August 2013

Site R in Figure 48 is a solar farm surrounded by open naturally vegetated land. Access to the solar farm is very restricted; the road to the facility is private and gated. The solar farm and adjacent vacant land is shown in Figure 52.

Figure 52: Site R as of August 2013

No photo of site S is provided. There is no physical access to it or public roads to be able to investigate.

Soil 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.

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, "Xeriscape" has been installed for aesthetics and dust control.

- Decorative rock and xeriscape 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 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:

- Local Conservation Districts and farmers hold monthly meetings as an informal Soil Health Group, discussing ways to improve soil health. Cover crops, compost applications, and reduced tillage are the targeted practices. Public tours are held twice a year.
- NRCS continues to work with area farmers in the development of conservation compliance plans to also protect topsoil;
- NRCS encourages planting perennial grasses or the leaving weeds undisturbed or mowed on the corners of center pivots (instead of tilling that might lead to open, barren lands) to reduce soil blowing;
- NRCS “cost shares” on soil health practices and perennial grass seeding conservation practices with local farmers to prevent soil erosion, and;
- The NRCS is working with Colorado State University, local Water Conservation District, and Farm Service Agency to encourage retirement of marginal cropland in the Conservation Enhanced Reserve Program (CREP) and seeding those acreages back to native grass, forbs and shrubs.

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 for Alamosa in Appendix C for more detail if needed.

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) on December 1, 2011

Elevated 24-hour PM_{10} concentrations were recorded in Alamosa on Dec. 1, 2011. Both of the Dec. 1 2011 twenty-four-hour PM_{10} concentrations measured in Alamosa were above the 90th percentile concentrations for their locations produced the maximum values in both of the two datasets. The statistical and meteorological data clearly shows that but for this high wind and blowing dust event, Alamosa, would not have exceeded the 24-hour NAAQS on December 1, 2011.

The PM_{10} exceedances in Alamosa, on December 1, 2011 would not have occurred if not for the following: (a) dry soil conditions in the San Luis Valley with 30-day precipitation totals below the threshold identified as a precondition for blowing dust; (b) the result of intense surface winds produced by a very tight pressure gradient in the wake of a passing cold front; and (c) The elevated friction velocities shown in Figure 20 of the report.

GASP and MODIS satellite imagery reveal that a dust storm was taking place in the San Luis Valley of south-central Colorado during the morning of December 1, 2011. The drought-stricken and largely undeveloped eastern half of the San Luis Valley was the source region for the blowing dust that produced the PM_{10} exceedance in Alamosa.

NOAA HYSPLIT backward trajectories in tandem with MODIS imagery provide clear supporting evidence that air transported from the arid, dust-prone sections of the eastern San Luis Valley caused or significantly contributed to the PM_{10} exceedance measured in Alamosa on December 1, 2011.

As shown in Section 2.0 and particularly in Table 4 and Figure 33, the PM_{10} exceedances and other elevated PM_{10} concentrations in Alamosa on December 1, 2011 would not have occurred “but for” the storm front moving through the valley on December 1, 2011.

7.0 References

Draxler, R.R. and G.D. Rolph, 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.

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."

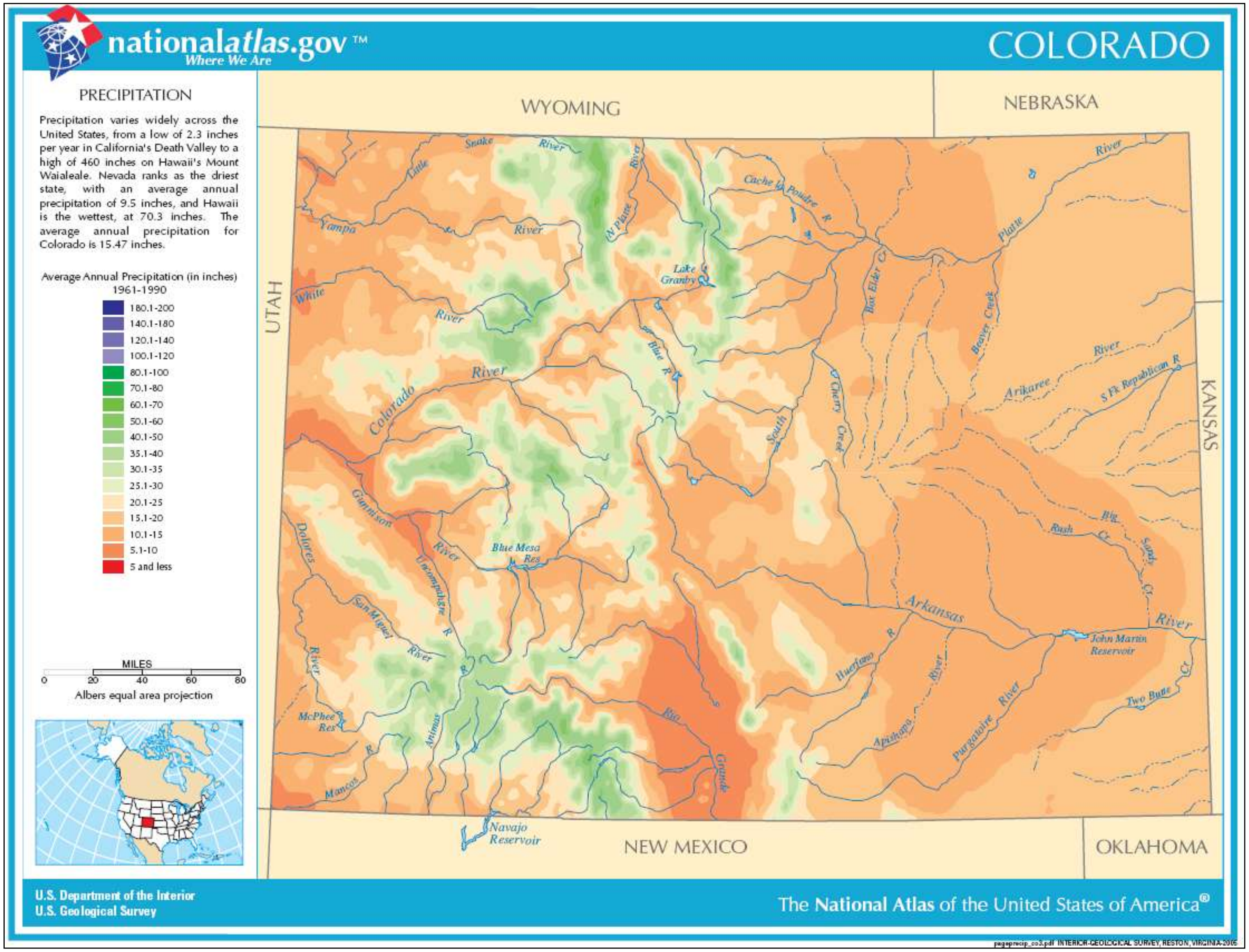


Figure A-1. Average annual precipitation in Colorado based on 1961-1990 normals.

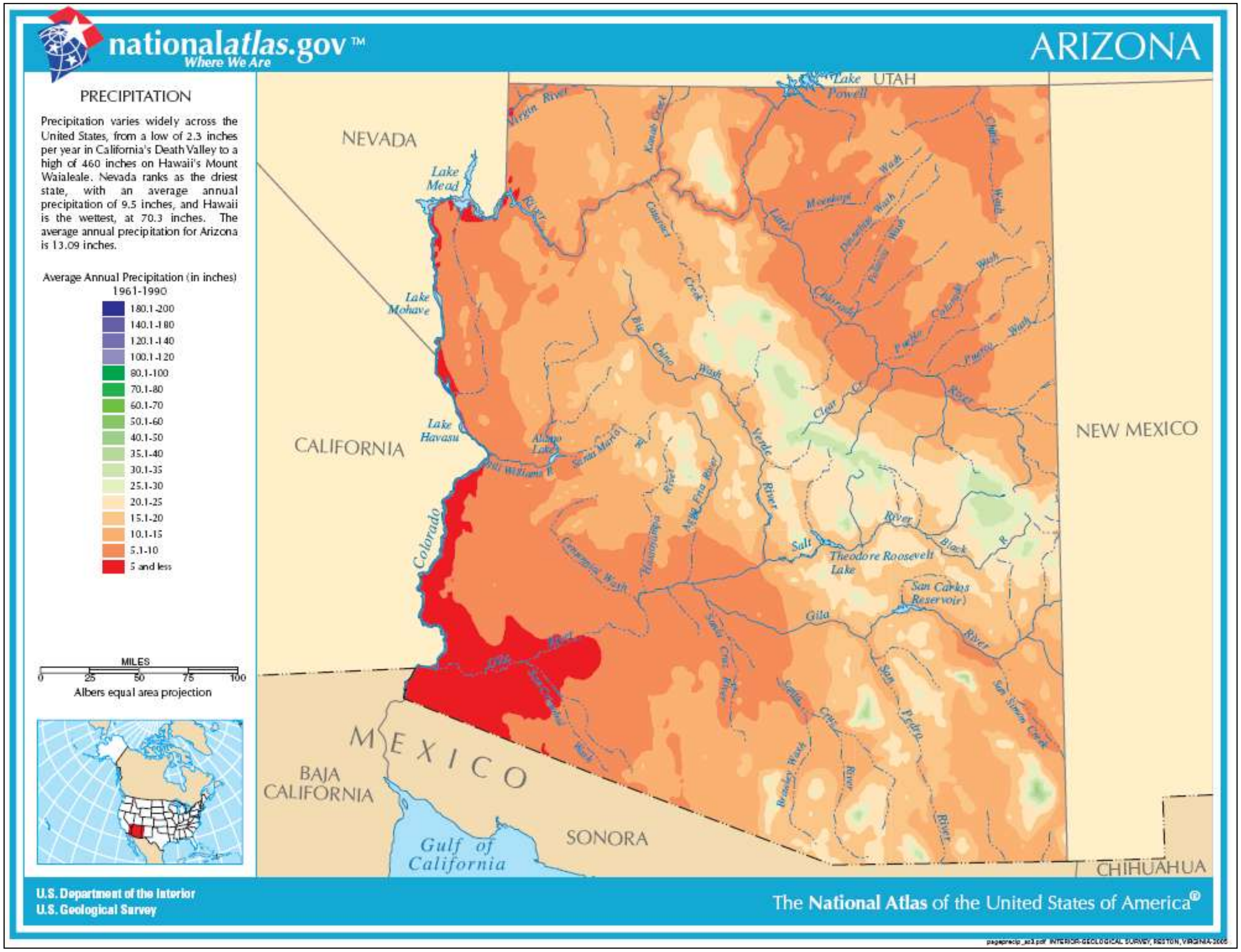


Figure A-2. Average annual precipitation in Arizona based on 1961-1990 normals.

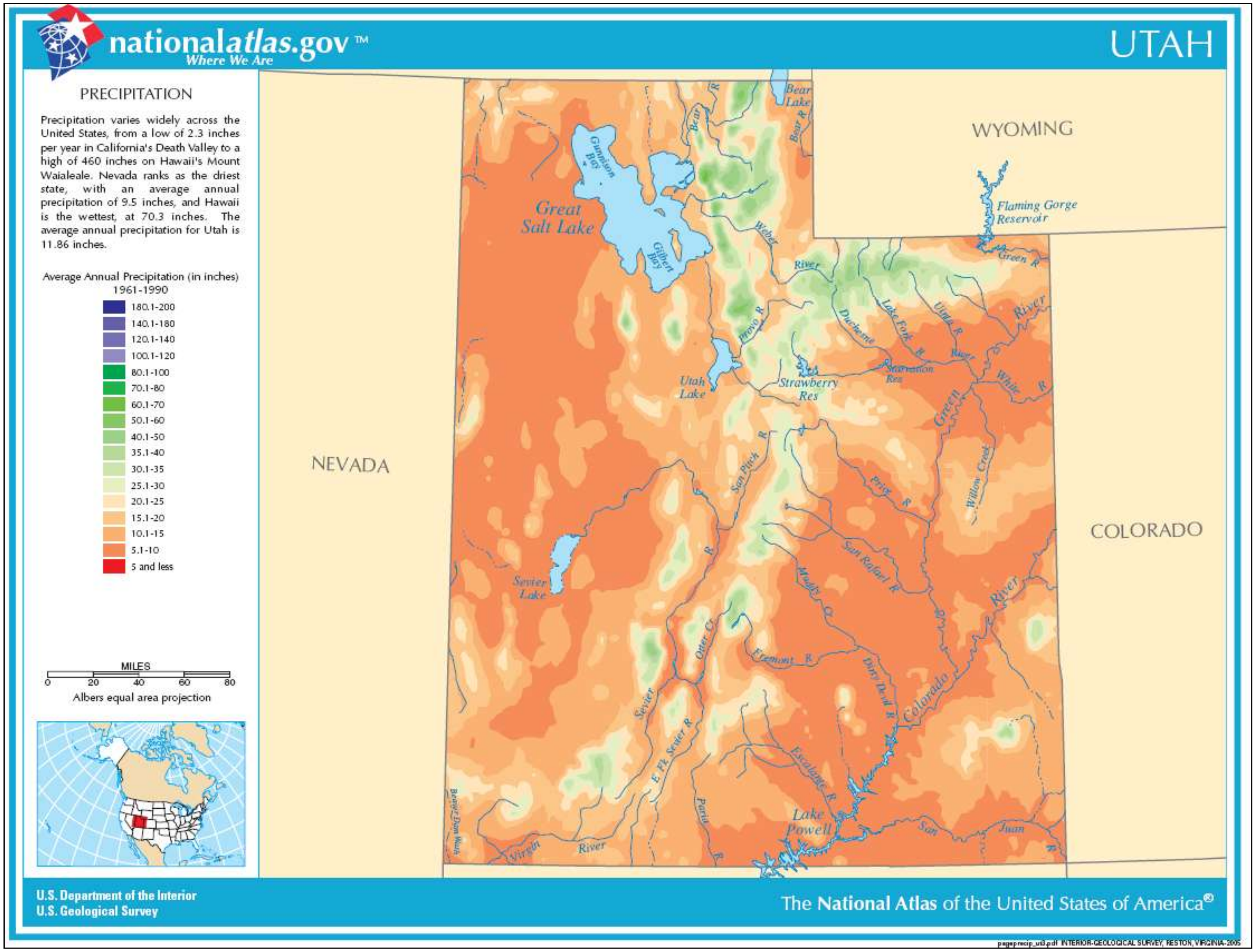


Figure A-3. Average annual precipitation in Utah based on 1961-1990 normals.

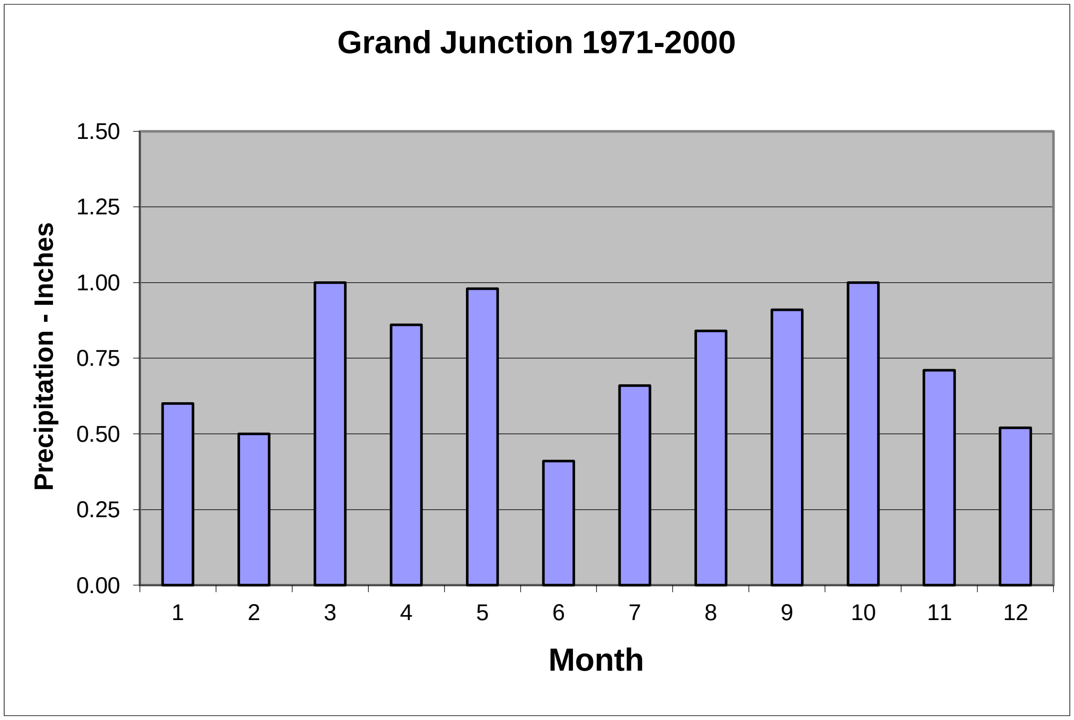


Figure A-4. 1971-2000 monthly normal precipitation in Grand Junction Colorado.

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.

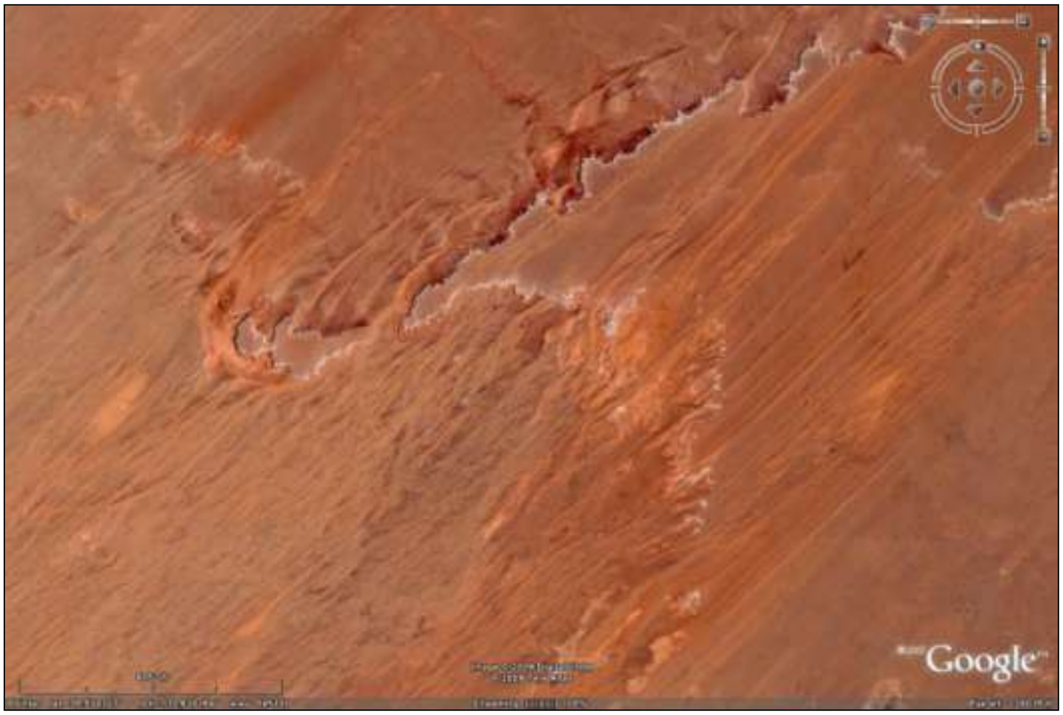


Figure A-6. Southwest to northeast soil and sand erosion structures in southeastern Utah.

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

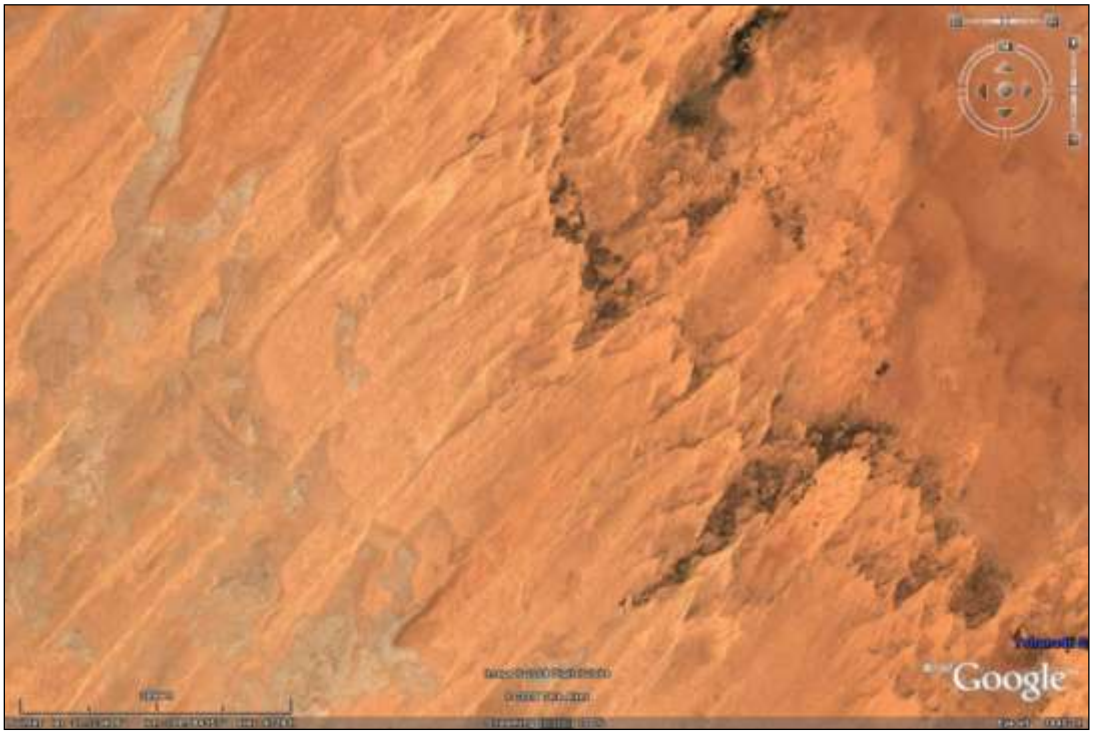


Figure A-8. Southwest to northeast soil and sand erosion structures in southeastern Utah.

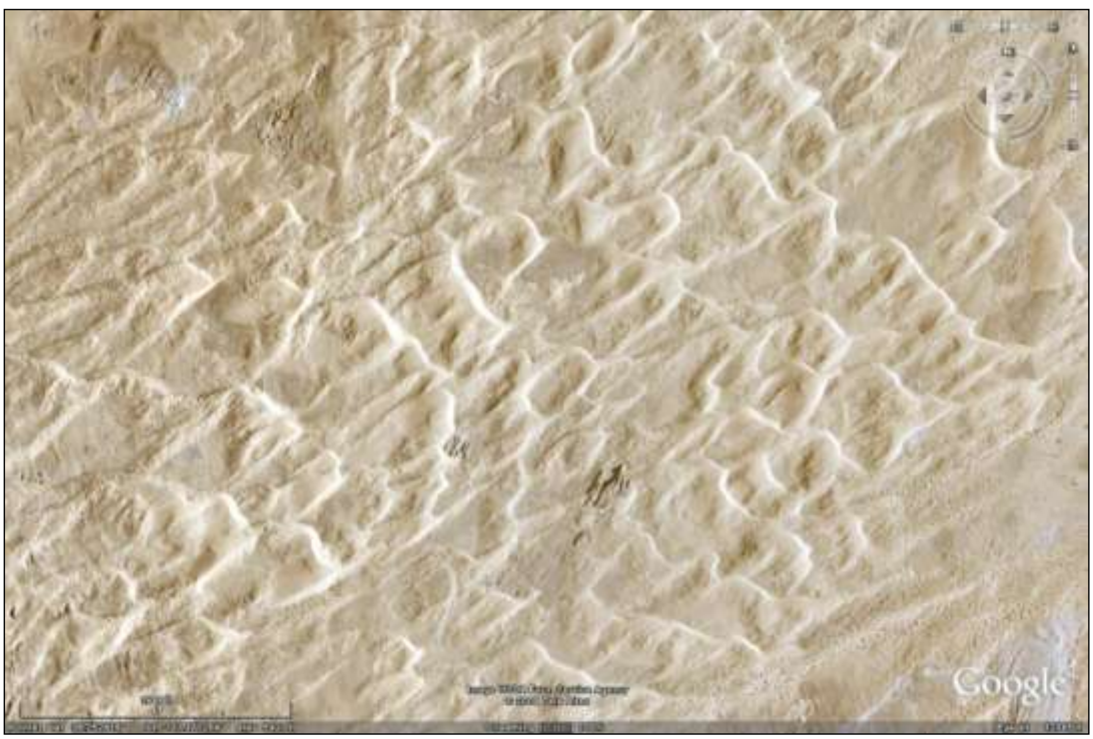


Figure A-9. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert). The slip faces of dunes (lighter bands) face in the direction of wind flow – toward the northeast.

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).

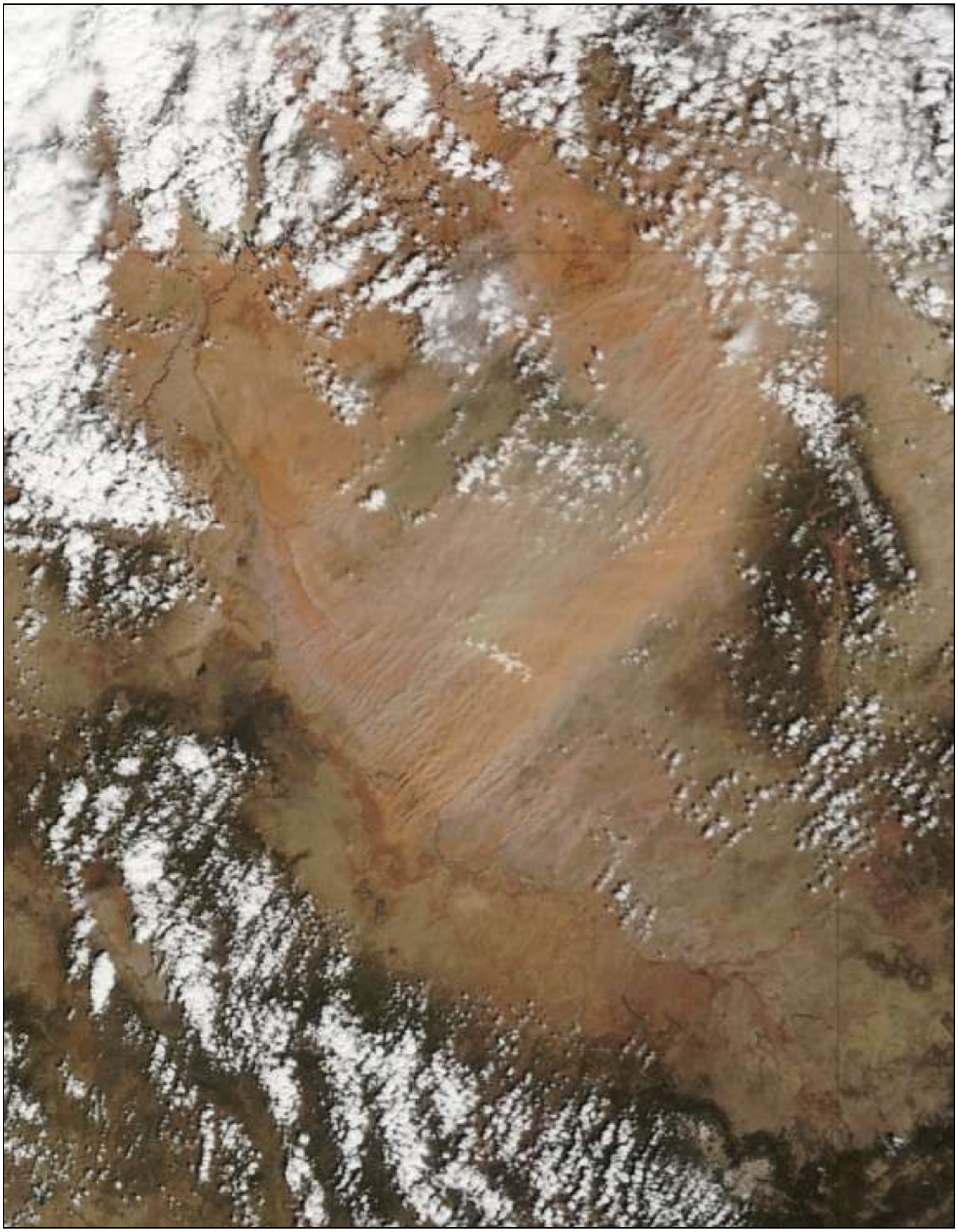


Figure A-13. NASA Tera satellite image of a dust storm on April 3, 2009, in southwesterly flow over the Painted Desert of northeastern Arizona (http://earthobservatory.nasa.gov/IOTD/view.php?id=37791).

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.

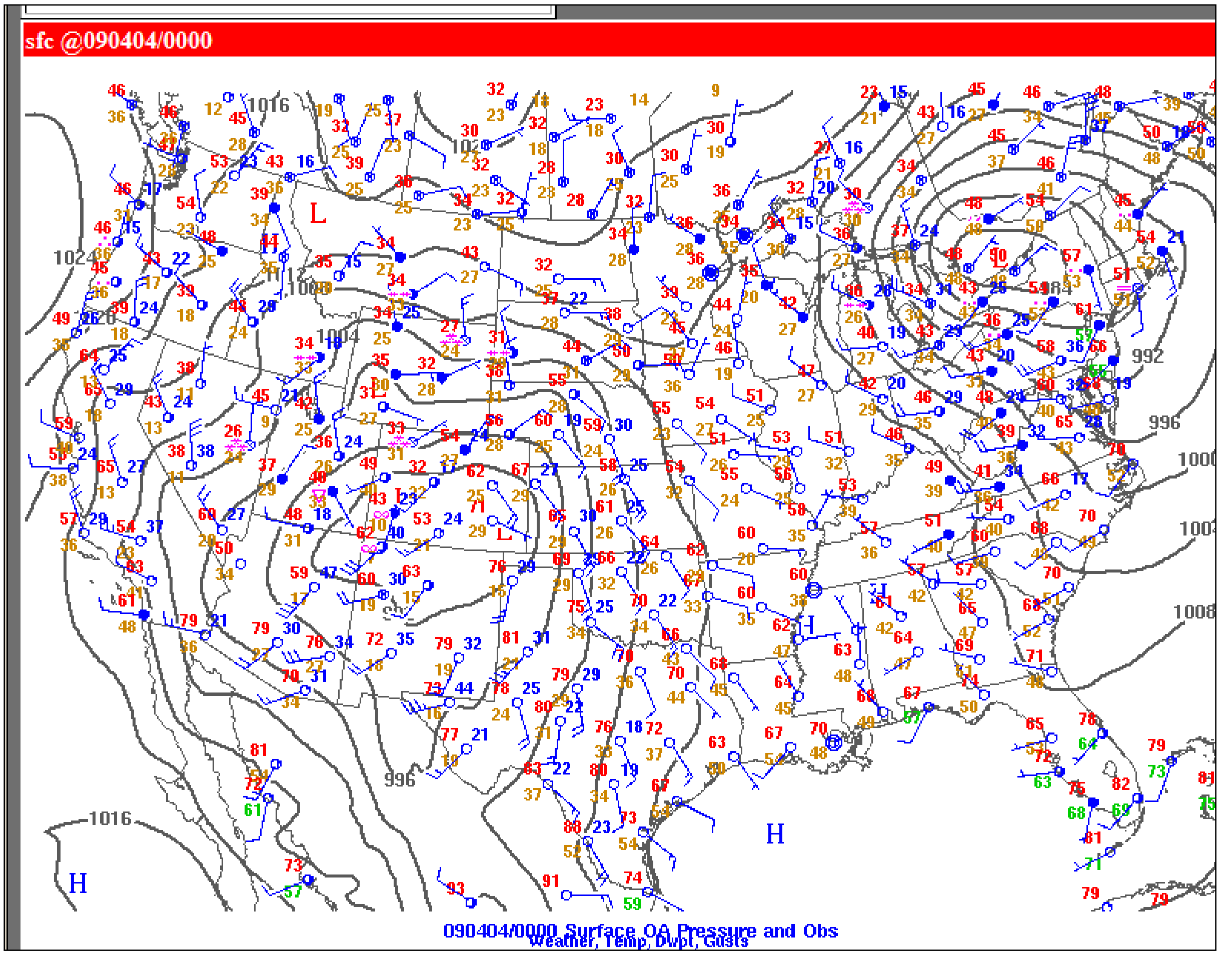


Figure A-14. Surface weather map for 00Z April 4, 2009, (5 PM MST April 3, 2009), showing a strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado).

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.

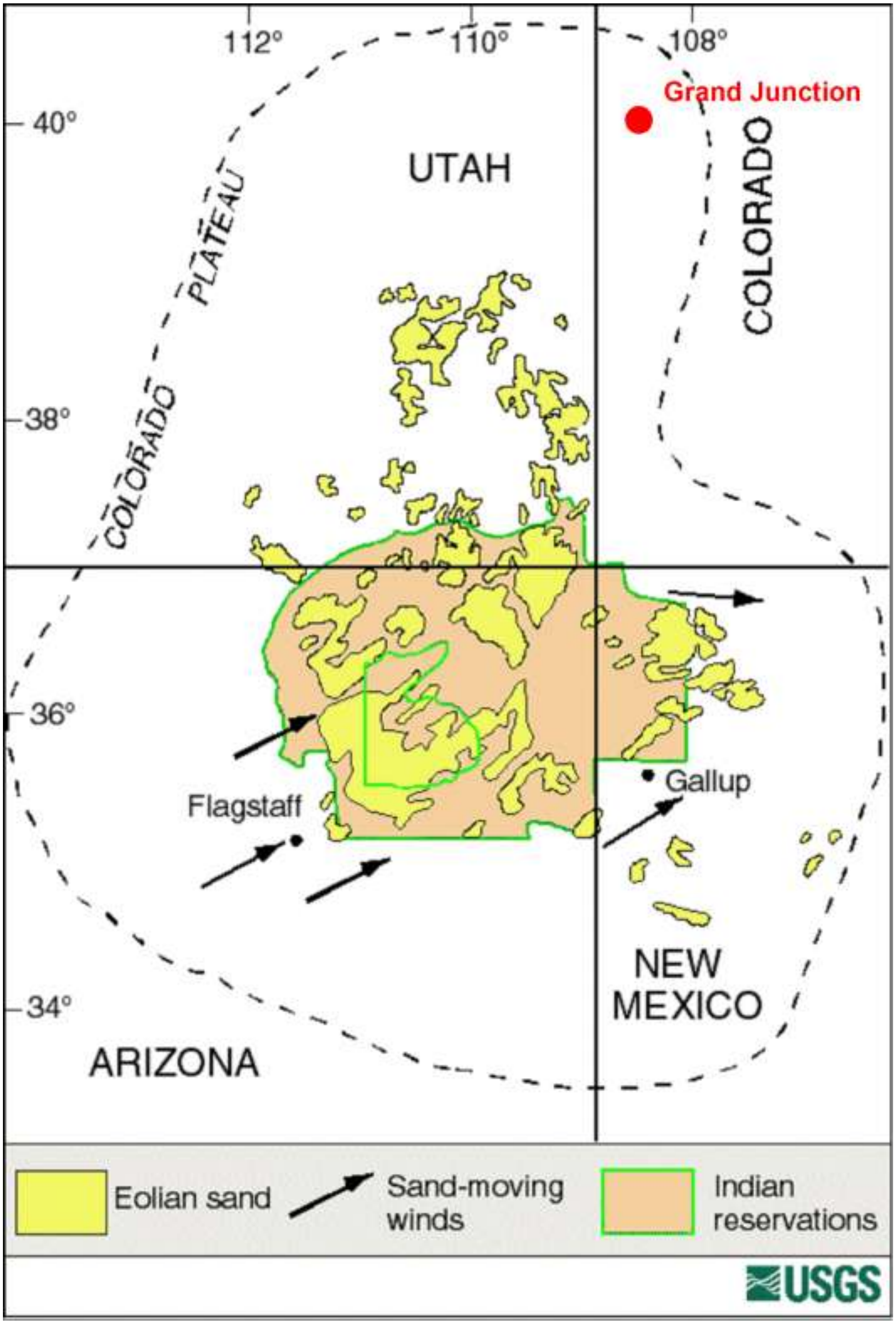


Figure A-15. USGS map of eolian sand features on the Colorado Plateau (http://geochange.er.usgs.gov/sw/impacts/geology/sand/).

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

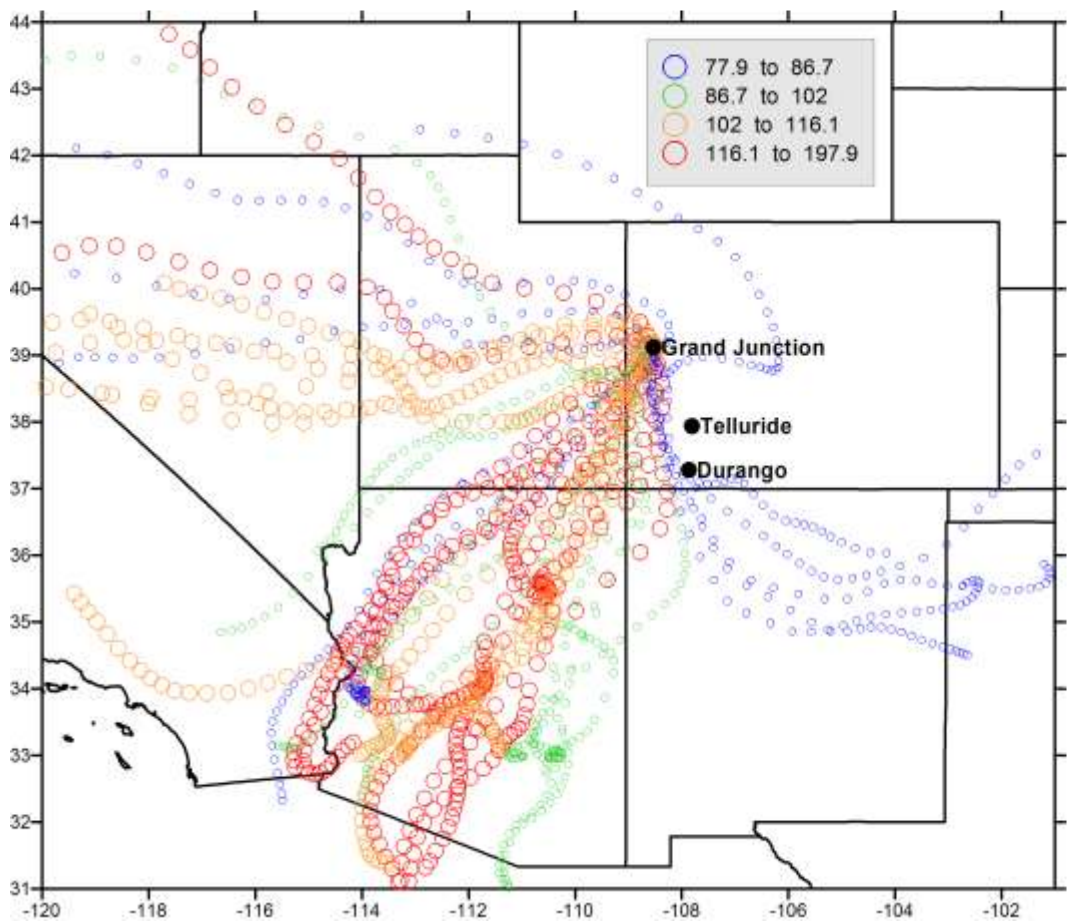


Figure A-17. NOAA HYSPLIT 36-hour back trajectories for Grand Junction for those eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM10 concentrations in excess of 75 ug/m3, strong regional winds, and dry soils. Trajectory points are sized and color-coded to reflect 24-hour PM10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

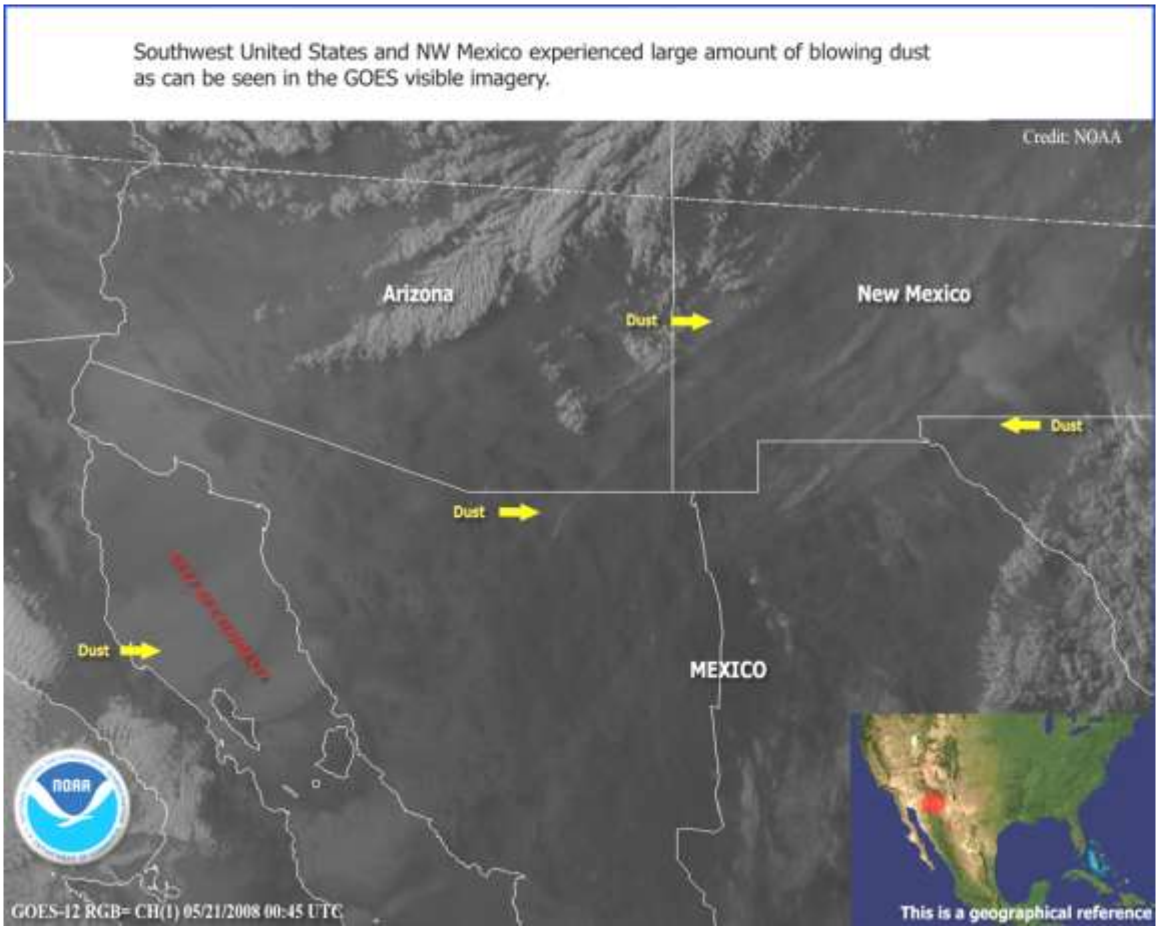


Figure A-18. Discreet plumes of blowing dust in New Mexico, Mexico, and Arizona visible in GOES satellite imagery for May 20, 2008 (http://www.osei.noaa.gov/Events/Dust/US_Southwest/2008/DSTusmx142_G12.jpg).

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.

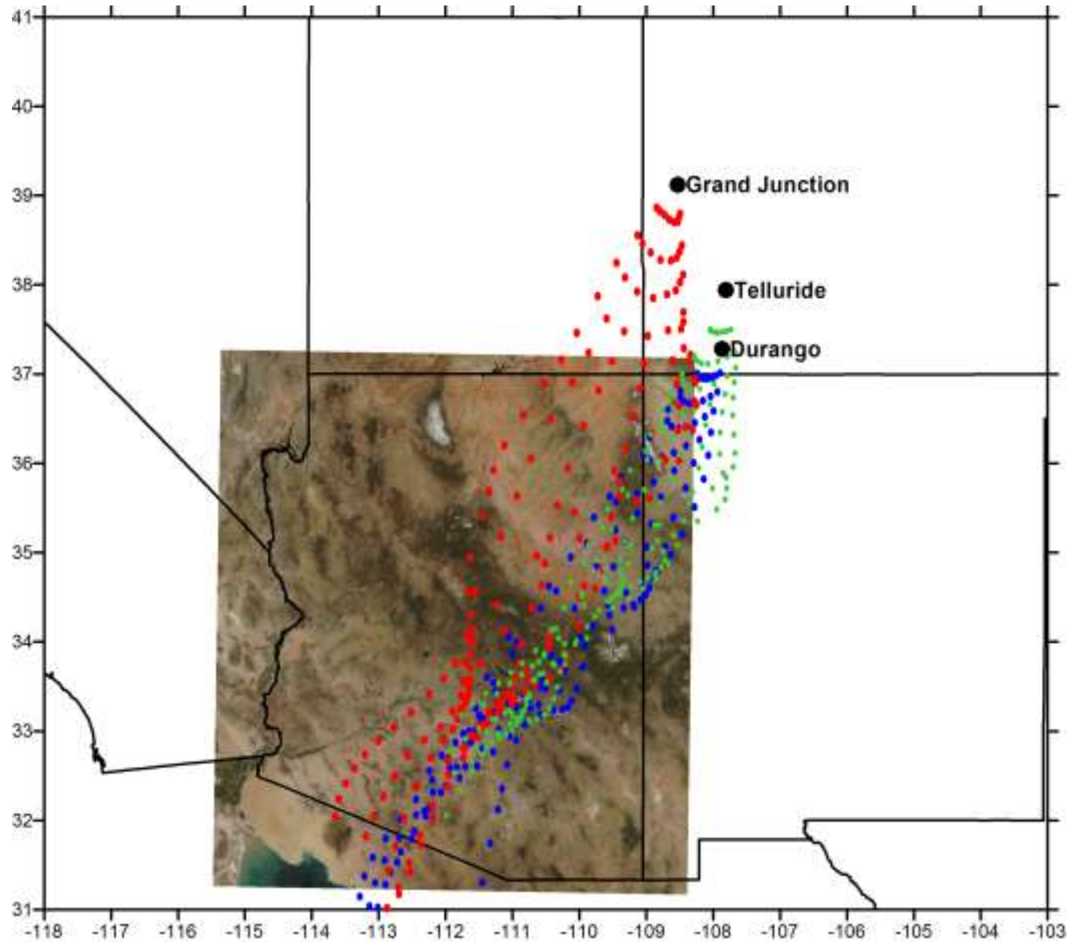


Figure A-19. 24-hour NOAA HYSPLIT back trajectories for every hour from 1500 MST to 2200 MST for Grand Junction (red), Telluride (green), and Durango (blue) for the dust storm of April 19, 2005.

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

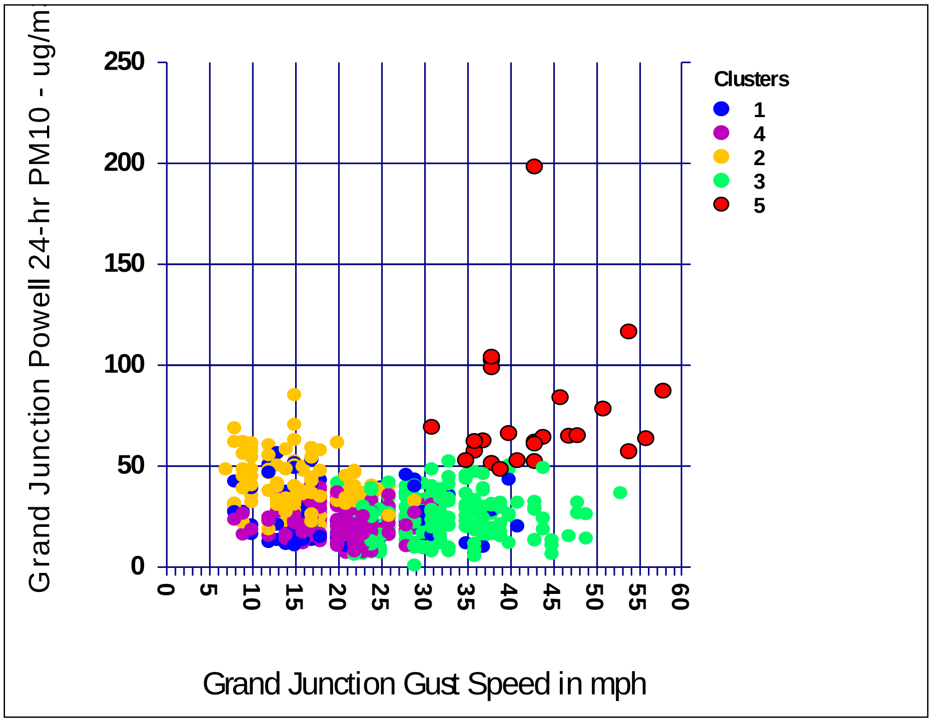


Figure A-20. Grand Junction Powell 24-hour PM10 concentrations versus Grand Junction gust speed by cluster.

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."

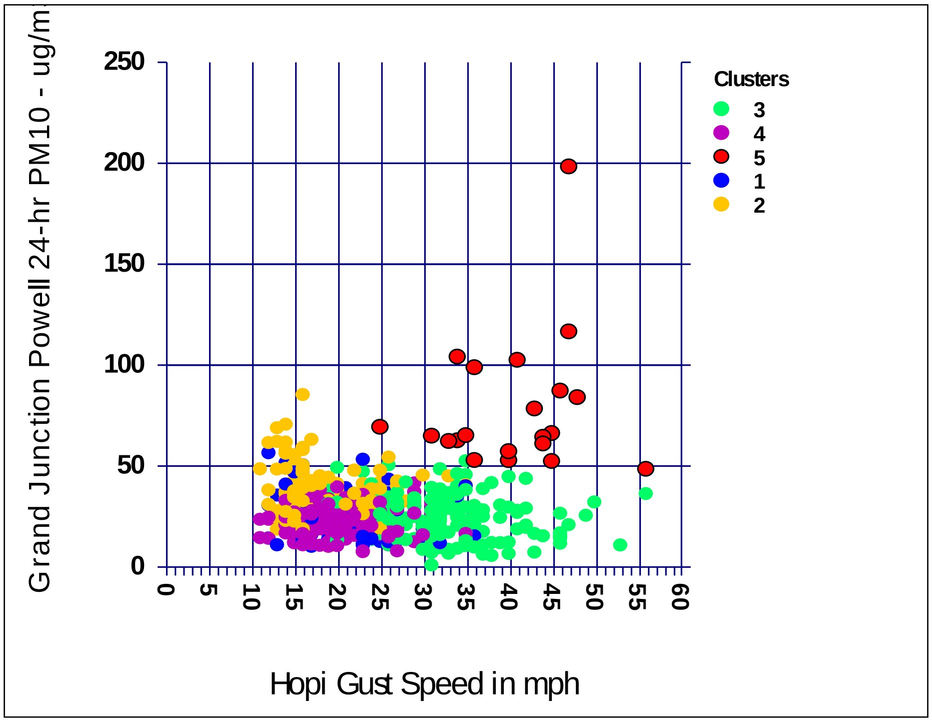


Figure A-21. Grand Junction Powell 24-hour PM10 concentrations versus Hopi gust speed by cluster.

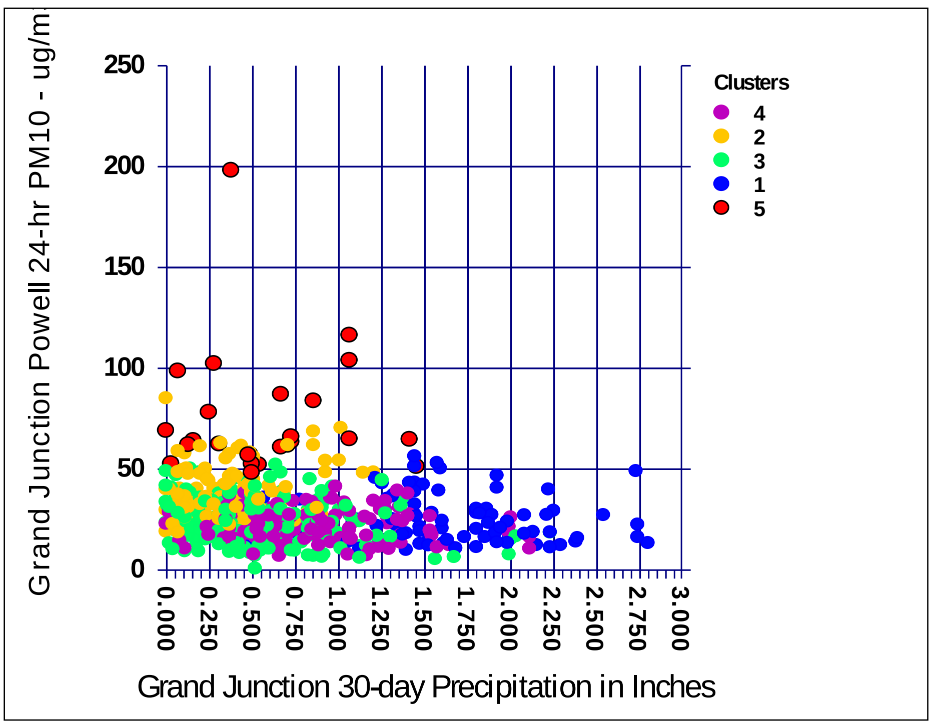


Figure A-22. Grand Junction Powell 24-hour PM10 concentrations versus Grand Junction 30-day total precipitation by cluster.

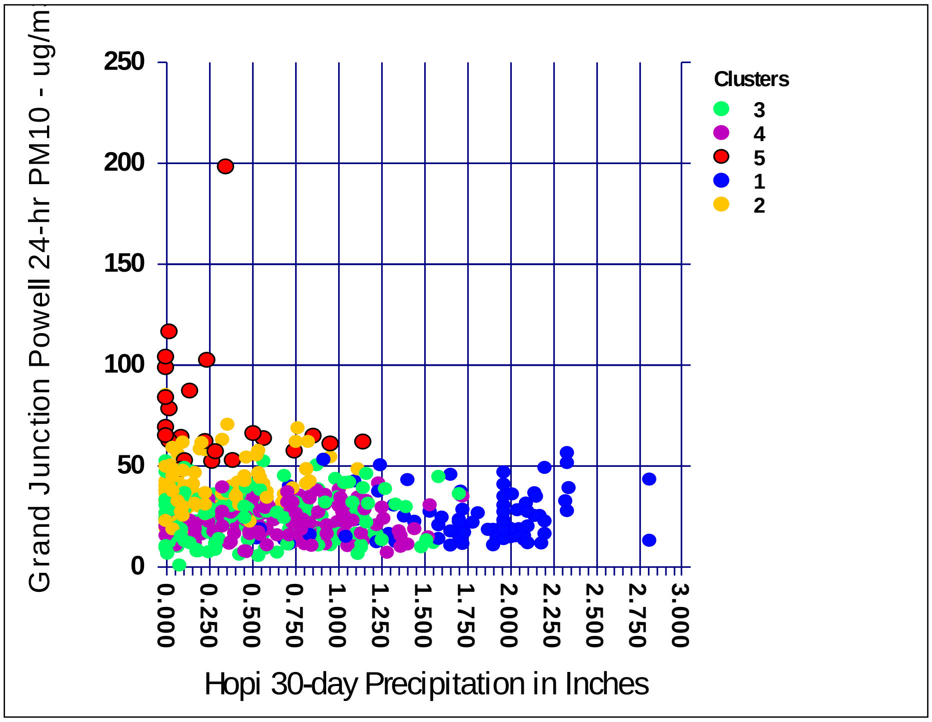


Figure A-23. Grand Junction Powell 24-hour PM10 concentrations versus Hopi 30-day total precipitation by cluster.

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.

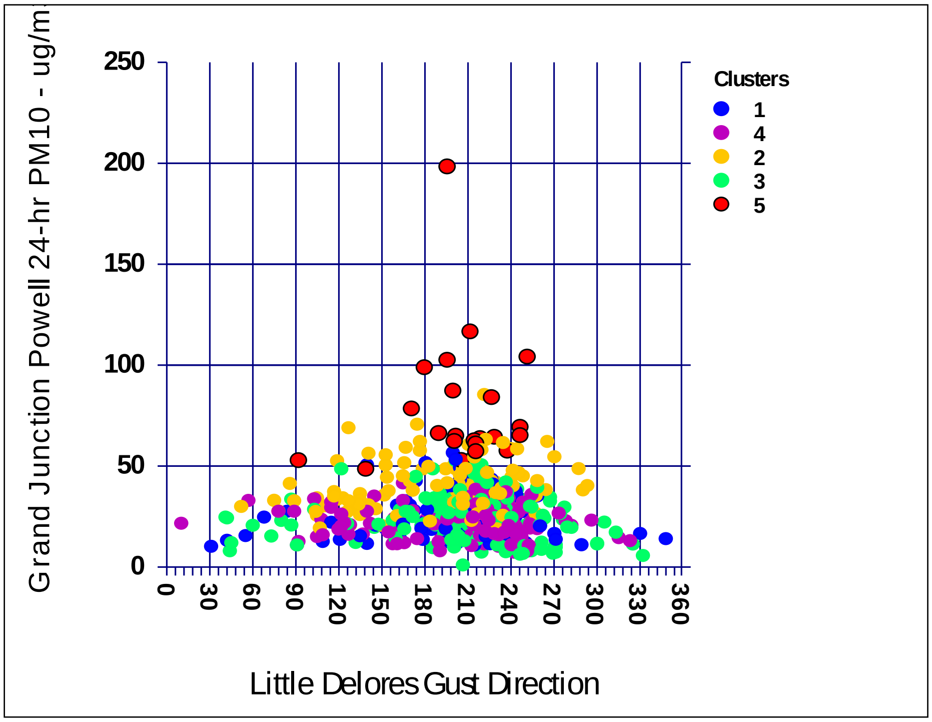


Figure A-24. Grand Junction Powell 24-hour PM10 concentrations versus peak gust wind directions at the Little Delores RAWS weather station, by cluster.

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

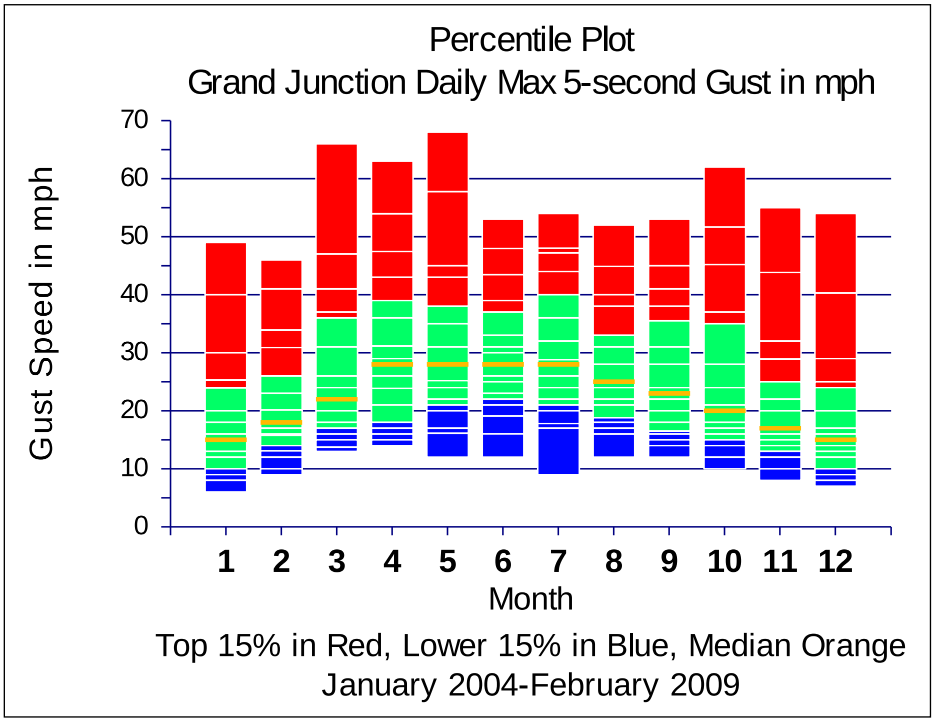


Figure A-25. Percentile plot of Grand Junction daily maximum 5-second gust speed in miles per hour showing that gusts of 40 mph or greater always occur within the top 15 percentile speeds for each month of the year.

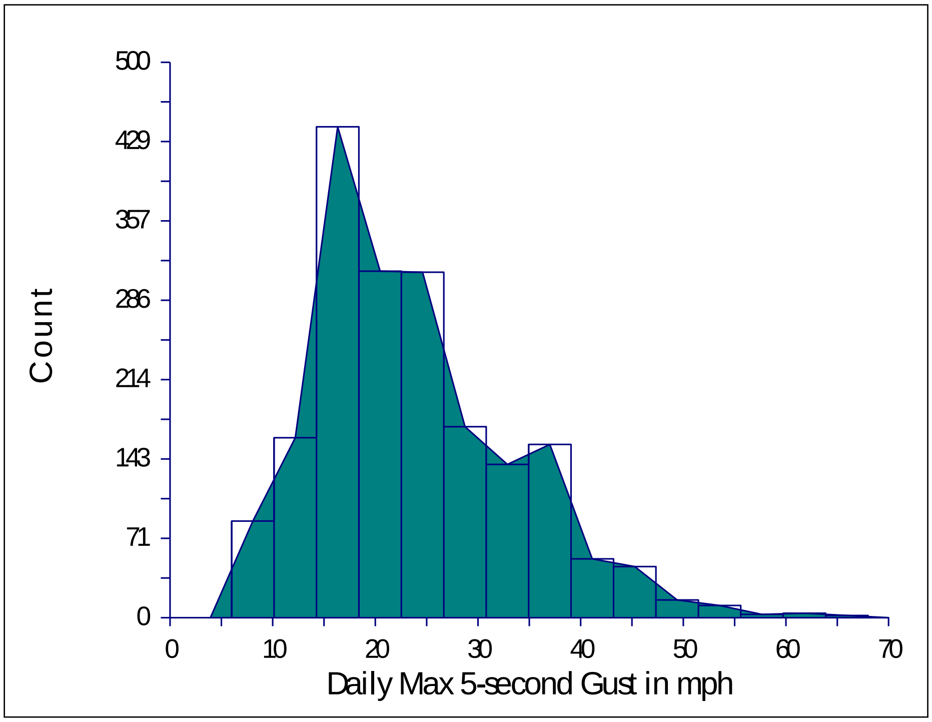


Figure A-26. Histogram of daily maximum 5-second wind gusts at Grand Junction based on January 2004 – February 2009.

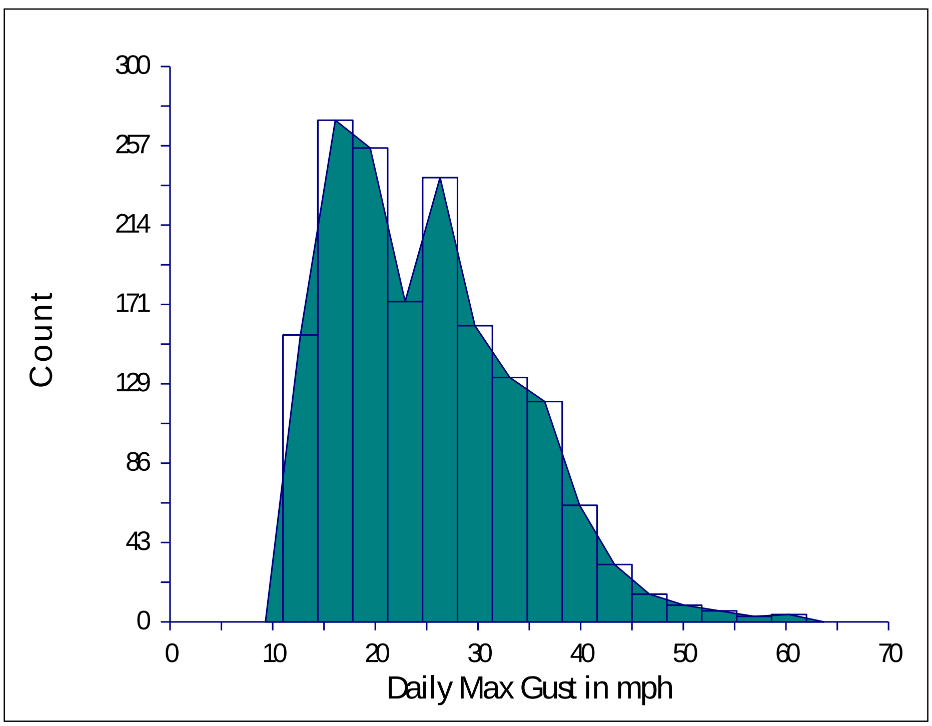


Figure A-27. Histogram of daily maximum 5-second wind gusts at Hopi based on January 2004 – February 2009

Appendix B – Weather Warnings and Blowing Dust Advisories for December 1, 2011

Air Quality Advisory

Denver Metro/Front Range:
Issued: 12/1/2011 2:28:00 PM
Residential Burning Restricted - Visibility
Effective: 12/1/2011 4:00:00 PM - 12/2/2011 4:00:00 PM
Light northeast winds are expected to develop Friday afternoon. These light winds along with a strong inversion are expected to cause Visibility to be in the Poor category Friday afternoon.

Other Areas:
Blowing Dust Advisory for the San Luis Valley
Effective: Dec 1, 2011 1:30 PM to 8:00 PM

Strong easterly winds in the San Luis Valley are causing areas of blowing dust. If significant blowing dust is present and reducing visibility to less than 10 miles across a wide area, the elderly, the very young, and those with respiratory problems should avoid prolonged exertion; everyone else should limit prolonged exertion. Limiting outdoor exposure is also advised.

Denver Metro/Front Range:
Issued: 12/1/2011 1:43:00 PM
Residential Burning Unrestricted - No Action Day
Effective: 11/30/2011 4:00:00 PM - 12/1/2011 4:00:00 PM
Snow will keep pollutant levels the Good category on Thursday.

Other Areas:
Blowing Dust Advisory for the San Luis Valley
Effective: Dec 1, 2011 1:30 PM to 8:00 PM

Strong easterly winds in the San Luis Valley are causing areas of blowing dust. If significant blowing dust is present and reducing visibility to less than 10 miles across a wide area, the elderly, the very young, and those with respiratory problems should avoid prolonged exertion; everyone else should limit prolonged exertion. Limiting outdoor exposure is also advised.

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 PM_{10} (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 PM_{10} 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 PM_{10} emissions; and,

5. Emission controls should be applied to sources that contribute to exceedances of the PM_{10} NAAQS when those controls will result in fewer violations of the standards.

In response to Alamosa's four exceedances of the PM_{10} 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 PM_{10} 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 PM_{10} 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.

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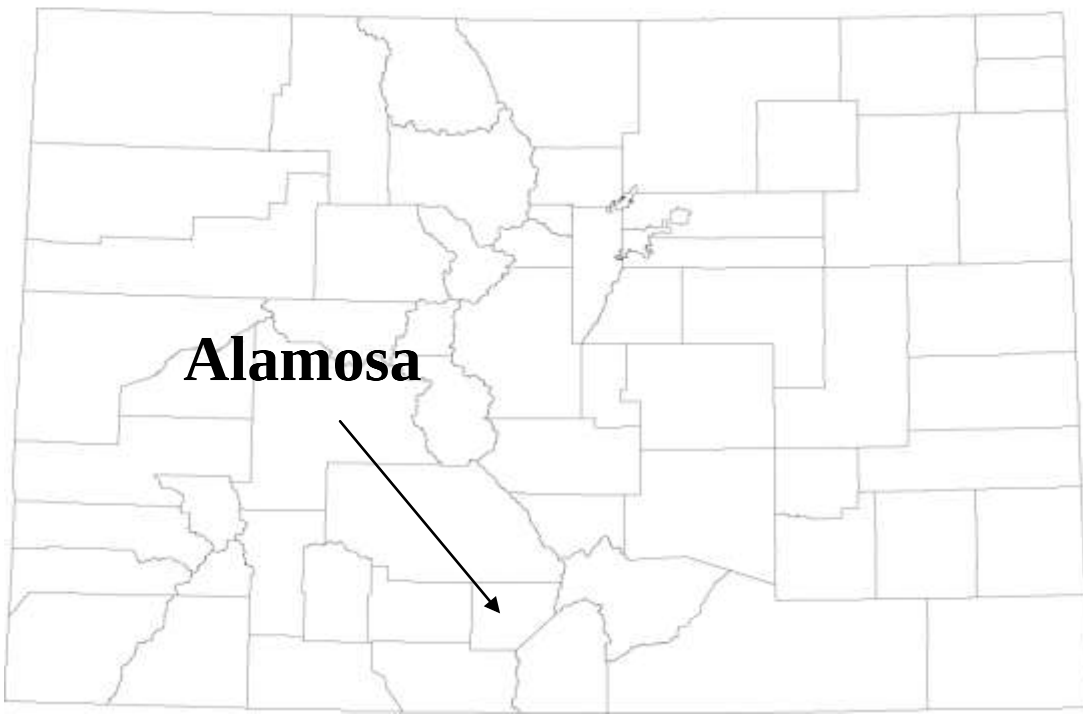
II. INTRODUCTION

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 PM_{10} problems for the area.

Area Map



On March 31 and April 9, 1999 and again on April 18 and December 17, 2000 the PM_{10} monitor located on the roof of Alamosa's Adams State College recorded exceedances of the primary 24-hour NAAQS for PM10. The PM_{10} 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 PM_{10} concentrations measured. This documentation has been previously submitted to EPA.

Recognizing the need to protect public health in areas where PM_{10} 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 PM_{10} 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 PM_{10} monitor at Adams State College, operates on an everyday sampling protocol.

Alamosa's monitoring history shows that the annual PM_{10} standard of 50 $\mu g/m^3$ (averaged over an annual period) has never been exceeded. The 24-hour PM_{10} 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 PM_{10} 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 PM_{10} NAAQS are violated due to natural events. Under this policy three categories of natural events are identified as affecting the PM_{10} 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 PM_{10} 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 PM_{10} 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 PM_{10} 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 PM_{10}, and (d) suggest precautions to take if exposure cannot be avoided.

4. Abate or minimize appropriate contributing controllable sources of PM_{10}. Programs to minimize PM_{10} 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 PM_{10} 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.

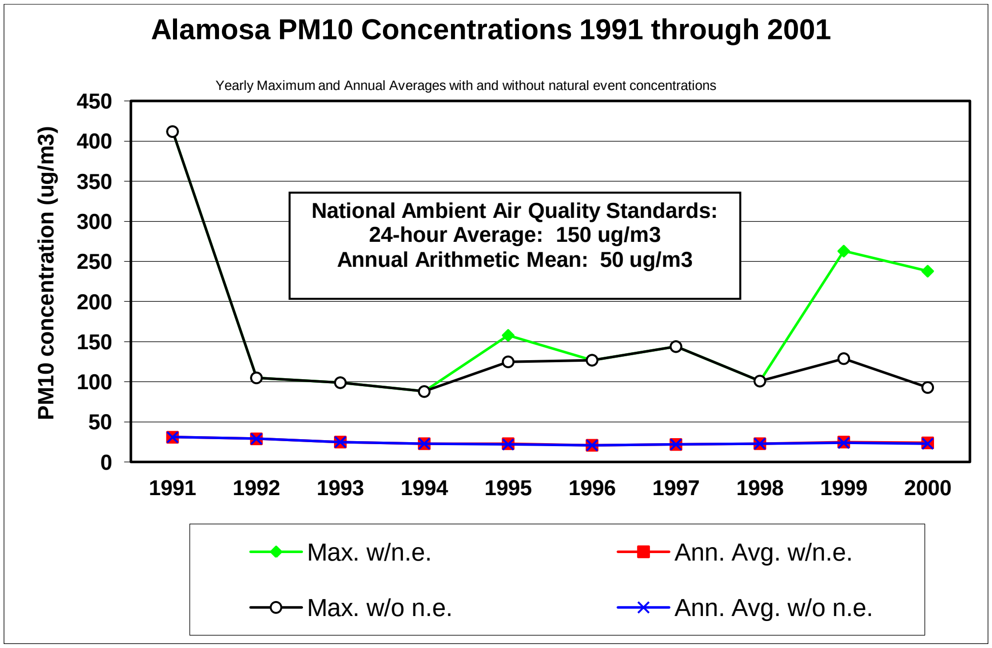
The following text describes the Alamosa NEAP and its conformance with the above-described EPA guidance on natural events.

III. NATURAL EVENTS ACTION PLAN

A. Element 1: <u>Documentation & Analysis</u>

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 PM_{10} (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 PM_{10} NAAQS due to natural events. The documentation contained monitoring data, meteorological data, PM_{10} 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 PM_{10} 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 PM_{10} 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 PM_{10} 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: <u>Public Education Programs</u>

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 PM_{10} 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 PM_{10} 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 PM_{10} 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: <u>Determination and Implementation of BACM</u>

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 PM_{10} 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 PM_{10} NAAQS:

10. High concentrations of PM_{10} 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 PM_{10} 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 PM_{10} emissions and does so through public education and outreach efforts.

(i) Reducing or Postponing Tilling and Plowing or Other Agricultural Practices that Contribute to PM_{10} Emissions- It is well recognized that dust-producing activities such as tilling, plowing, and other agricultural practices increase the amount of PM_{10} released. As such, these control measures were discussed as part of the effort to reduce PM_{10} 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 PM_{10} Stationary Source Emissions

To ensure that PM_{10} 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 PM_{10} emission inventory for the Alamosa area. The following table demonstrates their limited impacts on the total emission estimation.

Alamosa PM_{10} 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. <u>BACM Options Discounted</u>

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 PM_{10}). With that, water restrictions (and related economic impacts of the drought) will likely dictate the utility of this control measure.

4. <u>BACM Implemented</u>

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 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 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 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 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 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.

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 PM_{10} 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 PM_{10} emissions in Alamosa, especially as it relates to impacts on the community and high recorded PM_{10} values. The Division commits to providing copies of this language to EPA upon finalization and availability.

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 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 PM_{10} 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 PM_{10} 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 PM_{10} 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.