Exceptional Events Demonstration Requesting Exclusion of $PM_{2.5}$ and PM_{10} Monitor Values at Pinehurst, Idaho, Impacted by September 15–16, 2013, High Wind Dust Event

State of Idaho
Department of Environmental Quality

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July 2016

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Executive Summary

The high particulate matter (PM) values measured at Pinehurst on September 15 and 16, 2013, exceeded the PM_{10} 24-hour standard and contributed to a violation of the $PM_{2.5}$ annual standard. The event was characterized by extremely high hourly PM_{10} concentrations (over 2,000 micrograms per cubic meter [$\mu g/m^3$]) and high hourly $PM_{2.5}$ concentrations.

Thunderstorms in north-central Oregon produced strong outflow winds that spawned a linear, northeast-traveling gust front. The gust front entrained agricultural soils in northern Oregon and the Horse Heaven Hills of south-central Washington and carried the dust across the Columbia Basin and into the northern Idaho Panhandle. The meteorological data show that the winds in Pinehurst, Idaho, during the day of the dust event were too low to produce this exceptional dust storm locally. All other evidence indicates that the dust event in Pinehurst resulted from the gust front that originated in northern Oregon and south-central Washington.

The State of Washington Department of Ecology (ECY) submitted documentation under the Exceptional Event Rule (EER) to exclude September 15, 2013, PM_{10} data at the Kennewick, Washington, monitor. The ECY documentation is important to the Idaho Department of Environmental Quality's (DEQ's) case for the following reason:

- The source area for the high wind dust storm on September 15, 2013, is located in northern Oregon and Washington. This is outside of DEQ's jurisdiction.

ECY thoroughly documented the soil erosion and dust control practices in effect throughout the source region. Reasonable controls were in place, but the strength of the storm overwhelmed the controls. Extenuating circumstances, such as ongoing drought, early crop kill, and naturally vulnerable soils, all contributed to the susceptibility of the area's soil to entrainment by high winds. The source area is entirely in northern Oregon and Washington, so DEQ will rely on the ECY demonstration for not reasonably controllable or preventable and human activities unlikely to recur or natural event criteria. The ECY demonstration is found at *https://fortress.wa.gov/ecy/publications/SummaryPages/1502018.html.*

To address high monitor values that result from exceptional events that are not reasonably controllable or preventable, the US Environmental Protection Agency (EPA) promulgated EER in 40 CFR 50 and 51 (72 FR 13560) on March 22, 2007. EER allows states to *flag* air quality data as *exceptional* and exclude those data from use in determining compliance with the National Ambient Air Quality Standards (NAAQS) if EPA concurs with the state's demonstration that it satisfies the rule requirements.

As required in the *Final Rule for the National Ambient Air Quality Standards for Particulate Matter* (78 FR 10), DEQ submitted a letter recommending designation status for the $PM_{2.5}$ annual NAAQS for all areas in Idaho, outside the five Indian reservation boundaries. To lower the Pinehurst design value for the annual $PM_{2.5}$ NAAQS, monitor values during the September 15–16, 2013, high wind dust event that meet the criteria for exceptional events must be excluded. Lowering the $PM_{2.5}$ annual design value has regulatory impact because the control measures selected for the West Silver Valley (Pinehurst) attainment demonstration are directly dependent on the design value. In addition, the PM_{10} value on September 15, 2013, exceeding the 24-hour NAAQS should also be excluded as it may influence DEQ's upcoming effort to

remove the PM_{10} nonattainment status for Pinehurst. With the two cases of regulatory impact that this request for concurrence includes, this demonstration falls within EPA policy for determining which concurrence requests to act upon.

Following EER procedures, DEQ flagged $PM_{2.5}$ and PM_{10} values for September 15 and 16, 2013, and requests concurrence that the flagged values are exceptional events (Table A).

Table A. Monitor values for which DEQ is requesting EPA concurrence.

Pinehurst, Shoshone County, Idaho, Monitor Site AQS 16-079-0017 Primary, 24-hour average Filter Dynamics Measurement System Monitor Values		
Date	**$PM_{2.5}$ (µg/m^3)**	**PM_{10} (µg/m^3)**
9/15/2013	25.4	157.1
9/16/2013	20.3	Not requested

DEQ demonstrates in this report, and requests EPA concurrence, that these exceptional concentration values occurred as a result of a high wind dust storm originating in northern Oregon and Washington, that they were not reasonably controllable or preventable by the State of Idaho, and that they fully meet the EER criteria for excluding monitor values from the data used to determine compliance with NAAQS.

Table B summarizes the evidence included in the demonstration that satisfies the required EER elements of the data exclusion request.

Table B. Summary of DEQ demonstration in this report meeting Exceptional Event Rule elements.

Exceptional Event Rule (EER) Element	Section	Summary
Conceptual model (EPA guidance, not an EER element)	1	The conceptual model describes the weather phenomena that caused the event, source area, and path and timeline from source area to monitor.
Not reasonably controllable or preventable (nRCP)	2	Agricultural fields in northern Oregon and south-central Washington are identified as the source area. The area, which is in a state outside of Idaho's jurisdiction, was exposed to thunderstorm outflow winds that overwhelmed any controls that were in place. Dust generation from the source area is *not reasonably controllable or preventable* for DEQ.
Historical fluctuations (HF)	3	The PM_{10} and $PM_{2.5}$ concentrations observed at Pinehurst on September 15 and 16, 2013, are exceptionally high when compared to the 5-year historical record at the monitor. The *historical fluctuations* analysis demonstrates the rarity of the high wind dust event from both an annual and seasonal perspective.
Clear causal relationship (CCR)	4	A *clear causal relationship* between the weather event, source emissions, and elevated concentrations at the Pinehurst monitor is demonstrated by examining the weather conditions that caused the event, analyzing wind data across the event region, inspecting PM concentrations, and exploring the temporal relationship between the event and elevated particulate concentrations at the Pinehurst monitor. A comparison of event-affected days to nonevent days in terms of PM concentrations is also presented. Alternative source hypotheses are discussed and shown to be incapable of creating levels as high as those on the event days.

Exceptional Event Rule (EER) Element	Section	Summary
Affects air quality (AAQ)	5	The *affects air quality* element is met by demonstrating PM_{10} and $PM_{2.5}$ in excess of *historical fluctuations* and by establishing a *clear causal relationship* between the source and monitored values.
Natural event or human activity unlikely to recur (NE/HAUR)	6	The *natural event or human activity unlikely to recur* criterion is met by demonstrating that the event is *not reasonably controllable or preventable* and that a *clear causal relationship* exists between the source and monitored values.
No exceedance *but for* event (NEBF)	7	A quantitative *no exceedance but for* analysis for 2009–2013 shows that the event contributed at least 117.1 µg/m^3 PM_{10} on 9/15/2013. The PM_{10} NAAQS would not have been exceeded but for the event. The percentiles relative to annual data for $PM_{2.5}$ on 9/15 and 9/16, 2013, were 87% and 80%, respectively. The $PM_{2.5}$ concentrations would not have been so high but for the event.
Mitigation	8	Mitigation was not possible given the short-lived duration and overnight timing of the event. DEQ regularly informs the public of ambient air quality levels and provides education concerning actions that individuals may take to reduce exposure to unhealthy levels of air quality during and following such an exceptional event.
EER procedures	9	DEQ met EER procedural requirements for flagging, demonstration, and public comment as summarized in this section.

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Introduction

To address high monitor values that result from exceptional events that are not reasonably controllable or preventable, the US Environmental Protection Agency (EPA) promulgated the Exceptional Rule Event (EER) in 40 CFR 50 and 51 (72 FR 13560) on March 22, 2007. EER allows states to *flag* air quality data as *exceptional* and exclude those data from use in determining compliance with National Ambient Air Quality Standards (NAAQS) if EPA concurs with the state's demonstration that it satisfies the rule requirements.

In this report, DEQ demonstrates, and requests EPA concurrence, that exceptional concentration values that occurred as a result of a high wind dust storm originating in northern Oregon and Washington were not reasonably controllable or preventable by the State of Idaho, and that the conditions fully meet the EER criteria for excluding monitor values from the data used to determine compliance with NAAQS (Appendix A).

1 Conceptual Model

High particulate matter (PM) values measured at the Pinehurst, Idaho, monitor on September 15 and 16, 2013, exceeded the PM_{10} 24-hour standard and contributed to a violation of the $PM_{2.5}$ annual standard. The event was characterized by extremely high hourly PM_{10} concentrations (over 2,000 micrograms per cubic meter [$\mu g/m^3$]) and high hourly $PM_{2.5}$ concentrations. This section discusses a conceptual model for the relationship between the weather conditions and the subsequent spike in PM_{10} and $PM_{2.5}$ values at the Pinehurst monitor.

1.1 Overview

On the afternoon of September 15, 2013, a series of thunderstorms developed in north-central Oregon, near the Washington border. The convective system was strong and created an outflow boundary. The gust front moved towards the northeast, entraining soil from agricultural lands in northern Oregon and Horse Heaven Hills, southwest of Kennewick, Washington. The gust front may have continually picked up dust as it moved across the Columbia Plateau and into Idaho; however, by the time the haboob reached Idaho and DEQ's jurisdiction, the forest-covered landscape and diminished wind speeds make it unikely that dust was entrained in Idaho. The entrained dust formed a haboob (a type of large dust storm carried by a weather front) and was carried across the Columbia Plateau in eastern Washington and into northern Idaho and southern Canada during the evening of September 15 and the early morning hours of September 16. The dust entrainment and transport caused an air quality event throughout the region. Particulate concentrations at Idaho's Pinehurst monitor spiked and caused exceedances of the $PM_{2.5}$ annual NAAQS and the PM_{10} daily NAAQS.

1.2 Contributing Weather Phenomena Synopsis

Around 2 p.m. on September 15, 2013, a mesoscale convective system spawned a squall line of thunderstorms in north-central Oregon. The squall line developed a gust front that intensified

throughout the afternoon as it tracked to the northeast, carrying entrained dust across the Columbia Plateau and into northern Idaho (Figure 1). By 8:30 p.m., radar detected wind speeds ranging from 40 to 80 miles per hour (mph) along the gust front. The storm passed through Spokane, Washington, by 9 p.m., where wind speeds up to 53 mph were recorded (Figure 2). During the following hour, the gust front encountered the complex, mountainous terrain of northern Idaho. As the outflow boundary interacted with the terrain, the gust front split into two discrete segments. One section passed through Coeur d'Alene, Idaho, by 9:53 p.m. By 10:27 p.m., the gust front had passed through Pinehurst (Figure 3).

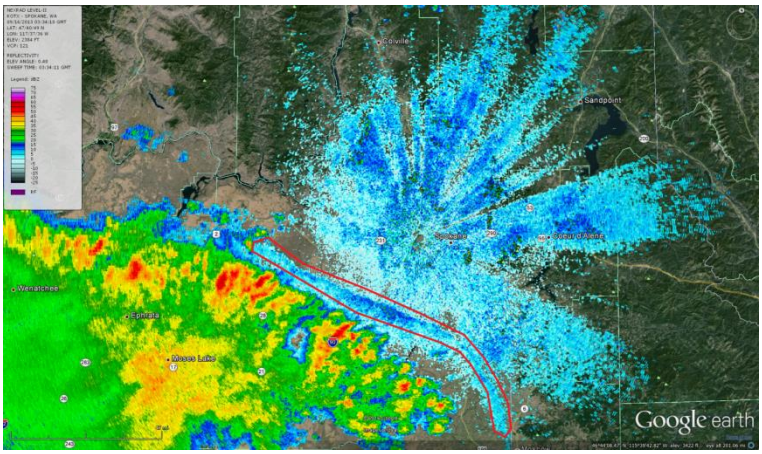


Figure 1. Gust front southwest of Spokane, Washington. Outflow boundary is outlined in red.

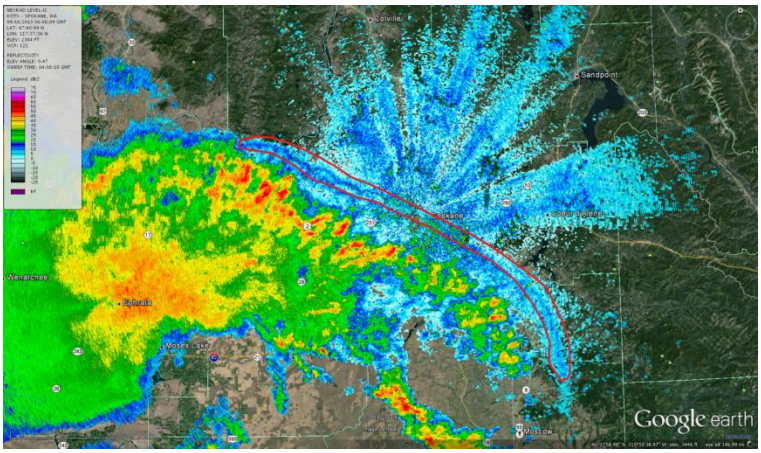


Figure 2. Gust front as it passes through Spokane, Washington.

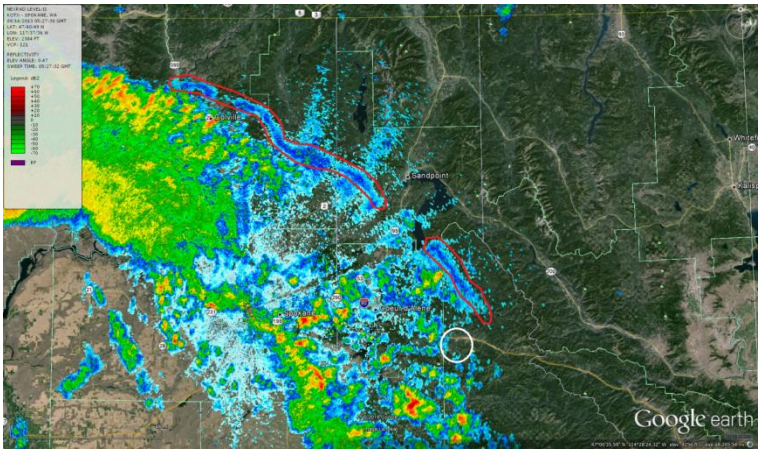


Figure 3. Gust front northeast of Idaho's Silver Valley after passing through Pinehurst. The white circle identifies Pinehurst.

1.3 Sources

The source of the entrained dust is likely in or near northern Oregon and the Horse Heaven Hills area of Washington, southwest of Kennewick in Benton County (Figure 4).

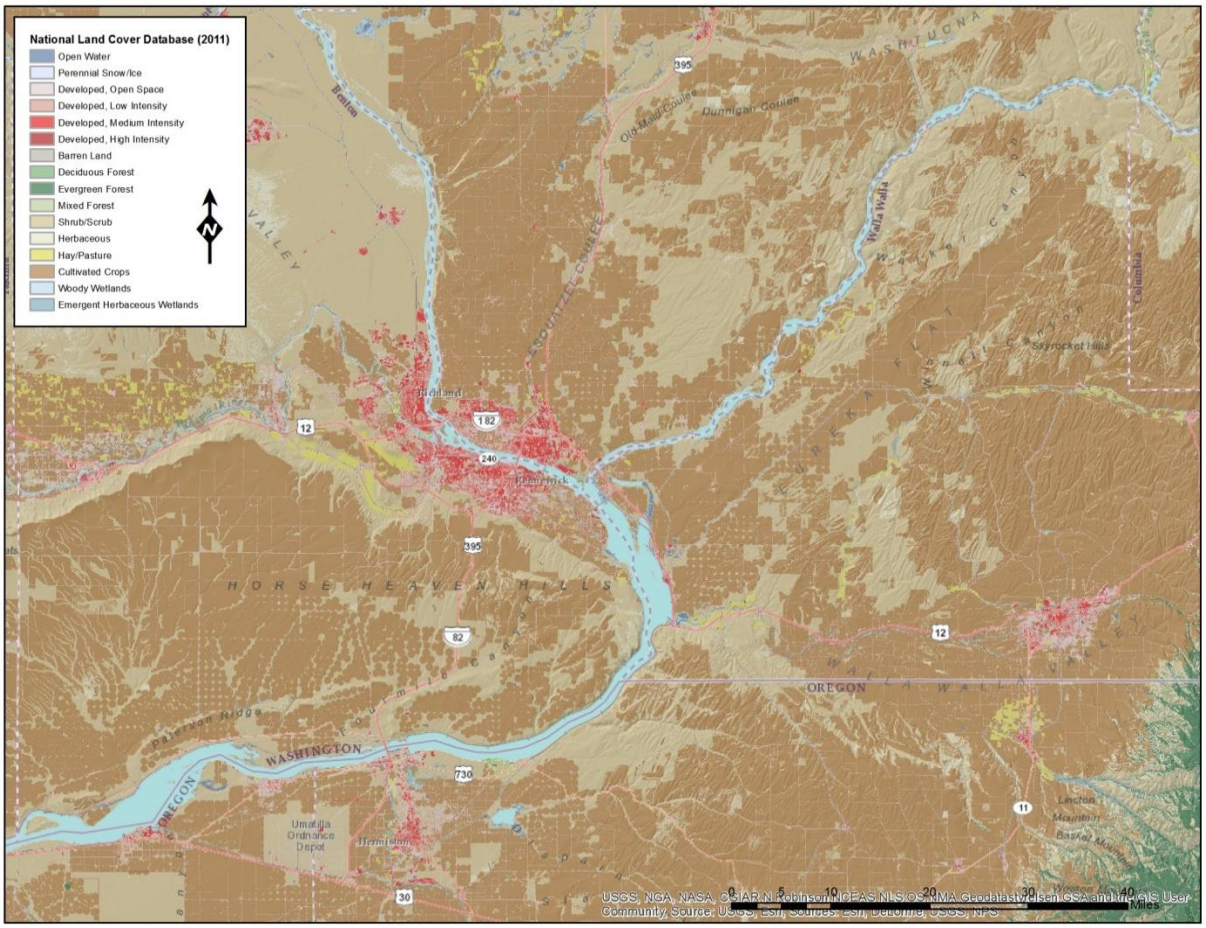


Figure 4. Land cover in the source region of northern Oregon and Kennewick, Washington. Horse Heaven Hills is dominated by cultivated crops and shrub/scrub landscapes.

This area is just north of where thunderstorms were first detected by radar on the afternoon of September 15 (section 4.1, Figure 13). Wind gusts at BPHOR (meteorological station located south of the Horse Heaven Hills) reached nearly 60 mph at 5:40 p.m. and increased to greater than 90 mph at BPKEN (meteorological station located near Kennewick) 40 minutes later (section 4.2, Figure 19). The PM_{10} concentration at Kennewick registered 4,000 µg/m^3 at 5 p.m., indicating that the dust had been entrained by the time the gust front reached Kennewick.

Northern Oregon and the Horse Heaven Hills is an area with land cover dominated by cultivated crops, both irrigated and nonirrigated (Figure 4). A number of factors contributed to making the soils in this region highly erodible. Crop cultivation disturbs the soil and prevents the soil from forming a crust that would stabilize the surface. Soil types in the region are very fine and have difficulty forming strong surface crusts. Preexisting drought conditions also made the soils more susceptible to entrainment during the high wind event on September 15 (Figure 5).

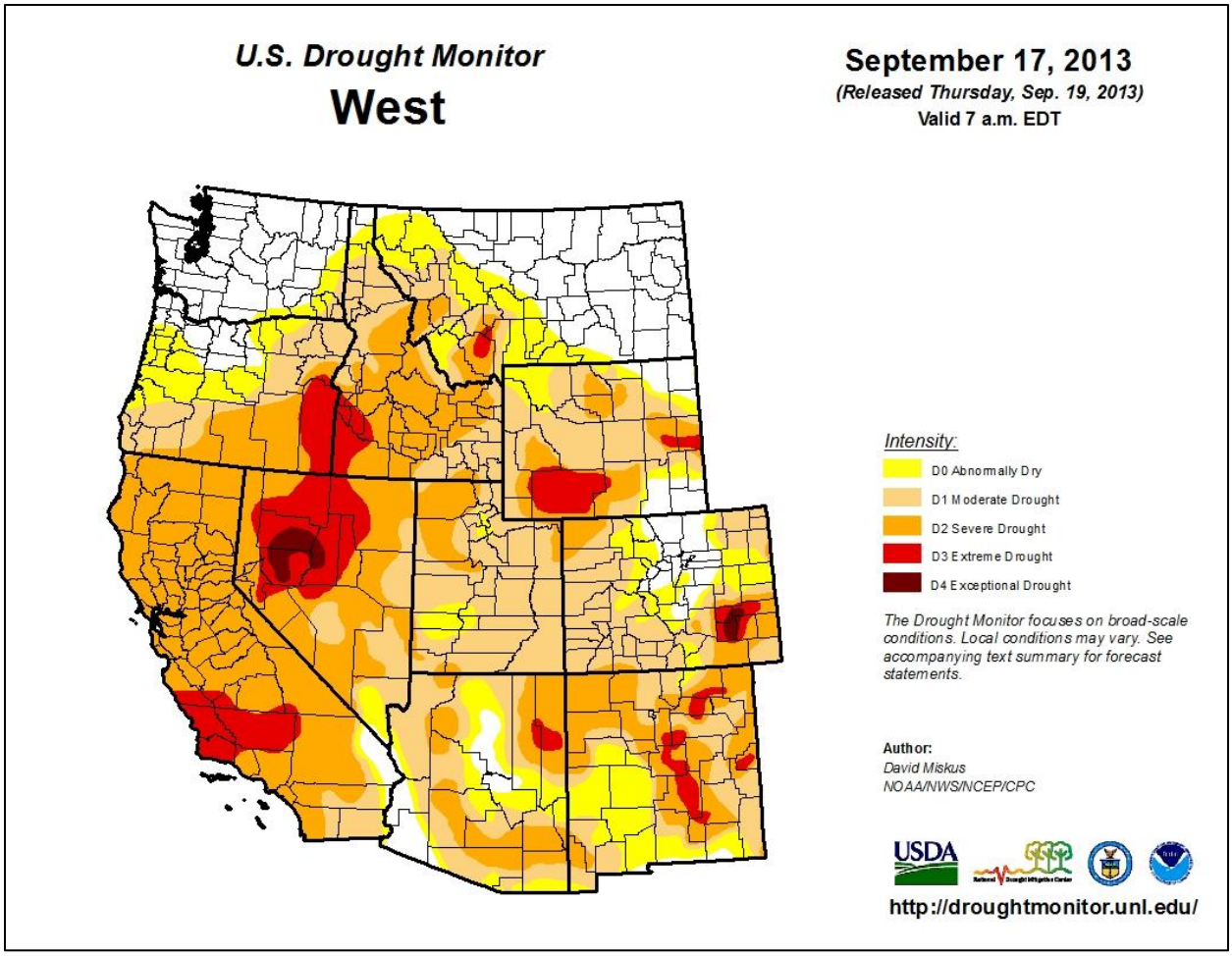


Figure 5. Areas in western United States experiencing drought in September 2013.

Finally, the spring crop had been killed by a late season frost and, therefore, the fields lacked the typical wheat residue usually present in the fall that acts to anchor the soil in place. These combined factors made the soils in northern Oregon and the Horse Heaven Hills source area highly susceptible to entrainment by high winds. The State of Washington Department of Ecology (ECY) exceptional event demonstration for this same event contains additional details on the source region (*https://fortress.wa.gov/ecy/publications/SummaryPages/1502018.html*).

It is unlikely that additional dust was entrained in Idaho along the gust front. By the time the haboob reached Idaho, the winds had diminished below the threshold for entrainment. The land cover between the border and Pinehurst that is within DEQ's jurisdiction (e.g. outside the Coeur d'Alene Indian Reservation boundary) is heavily forested and would not provide a source of dust for entrainment (Figure 6).

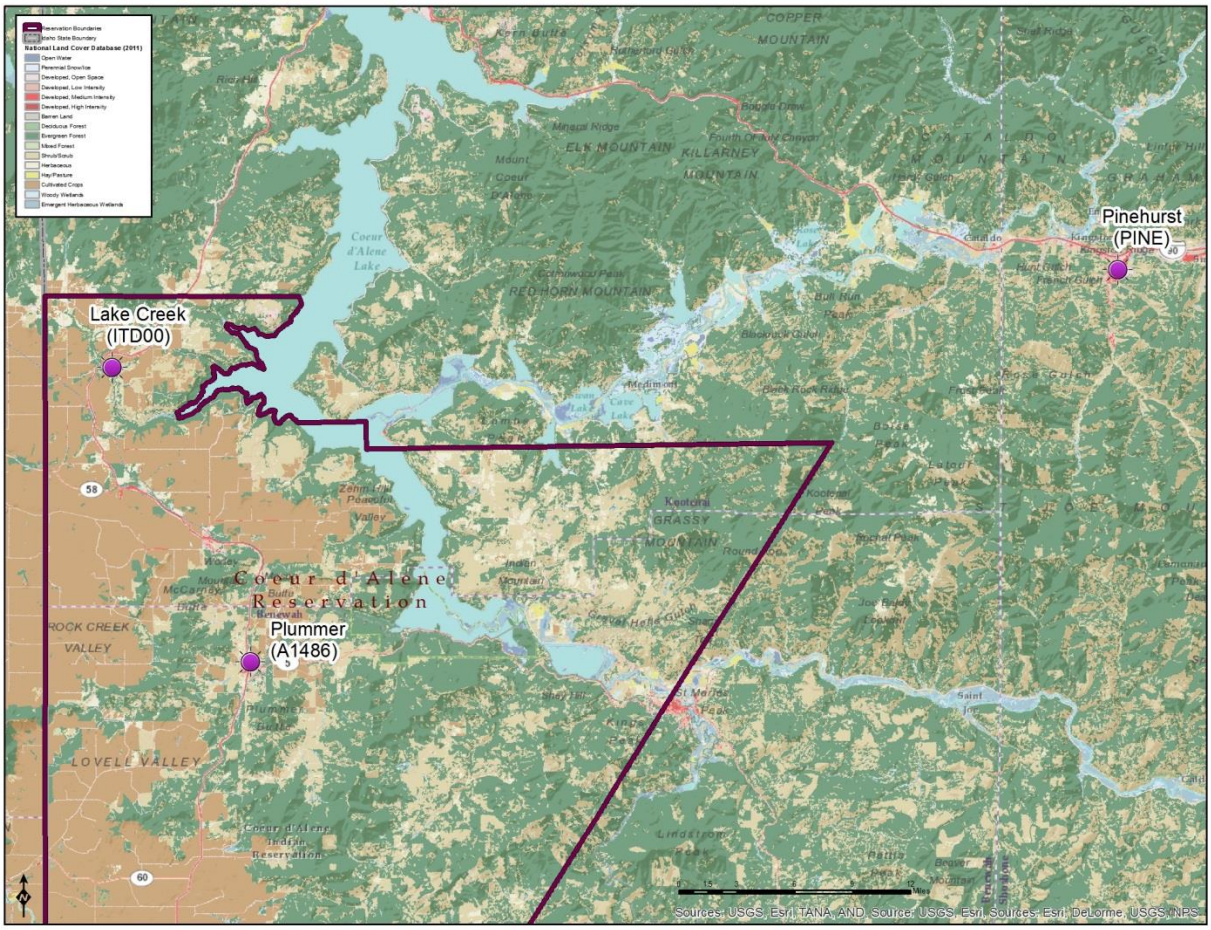


Figure 6. Land cover in Idaho along the gust front path. Dark green is evergreen forest, which dominates the landscape in the area downwind of Pinehurst and outside the Coeur d'Alene Reservation boundary.

1.4 Path and Timeline from Source Area to Monitor

The path of the gust front from source area to monitor can be reconstructed by following wind speed spikes and directions at meteorological stations located across the region of impact, from the Horse Heaven Hills in Washington to Sandpoint in northern Idaho. Concentrations at PM_{10} monitors along the same path tell a similar story, spiking one by one as the gust front passed through the area. The PM_{10} concentration at the Pinehurst monitor reached a concentration greater than 2,000 µg/m^3 at 9 p.m. on September 15 when the gust front passed through Pinehurst. This value is well beyond that recorded during a normal day.

Figure 7 identifies the gust front arrival times across the region. Times are estimated from the National Weather Service radar loop. The gust front arrived in Kennewick, Washington, at 5:09 p.m. and was tracked through Bonners Ferry, Idaho, at 11 p.m. It entered Pinehurst at 9:10 p.m.

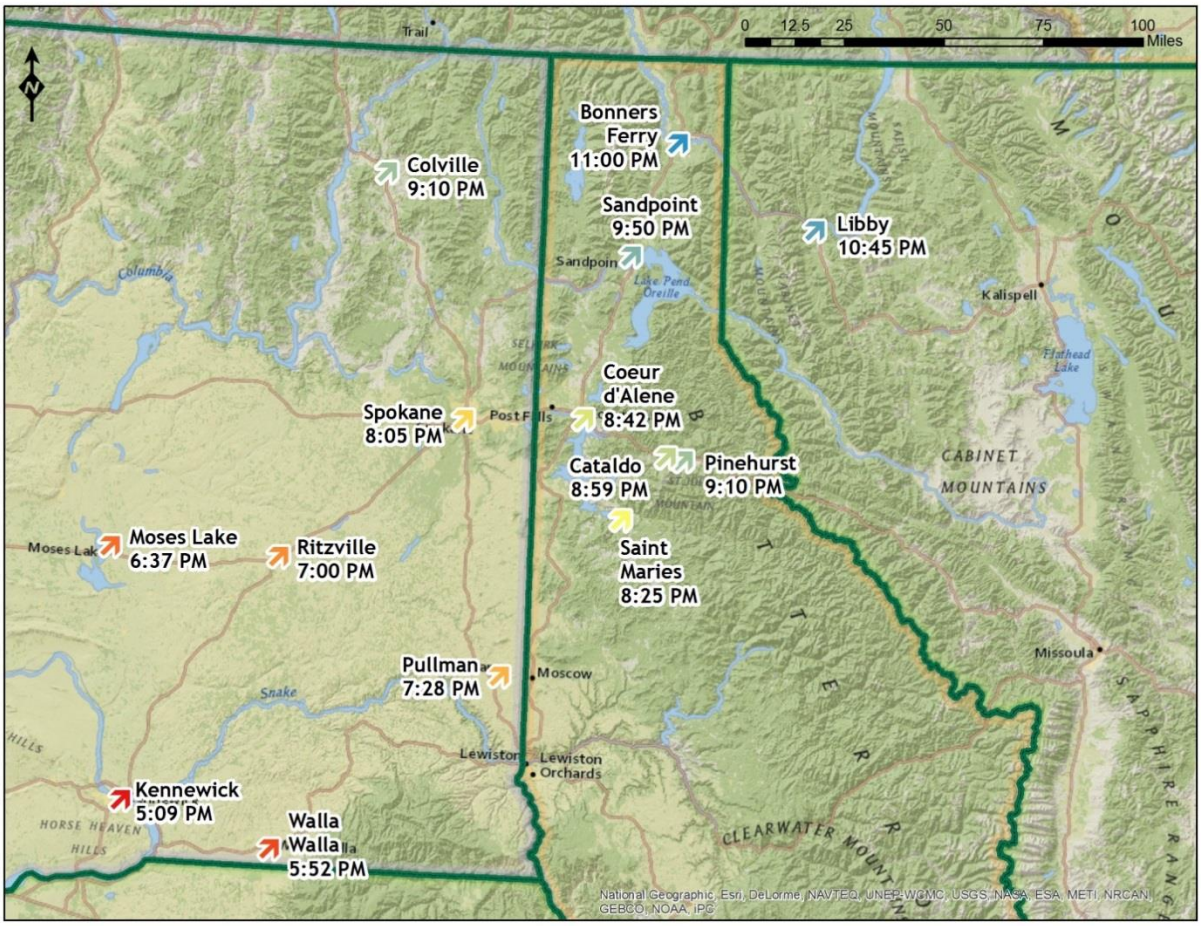


Figure 7. Gust front arrival times (Pacific daylight time) on September 15, 013.

Wind speeds, wind direction, particulate concentrations, and timing will be examined in depth in Section 4, "Clear Causal Relationship."

Reports about the haboob on September 15, 2013, were published on the Internet, and a variety of eyewitness reports are provided in Appendix B.

2 Not Reasonably Controllable or Preventable

As described in section 1.1, the $PM_{10}/PM_{2.5}$ event at Pinehurst was caused by a thunderstorm outflow boundary that originated along the state line between north-central Oregon and south-central Washington. The dust was entrained from agricultural fields in northern Oregon and the Horse Heaven Hills, southwest of Kennewick, Washington. The location and scale of the emission sources and the weather conditions were all beyond DEQ's control.

An extensive discussion of the source soil regions, along with dust and soil management practices, is provided by ECY in the exceptional event demonstration (*https://fortress.wa.gov/ecy/publications/SummaryPages/1502018.html*). In the demonstration, ECY shows that reasonable controls were in place in the source region, but the controls were

overwhelmed by the high winds associated with the thunderstorm outflow and subsequent gust front.

The exceptional event occurred in northern Oregon and Washington, which is outside of DEQ's jurisdiction; therefore, the contributing emissions from the upwind state were not reasonably controllable or preventable, and the criterion is satisfied.

3 Historical Fluctuations

The days requested for removal from the record are compared to historical values during the past 5 years at the Pinehurst monitor. Figure 8 compares the 24-hour average PM_{10} concentration at Pinehurst on September 15, 2013, to all other daily values during January 1, 2009, to December 31, 2013. The 5-year average daily concentration is 14.7 µg/m^3 identified by the red line in Figure 8. The 5-year 95th percentile is 29 µg/m^3 identified by the green line in Figure 8. On the event day, September 15, 2013, the concentration is 157.1 µg/m^3, which is the highest value for the entire period. The closest value was 156 µg/m^3 on August 26, 2010. A high wind dust event also occurred on this day. This initial comparison to historical values shows that the PM_{10} concentration on September 15, 2013, was a rare and exceptional event.

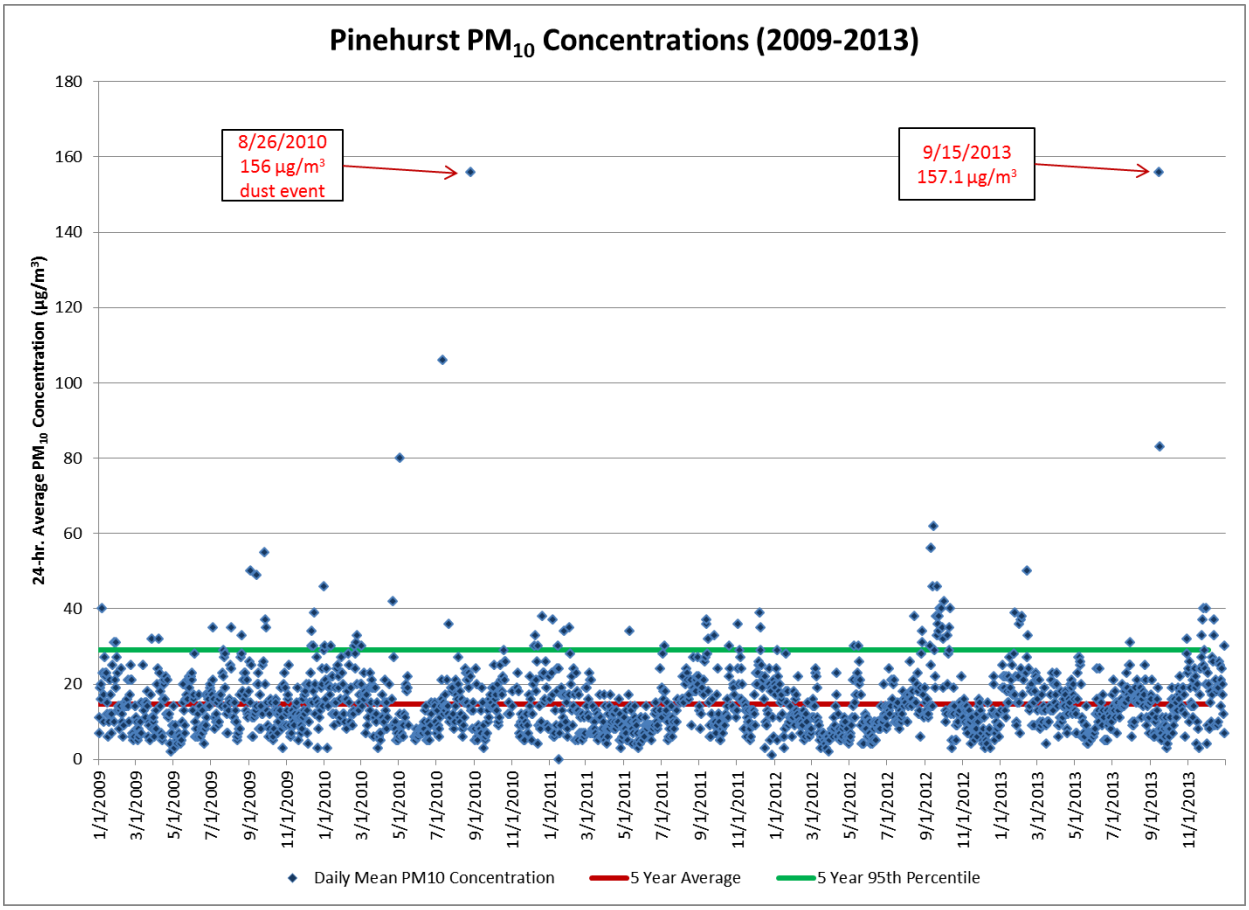


Figure 8. Daily PM_{10} concentrations from 2009–2013 in Pinehurst, Idaho.

Next, the concentration on the event day is compared to a seasonal 5-year dataset in Figure 9. Since high wind dust events do not typically occur during a particular season in the Pacific Northwest, a comparison was made using values from September during the 5-year period. The 5-year September average is 19 µg/m^3 (red line), and the 95th percentile is 46 µg/m^3 (green line). These values are higher than the statistics for the annual dataset. Regardless, the event day again stands out when compared to the seasonal data as a rare and exceptional event. The concentration was the highest to have occurred during five Septembers between 2009 and 2013. The concentration nearest to the event day value is 83 µg/m^3 occurring the day after the event day (September 16, 2013) when dust from the event was still settling in Pinehurst. The second comparison to historical seasonal concentrations reinforces the outlier status of this event on PM_{10} concentrations at the Pinehurst monitor.

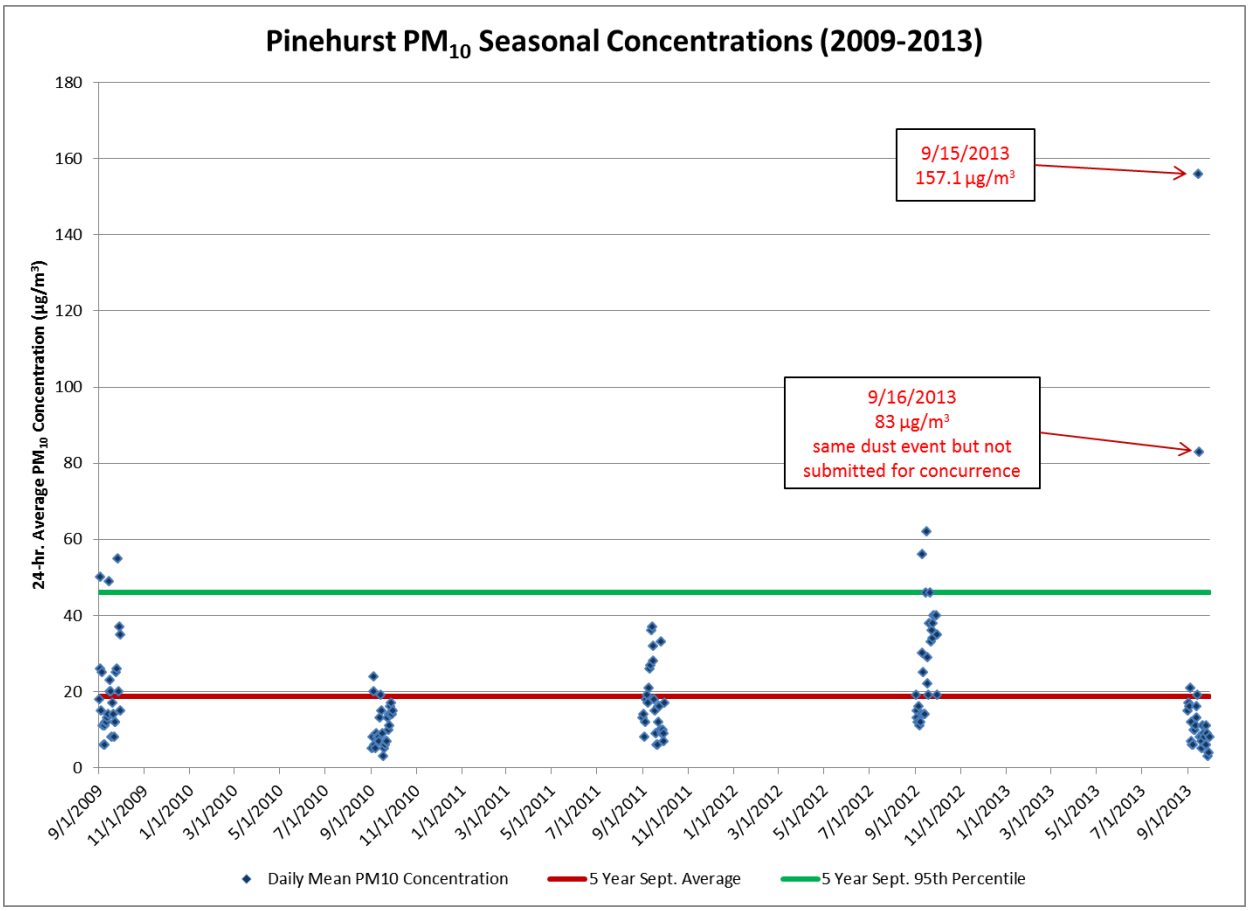


Figure 9. Daily PM_{10} concentrations for September from 2009–2013 in Pinehurst, Idaho.

The same comparisons to historical data were made for the two $PM_{2.5}$ daily values requested for exclusion. Figure 10 identifies the two event days (September 15 and 16, 2013) in the red circles. The 24-hour average $PM_{2.5}$ concentrations for those days, 25.4 and 20.3 µg/m^3, respectively, are greater than the 5-year average of 13.6 µg/m^3 and less than the 95th percentile of 33.6 µg/m^3. Many values during the period are higher than the event days, mainly during the residential wood combustion season in the winter and wildfire and prescribed burning seasons in the summer and fall. By looking at the seasonal comparison, the rarity of the event days becomes clearer. Note

that the request for exclusion for these $PM_{2.5}$ days is for the annual NAAQS (12.0 µg/m^3) and not for the daily NAAQS (35 µg/m^3).

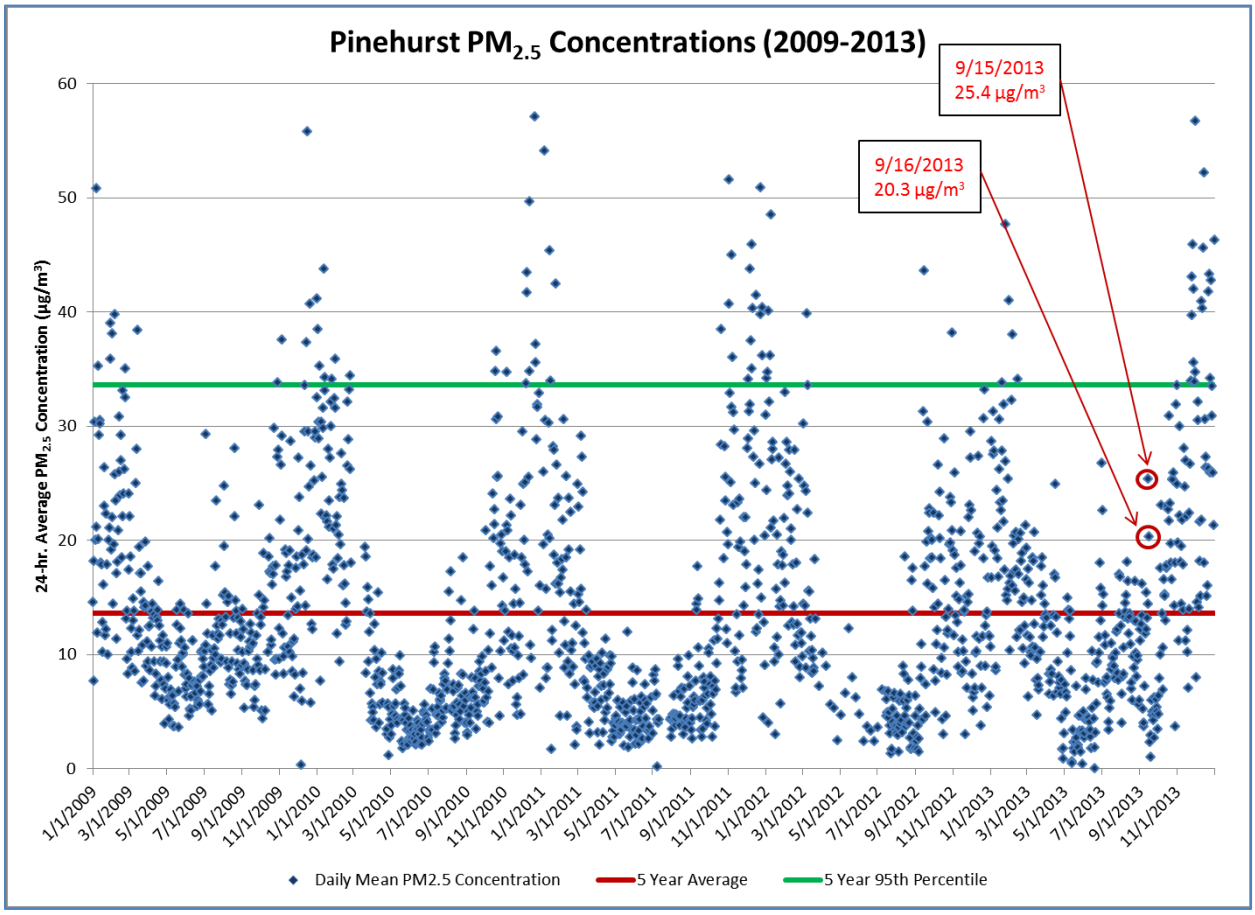


Figure 10. Daily $PM_{2.5}$ concentrations from 2009–2013 in Pinehurst, Idaho.

When the $PM_{2.5}$ event days are compared to the seasonal dataset (Figure 11), they occupy the higher end of days in Septembers from 2009–2013. After identifying previous exceptional event days within the dataset that have been either concurred or submitted, the event days indicate even higher values. The September 15, 2013, event day results in the highest value in the seasonal dataset with September 16 as the third highest value.

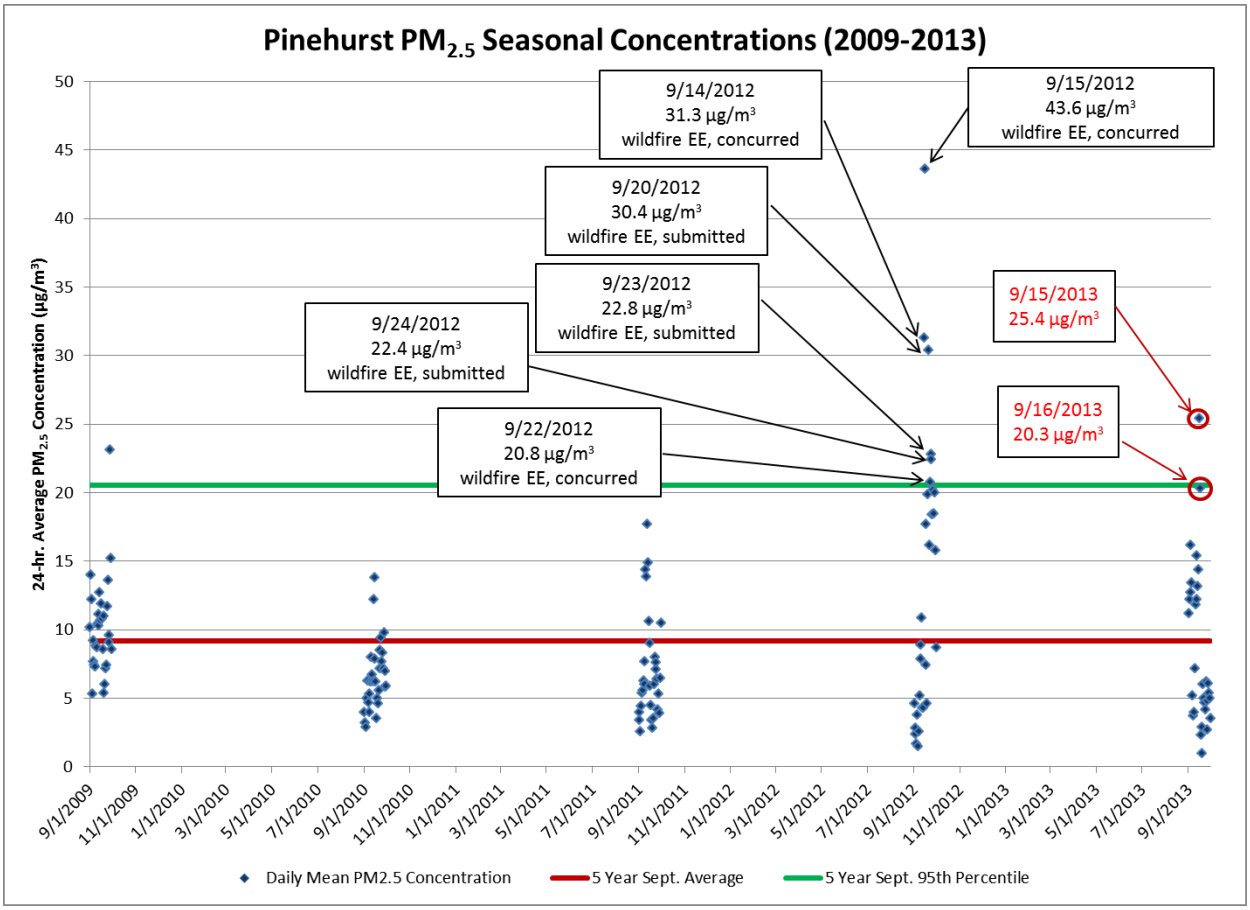


Figure 11. Daily $PM_{2.5}$ concentrations for September from 2009–2013 in Pinehurst, Idaho.

The seasonal historical comparison reveals that wildfire season is still in full swing during September. Wildfire impacts on the monitor cause $PM_{2.5}$ excursions regularly in September. $PM_{2.5}$ from the high wind dust event examined comes from a different source (soils) than $PM_{2.5}$ derived from wildfire events (biomass burning), so it is instructive to examine the seasonal data in terms of PM_{coarse}, to identify from which source the $PM_{2.5}$ is derived.

Figure 12 charts the PM_{coarse} concentrations for the seasonal data. The wildfire events fall out because the coarse fraction from biomass burning is much lower than the fraction from dust. Now a better comparison can be made, and the days requested for exclusion are more obviously rare and exceptional events.

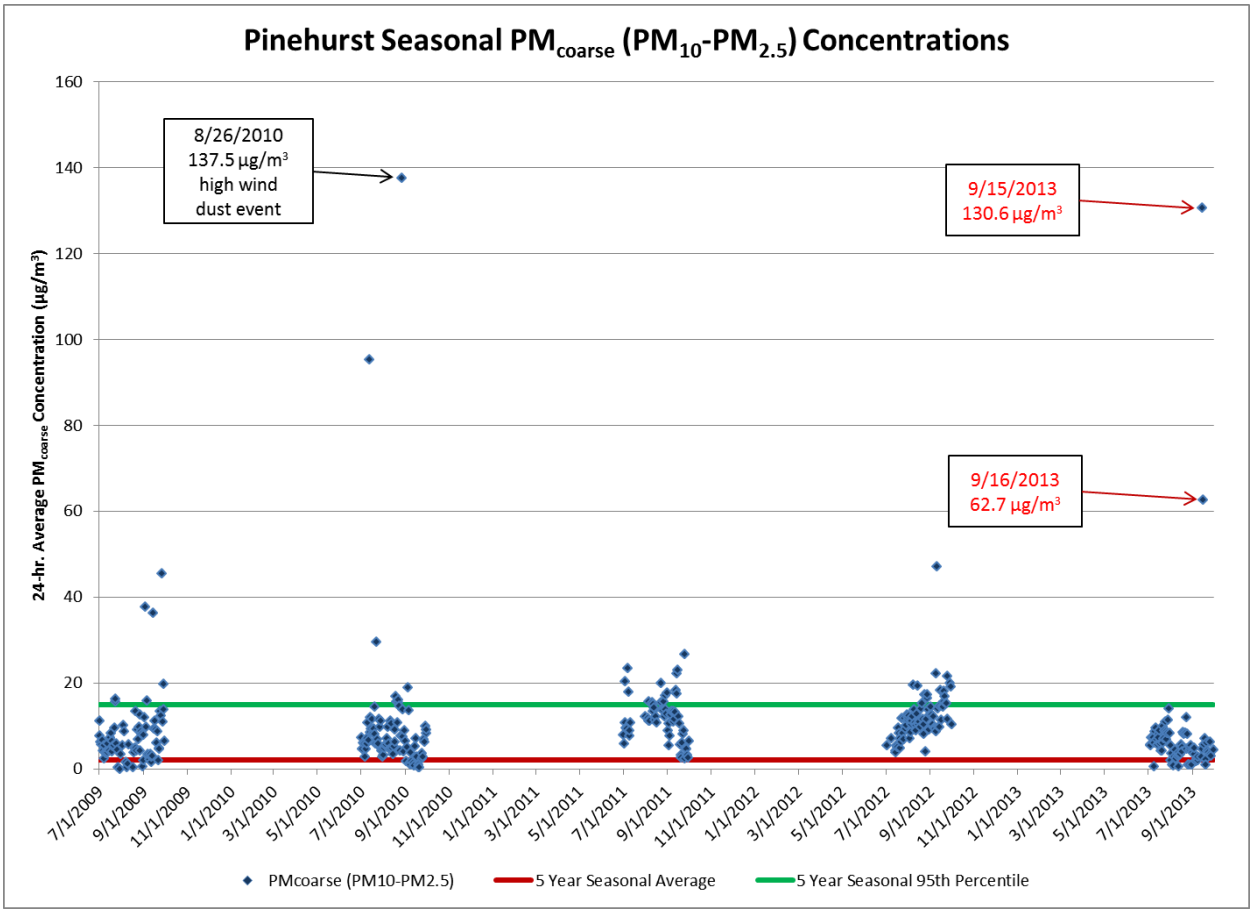


Figure 12. Daily PM_{coarse} concentrations for July–September from 2009–2013 in Pinehurst, Idaho.

Table 1 presents the percentile statistics from the historical comparisons. For the PM_{10} event day (September 15, 2013), the percentile relative to the 5-year dataset is 1. When the dust event on August 26, 2010, is removed, the percentile is also 1. The percentile relative to the September days is 1 for PM_{10}. For the $PM_{2.5}$ event days (September 15 and 16, 2013), the statistics are presented for both $PM_{2.5}$ and PM_{coarse}. Compared to the annual data, the percentiles for $PM_{2.5}$ are 0.866 and 0.79. These values rise slightly, to 0.867and 0.793, when exceptional event days in 2012 are removed. The percentiles relative to the seasonal data, 0.979 and 0.946, are much higher, and rise even more to 1 and 0.986 with exceptional event days removed. The PM_{coarse} percentiles are universally high when compared to both annual and seasonal data.

Table 1. Percentile statistics with respect to annual and seasonal datasets, with and without dust events or other exceptional events, 2009–2013.

Pollutant	Date	Concentration ($\mu g/m^3$)	Percentile Relative to			
			Annual Data[a]	Annual Data without Dust Event or Other Exceptional Events	Seasonal Data	Seasonal Data without Dust Event or Other Exceptional Events
Number of Observations			*1,751*	*1,750*[b]	*146*[c]	*NA*
PM_{10}	9/15/2013	157.1	100%	100%	100%	NA
Number of Observations			*1,658*	*1,652*[d]	*150*[c]	*144*[e]
$PM_{2.5}$	9/15/2013	25.4	87%	87%	98%	100%
$PM_{2.5}$	9/16/2013	20.3	79%	79%	95%	98%
Number of Observations			*1,593*	*1,592*[f]	*414*[g]	*413*[h]
PM_{coarse}	9/15/2013	130.6	99%	100%	99%	100%
PM_{coarse}	9/16/2013	62.7	99%	99%	99%	99%

a. Annual data including all observations, 2009–2013
b. Annual data excluding 8/26/2010 for PM_{10}
c. Seasonal data including all observations in September, 2009–2013
d. Annual data excluding 9/14/2012, 9/15/2012, 9/20/2012, 9/22/2012, 9/23/2012, and 9/24/2012 for $PM_{2.5}$
e. Seasonal data (September, 2009–2013) excluding 9/14/2012, 9/15/2012, 9/20/2012, 9/22/2012, 9/23/2012, and 9/24/2012 for $PM_{2.5}$
f. Annual data excluding 8/26/2010
g. Seasonal data including all observations in July, August, and September, 2009–2013
h. Seasonal data excluding 8/26/2010
Note: NA – not applicable

It is clear from these statistics that the PM_{10} and $PM_{2.5}$ concentrations observed at Pinehurst on September 15 and 16, 2013, are exceptionally high when compared to the 5-year historical record at the monitor. The historical context demonstrates the rarity of the high wind dust event from both an annual and seasonal perspective.

4 Clear Causal Relationship

To demonstrate a clear causal relationship between the high wind dust event and the monitor exceedances at Pinehurst, DEQ examined the weather conditions that caused the event, occurrence and geographic extent of the event, transport of emissions from source to monitor, and temporal relationship between the event and the elevated concentrations at the Pinehurst monitor. Event-affected days were compared to nonevent days.

4.1 Description of Weather Conditions that Caused the Event

A strong squall line developed from a mesoscale convective system and appeared on the Spokane, Washington, radar by 21Z (2 p.m. PDT) on September 15, 2013 (Figure 13). The system began as a series of individual thunderstorms in north-central Oregon. The squall line was quite vigorous and developed into a gust front. A gust front is a mesoscale boundary separating thunderstorm-cooled air (outflow) from the surrounding air. Outflow boundaries can persist for 24 hours or more after the thunderstorms that generated them dissipate and can travel

hundreds of miles from their area of origin. An outflow gust front that entrains significant particulate matter is often referred to as a haboob.

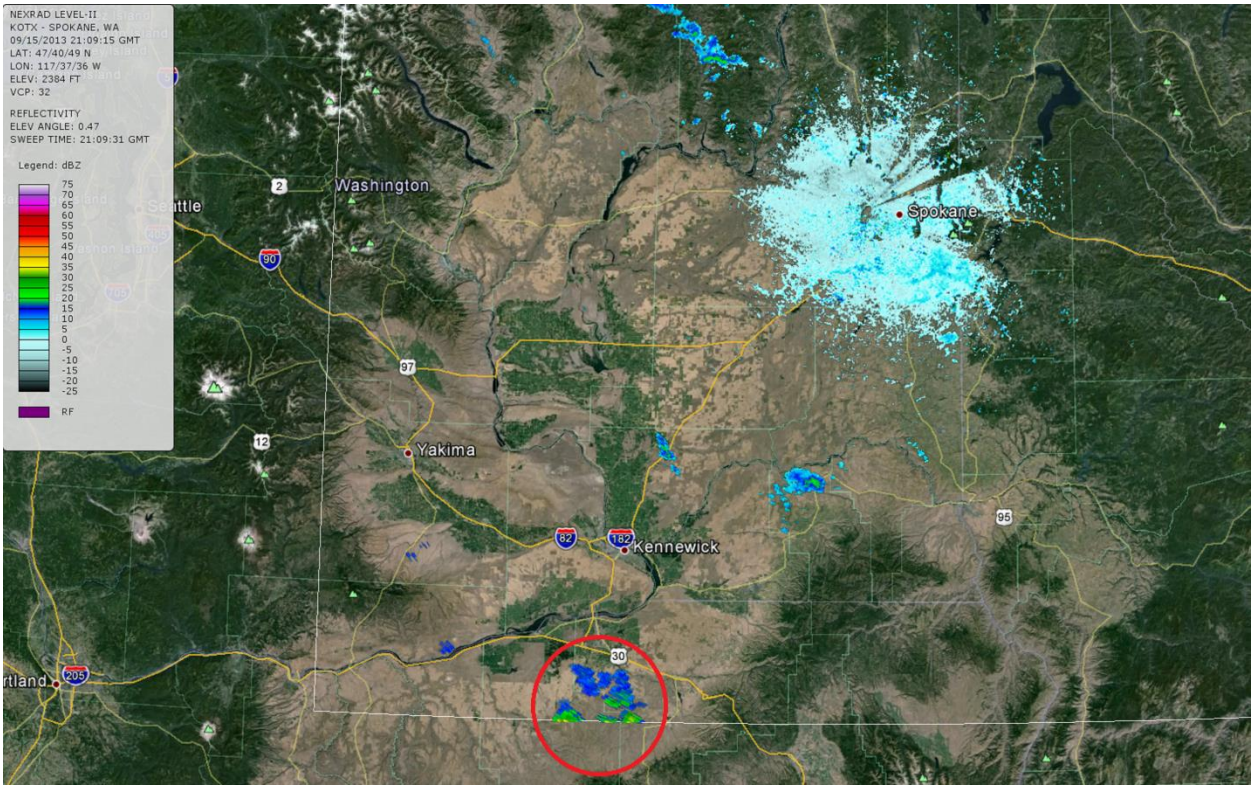


Figure 13. Developing thunderstorms in north-central Oregon. Red circle identifies radar-detected thunderstorms at 2109Z on 09/15/13 (2:09 p.m. PDT) from 0.5-degree base reflectivity radar at KOTX in Spokane, Washington (*http://www.ncdc.noaa.gov/*).

This collection of thunderstorms intensified through the afternoon as the cluster of storms progressed over the relatively flat Columbia Plateau and tracked to the northeast. By 0334Z (8:34 p.m. PDT), a visible gust front had developed across the leading edge of the squall line (Figure 14). This gust front had echo returns of 70 knots (kts) (81 mph) along the western section, with lower speeds ranging from 10–40 kts (11–45 mph) along the southeast section (Figure 15).

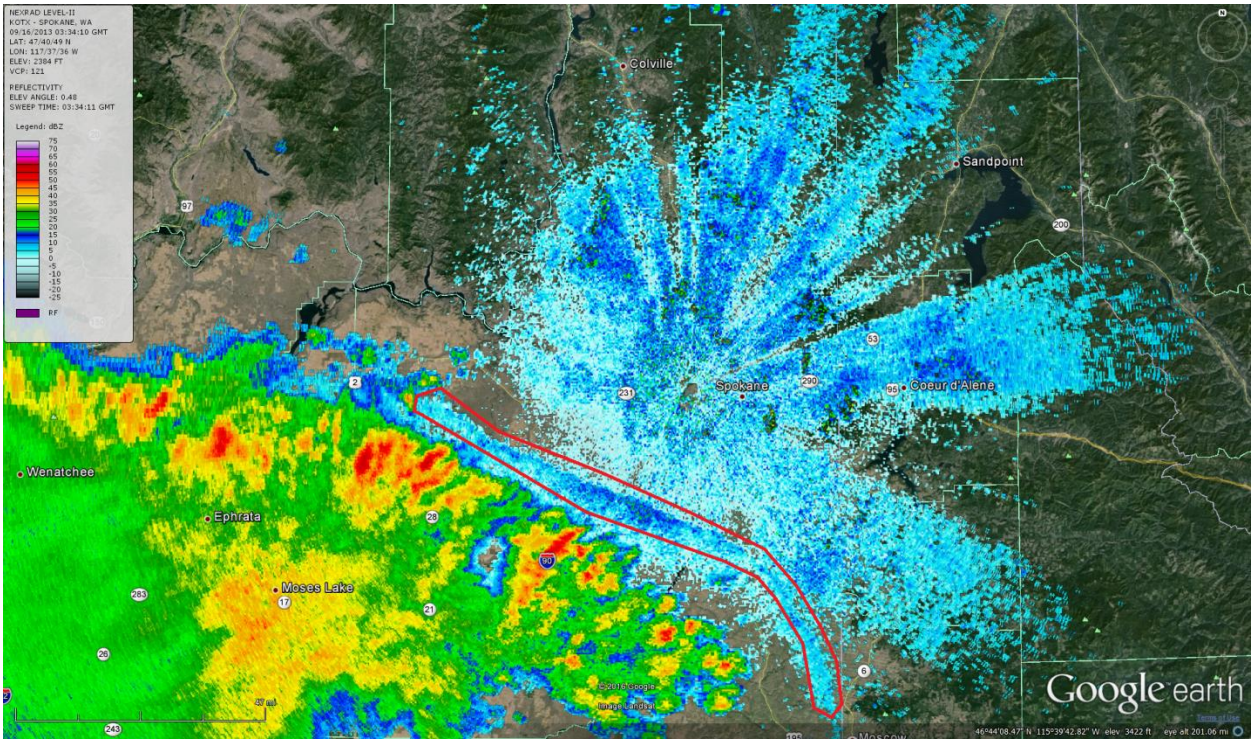


Figure 14. Visible gust front develops across the lead edge of the squall line. Red line identifies the location of the gust front at 0334Z on 09/16/13 (8:34 p.m. PDT on 9/15/13) from 0.5-degree base reflectivity radar at KOTX in Spokane, Washington (*http://www.ncdc.noaa.gov/*).

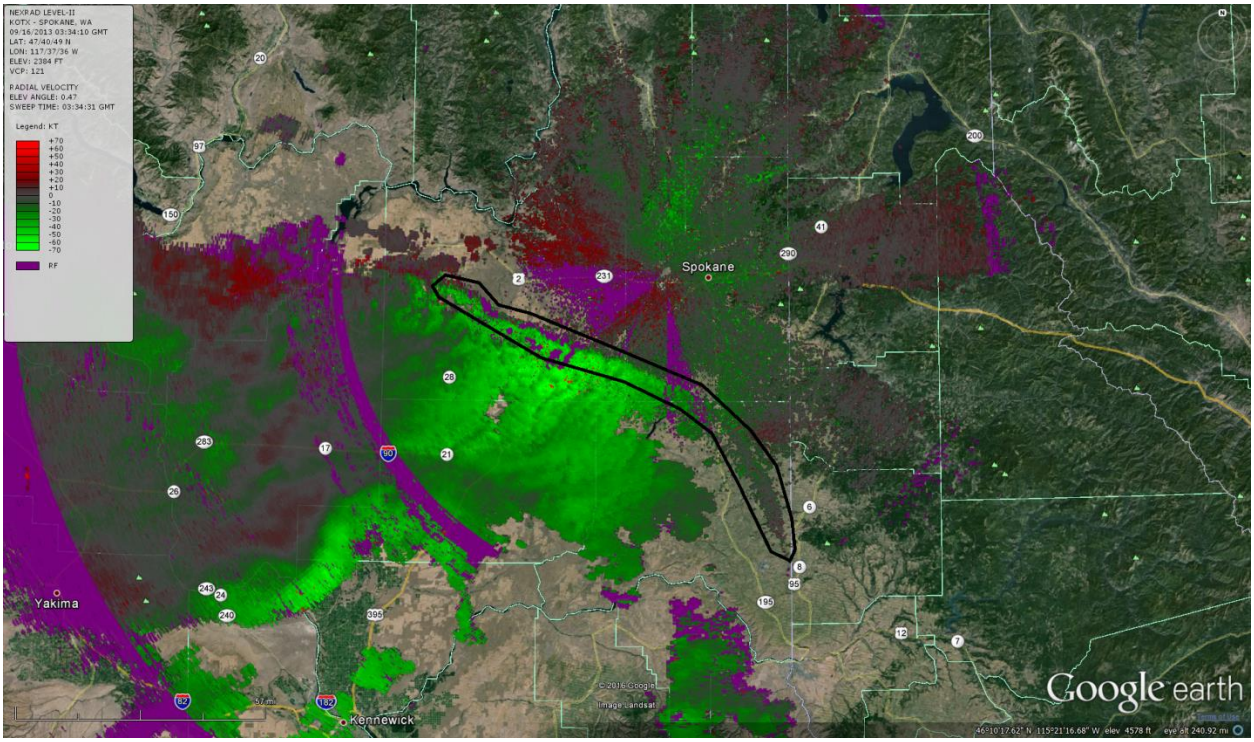


Figure 15. Gust front wind speeds from radar echo returns. Black line denotes location of gust front at 0334Z on 09/16/13 (8:34 p.m. PDT on 9/15/13) from 0.5-degree radial velocity radar at KOTX in Spokane, Washington (*http://www.ncdc.noaa.gov/*).

During the evening, this storm system progressed to the northeast and reached the Spokane, Washington, area by 0400Z (9 p.m. PDT) and maintained a uniform gust front boundary (Figure 16). While the system looks split in the radar image, this is an artifact of the front's passage over the radar site, which limits the height to nearly zero. The wind speeds at the Spokane airport radar site at this time were recorded at 43 mph, with gusts to 53 mph at the surface.

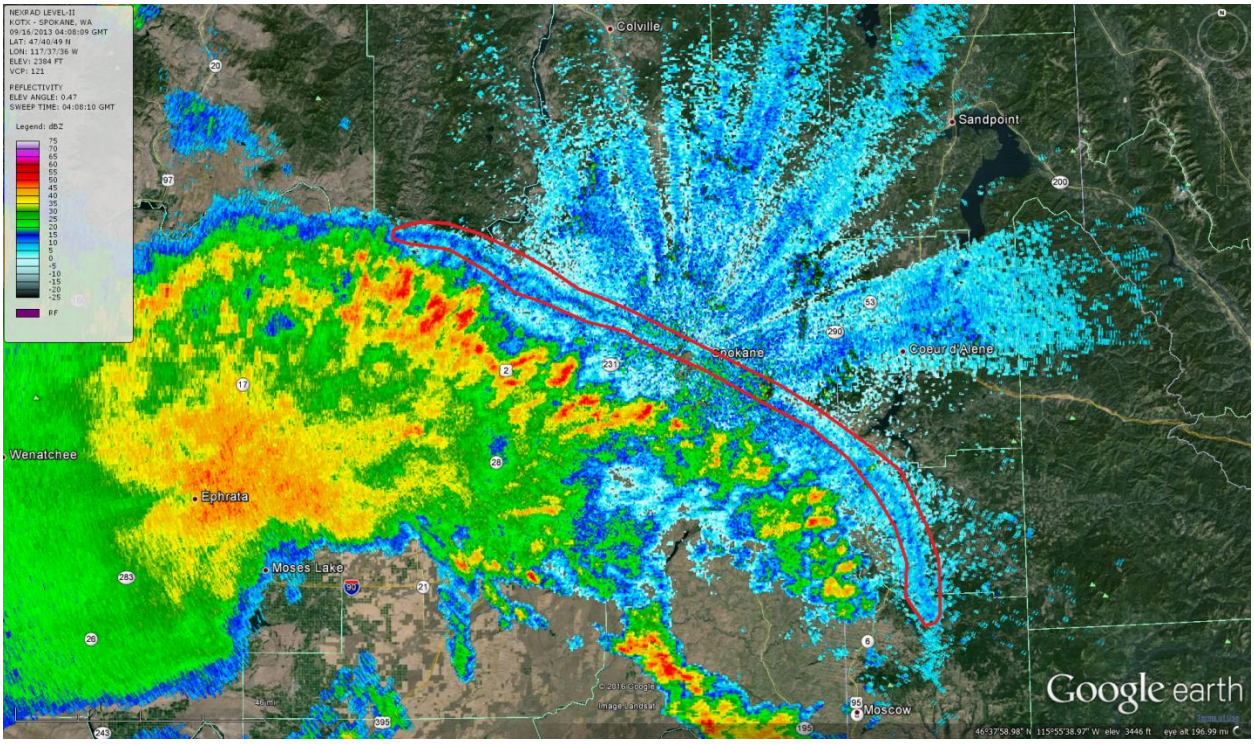


Figure 16. Location of gust front at 0408Z on 09/16/13 (9 p.m. PDT on 9/15/13) from 0.5-degree base reflectivity radar at KOTX in Spokane, Washington. Red line denotes location of gust front (*http://www.ncdc.noaa.gov/*).

Within the hour, the gust front crossed the state boundary between Washington and Idaho and began to interact with the complex, mountainous terrain of the Idaho Panhandle. This interaction complicated the frontal boundary and led to the development of discrete segments that, while independent in speed, continued to travel towards the northeast. The stronger, faster-moving northern section passed through Coeur d'Alene, Idaho, by 0453Z (9:53 p.m. PDT) with wind speeds peaking at 24 mph and gusts to 40 mph (Figure 17). The gust front, identified in red in Figure 17, moved away from the radar site. Earlier in the afternoon, the front, shown in green in Figure 17, moved towards the radar site. The front had not yet reached the Pinehurst area.

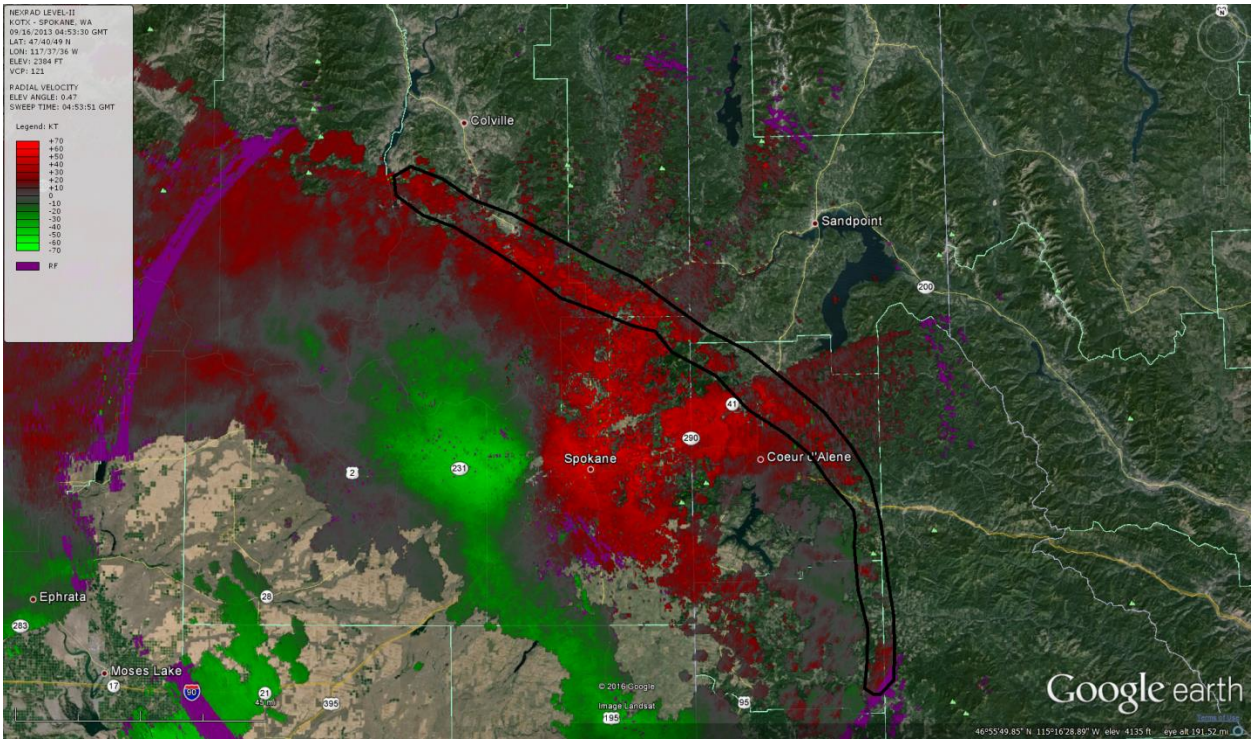


Figure 17. Gust front moves into Idaho, interacts with terrain, and breaks into segments. The black line identifies the gust front at 0453Z on 09/16/13 (9:53 p.m. PDT on 9/15/13) from 0.5-degree radial velocity radar at KOTX in Spokane, Washington (*http://www.ncdc.noaa.gov/*).

By 0527Z (10:27 p.m. PDT), the gust front had effectively become two discrete gust fronts tracking to the north-northeast and northeast. The southern, northeast-traveling branch passed through Pinehurst at some time between 0453Z (9:53 p.m. PDT) and 0527Z (10:27 p.m. PDT). Figure 18 depicts the southern branch located to the northeast of the Pinehurst area by 0527Z (10:27 p.m. PDT).

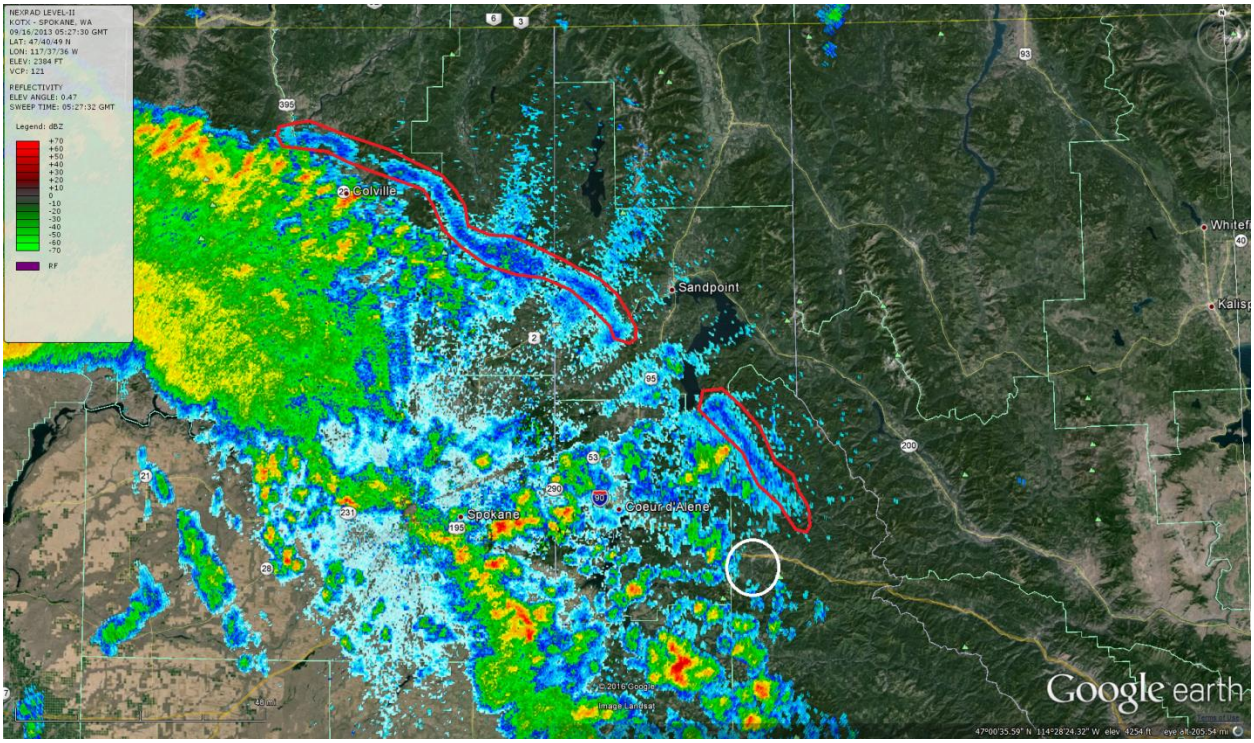


Figure 18. Location of the gust front after it passed through Pinehurst, Idaho, at 0527Z on 09/16/13 (10:27 p.m. PDT on 9/15/13) from 0.5-degree base reflectivity radar at KOTX in Spokane, Washington. Red lines delineate the gust front segments, and the white circle identifies the location of Pinehurst (*http://www.ncdc.noaa.gov/*).

4.2 Occurrence and Geographic Extent of the Event

The event began in the afternoon of September 15, 2013 in north-central Oregon, when thunderstorms spawned a gust front that entrained agricultural soils in northern Oregon and the Horse Heaven Hills of Washington. The dust was carried by the wind across the Columbia Plateau of eastern Washington and into the northern Idaho Panhandle, where it dissipated in the early morning hours of September 16, 2013. The timing and progress of the storm are reconstructed by examining wind data at meteorological stations across the region. Figure 19 identifies the location of the meteorological stations across the region, and Figure 20 charts the wind speed, wind gusts, and wind direction at each station.

Beginning at Horse Heaven Hills (BPHOR), the gust front arrived at 5:30 p.m. PDT and maxed out at 5:50 p.m. with wind gusts of 58.5 mph. As the wind suddenly increased, the direction switched from around 20° north-northeast to 250° southwest, which is the direction from which the thunderstorm outflow came. The initial gust front passed BPHOR by 6:05 p.m., when the gusts subsided to 15.8 mph, and the winds switched back to northwesterly. Secondary pulses of outflow winds passed through periodically in the hours following the event.

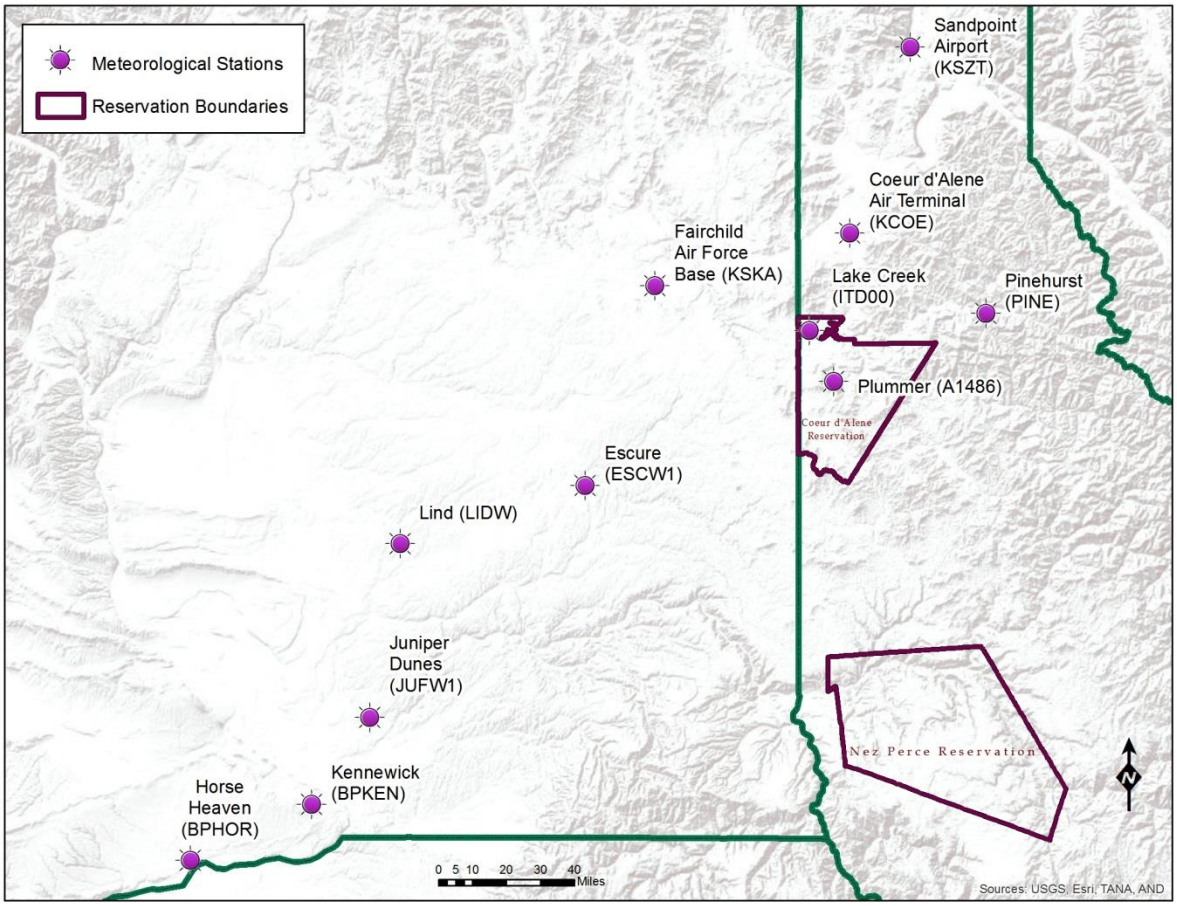


Figure 19. Locations of meteorological stations across the gust front path.

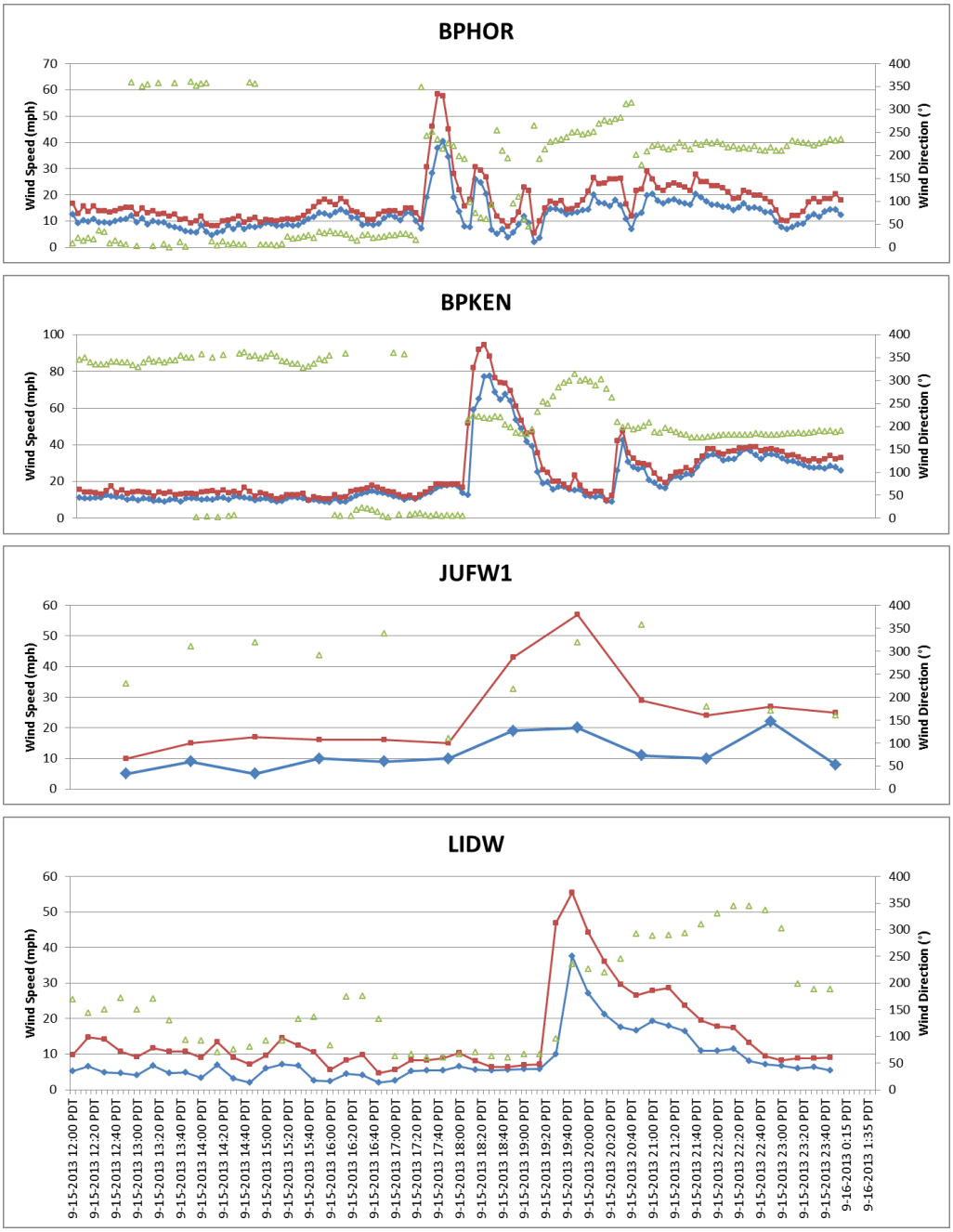


Figure 20. Wind speed, wind gusts, and wind direction recorded at meteorological stations along the path of the gust front during the event.

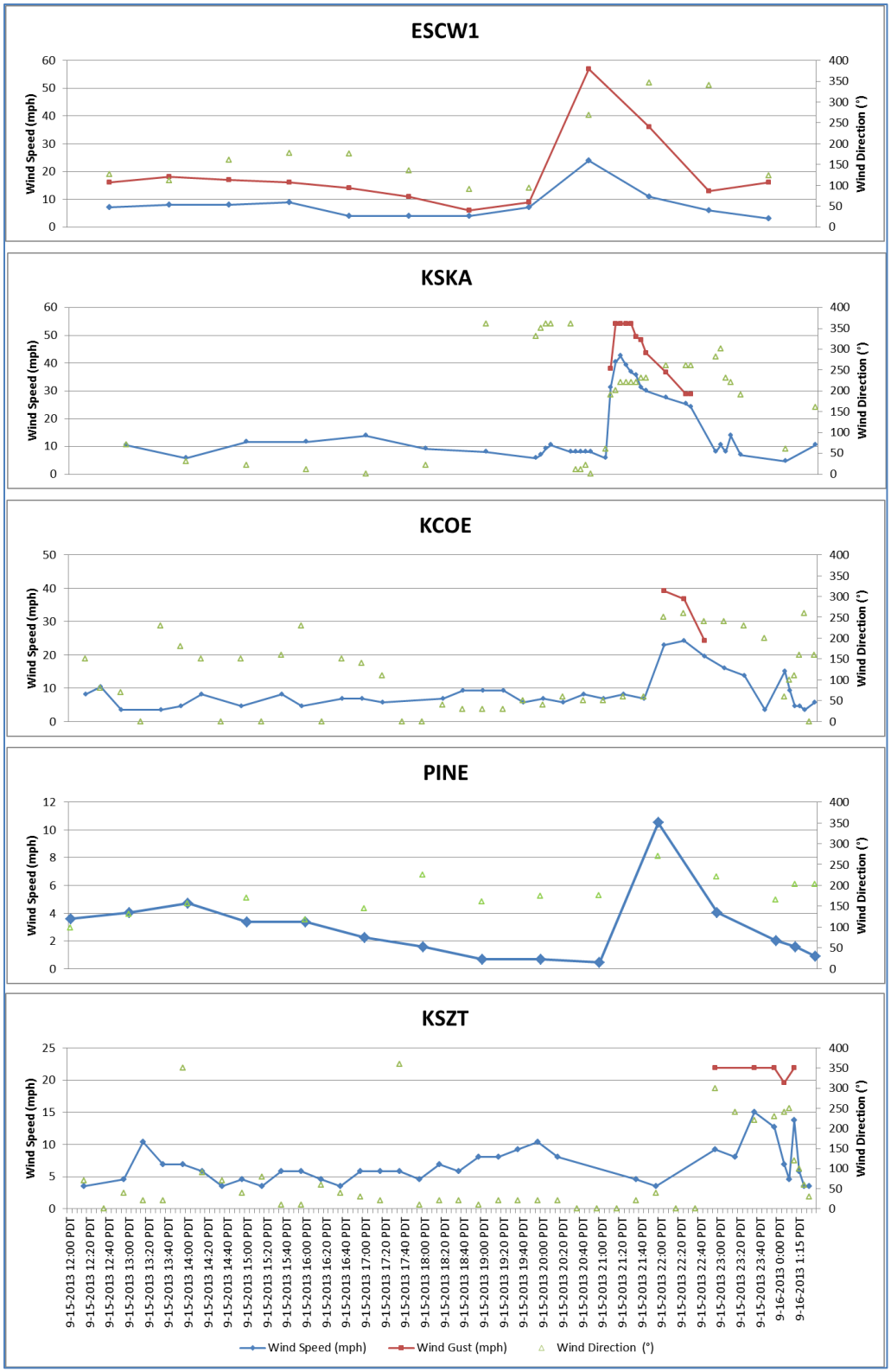


Figure 20 (continued). Wind speed, wind gusts, and wind direction recorded at meteorological stations along the path of the gust front during the event.

At Kennewick (BPKEN), the wind rose beginning at 6:10 p.m., as the wind direction switched from northerly to soutwesterly (~230°). The maximum gust recorded was 94.4 mph at 6:20 p.m. Winds stayed high and southwesterly until 7:10 p.m.

After moving through Kennewick, Washington, the gust front reached the Juniper Dunes (JUFW1) station at around 6:50 p.m. Timing was less precise at this station because data were recorded hourly. The maximum gust recorded at JUFW1 was 57 mph at 7:50 p.m.

The meteorological station at Lind (LIDW), nearly due north of Juniper Dunes, received the southwesterly gusts starting at 7:30 p.m. The peak gust was 55.5 mph at 7:45 p.m. Gusts recorded at 15-minute intervals did not drop below 20 mph until 9:45 p.m.

The gust front continued across the Columbia Plateau and arrived at Escure (ESCW1) at about 8:40 p.m. The winds were more westerly here (269°) and peaked at 57 mph. Average wind speeds dropped below 10 mph by 10:40 p.m.

The gust front arrival at Fairchild Air Force Base in Spokane, Washington (KSKA) was accompanied by an abrupt switch in wind direction from 60° northeast to 190° to 230° southwest. Data were recorded at this station in 5-minute bursts, and gusts were only recorded when wind speeds were above 25 mph. Peak gusts reached 54.1 mph, and the episode lasted until about 10:20 p.m.

The gust front reached northern Idaho at 9:55 p.m. at the Coeur d'Alene Air Terminal (KCOE). Its impacts were first recorded at Pinehurst 5 minutes later, at 10 p.m. As the gust front entered Idaho's mountainous terrain, the wind speeds slowed considerably. The peak gust recorded at KCOE was 39.1 mph. The meteorological station at Pinehurst does not record gusts. However, the wind direction (250° to 270°) and accompanying jump in wind speeds at the time of wind switch followed the same pattern as the previously affected meteorological stations.

The gust front reached the final location, Sandpoint Airport (KSZT), at 10:55 p.m. After interacting with the complex terrain, the gust front dissipated and grew more disorganized, so the spike in wind speed was less obvious, but the abrupt wind shift was clear, as were the sustained wind gusts of 21.9 mph that lasted until midnight.

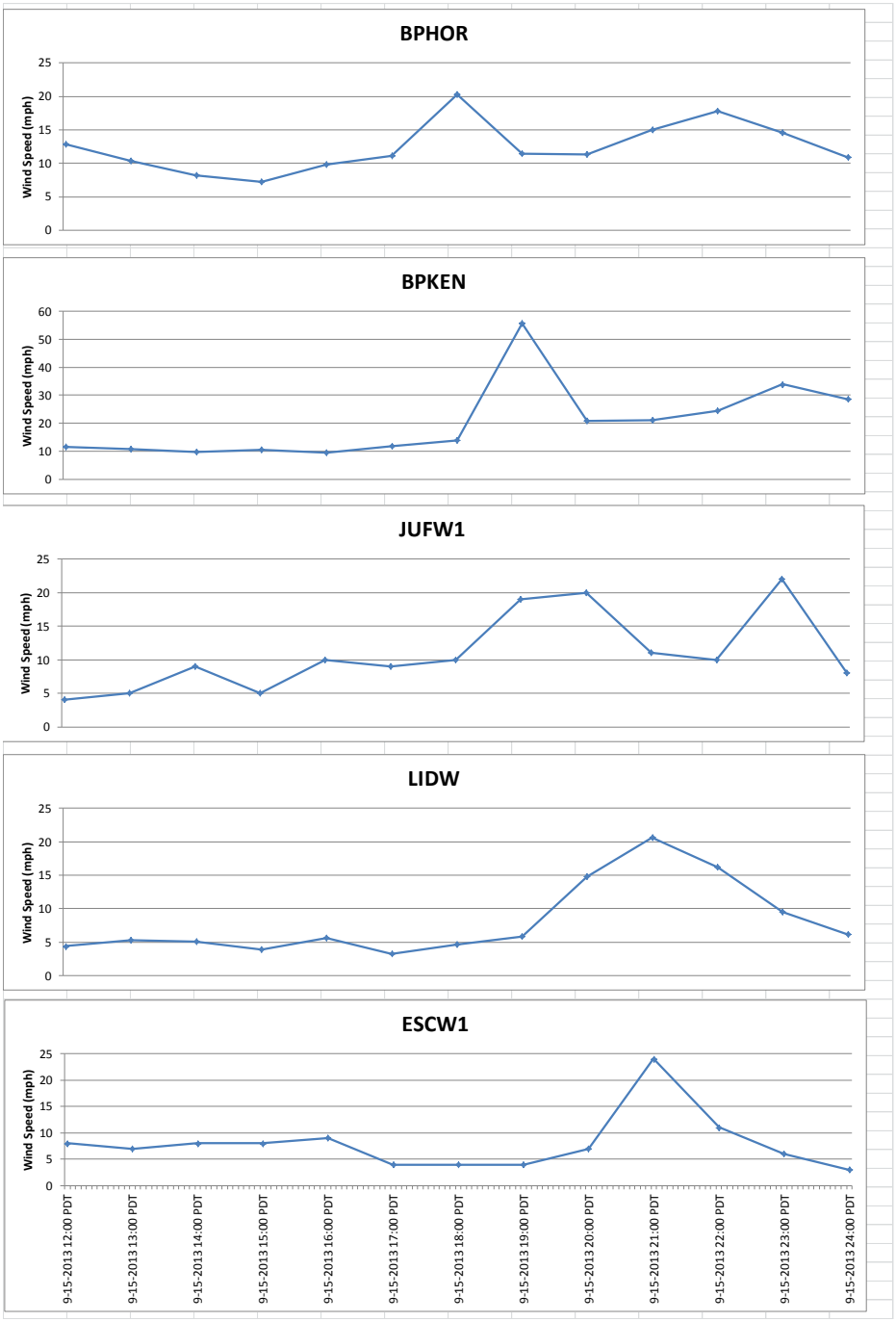
Following the progression of the gust front from inception at the Oregon-Washington border across the Columbia Plateau to northern Idaho establishes the regional extent and temporal scale of the event.

4.3 Transport of Emissions from Source to Monitor

A comparison of the hourly average wind speeds with the area specific wind dust thresholds along the haboob path and an examination of the timing and magnitude of the event's impacts on the region's PM_{10} and $PM_{2.5}$ monitors, similar to the meteorological station wind analysis in section 4.2, establishes the transport of emissions generated by and carried along with the gust front.

Figure 21 shows the hourly average wind speeds at meteorological stations along the gust front. Similar to the more detailed data presented in Figure 20, the peak hourly wind speeds

demonstrate the progression of the gust front from the northern Oregon/southern Washington source area, across the Columbia Plateau, and into northern Idaho.



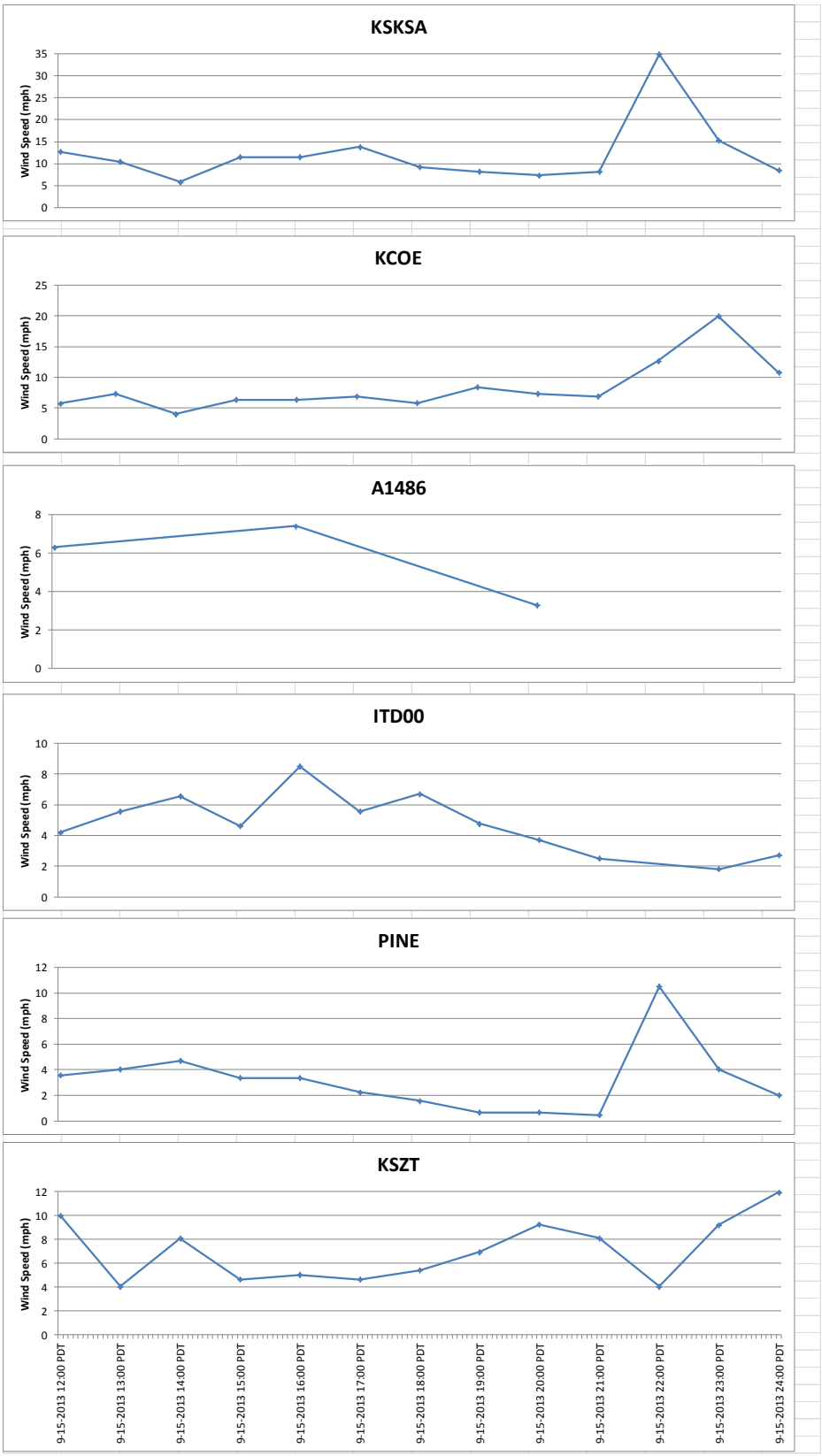


Figure 21. Hourly average wind speed recorded at meteorological stations along the path of the gust front during the event.

Table 2 highlights the wind speeds that meet or exceed the area specific high wind dust thresholds. The Columbia Plateau has a threshold of 18 mph (*https://fortress.wa.gov/ecy/publications/SummaryPages/1502018.html*). Idaho does not have an area specific threshold, so the default of 25 mph is used. In Table 2, green boxes highlight the hourly averages that are greater than 18 mph and less than 25 mph. The red boxes identify the hourly averages that exceed 25 mph. There are 8 hourly exceedances of the Columbia Plateau threshold (18 mph) at Washingtom meteorological stations during the event and one exceedance in Idaho. There are 4 hourly exceedances of the default 25 mph high wind dust threshold in Washington and none in Idaho. These data indicate that winds were only strong enough to entrain dust in Washington and not in Idaho. This evidence supports the conceptual model that the source area for the high wind dust event was in the state of Washington and therefore outside of DEQ's jurisdiction.

Table 2. Hourly average wind speed (mph) recorded at meteorological stations in WA and ID, along the path of the gust front during the event. Green boxes identify windspeeds between 18 and 25 mph. Red boxes identify windspeeds greater than 25 mph.

Time	BPHOR	BPKEN	JUFW1	ESCW1	KSKSA	KCOE	A1486	ITD00	PINE	KSZT
9-15-2013 12:00 PDT	12.8	11.6	4.0	8.0	12.7	5.8	6.3	4.2	3.6	10.0
9-15-2013 13:00 PDT	10.4	10.8	5.0	7.0	10.4	7.3		5.6	4.0	4.1
9-15-2013 14:00 PDT	8.2	9.8	9.0	8.0	5.8	4.1		6.6	4.7	8.1
9-15-2013 15:00 PDT	7.2	10.5	5.0	8.0	11.5	6.4		4.6	3.4	4.6
9-15-2013 16:00 PDT	9.8	9.6	10.0	9.0	11.5	6.4	7.4	8.5	3.4	5.0
9-15-2013 17:00 PDT	11.1	11.9	9.0	4.0	13.8	6.9		5.6	2.2	4.6
9-15-2013 18:00 PDT	20.3	13.8	10.0	4.0	9.2	5.8		6.7	1.6	5.4
9-15-2013 19:00 PDT	11.5	55.7	19.0	4.0	8.1	8.4		4.8	0.7	6.9
9-15-2013 20:00 PDT	11.3	20.8	20.0	7.0	7.3	7.3	3.3	3.7	0.7	9.2
9-15-2013 21:00 PDT	15.0	21.0	11.0	24.0	8.1	6.9		2.5	0.4	8.1
9-15-2013 22:00 PDT	17.8	24.4	10.0	11.0	34.9	12.7			10.5	4.1
9-15-2013 23:00 PDT	14.5	33.9	22.0	6.0	15.2	20.0		1.8	4.0	9.2
9-15-2013 24:00 PDT	10.9	28.5	8.0	3.0	8.4	10.8		2.7	2.0	11.9

Figure 22 shows the location of PM_{10} monitors in the event region. Each of the five monitors recorded a spike in particulates during the event period. The sites near or collocated with a meteorological station exhibit a correlation between the wind direction shifts, wind speed spikes, and elevated particulate concentrations. This analysis provides evidence supporting a clear causal relationship between the event and monitor exceedances.

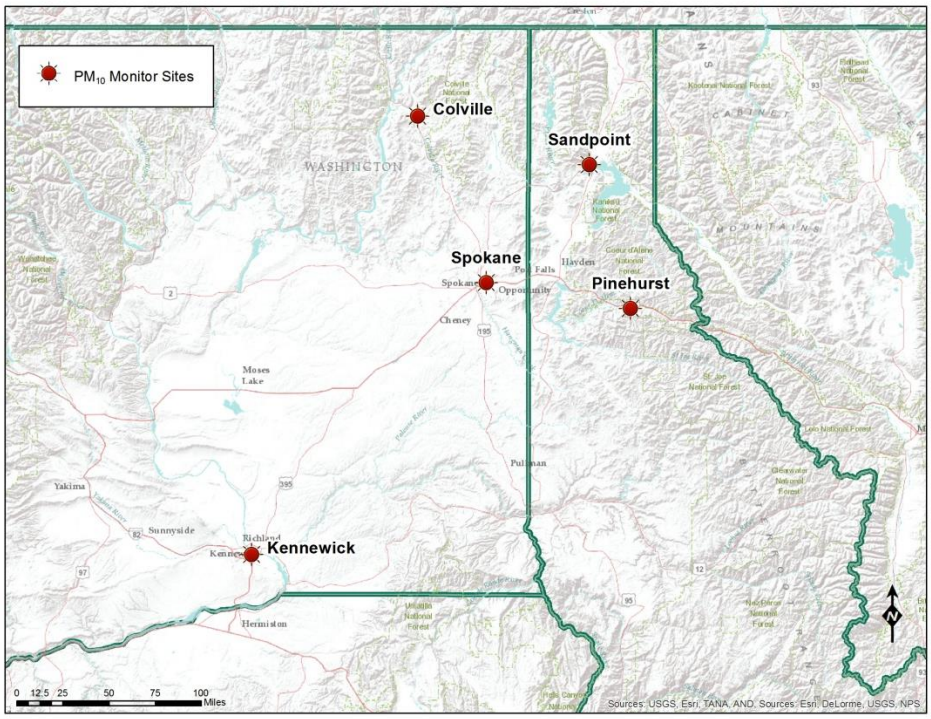


Figure 22. Location of PM_{10} monitors along the gust front path.

Figure 23 charts the timing and magnitude of elevated PM_{10} concentrations at monitor sites along the gust front path. At the Kennewick monitor, the hourly PM_{10} concentration spiked to 4,037 µg/m^3 between 5 and 6 p.m. Wind gusts rose to over 80 mph at the same time. [Note: Wind data are presented in PDT and concentration data are in PST].

The Spokane PM_{10} monitor was the next to be affected by the event. Here, the hourly PM_{10} concentration topped out at 6,471 µg/m^3 between 8 and 9 p.m. The wind gusts at Fairchild Air Force Base rose concurrently at 8:05 p.m.

The Pinehurst and Colville PM_{10} monitors were both hit at 9-10 p.m. with maximum concentrations reaching 2,177 µg/m^3 and 240 µg/m^3, respectively. Pinehurst's collocated meteorological monitor peaked at 9:10 p.m., but the wind speed was relatively low at 10.51 mph.

Finally, the Sandpoint PM_{10} monitor recorded a jump in concentration to 1,700 µg/m^3 at 10-11 p.m. Sandpoint's collocated meteorological monitor spiked at 9:55 p.m.

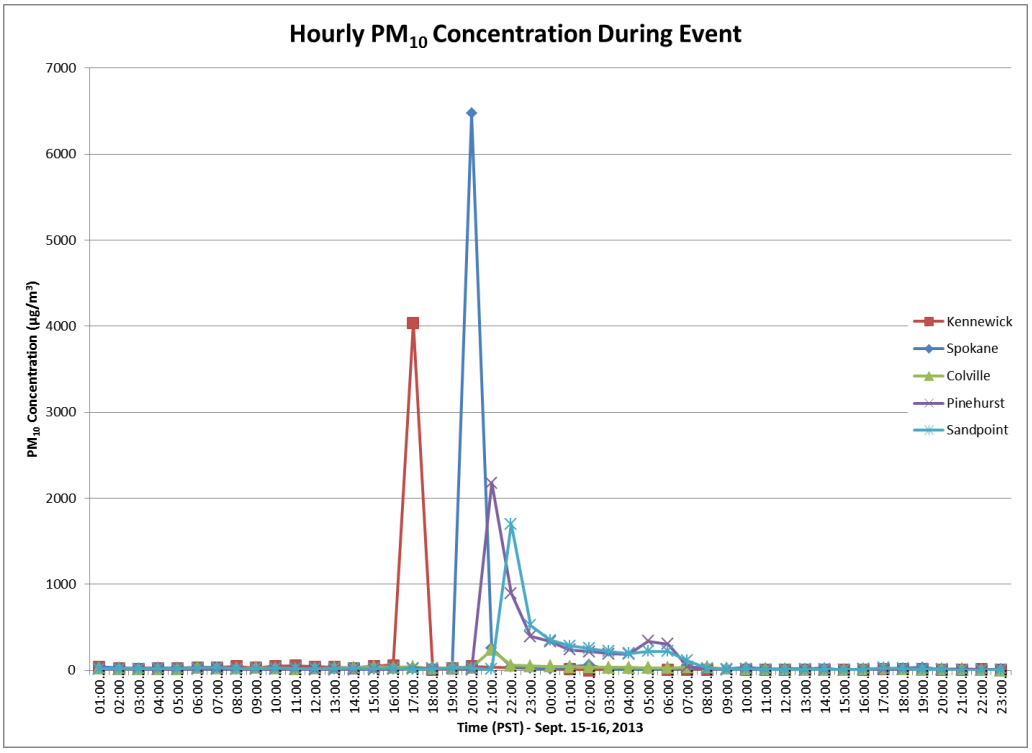


Figure 23. Peak hourly concentrations recorded at PM_{10} monitors as the gust front passed.

At the Spokane and Pinehurst monitors, $PM_{2.5}$ was also recorded. These concentrations peaked at the same time as the PM_{10} values. Figure 24 shows that the hourly $PM_{2.5}$ concentration at Spokane rose to 228.1 µg/m^3 at 8 p.m. Pinehurst had an initial spike of 155.1 µg/m^3 at 9 p.m. and a secondary peak of 84.4 µg/m^3 at 6 a.m. on September 16.

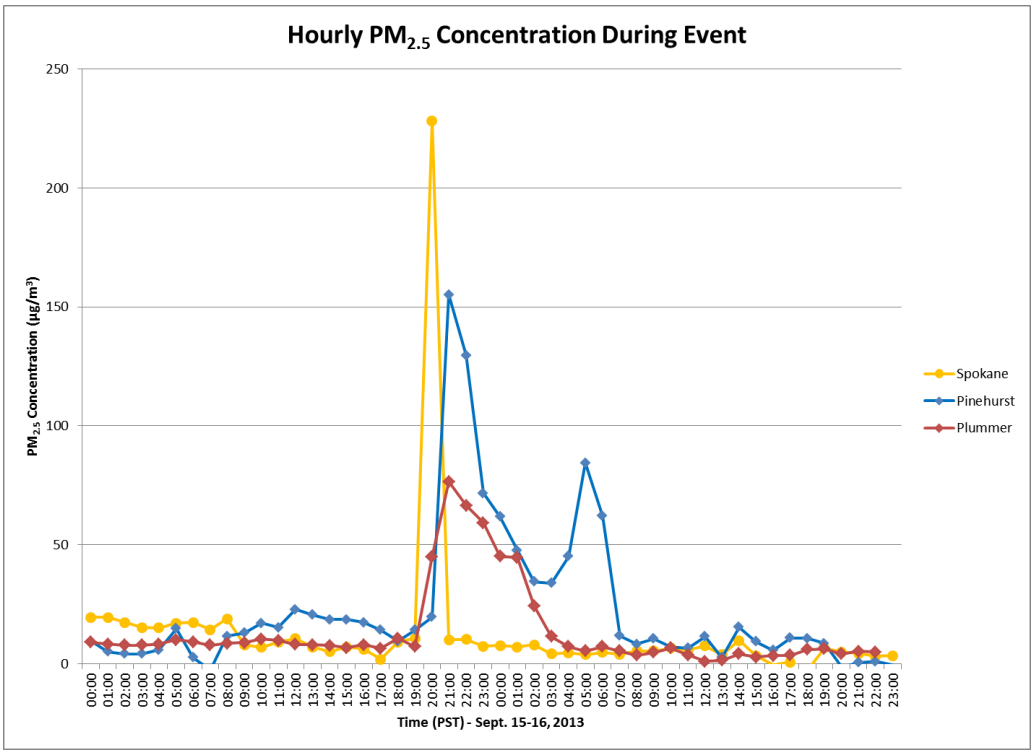


Figure 24. Peak hourly concentrations recorded at $PM_{2.5}$ monitors as the gust front passed.

The temporal correlation between PM_{10} and $PM_{2.5}$ peaks and gust front arrival times demonstrates a clear causal relationship between the event and particulate matter concentrations.

4.4 Temporal Relationship between the Event and Elevated Particulate Concentrations at the Pinehurst Monitor

In Pinehurst, the event lasted for 10 hours from impact to dissipation. The particulate monitor recorded the first hit of dust at 9 p.m. on September 15. Concentrations did not return to normal, preevent levels until 7 a.m. on the following day. Figure 25 charts the hourly $PM_{2.5}$ and PM_{10} concentrations and the $PM_{2.5}/PM_{10}$ mass ratio to illustrate the temporal relationship between the event and the elevated particulate concentrations at the Pinehurst monitor (Appendix C).

From midnight on the morning of September 15 through 8 p.m. that night, hourly $PM_{2.5}$ and PM_{10} concentrations were low (<23 µg/m^3 for $PM_{2.5}$ and <25 µg/m^3 for PM_{10}). At 9 p.m., concentrations rose sharply with the arrival of the gust front and remained high for the next 10 hours as the dust settled and dissipated. At 7 a.m. on September 16, PM concentrations returned to normal values.

Throughout the same period, the mass ratio of $PM_{2.5}/PM_{10}$, an indicator of how coarse or fine the particulate matter is, shows the effects of the event. During midnight to 8 p.m. on September 15, the mass ratio fluctuated widely, indicating mixing and changing of the particulate content of the air mass at the monitor. At 9 p.m., the mass ratio abruptly dropped to 7% and remained unusually steady during the duration of the event. A low mass ratio signifies that that the proportion of fine particulates to coarse particulates is low in the sample. Agricultural soil or dust

is a coarse particulate, as opposed to woodsmoke, which is a fine particulate. Therefore, the low mass ratio points to the arrival of an air mass containing coarse particulates. The persistence of the low magnitude throughout the event hours implies that the air mass remained in place. At 7 a.m. on September 16, when particulate concentrations returned to normal levels, the mass ratio fluctuated widely again, as it had before the event.

This analysis demonstrates that the dramatic PM_{10} and $PM_{2.5}$ elevations at Pinehurst were the result of dust carried by the storm from northern Oregon and south-central Washington. The passage of the storm lasted about 2 hours (Figure 20). However, it took 10 hours for dust to disperse and deposit, a process likely due to nighttime stable air, which trapped the dust in the valley. The $PM_{2.5}/PM_{10}$ ratio shows this dissipation process.

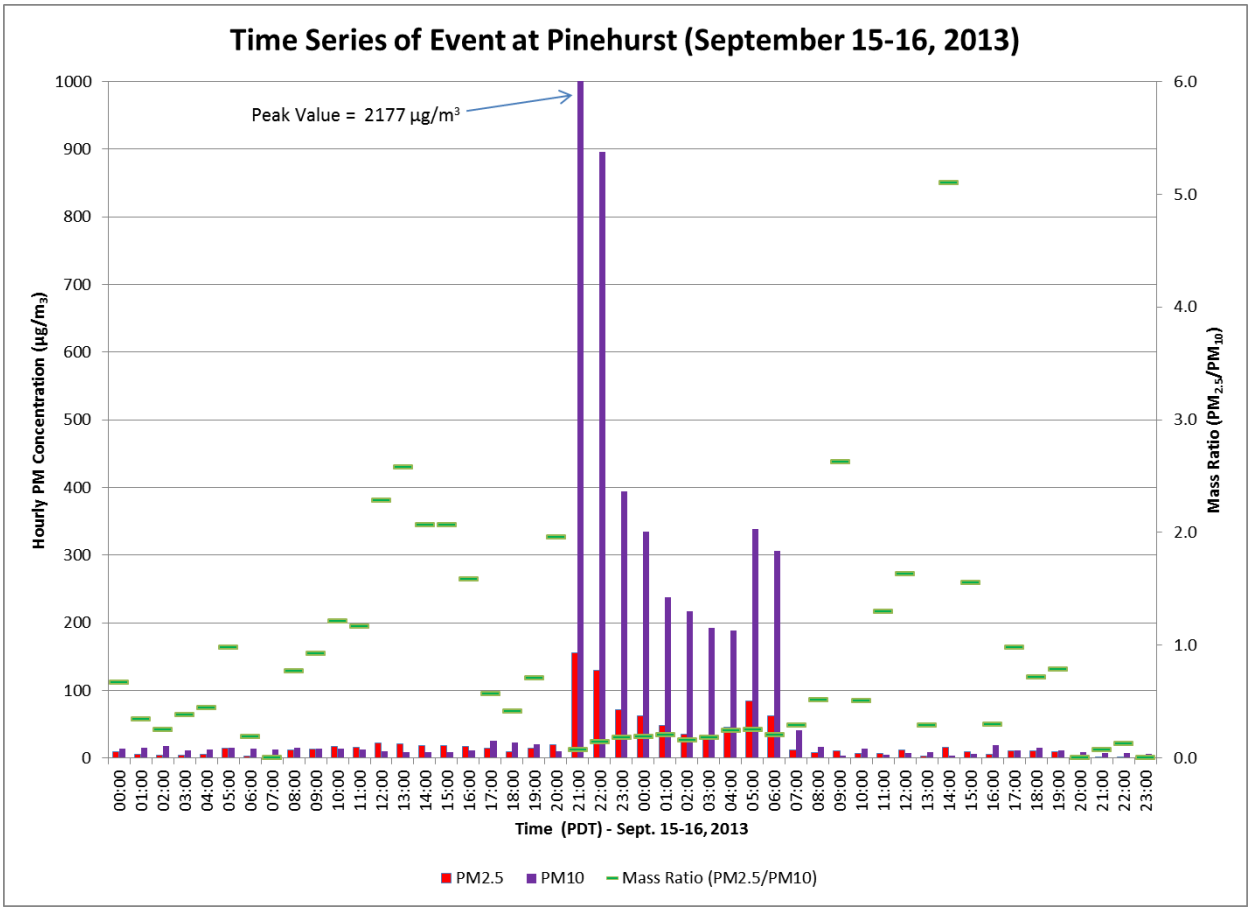
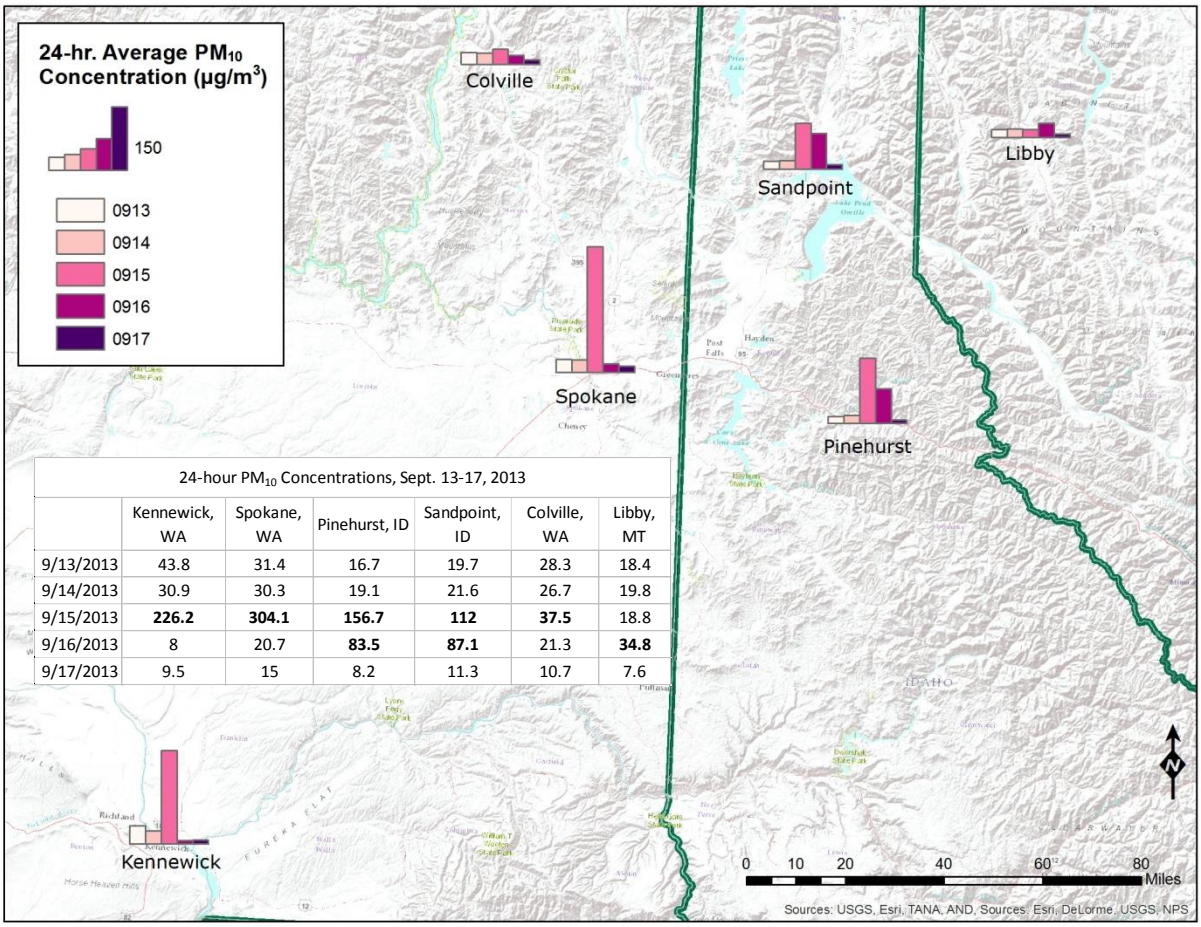


Figure 25. Hourly $PM_{2.5}$ and PM_{10} concentrations and $PM_{2.5}/PM_{10}$ mass ratio during the event. The $PM_{2.5}/PM_{10}$ mass ratio (green dashes) sharply dropped to 7% when the storm hit the area, remained below 25% during the event, and recovered in the morning of September 16 to preevent levels.

4.5 Comparison of Event-Affected Days to Nonevent Days

As a final analysis for the clear causal relationship criterion, data are presented comparing particulate concentrations in the event region for both event-affected and nonevent days. The data show that the event caused elevated particulate concentrations to occur that were significantly higher than the days preceding and following the event (Appendix C).

Figure 26 plots histograms of 24-hour average PM_{10} concentrations for September 13–17, 2013, at monitor sites throughout the event region. A chart giving the exact values plotted on each day is included in the figure. The 24-hour PM_{10} concentrations at all sites were consistently low on the two days preceding the event, September 13 and 14. Compared to the other sites, Pinehurst had the lowest concentrations on both days. On the event day, September 15, concentrations at all sites except for Libby rose dramatically. Kennewick, Spokane, and Pinehurst all jumped more than 100 µg/m^3. Colville rose much less, as it is on the far northern edge of the event's impact zone. Libby's concentrations did not rise until September 16 because the remnants of the gust front did not reach the area until the early hours of that morning. Both Pinehurst and Sandpoint showed high concentrations remaining on September 16. The dust continued to dissipate into the morning of September 16. On September 17, concentrations at all sites dropped to preevent levels.



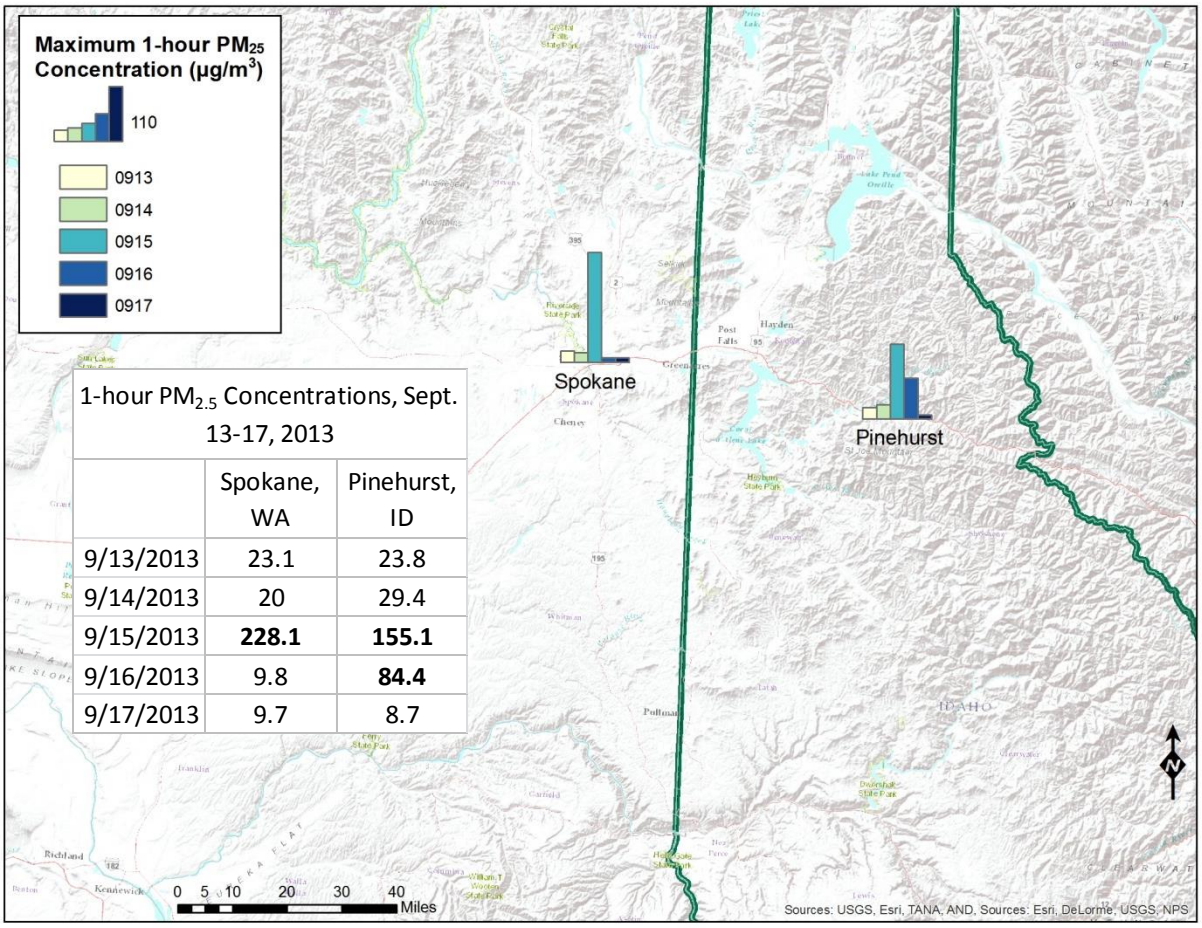
24-hour PM_{10} Concentrations, Sept. 13-17, 2013

	Kennewick, WA	Spokane, WA	Pinehurst, ID	Sandpoint, ID	Colville, WA	Libby, MT
9/13/2013	43.8	31.4	16.7	19.7	28.3	18.4
9/14/2013	30.9	30.3	19.1	21.6	26.7	19.8
9/15/2013	**226.2**	**304.1**	**156.7**	**112**	**37.5**	18.8
9/16/2013	8	20.7	**83.5**	**87.1**	21.3	**34.8**
9/17/2013	9.5	15	8.2	11.3	10.7	7.6

Figure 26. The 24-hour average PM_{10} concentrations for days before, during, and after the event.

Figure 27 shows the PM_{10} monitors in the event region that also measure $PM_{2.5}$. Spokane and Pinehurst exhibited similarly low concentrations on the two preevent days and then sharp elevations on September 15. On September 17, Spokane dropped to values even lower than before the event. Pinehurst again showed high concentrations on September 16 as the dust settled out and values dropped to normal.

The comparison of event-affected days to nonevent days demonstrates the effect the event had on elevating particulate concentrations at the Pinehurst monitor.



1-hour $PM_{2.5}$ Concentrations, Sept. 13-17, 2013

	Spokane, WA	Pinehurst, ID
9/13/2013	23.1	23.8
9/14/2013	20	29.4
9/15/2013	**228.1**	**155.1**
9/16/2013	9.8	**84.4**
9/17/2013	9.7	8.7

Figure 27. Maximum 1-hour $PM_{2.5}$ concentrations for days before, during, and after the event.

4.6 Alternative Hypotheses

One important element of the clear causal relationship analysis is to explore alternate hypotheses for potential sources. The peak $PM_{2.5}$ and PM_{10} concentrations at Pinehurst only contained 7% fine material (<2.5 µm), strongly suggesting that wildland biomass burning and other combustion sources such as crop residue burning, vehicle exhaust, and industrial combustion sources did not contribute to the event. The photographs of the dust cloud (Appendix B) indicate that normal dust sources were not responsible for the event. In addition, the low wind speeds in Pinehurst during the event were not sufficient to create enough wind erosion to cause the kind of peak $PM_{2.5}$ and PM_{10} concentrations observed. Finally, no known changes in industrial sources occurred at the time.

5 Affects Air Quality

EER requires agencies to document that the identified source of an exceptional event truly affected air quality at the location of the monitor in question. EPA's interim high wind guidance (EPA 2013) indicates that if values exceeding normal historical fluctuations and a clear causal relationship are adequately demonstrated then the affects air quality element is met. DEQ shows that the historical fluctuations and clear causal relationship evidence are strong and fully demonstrated; therefore, the affects air quality requirement is met.

6 Natural Event or Human Activity Unlikely to Recur

EER requires agencies to document that the identified source of an exceptional event is either a natural event or a human activity unlikely to recur at the same location. EPA's interim high wind guidance (EPA 2013) indicates that if an agency has adequately demonstrated (1) a clear causal relationship between the identified source and the affected monitor, and (2) the event was not reasonably controllable or preventable, then the natural event or human activity unlikely to recur criterion is satisfied.

The event produced thunderstorm outflow winds that entrained agricultural soil into a haboob, which traveled across eastern Washington and northern Idaho, causing exceedances of $PM_{2.5}$ and PM_{10} at the Pinehurst monitor. All PM data, meteorological data, and visual observations strongly demonstrate a clear causal relationship between source and monitor for September 15 and 16, 2013. The event was not reasonably controllable or preventable because (1) the scale of the meteorological event overwhelmed any agricultural controls in place in northern Oregon and the Horse Heaven Hills, and (2) the source area in northern Oregon and Washington is outside of DEQ's jurisdiction; thus, the natural event or human activity unlikely to recur criterion is satisfied.

7 No Exceedance But For this Event

EER 40 CFR 50.14(b)(1) directs EPA to exclude data only where an agency demonstrates an exceptional event caused a concentration in excess of NAAQS. The PM_{10} concentration on September 15, 2013, exceeded the 24-hour NAAQS of 150 $\mu g/m^3$. The $PM_{2.5}$ concentrations on September 15 and 16, 2013, exceeded the annual standard of 12 $\mu g/m^3$.

DEQ must also show that the concentrations at the monitor would have been below the standard if the event had not occurred (i.e., but for the event). The clear causal relationship information establishes the connection between the event and monitored values. All data—the well-defined spike, observations in various locations in Washington and Idaho, $PM_{2.5}/PM_{10}$ mass ratio, and meteorology—consistently demonstrate that the short-lived, exceptionally high $PM_{10}/PM_{2.5}$ event was due to the dust carried over from northern Oregon and the Horse Heaven Hills in Washington. No other significant source was capable of causing the high monitor values.

As the historical fluctuations analysis demonstrates (Table 1), these events exceed the normal range of historical fluctuations above the mean value.

Table 3 shows the PM_{10} and $PM_{2.5}$ concentrations at the Pinehurst monitor representing the average, 95th, and 99th percentile concentration values for annual and seasonal monitoring data, 2009–2013. The range of concentrations expected at Pinehurst may be represented by the span between the average and 95th percentile values.

The statistics shown in Table 3 indicate that the normal year-round PM_{10} concentrations at Pinehurst, but for the event on September 15 and 16, 2013, would have been at or below the range 14.7–29 µg/m^3, and 99% of the time it would have been 40 µg/m^3 or less. The Pinehurst PM_{10} concentration on September 15 was 157.1 µg/m^3, so it is clear that the event contributed at least 117.1 µg/m^3 on September 15 (157.1 − 40 = 117.1 µg/m^3). Thus, the event contributed more than half the PM_{10} on this day, and it is clear that the NAAQS (150 µg/m^3) would not have been exceeded but for the event described in this document.

For $PM_{2.5}$, the expected concentrations, but for the event, would have been in the range 13.5–33.6 µg/m^3, and 99% of the time, it would have been less than 44.4 µg/m^3 (Table 3). The $PM_{2.5}$ concentrations for September 15 and 16, 25.4 and 20.3 µg/m^3, respectively, lie between the mean and 95th percentile. These values are not exceptional when compared to the annual data. However, Pinehurst is affected by wildfires, prescribed burning, crop residue burning, and residential wood combustion throughout the year. $PM_{2.5}$ is one of the main emissions from these biomass burning activities and, therefore, average concentrations for this species at this monitor are high. The event described in this demonstration derives from a different source than biomass burning. High wind dust events overwhelmingly produce coarse particulates, but fine particulates do make up a small part of the concentrations. As shown in section 4.4, with the $PM_{2.5}/PM_{10}$ mass ratio analysis (Figure 25), the proportion of $PM_{2.5}$ in the particulate mass derived from the transported dust was about 7%.

As shown in section 3 with the PM_{coarse} analysis (Figure 12), when the $PM_{2.5}$ attributable to biomass burning sources is removed from the dataset, the exceptionality of the $PM_{2.5}$ concentrations on September 15 and 16 are shown. Table 3 provides the seasonal averages and 95th and 99th percentiles expected to occur during September for nonbiomass burning sources in Pinehurst. Between 2009 and 2013, normal values ranged from 8.3 to 18.3 µg/m^3. In conclusion, the $PM_{2.5}$ concentrations on September 15 and 16, 2013, would not have been so high but for the event.

Table 3. Average, 95th, and 99th percentile annual and seasonal concentrations for PM_{10} and $PM_{2.5}$ at Pinehurst monitor, 2009–2013, compared to concentrations on days requested for exclusion. Seasonal data are for September.

Pollutant	Date	Annual Average	Annual 95th Percentile	Annual 99th Percentile	Monitor Concentration (µg/m3)
PM_{10}	9/15/2013	14.7	29	40	157.1
$PM_{2.5}$	9/15/2013	13.5	33.6	44.4	25.4
$PM_{2.5}$	9/16/2013	13.5	33.6	44.4	20.3
Pollutant	**Date**	**Seasonal Average**	**Seasonal 95th Percentile**	**Seasonal 99th Percentile**	**Monitor Concentration (µg/m^3)**
PM_{10}	9/15/2013	18.7	46	73.6	157.1
$PM_{2.5}$	9/15/2013	8.3	18.3	21.9	25.4
$PM_{2.5}$	9/16/2013	8.3	18.3	21.9	20.3

Note: $PM_{2.5}$ data do not include 2012 exceptional event days.

8 Mitigation

The mitigation provisions of the EER (40 CFR 51.930) require the following (EPA 2013):

> A State requesting to exclude air quality data due to exceptional events must take appropriate and reasonable actions to protect public health from exceedances or violations of the national ambient air quality standards. At a minimum, the State must:
>
> (1) Provide for prompt public notification wherever air quality concentrations exceed or are expected to exceed an applicable ambient air quality standard.
>
> (2) Provide for the public education concerning actions that individuals may take to reduce exposure to unhealthy levels of air quality during and following an exceptional event; and
>
> (3) Provide for the implementation of appropriate measures to protect public health from exceedances or violations of ambient air quality standards caused by exceptional events.

DEQ implements the "Air Pollution Emergency Rule" (IDAPA 58.01.01.550) during air pollution emergency episodes by prohibiting open burning and notifying the public of deteriorating air quality. DEQ provides daily air quality forecasts in each of its regions and issues a Stage 1 Forecast and Caution when necessary to protect public health. A Stage 1 notification, which prohibits all open burning, includes information concerning actions that individuals may take to reduce exposure to unhealthy levels of air quality. A haboob in the Pacific Northwest is rare, and forecasting haboob events is not practical. However, DEQ provides public education concerning actions that individuals may take to reduce exposure to unhealthy levels of air quality during and following such an exceptional event.

For the event on September 15–16, 2013, public notification was not realistic. It was a short-lived event that arrived in Pinehurst at 9 p.m. and ended by 6 a.m. the following morning. Thunderstorm outflow winds and subsequent dust storms are difficult to forecast. Public exposure to high levels of particulates was likely minimal because of the overnight timing of the event. Most residents were probably indoors, sleeping, during the majority of the event.

9 Procedural Requirements

EER establishes specific procedural requirements that an air agency must follow to request data exclusion (EPA 2013). Those requirements and DEQ's actions to meet them are summarized in Table 4.

Table 4. DEQ compliance with procedural requirements of the Exceptional Events Rule.

Exceptional Event Rule Procedural Requirements	DEQ Action/Intended Action
A State shall notify EPA of its intent to exclude one or more measured exceedance of an applicable ambient air quality standard as being due to an exceptional event by placing a flag in the appropriate field for the data record of concern which has been submitted to the AQS database. 40 CFR § 50.14(c)(2)(i).	DEQ notified EPA of its intent to exclude these days.
The placement of the flags and the submittal of an initial event description must be done not later than July 1 of the calendar year following the year in which the flagged measurement occurred. 40 CFR § 50.14(c)(2)(iii).	The flags and description of the events on September 15 and 16, 2013 were in place by July 1, 2014.
A State that has flagged data as being due to an exceptional event and is requesting exclusion of the affected measurement data shall, after notice and opportunity for public comment, submit a demonstration to justify data exclusion to EPA not later than the lesser of 3 years following the end of the calendar quarter in which the flagged concentration was recorded, or, 12 months prior to the date that a regulatory decision must be made by EPA. A State must submit the public comments it received along with its demonstration to EPA. 40 CFR § (50.14(c)(3)(i)).	DEQ provided an opportunity for public comment from July 29 to August 29, 2016.
With the submission of the demonstration, the air agency must document that the public comment process was followed. 40 CFR § (50.14(c)(3)(iv)).	To be documented following public comment period.

10 References

EPA (United States Environmental Protection Agency). 2013. *Interim 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*. Washington, DC: EPA.

Appendix A. EPA Completion Checklist

Site Name: Pinehurst
AQS ID: 16-079-0017
Pollutants: PM_{10}, $PM_{2.5}$
Dates: September 15 and 16, 2013

Table A-1. EPA completion checklist.

Procedural Criteria	Information Included	Pages	EPA Use
Did an exceedance of NAAQS occur?	Yes	vi	
Were data flagged by July 1st of following year (or by another appropriate deadline associated with a new or revised NAAQS)?	Yes	32	
Was there a 30-day public comment period?	Yes	37	
Is documentation for the comment period included?			
If public comments were received, are the public comments and responses included?			
Was the package submitted within 3 years of the end of the quarter in which the event occurred and 12 months prior to the date that any regulatory decision must be made by the EPA (or by another appropriate deadline associated with a new or revised NAAQS)?	Yes	37	
Evidence	**Information Included**	**Pages**	**EPA Use**
Conceptual Model		1-6	
-description of weather phenomena resulting in high wind	Yes	1-3	
-description of what sources were likely entrained by the high wind	Yes	3-5	
-explanation of the path by which the dust reached the monitor(s)	Yes	5-6	
-map showing relevant monitors, topography, other relevant geographic features	Yes	4,5,6	
-description of how the event day differs from non-event days	Yes	1-6	
-description of concentration and wind patterns for the exceeding monitor(s) and surrounding area	Yes	1-6	
Wind Statistics			
-max sustained wind (Hourly avg)	20.6 mph (at Kennewick)	20-21	
- max sustained wind (1–5 min avg)	36.3 mph (at Kennewick)	20-21	

-max gust (1 min avg)	43.3 mph (at Kennewick)	20-21	
-wind trajectories included?	No		
-other:	Charts and analysis of wind speed, gusts, and wind direction at met stations	20-21	
nRCP		6-7	
-Area-specific high wind threshold (default = 25 mph)	25 mph		
-sources contributing to event identified, including anthropogenic vs. natural?	Yes	6-7	
-controls identified for anthropogenic sources? (note: level of control analysis depends on wind speed)	n/a – source outside of jurisdiction		
-are natural sources not reasonably controllable?	n/a		
-was a High Wind Action Plan included?	n/a		
HF		7-13	
-were time-series analyses for concentration and wind data included?	Yes – for concentration	8-12	
-annual comparison to historical data (wind and concentrations)	99%ile PM_{10} on 9/15/2013 87%ile $PM_{2.5}$ on 9/15/2013 79%ile $PM_{2.5}$ on 9/16/2013	8,10	
-seasonal comparison to historical data (wind and concentrations)	100%ile PM_{10} on 9/15/2013 98%ile $PM_{2.5}$ on 9/15/2013 95%ile $PM_{2.5}$ on 9/16/2013	9,11,12	
CCR (=> AAQ & / Natural Event)		13-28	
-were spatial analyses included, establishing a spatial relationship between the event, sources, transport of emissions, and recorded concentrations?	Yes	18-25	
-were temporal analyses included, establishing a temporal relationship between the high wind and elevated PM concentrations at the monitor?	Yes	25-26	
-comparison of event-affected day(s) to specific non-event days?	Yes	26-28	
-was the dust shown to be from the sources discussed in the nRCP section?	Yes	25-26	
-were alternative hypotheses discussed?	Yes	28	
-was a causal (not just correlational) relationship established?	Yes	13-28	
NEBF		29-31	
-was a “but for” analysis included?	Yes	29-31	

Appendix B. Eyewitness and Media Accounts

The following photos and reports are eyewitness accounts gathered from internet sources noted after each report.

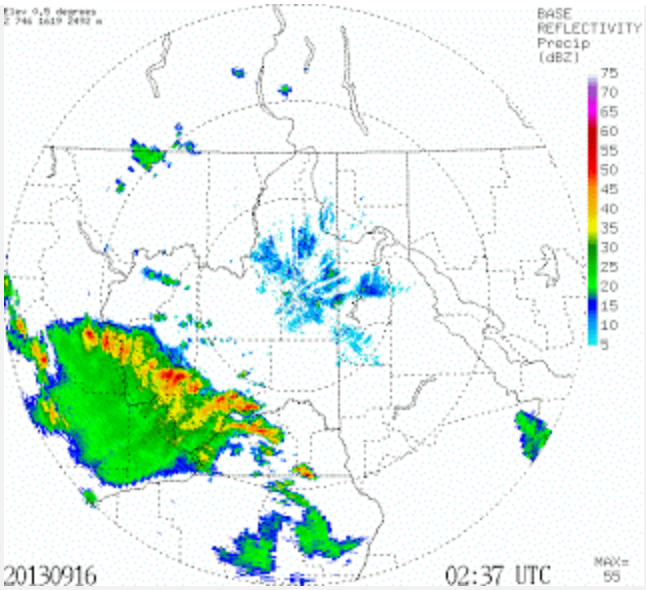
Tuesday, September 17, 2013

Haboob Hits Eastern Washington

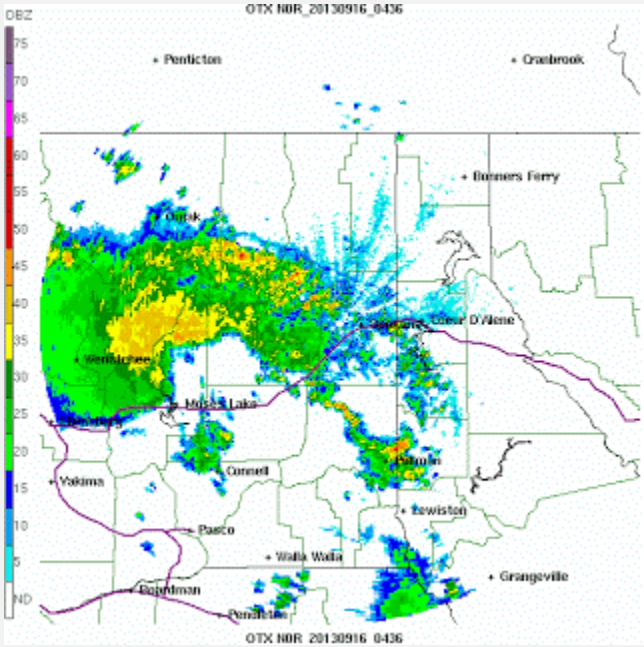
Picture by Robert Ames on Hightway 12 around 7 PM Sunday.

Haboob. An exotic name for an exotic weather feature. Haboobs are dramatic dust storms produced by strong winds that are generally associated with thunderstorm gust fronts or very strong cold fronts. Early Sunday evening the characteristic wall of dust was seen over a number of locations of eastern Washington as strong outflow winds from thunderstorms pushed northward over the inland empire.

An intense line of convection was moving northeastward into eastern Washington at 7:37 PM as seen by the Spokane NWS radar. Reds are intense rain and hail.

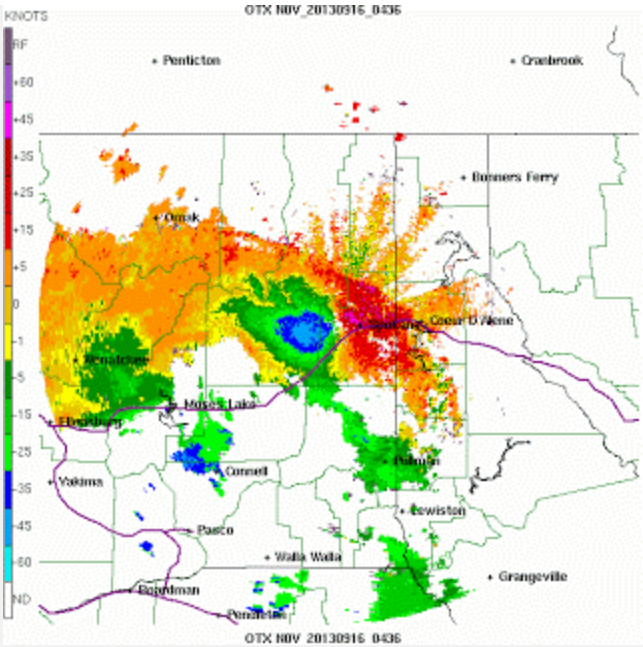


Two hours later it had push northward in a line extending from Wenatchee to Spokane.

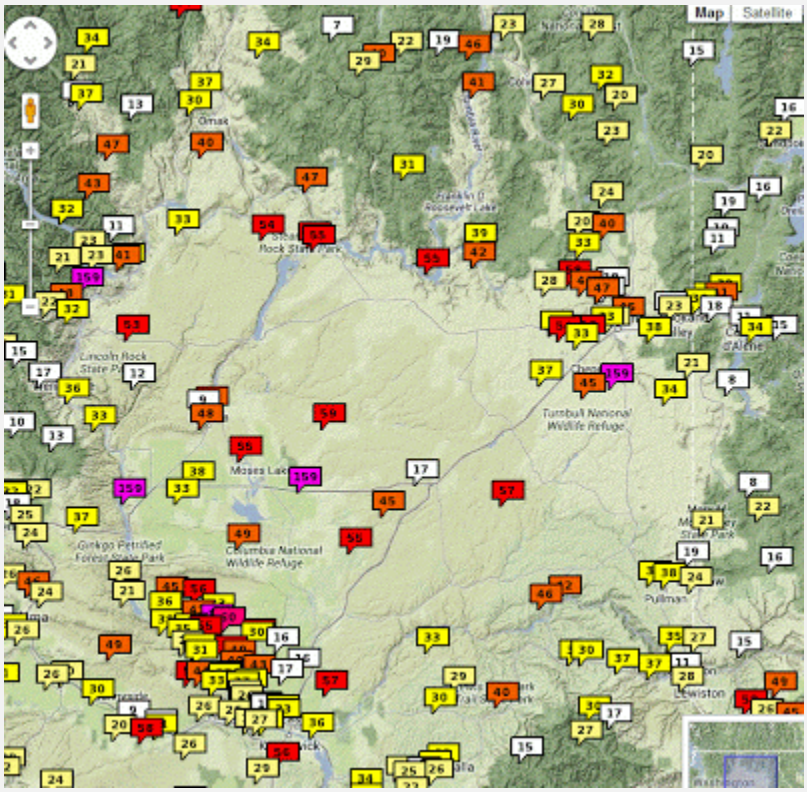


If you look carefully on the radar image you will see a thin line preceding the main echo....that is the gust front, the leading edge of the strong winds.

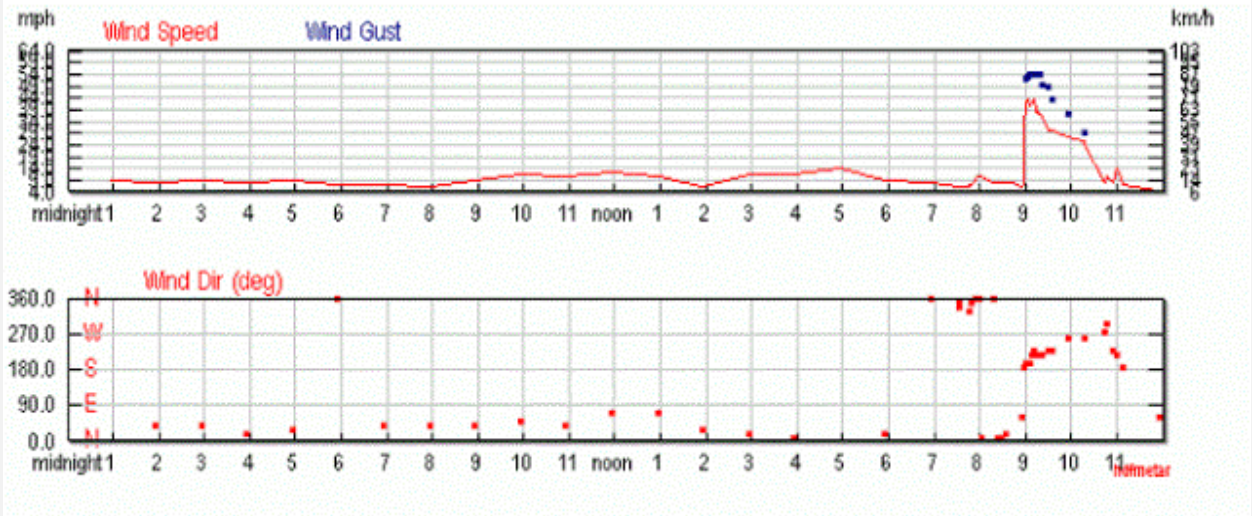
Since the NWS radars have Doppler capability, we can view winds from them as well. Here is the Doppler winds at 9:26 PM. Remember these are the components of the wind toward or away from the radar, not the total wind. Wow. At least 45 knots.



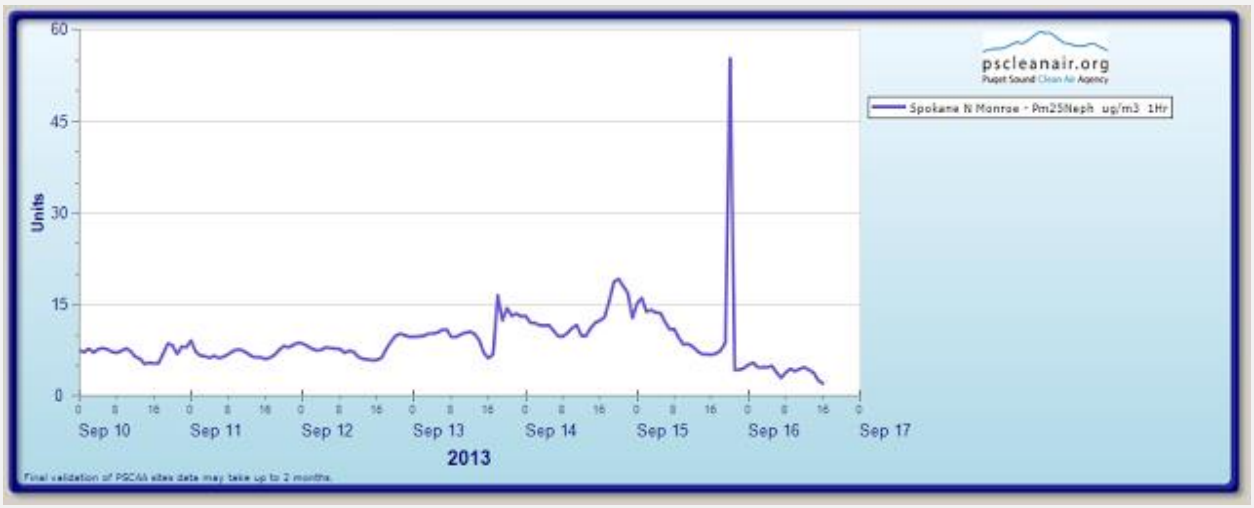
Take a look at a plot of the highest gusts for the 24 h period ending 7 PM Monday. Virtually all the max winds occurred during the thunderstorms. Plenty of gusts between 45 and 55 mph. (Ignore the 159s....something is wrong at those stations).



As a sample of the strong winds, here is what happened at Spokane's Fairchild AFB. Strong gusts (in the 50s mph) and a wind shift to the south. Several thousand homes lost power in areas of eastern Washington and a number of trees were toppled.



With a dust storm going on, you would expect some deterioration in air quality, right? Check out the measurements from the nephelometer (measures the particles in the air) at Spokane. A very well defined spike before midnight Sunday. That's the Haboob.



Haboobs are getting less frequent in eastern Washington as farmer's practice better soil conservation approaches, but it is hard not to get one after a parching summer and such strong winds.

By the way, Haboob or Arabic *habūb* means violent storm or strong winds.

Report from: *http://cliffmass.blogspot.com/2013/09/haboob-hits-eastern-washington.html*

Massive Dust Storm Clouds Eastern Washington

A giant dust storm blew over Eastern Washington this Sunday. | credit: Flickr Creative Commons: KauaiGuy808 | *rollover image for more*

Some really amazing photos have been circulating around the internet after storms recently rolled through Eastern Washington. I was driving back from Seattle to Richland, Wash., and into the storms.

If you haven't yet heard, an unusually large wall of dust clouded Eastern Washington skies this weekend. The storm is known by a Middle Eastern term: haboob.

A rainbow behind the storms.

Behind the menacing clouds the sky looked like it was on fire. A brilliant orange and red sunset melted into the storm. Even cooler, lightning danced around a faint rainbow. (My sad iPhone photo doesn't do it any justice, but I'll post it anyway. You can kind of see the orange in the rearview mirror. Don't worry — I wasn't driving.)

Ahead of the storm was where the real photographic magic happened.

Here's what Greg Koch, a senior forecaster with the National Weather Service in Spokane, told theNorthwest News Network:

"To get a haboob, you need to have a clash between very hot air, very dry air and a pretty vigorous storm system," Koch explained. "We had that collision. And it happened at just the time of year where a lot of agricultural activity has worked the ground, so that dust was ready to blow in the dry wheat country."

USA Today has a pretty cool video, although the corresponding article says haboobs only happen in Arizona, the Sahara desert and the Middle East.

Report from: *http://earthfix.opb.org/land/article/massive-dust-storm-clouds-eastern-washington/*

Dust, thunderstorm hit Mid-Columbia

BY TRI-CITY HERALD STAFF

RECENT HEADLINES

A thunderstorm swept through the Tri-Cities on Sunday night, causing lightning and gusty winds.

A large dust cloud came over the west side of Badger Mountain and rolled north through the Tri-Cities.

The storm started about 5:30 p.m. and a thunderstorm warning was effect in Benton County until 7:15 p.m.

Winds of almost 50 mph were recorded at the Tri-Cities Airport in Pasco. The lightning sparked several small fires, fire officials said.

Downed power lines and trees also were reported in Benton and Franklin counties. Crews worked into the night to remove branches from power lines and to keep the roadways clear.

Benton Fire District 1 responded to reports of small fires, but they were quickly put out by the rain. No injuries were reported.

Today, expect mostly sunny skies with a high near 80 and 17 mph winds with gusts as high as 28 mph, the National Weather Service reported.

There is a chance of showers Tuesday, according to the weather service.

Report from: *http://www.tri-cityherald.com/news/local/article32141688.html*

Photo size: Medium - Large Sunday September 15, 2013 Walla Walla, WA (Current Conditions)

Photo from:
http://classic.wunderground.com/wximage/viewsingleimage.html?mode=singleimage&handle=hitech101&number=0&album_id=0&thumbstart=0&gallery=

Eastern Washington Dust Storms & Habubs

4:00pm
I checked the Wunderground updates and the following warning was issued.

AT 346 PM PDT…DOPPLER RADAR WAS TRACKING A LINE OF STRONG THUNDERSTORMS ALONG A LINE EXTENDING FROM SUNNYSIDE THROUGH THE TRI
CITIES TO NORTH OF WALLA WALLA AND MOVING NORTH AT 35 MPH.

A GUSTS FRONT PRODUCING WINDS 60 TO 70 MPH WILL BE POSSIBLE WHEN THESE STORMS MOVE INTO SOUTHERN GRANT…ADAMS…WHITMAN AND NORTHERN
GARFIELD COUNTIES.

THESE WINDS WILL MOVE INTO MATTAWA…OTHELLO…HAY AND POMEROY BY 430.

LOCATIONS IMPACTED INCLUDE…
MOSES LAKE…OTHELLO…COLFAX…WARDEN…RITZVILLE…POMEROY…
CASCADE VALLEY…MATTAWA…ROYAL CITY…LIND…ST. JOHN…GEORGE…
ENDICOTT…WASHTUCNA…HATTON…SMYRNA…DODGE…PAHA…WINONA AND BEATRICE.

THOSE ATTENDING THE GRANT COUNTY FAIR ARE IN THE PATH OF THESE STORMS AND SHOULD PREPARE FOR IMMINENT DANGEROUS WEATHER CONDITIONS.

A SEVERE THUNDERSTORM WATCH REMAINS IN EFFECT UNTIL 800 PM PDT TUESDAY EVENING FOR NORTH CENTRAL WASHINGTON

Next I checked the Nexrad radar to find a cluster of storms over Tri-Cities, with mesocyclone systems on both sides extending 100 miles wide. The systems were forming that tell-tale line we now associate with haboobs (habub). There were two last year (2013) in September and one El Derecho in July of 2012, so the radar can be a very useful tool.

Nexrad Radar Picture after the storm passed

4:15pm

The air was dead calm and the temperature read 100°
I read the report out loud to Will and the response was “time to go get ready, it’s probably moving fast”.

4:20pm
It took 1/2 hour an hour to run through the check list: Release and lower the tensile structure, weight it down on the deck, Close all outbuilding doors, chairs up against the north wall, umbrella down, chickens into greenhouse, pull the tarp over their enclosure down and weight it in place, close all but one greenhouse door (100° and chickens inside), secure anything loose or laying around, find cats and put them in the shop with doors closed.

4:40pm
We came around the west side of the house to roll up the awnings, looked south and saw it would be a habub. The sky has such a strange appearance when this happens; in front of the usual dark various dark shades of gray thunderheads – a giant red brown tinted wall roils and appears to move like a giant north shore Oahu wave.

5:03
After we rolled up the awnings I was able to snap the following pictures, at 5:03pm, from the edge of the driveway looking south. There was a light breeze & the temperature still read 100°. I thought the wall was at least 30 minutes away.

Ocean Wave of Red Brown Dust

Wall of Voodoo Nine Minutes Away

5:09

That would be me, being wrong. I walked down the driveway to the house, onto the deck, turned around to see Will latching the last greenhouse door shut and looked just beyond him to see the wall cross the road onto the property. I went in, stood by the door, took this photo and then opened the door for Will.

Two Minutes Too Late

The door to the middle silo wasn't latched tight enough and the wind ripped it off its hinges. The silo door is made of solid steel. The haboob was so severe you could not see beyond 4 feet outside. Inside the house we required lights to see anything. It vacillated between total darkness and an eerie yellow and lasted for ½ and hour. The large system responsible for the habub pushed north becoming discordant, flailing off in all directions and unfortunately did not bring us the rain we were hoping for. Instead it changed course and moved away in a NW pattern (not normal) after hitting Spokane. (Nexrad photo)

At 6pm the temperature read 70°.

Here's an explanation from Wikipedia

"When this downdraft of cold air, or *downburst*, reaches the ground, it blows dry, loose silt and clay (collectively, dust) up from the desert, creating a wall of sediment that precedes the storm cloud. This wall of dust can be up to 100 km (62 mi) wide and several kilometers in elevation. At their strongest, haboob winds often travel at 35–100 km/h (22–62 mph), and they may approach with little or no warning. Often rain does not appear at ground level as it evaporates in the hot, dry air (a phenomenon known as virga). The evaporation cools the rushing air even further and accelerates it. Occasionally, when the rain does persist, it can contain a considerable quantity of dust. Severe cases are called *mud storms*. Eye and respiratory system protection are advisable for anyone who must be outside during a haboob. Moving to shelter is highly desirable during a strong event."

Looks like we made the National News

http://www.usatoday.com/story/news/nation-now/2014/08/13/haboob-dust-storm-eastern-washington/13989481/

http://www.kgw.com/story/news/local/vancouver/2014/08/13/haboob-dust-storm-washington-ritzville/13999587/

Report from: *http://columbiabasinpermaculture.com/?p=5323*

Appendix C. Particulate Concentration Data

Table C-1. Location and magnitude of $PM_{2.5}$ concentrations before, during, and after the event.

Date	Spokane, WA	Pinehurst, ID	Plummer, ID	Ritzville, WA	Rosalia, WA	Pullman, WA	Lacrosse, WA	Wellpinit, WA	Libby, MT
Maximum 1-hour $PM_{2.5}$ Concentration									
9/13/2013	23.1	23.8	13.3	8.3	9.4	13.1	9.5	8.6	16.3
9/14/2013	20	29.4	12.2	10.7	10.4	12.5	10.9	12	20.6
9/15/2013	**228.1**	**155.1**	**76.6**	**24.3**	**31.8**	**24.2**	**18.9**	**17.6**	13.8
9/16/2013	9.8	**84.4**	**59.3**	6.8	5.6	10.4	6.1	6.5	**29.1**
9/17/2013	9.7	8.7	8.8	3.8	4.8	4.3	4.2	3.8	8.1
24-hour Averaged $PM_{2.5}$ Concentration									
9/13/2013	11.2	13.2	8.3	7.0	8.1	10.1	8.7	6.6	7.2
9/14/2013	13.1	14.5	9.7	8.1	8.4	10.0	8.9	8.9	9.8
9/15/2013	**16.0**	**25.5**	**15.2**	**7.2**	**8.3**	**9.5**	**7.7**	**8.1**	9.0
9/16/2013	4.2	**20.3**	11.3	2.8	3.0	3.7	2.3	4.5	**9.6**
9/17/2013	3.9	2.3	4.6	2.2	2.9	3.3	2.5	2.6	2.1

Table C-2. Hourly location and magnitude of PM_{10} concentrations during the event.

Date Local	Local Time	Kennewick, WA	Spokane-Augusta Ave., WA	Pinehurst, ID	Colville, WA	Sandpoint, ID	Libby, MT
9/15/2013	0:00	36	39	14	22	16	14
9/15/2013	1:00	37	44	15	20	16	13
9/15/2013	2:00	27	30	17	18	19	13
9/15/2013	3:00	18	27	11	15	19	12
9/15/2013	4:00	24	30	13	15	23	9
9/15/2013	5:00	27	30	15	19	19	9
9/15/2013	6:00	33	28	14	30	25	12
9/15/2013	7:00	36	23	13	24	33	17
9/15/2013	8:00	45	23	15	21	19	20
9/15/2013	9:00	30	23	14	30	20	23
9/15/2013	10:00	49	24	14	26	24	17
9/15/2013	11:00	57	21	13	18	23	25
9/15/2013	12:00	41	20	10	20	20	15
9/15/2013	13:00	40	17	8	31	20	14
9/15/2013	14:00	24	11	9	36	25	13
9/15/2013	15:00	50	16	9	42	21	13
9/15/2013	16:00	60	19	11	32	27	12
9/15/2013	17:00	**4037**	16	25	41	12	23
9/15/2013	18:00	7	31	23	22	16	31
9/15/2013	19:00	24	30	20	34	25	44
9/15/2013	20:00	48	**6471**	10	32	27	38

Date Local	Local Time	Kennewick, WA	Spokane-Augusta Ave., WA	Pinehurst, ID	Colville, WA	Sandpoint, ID	Libby, MT
9/15/2013	21:00	14	**257**	**2177**	**240**	13	26
9/15/2013	22:00	1	42	**896**	**60**	**1700**	26
9/15/2013	23:00	3	26	**394**	**52**	**525**	13
9/16/2013	0:00	5	19	**335**	**47**	**354**	16
9/16/2013	1:00	6	44	**238**	**42**	**285**	23
9/16/2013	2:00	8	65	**217**	37	**257**	34
9/16/2013	3:00	9	13	**192**	34	**222**	**48**
9/16/2013	4:00	6	12	**188**	36	**199**	**47**
9/16/2013	5:00	9	12	**339**	31	**221**	**43**
9/16/2013	6:00	8	15	**306**	31	**223**	**50**
9/16/2013	7:00	7	17	**41**	39	**113**	**56**
9/16/2013	8:00	9	20	16	37	26	**86**
9/16/2013	9:00	12	23	4	20	15	**98**
9/16/2013	10:00	16	36	14	12	17	**102**
9/16/2013	11:00	13	20	5	11	9	**44**
9/16/2013	12:00	4	17	7	11	10	22
9/16/2013	13:00	5	17	9	10	12	11
9/16/2013	14:00	12	27	3	9	12	9
9/16/2013	15:00	4	4	6	7	9	7
9/16/2013	16:00	5	14	19	11	13	10
9/16/2013	17:00	6	19	11	26	28	13
9/16/2013	18:00	6	24	15	14	21	20
9/16/2013	19:00	7	33	11	8	13	15
9/16/2013	20:00	6	8	8	16	13	6
9/16/2013	21:00	6	17	7	12	4	6
9/16/2013	22:00	9	8	7	9	4	5
9/16/2013	23:00	7	13	6	2	10	2