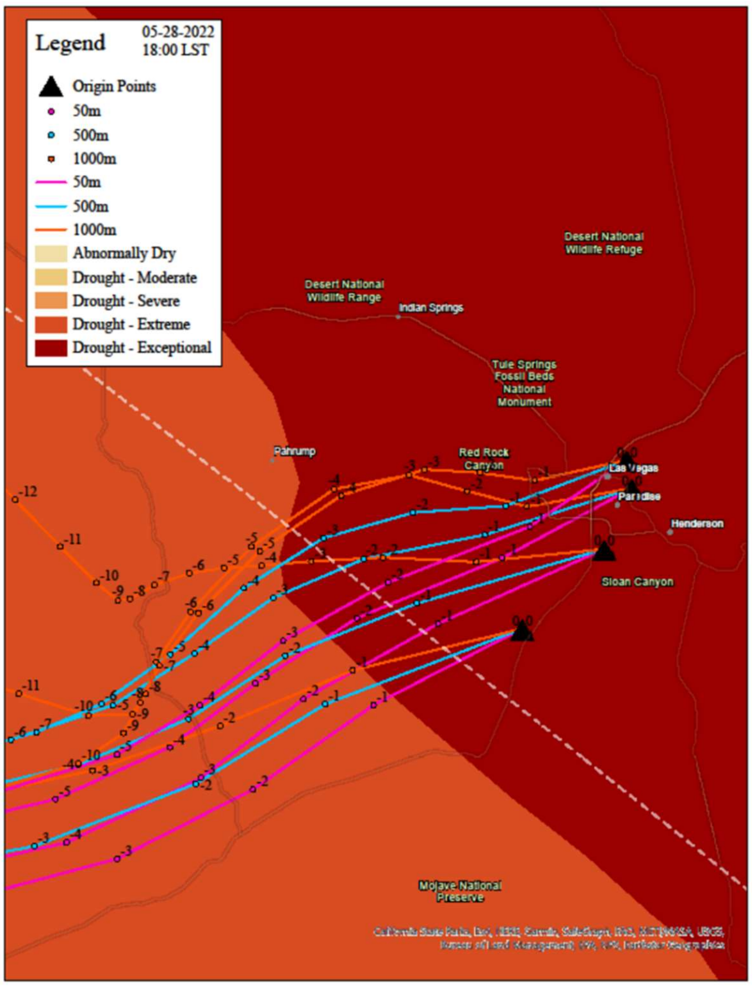
Exceptional Event Demonstration for PM_{10} Exceedances in Clark County, Nevada – May 28-29, 2022



Final Report Prepared for

U.S. EPA Region 9
San Francisco, CA

June 2024

STi Sonoma Technology

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Exceptional Event Demonstration for PM_{10} Exceedances in Clark County, Nevada – May 28-29, 2022

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The cover graphic shows HYSPLIT results for the May 28-29, 2022, high wind dust event overlaid with drought condition data for May 2022 in the southeastern California and southern Nevada areas.

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Contents

Figures

Tables

1. Narrative Conceptual Model

In late May 2022, a strong frontal passage traversed southeastern California, driving a windblown dust event that increased particulate matter concentrations in Clark County, Nevada, on May 28-29, 2022. During this episode, the 2012 24-hour National Ambient Air Quality Standards (NAAQS) threshold was exceeded for particles with a diameter of less than 10 microns (PM_{10}) at the Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley monitoring sites in Clark County. One additional site also experienced NAAQS exceedances, and all other sites throughout Clark County also experienced significantly enhanced hourly PM_{10} concentrations that were not regulatorily significant. The widespread impact on PM_{10} concentrations in Clark County indicates a regional dust event. The exceedances at the four regulatorily significant sites affect the PM_{10} attainment designation for Clark County during the 2021-2023 design value period.

Due to severe drought conditions in the Mojave Desert in southeastern California, strong winds from the frontal passage lofted, entrained, and transported dust to Clark County arriving in the late afternoon on May 28, 2022. The U.S. Environmental Protection Agency (EPA) Exceptional Event Rule (EER) (EPA, 2016) allows air agencies to omit air quality data from the design value calculation if it can be demonstrated that the measurement in question was caused by an exceptional event. In this case, enhanced wind speeds greater than 25 mph in the Mojave Desert source region coincide with the frontal passage and increased PM_{10} concentrations along the transport path, which is consistent with a high-wind dust event as described in the EPA Guidance on High Wind Dust Events (U.S. Environmental Protection Agency, 2019).

Overall, the May 28 and 29, 2022, PM_{10} events at the four affected sites rank above the 99th percentile for all 2018-2022 PM_{10} events in Clark County and is clearly exceptional compared to typical PM_{10} conditions. Windblown dust from the Mojave Desert is shown to be entirely from natural, undisturbed lands and can be considered a natural event that could not be mitigated by anthropogenic actions beyond public warnings. Overall, this report includes detailed analyses that establishes a clear causal relationship between the high-wind event in the Mojave Desert region of southeastern California with the enhanced PM_{10} concentrations measured at the four affected sites in Clark County, Nevada – designating the May 28-29, 2022 event as a High Wind Dust Exceptional Event.

Key narrative evidence and timeline elements are shown below and expanded on in this document.

Pre-Event Climatological Context

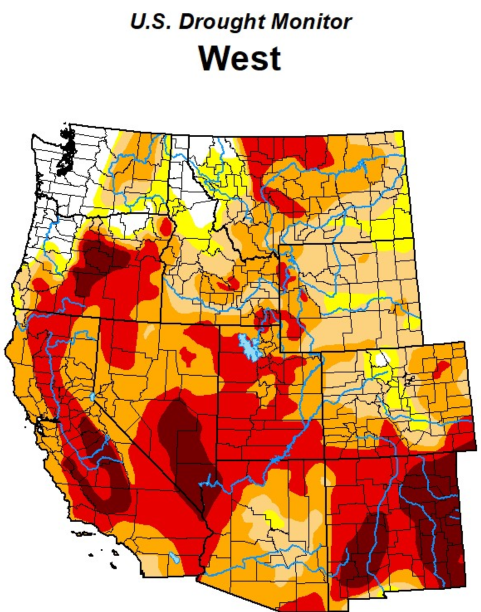

Figure 2.2-6

The Mojave Desert in southeastern California and Clark County, Nevada, was under extreme-to-exceptional drought conditions on and before the May 28-29, 2022, event. Temperatures were above normal and precipitation was below normal compared to climatology. The barren land cover, including the Mojave Desert source region, was primed for significant dust production during the high-wind event.

See Section 2.2.

Inciting High-Wind Event

Figure 3.1-6

A frontal passage containing high wind speeds and gusts pushed through southeastern California and across the Mojave Desert between 12:00 and 19:00 PST on May 28, 2022. Meteorological analysis and radar images of this event show the frontal passage (and associated dust) entering Clark County, Nevada, between 16:00 and 18:00 PST on May 28. Wind speeds in the Mojave Desert well exceeded the 25-mph sustained wind threshold over natural undisturbed lands. This caused lofting, entrainment, and transport of PM_{10} from the source region into Clark County.

See Section 3.1.

Transport of PM_{10} from the Source Region to Clark County

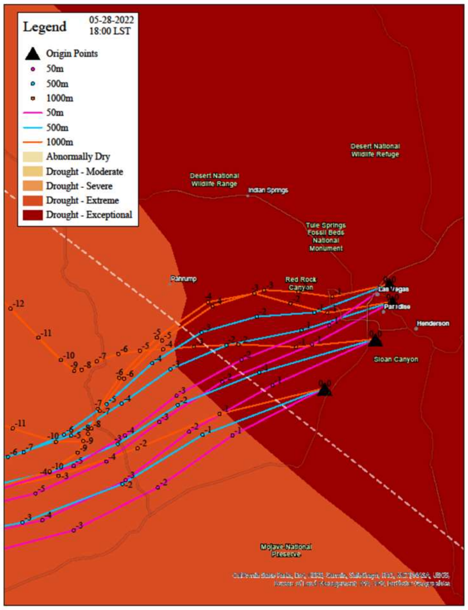

Figure 3.2-3

Back trajectories and meteorological data along the frontal passage confirm the Mojave Desert in southeastern California (located to the southwest of Clark County) as the source region for the high-wind dust event. The frontal passage pushed northeastward through the source region enroute to Clark County, Nevada, carrying PM_{10} to the area within four to six hours of the exceedance.

See Section 3.2

Enhanced PM_{10} Concentrations from High Wind Dust Event Arrives in Clark County

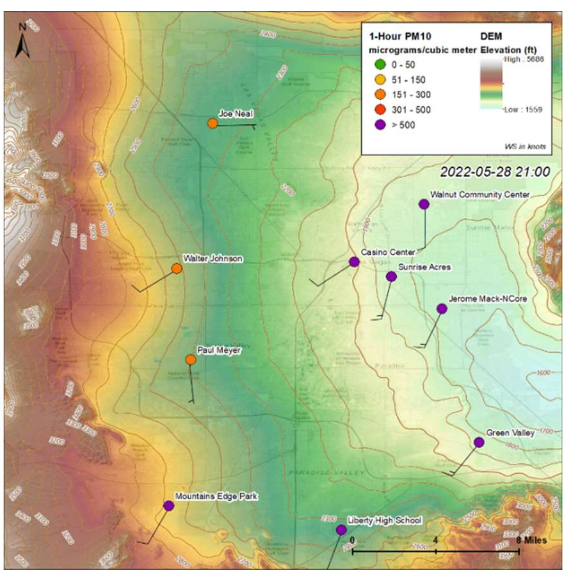

Figure 3.2-11

Enhanced PM_{10} concentrations arrived in Clark County beginning at 16:00-18:00 PST on May 28, 2022, and concentrations remained enhanced through 08:00-11:00 PST on May 29. High PM_{10} concentrations at the Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley sites coincided with the frontal passage and occurred just after high wind speeds occurred at the upwind sites. The Jean monitoring site also exceeded the NAAQS on May 28-29. Widespread high PM_{10} concentrations at all Clark County sites occurred simultaneously, indicating a regional high-wind event.

See Section 3.2

Effect of PM_{10} Concentrations in Clark County

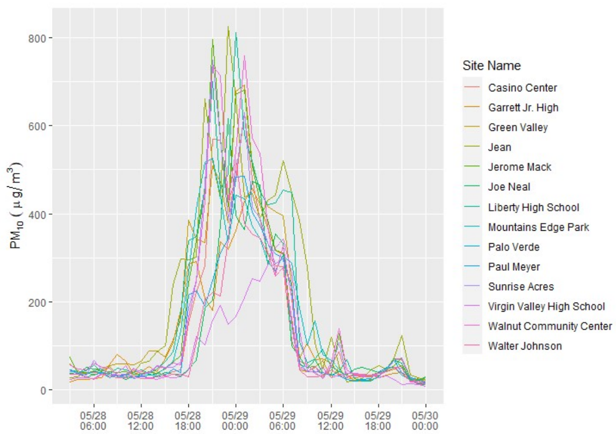

Figure 3.3-4

Five PM_{10} monitoring sites exceeded the NAAQS on May 28-29, 2022, though not all site exceedances were regulatorily significant. All sites throughout Clark County showed peak hourly concentrations of PM_{10} greater than 400 µg/m^3. The widespread high PM_{10} concentrations concur with a regional high-wind exceptional event. PM_{10} concentrations at the Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley sites exceeded the five-year 98th percentile and the NAAQS on May 28-29, 2022.

See Section 3.3

High Wind or PM_{10} Alerts Issued

News Release

County Commission:
James B. Gibson, Chairman
Justin Jones, Vice Chairman
Marilyn Kirkpatrick
William McCurdy II
Ross Miller
Michael Naft
Tick Segerblom

Yolanda King, County Manager

Office of Public Communications • (702) 455-3546 • FAX (702) 455-3558 •

Contact: Kevin J. MacDonald, Public Information Officer
Mobile: (702) 232-0931
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For Immediate Release **Sunday, May 29, 2022**

Air Quality Dust Advisory Issued for Sunday

The Clark County Department of Environment and Sustainability has issued a dust advisory for **Sunday, May 29,** to advise residents and local construction sites of the possibility of elevated levels of blowing dust due to the forecast of high winds in our area. Dust transported overnight into the region from the Mojave Desert.

Airborne dust is a form of inhalable air pollution called particulate matter or PM, which aggravates respiratory diseases. Under windy conditions people with heart or lung disease, older adults, and children may feel better staying indoors as much as possible because they could be at greater risk from particulates, especially when they are physically active, according to the U.S. Environmental Protection Agency. Consult your physician if you have a medical condition that makes you sensitive to air pollution.

Figure 3.3-2

Clark County, Nevada, issued a Construction Notice in advance of the May 28-29, 2022, event and a Dust Alert for May 29 due to high winds and lofted dust. They advised residents and local construction sites that enhanced levels of blowing dust is possible due to high winds. The news release mentioned that the dust was transported overnight into the area from the Mojave Desert. The National Weather Service also issued several alerts as well as social media statements. Multiple news outlets reported on the high wind and dusty conditions on May 28-29, 2022.

See Section 3.3

Comparison with Historical Data

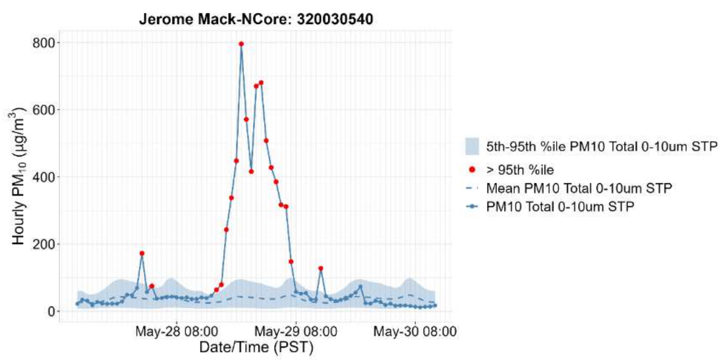


Figure 3.4-11

PM_{10} concentrations at the Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley sites exceeded the five-year 98th percentile and the NAAQS on May 28 and 29, 2022. These PM_{10} concentrations are also significantly outside typical seasonal and monthly ranges. 30-year climatology analyses show temperatures, wind speeds, and soil moisture in the Mojave Desert source region and Clark County were significantly outside of the historical normal on the event date.

See Section 3.4.

Not Reasonably Controllable or Preventable

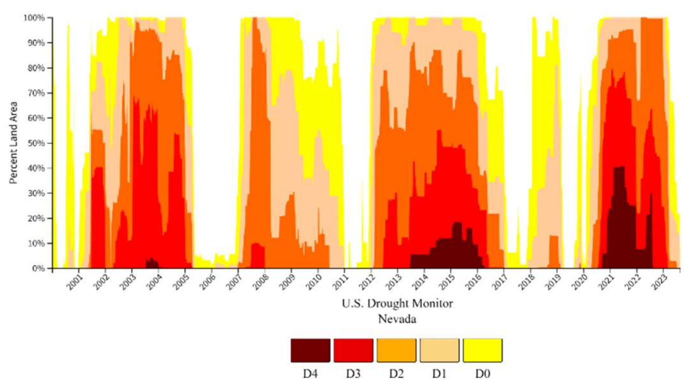


Figure 4.3-3

Based on the severe drought in the source region and the high wind frontal passage, control measures for PM_{10} concentrations within Clark County were quickly overwhelmed and unable to prevent an exceedance event. Significant evidence showing high winds lofted, entrained, and transported PM_{10} from natural undisturbed lands indicates that this event was natural and not reasonably controllable or preventable.

See Section 4 and 5.

2. Background

2.1 Demonstration Description

2.1.1 PM_{10} Exceptional Event Rule Summary

The U.S. EPA EER (EPA, 2016) allows air agencies to omit air quality data from the design value calculation if it can be demonstrated that the measurement in question was caused by an exceptional event. According to EER, exceptional events such as high-wind dust events that affect PM_{10} concentrations can be subject to exclusion from calculations of the NAAQS attainment (i.e., design values) if a clear causal relationship can be established between a specific event and the monitoring exceedance (EPA, 2016). The EER states that an exceptional event demonstration must meet the following six statutory elements:

1. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s),
2. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation,
3. Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times,
4. A demonstration that the event was both not reasonably controllable and not reasonably preventable,
5. A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event, and
6. Documentation that the air agency followed the public comment process.

Specifically, a high-wind dust demonstration must show that the dust event is a "natural event," where windblown dust is from natural sources or all significant anthropogenic sources of windblown dust have been reasonably controlled using Best Available Control Measures (BACM) (EPA, 2016). Further, air agencies must show that the event met the high wind threshold of a sustained wind speed of 25 mph or more, or an alternative area-specific high wind threshold. The high wind threshold is the minimum wind speed capable of causing PM emissions from natural undisturbed lands. If the 25-mph wind speed threshold was not met, a more detailed analysis is necessary to support the "not reasonably controlled or preventable" criterion. The winds causing the PM_{10} exceedance on May 28 and 29, 2022, met the 25-mph sustained wind speed threshold in the Mojave Desert dust source region.

2.1.2 Requirements for Demonstration Based on Tier

The EPA "Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Influenced by High Wind Dust Events Under the 2016 Exceptional Events Rule" (EPA, 2019) describes a three-tier analysis approach to determine a "clear causal relationship" for exceptional events demonstrations from an air agency. A summary of analysis requirements for each tier is listed in **Table 2.1-1**.

- Tier 1 analysis is applicable when the exceptional event is associated with a large-scale dust storm where recorded visibility is ≤ 0.5 miles, sustained winds are ≥ 40 mph, and is a focus of a Dust Storm Warning.
- Tier 2 analysis is applicable when the impacts of the dust event on PM_{10} levels are less clear and require more supportive documentation than Tier 1 analysis. Tier 2 analysis is warranted when sustained winds during the exceptional event are ≥ 25 mph but does not meet the other thresholds required in Tier 1 analysis.
- Tier 3 analysis is necessary when the impacts of the dust event on PM_{10} levels are more complicated than conditions described in the first two Tiers. Tier 3 analysis is needed when sustained winds during the exceptional event do not meet the 25-mph threshold; events categorized as Tier 3 may require additional analysis such as Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model trajectories from the source area or source-specific emissions inventories.

Table 2.1-1. High wind PM_{10} exceptional event guidance requirements by tier

Tier	Requirements
1	• Referred to as "Large-Scale, High-Energy High Wind Dust Events." • Does not need justification to support the "not reasonably controllable or preventable" (nRCP) criterion. • To satisfy the nRCP criterion, the exceedance(s) must be associated with: - A dust storm that is the focus of a Dust Storm Warning. - Sustained winds that are ≥ 40 mph. - Reduced visibility ≤ 0.5 miles. • Must occur over a "large geographic area."
2	• Referred to as "High Wind Dust Events with Sustained Winds at or above the High Wind Threshold." • Does not meet criterion of Tier 1 high-wind dust events. • High wind threshold: - Default of ≥ 25 mph for certain states. - Measured as "at least one full hour in which the hourly average wind speed was at or above the area specific high wind threshold;" EPA will consider shorter averaging times as part of the weight-of-evidence demonstration, even if the hourly average was not above the threshold. • Must conduct a controls analysis for events where the dust source was anthropogenic: - Identify anthropogenic and natural sources. - Document whether a SIP, FIP, or other control measures addresses the event-related pollutant and all sources. - Confirm effective implementation of control measures.
3	• Referred to as "High Wind Dust Events with Sustained Winds less than the High Wind Threshold." • Sustained winds did not meet the threshold (i.e., sustained winds ≤ 25 mph). • Requirements same as Tier 2, except with the addition of the following possible analyses: - HYSPLIT trajectories of source area. - Source-specific emissions inventories. - Meteorological and chemical transport modeling. - PM filter chemical speciation analysis where filter-based monitors are used.

2.1.3 Demonstration Outline

The PM_{10} exceedance on May 28-29, 2022, qualifies for Tier 2 analysis since it is a high-wind dust event with sustained winds at or above the high-wind threshold of 25 mph in the source region when compared against shorter-averaged wind speed observations. Observations from the closest weather station to the source region—KBYS near Baker, CA—show sustained wind speeds above 30 mph and gusts up to 47 mph in the hours before the PM_{10} event in Clark County. The intense wind conditions upwind of Clark County described by the shorter-averaged data, coupled with the severe drought conditions that persisted in the source region and Clark County during May 2022, provides support that May 28-29, 2022, should be designated a Tier 2, high-wind dust event.

Table 2.1-2 provides a breakdown by section of all required analyses for the high-wind exceptional event. **Sections 3.1-3.3** discuss the high-wind event in detail, including a meteorological analysis (Section 3.1), the timeline of the high-wind dust event (**Section 3.2**), and evidence of the high-wind dust event observed at the surface (Section 3.3). This includes media coverage of (**Sections 3.3.2**) and ground images during the event (**Section 3.3.5**). Guidance for a Tier 2 analysis recommends a controls analysis when the dust source is not anthropogenic. **Section 2.2** identifies anthropogenic and natural sources of dust. **Sections 2.2.1 and 2.2.2** discuss the dust source for the event on May 28-29, which are natural, undisturbed lands southwest of Las Vegas; these sections also include an analysis of climatological factors that fostered prime conditions for lofted dust. **Sections 2.2.3 and 4.1** identify regional emissions and other sources of PM_{10}, and **Section 4** identifies control measures against PM_{10} emissions that exist in Clark County.

Table 2.1-2. Analysis elements required for a Tier 2 and 3 High Wind Exceptional Event by section in this report.

Tier	Elements	Section of This Report (Analysis Type)
2	High-wind dust event	Section 3 (Clear Causal Relationship)
	Sustained wind threshold	Section 3.1.1 (Meteorological Analysis) and 3.2.2 (High-Wind Event Timeline)
	Controls analysis for dust source	Section 2.2.3 (Regional Emissions of PM_{10}), Section 4.1 (Other Possible Source of PM_{10} in Clark County), Section 4.2 (PM_{10} Control Measures in Clark County), Section 4.3 (Reasonableness of Control Measures), and Section 4.4 (Effective Implementation of Control Measures)
3	HYSPLIT trajectories of source area	Section 3.2 (Transport to Clark County)
	Source-specific emissions inventories	Section 2.2.3 (Regional Emissions of PM_{10})
	Meteorological and chemical transport modeling	Section 3.1.1 (Meteorological Analysis)
	PM filter chemical speciation analysis where filter-based monitors are used	Section 3.3.4 (Particulate Matter Analysis)

Following the EPA's exceptional event guidance, we performed Tier 2 and Tier 3 analyses to show the "clear causal relationship" between the high-wind dust event and the PM_{10} exceedance event in Clark County, Nevada, on May 28-29, 2022. Focusing on the characterization of the meteorology, source region terrain and climatology, transport, and air quality on the days leading up to the event, we conducted the following specific analyses, the results of which are presented in Section 3:

- Performed a top-down meteorological analysis to trace the conditions between the surface and 250 millibars (mb) that led to the high-wind event in southern Nevada,
- Compiled maps and imagery of suspended dust, aerosol optical depth (AOD), and regional wind speed from satellite data,
- Showed the transport patterns via HYSPLIT modeling, and identified where the back trajectory air mass intersected with dust sources,
- Compared the timeline of meteorological events, high wind speeds, and enhanced PM_{10} concentrations,

- Tracked surface meteorological conditions along the transport path between the source region and Clark County,
- Compiled media coverage of the high-wind dust event and ground-based visibility imagery during the event,
- Examined speciated PM concentrations during the event,
- Compared diurnal patterns of PM_{10} during the event to historical measurements,
- Performed meteorologically similar day analysis to assess PM_{10} concentrations on days with comparable wind conditions.

2.1.4 Regulatory Significance

The high-wind dust event that occurred on May 28-29, 2022, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at the Green Valley (Monitor AQS ID 32-003-0298, POC 1), Liberty High School (Monitor AQS ID 32-003-0299, POC 1), Jerome Mack (Monitor AQS ID 32-003-0540, POC 1), and Walnut Community Center (Monitor AQS ID 32-003-2003, POC 1). The 24-hour PM_{10} exceedance values are listed in Table 2.1-3.

Table 2.1-3. The 24-hour PM_{10} concentrations for sites that exceeded the NAAQS on May 28-29, 2022.

Monitor AQS ID	Site Name	24-hour PM_{10} Exceedance Concentration (µg/m^3)	
		May 28, 2022	May 29, 2022
32-003-0298	Green Valley	--[a]	183
32-003-0299	Liberty High School	169	204
32-003-0540	Jerome Mack	158	175
32-003-2003	Walnut Community Center	155	179

[a] 24-hour PM_{10} concentration did not exceed the PM_{10} NAAQS.

A NAAQS exceedance that is approved by the EPA as an exceptional event may be excluded from regulatory examination under the EER. Seven additional suspected wind-blown dust events occurred between 2021 and 2023. Table 2.1-4 shows the 2021-2023 design values at each of these of the monitoring sites with and without EPA concurrence on the proposed exceptional PM_{10} events between 2021 and 2023.

Table 2.1-4. 2021-2023 design values at monitoring sites in the Las Vegas Valley without and with EPA concurrence that the May 28-29, 2022, and other suspected events qualify as exceptional events.

Monitor Site Name	Design Value Without EPA Concurrence	Design Value With EPA Concurrence
Green Valley	2.7	0.0
Liberty High School	3.0	0.3
Jerome Mack	3.7	0.3
Walnut Community Center	4.0	1.0

Further details on the design values with and without concurrence, as well as data completeness, may be found in the Initial Notification Summary Information (INI) submitted by Clark County, DES, to EPA Region 9 on February 12, 2024.

We request that the EPA evaluate the following assessment of the wind-blown dust event that occurred in Clark County on May 28-29, 2022, and agree to exclude the event from regulatory decisions regarding PM_{10} attainment.

2.2 Historical Non-Event Model

2.2.1 Land Type for Source Region and Clark County

Land use and cover type data from both the 2019 National Land Cover Database (NLCD) (Dewitz, 2021) and Sentinel-2 satellite are shown for the approximate source region of Mojave Desert in southeastern California (Figure 2.2-1). The primary land classifications in this region, shown by the Sentinel-2 Land Use/Land Cover map, are bare ground and rangeland, with small pockets of built area. Bare ground is defined as "areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation." Rangeland is defined as "open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting." The primary classifications shown by the 2019 NLCD map are mostly shrub/scrub, grasslands/herbaceous, and barren land (rock/sand/clay). Classifications from both maps indicate that the source region is primarily land with little to no vegetation cover with natural sources of dust that are predisposed to high-wind events.

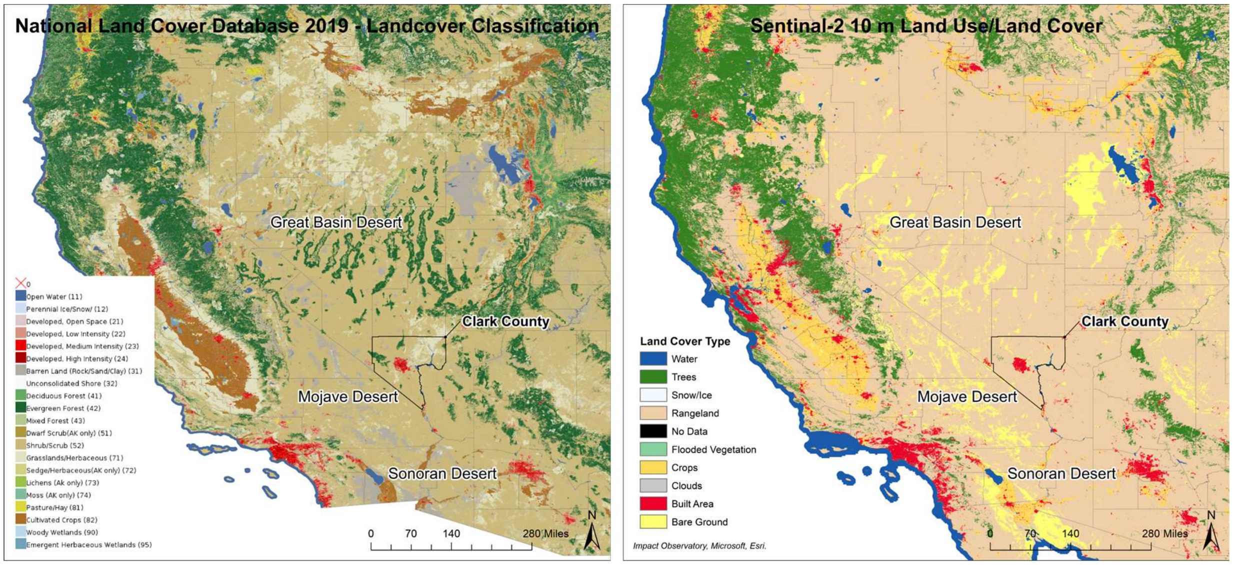


Figure 2.2-1. Land cover type for the western U.S. from (left) the National Land Cover Database-2019 and (right) Sentinel-2 satellite.

Figure 2.2-2 shows the land use and cover of Clark County and the surrounding area. The dominant land cover type in Clark County and the surrounding area is rangeland with pockets of bare ground and built area. Built area is defined as "human made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings, and residential housing." Central Clark County (i.e., Las Vegas and surrounding communities) is mostly classified as built area with some small areas of bare ground, surrounded by rangeland.

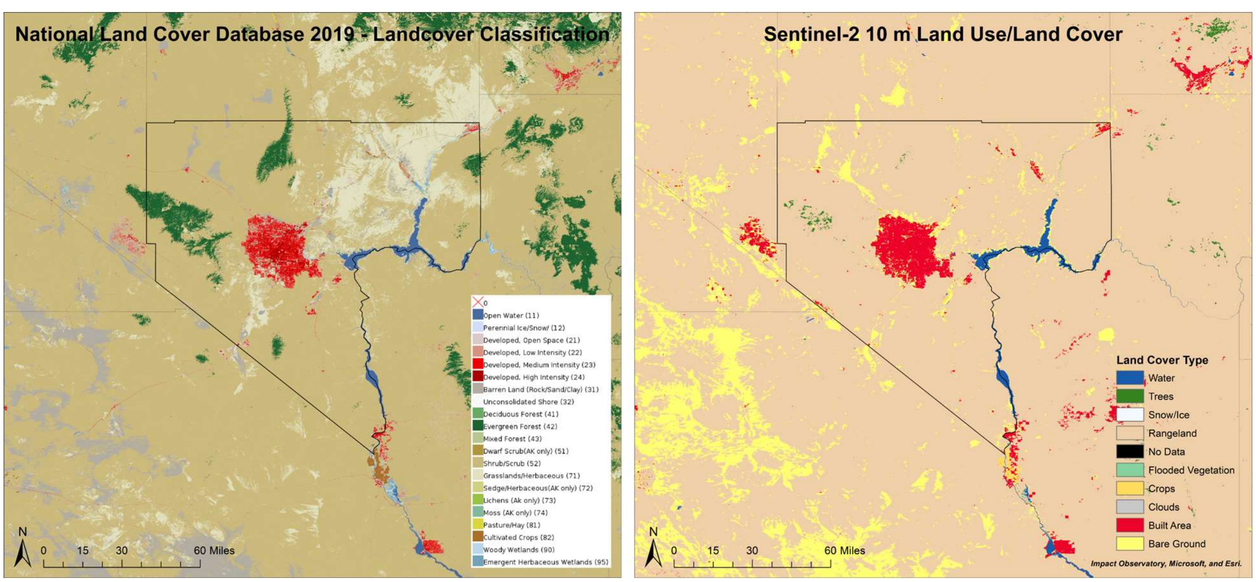


Figure 2.2-2. Land cover type for Clark County, Nevada, and surrounding area from the (left) National Land Cover Database-2019 and (right) Sentinel-2 satellite.

2.2.2 Climatology for Source Region and Clark County

The source region is the Mojave Desert in southeastern California. The Mojave Desert is part of the Mojave Basin and Range Ecoregion, which is located primarily in southern California and southern Nevada (including Clark County), with smaller portions in Arizona and Utah (Sleeter and Raumann, 2012). In general, the roughly 130,000 km^2 ecoregion is composed of broad basins and scattered mountains that are generally lower, warmer, and drier than those of the Central Basin and Range (which border the ecoregion to the north and covers the majority of Nevada). The ecoregion climate is characterized by high temperatures during summer months and very little annual precipitation (50–250 mm in the valleys). In addition to the Mojave Desert, the ecoregion includes other desert areas in southeastern California and southern Nevada. The Mojave Desert is the driest of the deserts that comprise the greater North American Desert. This is due in part to the presence of the Sierra Nevada Mountain ranges to the west, which produce a rain shadow effect that inhibits significant moisture from reaching the Desert. Additionally, heavy use of off-road vehicles and motorcycles in some areas has made the soils susceptible to wind and water erosion (Griffith et al. 2016).

Clark County is located in the southern portion of Nevada and borders California and Arizona. The county includes the City of Las Vegas, one of the fastest growing metropolitan areas in the United States with a population of approximately 2.2 million (U.S. Census Bureau, 2020). Las Vegas is located in a 1,600 km^2 desert valley basin at 500 to 900 m above sea level (Langford et al., 2015). It is surrounded by the Spring Mountains to the west (3,000 m elevation) and the Sheep Mountain Range to the north (2,500 m elevation). Three mountain ranges comprise the southern end of the valley. The valley floor slopes downward from west to east, which influences surface wind, temperature, precipitation, and runoff patterns. The Cajon Pass and I-15 corridor to the east is an important atmospheric transport pathway from the Los Angeles Basin into the Las Vegas Valley (Langford et al., 2015).

The Las Vegas Valley climatology features abundant sunshine and hot summertime temperatures (average summer month high temperatures of 34 °C to 40 °C). Because of the mountain barriers to moisture inflow, the region experiences dry conditions year-round (~107 mm annual precipitation, 22% of which occurs during the summer monsoon season from July through September). The urban heat island effect in Las Vegas during summer leads to large temperature gradients within the valley, with generally cooler temperatures on the eastern side. During the summer season, monsoon moisture brings high humidity and thunderstorms to the region, typically in July and August (National Weather Service Forecast Office, 2020). Winds in the Las Vegas basin tend to be out of the southwest during spring and summer (Los Angeles is upwind), while winds in the fall and winter tend to be out of the northwest, with air transported between the neighboring mountain ranges and along the valley.

Before the event on May 28, 2022, the temperature in the Las Vegas area was above the normal temperature range compared to the climate record (**Figure 2.2-3**), followed by cooler temperatures observed during the event. Concurrently, precipitation accumulation for the Las Vegas area was well below normal, nearing record lows, for late May (**Figure 2.2-4**).

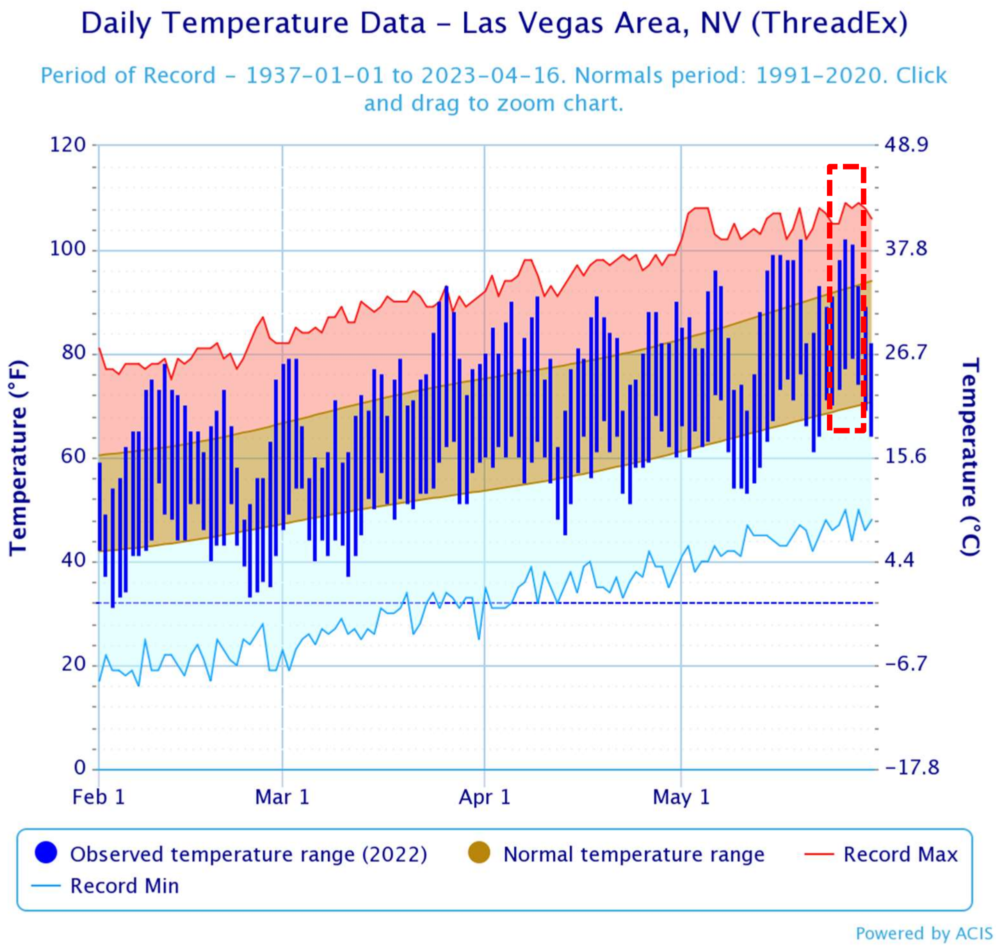


Figure 2.2-3. The temperature records for the Las Vegas area in Nevada from January 1, 1937, through December 26, 2022, by day, including (dark blue) observed temperature range 2020, (brown) normal temperature range, (red) record maximum, and (light blue) record minimum. The red box indicates the dates of high and near record heat before the May 28-29, 2022, event. Data from NWS: https://www.weather.gov/wrh/Climate?wfo=vef.

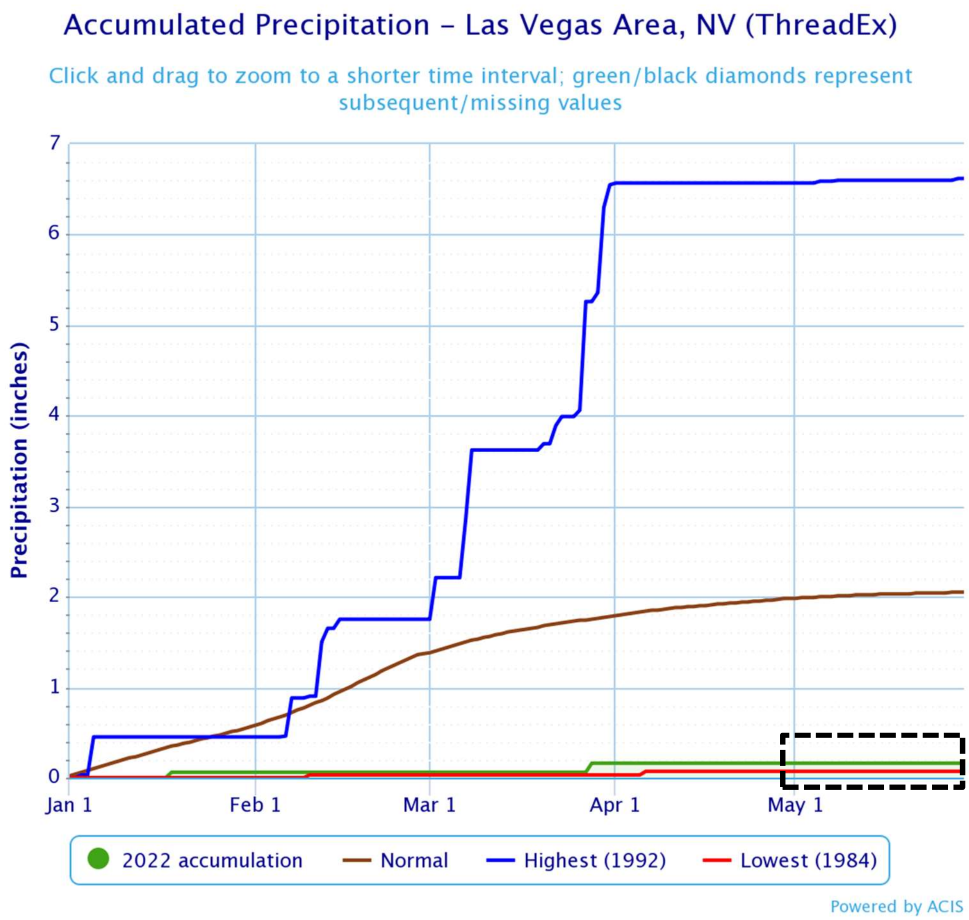


Figure 2.2-4. The precipitation records for the Las Vegas area in Nevada by day, including (green) accumulation in 2022, (brown) normal, (blue) record maximum, and (red) record minimum. The black box indicates the period of low accumulated precipitation before the May 28-29, 2022, event. Data from NWS: https://www.weather.gov/wrh/Climate?wfo=vef.

The extreme dry conditions in 2022 are also highlighted by the Palmer Drought Severity Index (PDSI) produced by the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Protection (NCEP). The areas of the western U.S. that experienced "extreme drought" conditions progressively increased in size and severity in the months before the PM_{10} exceedance (Figure 2.2-5). In May 2022, all counties in the California source-region are classified as in an extreme drought, as well as most counties in Nevada.

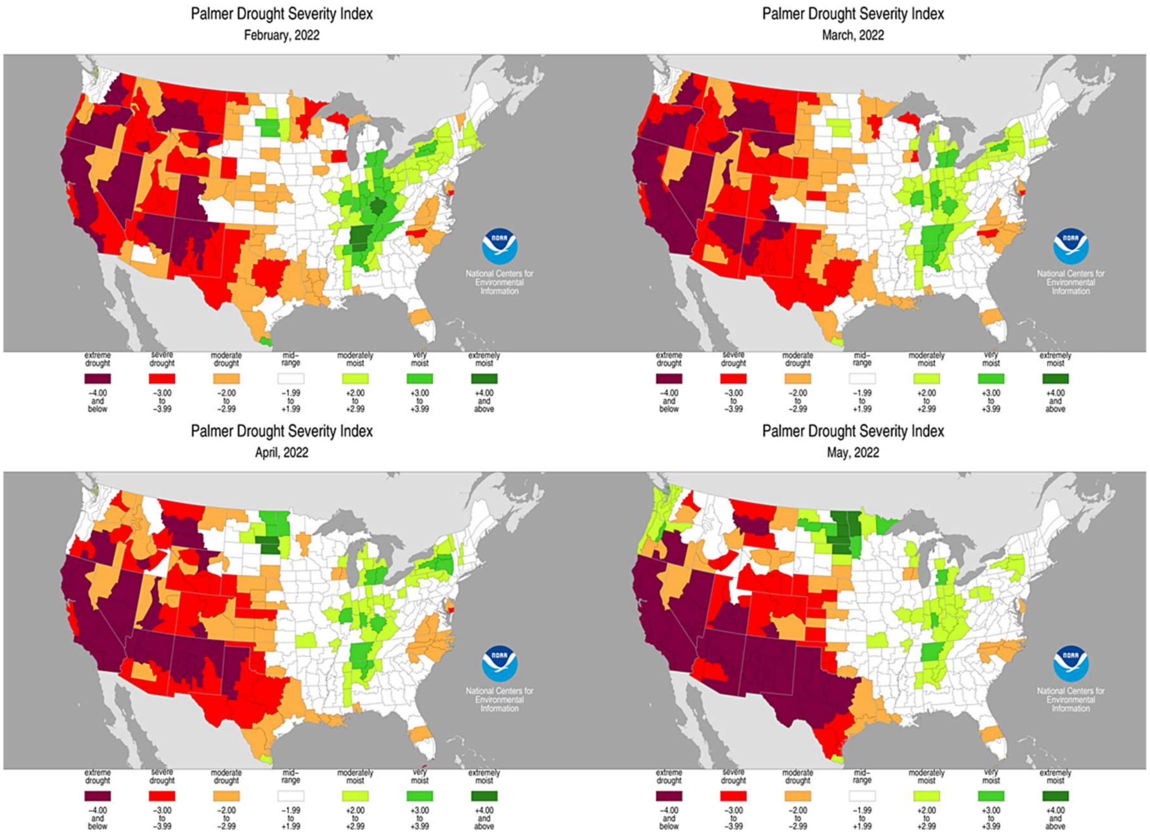
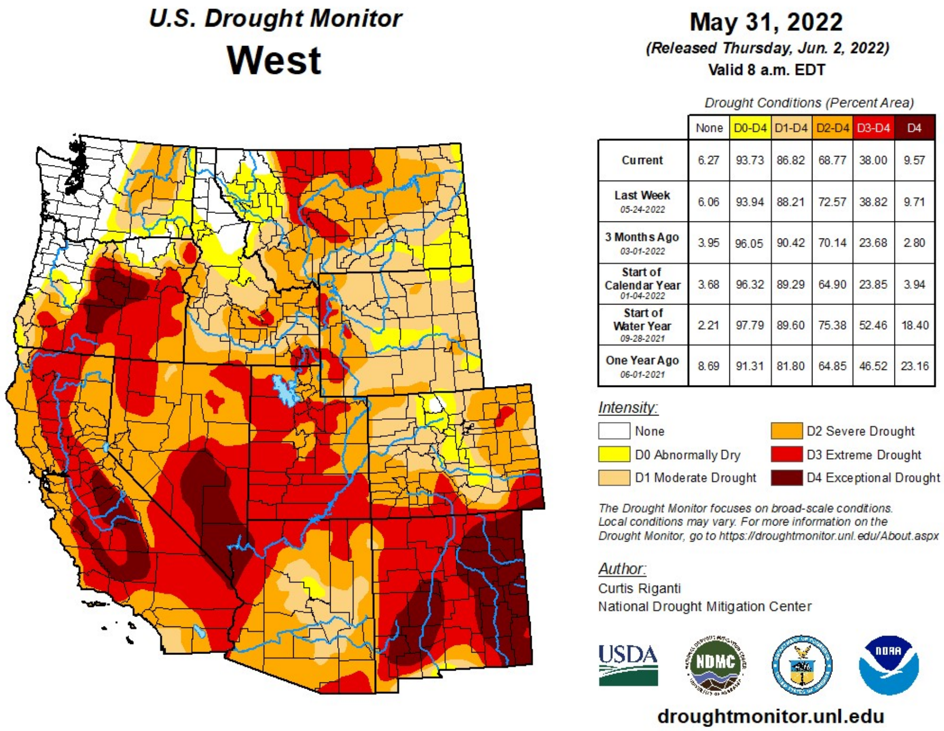


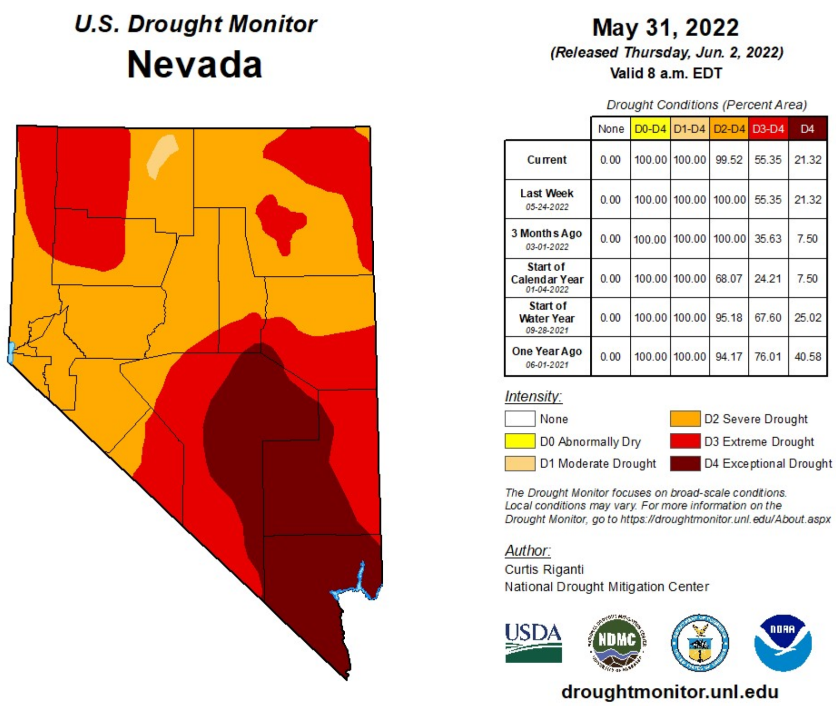
Figure 2.2-5. Palmer Drought Severity Index for February-May 2022.

By May 31, 2022, the western U.S. was under widespread drought conditions (**Figure 2.2-6**). The western U.S., including all of California and Nevada, remained in widespread drought conditions in area and severity in the year, months, and week before the PM_{10} exceedance. Extreme drought in the southwestern U.S. increased in area in the months before the exceedance. The California source region for this event was under severe-to-exceptional drought (D2 - D4). As of May 31, 2022, all (100.0%) of Nevada was included in the drought (**Figure 2.2-7**), including 68.77% in severe to exceptional drought (D2 - D4).



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	6.27	93.73	86.82	68.77	38.00	9.57
Last Week 05-24-2022	6.06	93.94	88.21	72.57	38.82	9.71
3 Months Ago 03-01-2022	3.95	96.05	90.42	70.14	23.68	2.80
Start of Calendar Year 01-04-2022	3.68	96.32	89.29	64.90	23.85	3.94
Start of Water Year 09-28-2021	2.21	97.79	89.60	75.38	52.46	18.40
One Year Ago 06-01-2021	8.69	91.31	81.80	64.85	46.52	23.16

Figure 2.2-6. U.S. Drought Monitor values for the western U.S. on May 31, 2022.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	99.52	55.35	21.32
Last Week 05-24-2022	0.00	100.00	100.00	100.00	55.35	21.32
3 Months Ago 03-01-2022	0.00	100.00	100.00	100.00	35.63	7.50
Start of Calendar Year 01-04-2022	0.00	100.00	100.00	68.07	24.21	7.50
Start of Water Year 09-28-2021	0.00	100.00	100.00	95.18	67.60	25.02
One Year Ago 06-01-2021	0.00	100.00	100.00	94.17	76.01	40.58

Figure 2.2-7. U.S. Drought Monitor values for the Nevada on May 31, 2022.

There are several Automated Surface Observing Systems (ASOS) weather measurement sites in the wind-blown dust source region with data spanning multiple decades (Figure 2.2-8). Figure 2.2-9 shows the distribution of the maximum daily temperatures at several sites in the wind-blown dust source region on May 27, 28, and 29 from 1991 through 2021. The median maximum daily temperatures have a wide range, but generally are between approximately 75 °F and 93 °F.

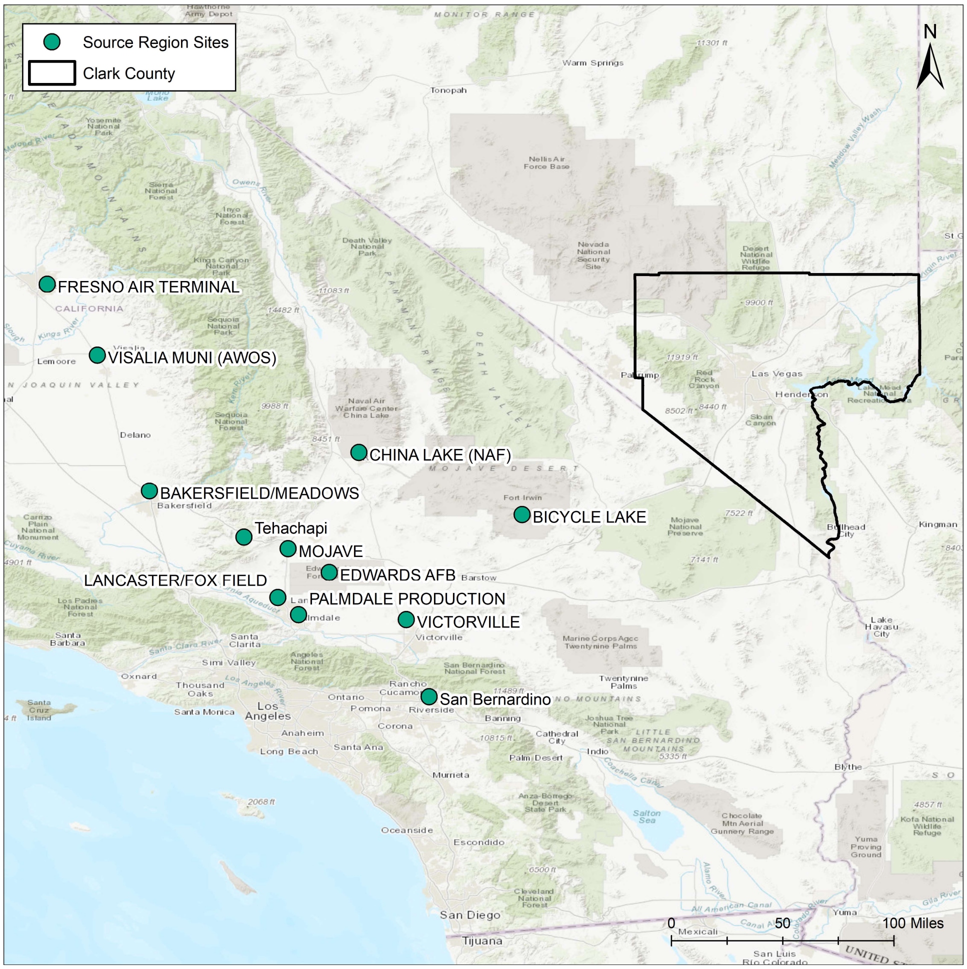


Figure 2.2-8. Location of ASOS measurement sites in the wind-blown dust source region.

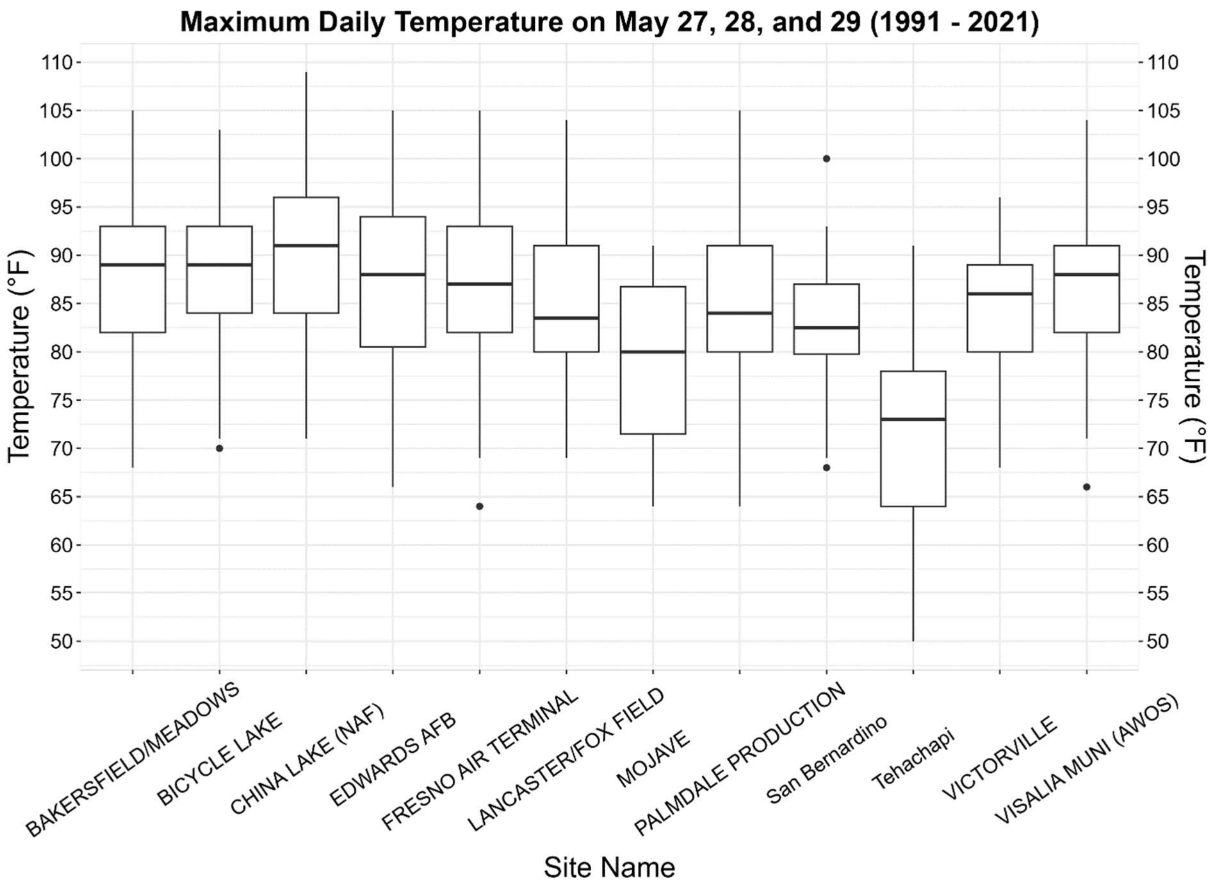


Figure 2.2-9. The average maximum daily temperature on May 27-29 from 1991 through 2021.

2.2.3 Regional Emissions of PM_{10}

Open lands account for approximately 86% of the total area of Clark County (~4.3 million acres), followed by incorporated lands at 8% (~400,000 acres), tribal lands at 1.5% (~80,000 acres), and the remaining planned land use categories at a combined 4.5% (~242,000 acres) (Figure 2.2-10). Open lands and incorporated Clark County largely align with bare ground and rangeland (see Figure 2.2-2), suggesting that dust may have been picked up in Clark County during the high-wind event.

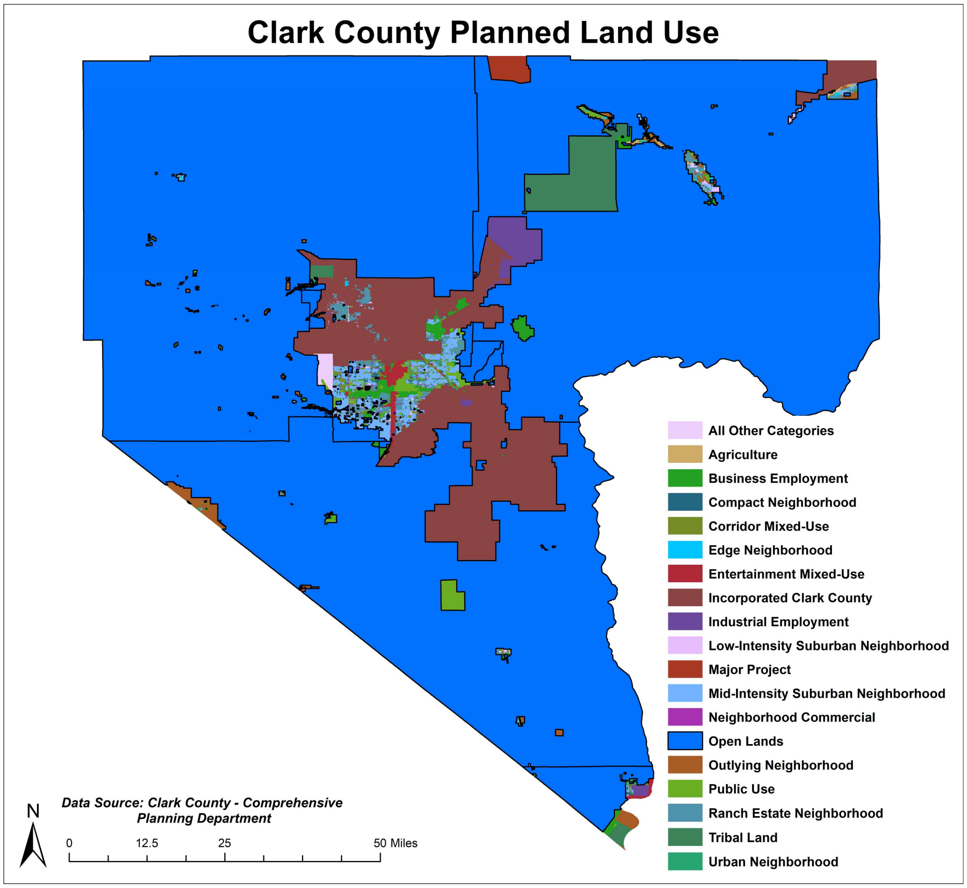


Figure 2.2-10. Planned land-use boundaries of Clark County.

Planned land use around the Green Valley site is comprised of incorporated Clark County (Figure 2.2-11). The sports complex to the south includes exposed land such as a dog park and dirt bike tracks. The remainder of the surrounding area is residential buildings and paved surfaces, with little exposed dirt or gravel.

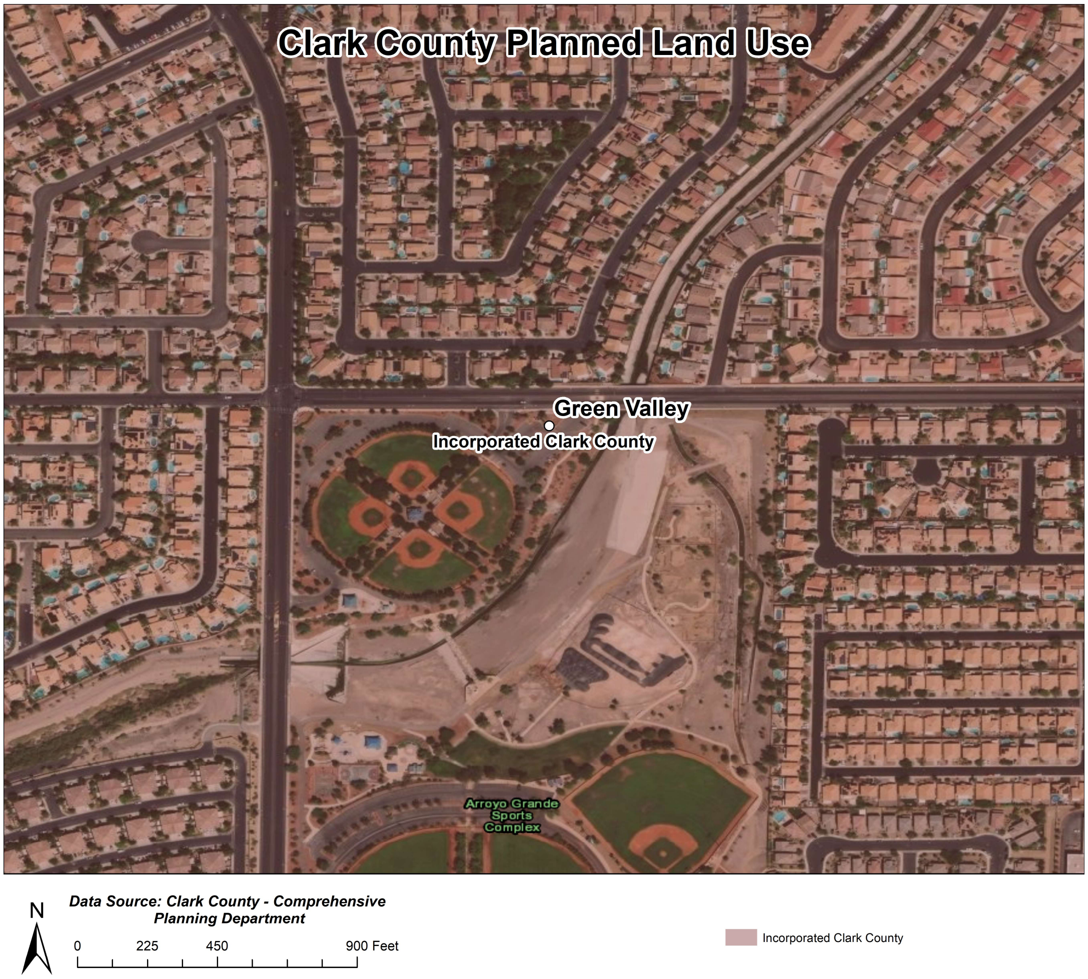


Figure 2.2-11. Planned land-use boundaries in the area around the Green Valley monitoring station.

Planned land use around the Jerome Mack site is comprised of public use to the west (Jerome Mack Middle School campus), a mid-intensity suburban neighborhood to the south, an urban neighborhood to the southeast, a compact neighborhood to the northeast, and business employment to the north and northwest. An aqueduct borders the Jerome Mack site immediately to the north (Figure 2.2-12). Much of the surrounding area includes buildings and paved surfaces such as parking lots and roads, with little exposed dirt or gravel.

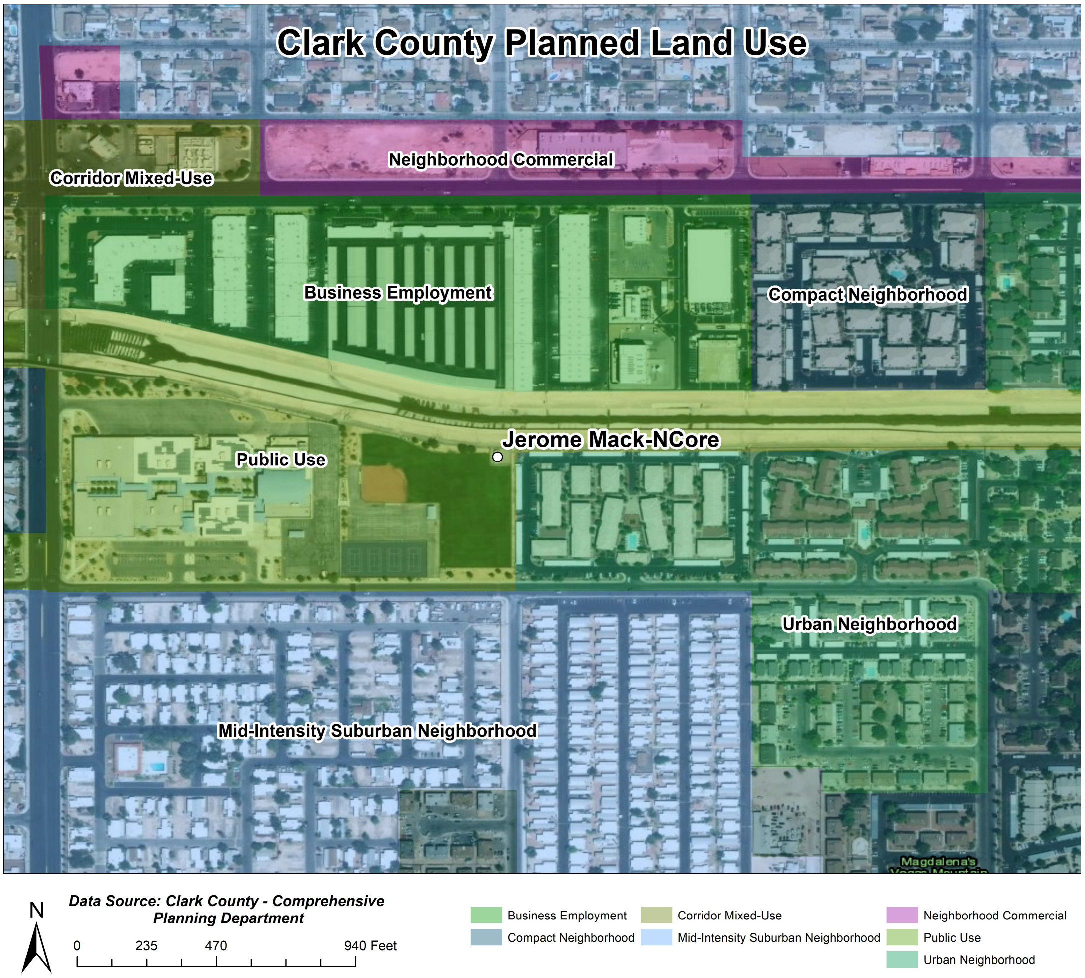


Figure 2.2-12. Planned land-use boundaries in the area around the Jerome Mack monitoring station.

Planned land use around the Liberty High School site is comprised of incorporated Clark County, Ranch Estate neighborhood, neighborhood commercial, and mid-intensity suburban neighborhood to the west, and mid-intensity suburban neighborhood and corridor mixed-use to the east (Figure 2.2-13). The Liberty High School site is at the southeastern edge of the Liberty High School campus near a baseball field and bordering a road. With the exception of the baseball field and a small strip of shrubs, grass, dirt, and gravel to the east, the immediate surroundings of the Liberty High School site are mostly paved surfaces with little exposed dirt and gravel.

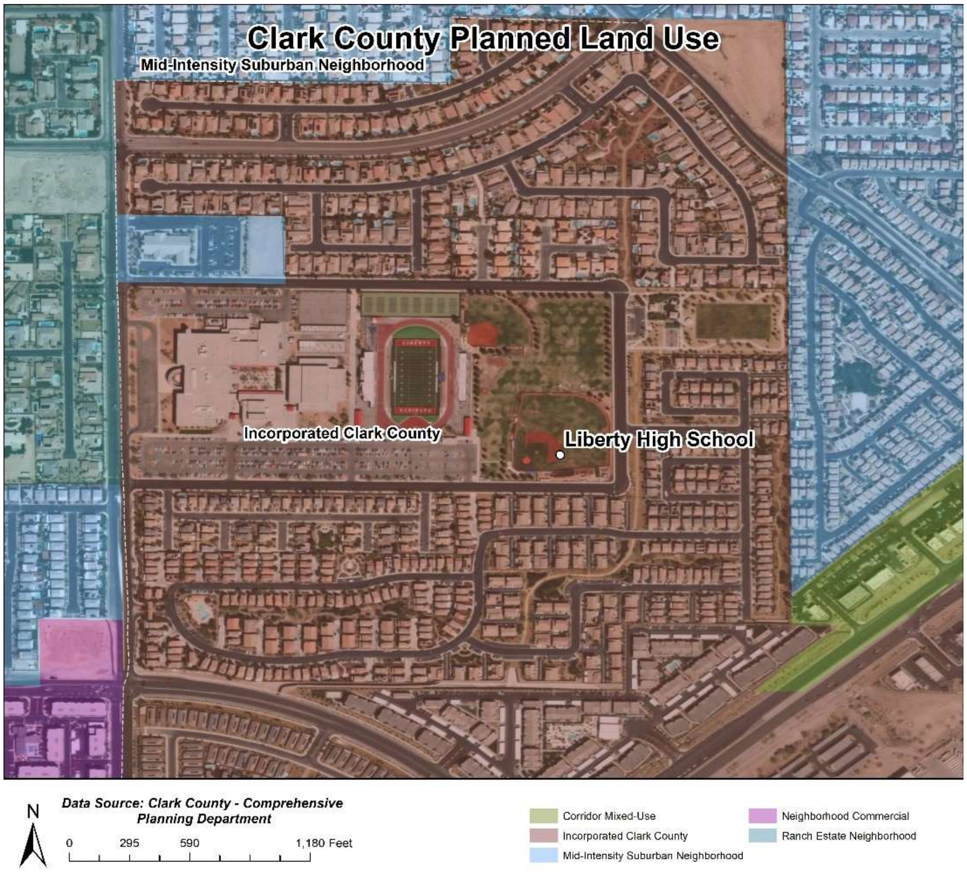


Figure 2.2-13. Planned land use boundaries around the Liberty High School monitoring station.

Planned land use around the Walnut Community Center site is comprised of public use (Walnut Park) and business employment to the south (Figure 2.2-14). With the exception of grass fields to the west and east, there is virtually no area with grass or exposed dirt or gravel.

Figure 2.2-14. Planned land use boundaries around the Walnut Community Center monitoring station.

Figure 2.2-15 shows the 2020 National Emissions Inventory (NEI) PM_{10} point sources around the Jerome Mack and Green Valley sites, where the size of the point source marker is proportional to the total annual of PM_{10} emissions. The map shows that there are no PM_{10} point sources within approximately two miles of the Jerome Mack site, and the closest point sources emit less than three tons of PM_{10} annually. The Green Valley site is approximately three miles from the nearest point sources; there are three sources to the East that emit up to 8-18 tons of PM_{10} annually, and one source to the North that emits 4-7 tons of PM_{10} annually.

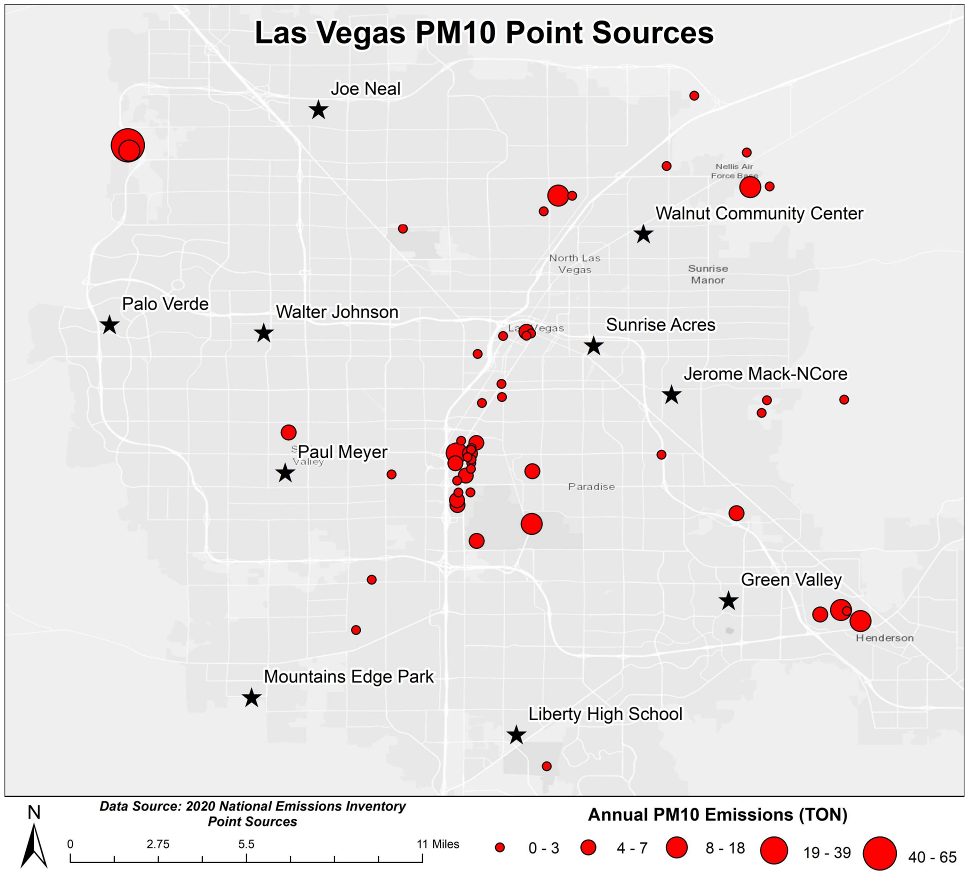


Figure 2.2-15. 2020 NEI point sources of PM_{10} emissions in Clark County.

Clark County provided information on all PM_{10} emissions as part of the 2012 "Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})" document. Point sources contributed 0.31% of PM_{10} emissions in 2008 and are projected to contribute 0.59% of PM_{10} emissions in 2023. Given the small contribution of point sources to total PM_{10} emissions and the lack of significant point sources near the sites, it is unlikely that point sources contributed to the May 28-29, 2022, exceedance.

Nonpoint sources in Clark County contribute greater than 98% of PM_{10} emissions. The assessment shows a reduction of 31% in total PM_{10} emissions between 2008 and 2023, with notable decreases in the contribution of wind erosion (vacant lands) to total PM_{10} emissions between 2008 and 2023 (Figure 2.2-16). Increasing contributions from construction-related emissions are due to increasing conversion of vacant lands to built areas. Therefore, there has been an increasing contribution to total emissions from wind erosion associated with construction, paved roads, and other sources. The Jerome Mack site is approximately a quarter of a mile away from a major paved road source (S Lamb Blvd), as is the Green Valley site (N Stephanie St), so paved roads and on-road emissions likely did not contribute to the May 28-29, 2022, exceedance.

A Construction Notice was issued for Friday, May 27 through Saturday, May 28, 2022. Subsequently, a Dust Alert was issued for Sunday, May 29, 2022, due to blowing dust via southwesterly winds from the Mojave Desert. A Construction Notice requires construction sites to immediately inspect their construction sites, implement BACM, and avoid blasting activity at threshold wind speeds to mitigate wind-blown dust.

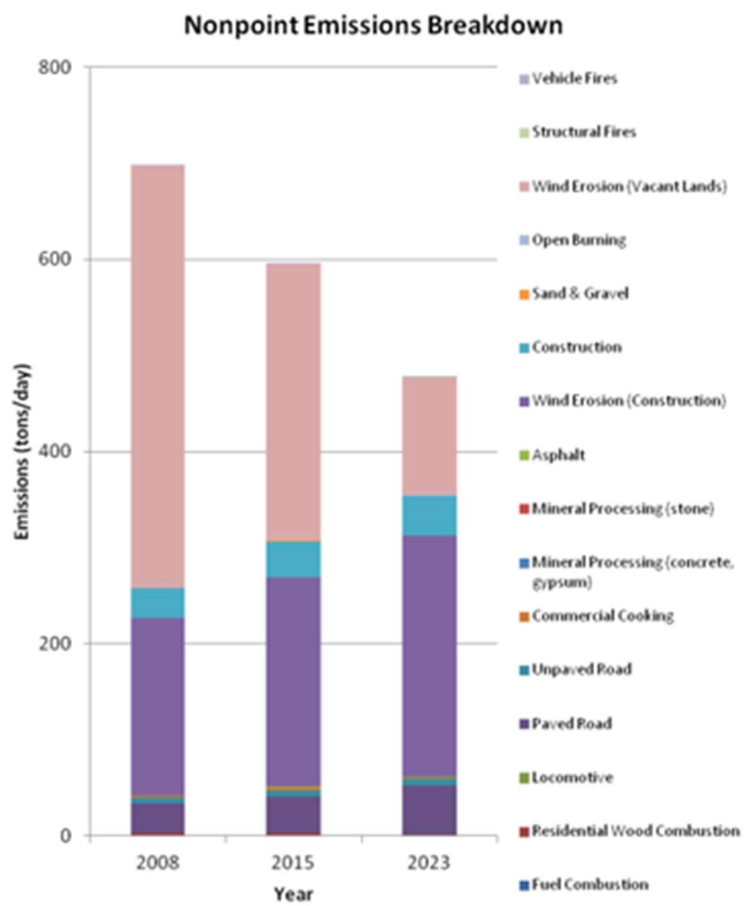


Figure 2.2-16. Nonpoint emissions inventory breakdown from the 2012 "Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})" document.

2.2.4 Historical Analysis of PM_{10} in Clark County

The PM_{10} concentration values recorded on May 29, 2022, were 175 µg/m^3 at the Jerome Mack site and 183 µg/m^3 at the Green Valley site, well above the seasonal averages and the 99th percentile for both sites. Table 2.2-1 displays a statistical summary of 24-hour average PM_{10} concentrations from the five years preceding the event (2018-2022) at all affected sites, which include the Green Valley, Jerome Mack, Jean, Liberty High School, and Walnut Community Center sites. Although the Jean is not a regulatory significant monitoring site (due to its location outside the nonattainment area), the table includes statistics for this site to examine the regional effect of the high-wind dust event. Data collection did not begin at the Liberty High School and Walnut Community Center monitoring sites until May 2021; therefore, summary statistics are shown for the data available from May 2021 – December 2022. The median concentration ranges from 16 µg/m^3 at the Jean site to 37 µg/m^3 at the Walnut Community Center site. The 99th percentile values were at or below 116 µg/m^3 at the three sites with a complete five years of data, including the Jerome Mack and Green Valley sites, and at or below 201 µg/m^3 at the newer sites with less than two years of data.

Table 2.2-1. Five-year* statistical summaries of 24-hour average PM_{10} concentration at the affected sites from 2018 – 2022.

Statistic (µg/m^3)	Green Valley	Jean	Jerome Mack	Liberty High School*	Walnut Community Center*
Mean	25	20	35	31	42
Median	21	16	31	26	37
Mode	20	17	31	18	36
St. Dev	24	18	25	32	35
Minimum	2	1	4	2	7
95th percentile	49	47	66	62	76
99th percentile	108	89	116	201	181
Maximum	586	236	445	365	470
Range	584	235	441	363	463
Count	1820	1795	1790	610	579
Exceedances (> 150 µg/m^3)	9	7	13	8	10

*Data collection at the Liberty High School and Walnut Community Center sites began in May 2021, and summary statistics for these sites are for May 2021 through December 2022.

Seasonal and monthly trends in the 24-hour average PM_{10} data at all affected sites for the five years preceding the event (2018-2022) are shown in boxplots in Figure 2.2-17 and Figure 2.2-18 (note that data is limited for several sites, as described in Table 2.2-1). The lower and upper edges of the box correspond to the interquartile range (the 25th and 75th percentiles, respectively), and the middle bar is the median value. The whiskers extend to the smallest and largest value within 1.5 times the interquartile range. Points beyond this range are considered outliers and have been removed for monthly and seasonal trend clarity (see Section 3.4.2 for trends that include outliers). Median 24-hour average PM_{10} values are lowest in winter (median value of 18 µg/m^3) and highest in summer and autumn (median values of 26 µg/m^3), and interquartile ranges across the seasons show significant overlap. For May, the interquartile range is 17 – 32 µg/m^3, with a median value of 24 µg/m^3.

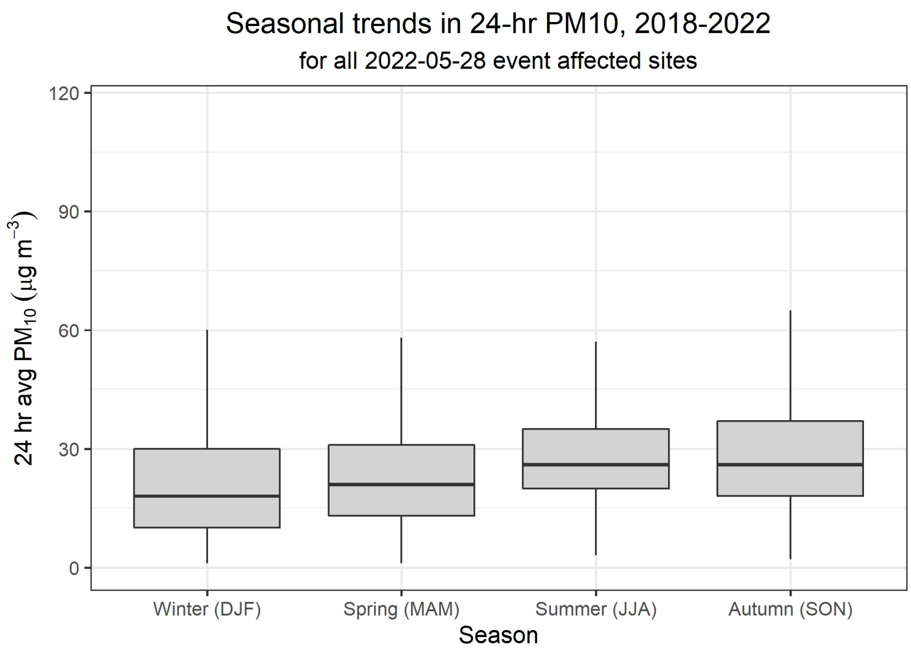


Figure 2.2-17. Seasonal trends in values of PM_{10} from 2018-2022 (outliers have been removed for trend clarity).

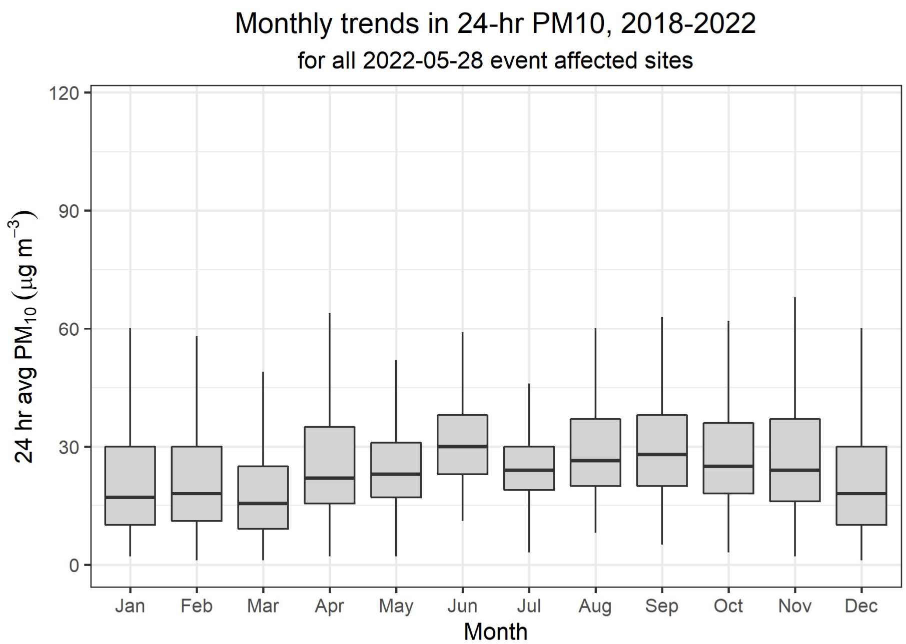


Figure 2.2-18. Monthly trends in values of PM_{10} from 2018-2022 (outliers have been removed for trend clarity).

3. Clear Causal Relationship

During late May 2022, a frontal passage through southeastern California drove a windblown dust event that increased PM_{10} concentrations in Clark County, Nevada, on May 28 through 29. Strong, sustained winds in the Mojave Desert source region were greater than 30 mph with wind gusts reaching 47 mph. The frontal passage lofted, entrained, and transported dust from the source region to Clark County starting at 16:00-18:00 PST on May 28 and lasting through 08:00-11:00 PST on May 29. The severe drought conditions affecting the Mojave Desert in southeastern California, as shown in **Section 2.2**, created an ample source of dust from friable soils. Enhanced wind speeds of approximately 20 mph (5-minute averaged data from the Harry Reid International Airport [LAS]) in the Las Vegas Valley coincided with increased PM_{10} concentrations during the period from May 28 at 16:00 PST to May 29 at 11:00 PST. The Mojave Desert source region experienced sustained winds speeds above 30 mph, and evidence shows that (1) transport from the Mojave Desert to Clark County is clearly evident via HYSPLIT, meteorological analyses, and radar images; (2) visibility was greatly reduced in Clark County during the high PM_{10} concentrations; and (3) PM_{10} concentrations in Clark County were exceptionally outside of typical ranges. Within this section, we provide meteorological evidence of lofting, entrainment, and transport of dust from the dust source region (the Mojave Desert) with the frontal passage, evidence of transport from the source region to Clark County via HYSPLIT trajectory modeling and meteorological analysis, and evidence of impacts of the high-wind dust event at the surface in Clark County. We also provide additional evidence using statistical and meteorological similar event analysis to compare this dust event with other high PM_{10} days in Clark County.

3.1 High-Wind Event Origin

3.1.1 Meteorological Analysis

During the period between May 28-29, 2022, dust from the Mojave Desert impacted the Las Vegas region and led to 24-hour average PM_{10} concentrations of 158 µg/m^3 at Jerome Mack, 169 µg/m^3 at Liberty High School, and 155 µg/m^3 at Walnut Community Center on May 28, 2022, and concentrations of 175 µg/m^3 at Jerome Mack, 204 µg/m^3 at Liberty High School, and 183 µg/m^3 at Green Valley on May 29. Strong winds in the Mojave Desert region of southeastern California produced dense blowing dust that was transported to the Las Vegas metropolitan area, increasing PM_{10} concentrations starting at 16:00-18:00 PST and peaking at 20:00 PST on May 28, 2022. Enhanced PM_{10} concentrations lasted through 08:00-11:00 PST on May 29, 2022. One other site (Jean) also experienced PM_{10} concentrations greater than the 24-hour PM_{10} NAAQS, however the site is outside the nonattainment area and not considered regulatorily significant. All other sites within the Las Vegas Valley experienced enhanced PM_{10} concentrations concurrently with the exceeding sites. Several large-scale meteorological factors led to favorable conditions for blowing dust on this day. To account for these meteorological factors, observation data were analyzed leading up to and during the dust event. The following narrative will discuss the meteorological factors that led to this blowing dust event.

To assess the meteorological conditions that led to poor air quality during this period, observational data were analyzed from the following sources:

- Upper-air winds and geopotential heights
- Satellite and Doppler radar imagery
- Hourly surface wind speed and direction

This meteorological analysis takes a "top-down" approach, first investigating the upper-level weather conditions, then linking the upper-level observations to the corresponding mid-level and surface weather patterns. For completeness, this analysis examines the period between the mornings of May 27 and May 30, 2022.

250-mb Analysis

The prevailing upper-level weather pattern at 250 mb the morning of May 27, 2022, showed a weak shortwave trough of low pressure over Nevada, a zonal wind pattern along the Pacific Northwest coastline, and a 75-150 kt jet streak analyzed off the Oregon/northern California coastline. This jet streak would aid in the development of a new shortwave trough at 250 mb.

By the early evening of May 27, the 75-150 kt jet streak had entered northern California, with the core of the strongest winds offshore and an associated shortwave trough axis over the northern California coast. This trough continued to move inland during the overnight hours, arriving in western Nevada by the morning of May 28. At the National Weather Service Las Vegas upper-air meteorological station (code: KVEF), 250-mb winds were westerly, indicating the trough was positioned over southern Nevada. Also at this time, the jet streak nosed into western Nevada, while the strongest winds (100+ knots [kt]) were located west of the trough axis in northern California (**Figure 3.1-1**). Due to the position of the jet streak relative to the trough axis, the trough continued to move east and strengthen.

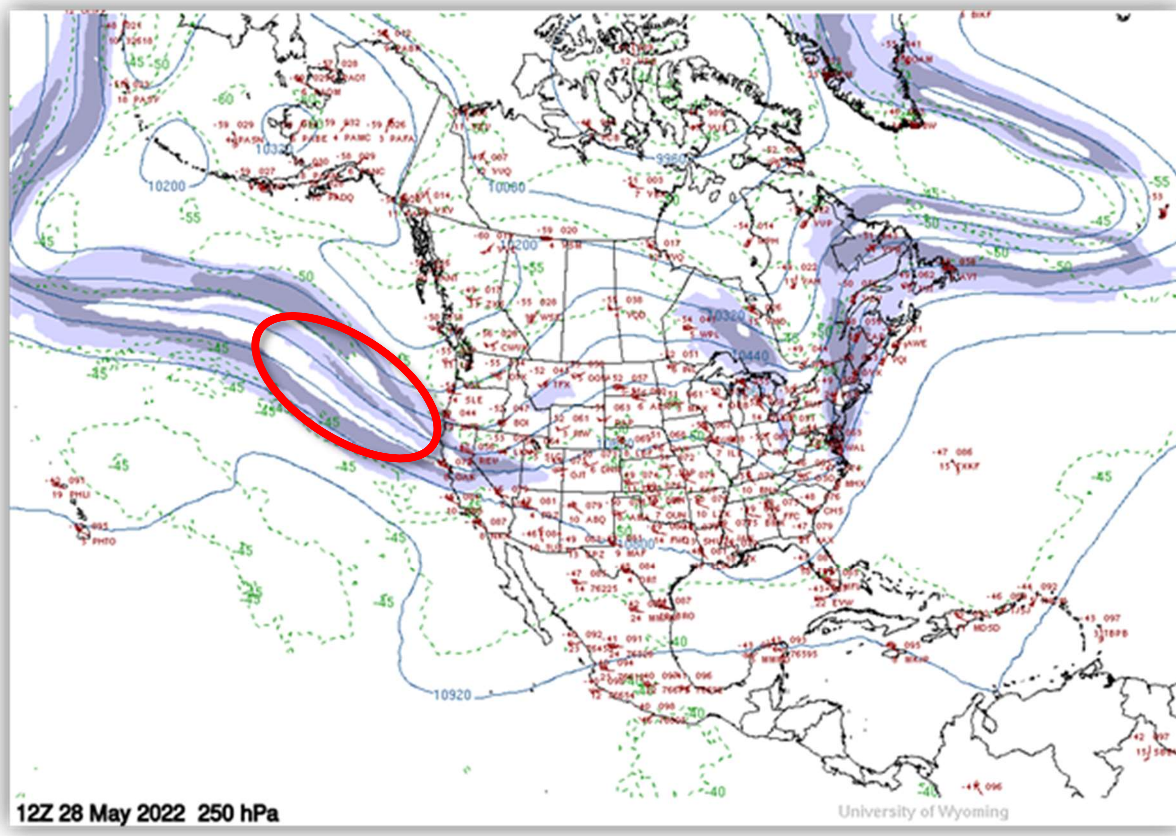


Figure 3.1-1. 250-mb map showing meteorological conditions on the morning of May 28, 2022. A strong core of upper-level winds, known as a jet streak (circled), resided west of the trough axis, serving to intensify the trough and advect it into southern Nevada. Courtesy: University of Wyoming.

The upper-level trough axis moved past the Las Vegas region by the morning of May 29, as indicated by the upper-level wind shift at KVEF from westerly to west-northwesterly. West of the trough axis, the core of the strongest jet streak winds was positioned from far northwestern Arizona, through southern Nevada, and off the northern California coast. This allowed the upper-level trough to continue moving eastward, away from southern Nevada, throughout much of the day on May 29. By the early evening of May 29 and the morning of May 30, the jet streak started to advance eastward, entering the eastern flank of the trough axis over the Four Corners. This resulted in the trough weakening east of the Las Vegas region.

500-mb Analysis

As the jet streak impacted the progression and amplitude of the 250-mb trough, it also influenced development of the mid-level trough at 500 mb. On May 27, a weak 500-mb trough of low pressure was positioned off the Pacific Northwest and northern California coast. However, as the 250-mb jet streak entered northern California and western Nevada late on May 27 and the early morning hours of May 28, the 500-mb trough deepened over the California/Nevada border. At KVEF, the morning upper-air sounding on May 28 analyzed a 500-mb height of 579 decameters (dm), with a 30-knot westerly wind, indicating a trough axis directly over the site (see **Figure 3.1-2**).

Despite the stationary nature of the mid-level trough throughout the day on May 28, 500-mb heights continued to fall at KVEF. On the evening of May 28, the shortwave mid-level trough axis remained over the California/Nevada border, but 500-mb heights at KVEF fell to 575 dm. 12 hours later, during the morning of May 29, the 500-mb height at KVEF dropped to 569 dm, marking a 10 dm height fall in 24 hours. This height fall can be attributed to the upper-level jet streak entering southern Nevada and northwestern Arizona, which allowed the mid-level trough to deepen as it approached the Las Vegas region.

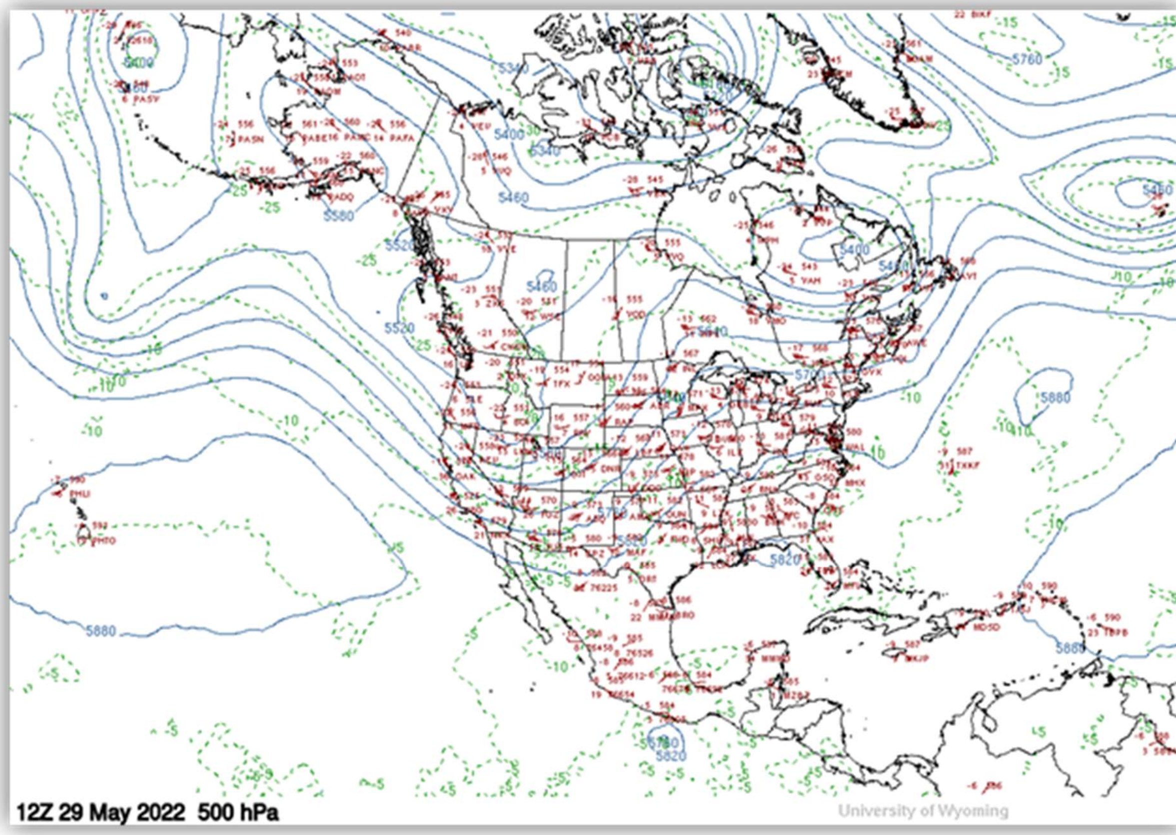


Figure 3.1-2. 500-mb map showing meteorological conditions on the morning of May 29, 2022. A shortwave trough of low pressure aloft sits over Nevada, which led to falling geopotential heights at KVEF. Courtesy: University of Wyoming.

The mid-level trough at 500-mb shifted into Utah and Arizona by the evening of May 29, coinciding with a 500-mb wind shift at KVEF to northwesterly. Simultaneously, the 500-mb height dropped to 566 dm, which was the lowest height recorded during this dust event. At this time, the 500-mb trough would start to weaken, as the upper-level jet streak started to move east of the upper-level trough axis. By the morning of May 30, the 500-mb height at KVEF remained at 566 dm, while the mid-level trough axis was nearly stationary over Utah and Arizona. At 250-mb, the jet streak was present on both flanks of the upper-level trough axis, reducing further trough development at 500-mb.

Surface Analysis

At the surface, a passing cold front was the primary factor in this blowing dust event. On the evening of May 27, the upper-level jet streak at 250 mb entered northern California, with the strongest core of the jet streak (where winds were analyzed at 100+ kts) over the Pacific Ocean. At this time, a surface cold front and 1,008-mb low pressure center was analyzed at 43° North, 138° West. With the core of the upper-level jet streak remaining west of the surface low and cold front, the surface front continued to strengthen. In addition, the mid-level trough axis at 500-mb also remained west of the front, which helped strengthen the front and push it toward Nevada.

The strongest core of the upper-level jet streak remained trailing the surface cold front on May 28, as the surface low deepened to 996 mb and the front approached the Oregon/northern California coast (see **Figure 3.1-3**). As the front gradually moved onshore into northern California on the afternoon of May 28, the pressure gradient ahead of the front increased over eastern California and southern Nevada. With a strengthening pressure gradient in place, southerly to southwesterly surface winds across the region increased in speed.

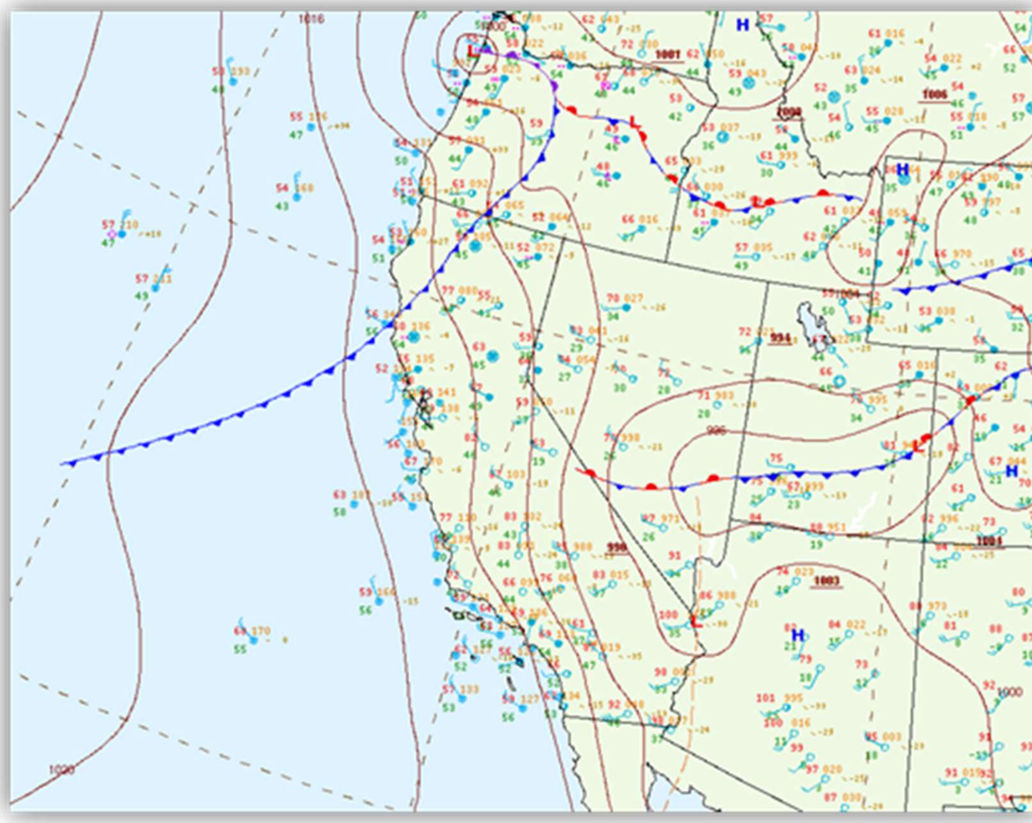


Figure 3.1-3. Surface weather map at 16:00 PST on May 28, 2022. A cold front in far northwestern California produced a strong pressure gradient (brown lines) over southern Nevada and eastern California, which led to strong winds. Courtesy: NOAA Weather Prediction Center.

As surface winds strengthened throughout the afternoon and evening on May 28, they interacted with abnormally dry soils in the Mojave Desert across southern California and Nevada. In the days leading up to this event, the United States Drought Monitor classified southeastern California and southern Nevada in the Extreme to Exceptional drought categories, as shown in Figure 3.1-4. The strong winds over dry soils generated dense blowing dust on the afternoon of May 28 in the Mojave Desert, and PM_{10} was transported into the Las Vegas metropolitan area by the early evening hours on May 28, 2022.

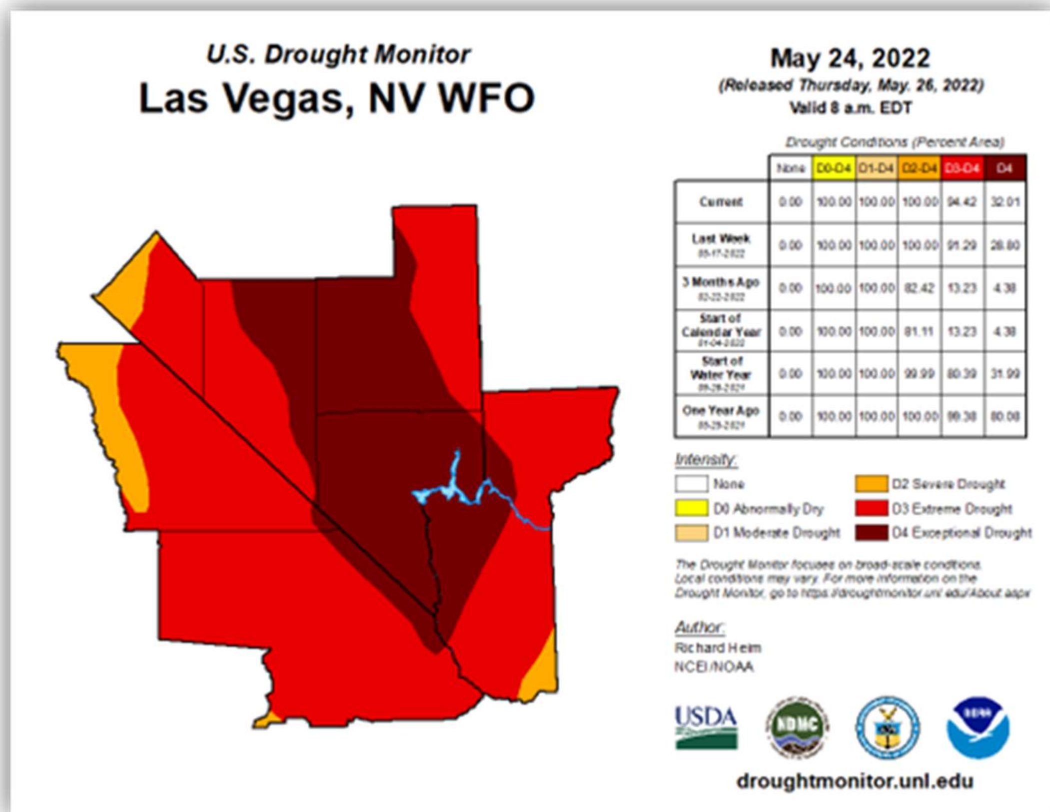


Figure 3.1-4. U.S. Drought Monitor, valid May 24, 2022. Extreme to Exceptional drought conditions across southern Nevada and the Mojave Desert resulted in abnormally dry soils. Courtesy: U.S. Drought Monitor.

Southerly to southwesterly winds remained strong into the early morning hours on May 29, as hourly PM_{10} concentrations ranged from 360-811 µg/m^3 in the Las Vegas region. As the front approached southern Nevada throughout the morning on May 29, the surface pressure gradient began to weaken, allowing wind speeds to decrease. While the diminished wind speeds limited the generation of blowing dust, they also hindered the dispersion of lofted dust. This allowed hourly PM_{10} concentrations to remain enhanced through 10:00 PST on May 29.

The surface cold front exited the Las Vegas area during the morning of May 29, weakening as it departed southern Nevada. Throughout the day, upper-level support from the 250-mb jet streak diminished, with the jet streak reaching the eastern flank of the upper-level trough axis by the early evening. This not only inhibited the upper-level trough from moving eastward, but the lack of support from the upper-level jet streak also mitigated further development of the mid-level trough at 500 mb. Meanwhile, at the surface, the limited mid- and upper-level support allowed the front to weaken and become stationary south of Nevada during the afternoon and evening hours of May 29, 2022.

Radar Images

Radar imagery taken during the event period at a 0.5° tilt are shown in **Figure 3.1-5 through Figure 3.1-8**. The location of a radar shadow to the west-southwest of the station, a result of mountainous terrain, is noted in the top-left image in each figure. A buildup of airborne dust to the west of Clark County from the Mojave Desert creates a radar signature which peaks between 11:00-18:00 PST on May 28, 2022. The region of interest is circled in red in **Figure 3.1-5 and Figure 3.1-6**. The dust signature is pushed eastward through Clark County by strong westerly surface winds, and is still visible through 02:00 on May 29, 2022.

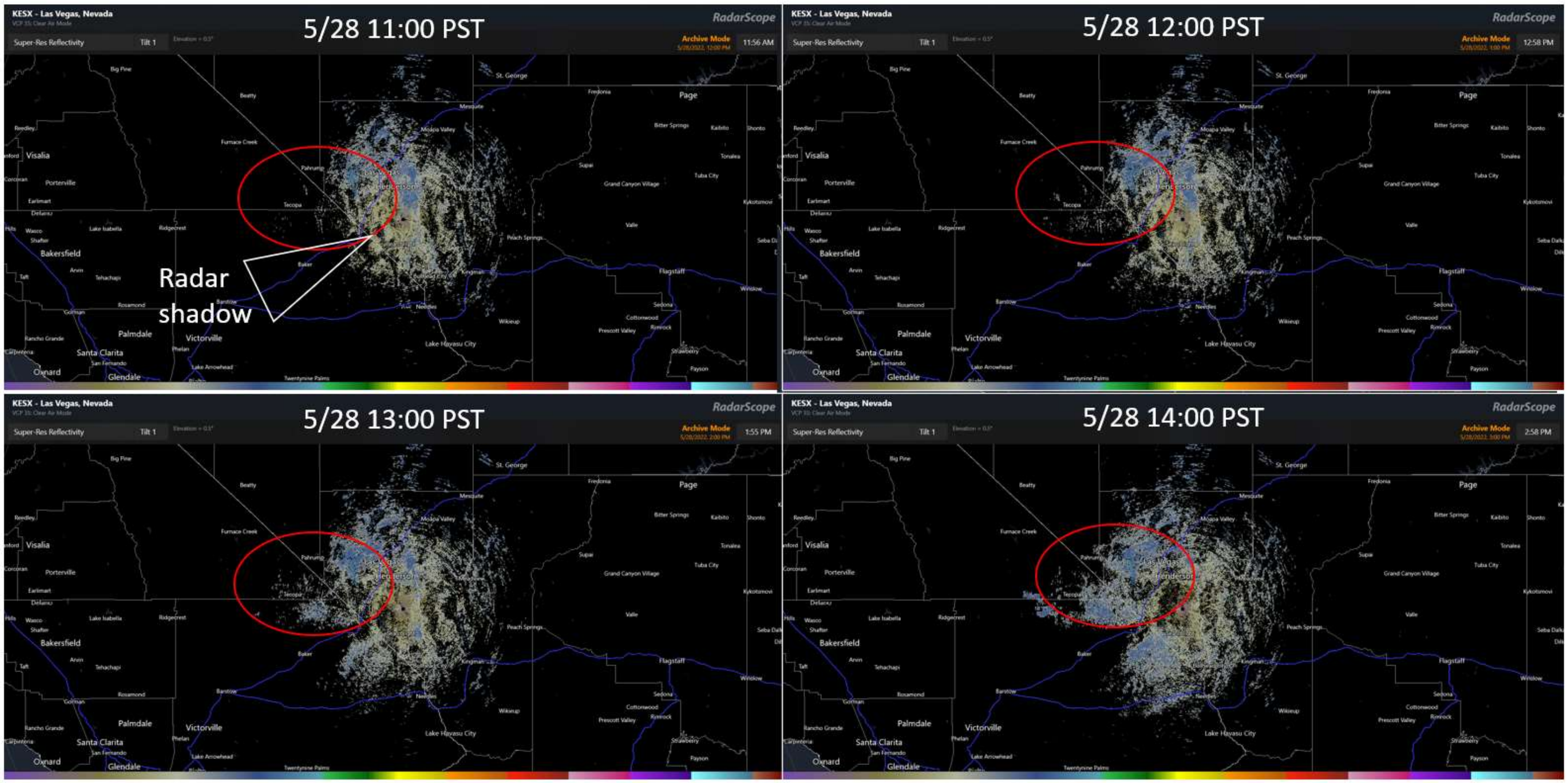


Figure 3.1-5. Radar imagery from KESX, Las Vegas at a 0.5° tilt on May 28, 2022, between 11:00 PST and 14:00 PST (converted from PDT in top right corner of images). An area of significant dust buildup in the source region between 11:00 PST and 18:00 PST is circled in red. The location of a non-detectable region within a radar shadow is noted in the top-left figure.

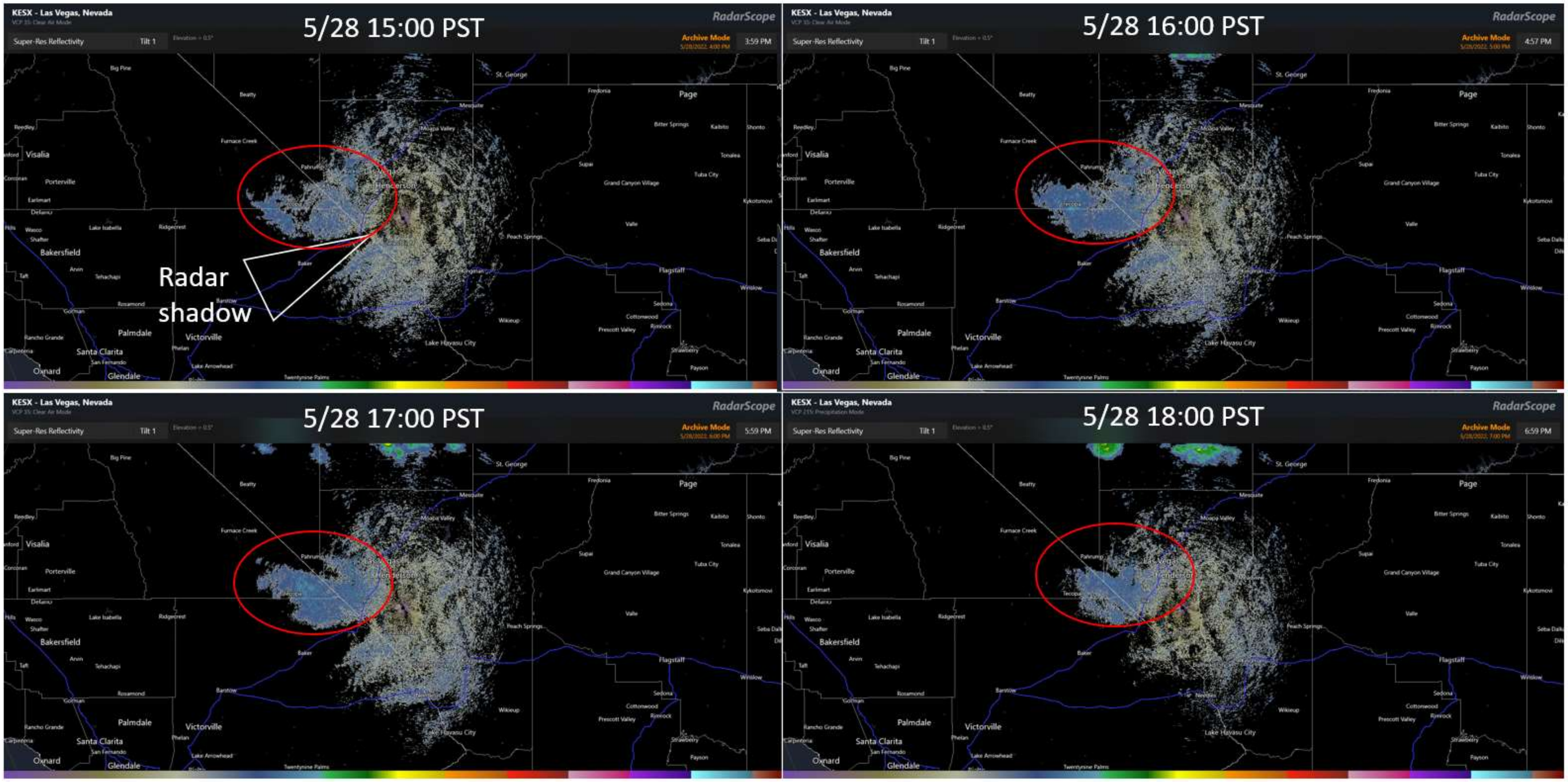


Figure 3.1-6. Radar imagery from KESX, Las Vegas at a 0.5° tilt on May 28, 2022, between 15:00 PST and 18:00 PST (converted from PDT in top right corner of images). An area of significant dust buildup in the source region between 11:00 PST and 18:00 PST is circled in red. The location of a non-detectable region within a radar shadow is noted in the top-left figure.

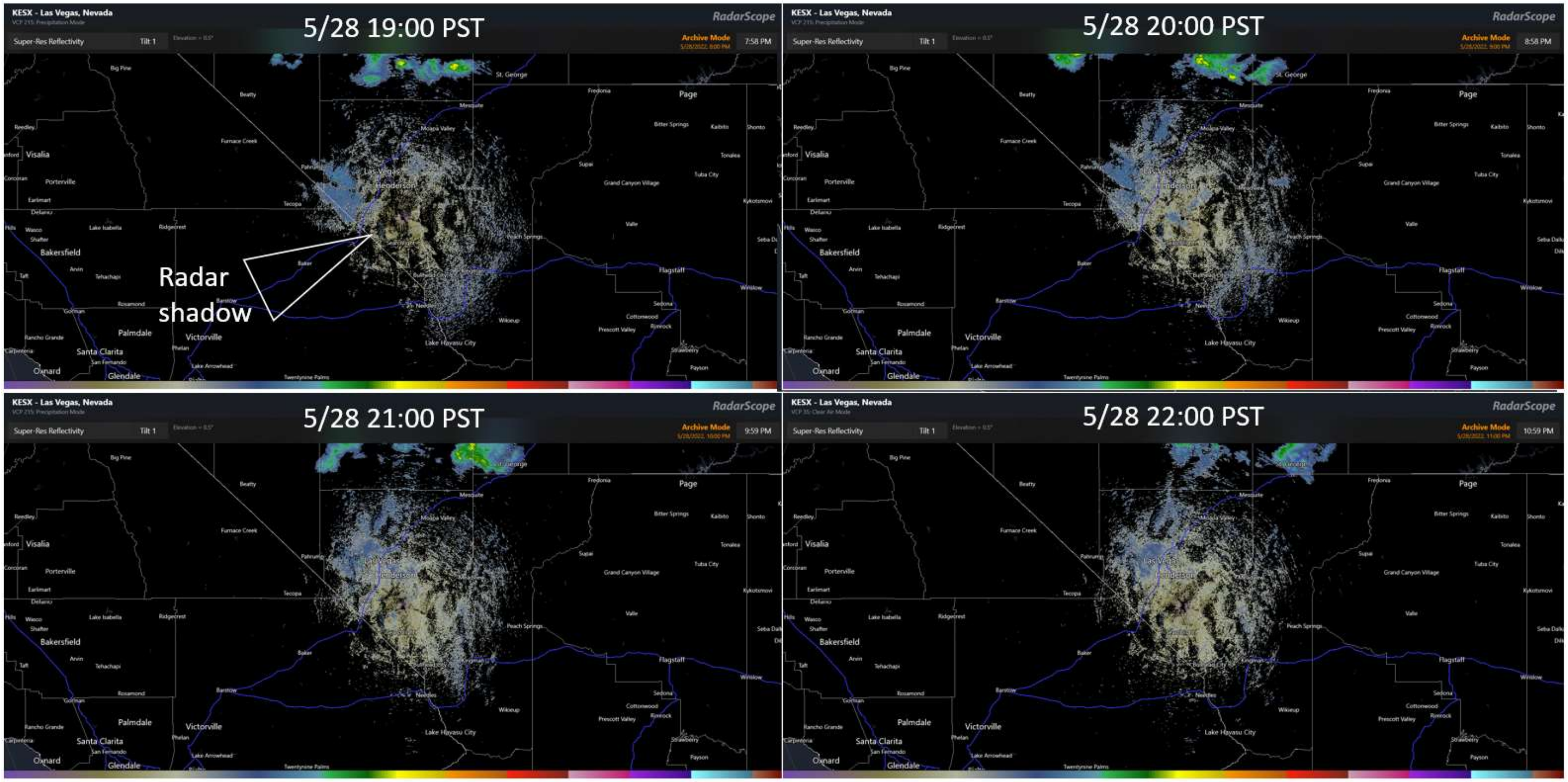


Figure 3.1-7. Radar imagery from KESX, Las Vegas at a 0.5° tilt on May 28, 2022, between 19:00 PST and 22:00 PST (converted from PDT in top right corner of images). The location of a non-detectable region within a radar shadow is noted in the top-left figure.

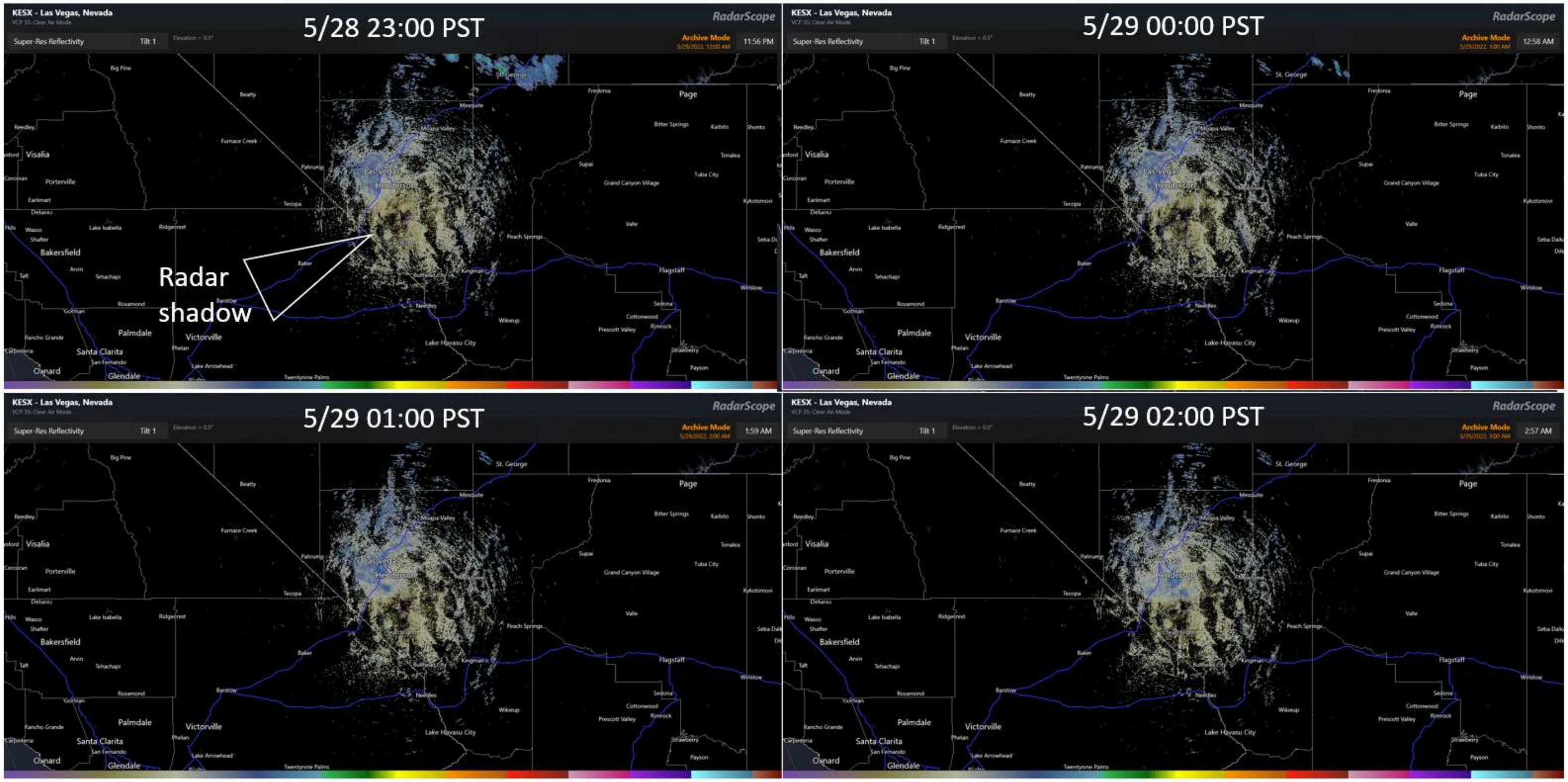


Figure 3.1-8. Radar imagery from KESX, Las Vegas at a 0.5° tilt between May 28, 2022 at 23:00 PST and May 29, 2022 at 02:00 PST (converted from PDT in top right corner of images). The location of a non-detectable region within a radar shadow is noted in the top-left figure.

3.1.2 Satellite Images and Analysis

Satellite imagery and reanalysis products also provide evidence of dust from the Mojave region of California to Clark County, NV. Multi-Angle Implementation of Atmospheric Correction (MAIAC) Aerosol Optical Depth (AOD) imagery from Moderate Resolution Imaging Spectroradiometer (MODIS) show some medium to high AOD values in Clark County on May 29, 2022 (**Figure 3.1-9**). The highest AOD values are shown near Las Vegas, California, and Arizona. Unfortunately, visible imagery does not capture the dust event because the frontal passage occurred after the visible imagery satellite overpassed the area for the day (approximately 1-2 p.m. local time).

The Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) reanalysis data show high hourly average and hourly peak wind speeds in the source region and in the Las Vegas valley for May 28 and May 29, 2022 (**Figure 3.1-10 through Figure 3.1-13**). The increasing pressure gradient in the Mojave Desert generated moderate and gusty west-southwesterly winds as the front approached southern Nevada. The MERRA-2 reanalysis figures show average winds speeds at 10-14 m/s (22-31 mph) with maximum wind speeds greater than 16 m/s (36 mph) for May 28 and May 29, 2022.

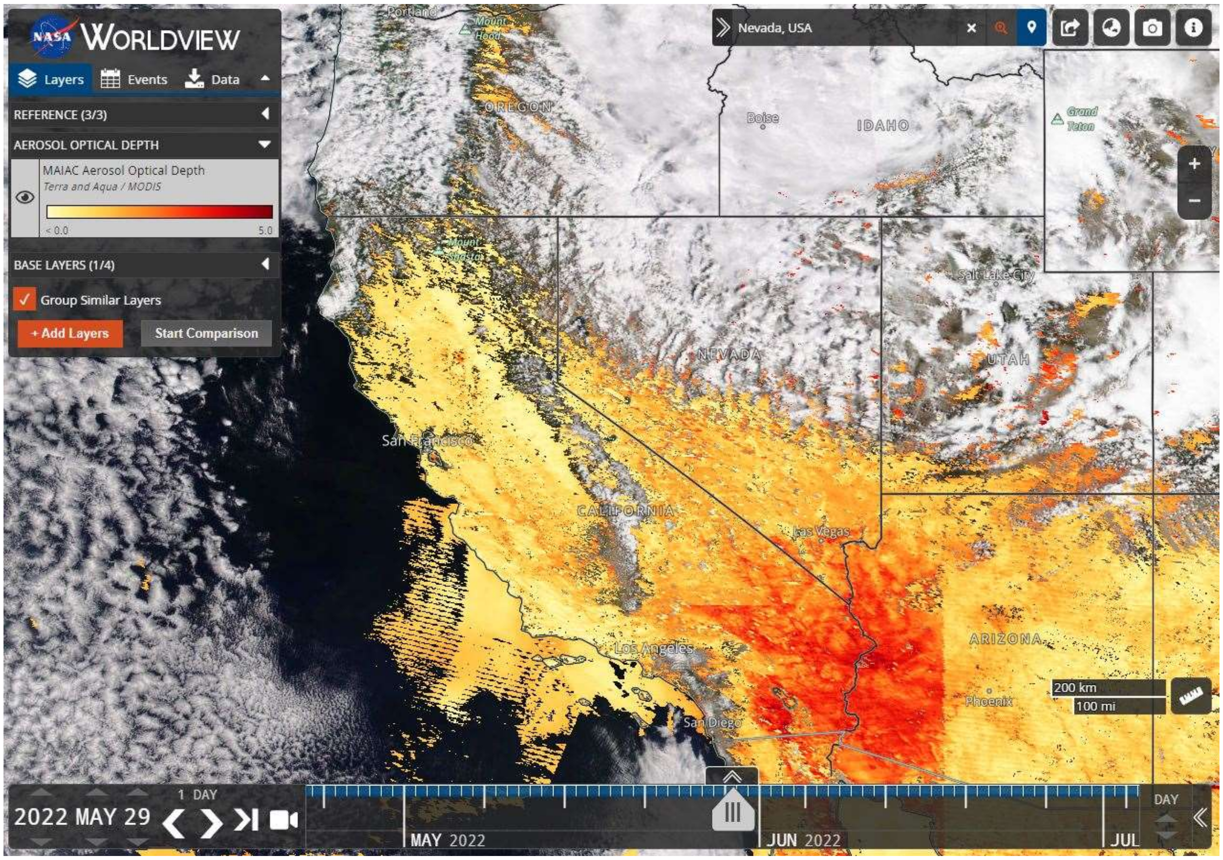


Figure 3.1-9. Satellite aerosol optical depth from MAIAC Aqua and Terra combined. Terra imagery was captured at 10:30 PST, and Aqua imagery was captured at 13:30 PST on May 29, 2022.

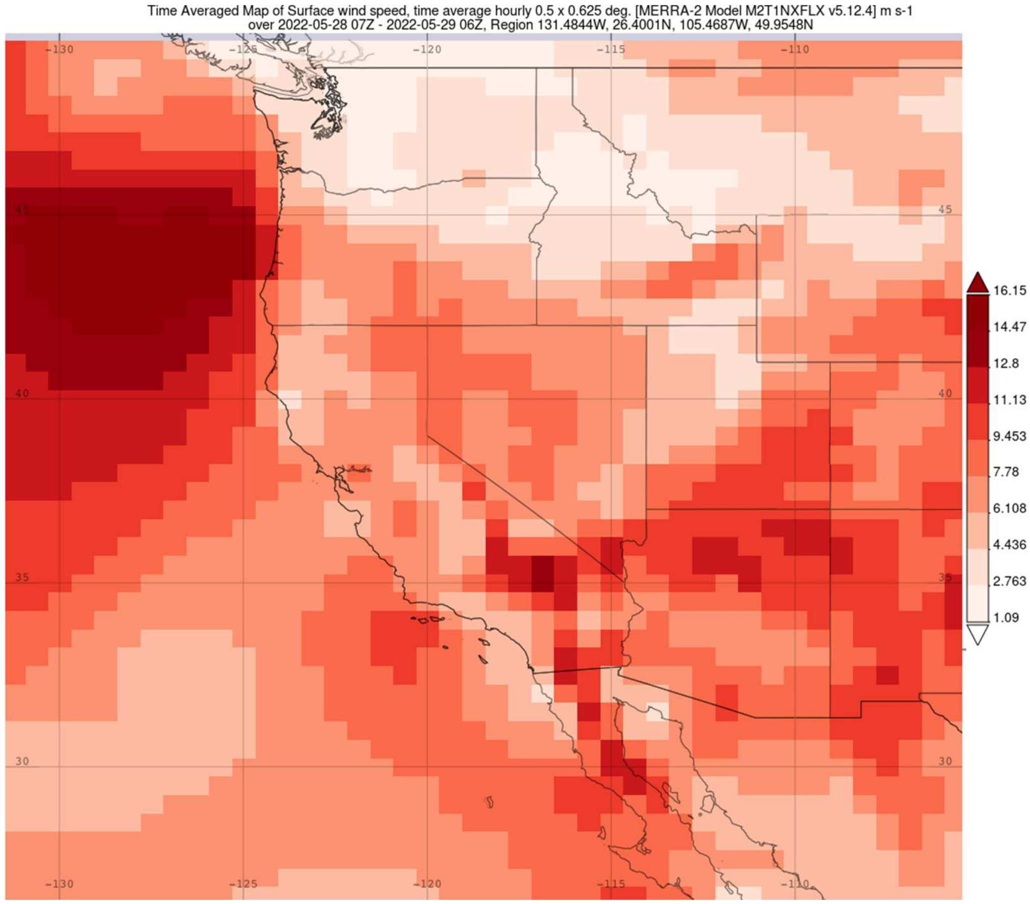


Figure 3.1-10. MERRA-2 reanalysis data showing hourly averaged surface wind speeds (m/s) from May 28, 2022, at 07:00 UTC (May 28, 2022, at 00:00 PDT) to May 29, 2022, at 06:00 UTC (May 28, 2022, at 23:00 PST).

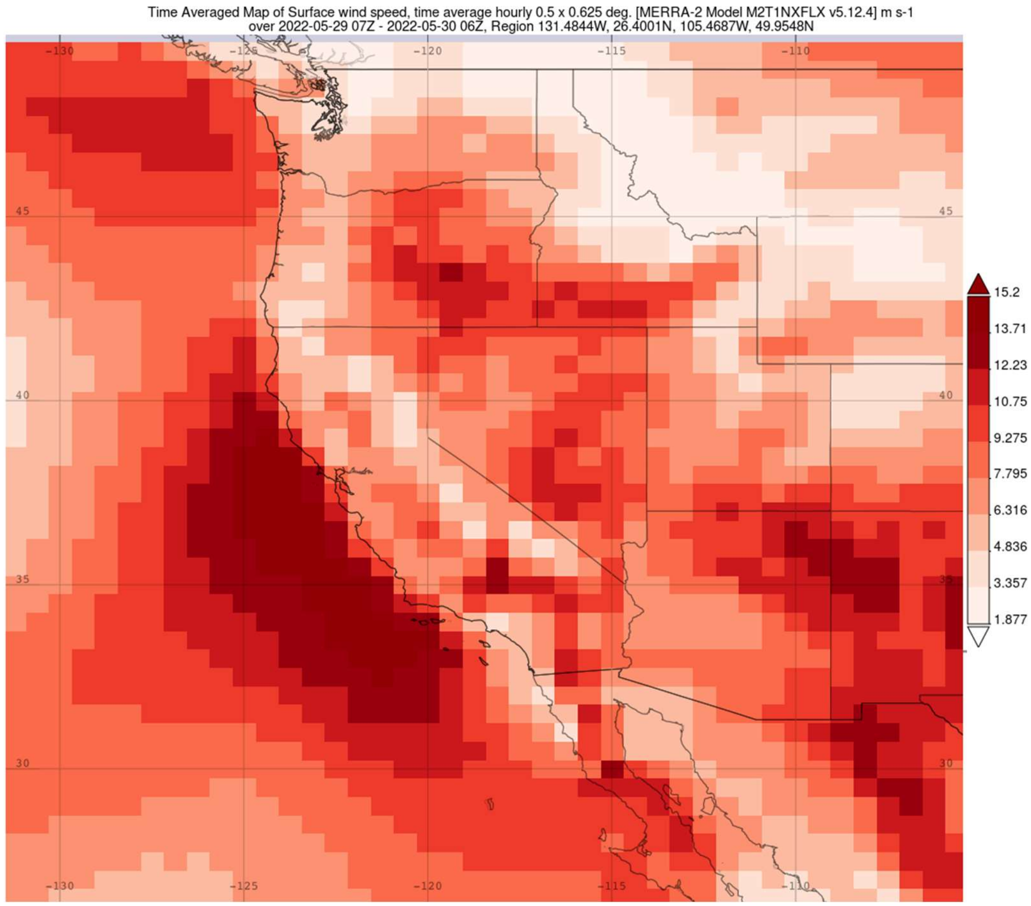


Figure 3.1-11. MERRA-2 reanalysis data showing hourly averaged surface wind speeds (m/s) from May 29, 2022, at 07:00 UTC (May 29, 2022, at 00:00 PDT) to May 30, 2022, at 06:00 UTC (May 29, 2022, at 23:00 PST).

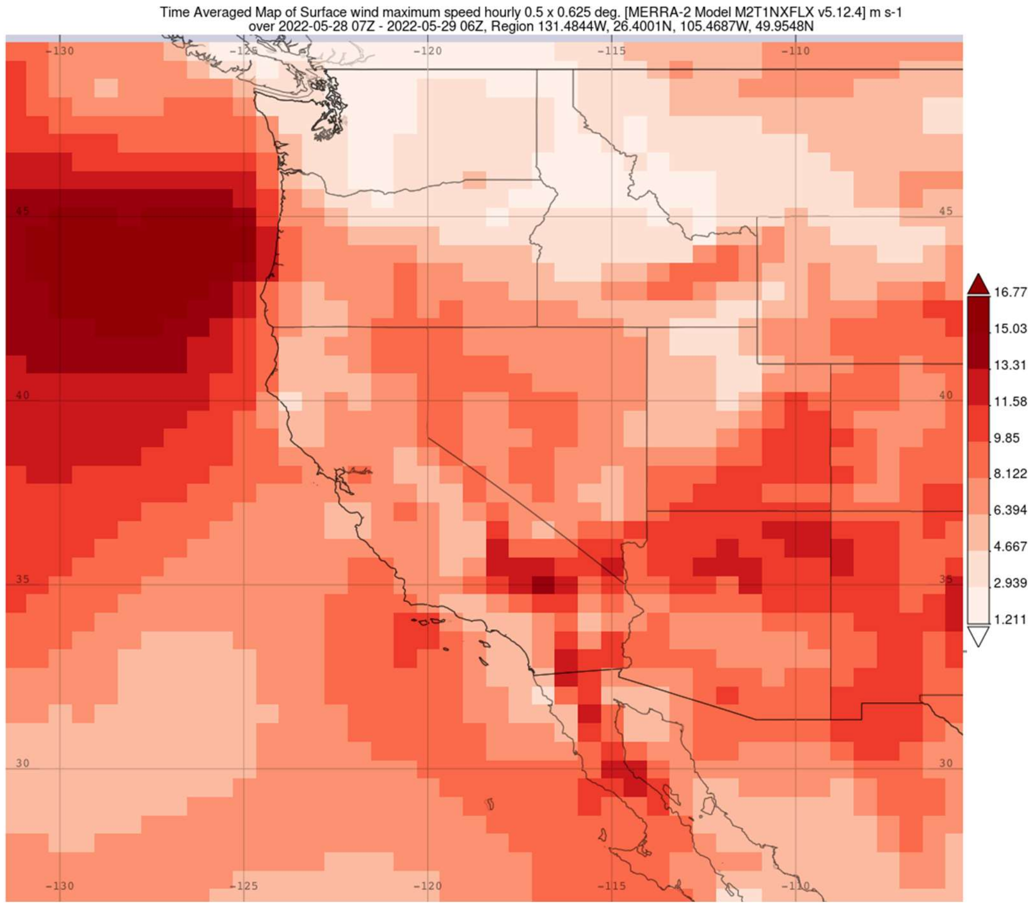


Figure 3.1-12. MERRA-2 reanalysis data showing hourly maximum surface wind speeds (m/s) from May 28, 2022, at 07:00 UTC (May 28, 2022, at 00:00 PDT) to May 29, 2022, at 06:00 UTC (May 28, 2022, at 23:00 PST).

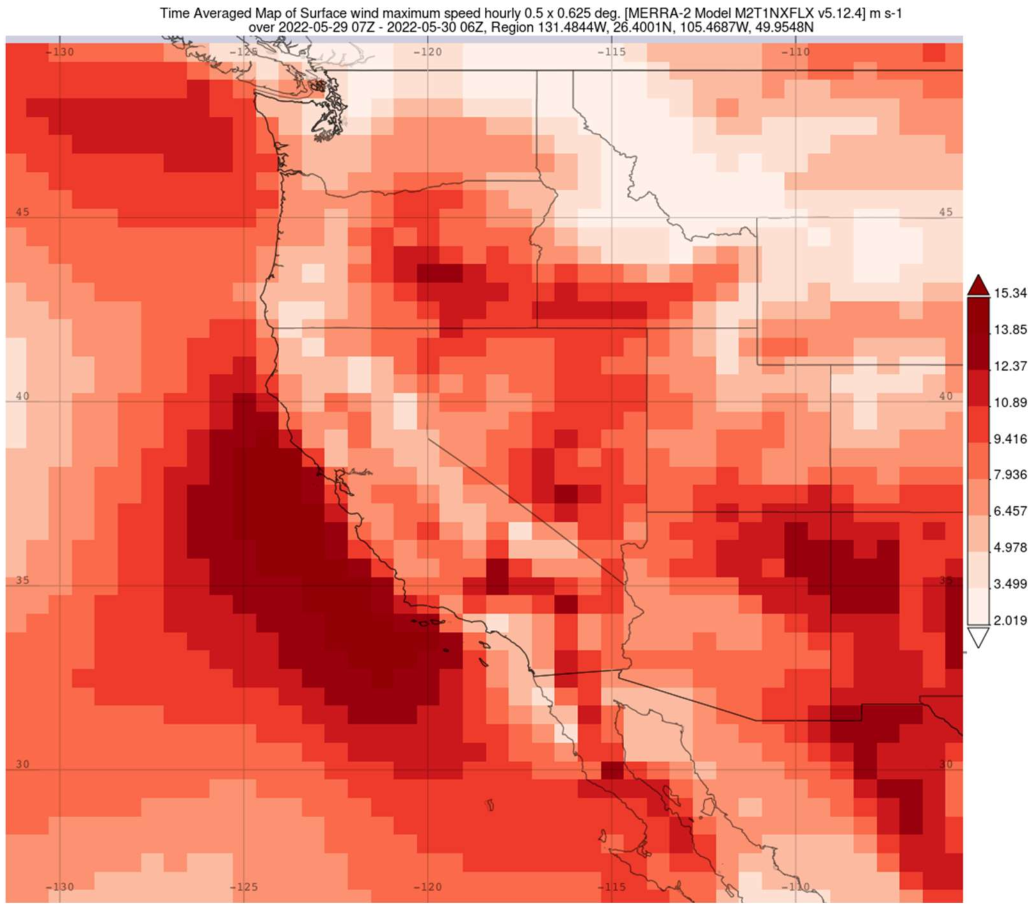


Figure 3.1-13. MERRA-2 reanalysis data showing hourly maximum surface wind speeds (m/s) from May 29, 2022, at 07:00 UTC (May 29, 2022, at 00:00 PDT) to May 30, 2022, at 06:00 UTC (May 29, 2022, at 23:00 PST).

3.1.3 Supporting Ground-Based Data

We were unable to find ground-based images in the source region due to its remote location. Satellite imagery was highlighted in the previous section as a substitute.

Peak sustained winds in the Mojave Desert (southeastern California) were developed via the Iowa State University Mesonet Automated Data Plotter. This tool aggregates automated weather data records from the selected region. Figure 3.1-14 shows peak sustained wind speeds in southeastern California and Mojave Desert of 52 mph on May 28, 2022. Figure 3.1-15 shows peak sustained wind speeds in southeastern California and Mojave Desert around 40 mph on May 29, 2022. These peak sustained wind speeds were well above the 25-mph threshold in the source region and could easily loft, entrain, and transport PM_{10} downwind quickly to Clark County.

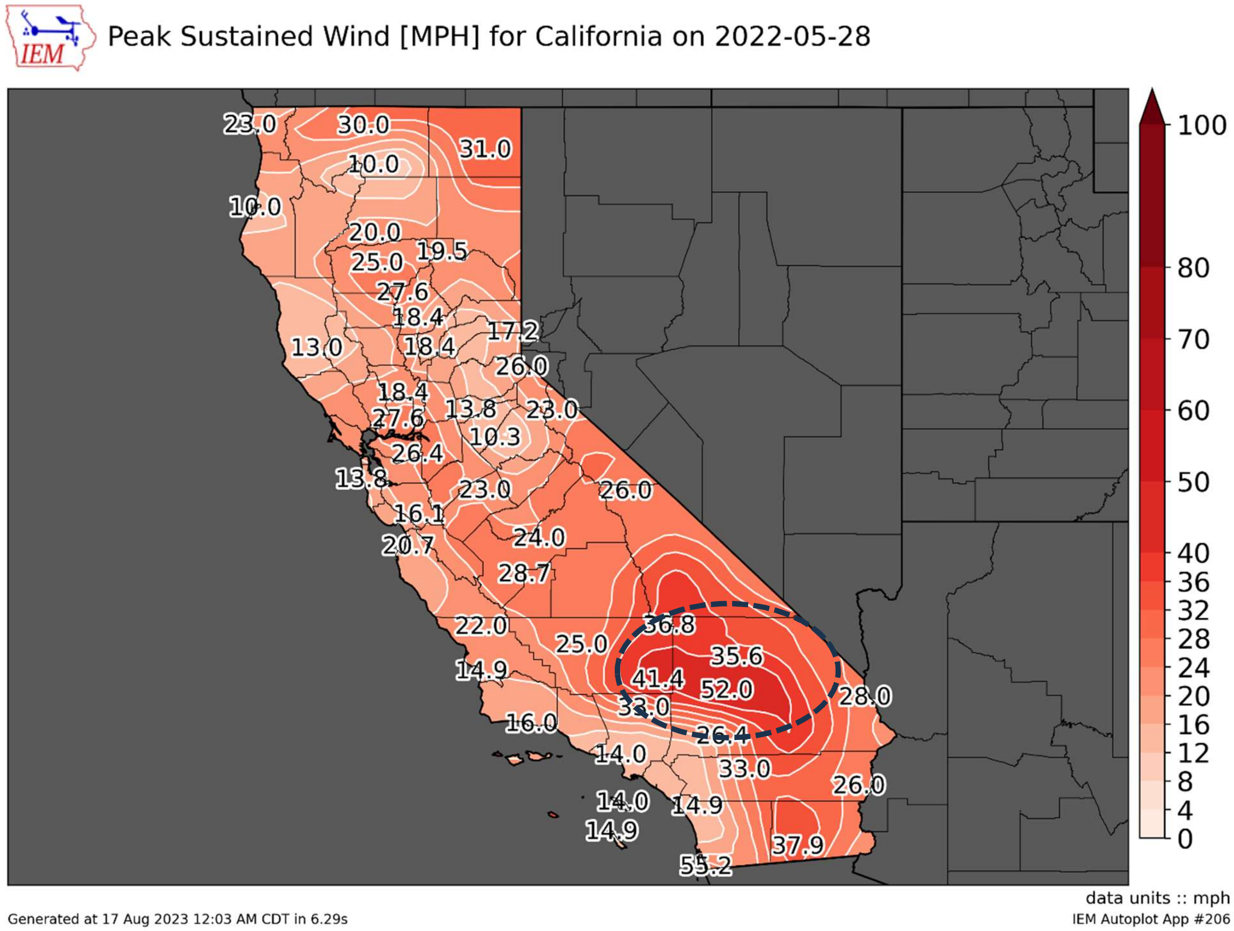


Figure 3.1-14. Peak sustained winds in California on May 28, 2022. The source region, shown approximately by the black dashed line, is located in southeastern California (the Mojave Desert region). Data source https://mesonet.agron.iastate.edu/plotting/auto/.

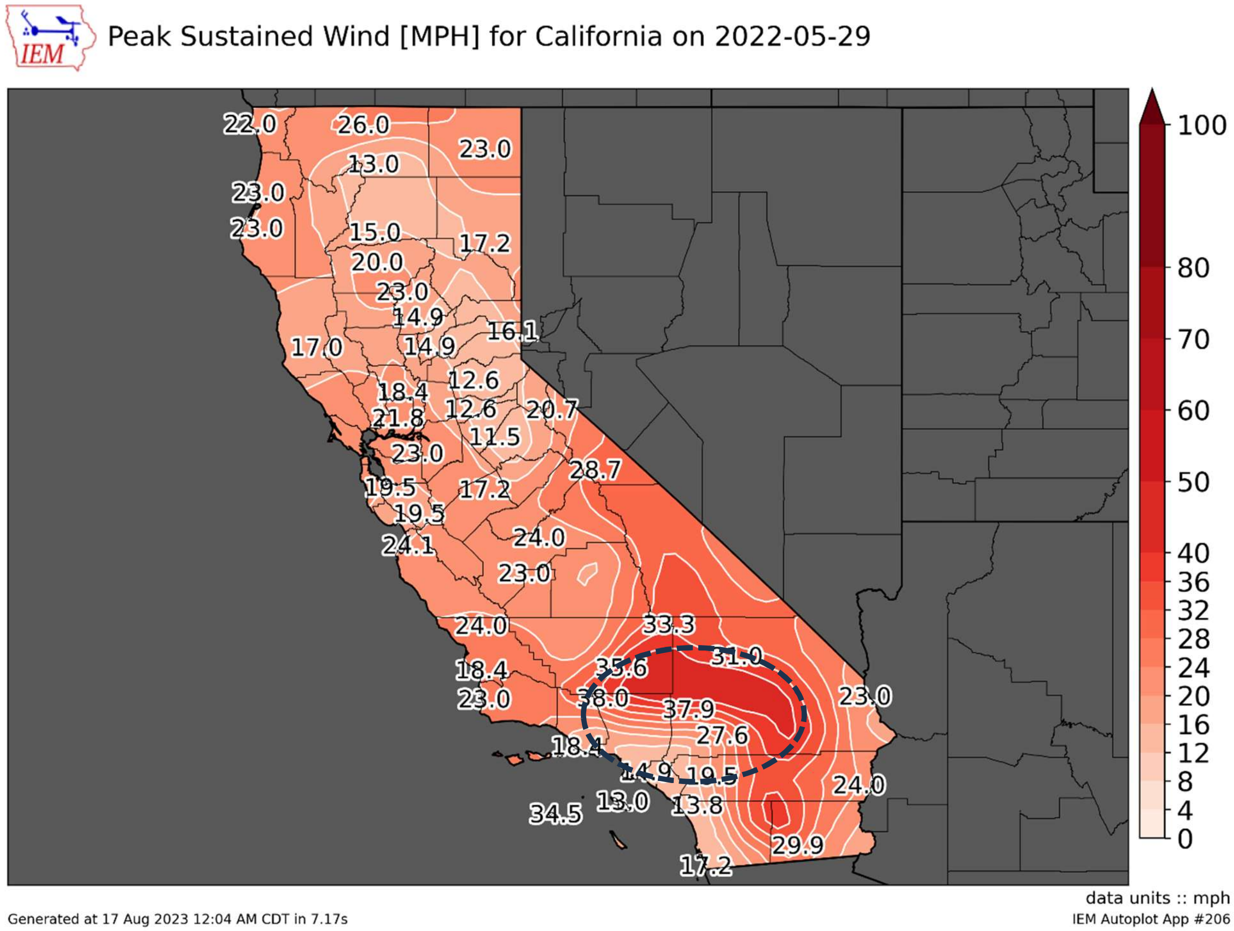


Figure 3.1-15. Peak sustained winds in California on May 28, 2022. The source region, shown approximately by the black dashed line, is located in southeastern California (the Mojave Desert region). Data source https://mesonet.agron.iastate.edu/plotting/auto/.

Figure 3.1-16 shows the distribution of maximum daily temperature recorded at several sites in the wind-blown dust source region on May 27, 28, and 29 (1991 – 2021), and the maximum daily temperatures recorded on May 27, 28, and 29, 2022. The site locations are shown in Figure 2.2-8. Maximum daily temperatures recorded at eight out of 12 sites on May 27, 2022, were above the 75th percentile compared to 1991 – 2021. The maximum temperatures recorded on May 27 provide evidence that the wind-blown dust source region was unusually hot on the day before the PM_{10} exceedance. The decrease in temperatures on May 28 and 29, 2022, are likely due to the passage of the cold front and associated with the high-wind dust event.

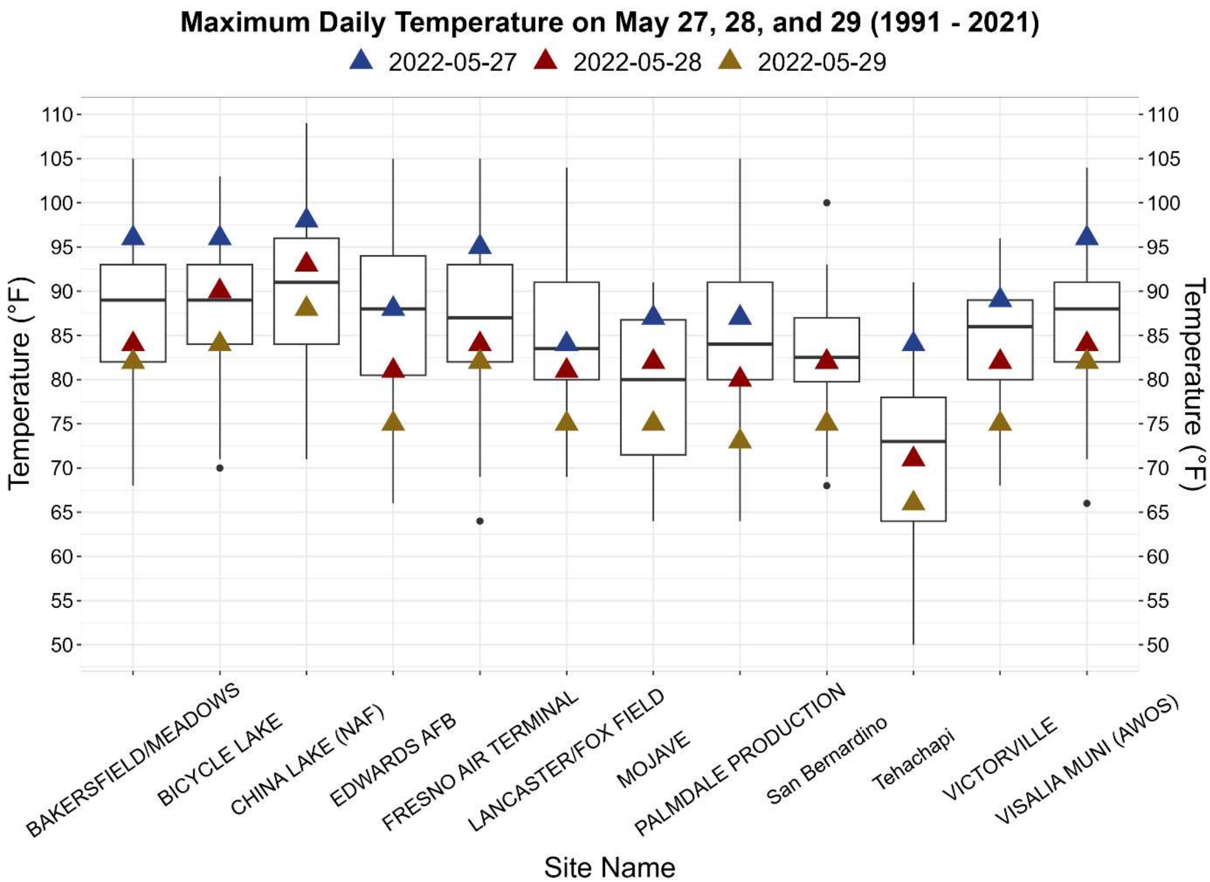


Figure 3.1-16. Maximum daily temperature on May 27, 28, and 29, 2022, compared to the 1991 – 2021 distribution at each site. Note: there was insufficient data on May 27, 2022, to calculate the maximum daily temperature at the Palmdale Production site.

Overall, we find overwhelming evidence that PM_{10} was very likely lofted, entrained, and transported from the Mojave Desert region in southeastern California in the afternoon and evening of May 28, 2022, via a strong frontal passage. The evidence corroborating this assertion includes (1) the meteorological analysis that shows conditions were consistent with a high-wind event in the Mojave Desert, (2) radar images from Las Vegas showing the progression of dust moving from the Mojave Desert into the Clark County area, (3) satellite retrievals showing high AOD and winds in the Mojave Desert and Clark County immediately after the event, (4) ground-based measurements of high temperatures in the Mojave Desert region before the event on May 27, 2022, and (5) aggregated measurements of high winds in the Mojave Desert source region on May 28 and 29, 2022.

3.2 Transport to Clark County

3.2.1 HYSPLIT Analysis

Backwards trajectories were modeled from the Jerome Mack, Jean, Liberty High School, and Walnut Community Center monitoring sites starting at May 28, 2022, at 18:00 PST, the start of the high PM_{10} concentrations associated with the event (hourly concentration greater than 150 µg/m^3). These trajectories were modeled at 50, 500, and 1,000-m heights (**Figure 3.2-1**). Archived North American Mesoscale Forecast System (NAM) data with resolution of 12 km was used as meteorologic input. Temporal resolution of the NAM 12 km is three hours and is run by NCEP.

At all heights, trajectories approach the Las Vegas region from the west-southwest, over the Mojave National Preserve, revealing it as the source region. The Mojave Desert is just east-southeast of the Sierra Nevada range and located within its rain shadow, yielding a majorly barren and scrub/shrub landcover (**Figure 3.2-2**). Throughout the Mojave Desert, each trajectory passes through areas in both severe, extreme, and exceptional drought conditions (**Figure 3.2-3**).

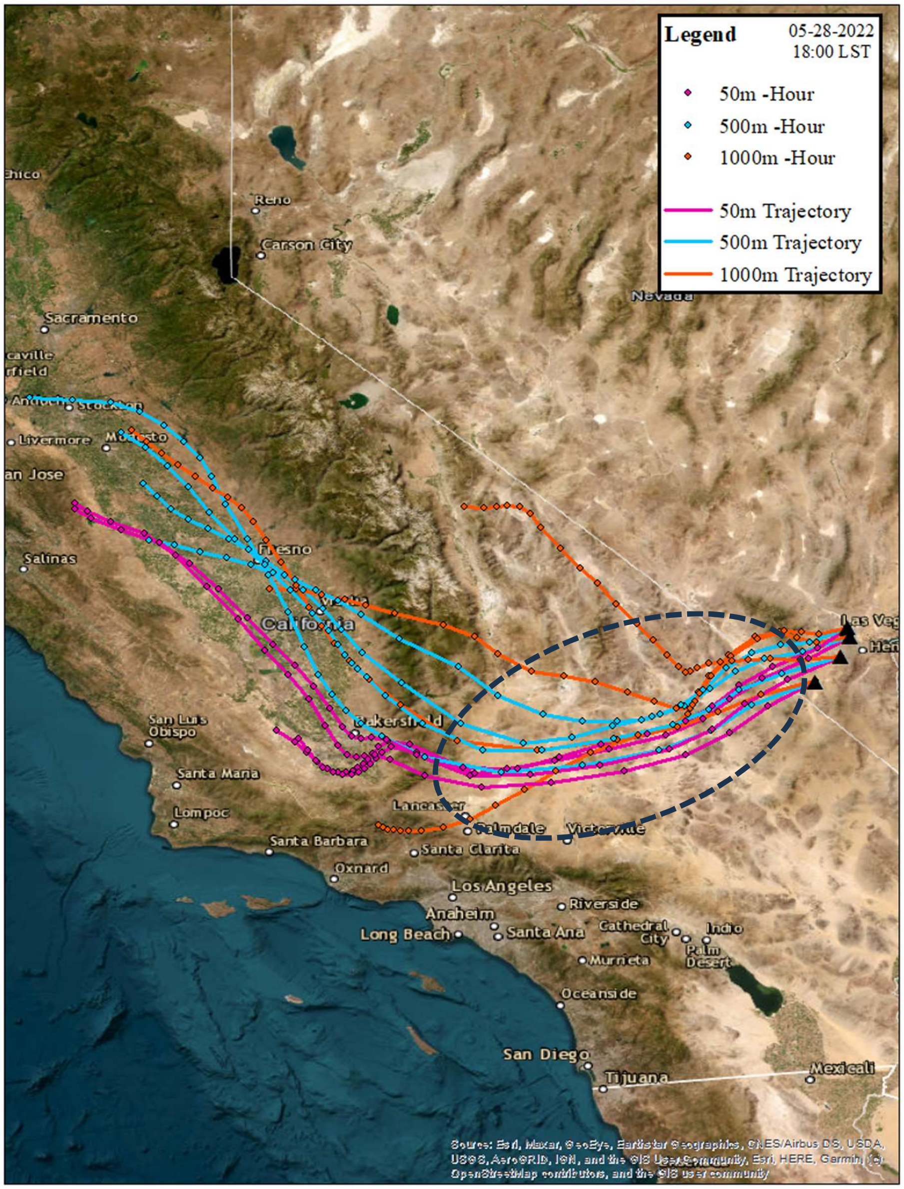


Figure 3.2-1. HYSPLIT 24-hour back trajectories showing hourly points from the Jerome Mack, Jean, Liberty High School, and Walnut Recreation monitoring sites on May 28, 2022, at (left) 01:00 PST and (right) 18:00 PST, originating at (maroon) 50-m, (green) 500-m, and (blue) 1,000-m heights. The approximate location of the Mojave Desert source region is shown by a black, dashed circle.

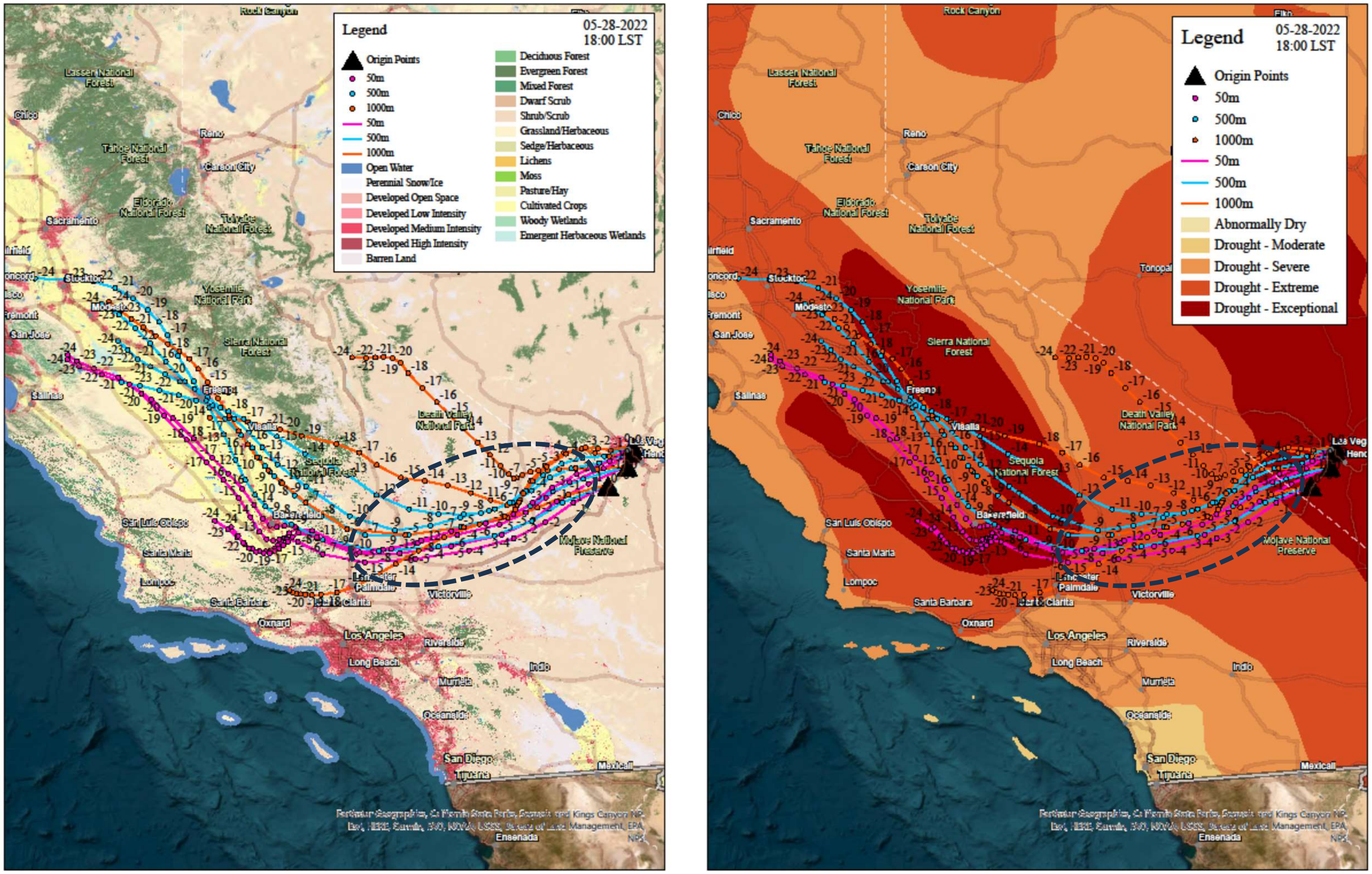


Figure 3.2-2. HYSPLIT 24-hour back trajectories from the Jerome Mack, Jean, Liberty High School, and Walnut Recreation monitoring sites on May 28, 2022, at 18:00 PST, overlayed on (left) national land type database and (right) drought monitor class data. The approximate location of the Mojave Desert source region is shown by a black, dashed circle.

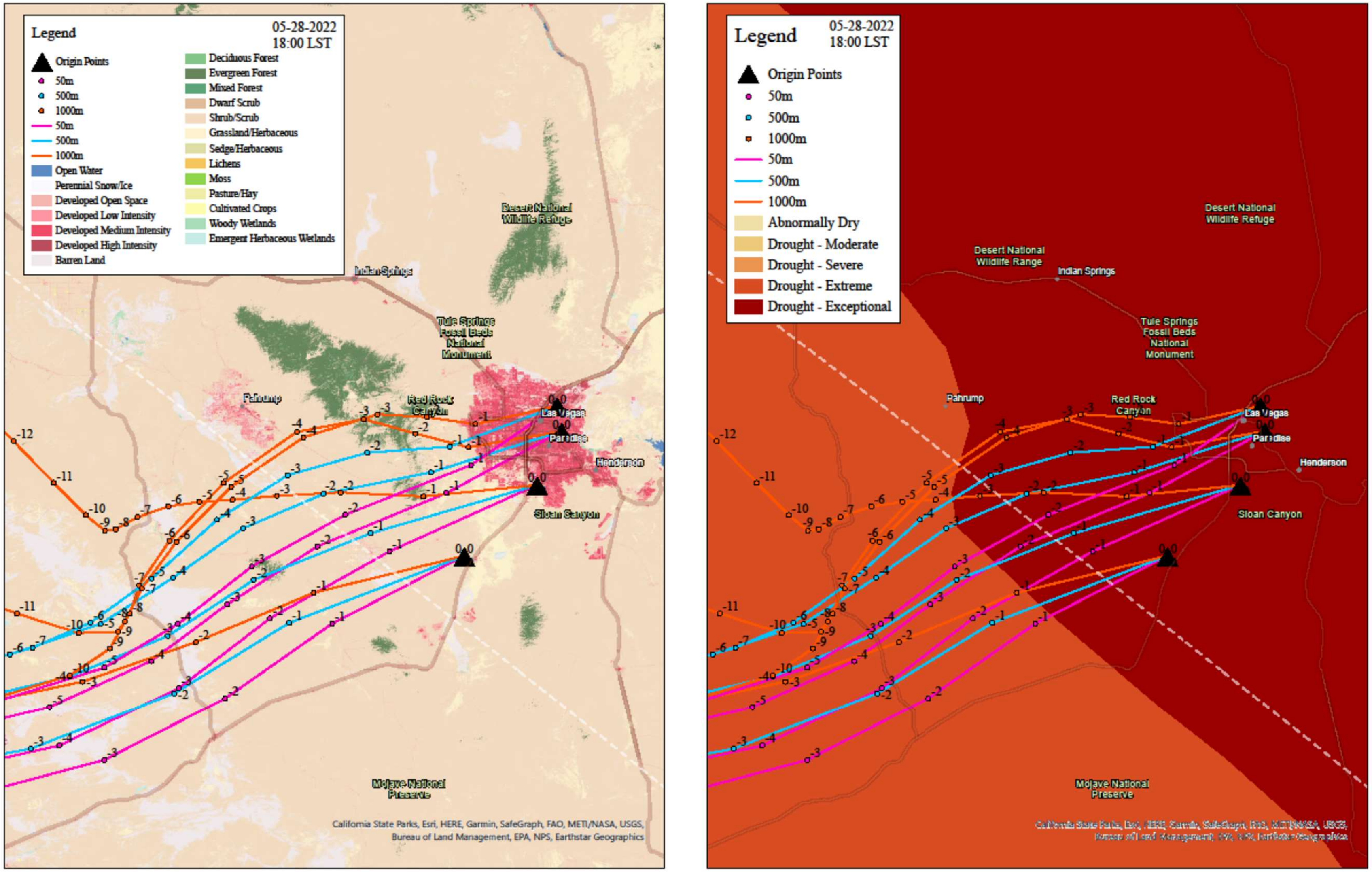


Figure 3.2-3. Zoomed in HYSPLIT 24-hour back trajectories from the Jerome Mack, Jean, Liberty High School, and Walnut Recreation monitoring sites on May 28, 2022, at 18:00 PST, overlayed on (left) national land type database and (right) drought monitor class data.

3.2.2 High-Wind Event Timeline

While an interpolated map of wind speeds in the source region was provided in Figure 3.1-14 and Figure 3.1-15, this section analyzes in-situ monitor data to confirm the wind speeds shown in the interpolated maps. Concentrations of PM_{10} increased rapidly in Clark County between 16:00 and 18:00 PST on May 28, 2022, reaching peak concentrations from 20:00 PST onward. A timeline of two-minute rolling average wind speeds at stations between the source region and Las Vegas is provided in **Figure 3.2-4**. The Bicycle Lake Army Airfield station [KBYS], the closest weather station to the source region, records and reports two-minute average wind speeds each hour. On May 28, wind speeds at KBYS increased in speed rapidly starting at 10:00 PST, and by 12:00 PST were sustained above 25-mph. Wind speeds remained above 25 mph for the next eight hours until 20:00 PST, reaching a maximum sustained speed of 35 mph and maximum gust speed of 47 mph.

HYSPLIT analyses presented in **Section 3.2-1** suggest that the time of transport between the source region in the Mojave Desert region of southeastern California and Las Vegas was approximately four to five hours. An examination of conditions in the source region at 12:00 PST, five hours prior to the event start in Clark County, shows rapidly increasing wind speeds and the beginning of visibility fluctuating below the 10-mile maximum, indicating the presence of lofted dust in the source region. Conditions were prime for airborne dust production along the entire transport path, a region comprised of bare ground and rangeland under severe to exceptional drought conditions. **Figure 3.2-5** shows decreasing visibility at the KBYS station four to five hours preceding the drop in visibility experienced at the Harry Reid International Airport station (KLAS) in Las Vegas. Sustained wind speeds greater than 25 mph were recorded just south of Las Vegas in the hour prior to the PM_{10} event at the Erie weather station (UP167) directly southwest of Las Vegas (Figure 3.2-4). This combination of low soil moisture and the existence of enhanced wind speeds between KBYS and Las Vegas provides strong evidence that a buildup of airborne dust continued as the air mass traveled between the source region and KLAS between 12:00 and 18:00 PST, which enhanced PM_{10} values in Clark County as the air mass passed through the region. This timeline is further confirmed by the radar imagery presented in **Section 3.1.1**.

In addition to the meteorological evidence of the frontal passage, timeseries graphs and a map showing PM_{10} concentrations and hourly average wind speeds in Kern, San Bernardino, and Inyo counties in California, as well as in Pahrump and Las Vegas, Nevada, are provided in Figure 3.2-6 **and Figure 3.2-7**. As stated in the meteorological analysis in Section 3.1.1, the frontal passage entered the Mojave region in southeastern California starting around 12:00 PST on May 28, 2022. Kern County was the first area impacted by lofted dust from the western Mojave Desert and showed an enhancement in PM_{10} concentrations starting just before 12:00 PST. As the front moves eastward, San Bernardino County was affected by enhanced PM_{10} concentrations starting at approximately 12:00 PST, and Inyo County was affected starting at approximately 14:00 PST. The stations in Inyo County were impacted later due to shielding from the mountains to the east. All three California counties show significant enhancements in PM_{10} concentrations with the frontal passage. Increases in

PM_{10} concentrations occur concurrently with enhanced wind speeds. Hourly average wind speeds exceed 25 mph at multiple AQS measurement sites in the Mojave Desert region including Ridgecrest-Ward, Shell Cut, Barstow, Trona, and Victorville-Park Avenue (Figure 3.2-7), fulfilling a key factor for a Tier 2 high-wind dust event as defined by EPA guidance (i.e., sustained winds above 25 mph in a natural undisturbed desert source region). **Figure 3.2-8** shows an interpolation of peak sustained wind speeds during the event and confirms that surface winds were enhanced throughout the region southwest of Las Vegas. Winds in San Bernardino County in California show sustained speeds of greater than 52 mph in the Mojave Desert source region. As the frontal passage continues to move east, the town of Pahrump in Nye County, Nevada, and Las Vegas were impacted by enhanced PM_{10} starting at approximately 18:00 PST on May 28, 2022. Figure 3.2-8 also confirms sustained winds between 25 and 35 mph are in Clark County, indicating that the majority of the lofted dust likely came from upwind of Las Vegas. All sites affected by the frontal passage show extremely enhanced PM_{10} concentrations. The PM_{10} enhancements in the California counties occurred four to six hours before the PM_{10} enhancements in Clark County; this timing is consistent with the HYSPLIT analyses discussed in Section 3.2.1. These measurements provide significant evidence of windblown dust along a frontal passage due to high winds.

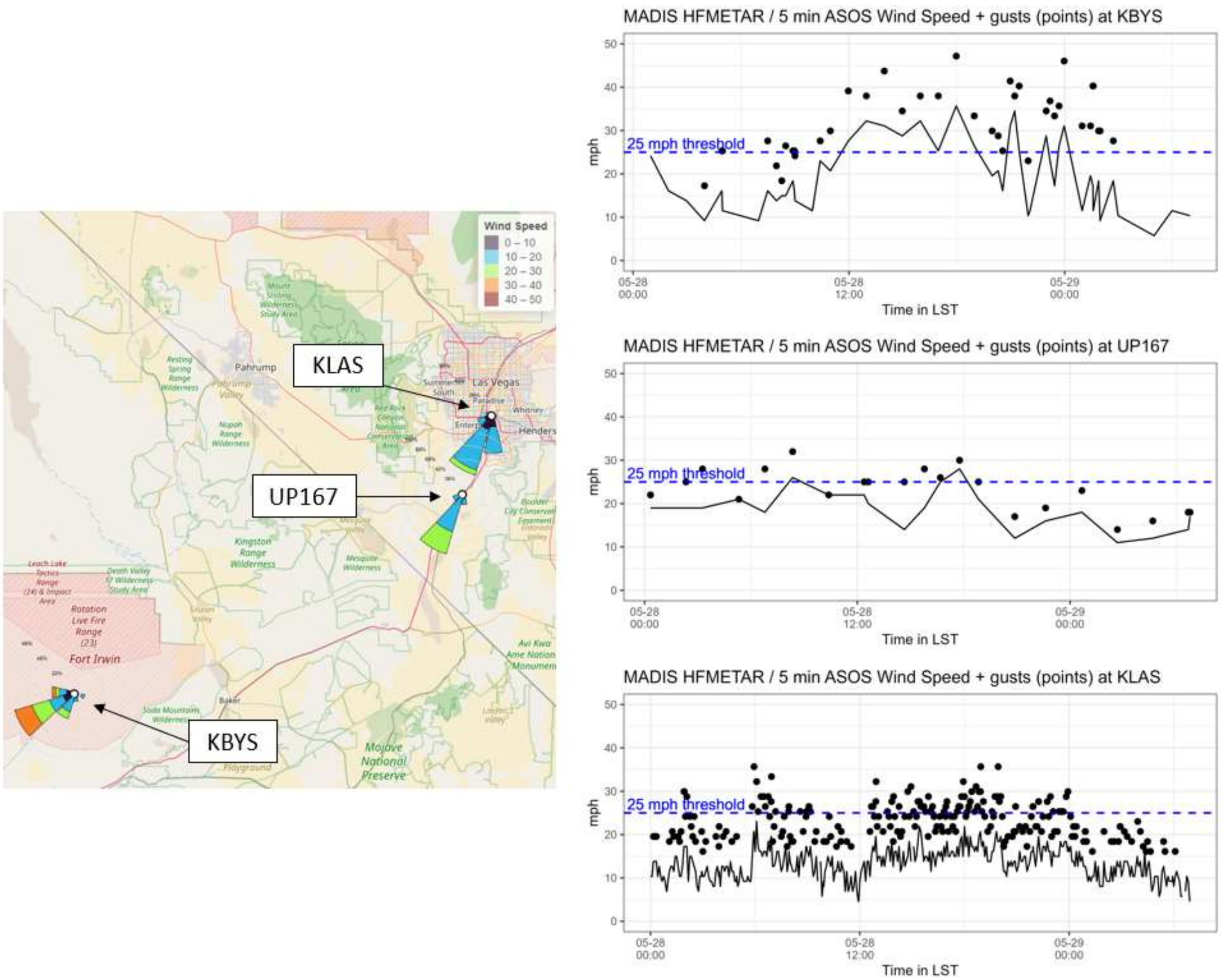


Figure 3.2-4. (left) Weather stations (Bicycle Lake Army Airfield [KBYS], Erie [UP167], and Harry Reid Int'l Airport [KLAS]) between the source region and Las Vegas, overlaid with wind roses displaying wind speed and wind direction between 12:00 on May 28, 2022, and 06:00 on May 29, 2022. (right) Timeseries of wind speed and wind direction data at KBYS, UP167, and KLAS on May 28-29, 2022. Data comprises two-minute rolling average wind speeds (line) and gusts (points) reported at 5-min or hourly intervals (including sub-hourly special reports). Data is sourced from the NWS Weather and Hazards Data Viewer (https://www.wrh.noaa.gov/map).

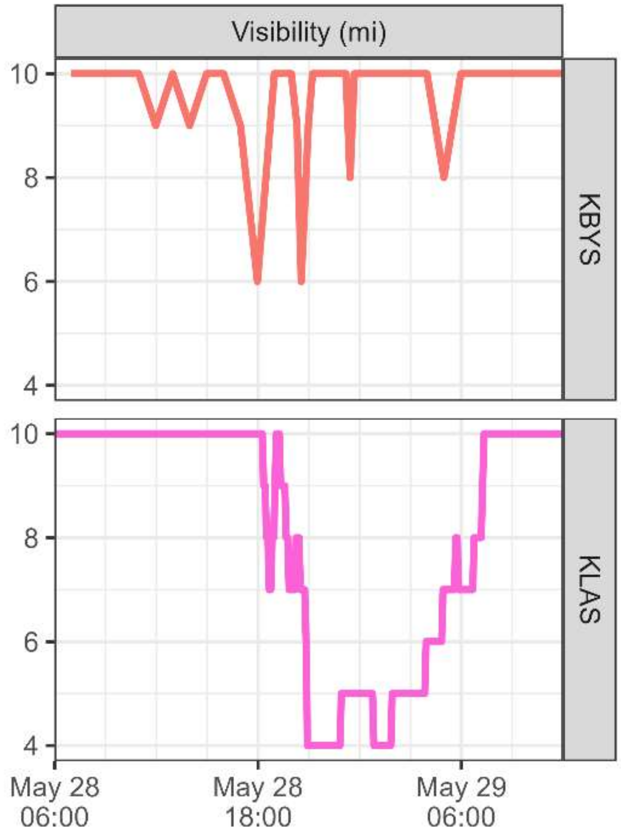


Figure 3.2-5. Visibility conditions reported hourly at the KBYS and KLAS weather stations. Data is sourced from the Iowa Environmental Mesonet (https://mesonet.agron.iastate.edu/).

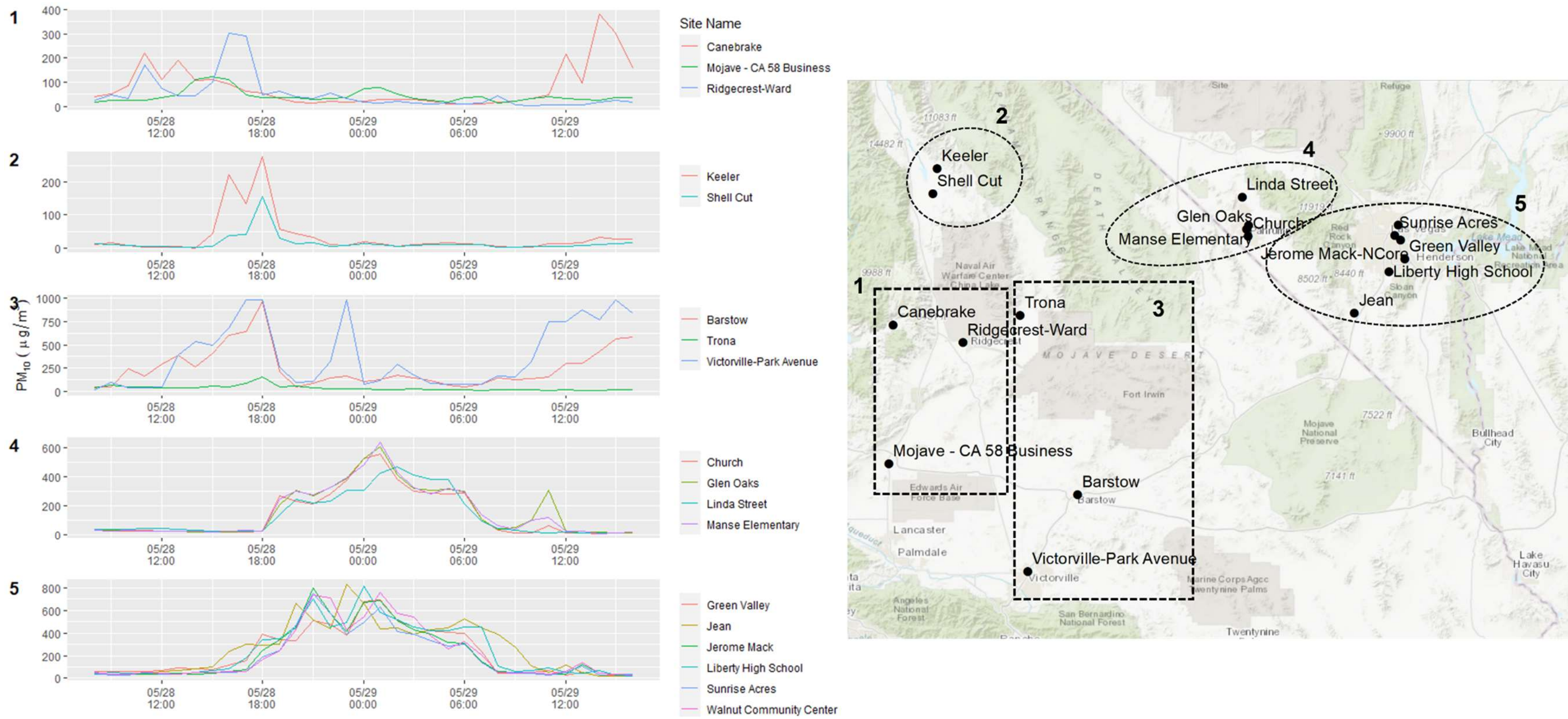


Figure 3.2-6. Timeseries graphs and a map showing PM_{10} concentrations along the frontal passage from the source region into Clark County. (Left) The graphs show data from (1) Kern County, California; (2) Inyo County, California; (3) San Bernardino County, California; (4) the town of Pahrump in Nye County, Nevada; and (5) the Las Vegas, Nevada, area. (Right) The map shows the site locations and regions indicated and numbered in the timeseries graphs.

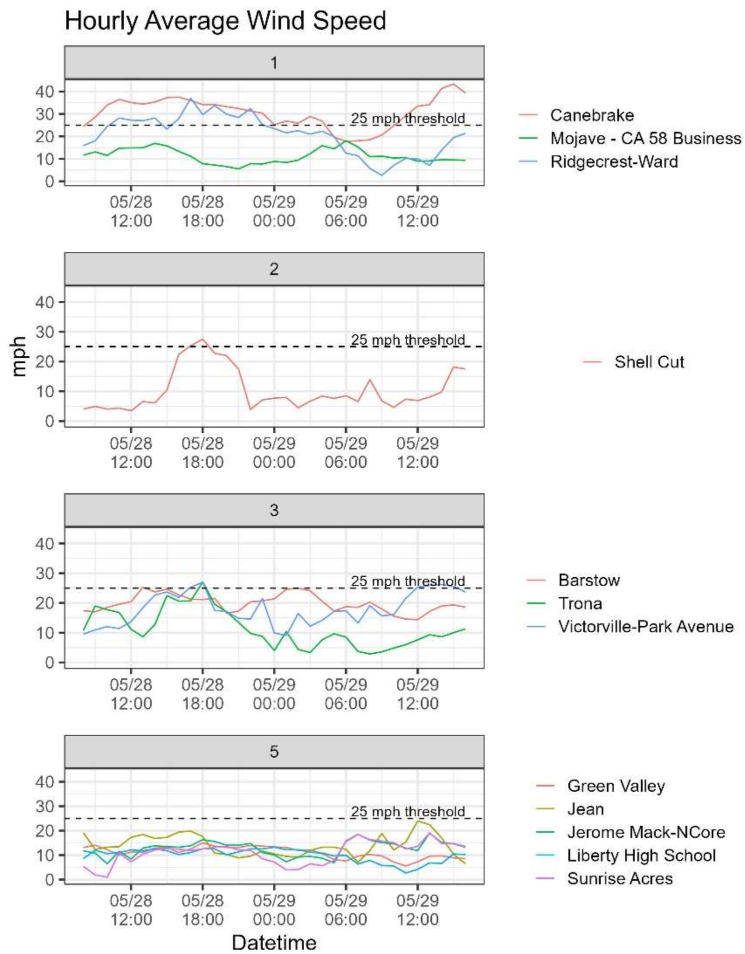


Figure 3.2-7. Hourly average wind speed at sites shown in Figure 3.2-6 sourced from the AQS database. Sites that do not report meteorological data are omitted. The number above each plot panel matches the numbered panels and circled regions in Figure 3.2-6.

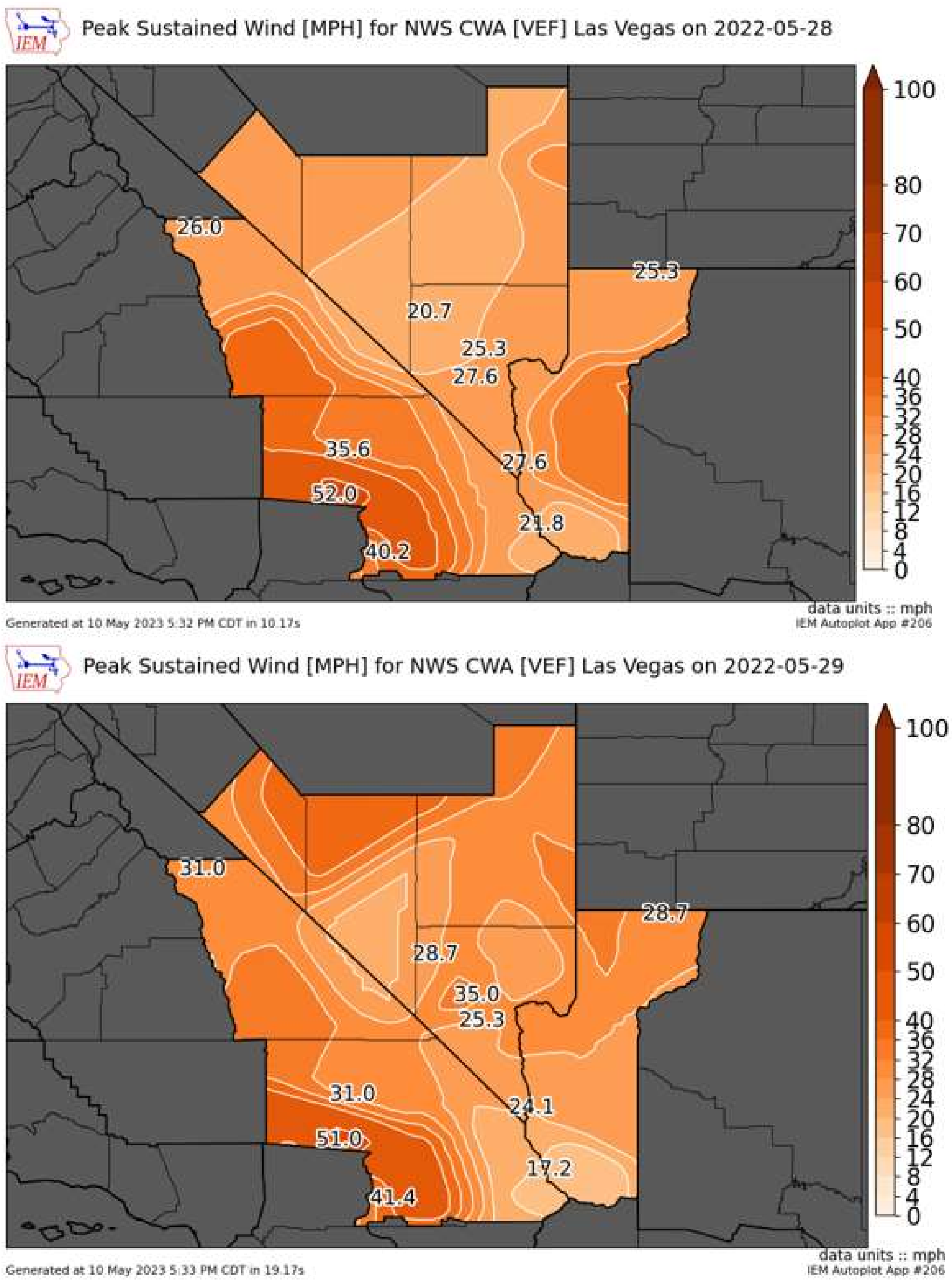


Figure 3.2-8. Spatial distribution of peak sustained wind speeds on May 28 (top) and May 29 (bottom), 2022, in Clark County and surrounding regions. Generated from automated ASOS data using the Iowa Environmental Mesonet's plotter tool (https://mesonet.agron.iastate.edu/plotting/auto).

Wind speed, direction, and concentrations across Clark County, Nevada, are also consistent with a frontal passage. Figure 3.2-9 to Figure 3.2-17 show wind speed and pollutant concentration data from 16:00 PST on May 28 through 09:00 PST on May 29, 2022. At the start of the high-wind dust event, all sites show southwesterly winds, but the southern and eastern Las Vegas Valley sites show high concentrations compared to the northern and western sites. This is due to the mountain pass located at the southwestern corner of the Las Vegas Valley between the Spring Mountains and the McCullough Range, which is a major wind and transport corridor into the Valley. This sites nearest the mountain pass (southern sites) and directly downwind at lower elevation (eastern sites) are affected by the high wind event first due to the topography. PM_{10} accumulates starting at the south and east sites up to the north and west sites as the event ramps up between 16:00 and 21:00 PST on May 28. At 22:00 PST, winds decrease and become light and variable, allowing PM_{10} to remain with the Valley keeping concentrations high through 05:00 PST on May 29. By 06:00 PST, northwesterly winds pick up, driving out the PM_{10} from the event and allowing concentrations to drop by 08:00-09:00 PST.

Enhanced PM_{10} concentrations at the Green Valley, Jerome Mack, Liberty High School, and Walnut Community Center sites were likely caused by a high wind event in the source region rather than local emissions in part because planned land use around these sites, which can be generally described as developed with little exposed dirt or gravel, is not conducive to elevated concentrations. Further, enhanced PM_{10} concentrations at all sites in the Las Vegas Valley is indicative of a regional high-wind dust event. While it is possible that some portions of planned land use, such as the dirt-covered part of the sports complex near the Green Valley site, may have contributed to local dust during the high wind event, evidence of high winds over a natural, undisturbed desert region upwind of Clark County is clearly the main driver of this dust event. As shown by the timeline of events, high winds from a frontal passage lofted PM_{10} in the Mojave Desert source region and caused a regional dust event across southern California extending into Clark County. Even if there were some contributions from local dust sources due to high winds, the regional dust event is the main source of the extreme PM_{10} concentrations experienced on May 28 and 29, 2022.

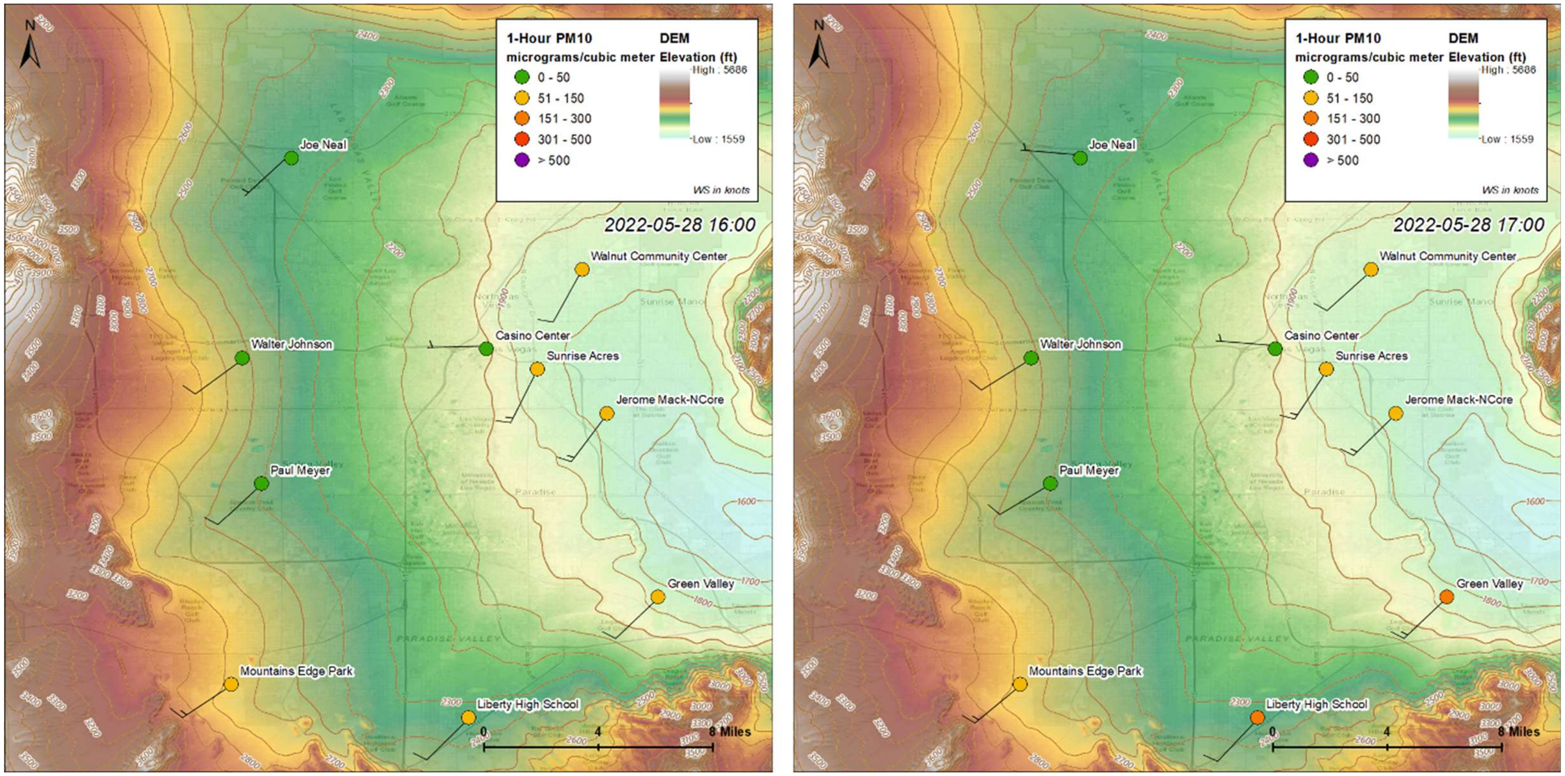


Figure 3.2-9. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 28, 2022, from 16:00 PST to 17:00 PST.

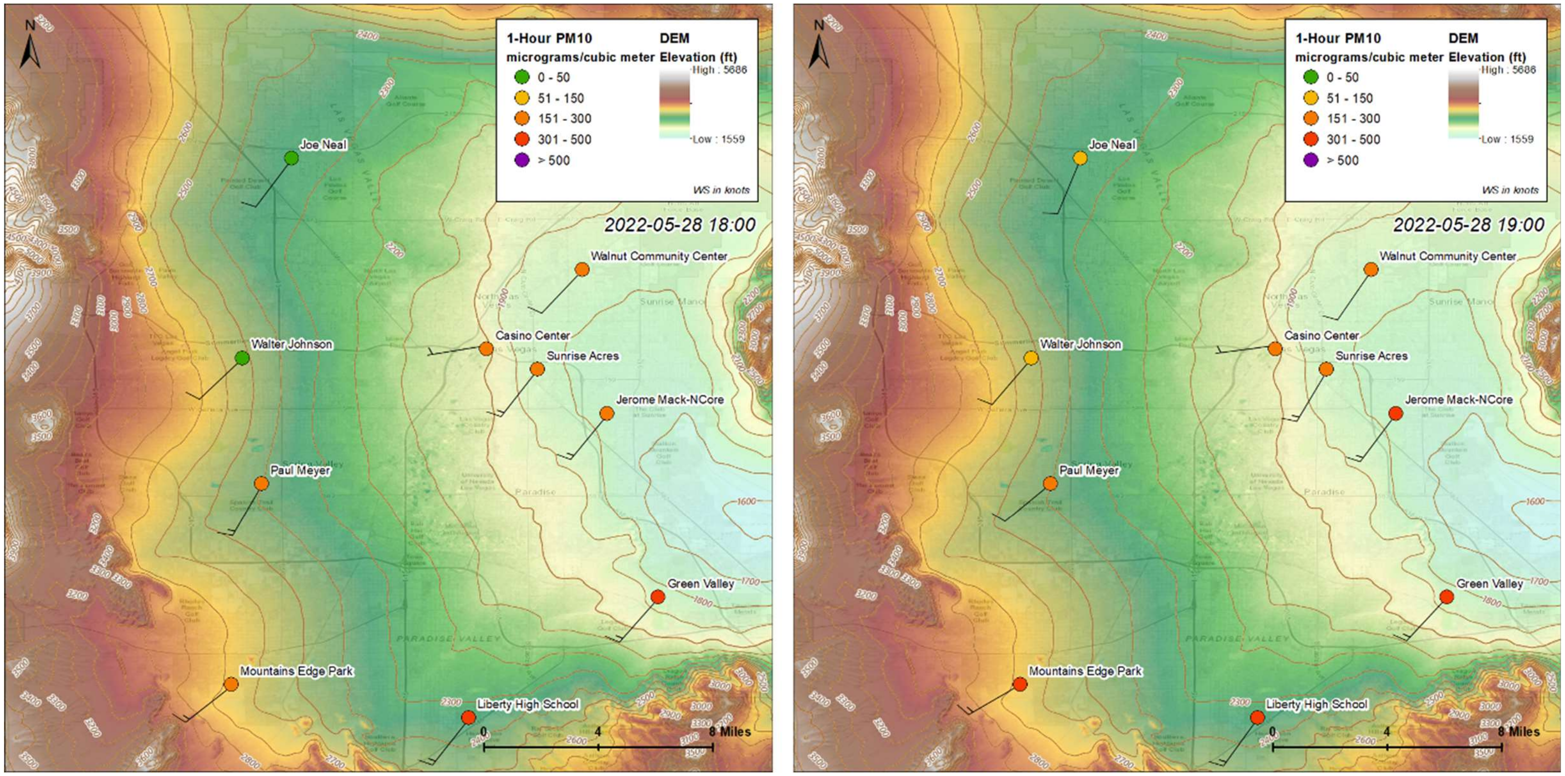


Figure 3.2-10. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 28, 2022, from 18:00 PST to 19:00 PST.

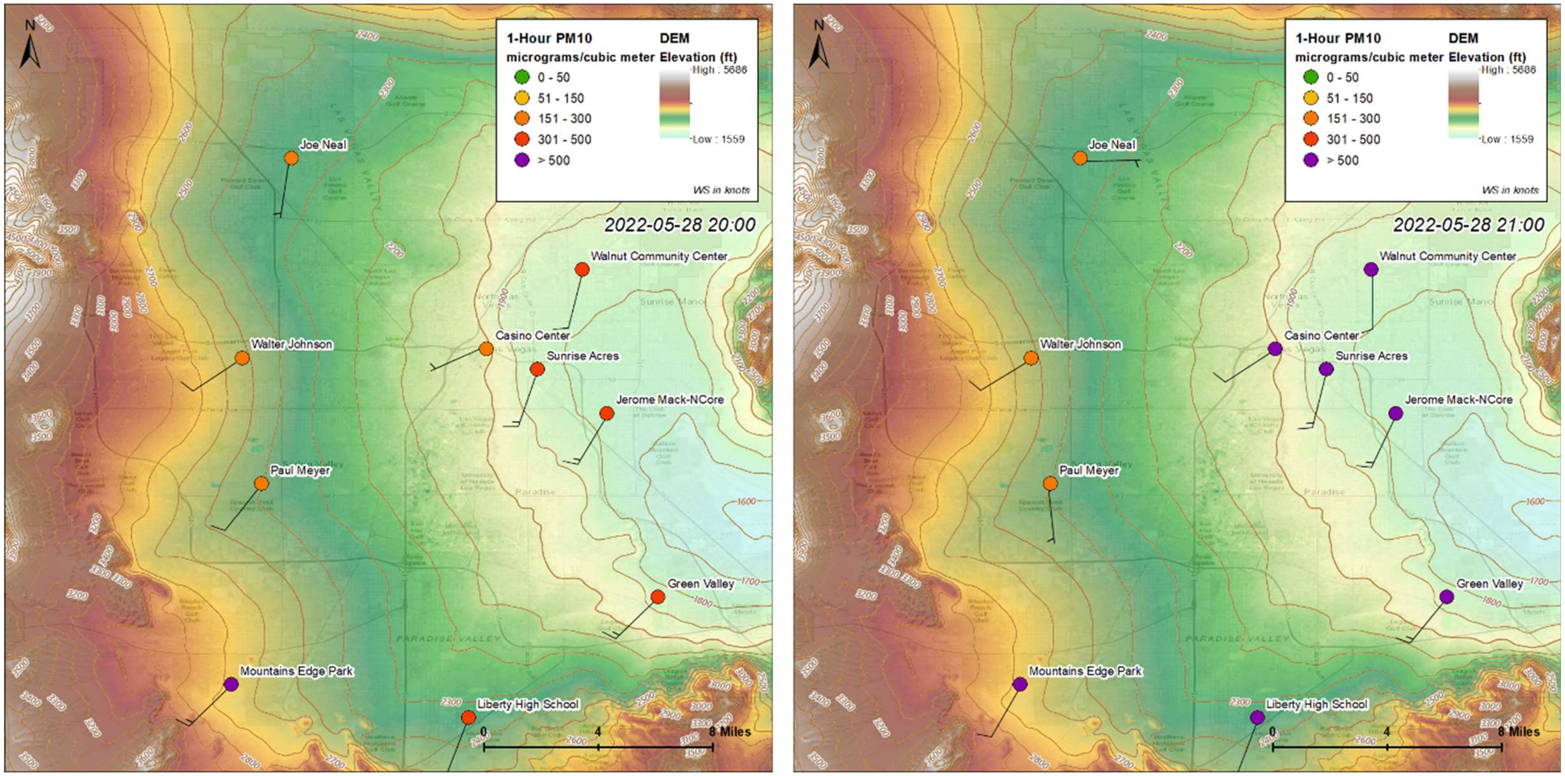
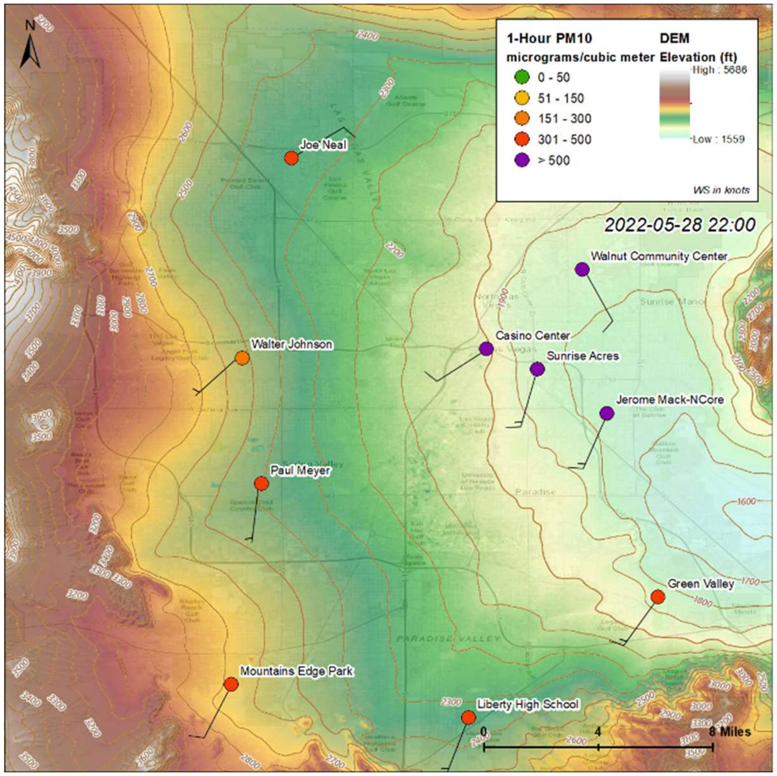


Figure 3.2-11. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 28, 2022, from 20:00 PST to 21:00 PST.



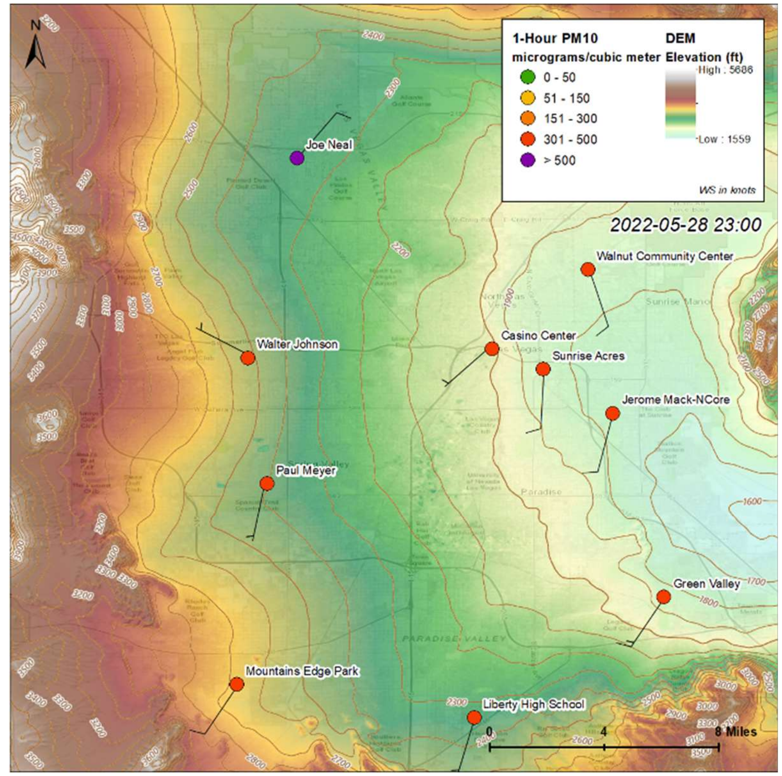


Figure 3.2-12. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 28, 2022, from 22:00 PST to 23:00 PST.

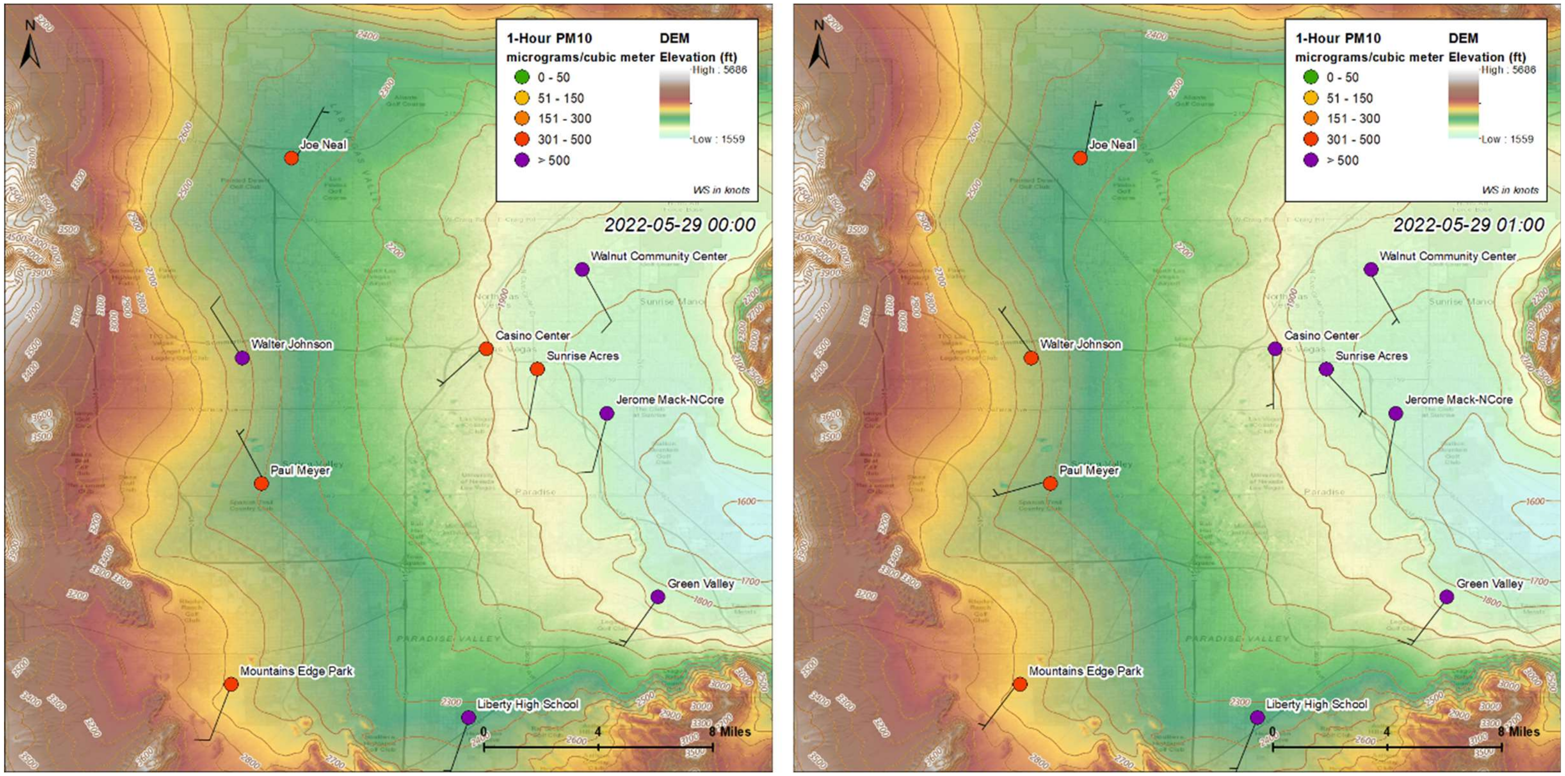


Figure 3.2-13. Topographical map showing surface observations of wind speed, wind direction, hourly PM_{10} from each measurement site in Clark County, Nevada and ground elevation for May 29, 2022, from 00:00 PST to 01:00 PST.

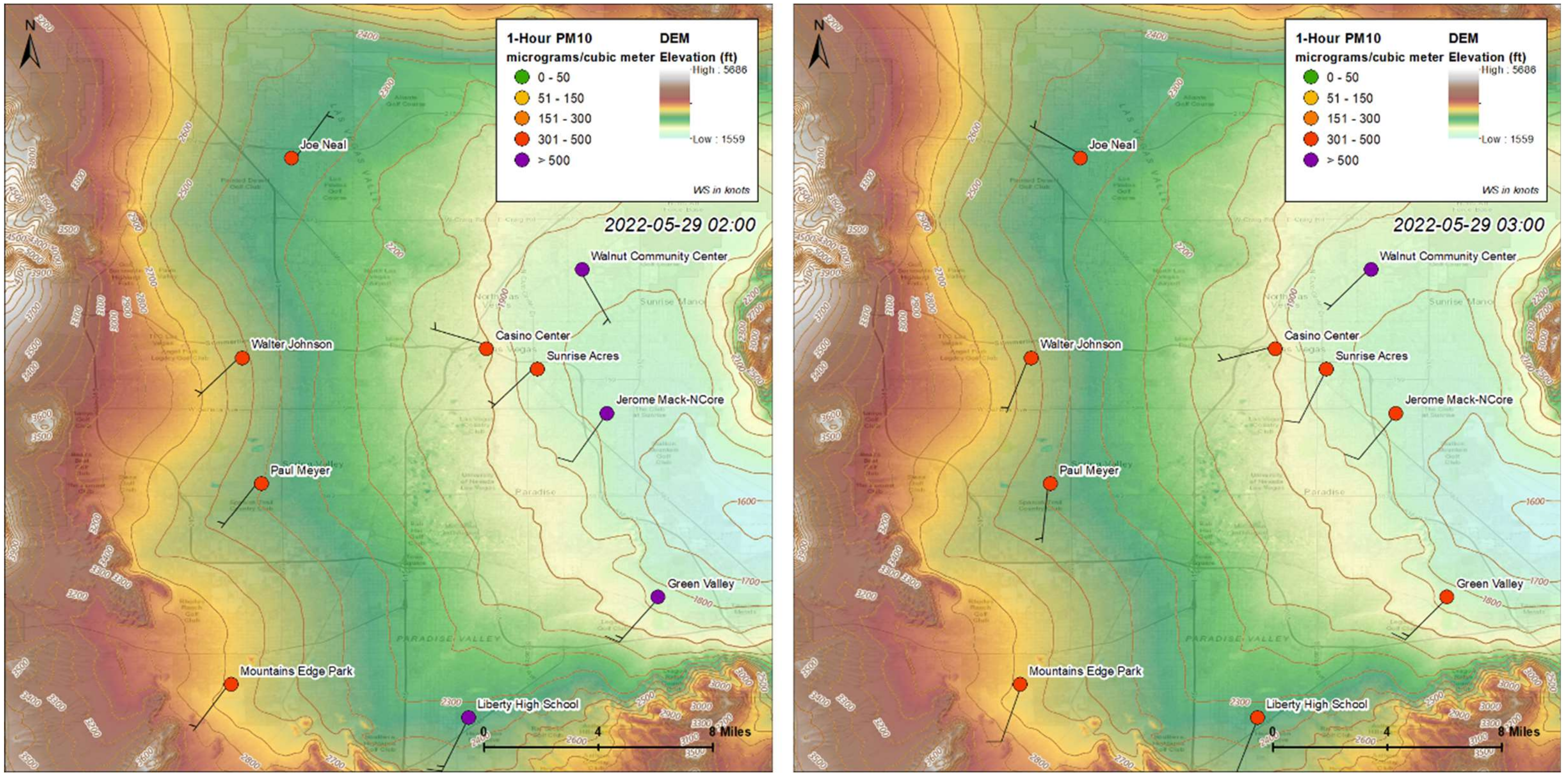


Figure 3.2-14. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 29, 2022, from 02:00 PST to 03:00 PST.

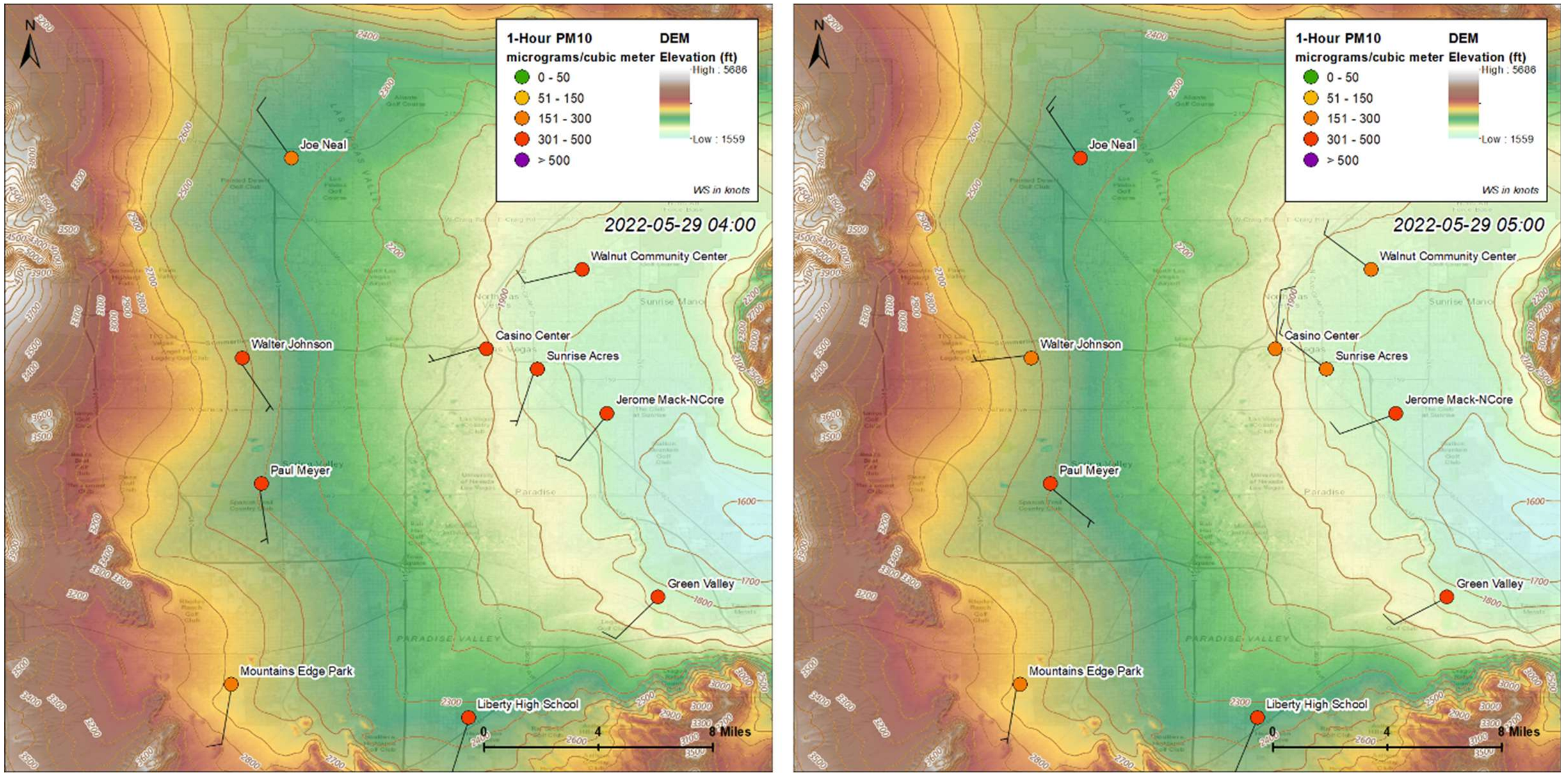


Figure 3.2-15. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 29, 2022, from 04:00 PST to 05:00 PST.

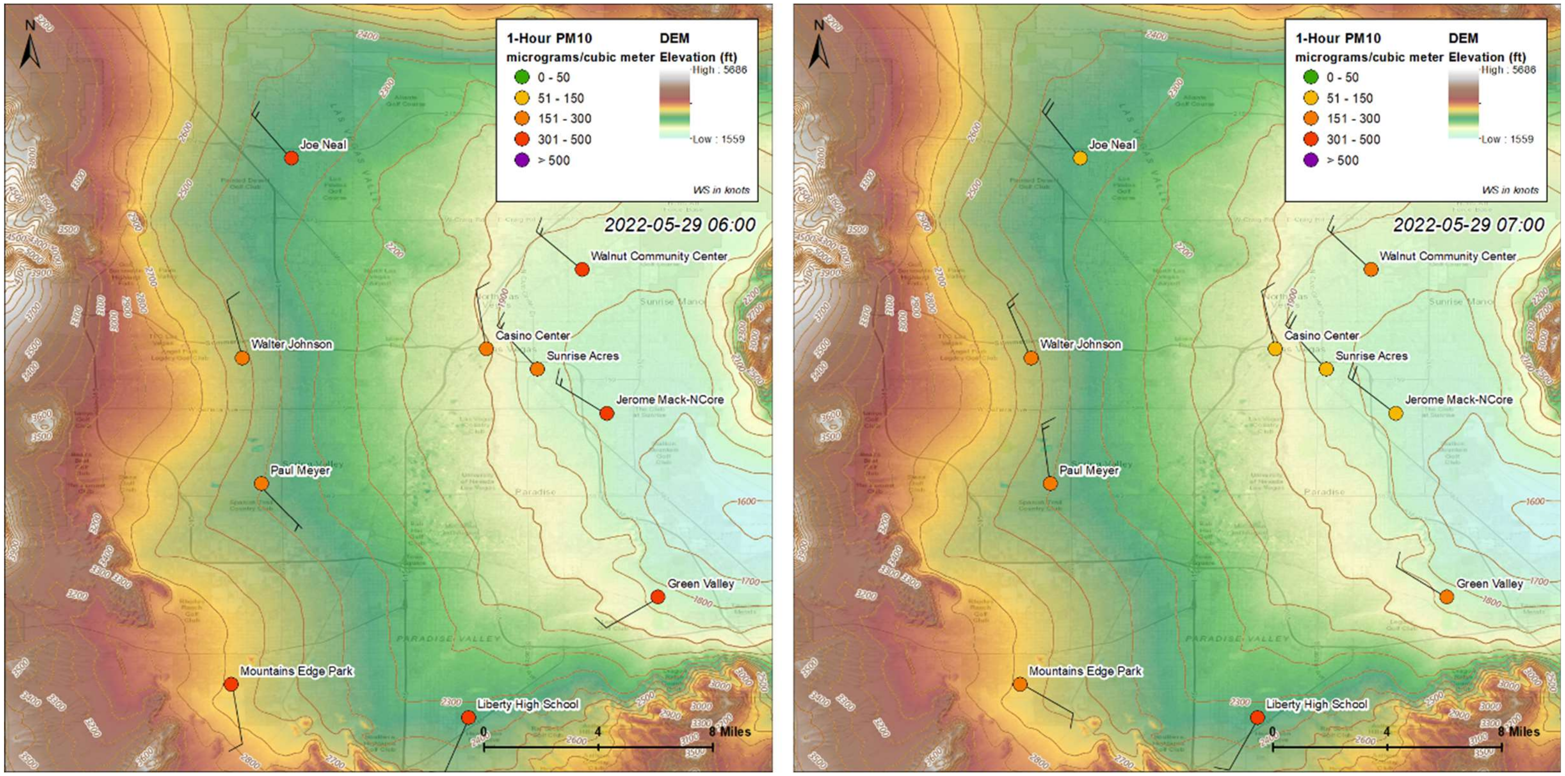


Figure 3.2-16. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 29, 2022, from 06:00 PST to 07:00 PST.

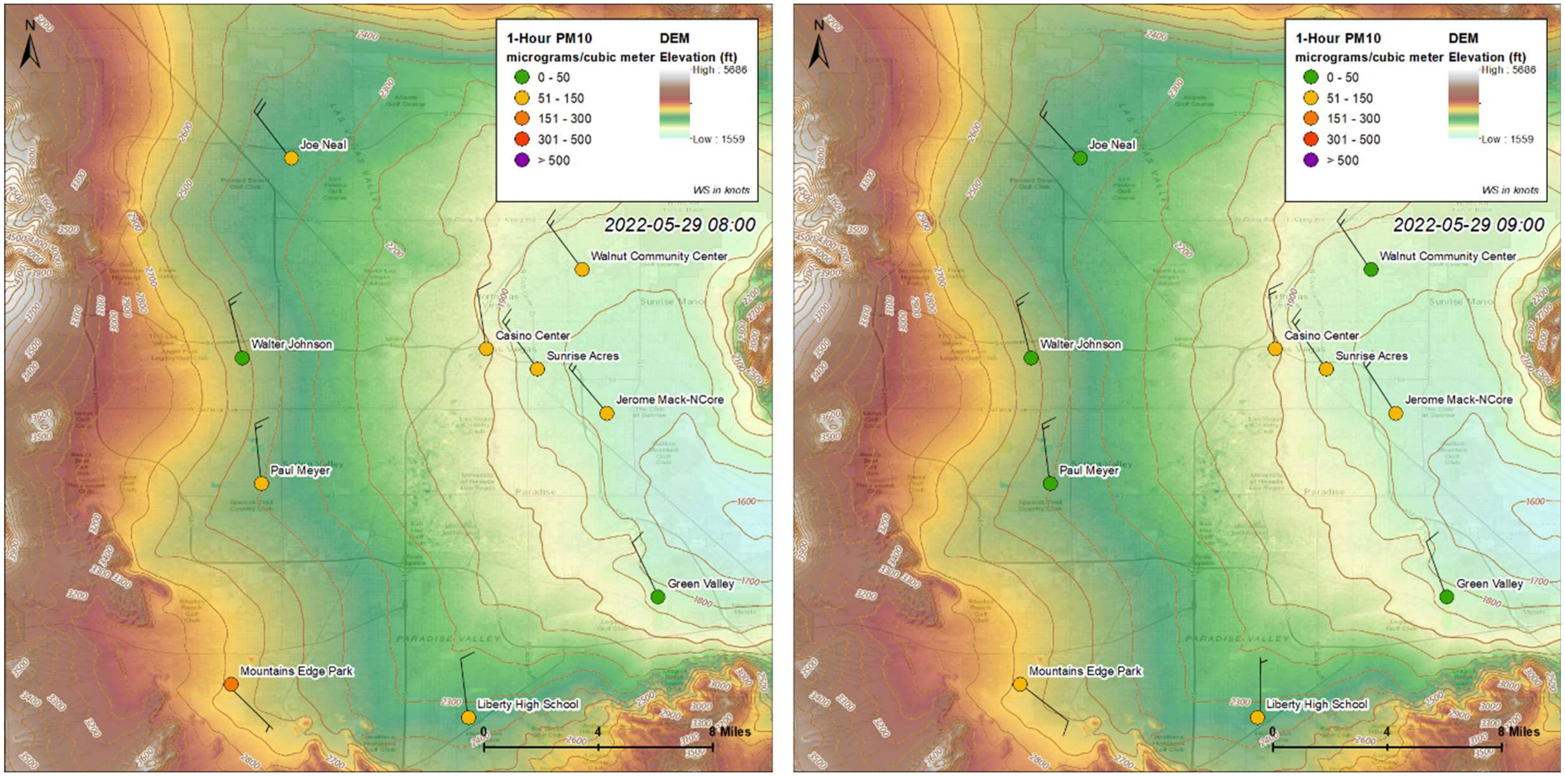


Figure 3.2-17. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for May 29, 2022, from 08:00 PST to 09:00 PST.

Overall, we find overwhelming evidence that PM_{10} was transported by a strong frontal passage from the Mojave Desert in the afternoon and evening on May 28, 2022. Wind speeds in the source region and along the transport path show sustained speeds greater than 25 mph, the high-wind threshold. PM_{10} concentrations from monitors along the frontal passage also show the lofted dust from the Mojave Desert in southeastern California. The evidence corroborating this assertion includes (1) HYSPLIT analyses showing transport from the Mojave Desert in southeastern California to Clark County within four to six hours, (2) abrupt changes in wind speed and visibility along the transport path, (3) PM_{10} concentrations from monitoring sites along the transport path, and (4) ground-based observation of PM_{10} and wind speed/direction in Clark County that corroborate the time of arrival for the PM_{10} event.

3.3 Impacts of Wind-Blown PM_{10} Dust at the Surface

3.3.1 Clark County Alerts

On Friday, May 27, 2022, Clark County issued a Construction Notice to all dust control permit holders, contractors, and stationary sources to immediately inspect their sites and employ BACM to control and stabilize soil in advance of the dust event forecasted for May 27-28 (see **Figure 3.3-1**). Subsequently, a Dust Advisory was issued for May 29, 2022, due to blowing dust from the Mojave Desert to the southwest. Clark County, Nevada, created a news release for May 29, 2022, with an air quality advisory for dust to warn people to limit their time outdoors (**Figure 3.3-2**). They advised residents and local construction sites that enhanced levels of blowing dust would be possible due to high winds. The new release mentioned that the dust was transported overnight into the area from the Mojave Desert. Airborne dust is described as a form of inhalable particulate matter air pollution that aggravates respiratory diseases. The news release suggested that the public should stay indoors under windy conditions as much as possible, especially those who would be at greater risk from particulate matter pollution.

DES
DEPARTMENT OF ENVIRONMENT AND SUSTAINABILITY

Clark County Department of Environment and Sustainability

Division of Air Quality

CONSTRUCTION NOTICE

for Friday and Saturday, May 27 and 28, 2022

Attention Dust Control Permit Holders, Contractors, and Stationary Sources

National Weather Service and the weather models used by the Division of Air Quality (DAQ) show the potential for high winds beginning Friday afternoon and lasting throughout Saturday. The forecast is for **sustained winds at 20 mph,** with gusts **30 mph.**

DAQ directs all permittees to inspect their site(s) and employ Best Available Control Measures to stabilize all disturbed soils. Permittees with multiple sites should contact each site superintendent or dust monitor to ensure compliance with the Clark County Air Quality Regulations.

BLASTING: This forecast is for wind gusts 30 mph or more. Project operators should not load blasting materials or perform any blasting operations. You are required to monitor National Weather Service reports for wind speeds; if wind gusts above 25 mph are forecast, discontinue charging additional blast holes. Limit the blast to holes charged at the time the wind report is made.

DAQ will continue to monitor these forecasts for any further wind developments. If the weather forecast is upgraded and conditions warrant, you will be notified of a Dust Advisory.

Figure 3.3-1. Email from AQDCP@ClarkCountyNV.gov to all Dust Control Permit holders in advance of the May 28-29, 2022, dust event.

CLARK COUNTY NEVADA

News Release

County Commission:
James B. Gibson, Chairman
Justin Jones, Vice Chairman
Marilyn Kirkpatrick
William McCurdy II
Ross Miller
Michael Naft
Tick Segerblom

Yolanda King, County Manager

Office of Public Communications • (702) 455-3546 • FAX (702) 455-3558 • www.ClarkCountyNV.gov

Contact: Kevin J. MacDonald
Public Information Officer

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E-mail: KevMac@ClarkCountyNV.gov

For Immediate Release **Sunday, May 29, 2022**

Air Quality Dust Advisory Issued for Sunday

AIR QUALITY ADVISORY
DUST
ADVISORY

The Clark County Department of Environment and Sustainability has issued a dust advisory for **Sunday, May 29,** to advise residents and local construction sites of the possibility of elevated levels of blowing dust due to the forecast of high winds in our area. Dust transported overnight into the region from the Mojave Desert.

Airborne dust is a form of inhalable air pollution called particulate matter or PM, which aggravates respiratory diseases. Under windy conditions people with heart or lung disease, older adults, and children may feel better staying indoors as much as possible because they could be at greater risk from particulates, especially when they are physically active, according to the U.S. Environmental Protection Agency. Consult your physician if you have a medical condition that makes you sensitive to air pollution.

Figure 3.3-2. News release by Clark County, Nevada, on May 29, 2022, issuing the air quality dust advisory.

3.3.2 Media Coverage

Several news sources, including KTNV Las Vegas and the Las Vegas Review-Journal reported on the windy conditions and dust present on May 28 and May 29, 2022. Screenshots of the news articles referenced in this section are in Appendix A.

KTNV Las Vegas reported that there was elevated fire danger during this weekend due to southwest gusts of 30-35 mph on Friday, Saturday, and Sunday for most of Southern Nevada. Both blowing dust and debris were possible throughout the weekend with choppy conditions on the lakes within the area. (https://www.ktnv.com/weather/13-first-alert-weather-forecast-saturday-morning-may-28-2022)

The Las Vegas Review-Journal reported on red flag warnings continuing through Sunday due to gusty winds, low humidity, and dry conditions for the Las Vegas area (Figure 3.3-3). The red flag warning was from noon to 20:00 on Monday. Saturday winds of 20-25 mph with gusts of 30 mph were forecasted for Sunday, and blowing sand and flying debris was considered possible. (https://www.reviewjournal.com/local/weather/red-flag-warning-runs-through-sunday-2584315/).

Red flag warning runs through Sunday

Winds could gusts could reach 40 mph on Sunday, May 29, 2022, in Las Vegas, according to the National Weather Service. Hope Barett, 7, of Medford, Ore., has her hair blown by strong wind as she enters the Regional Justice Center on Thursday, March 10, 2022, in Las Vegas. (Bizuayehu Tesfaye/Las Vegas Review-Journal) @btesfaye

By Marvin Clemons Las Vegas Review-Journal
May 29, 2022 - 5:30 am

Figure 3.3-3. Photo from the Las Vegas Review-Journal article from May 29, 2022.

Additionally, the National Weather Service (NWS) Las Vegas office also issued Urgent Weather Messages containing Wind Advisories for the source region and Clark County, describing high gusty winds and possible dust conditions for the counties listed in Table 3.3-1. The Urgent Weather Messages concerning the dusty conditions in southeastern California and southern Nevada included Clark County. Appendix A includes all NWS alerts for this event.

Table 3.3-1. Dust event warnings issued by the National Weather Service office in Las Vegas, Nevada, on May 28 and May 29, 2022.

Warning	Time (PDT)	Warning Type	Location
Urgent Weather Message	May 28, 2022, at 02:05	Wind Advisory in Effect.	Eastern Sierra Slopes-Owens Valley, Eastern Mojave Desert-Morongo Basin-Southern Clark County, Western Mojave Desert, Lake Mead National Recreation Area
Urgent Weather Message	May 28, 2022, at 11:09	Wind Advisory in Effect.	Eastern Mojave Desert-Morongo Basin-Southern Clark County, Western Mojave Desert, Eastern Sierra Slopes-Owens Valley, Lake Mead National Recreation Area
Urgent Weather Message	May 28, 2022, at 14:15	Wind Advisory in Effect.	Owens Valley, Eastern Mojave Desert-Morongo Basin, Northwest Plateau-Esmeralda and Central Nye County-Lincoln County, Southern Clark County, Western Mojave Desert, Eastern Sierra Slopes, Lake Mead National Recreation Area
Urgent Weather Message	May 28, 2022, at 22:54	Wind Advisory in Effect.	Eastern Mojave Desert-Morongo Basin, Southern Clark County, Lake Mead National Recreation Area, Owens Valley, Northwest Plateau-Esmeralda and Central Nye County-Lincoln County, Western Mojave Desert, Eastern Sierra Slopes
Urgent Weather Message	May 29, 2022, at 02:10	Wind Advisory in Effect.	Owens Valley, Eastern Sierra Slopes, Northwest Plateau-Esmeralda and Central Nye County-Lincoln County, Eastern Mojave Desert-Morongo Basin, Western Mojave Desert
Urgent Weather Message	May 29, 2022, at 06:44	Wind Advisory in Effect.	Northwest Plateau-Esmeralda and Central Nye County-Lincoln County, Eastern Mojave Desert-Morongo Basin, Western Mojave Desert, Owens Valley

Warning	Time (PDT)	Warning Type	Location
Urgent Weather Message	May 29, 2022, at 14:00	Wind Advisory in Effect.	Northwest Plateau-Esmeralda and Central Nye County-Lincoln County, Owens Valley, Eastern Mojave Desert-Morongo Basin, Western Mojave Desert

3.3.3 Pollutant and Diurnal Analysis

As discussed in **Section 3.2**, the period of high PM_{10} concentrations in the Las Vegas Valley on May 28 and 29, 2022 coincided with high wind speeds. Wind speeds measured at the weather stations in and around the Las Vegas Valley rose as the frontal passage moved into Clark County between 16:00 and 18:00 PST on May 28. **Figure 3.3-4** shows the hourly PM_{10} concentrations at the Jerome Mack, Liberty High School, Walnut Community Center, Green Valley, and all other PM_{10} monitoring sites around the Clark County area for May 28-29. PM_{10} concentrations initially increased at the Jean site (the westernmost site in Clark County), consistent with the frontal passage moving from west-to-east and the radar images shown in **Section 3.1.1**. PM_{10} concentrations at all sites peaked above 400 µg/m^3 as dust entered the county late in the day on May 28 and kept concentrations enhanced through the morning on May 29. The concurrent rise in PM_{10} concentrations at all sites around Clark County indicates a regional dust event.

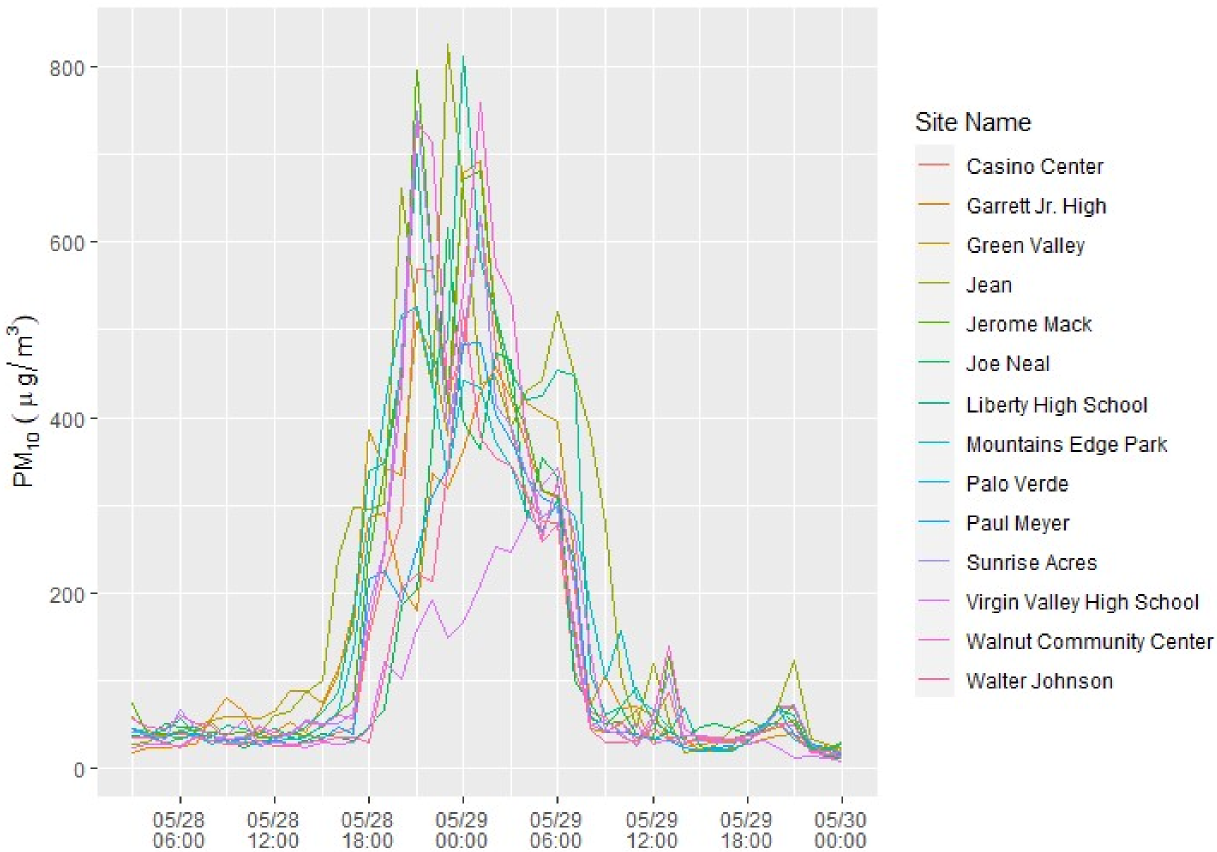

Figure 3.3-4. Hourly PM_{10} concentrations in µg/m^3 measured at all sites around Clark County, including the regulatorily significant sites: Green Valley, Liberty High School, Walnut Community Center, and Jerome Mack.

Figure 3.3-5 shows the measured hourly PM_{10} concentrations on May 28-29, 2022, together with the 5th-95th percentiles of the five-year historical hourly PM_{10} data from 2018-2022 for all affected sites. On May 28, 2022, starting between 16:00 to 18:00 PST, the hourly PM_{10} concentration surpassed the five-year 95th percentile at all sites. The event reached a peak between May 28 at 21:00 PST and May 29 at 01:00 PST, recording maximum hourly values near 800 µg/m^3. The concentrations remained above the 95th percentile until approximately 09:00 PST on May 29.

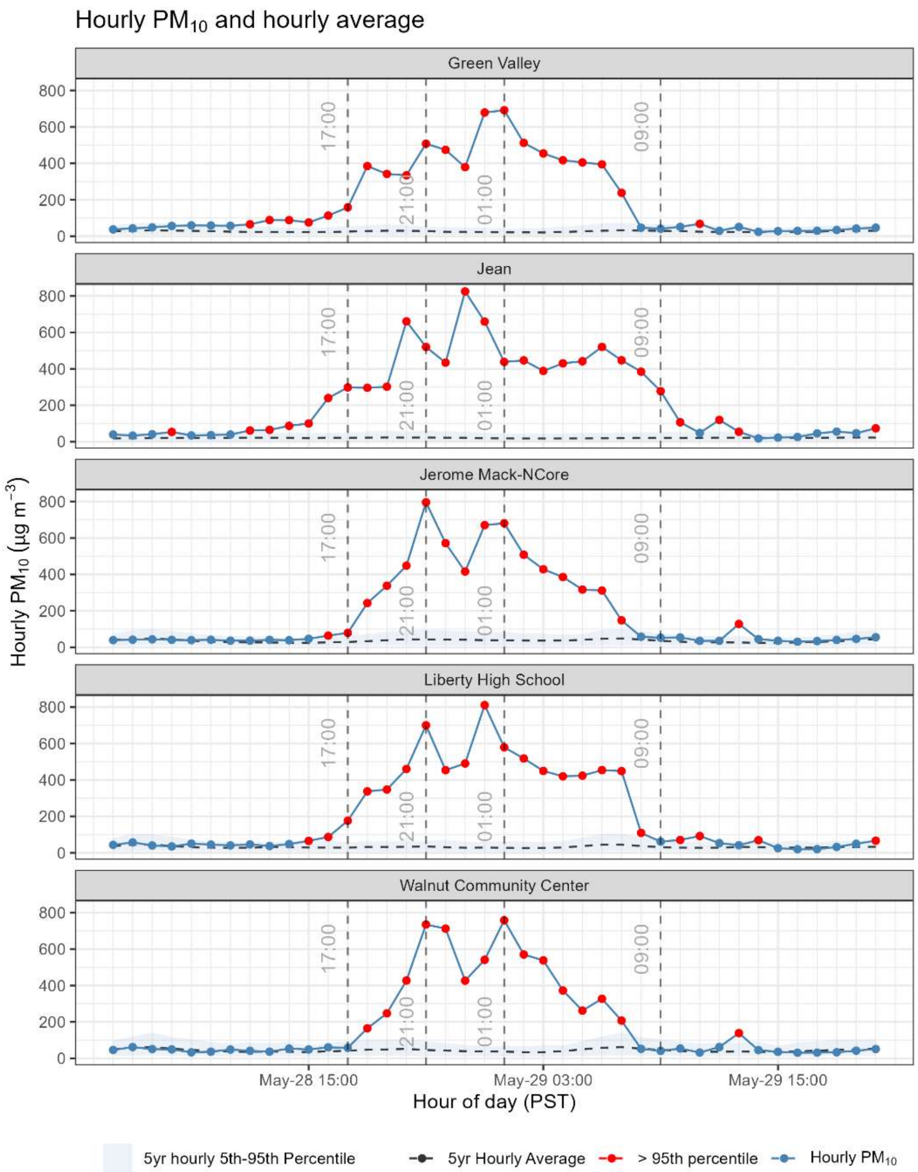

Figure 3.3-5. Hourly PM_{10} concentrations compared to the hourly average (dashed line) and 5th-95th percentile (shaded area) in 1-hour PM_{10} concentrations from 2018-2022 at affected sites. Hourly concentrations exceeding the 95th percentile are shown in red.

The 24-hour average PM_{10} values at all sites in Clark County before and after the exceedance event on May 28 and 29, 2022, shown in Figure 3.3-6, remained below the 99th percentile of the five-year (2016-2020), except for May 20, 2022. On May 27, 2022, the 24-hour average PM_{10} values at all sites were well below the 99th percentile five-year historical data value (2016-2020) of 99.3 µg/m^3. On May 28, the first day of the exceedance event, the 24-hour average PM_{10} values at 10 out of the 14 sites exceeded the 99th percentile value. On May 29, the second day of the event, all sites throughout the Clark County area exceed the 99th percentile value. PM_{10} concentrations at the

Jerome Mack, Green Valley, Liberty High School, Jean, and Walnut Community Center sites on one or both dates. The simultaneous increase in PM_{10} concentrations at all sites, with many exceeding the 99th percentile threshold, suggests a regional source of PM_{10} pollution such as a wind-blown dust event.

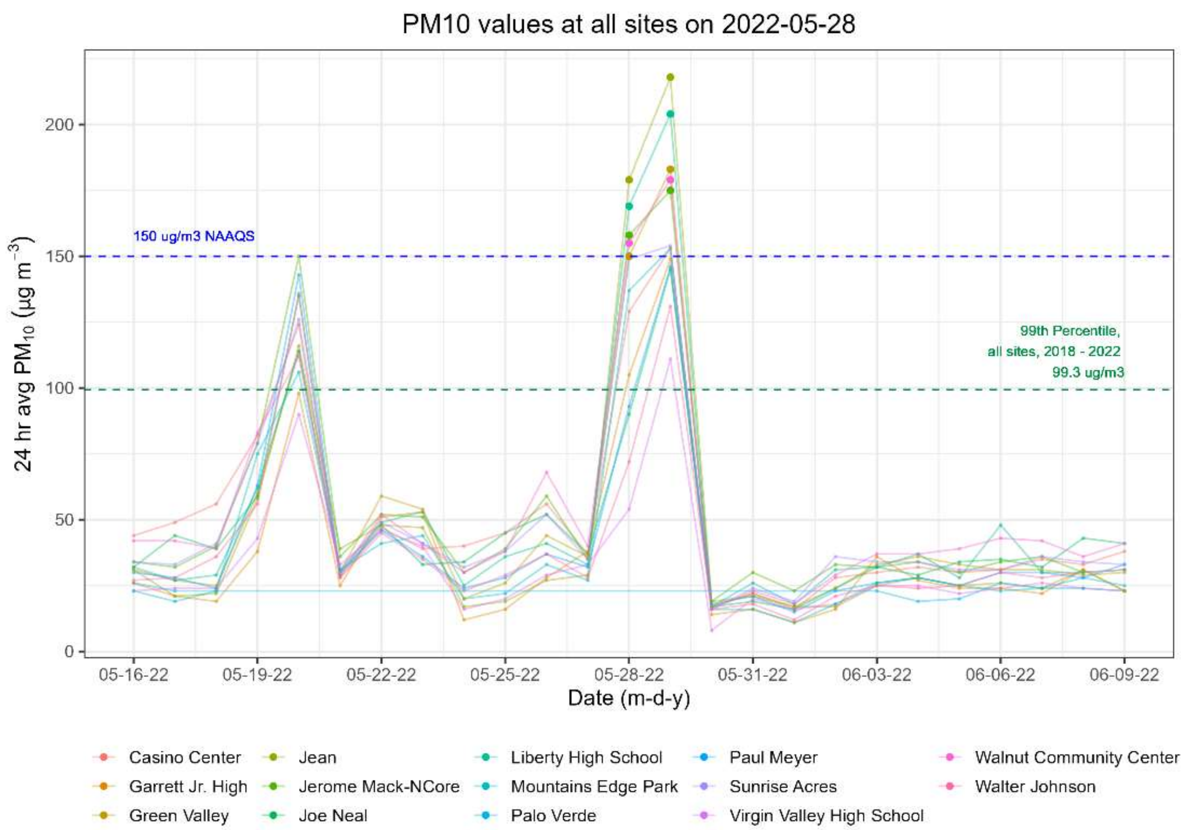

Figure 3.3-6. PM_{10} values at all Clark County, Nevada, measurement sites from 2018-2022 with the NAAQS (blue dash) indicated. The green dashed line indicates 99.3 µg/m^3, the 99th percentile of the five-year historical values at these sites.

3.3.4 Particulate Matter Analysis

Before the suspected high-wind dust event on May 28 and 29, 2022, the hourly $PM_{2.5}/PM_{10}$ ratios at all sites were slightly below the three-month hourly average based on 2018-2022 ratio data, but were variable (Figure 3.3-7). In the late afternoon and evening of May 28, the hourly $PM_{2.5}/PM_{10}$ ratio at the Green Valley, Jean, Jerome Mack, Paul Meyer, and Sunrise Acres sites fell to approximately 0.1 and remained low into the next day (May 29). The low $PM_{2.5}/PM_{10}$ ratio of 0.1, which is below the 5th percentile of data across 2018-2022, is consistent with values from dust events reported in prior studies (Jiang et al., 2018). The decrease in the $PM_{2.5}/PM_{10}$ ratios observed mid-to-late in the day on May 28 and in the morning on May 29 is consistent with the increase in hourly PM_{10} concentrations and wind speeds, as described in Section 3.2. $PM_{2.5}/PM_{10}$ ratios rose beginning on May 30 and continued to increase into the day. This precipitous drop in $PM_{2.5}/PM_{10}$ ratios is highly indicative of a windblown dust event because mechanically entrained and transported dust particles are most likely to be in the PM_{10} (coarse) mode rather than the $PM_{2.5}$ (fine) mode, causing the ratio of the two to drop.

Speciated $PM_{2.5}$ measurements were recorded at the Jerome Mack site on May 29, 2022; $PM_{2.5}$ measurements are collected on a three-day cadence in Clark County. Figure 3.3-8 shows the measurement of crustal elements of calcium, iron, and potassium, as well as calculated soil during the windblown dust event in comparison to the 90th percentile measurement calculated across seven years of data. On May 29th, the concentration of each examined parameter was well above the 90th percentile concentration. This evidence strongly supports the abundance of airborne, soil-based dust during the event period.

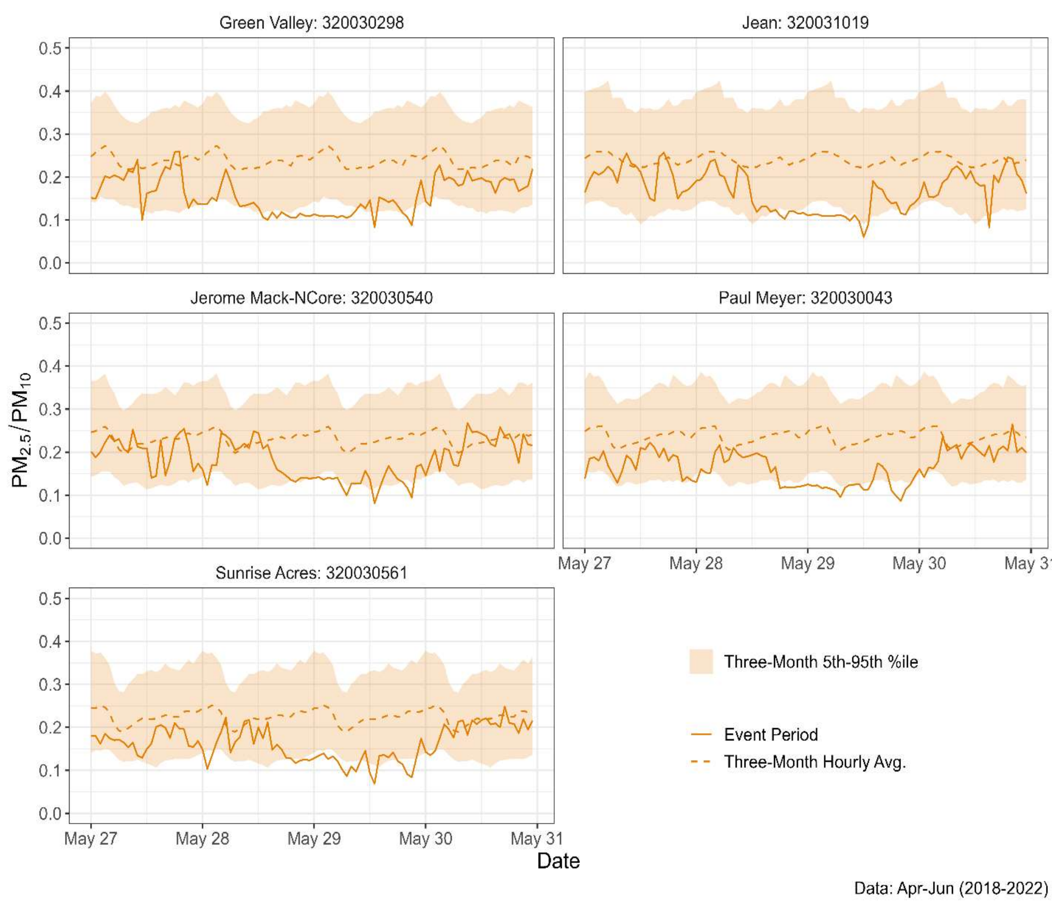

Figure 3.3-7. Ratio of $PM_{2.5}/PM_{10}$ concentrations before, during, and after the May 28 and 29, 2022, PM_{10} exceedance. The five-year average $PM_{2.5}/PM_{10}$ diurnal ratio is displayed as a dotted line, and the 5th to 95th percentile range is shown as a shaded ribbon. The hourly average and the 5th to 95th percentile ratio is calculated across April-June of 2018-2022.

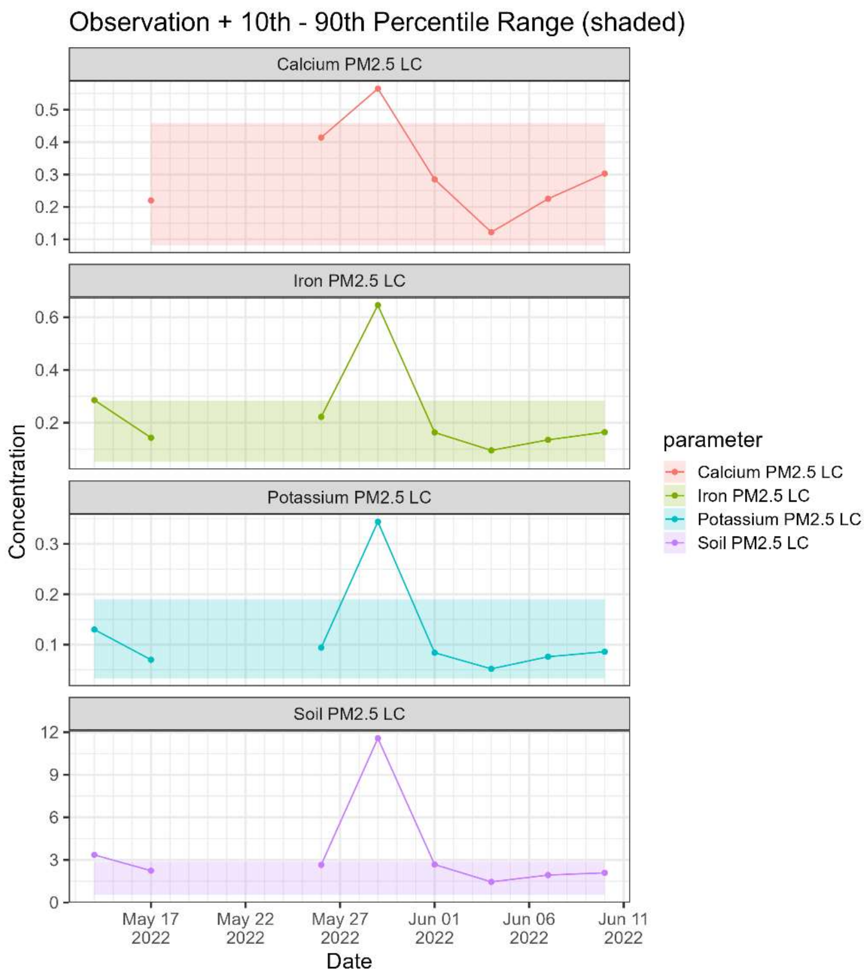

Figure 3.3-8. Speciated $PM_{2.5}$ measurements recorded at the Jerome Mack monitoring site. The shaded region shows the 10th to 90th percentile of measurements calculated over seven years (2016-2022).

3.3.5 Visibility/Ground-Based Images

Visibility data is available from LAS through the NWS Weather and Hazards Data Viewer. Figure 3.3-9 shows visibility observations for May 28 and May 29, 2022. Visibility rapidly declined from ten to four miles between 19:00 and 21:00 PST on May 28 and remained low through 09:00 PST on the morning of May 29. This drop in visibility is concurrent with the rise in PM_{10} concentrations at monitoring sites across Clark County, and indicative of airborne dust.

Because the windblown dust event occurred after sundown, camera images showing visibility conditions in the Las Vegas Valley are unavailable due to limitations of photography in low light.

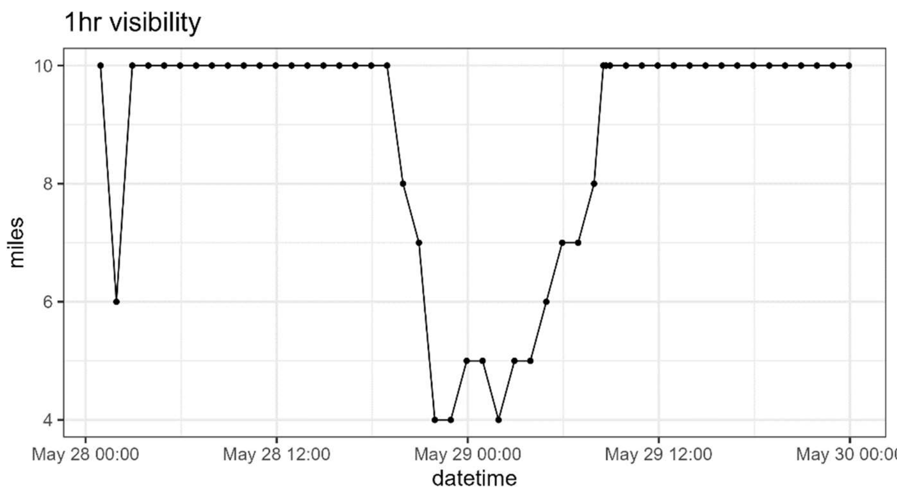

Figure 3.3-9. Visibility in miles on May 28-29, 2022, recorded at the Harry Reid International Airport (LAS). Visibility data is sourced from the Iowa Environmental Mesonet (https://mesonet.agron.iastate.edu/).

Overall, we find overwhelming evidence that PM_{10} was transported from the Mojave Desert in southeastern California to Clark County by approximately 16:00-18:00 PST on May 28, 2022. PM_{10} concentrations increase along with the frontal passage that entered the Clark County area at approximately 16:00 PST on May 28 and peaked at 20:00 PST on that day. This suggests that Clark County was impacted by a regional high-wind dust event originating in the Mojave Desert. The evidence corroborating this assertion includes (1) forecasted alerts and media coverage in Clark County and surrounding areas; (2) an abrupt, concurrent increase in PM_{10} concentrations at all monitoring sites in Clark County; (3) a drop in $PM_{2.5}/PM_{10}$ ratio values, indicating windblown dust sources; (4) an increase in crustal elements from speciated $PM_{2.5}$ measurements, indicating windblown dust as a major contributor; and, (5) decreased visibility at LAS corresponding with the PM_{10} event time of arrival on May 28 and lasting through the high PM_{10} concentrations on May 29.

3.4 Comparison of Exceptional Event with Historical Data

3.4.1 Percentile Ranking

Annual time series graphs of 24-hour average PM_{10} concentrations for each affected site are provided in Figure 3.4-1 through Figure 3.4-5. May 28 and 29, 2022, are marked by a red point for comparison to the 150 µg/m^3 NAAQS threshold (blue line) and the five-year (2018-2022) 99th percentile (green line), as described in Table 2.2-1 (note that for the Liberty High School and Walnut

Community Center sites, data are only available back to spring 2021). Although not regulatorily significant, data are included in the statistics from the Jean, Liberty High School, and Walnut Community Center monitoring sites in order to examine the regional effect of the high-wind dust event, and because they also had PM_{10} concentrations above the NAAQS. At most sites, observations of PM_{10} concentrations on May 28-29 were at or near the five-year 99th percentile, and observations at the Jean site were well above the five-year 99th percentile.

Five-year time series graphs of 24-hour average PM_{10} concentrations for each affected site are provided in Figure 3.4-6 through Figure 3.4-10 to further indicate the event day compared to the range of normal values. Other exceedances of the 150 µg/m^3 NAAQS threshold (blue dashed line) were further investigated for potential dust event evidence based on meteorological data and visibility camera images to compare to conditions on May 28-29, 2022. Days that showed preliminary evidence of being a high-wind dust event are also marked in the annual and five-year time series figures at all sites.

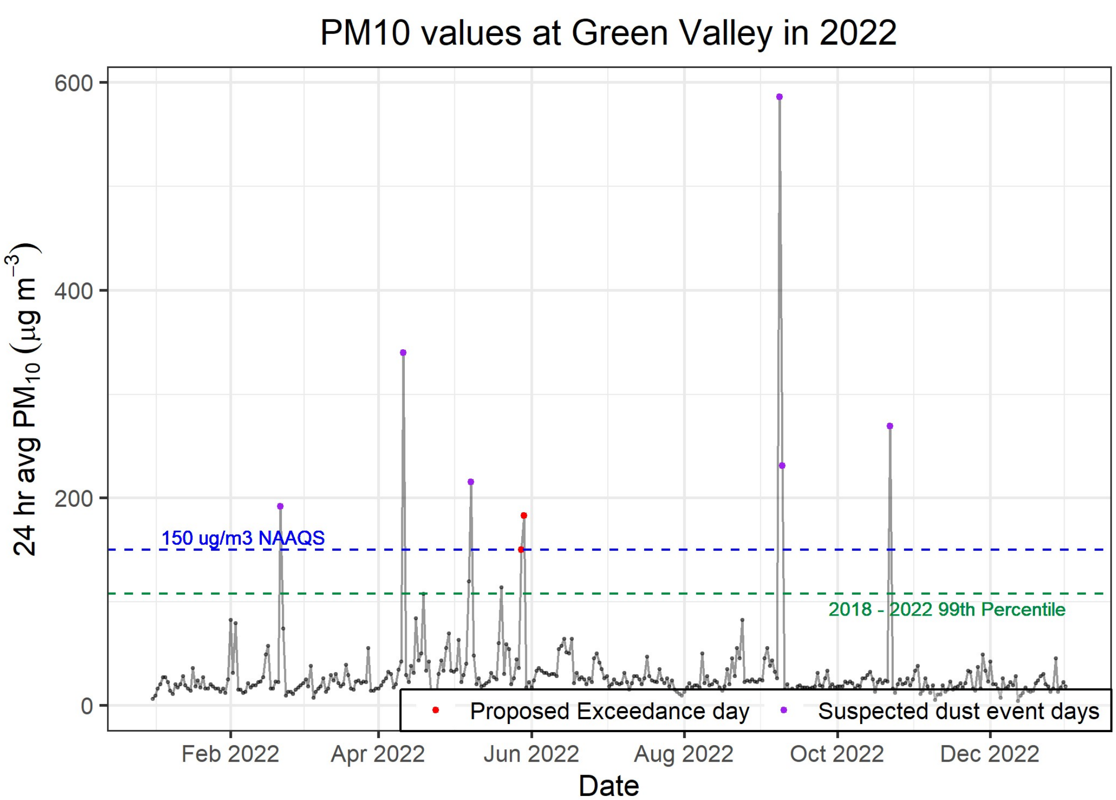

Figure 3.4-1. Green Valley monitoring site 24-hour PM_{10} measurements in µg/m^3 for 2022, showing (green dash) the five-year 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) the proposed exceedance day.

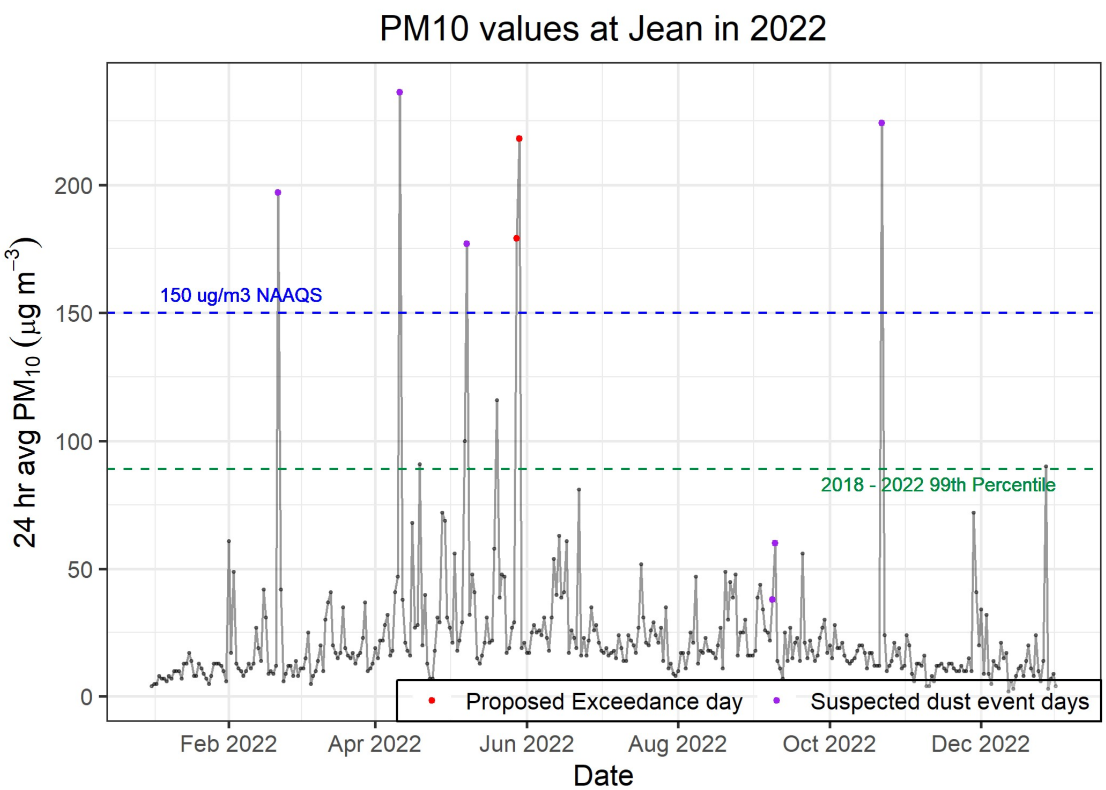

Figure 3.4-2. Jean monitoring site 24-hour PM_{10} measurements in µg/m^3 for 2022 showing (green dash) the five-year 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) the proposed exceedance day.

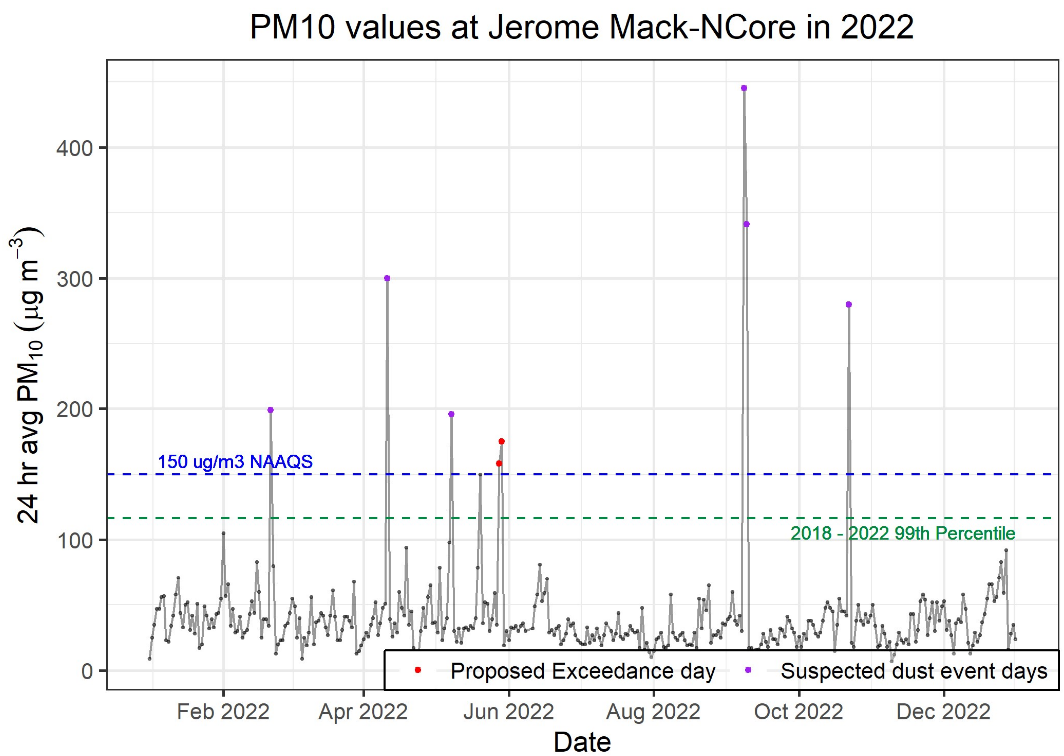

Figure 3.4-3. Jerome Mack monitoring site 24-hour PM_{10} measurements in µg/m^3 for 2022 showing (green dash) the five-year 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) the proposed exceedance day indicated.

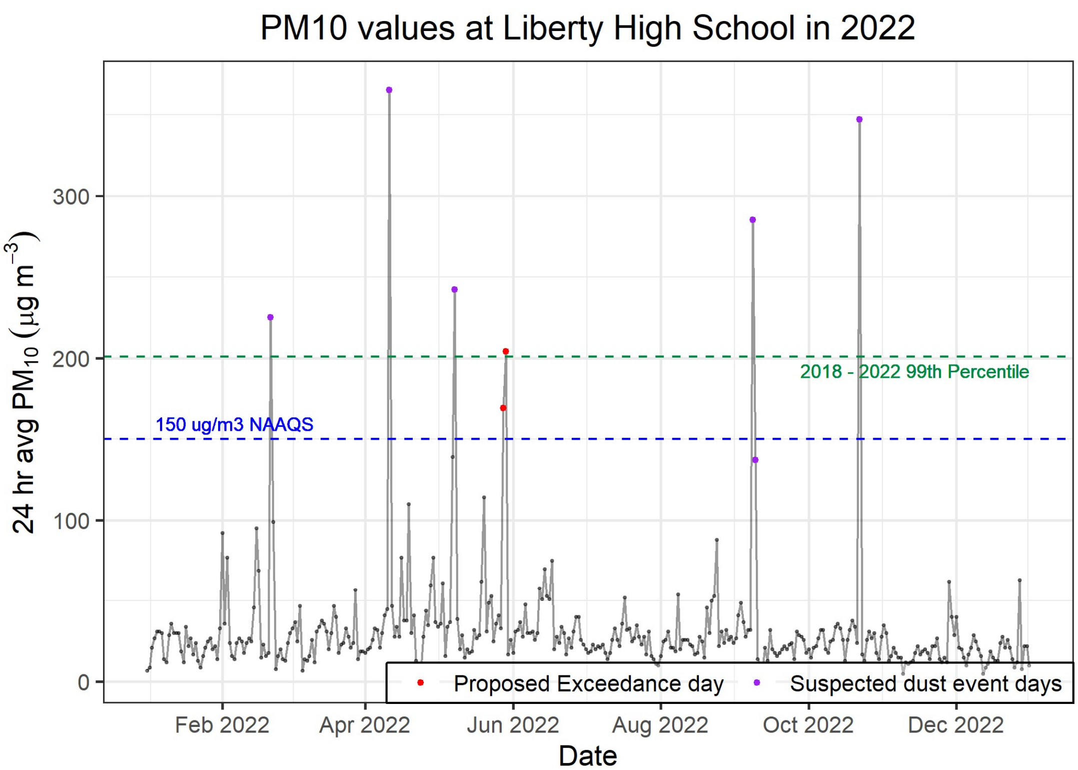

Figure 3.4-4. Liberty High School monitoring site 24-hour PM_{10} measurements in µg/m^3 for 2022 showing (green dash) the five-year 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) the proposed exceedance day. Note: earliest data available for Liberty High School is June 2021.

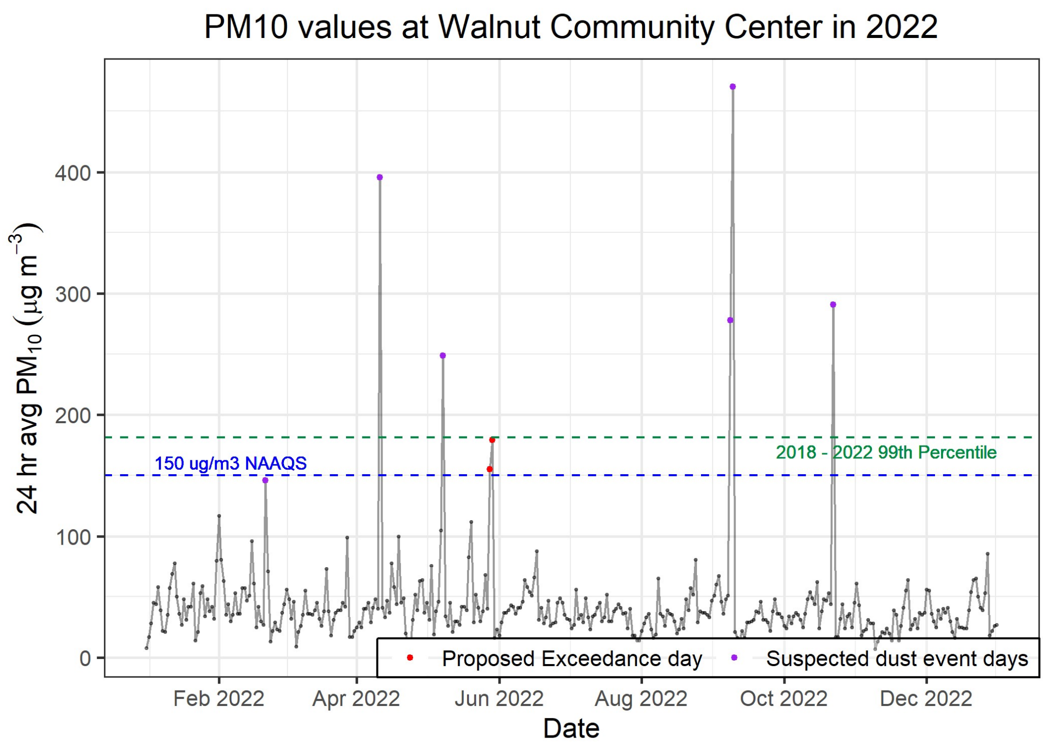

Figure 3.4-5. Walnut Community Center monitoring site 24-hour PM_{10} measurements in µg/m^3 for 2022 showing (green dash) the five-year* 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) the proposed exceedance day indicated. Note: earliest data available for Walnut Community Center is June 2021.

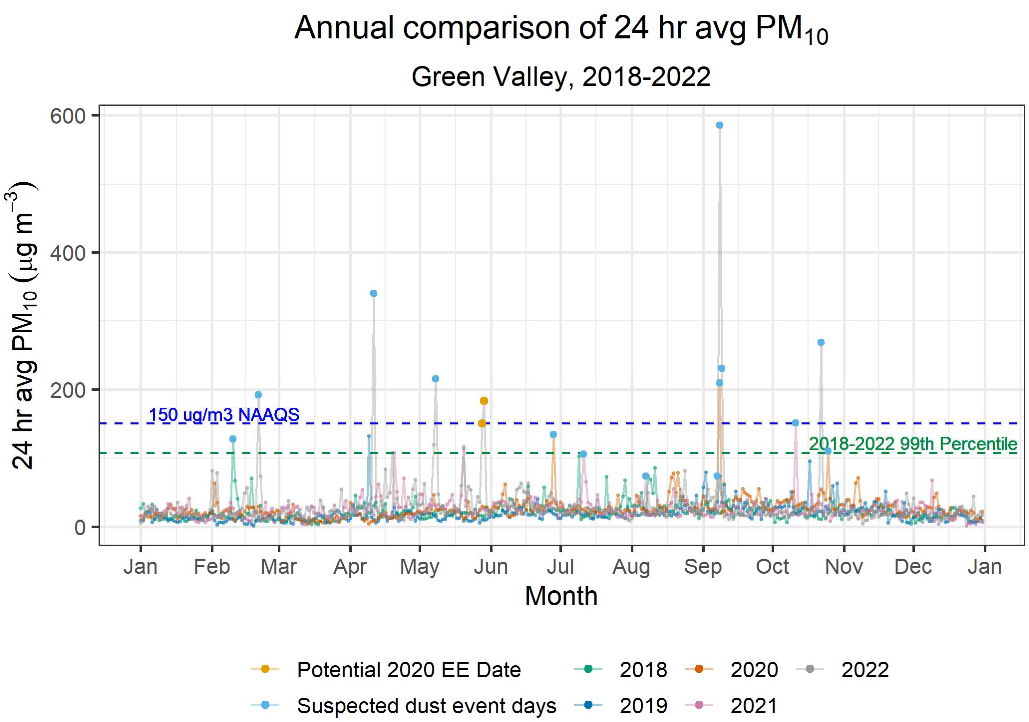

Figure 3.4-6. Green Valley monitoring site 24-hour PM_{10} measurements in µg/m^3 for the previous five years by year, with the 99th percentile (green dash) and NAAQS (blue dash) indicated.

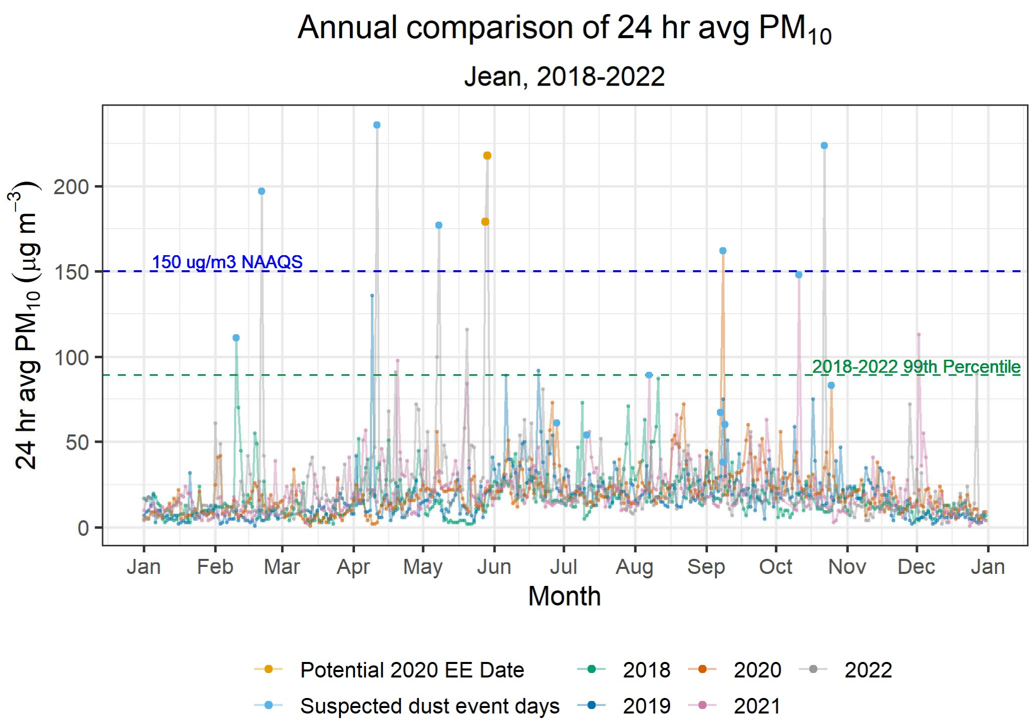

Figure 3.4-7. Jean monitoring site 24-hour PM_{10} measurements in µg/m^3 for the previous five years by year, with the 99th percentile (green dash) and NAAQS (blue dash) indicated.

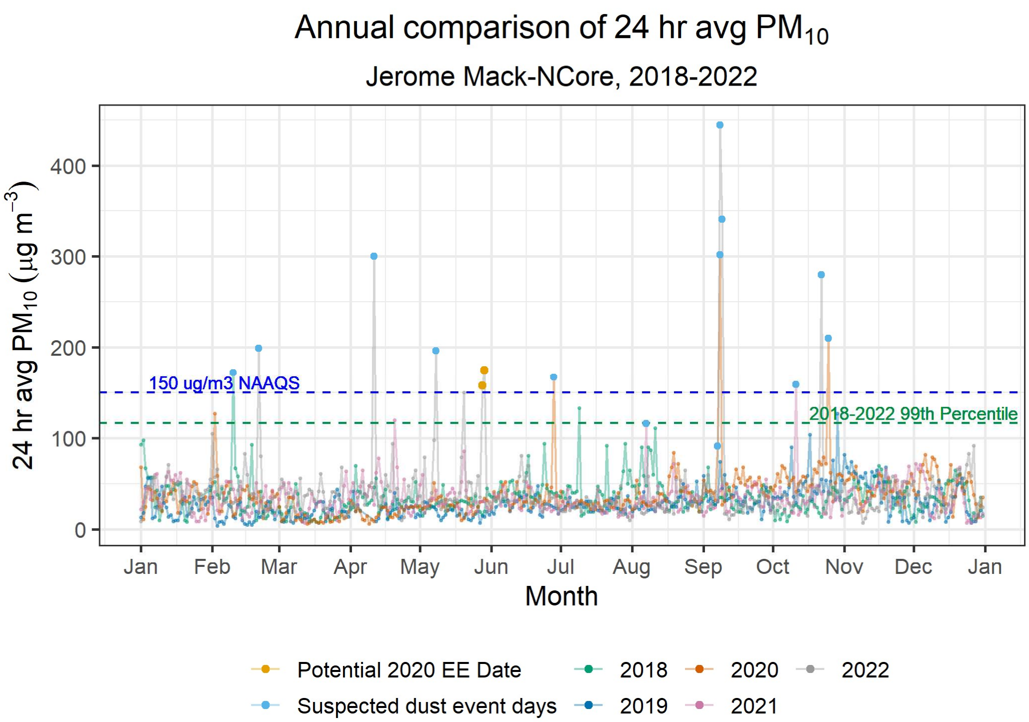

Figure 3.4-8. Jerome Mack monitoring site 24-hour PM_{10} measurements in μg/m^3 for the previous five years by year, with the 99th percentile (green dash) and NAAQS (blue dash) indicated.

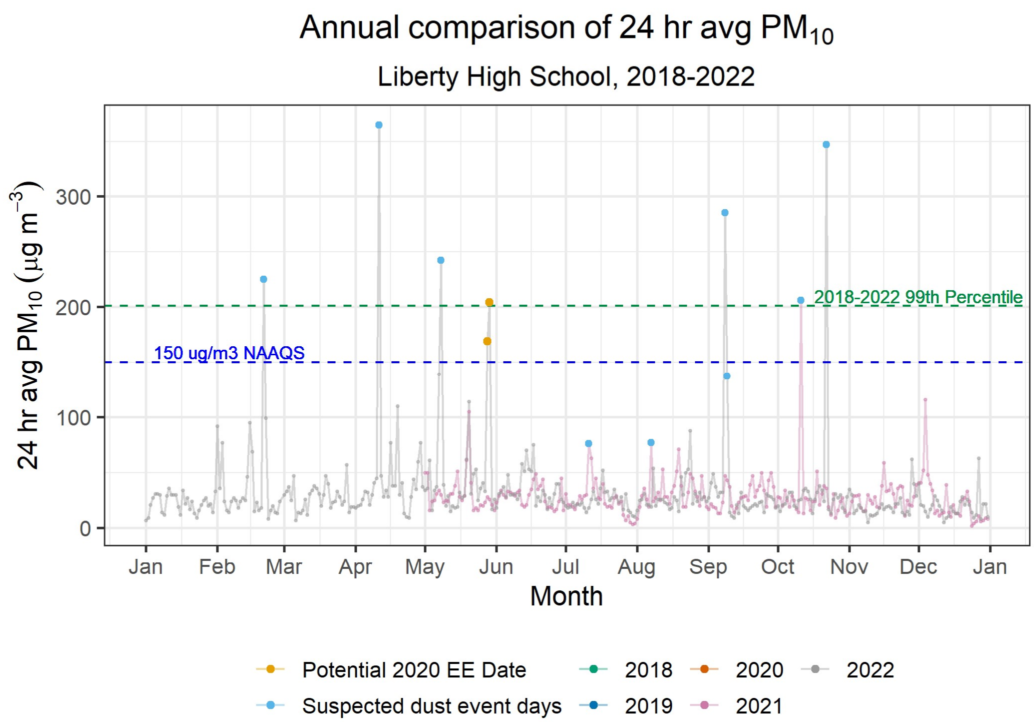

Figure 3.4-9. Liberty High School monitoring site 24-hour PM_{10} measurements in µg/m^3 for the previous five years by year, with the 99th percentile (green dash) and NAAQS (blue dash) indicated.

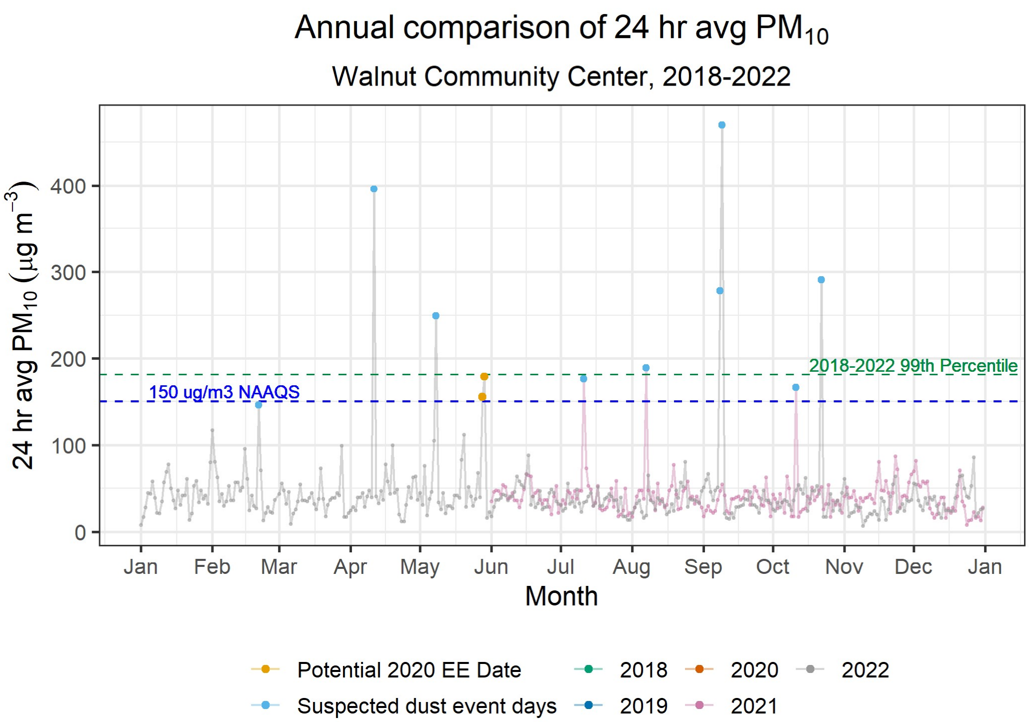

Figure 3.4-10. Walnut Community Center monitoring site 24-hour PM_{10} measurements in µg/m^3 for the previous five years by year, with the 99th percentile (green dash) and NAAQS (blue dash) indicated.

At all sites, the 24-hour average PM_{10} concentration observed on May 28 or 29, 2022, ranked within the top ten of all the concentrations observed in the five-year period from 2018-2022. Table 3.4-1 shows data from monitoring sites that exceeded the PM_{10} 24-hour NAAQS on May 28 and/or May 29, 2022 (Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley are regulatorily significant). The percentile ranks across the sites ranged from a low of 98.96% (7th highest value in the 4-year span) at the Walnut Community Center site (only limited data back to spring 2021 is available) to a high of 99.89% (third highest value in the 4-year span) at the Jean site.

Table 3.4-1. Five-year rank and percentile of PM_{10} values on May 28 and 29, 2022, at affected sites.

Date	Site	Rank	Percentile	24-hour PM_{10} ($\mu g/m^3$)
May 28, 2022				
5/28/2022	Green Valley	10	99.51	150
5/28/2022	Jean	5	99.78	179
5/28/2022	Jerome Mack	13	99.33	158
5/28/2022	Liberty High School*	8	98.85	169
5/28/2022	Walnut Community Center*	10	98.45	155
May 29, 2022				
5/29/2022	Green Valley	8	99.62	183
5/29/2022	Jean	3	99.89	218
5/29/2022	Jerome Mack	9	99.55	175
5/29/2022	Liberty High School*	7	99.02	204
5/29/2022	Walnut Community Center*	7	98.96	179

*Liberty High School and Walnut Community Center data collection began spring 2021.

3.4.2 Event Comparison with Diurnal/Seasonal Patterns

It is clear from the comparison of the hourly PM_{10} concentrations on May 28-29, 2022, to the typical range in the past five years that unusual factors were contributing to the exceedance event on that day. Maximum values observed compared to the five-year (2018-2022) 95th percentile ranged from an 8- to 16-fold increase and are summarized in Table 3.4-2. Data from monitoring sites that exceeded the PM_{10} 24-hour NAAQS on May 28 and/or May 29, 2022, are provided in Table 3.4-2 (Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley are regulatorily significant).

Table 3.4-2. Summary of how hourly PM_{10} values on May 28-29, 2022, at affected sites compared to five-year percentiles.

Site Name	Time of max hourly PM_{10} (PST)	Max Hourly PM_{10} (µg/m^3)	Five-year hourly PM_{10} 95th percentile (µg/m^3)	Ratio of hourly to Five-year 95th percentile
Green Valley	5/29/2022 01:00	692	43	16.0
Jerome Mack	5/28/2022 21:00	796	96	8.3
Liberty High School*	5/29/2022 00:00	811	60	13.6
Jean	5/28/2022 23:00	825	54	15.2
Walnut Community Center*	5/29/2022 01:00	758	70	10.8

*Liberty High School and Walnut Community Center data collection began spring 2021.

Figure 3.4-11 through Figure 3.4-15 show the hourly PM_{10} concentrations at the affected sites compared to the five-year (2018-2022) hourly average and 5th-95th percentile. The Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley sites experienced regulatorily significant exceedances, but Jean is also shown because it exceeded the NAAQS on May 28 and 29, 2022. At the Green Valley site, the hourly PM_{10} concentration surpassed the five-year 95th percentile on May 28 at 12:00 PST with a value of 89 µg/m^3. The event reached a maximum of 692 µg/m^3 on May 29 at 01:00 PST, 16 times the five-year 95th percentile value of 42.3 µg/m^3. At the Jerome Mack site, the event reached a maximum over a shorter period of time. Observations began exceeding the five-year 95th percentile on May 28 at 16:00 PST, with a value of 64 µg/m^3. By 21:00 PST, a maximum of 796 µg/m^3 was observed, more than 8 times the five-year 95th percentile of 96 µg/m^3. Similar trends were seen at the Liberty High School, Jean, and Walnut Community Center sites.

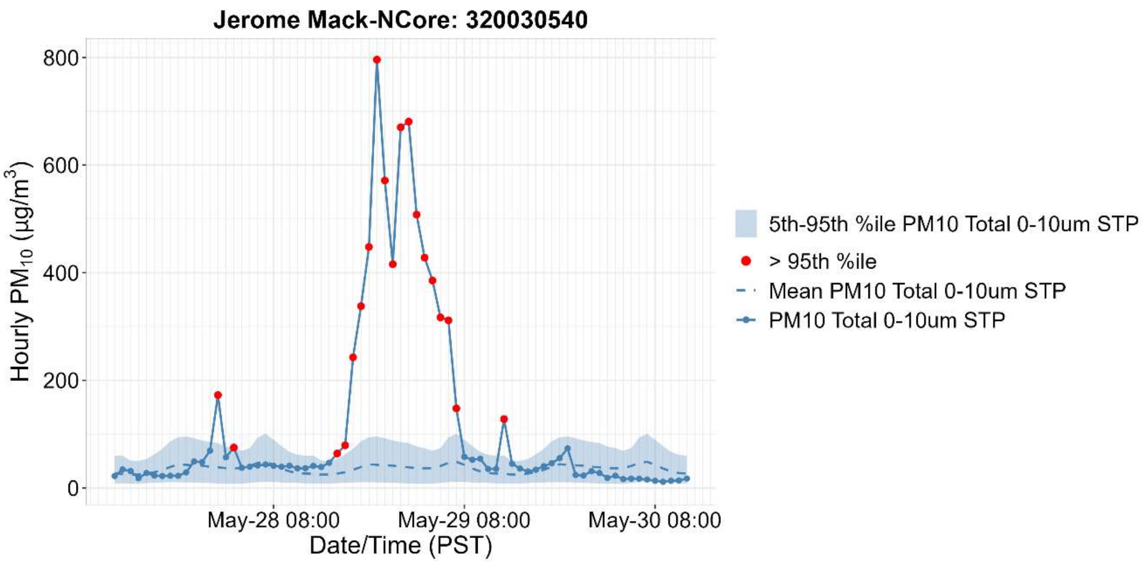

Figure 3.4-11. Measured hourly PM_{10} values at the Jerome Mack site for each hour across May 28-29, 2022. The dotted solid line represents the measured hourly PM_{10} values . The upper boundary of the blue area indicates the 95th percentile hourly PM_{10} concentration from 2018 to 2022 at the site, while the lower boundary indicates the 5th percentile. The dashed line represents the mean hourly PM_{10} concentration for each hour of the day from 2018-2022.

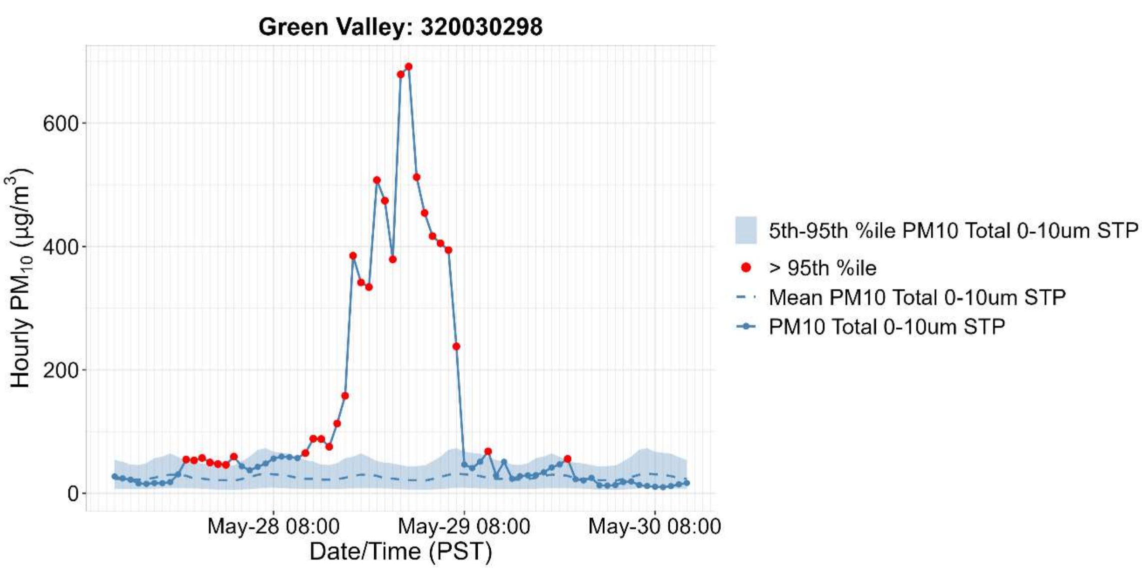

Figure 3.4-12. Measured hourly PM_{10} values at the Green Valley site for each hour across May 28-29, 2022. The dotted solid line represents the measured hourly PM_{10} values. The upper boundary of the blue area indicates the 95th percentile hourly PM_{10} concentration from 2018 to 2022 at the site, while the lower boundary indicates the 5th percentile. The dashed line represents the mean hourly PM_{10} for each hour of the day from 2018-2022.

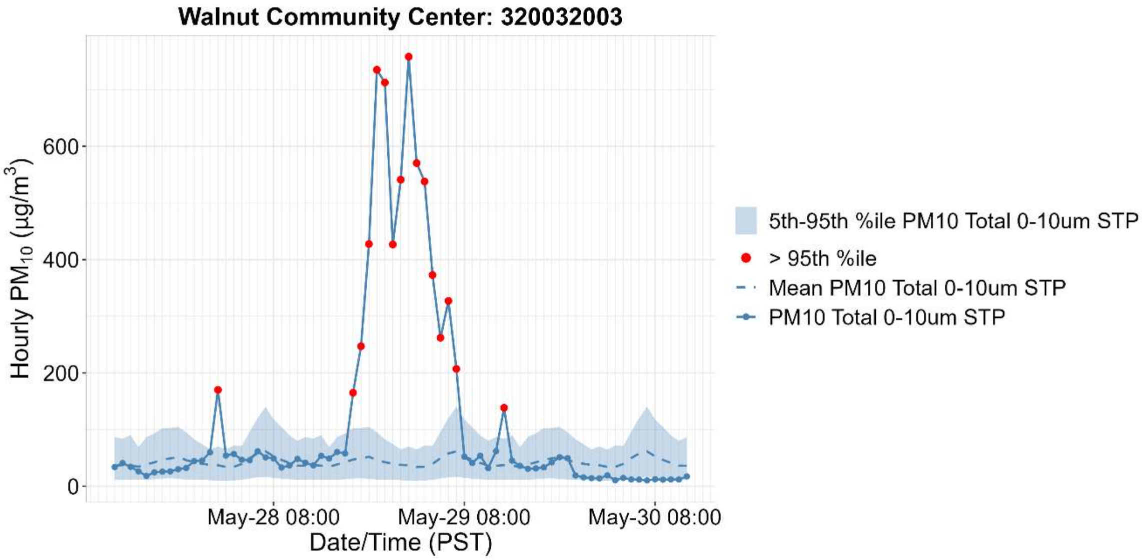

Figure 3.4-13. Measured hourly PM_{10} values at the Walnut Community Center site for each hour across May 28-29, 2022. The dotted solid line represents the measured hourly PM_{10} values. The upper boundary of the blue area indicates the 95th percentile hourly PM_{10} concentration from 2018 to 2022 at the site, while the lower boundary indicates the 5th percentile. The dashed line represents the mean hourly PM_{10} concentration for each hour of the day from 2018-2022.

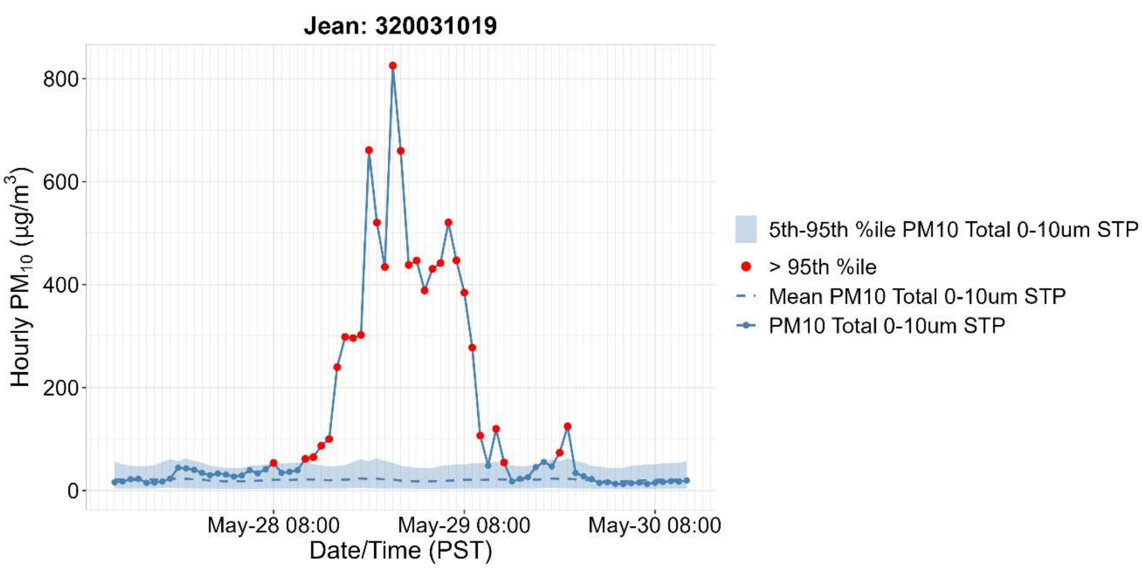

Figure 3.4-14. Measured hourly PM_{10} values at the Jean site for each hour across May 28-29, 2022. The dotted solid line represents the measured hourly PM_{10} values. The upper boundary of the blue area indicates the 95th percentile hourly PM_{10} concentration from 2018 to 2022 at the site, while the lower boundary indicates the 5th percentile. The dashed line represents the mean hourly PM_{10} concentration for each hour of the day from 2018-2022.

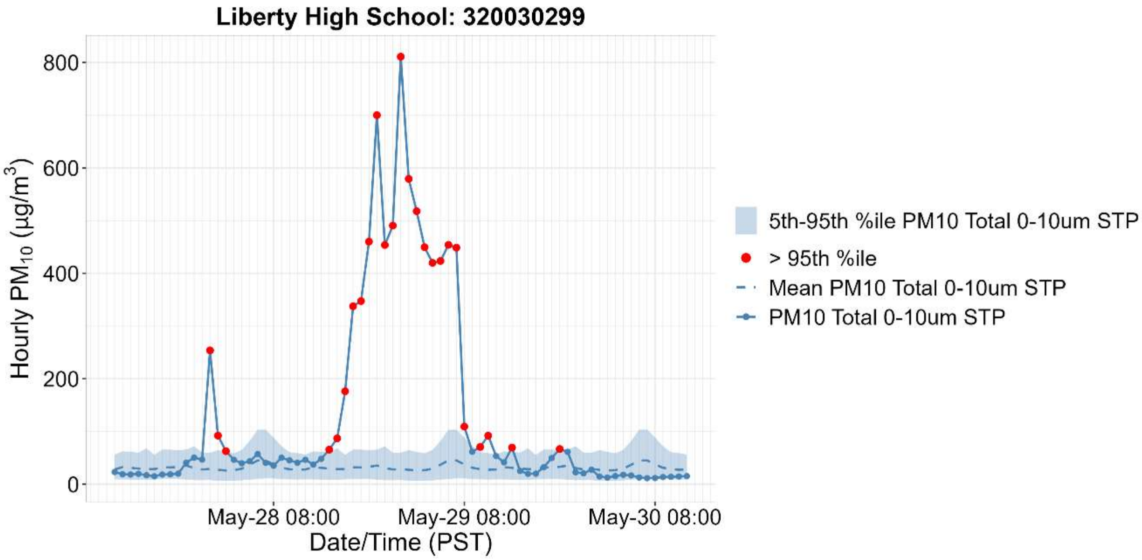

Figure 3.4-15. Measured hourly PM_{10} values at the Liberty High School site for each hour across May 28-29, 2022. The dotted solid line represents the measured hourly PM_{10} values. The upper boundary of the blue area indicates the 95th percentile hourly PM_{10} concentration from 2018 to 2022 at the site, while the lower boundary indicates the 5th percentile. The dashed line represents the mean hourly PM_{10} concentration for each hour of the day from 2018-2022.

The 24-hour average PM_{10} concentrations were compared to five-year (2018-2022) monthly and seasonal averages, as shown in the boxplots in Figure 3.4-16 through Figure 3.4-19. The Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley monitoring sites experienced regulatorily significant exceedances, but Jean is also shown because it exceeded the NAAQS on May 28 and 29, 2022. The lower and upper edges of the boxes correspond to the interquartile range (the 25th and 75th percentiles respectively), and the middle bar is the median value. The whiskers extend to the smallest and largest value within 1.5 times the interquartile range. Points beyond this range are considered outliers. The concentrations recorded on May 28 and 29, 2022, are shown to be some of the highest recorded outliers for May and Spring during the entire five-year period.

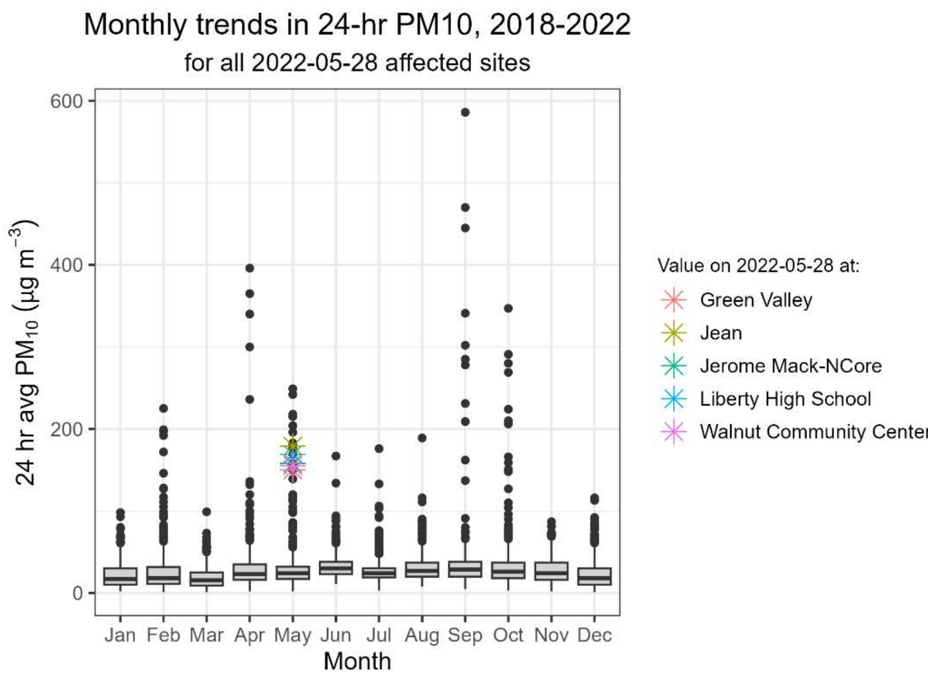

Figure 3.4-16. Monthly trend in 24-hour PM_{10} concentrations for 2018-2022 at the Green Valley, Jean, Jerome Mack, Liberty High School, and Walnut Community Center sites, including outliers and highlighting the May 28, 2022, exceptional event day.

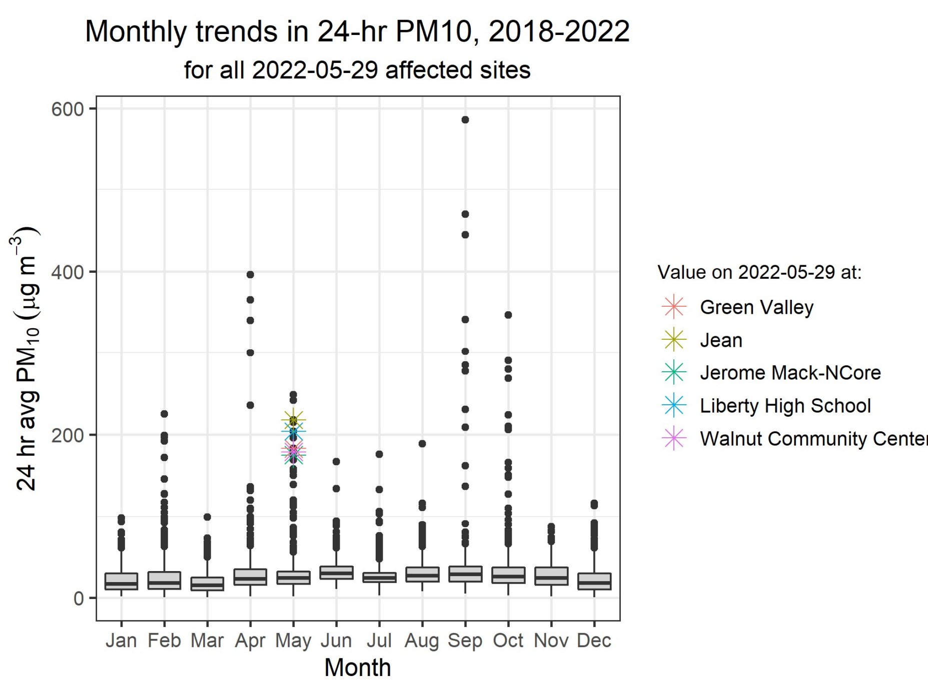

Figure 3.4-17. Monthly trend in 24-hour PM_{10} for 2018-2022 at the Green Valley, Jean, Jerome Mack, Liberty High School, and Walnut Community Center sites, including outliers and highlighting the May 29, 2022, exceptional event day.

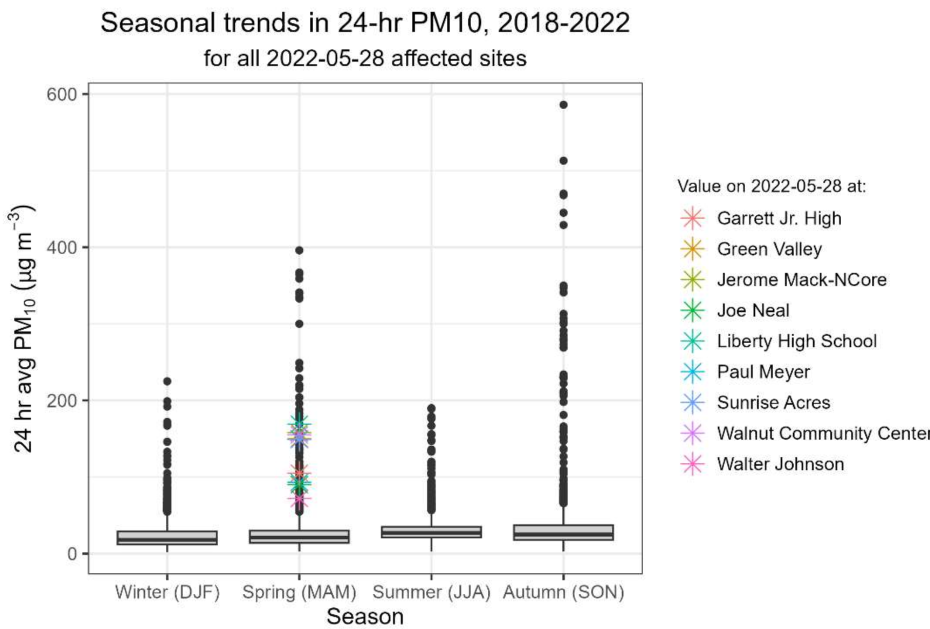

Figure 3.4-18. Seasonal trend in 24-hour PM_{10} for 2018-2022 at the Green Valley, Jean, Jerome Mack, Liberty High School, and Walnut Community Center sites, including outliers and highlighting the May 28, 2022, exceptional event day.

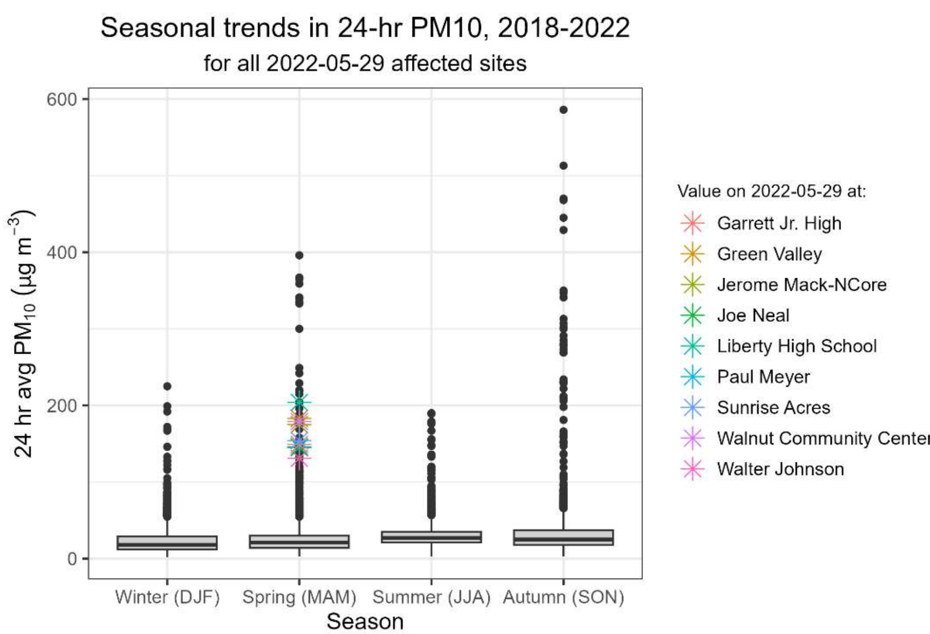

Figure 3.4-19. Seasonal trend in 24-hour PM_{10} for 2018-2022 at Green Valley, Jean, Jerome Mack, Liberty High School, and Walnut Community Center, including outliers and highlighting the May 29, 2022, exceptional event day.

3.4.3 Event Comparison with Climatology

Thirty-year seasonal climatology was created using European Environment Agency (ERA5) reanalysis at 0.25° x 0.25º horizontal resolution from 1993 through 2022 for both the Mojave Desert source region and Clark County. Temperature, volumetric soil moisture, and maximum winds speed were chosen and modeled as the most likely variables to influence a windblown dust event in both the source region and Clark County. **Figure 3.4-20** shows the climatology compared with the event date for the source region. This analysis shows the seasonal (March, April, and May) 30-year average for each variable in the top panel and the event date departure from the seasonal climatology in the bottom panel. On the event date, the source region experienced ground level temperatures at or greater than 15 °F above the long-term average, considerably lower-than-normal soil moisture, and maximum ground level wind speeds exceeding 5 m/s (11 mph) above average. **Figure 3.4-21** shows the climatology compared with the event date for Clark County. On the event date, Clark County experienced ground level temperatures greater than 15 °F above the long-term average and lower-than-normal soil moisture. Maximum ground level wind speeds southwest of Clark County (the Mojave Desert source region) are well above the typical climatological average. This climatological evidence provides proof that the conditions on the event date were abnormally hot, dry, and windy in both the source region and Clark County, leading to a windblown dust event.

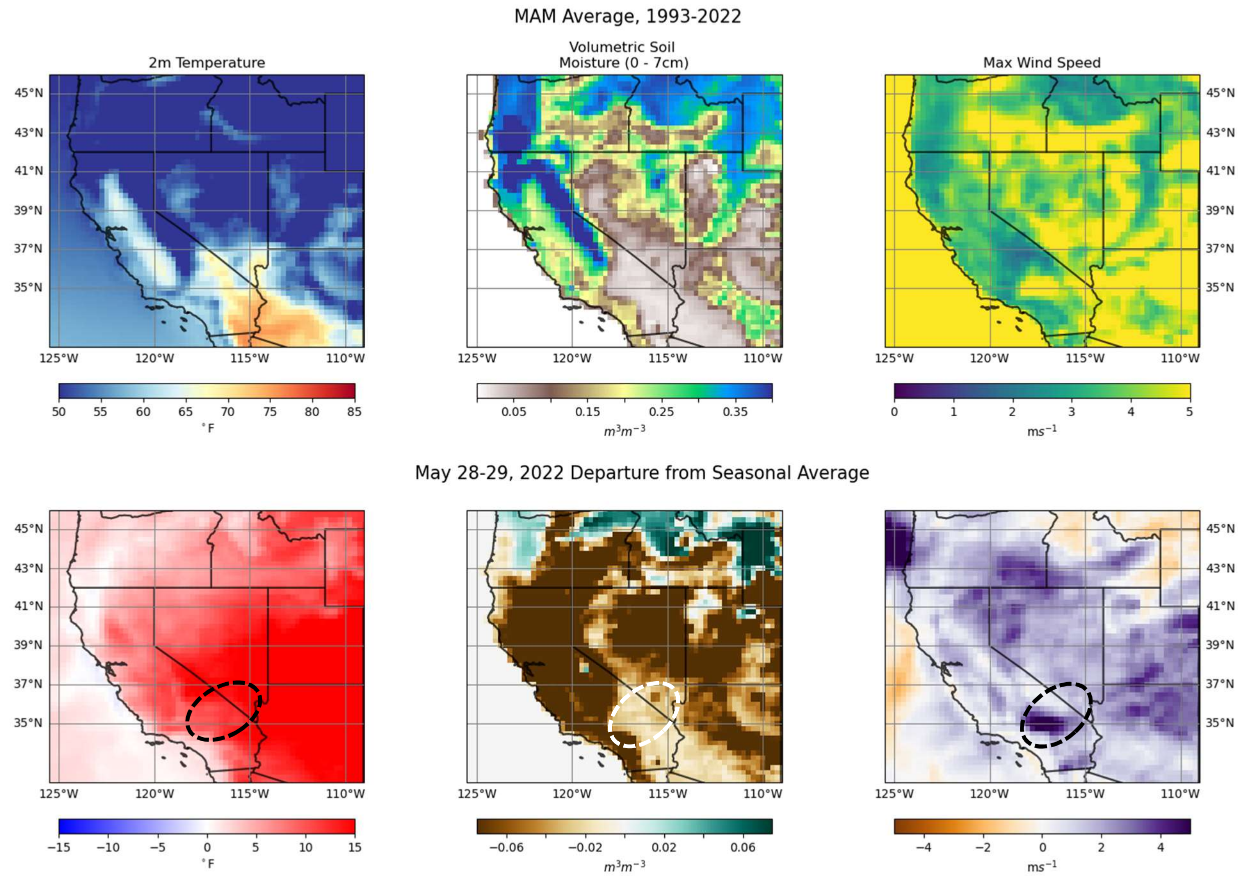

Figure 3.4-20. The 30-year March-May seasonal climatological averages for the Mojave Desert source region based on ERA5 reanalysis for (top row) 2-meter temperature, volumetric soil moisture of the first 7 centimeters, and maximum 10-meter wind speed, and (bottom row) the daily departure for these same variables on May 28-29, 2022, from the 30-year average. The source region is circled.

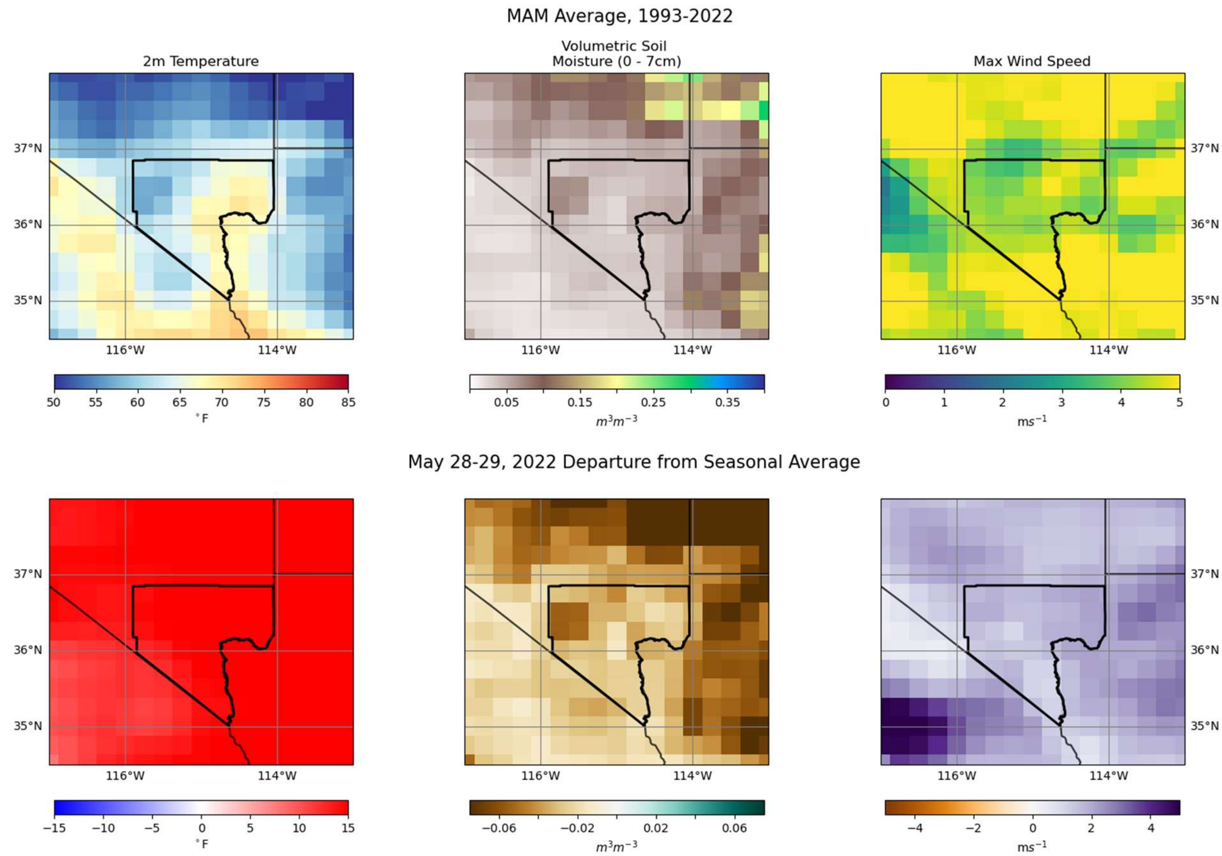

Figure 3.4-21. The 30-year March-May seasonal climatological averages for Clark County based on ERA5 reanalysis for (top row) 2-meter temperature, volumetric soil moisture of the first 7 centimeters, and maximum 10-meter wind speed, and (bottom row) the daily departure for these same variables on May 28-29, 2022, from the 30-year average. Clark County is outlined in black.

Overall, we find overwhelming evidence that Clark County was impacted by a high-wind dust event on May 28-29, 2022, and that PM_{10} concentrations caused by this event were well outside normal conditions. The evidence corroborating this assertion includes (1) the event rank was at or above the 99th percentile for both regulatorily significant sites and sites that exceeded the NAAQS; (2) the abrupt increase in PM_{10} concentrations was well outside the typical diurnal profile; (3) the PM_{10} 24-hour average event concentrations during the event were well outside typical monthly and seasonal norms; and (4) 30-year climatology shows higher temperatures, lower soil moisture, and higher winds on the event date in both the source region and Clark County compared with climatological averages.

3.5 Meteorological Similar Analysis

Enhanced surface-level wind speeds and frequent wind gusts on May 28-29, 2022, created prime conditions to maintain the suspension of dust particles in the air in the midst of a regional drought. The sustained hourly wind speeds were at or near 20 mph for most of the high-PM_{10} time period at LAS, and many wind gusts greater than 35 mph were recorded. The maximum gust for the event reached 38 mph in Clark County. During the event, winds were south-southwesterly out of the Mojave Desert. The timing of highest wind speeds and wind gusts aligns with the timing of enhanced PM_{10} concentrations. Visibility at LAS dropped to 4 miles late on May 28 and remained low through the early morning on May 29.

The following sections compare surface-level wind and visibility conditions on May 28-29, 2022, to dates that show (1) comparable wind profiles that did not show PM_{10} concentrations above the NAAQS, and (2) a PM_{10} concentration above the NAAQS, but a lack of high wind speeds. All PM_{10} concentrations in the subsequent two sections were recorded at the Jerome Mack site, and all wind speed, wind direction, and visibility values were measured at LAS and downloaded from the Iowa Environmental Mesonet (IEM) data portal (http://mesonet.agron.iastate.edu/).

3.5.1 Wind Event Days Without High Concentration

The comparison of the event date to specific non-event high-wind days without enhanced PM_{10} concentrations shows key differences between each comparable wind event and the event period of May 28-29, 2022. All dates in 2018-2022 were considered when identifying days with a wind event comparable to May 28-29. Any dates with wind gusts greater than 36 mph and a daily average wind speed above 14 mph were identified as comparable days. Additionally, dates were filtered to those without enhanced PM_{10} concentrations (less than 100 µg/m^3) in Clark County. Days associated with other suspected PM_{10} exceptional events were excluded. Many dates were identified as comparable wind events using this criteria, and the four comparable events close in time to the even period were examined in detail. These dates are listed in Table 3.5-1.

Table 3.5-1. Days with similar meteorological concentrations to the event period (May 28-29, 2022) without enhanced PM_{10} concentrations. These days were identified by average daily wind speeds above 11 mph and wind gusts above 36 mph.

Date	Daily Wind Speed (mph)	Peak Wind Gust (mph)	Daily PM_{10} ($\mu g/m^3$) per Monitoring Site: Jerome Mack	Jean	Green Valley	Walnut Rec. Center
2022-05-28/2022-05-29 (Event dates)	14/11	36/44	158/175	179/218	150/183	155/179
2022-03-20	16	62	41	19	29	38
2022-04-12	16	51	39	38	29	41
2022-05-10	11	41	22	48	20	26
2022-06-12	15	47	49	54	54	64

On each of the comparable events listed above, visibility remained high, mostly 9 miles or higher. In contrast, the event period saw a marked drop in visibility to 4 miles. Another key combination that distinguishes the event date from the identified comparable dates is notably higher wind speeds in the source region coupled with low-altitude transport of air across the source region towards Clark County. As detailed in Section 3.2.2, sustained wind speeds in the source region exceeded 50 mph preceding the event on May 28-29, 2022. Low-altitude transport of air into the region facilitated entrainment of dust from the source region along the course of travel. Comparable dates had either (1) lower sustained winds in the upwind region, or (2) higher-altitude transport towards Clark County, which hindered surface-level lofting of dust from bare-ground sources upwind of Las Vegas.

A specific comparison between the event date and the first comparable date listed in Table 3.5-1—March 20, 2022—is outlined below. Comparisons between the event date and the other comparable dates can be found in Appendix B.

Figure 3.5-1 through Figure 3.5-4 compare surface-level wind and visibility conditions on the May 28-29, 2022, event dates and March 20, 2022. Compared to the event period, the wind profile on March 20 experienced more intense winds, with wind gusts greater than 60 mph and a prolonged period where sustained winds were above 20 mph (Figure 3.5-1). Figure 3.5-2 shows the shift in winds from southerly to northerly during the May 28-29 event period, while the strongest winds on March 20 came steadily from the northwest. On March 20, visibility remained at the maximum value of 10 miles throughout the day, even during peak winds (Figure 3.5-3). The continued high visibility on March 20 confirms that the wind event did not dramatically affect levels of suspended dust particles. Daily PM_{10} concentrations were relatively low on March 20, less than 42 $\mu g/m^3$ across sites in Clark County.

The key difference between the May 28-29, 2022, event period and the comparable date of March 20, 2022, relates to air transport pathways. Figure 3.5-4 compares 24-hour HYSPLIT back-trajectories from Las Vegas ending at (1) the start of the May 28-29 event, at 03:00 UTC on May 29 (19:00 PST on May 28), and (2) 00:00 UTC on March 21, 2022 (16:00 PST on March 20), the time of maximum PM_{10} concentrations during this period. On the May 28-29 event dates, 50 m and 100 m transport paths over the source region travelled at low altitudes across the Mojave Desert, which facilitated entrainment and transport of dust from the source region towards Clark County. On March 22, 2022, air transport towards Las Vegas occurred at high altitudes mostly greater than 500 m, inhibiting surface-level lofting and transport of dust from sources surrounding Las Vegas. This lack of surface-level transport could explain the discrepancy between PM_{10} concentrations measured in Clark County on similarly windy days in the spring of 2022.

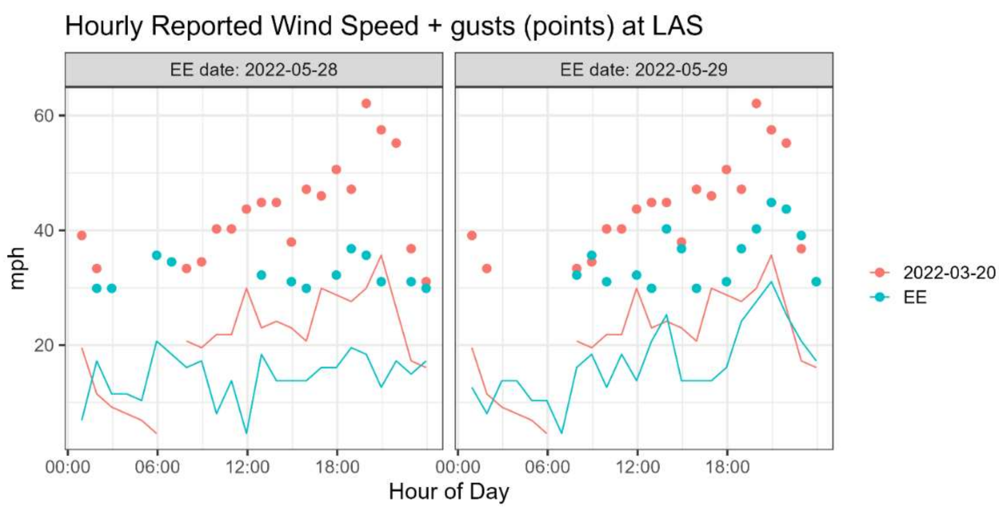

Figure 3.5-1. Wind speed and maximum hourly wind gust in mph at LAS for March 20, 2022 (pink), and the suspected exceptional event (EE) period (teal). May 28 is shown on the left, and May 29 is shown on the right.

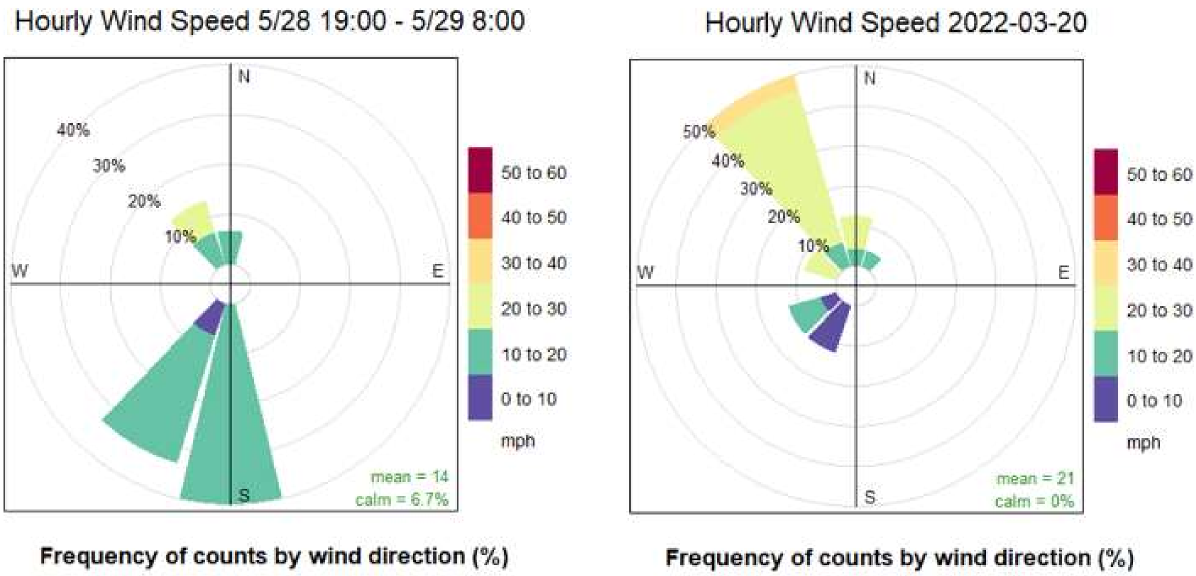

Figure 3.5-2. Hourly reported wind speed and direction frequency for (left) May 28-29, 2022, the suspected exceptional event day, and (right) March 20, 2022.

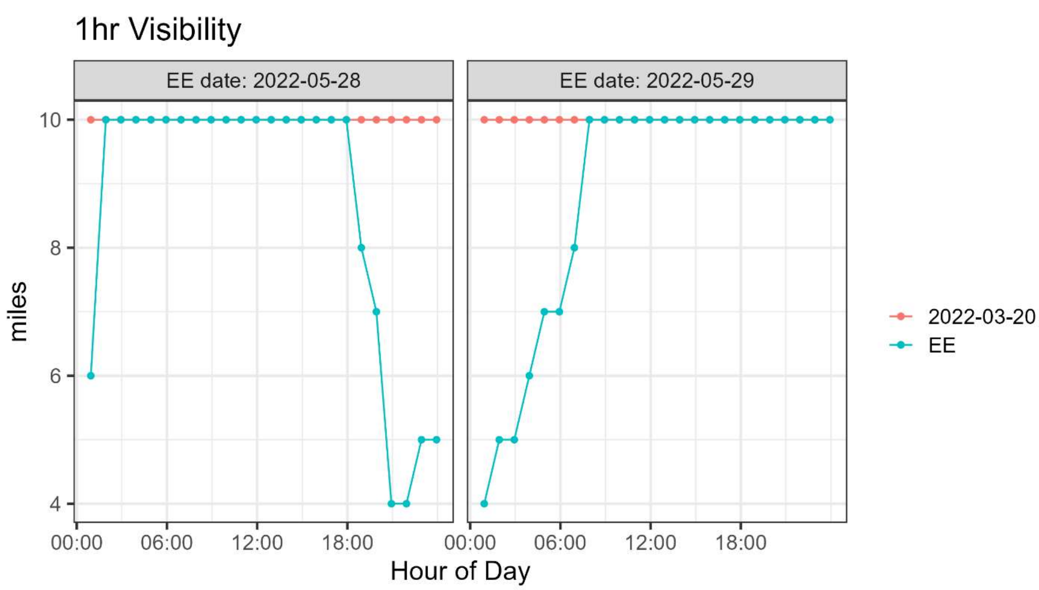

Figure 3.5-3. Hourly visibility in miles at LAS for March 20, 2022 (pink), and the May 28-29, 2022, suspected exceptional event (EE) period (teal). May 28 is shown on the left, and May 29 is shown on the right.

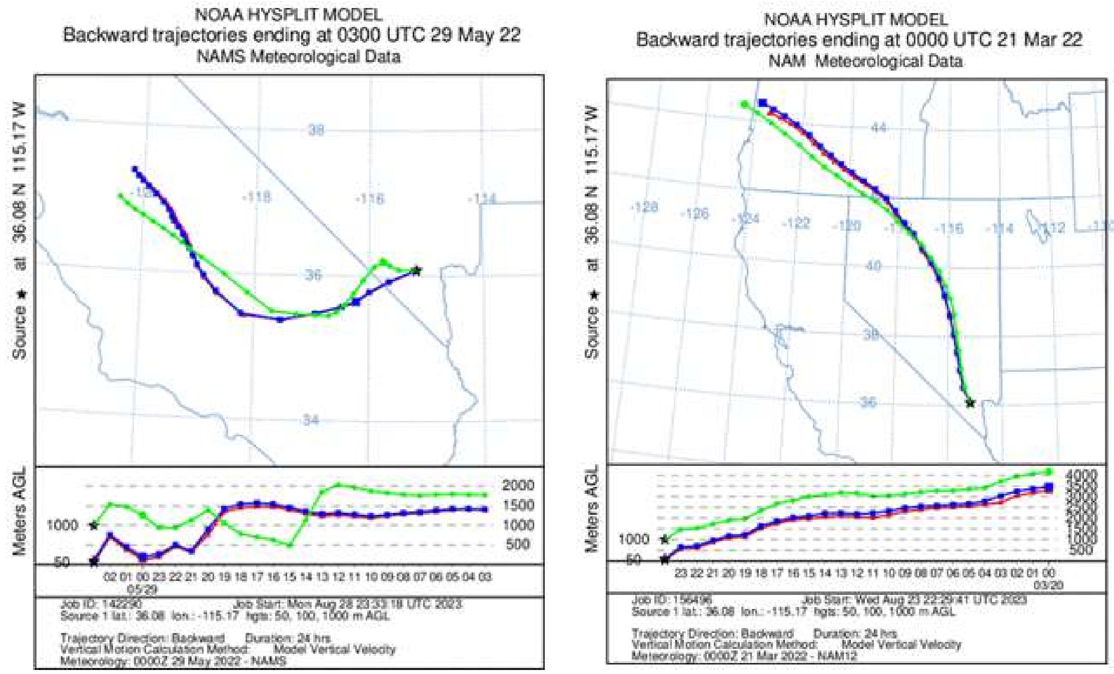

Figure 3.5-4. 24-hour HYSPLIT back-trajectories initiated from Las Vegas at (left) 03:00 UTC on May 29, 2022 (19:00 PST on May 28), and (right) 00:00 UTC on March 21, 2022, (16:00 PST on March 20) at 50 m (red), 100 m (blue) and 1,000 m (green).

3.5.2 High Concentration Days in the Same Season

Dates in the spring and early summer seasons of 2022—between March and July—were screened by daily PM_{10} concentrations to compare surface meteorological conditions against the conditions on the event date. The only other days when PM_{10} concentrations exceeded the NAAQS during this period were April 11 and May 8, which are also suspected high-wind dust events.

4. Not Reasonably Controllable or Preventable

4.1 Other Possible Sources of PM_{10} in Clark County

According to the EPA 2019 High Wind Dust Event Guidance document (and quoted Code of Federal Regulations [CFR] therein), agencies are required to (1) identify natural and anthropogenic sources of emissions contributing to the monitored exceedance, including contributions from local sources; (2) identify a relevant State Implementation Plan (SIP) for sources identified as natural and anthropogenic sources of emissions contributing to the monitored exceedance, including contributions from local sources and the implementation of these controls; and (3) provide evidence of effective implementation to satisfy the nRCP criterion.

Section 2.2.3 provides evidence for natural and anthropogenic sources near the Green Valley, Liberty High School, Jerome Mack, and Walnut Community Center monitoring sites of PM_{10} that could have contributed to the May 28-29, 2022, exceedance. As shown in Section 3.2, however, the main source of PM_{10} is the large bare ground/land area to the southwest of Clark County (identified in the rest of the document as the Mojave Desert source region), which is outside of the jurisdiction of Clark County and, therefore, not subject to control measures. Additional conclusions from this analysis indicate that anthropogenic point sources were unlikely to contribute to a PM_{10} exceedance event and BACM are in place to control fugitive sources such as construction emissions. According to the 2012 "Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})," the main sources of enhanced PM_{10} emissions in Clark County, Nevada, are (1) wind-blown dust, (2) re-entrained road dust, and (3) construction emissions. These nonpoint emission sources contribute approximately 98% of total annual PM_{10} emissions and are often amplified by dry arid conditions. Control measures have been implemented and enforced to mitigate emissions from the sources listed above within the jurisdiction of Clark County. Therefore, since natural bare ground was identified as the most likely source that contributed to the May 28-29, 2022, event (fulfilling nRCP part 1), in this section we focus on providing information on control measures used in Clark County to mitigate emissions from construction sites and possible dust sources in both the SIP (fulfilling nRCP part 2), and providing evidence of effective implementation (fulfilling nRCP part 3).

4.2 PM_{10} Control Measures in Clark County

For an air quality episode to qualify as a high-wind exceptional event, Clark County DES must show that all anthropogenic sources of PM_{10} are reasonably controlled (40 CFR 50.14(b)(5)(ii)). The Exceptional Event rule provides that enforceable control measures that EPA approved into the SIP within five years of the date of the event (40 CFR 50.14(b)(8)(v)) are presumptively reasonable. Controls adopted into the SIP more than five years before the event date may also be reasonable (81 FR 68238), and EPA will also consider other control measures not approved into the SIP if the air pollution control agency is implementing and enforcing the control measures (81 FR 68238-9).

Clark County DES operates one of the most robust fugitive emissions control programs in the country to reduce ambient air concentrations of PM_{10}. The 2001 PM_{10} SIP details emission sources and BACM that have been coded into the Clark County Air Quality Regulation (AQR). These include (1) stabilization of open areas and vacant lands (Section 90); (2) stabilization of unpaved roads and paving of unpaved roads when traffic volume is equal to or greater than 150 vehicles per day (Section 91); (3) stabilization of unpaved parking areas, including material handling and storage yards, and generally prohibiting the construction of new unpaved parking lots in the nonattainment area (Section 92); (4) requirements for paved roads, street sweeping equipment, and other dust-mitigating devices (Section 93); and (5) permitting and dust control requirements for construction activities (Section 94). These BACM are updated and continued in the most recent 2012 Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10}) (2012 Maintenance Plan) document for Clark County, Nevada, which was approved by EPA and extends through 2023. The 2012 updated SIP and AQR document are provided as evidence in **Appendix C**.

The 2012 Maintenance Plan also identified the Natural Events Action Plan for High-Wind Events: Clark County, Nevada (DES 2005) as a control measure. Since submission of the 2012 Maintenance Plan, DES replaced this action plan with the Clark County Mitigation Plan for Exceptional Events (DES 2018). DES developed this revised plan in response to EPA's 2016 EER (81 FR 68216) that required areas with historically documented or known seasonal exceptional events to develop mitigation plans (40 CFR 51.930(b)). EPA does not require this plan to be included in the SIP or be federally enforceable, but did review each plan to assure that the required elements were included. The revised plan includes practices from the first action plan:

- A high-wind event notification system that includes an early warning procedure.
- Education and outreach programs.
- Enhanced enforcement and compliance programs to reduce emissions.
- Submittal of required documentation to EPA in the event of an exceedance.

The new plan includes more sophisticated air quality advisories and alerts, and commits to maintaining an open line of communication with neighboring areas involved in high PM_{10} ambient air concentration events. The new plan also references the Clark County flood control system (Clark County 2018) and street sweeping schedule for Las Vegas Valley, Hydrological Area 212 (HA 212) referenced in Appendix J of the 2001 PM_{10} SIP (DES 2001). This system maintains a robust flood control system that minimizes silt deposition from flood waters onto roads, parking areas, and undeveloped land. The system undergoes continuous expansion to accommodate new development in the Las Vegas Valley, with the following recent plan changes:

- Duck Creek – Gilispie System: March 2023;
- Harry Reid Airport Peaking Basin Outfall and Van Buskirk System: Feb. 2022;
- Monson Channel-Jimmy Durant to Boulder Highway: Apr. 2022;
- Blue Diamond 02 Channel, Decatur-Le Baron to Richmar: July 2020;
- Gowan Outfall Facilities-Simmons to Clayton: May 2021;
- Pittman Wash-Interstate Channel: June 2020.[1]

The Nevada Department of Transportation, Clark County, the City of Las Vegas, the City of North Las Vegas, and the City of Henderson maintain policies requiring rapid removal of silt deposits from paved roads after storm events.

In addition to regulating direct releases of PM_{10} to the atmosphere, DES' control measures includes requirements to reduce precursors, including VOC, NO_x, and SO_x, which can react in the atmosphere to form PM_{10} emissions under certain meteorological conditions. The control measures also regulate mercury emissions. Mercury emissions are a source of PM pollution when emitted in a non-gaseous form or when adsorbed by PM to form particulate mercury. Thus, standards designed to control mercury emissions also reduce PM_{10} ambient air concentrations.

The following section explains the reasonable control measures that collectively assure that all local sources of anthropogenic sources impacting HA 212 were reasonably controlled before and after the event. The measures include controls that are presumptively reasonable because EPA approved the control measure into the SIP within five years of the event, along with other reasonable measures.

4.2.1 Presumptively Reasonable Controls

The following measures are reasonable because EPA approved the control measures into the SIP within five years of the event date:

Section 12.0-12.6 Permitting Programs – Sections 12.0 and 12.1 originally adopted November 3, 2009; last amended February 20, 2024, and awaiting SIP approval. Section 12.2 originally adopted May 18, 2010; last amended March 14, 2014, and SIP-approved October 17, 2014. Sections 12.3 and 12.4 originally adopted May 18, 2010; last amended July 20, 2021, and awaiting SIP-approval. Section 12.5 originally adopted May 18, 2010 and awaiting SIP-approval. Section 12.1 requires all minor stationary sources to obtain a permit to construct and operate if they have the potential to emit 5 tons per year (tpy) or more of a regulated pollutant, or if they are subject to another AQR, such as a control technique guideline (CTG) Reasonable Available Control Technologies (RACT) rule, that requires a minor source to obtain a permit. Some emissions units at these minor stationary sources must comply with RACT requirements when proposing an emissions increase that meet or

[1] The flood plan and updates are available at https://www.regionalflood.org/programs-services/document-library/master-plan-documents.

exceed the significance thresholds. Sections 12.2-12.5 requires all major stationary sources to obtain a permit to construct and operate. Some emissions units must comply with RACT requirements when they are the subject of an emissions increase in PM_{10} or its precursors that meets or exceeds the minor New Source Review (NSR) significance thresholds. In addition, these rules implement the federally mandated NSR Program for attainment, unclassifiable, and nonattainment areas. New major sources and existing major sources undertaking a modification that results in a significant increase in PM_{10} emissions or its precursors must install and operate Best Available Control Technology (BACT) or Lowest Achievable Control Technology (LAER).

Section 26 Emissions of Visible Air Contaminants – Amended April 26, 1983; last amended May 5, 2015; and SIP-approved June 16, 2017. This rule requires all sources to generally maintain an average opacity below 20%, with certain sources subject to a lower 10% average opacity standard.

Section 41 Fugitive Dust – Originally adopted June 25, 1992; last amended January 21, 2020; and SIP-approved May 19, 2022. This rule requires fugitive emissions abatement to prevent airborne PM emissions during construction and deconstruction activities, and during use of unpaved parking lots, agricultural operations, and raceways. The rule includes notice, registration, and permitting requirements.

Section 90 Fugitive Dust from Open Areas and Vacant Lots – Originally adopted June 22, 2000; last amended January 21, 2020; and SIP-approved May 19, 2022. This rule requires certain owners of land to take measures to prevent access of trespassers operating motor vehicles on the land. Owners must also create a stable surface area, including gravel installation that provides a 20% non-erodible cover. Landowners of large parcels must develop and submit a dust mitigation plan.

Section 93: Fugitive Dust from Paved Roads and Street Sweeping Equipment – Originally adopted June 22, 2000; last amended January 21, 2020; and SIP-approved May 19, 2022. This rule requires construction and reconstruction of roads in accordance with road shoulder widths and drivable median stabilization requirements. It also establishes an opacity standard for unpaved shoulders and medians, and for the use of road cleaning equipment. The rule requires road wetting when using rotary brushes and blowers to clean roads and allows only vacuum type crack cleaning seal equipment.

Section 94 Permitting and Dust Control for Construction and Temporary Commercial Activities – Adopted June 22, 2000; amended January 21, 2020; SIP-approved May 19, 2022; last amended August 3, 2021; and awaiting further revision before SIP approval. This rule applies to all construction and temporary commercial activities that disturb or have the potential to disturb soil. It requires a dust control permit and maintenance of a dust mitigation plan.

4.2.2 Other Reasonable Control Measures

The following identifies additional reasonable control measures that assure that all anthropogenic sources of PM_{10} emissions were controlled before and after the event. The controls fall into one of three categories: (1) EPA approved the control measures into the SIP more than five years before the event date; (2) the state submitted revisions that EPA has not yet approved into the SIP; or, (3) the Clean Air Act (CAA) and EPA do not require states to submit the type of control measure for SIP approval. As explained below, these control measures are reasonable because they meet or exceed CAA requirements, enhance enforcement efforts, and are equal or more stringent than control programs found in other state SIPs.

State Control Measures

Nevada Regional Haze State Implementation Plan – Originally adopted October 2009 and partially SIP approved March 26, 2012, and August 28, 2013, awaiting SIP approval. Prepared by the Nevada Division of Environmental Protection (NDEP) and codified by DES in AQR Section 12.14 on June 7, 2022. This plan requires reductions in visibility impairing pollutants, and thereby reduces the potential for PM_{10} formation. The plan specifically required Reid Gardner (a point source in Clark County) to meet PM control requirements by June 30, 2016, or to shutdown Units 1, 2, 3 by this date. The 2022 revised plan, which should become effective during the second maintenance period, requires the installation of low NO_x burners and selective non-catalytic reduction control equipment to reduce visibility impairing pollution on lime kilns operating in Clark County. This rule is reasonable because the controls imposed met the CAA's Best Available Retrofit Technology (BART) standard.

NAC 445B.737-774, Heavy-Duty Vehicle Program – adopted October 22, 1992; last amended October 18, 2002. The NDEP and Nevada Department of Motor Vehicles (DMV) jointly developed this rule to reduce motor vehicle related pollution by limiting excessive tailpipe or smokestack emissions from any gasoline or diesel-powered vehicle with a manufacturer's gross vehicle weight rating (GVWR) of 14,001 lbs. or more. Enforcement inspectors pull over heavy-duty vehicles for random roadside testing to determine if the exhaust from their vehicle exceeds state opacity standards. Violators must repair and retest the vehicle within 30 days. Fleets may also request opacity testing in their fleet yard. Fleet managers voluntarily repair and re-test vehicles failing the inspection. This regulation is reasonable because it exceeds EPA's inspection and maintenance program requirements, and actively prevents smoking vehicles from operating on roads.

NAC 445B.400-735, Inspection and Maintenance Program – adopted September 28, 1988; subsequently amended and SIP-approved July 3, 2008; last amended October 18, 2022. The NDEP and the Nevada DMV jointly developed this rule, administered by the DMV, to control vehicle emissions. The rule reduces motor vehicle-related NO_x and VOC emissions through the vehicle inspection and emissions-related repairs. Clark County requires annual emissions testing before renewing a vehicle's registration. All gasoline-powered vehicles must be tested, with limited exceptions, as well as diesel-powered vehicles weighing up to 14,000 lbs. gross vehicle weight rating (GVWR). EPA approved the inspection and maintenance program as part of the Carbon Monoxide State Implementation Plan: Las Vegas Valley Nonattainment Area, Clark County, Nevada (CO SIP[2]), in September 2004 (69 FR 56351). This inspection and maintenance program is reasonable because it (1) exceeds EPA's requirements for a basic inspection and maintenance program, and (2) follows a standard that qualifies as a low-enhanced performance standard.

NAC 445B.3611-3689 Nevada Mercury Control Program – Originally adopted May 4, 2006; last revised November 2, 2016. Mercury emissions can also be a source of PM pollution when emitted as in non-gaseous form a particulate or when adsorbed by PM to form particulate mercury. Thus, standards designed to control mercury emissions also reduce PM_{10} ambient air concentrations. The rule requires particulate emissions control technologies to reduce mercury emissions from thermal units located in precious metal mines. The CAA does not require states to submit hazardous air pollutant control measures for SIP approval. These measures are reasonable because they reduce the ambient air concentration of PM_{10} by requiring use of the Maximum Achievable Control Technology (MACT) and apply in addition to the federal standards at 40 CFR Part 63, Subpart E.

County Air Quality Regulations

Section 14 New Source Performance Standards (NSPS) - Originally adopted September 3, 1981; last amended March 15, 2022. Regulations in this section are reasonable because they implement EPA's federal PM and total suspended particulate (TSP) emissions limitations in 40 CFR Part 60 "New Source Performance Standards" (NSPS) that apply to a variety of stationary sources. EPA has delegated implementation and enforcement of the federal standards to DES. The CAA does not require states to submit NSPS control measures for SIP approval.

Section 13 National Emissions Standards for Hazardous Air Pollutants (HAP) – Originally adopted September 3, 1981; last amended March 15, 2022. Regulations in this section are reasonable because they implement federal HAP emissions limitations in 40 CFR Part 63 that apply to a variety of stationary sources that emit particulate emissions in the form of metal HAP. These standards are based on Maximum Achievable Control Technology. EPA has delegated implementation and enforcement of the standards to DES. The CAA does not require states to submit HAP control measures for SIP approval.

Section 27 Particulate Matter from Process Weight Rate – Originally adopted September 3, 1981 (SIP approved June 18, 1982); last amended July 1, 2004. Establishes process weight restrictions for PM emissions for all operations. This regulation is reasonable because it establishes maximum rates for PM emissions from stationary sources that are more stringent than any specific CAA or SIP

[2] https://webfiles.clarkcountynv.gov//Environmental%20Sustainability/SIP%20Related%20Documents/Carbon_Monoxide_State_Implementation_Plan_Revision-without_Appendices.pdf

requirement, and comparable to limits found in other state SIPs. Compare the rule, for example, to Chapter 1200-3-7 "Process Emission Standards" in the Tennessee SIP.[3]

Section 28 Fuel Burning Equipment – Originally adopted December 28, 1978; SIP-approved August 27, 1981; last amended July 1, 2004. This rule applies to fuel burned for the primary purpose of producing heat or power by indirect heat transfer. It regulates the burning of coke, coal, lignite, coke breeze, fuel oil, and wood, but not refuse. The regulation targets reductions in PM_{10} emissions, but by promoting good combustion practices, the rule also produces NO_x and VOC emissions reduction co-benefits that further reduce the potential for PM_{10} formation. The rule establishes PM emissions rates based on heat input. This regulation is reasonable because it establishes maximum rates for PM emissions from stationary sources that are more stringent than any specific CAA or SIP requirement and emissions limitations found in other states. Compare the rule, for example, to Chapter 13 "Emission Standards for Particulate Matter" in the Louisianna SIP.[4]

Section 42 Open Burning – Originally adopted December 28, 1978; SIP-approved August 27, 1981; last amended July 1, 2004. This rule requires preauthorization to burn any combustible material and prohibits open burning during air pollution episodes, which is consistent with the Nevada Emergency Episode Plan. This regulation is reasonable because it allows the Control Officer to assess and prevent any burning that could lead to a PM_{10} NAAQS exceedance. The rule also is comparable to similar control measures found in other SIPs. See, for example, South Coast Air Quality Management District's Rule 444[5].

Section 91 Fugitive Dust from Unpaved Roads, Unpaved Alleys, and Unpaved Easement Roads – Originally adopted June 22, 2000; last amended April 15, 2014; and SIP-approved October 6, 2014. This rule applies to unpaved roads, including unpaved alleys, unpaved road easements, and unpaved access roads for utilities and railroads. It requires PM emissions control measures including paving or application of dust palliatives. This regulation is reasonable because it targets and reduces emissions of event-related fugitive dust emissions using state-of-the-art emissions controls, which are more stringent than the best practices recommended by EPA. See "Fugitive Dust Control Measures and Best Practices," EPA, January 2022[6].

Section 92 Fugitive Dust from Unpaved Parking Lots and Storage Areas – Originally adopted June 22, 2000; amended April 15, 2014; SIP-approved October 6, 2014; last amended August 3, 2021. This rule applies to lot and storage areas greater than 5,000 ft^2. The rule generally requires owners of a lot or storage area to pave the area or cover it in two inches of gravel. It also prohibits visible dust plumes from crossing the property boundary. This regulation is reasonable because it targets and reduces emissions of event-related fugitive dust emissions using state-of-the-art emissions controls, which are more stringent than the best practices recommended by EPA. See "Fugitive Dust Control

[3] https://www.epa.gov/system/files/documents/2021-12/chapter-1200-3-7.pdf
[4] https://www.epa.gov/air-quality-implementation-plans/louisiana-lac-33iii-ch-13-section-1301-emission-standards
[5] https://ww2.arb.ca.gov/sites/default/files/2021-06/SouthCoastSMP.pdf
[6] https://www.epa.gov/system/files/documents/2022-02/fugitive-dust-control-best-practices.pdf

Measures and Best Practices," EPA, January 2022. The rule also regulates sources not typically regulated in other state SIPs.

Section 94 Permitting and Dust Control for Construction and Temporary Commercial Activities – Adopted June 22, 2000; amended January 21, 2020; SIP-approved May 19, 2022; last amended August 3, 2021. This rule applies to all construction and temporary commercial activities that disturb or have the potential to disturb soil. It requires a dust control permit and maintenance of a dust mitigation plan. This regulation is reasonable because it targets and reduces emissions of event-related fugitive dust emissions using state-of-the-art emissions controls, which are more stringent than the best practices recommended by EPA. See "Fugitive Dust Control Measures and Best Practices," EPA, Jan. 2022. The rule also regulates sources not typically regulated in other state SIPs.

Transportation Conformity – Clark County works closely with the Regional Transportation Commission of Southern Nevada (RTC) to assure that regional transportation plans and transportation improvement programs in HA 212 are consistent with and conform to Clark County's air quality program requirements, including the PM_{10} SIP and corresponding motor vehicle emissions budget (MVEB).

In this section (and in Appendix C), we have provided information on adopted presumptively and other reasonable control measures used in Clark County to mitigate emissions from construction sites and other possible dust sources, fulfilling part 2 of the nRCP criterion.

4.3 Reasonableness of Control Measures

Table 2 in the 2019 High-wind Dust Exceptional Event Guidance document provides example factors that an air agency and EPA may consider when assessing the reasonableness of controls as part of the nRCP criterion. This table details example factors, such as (1) control requirements based on area's attainment status, (2) the frequency and severity of past exceedances, (3) the use of widespread measures, and (4) jurisdiction. In this section, we address all the possible factors that evaluate the reasonableness of controls.

4.3.1 Historical Attainment Status

The 2012 Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10}) document for Clark County, Nevada, provides a comprehensive historical analysis of the Clark County nonattainment area. Briefly, after the passage of the 1990 Clean Air Act Amendments, EPA designated all areas previously classified as Group I areas as "moderate" nonattainment areas, including HA 212 (CAA §107(d)(4)(B)). EPA required these moderate nonattainment areas to submit a SIP by November 1991 that would demonstrate attainment of the PM_{10} NAAQS by December 1994. Because of unprecedented regional growth, high-wind events, and other factors, Clark County could not demonstrate attainment by the required date, and EPA reclassified HA 212 as a "serious" nonattainment area on January 8, 1993 (58 FR 3334). In 1997, a PM_{10} SIP revision was submitted. In December 2000, the Clark County Board of County Commissioners (BCC) requested that the state formally withdraw all previously submitted SIPs and addenda because none demonstrated attainment of the NAAQS.

After completing comprehensive research and work programs to address the problems identified in the 1997 PM_{10} SIP revision, Clark County submitted a new SIP to EPA in June 2001 that met federal requirements for remediating serious PM_{10} nonattainment areas. This new SIP demonstrated that the adoption and implementation of BACM for fugitive sources and continuation of controls for stationary sources would result in attainment of the annual average PM_{10} NAAQS by 2001, and attainment of the 24-hour NAAQS by December 31, 2006. Although the CAA required the SIP demonstrate attainment of the PM_{10} NAAQS no later than December 31, 2001, EPA granted Clark County a five-year extension for the 24-hour NAAQS attainment date. Clark County supported its extension request with a "Most Stringent Measure" control analysis that showed the emission control programs proposed for the valley were at least as stringent, if not more so, than control programs implemented in other nonattainment areas.

In June 2004, EPA published final approval of the Clark County PM_{10} SIP (69 FR 32273). In June 2007, Clark County submitted a milestone achievement report that described the county's progress in implementing the SIP. In August 2010, EPA determined HA 212 had attained the PM_{10} NAAQS (75 FR 45485).

In August 2012, the Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10}) (i.e., 2012 Maintenance Plan) was formally approved, and EPA redesignated the Clark County PM_{10} nonattainment area to attainment for the 1987 24-hour NAAQS. To achieve attainment of the 1987 24-hour PM_{10} NAAQS, Clark County DES implemented emissions control measures that lead to a permanent and enforceable improvement in air quality, as required by CAA Section 107(d)(3)(E)(iii) (42 U.S.C. 7407). The 2012 Maintenance Plan explained that Clark County adopted comprehensive fugitive dust controls in the Section 90 series of the AQR, and implemented and enforced SIP and non-SIP regulations to control PM_{10} emissions from stationary and nonpoint sources. The maintenance plan summarized the progress in attaining the PM_{10} standard, demonstrated that all Clean Air Act and Clean Air Act Amendment requirements for attainment had been met, and presented a plan to assure continued maintenance over the next 10 years. The plan became federally enforceable and determined how Clark County maintained the 1987 PM_{10} NAAQS through 2023.

In 2022, Clark County began work on a Second PM_{10} Maintenance Plan. For this plan, Clark County DES must show attainment in the background and assessment design value periods, specified as the 2017-2019 background period and the 2021-2023 assessment period. This exceptional event demonstration and the associated demonstrations for the 2021-2023 design value period will show that Clark County's HA 212 area is in attainment of the PM_{10} NAAQS but for the proven exceptional event dates. Approval and implementation of the Second PM_{10} Maintenance Plan is expected in 2024.

4.3.2 Historical Analysis of Past PM_{10} Exceedances

The 2012 Maintenance Plan document for Clark County, Nevada, provides historical context of regulatory efforts by Clark County to achieve attainment of PM_{10} NAAQS over the past 30 years, and a robust weight-of-evidence trend analysis for PM_{10} concentrations from 2001-2010. With the implementation of the PM_{10} SIP control measures, evidence shows a decreasing trend in PM_{10} design values, especially after BACM implementation (Figure 4.3-1). The decrease in wind erosion from vacant lands has driven the decreasing trend of PM_{10} emissions as construction within the Las Vegas Valley overtakes vacant lands. Given that the Las Vegas Valley was designated as being in "moderate" and later "serious" nonattainment for the PM_{10} NAAQS in the early 1990s, PM_{10} emissions before 1999 were likely high relative to the 2008-2010 period shown in Figure 4.3-1. This confirms that PM_{10} emissions have decreased over the past 30 years since the implementation of BACM from anthropogenic sources.

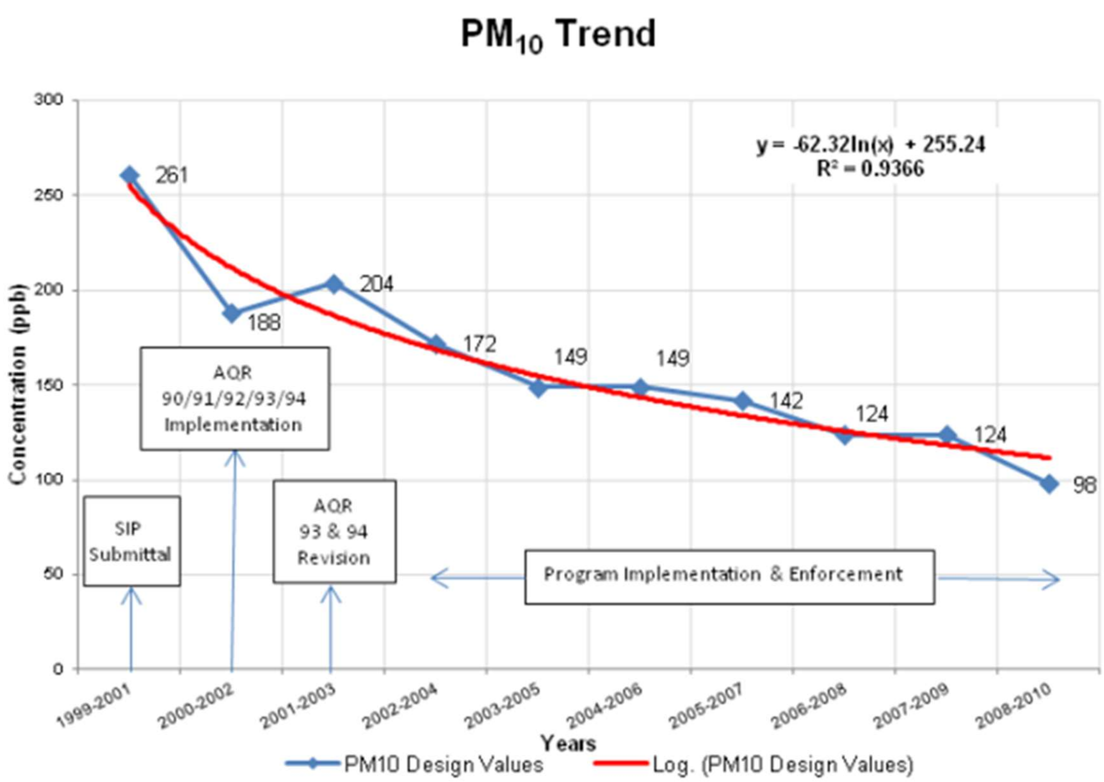

Figure 4.3-1. PM_{10} trends from the 2012 Maintenance Plan.

Continuing this evaluation through 2022, Figure 4.3-2 shows the three-year running average concentration at a long-running PM_{10} monitoring site in Clark County (Paul Meyer: AQS ID 32-003-0043) (orange line), along with the three-year running average of drought conditions in Nevada (blue bars). Drought conditions are categorized on a scale of D0 (abnormally dry) to D4 (exceptional), and Figure 4.3-2 shows the three-year running average of D2 (severe) conditions. We see that the typical five-year cyclical drought pattern in Nevada has increased in magnitude in the most recent years and this has corresponded to an uptick in average PM_{10} concentrations. This suggests that the control measures put in place via the 2012 SIP have been at least partially counterbalanced by increasing drought throughout the state of Nevada, affecting PM_{10} concentrations. **Figure 4.3-3** shows the D0 - D4 drought conditions for 2000-2023, highlighting the increase in D3 (extreme) and D4 drought conditions through the most recent years. According to NLCD 2019 data, 87% of Nevada's land cover is bare ground or land that has little vegetation cover. The expansion in magnitude of severe-to-exceptional drought conditions will disproportionately affect natural areas prone to dust lofting, entrainment, and transport, ultimately enhancing PM_{10} concentrations.

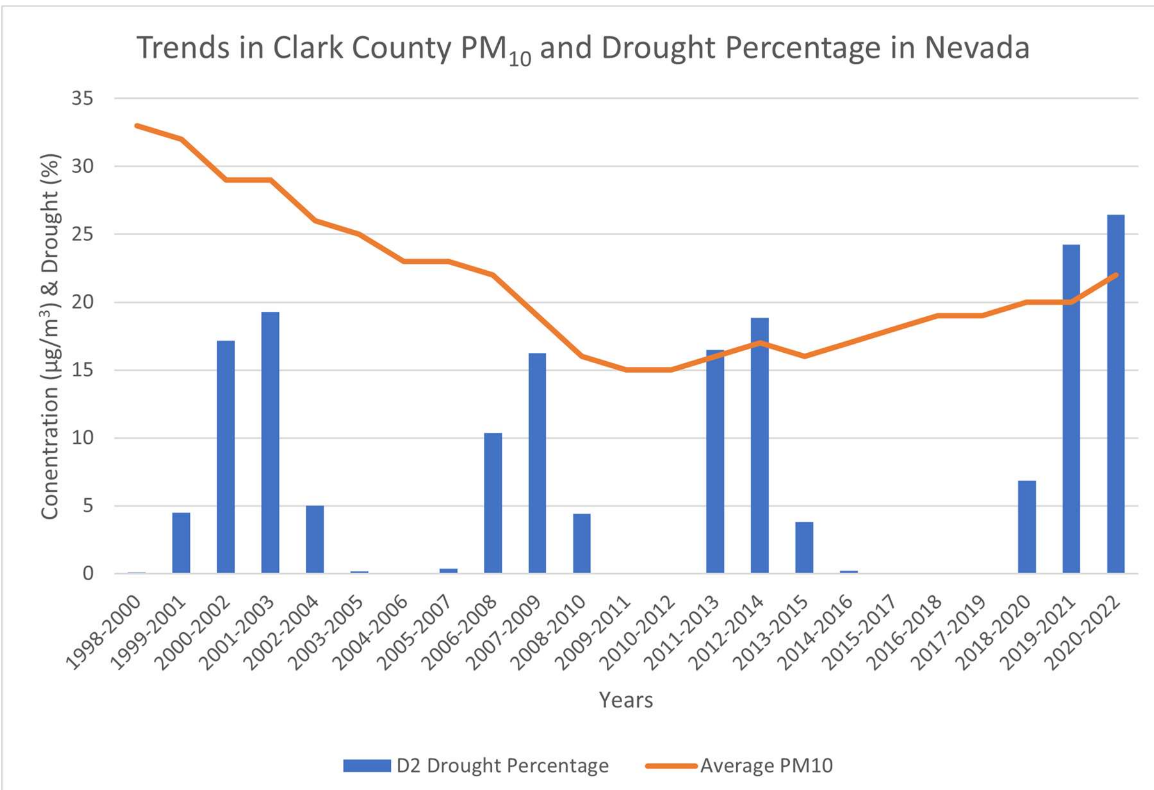

Figure 4.3-2. Three-year running average of PM_{10} concentrations (µg/m^3) at the long-running Paul Meyer monitoring site (AQS: 32-003-0043) (orange line) and the D2 (severe) drought percentage of Nevada (blue bars). Source: **https://www.drought.gov/states/nevada**.

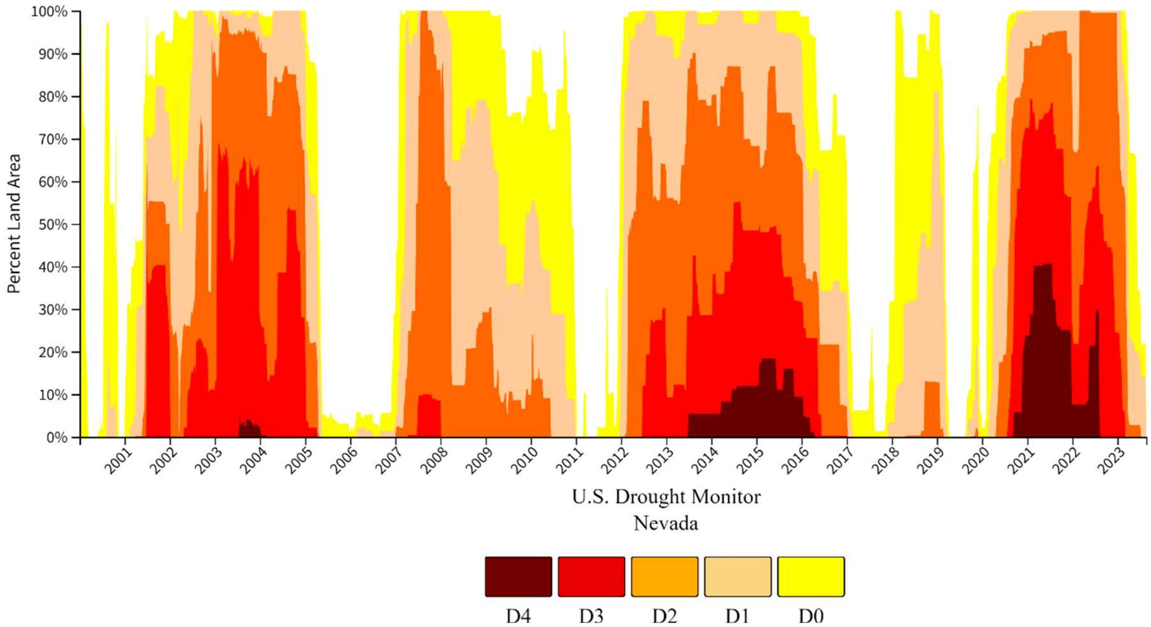

Figure 4.3-3. Drought statistics for Nevada from 2000-2023, colored by drought severity for D0 to D4. Source: https://www.drought.gov/states/nevada.

Historical PM_{10} exceedance frequency in Clark County has varied among air quality monitoring sites since the late 1990s and early 2000s. Figure 4.3-4 and Figure 4.3-5 show historical 24-hour PM_{10} exceedance count and concentration and design values at site in HA212 with at least 20 years of data. PM_{10} exceedances at the Joe Neal and Green Valley sites occurred at a greater frequency (≥1 exceedance per year) in the late 1990s and early 2000s followed by a drop to no exceedances per year in the mid-2000s coinciding with BACM implementation and less severe drought conditions. Other sites show one exceedance every few years before 2022. The number of exceedances per year increased in the 2010s for most long-term sites, coinciding with more widespread and severe drought conditions in Nevada. The number of exceedances rose significantly for all long-term sites in 2022 and 2023 due to the wind-blown dust exceptional events. Without these 2022 and 2023 events, the number of exceedances would more closely align with the mid-2000s period. These observations are consistent with the historical PM_{10} and drought analysis presented in the 2012 Maintenance Plan.

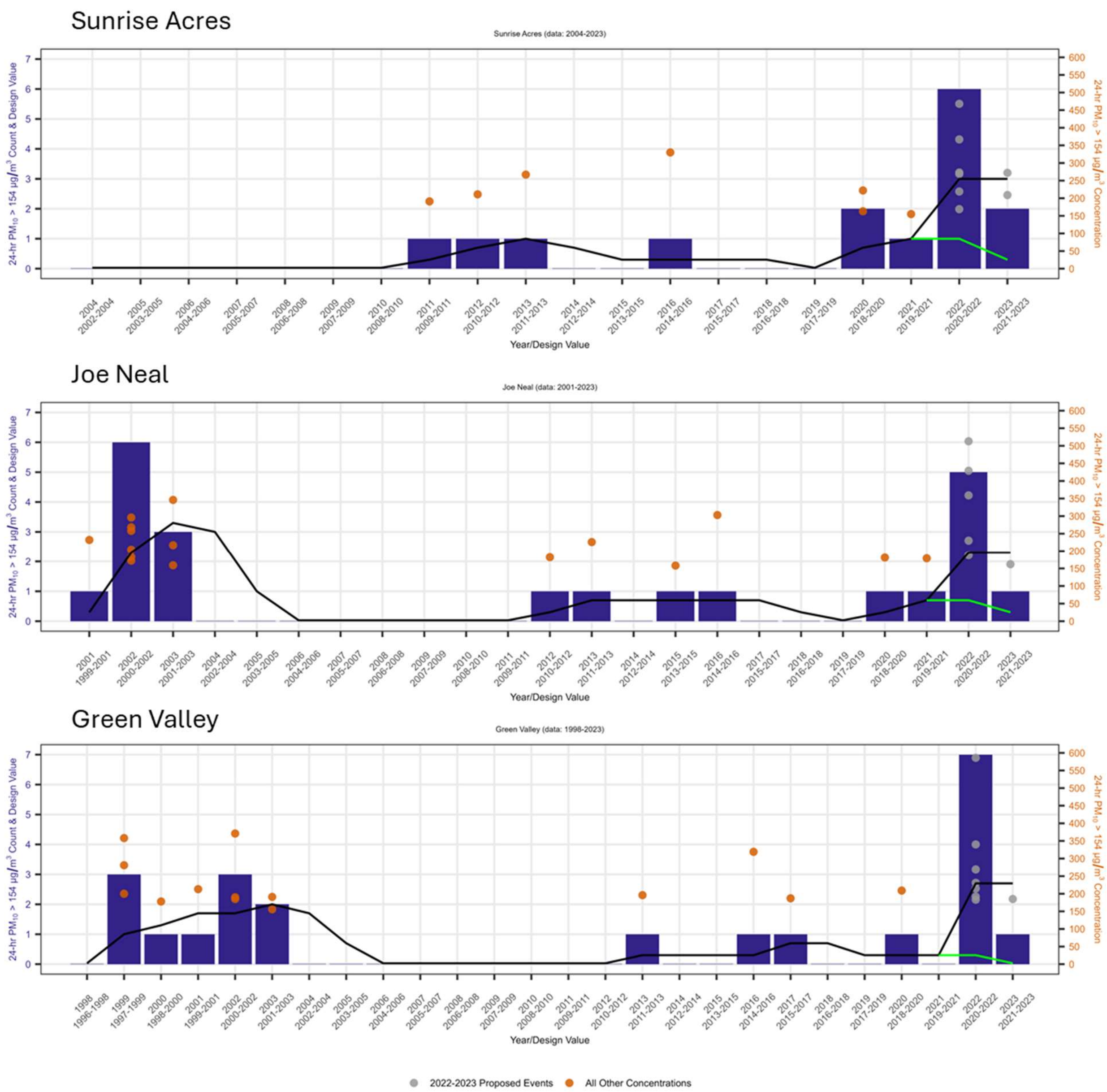

Figure 4.3-4. Historical 24-hour PM_{10} exceedance count (purple bars) and concentration (orange dots) per year/design value period at the Sunrise Acres, Joe Neal, and Green Valley monitoring sites (AQS: 32-003-0561; 32-003-0075; 32-003-0298). The gray dots represent the proposed 2022-2023 PM_{10} exceptional events, the black line represents the design value for all periods with all PM_{10} exceptional events included, and the green line represents the design value for the period with the 2022-2023 PM_{10} exceptional events excluded.

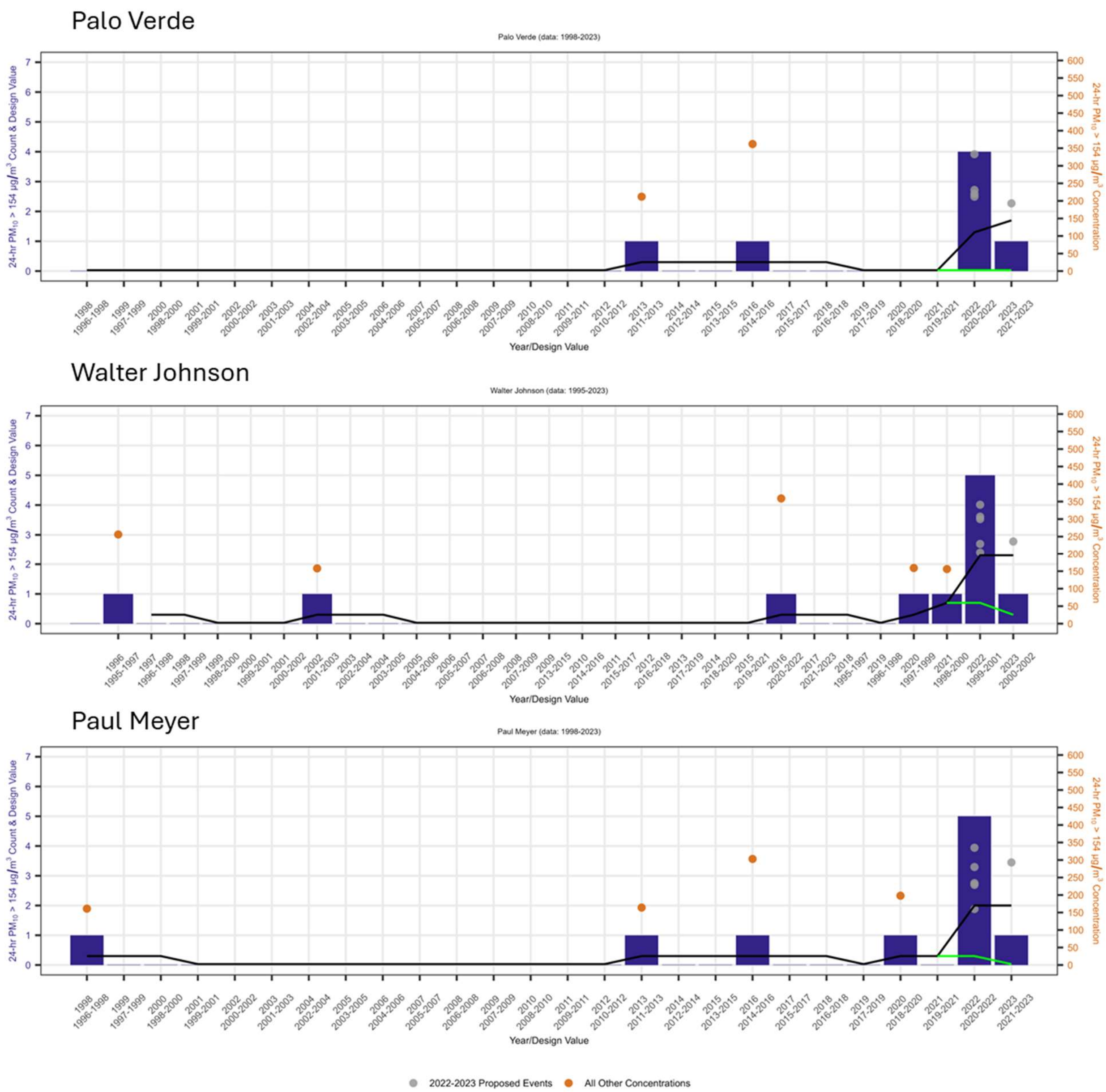

Figure 4.3-5. Historical 24-hour PM_{10} exceedance count (purple bars) and concentration (orange dots) per year/design value period at the Palo Verde, Walter Johnson, and Paul Meyer monitoring sites (AQS: 32-003-0073; 32-003-0071; 32-003-0043). The gray dots represent the proposed 2022-2023 PM_{10} exceptional events, the black line represents the design value for all periods with all PM_{10} exceptional events included, and the green line represents the design value for the period with the 2022-2023 PM_{10} exceptional events excluded.

4.3.3 Widespread Use of Controls

In addition to the similar controls listed per rule in Section 4.2, Clark County's dust control measure regulatory framework is similar to that of nearby jurisdictions. Rule 403 in the Rules and Regulations of the Mojave Desert Air Quality Management District (MDAQMD)[7] and Rule 310 of Maricopa County's (Arizona) Air Pollution Control Regulations[8] describe the regulations and enforcement of fugitive dust control measures. Like the fugitive dust controls outlined in Clark County's AQR, MDAQMD and Maricopa County provide definitions of control measures that dust-producing operations in the air agency's jurisdiction must apply to prevent, reduce, or mitigate fugitive dust. The control measures implemented by Clark County, MDAQMD, and Maricopa County emphasize the stabilization of site surfaces, and have requirements for equipment usage, permitting, and enforcement. The rules of the respective jurisdictions provide differing levels of detail and requirements regarding fugitive dust control measures. Further, the rules of the respective jurisdictions are tailored to fit the specific dust control challenges each jurisdictions faces.

The stabilization of site surfaces is defined similarly across Clark County, MDAQMD, and Maricopa County as the reduction of dust-producing capability of a disturbed surface through the treatment of the surface using methods such as watering, paving, manual compacting, or chemical treatment. Stabilization of site surfaces—where a portion of the earth's surface or material placed on the earth's surface is disturbed and has the potential to produce fugitive dust emissions—is required across all three jurisdictions. Stabilization is a critical component of dust control measures across the three jurisdictions. During high-wind events, all three jurisdictions must ensure that site surfaces are stabilized to prevent wind-blown dust. Maricopa County and Clark County specify in their respective rules that, during high-wind events, certain operations that destabilize surfaces such as blasting must cease, whereas MDAQMD requires that "non-essential" destabilizing operations must be reduced.

Specific rules regarding equipment use vary slightly across the three jurisdictions in requirements and level of detail, but generally include requirements such as speed limits for equipment while on site and limits on hauling vehicles (e.g., covers over dust-producing material). For example, MDAQMD requires that hauling vehicles working at a mining, stone, asphalt, or clay facility maintain at least six inches of freeboard (i.e., the distance between the hauled material and the top of the hauling container) on haul vehicles when transporting material on public roads, whereas Maricopa County requires that hauling vehicles working off-site in areas accessible to the public maintain at least three inches of freeboard on haul vehicles when transporting material. Maricopa County also provides detail on hauling truck operations working under other circumstances, such as on-site and not accessible to the public.

Dust control plans required across the three jurisdictions vary slightly, but are integral parts of the permitting process that detail control measures that will be implemented. All dust control plans require basic information such as site details, control measures, contingency control measures, and a summary of general day-to-day operations. The circumstance under which a dust-generating operation must submit a dust control plan differs between the jurisdictions. For example, there are seven circumstances that would require the submittal of a dust control plan to MDAQMD, such as a

[7] https://www.mdaqmd.ca.gov/home/showpublisheddocument/8482/637393282546170000

[8] https://www.maricopa.gov/DocumentCenter/View/5354/Rule-310---Fugitive-Dust-from-Dust-Generating-Operations-PDF?bidId=

"Residential Construction/Demolition Activity with a Disturbed Surface Area of at least ten (10) acres." Maricopa County, however, requires the submittal of a dust control plan for any potential dust-generating operation that would meet or exceed 0.10 acres. Clark County, under Section 94 of the AQR, requires the submittal of a dust control plan for "Construction and Temporary Commercial Activities" under four circumstances (e.g., Construction Activities that disturb soils 0.25 acres or greater in overall area).

Enforcement of dust control regulations and dust control plan compliance are also similar, but differ in level of detail and stringency between the three jurisdictions. Clark County's enforcement activities are extensive and detailed. For example, per Section 94 of the AQR, Clark County requires that, under certain circumstances, a Dust Control Monitor (i.e., a construction superintendent or other on-site representative) is given power to ensure the dust-generating operation is compliant with dust control regulations and follows the dust control plan. Maricopa County has similar rules regarding an official monitor of dust control regulation and dust control plan compliance. Officials in charge of monitoring dust-producing activities are trained in dust control practices and are generally responsible for managing and enforcing dust control practices at the dust-producing site. Dust-producing operations in violation of regulations and their dust control plan are subject to penalties.

The prevalence of similar standard fugitive dust control practices employed by Clark County, MDAQMD, and Maricopa County provide a benchmark for reasonable dust controls for similar environments in the southwest U.S.

4.3.4 Jurisdiction

As detailed in **Section 3.1.1**, on May 28-29, 2022, dense blowing dust from the Mojave Desert source region impacted the Las Vegas metropolitan area. Due to the strengthening pressure gradient caused by an associated cold front, surface wind speeds increased in Clark County and the Mojave Desert, which produced blowing dust in the late afternoon/evening hours on May 28 and in the early morning hours on May 29 in the area southwest of Las Vegas. Strong winds in the Mojave Desert source region were well above 25 mph from the frontal passage, which lofted, entrained, and transported dust from the source region to Clark County. From May 28 at 21:00 PST to May 29 at 02:00 PST, almost all sites in the Las Vegas Valley exceeded 500 $\mu g/m^3$ (as detailed in **Section 3.2.2**). Ground-based evidence, including particulate matter analysis (**Section 3.3.4**) and visibility monitors (**Section 3.3.5**), provide additional strong evidence that PM_{10} control measures within Clark County were overwhelmed and unable to prevent an exceedance event on May 28-29, 2022. The timeline shown in this exceptional event demonstration highlights the progression of extremely high concentrations of PM_{10} from the source region into Clark County (and HA 212) within a very short period of time. This progression clearly indicates an upwind source of windblown dust. As the strong winds lofted, entrained, and transported dust from the Mojave Desert in southeastern California and southern Nevada, this source region was outside the jurisdiction of Clark County and the implemented control measures.

4.4 Effective Implementation of Control Measures

In addition to the SIP and AQR documentation previously provided, the Clark County DES is responsible for monitoring and forecasting air quality and enforcing dust mitigation measures before, during, and after an exceptional event. Clark County issues “advisories” and “Construction Notices” when weather conditions are forecast to be favorable for a wind-blown dust event. Advisories consist of health-based notifications disseminated to the public that provide educational materials on how to limit exposure and mitigate emissions for dust, $PM_{2.5}$, seasonal ozone, ozone, and/or smoke. Construction Notices are notifications to stationary sources, dust control permit holders, and contractors that detail mitigation measures. The issuance of Construction Notices may not meet the wind threshold for a potential high-wind dust event, but if weather conditions change to prompt a public advisory or alert, stationary sources are sent a detailed form of the public advisory or an alert with language specific to their operations and dust abatement requirements.

Dust Advisories are issued for forecasts of sustained wind speeds of 25 mph or more, or wind gusts of 40 mph or more. Construction Notices are issued for forecasts of sustained wind speeds of 20 mph or more, or wind gusts of 30-35 mph or more. Upon issuance of either a Construction Notice or an Advisory, the DES directs stationary sources to inspect their site(s), cease blasting operations, and employ BACM to stabilize all disturbed soils and reduce blowing dust. Recipients of a Construction Notice are informed that the DES officials will inspect sites to ensure BACM is being implemented.

Specific construction-related control measures include required dust control classes for construction superintendents or other on-site representatives.[9] Clark County also collects air quality complaints (including dust complaints) submitted online, over the phone, or via email, and responds to all complaints within 24 hours or the next business day.[10] Expansive rules and BACM for dust control at construction and temporary commercial activities are included in AQR Section 94. These include requirements for dust control monitors, soil stabilization standards, testing methods, and rules for non-compliance or violations if a permit or Dust Mitigation Plan has been violated. During high-wind dust periods, Clark County compliance officers inspect construction and stationary source sites to ensure BACM are being implemented, and any observed violation may receive a Notice of Non-Compliance or a Notice of Violation.

On May 27, 2022, a Construction Notice was issued for Friday, May 27 through Saturday, May 28. On Sunday, May 29, a Dust Alert was issued by Clark County due to blowing dust via southwesterly winds from the Mojave Desert. In the case of a Dust Advisory, compliance officers inspect construction and stationary source sites during the episode to ensure BACM are being implemented, where any observed violation may receive a Notice of Violation. This and other Clark County public-facing alerts shown in **Section 3.3.1** indicated the implementation of BACM and enforcement

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[9] https://www.clarkcountynv.gov/government/departments/environment_and_sustainability/compliance/dust_classes.php
[10] https://www.clarkcountynv.gov/government/departments/environment_and_sustainability/division_of_air_quality/air_quality_complaints.php

procedures. **Appendix D** also provides all inspection information and notices of violation from the May 28-29, 2022, event.

The Clark County DES is comprised of Monitoring, Compliance and Enforcement, and Planning divisions. The Monitoring Division is primarily responsible for weather and air quality monitoring, forecasting Air Quality Index (AQI) levels and coordinating with other divisions and Clark County more broadly on the issuance of Construction Notices or Advisories. The Compliance and Enforcement Division is responsible for disseminating Construction Notices to appropriate stationary sources, dust control permit holders, and contractors. This department also disseminates Advisories to the public, conducts field inspections of sources before and during a dust event, alerts alleged violators of compliance statuses, and documents observations made in the field of enforcement actions. The Planning Division is responsible for coordinating with the other divisions to prepare exceptional event packages. Full details on these procedures can be found in **Appendix E**. Based on the implementation of increased control measures, as well as compliance and the enforcement of advisories for windblown dust, part 3 of the nRCP requirement is fulfilled.

The documentation and analysis presented in this demonstration and appendices demonstrate that all identified sources that caused or contributed to the exceedance were reasonably controlled, effectively implemented, and enforced at the time of the event; therefore, emissions associated with the May 28-29, 2022, PM_{10} event were not reasonably controllable or preventable.

5. Natural Event

The May 28-29, 2022, event is the result of a frontal passage and high winds proceeding directly over the Mojave Desert source region in southeastern California and transporting dust directly into Clark County, Nevada. In the case when high-wind events pass over natural undisturbed lands, the EPA considers high-wind dust events natural. In addition, there were controls in place for anthropogenic sources (see **Section 4.2**) during the high-wind dust event. Therefore, we conclude that this event meets the EPA criteria for a natural event.

6. Conclusions

The evidence provided within this report demonstrates that the PM_{10} exceedances on May 28 and 29, 2022, were caused by a high-wind dust event where dust was lofted, entrained, and transported from the extremely dry Mojave Desert in southeastern California. Key elements and evidence associated with the event timeline include:

1. A strong frontal passage quickly pushed through southeastern California (and the Mojave Desert) at approximately 12:00-19:00 PST on May 28, 2022. With this frontal passage, dust from the Mojave Desert was lofted, entrained, and transported to Clark County by 16:00-18:00 PST on May 28. Meteorological measurements in the source region and along the transport path show winds greater than the 25-mph threshold.

2. Back trajectories and meteorological data along the frontal passage confirm the Mojave Desert as the source region for the high-wind dust event. The frontal passage pushed northeasterly through the source region enroute to Clark County, Nevada, bringing dust from the Mojave Desert within 4-6 hours of the exceedance. Satellite data, meteorological data, and visibility measurements all align to confirm the event transport from the Mojave Desert. PM_{10} measurements along the frontal passage increased as winds pushed through Kern, Inyo, and San Bernardino Counties in California, then through Nye and Clark Counties in Nevada, confirming high PM_{10} concentrations along the timeline and trajectories established.

3. The frontal passage entered Clark County by 16:00-18:00 PST on May 28, 2022. Along with the frontal passage, PM_{10} concentrations were extremely enhanced, construction and weather alerts were issues, visibility measurements indicated dusty conditions, and the $PM_{2.5}/PM_{10}$ ratio dropped (indicating windblow dust). Winds calmed and shifted on the morning of May 29 and allowed PM_{10} concentrations to decrease back to normal levels after 11:00 PST.

4. PM_{10} concentrations increased at the same time as the frontal passage pushed into Clark County, starting at 16:00-18:00 PST and peaked in intensity by 20:00 PST on May 28, 2022. 24-hour PM_{10} concentrations were above the NAAQS threshold of 150 µg/m^3 at five sites. Four sites recorded regulatorily significant concentrations: 169 µg/m^3 at Liberty High School, 158 µg/m^3 at Jerome Mack, and 155 µg/m^3 at Walnut Community center on May 28; 183 µg/m^3 at Green Valley, 204 µg/m^3 at Liberty High School, 175 µg/m^3 at Jerome Mack, and 179 µg/m^3 at Walnut Community Center on May 29. One other site exceeded the 24-hour PM_{10} NAAQS recorded concentrations above the 99th percentile but was not regulatorily significant in this case. Hourly PM_{10} concentrations at all sites in Clark County peaked above 400 µg/m^3 through the event on May 28 and 29. The concurrent rise in PM_{10} at all sites around Clark County indicates a regional dust event.

5. Of regulatory significance, PM_{10} concentrations at the Jerome Mack, Liberty High School, Walnut Community Center, and Green Valley sites exceeded both the five-year 99th percentile and the NAAQS on May 28 and 29, 2022. PM_{10} concentrations were also significantly outside typical diurnal, monthly, and seasonal ranges.

6. Clark County, Nevada, and the surrounding source region was under increasingly severe drought conditions on and before the May 28-29, 2022, event. The 30-year climatology shows that temperatures and wind speeds were above normal, while soil moisture was below normal. The barren land cover in the Mojave Desert source region was primed for significant dust production during the high-wind event. PM_{10} control measures within Clark County were quickly overwhelmed and unable to prevent an exceedance event on May 28-29, 2022. Dust lofted and transported from this natural, undisturbed area experiencing severe drought conditions is considered to be a natural and not reasonable controllable event.

7. Analyses comparing other dates similar to May 28 and 29, 2022, include dates with comparable wind profiles that did not show PM_{10} concentrations above the NAAQS. This analysis indicates that, in the absence of an extremely dry source region and high surface winds, PM_{10} concentrations would not have been exceptionally high.

Within this document, the following requirements for the EER have been met:

1. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s),

2. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation,

3. Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times,

4. A demonstration that the event was both not reasonably controllable and not reasonably preventable,

5. A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event, and

6. Documentation that the air agency followed the public comment process (included in Appendix F).

The high-wind dust event that occurred on May 28-29, 2022, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at the Green Valley (Monitor AQS ID 32-003-0298, POC 1), Liberty High School (Monitor AQS ID 32-003-0299, POC 1), Jerome Mack (Monitor AQS ID 32-003-0540, POC 1), and Walnut Community Center (Monitor AQS ID 32-003-2003, POC 1) sites. On May

28, 24-hour PM_{10} concentrations reached 169 µg/m^3 at the Liberty High School site, 158 µg/m^3 at the Jerome Mack site, and 155 µg/m^3 at the Walnut Community Center site. On May 29, 24-hour PM_{10} concentrations reached 204 µg/m^3 at the Liberty High School site, 175 µg/m^3 at the Jerome Mack site, 179 µg/m^3 at the Walnut Community Center site, and 183 µg/m^3 at the Green Valley site. Seven additional suspected windblown dust events occurred between 2021 and 2023. Without EPA concurrence that the windblown dust event on May 28-29, 2022, and the other suspected events qualify as exceptional events, the 2021-2023 design value is 3.0 at the Liberty High School site, 4.0 at the Walnut Community Center site, 3.7 at the Jerome Mack site, and 2.7 at the Green Valley site. This is outside of the attainment standard of 1.0. With EPA concurrence on May 28-29, 2022, and the other suspected events, the 2021-2023 design value is 0.3 at the Liberty High School site, 1.0 at the Walnut Community Center site, 0.3 at the Jerome Mack site, and 0.0 at the Green Valley site, which are within the attainment standard. Within this demonstration, all elements of the EER have been addressed. Therefore, we request that the EPA consider the overwhelming evidence of windblown dust that occurred in Clark County on May 28-29, 2022, and agree to exclude the event from regulatory decisions regarding PM_{10} attainment.

7. References

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