Exceptional Event Demonstration for PM_{10} Exceedances in Clark County, Nevada – July 31, 2023

Final Report Prepared for

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San Francisco, CA

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STi Sonoma Technology

Exceptional Event Demonstration for PM_{10} Exceedances in Clark County, Nevada – July 31, 2023

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Cover graphic shows camera images from the M-Resort Hotel in Las Vegas, Nevada on July 31, 2023, at 12:00 PST.

This document contains blank pages to accommodate two-sided printing.

Contents

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Tables

1. Narrative Conceptual Model

In late July 2023, a series of thunderstorms created a strong outflow boundary and associated high winds, which traversed northern Mexico, southwestern Arizona, and southeastern California. This event lofted, entrained, and transported dust from the Sonoran and Mojave Deserts, increasing particulate matter (PM) concentrations in Clark County, Nevada, on July 31, 2023. 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 three monitoring sites in Clark County: Jerome Mack, Sunrise Acres, and Walnut Community Center. An additional site experienced NAAQS exceedances, and all other sites throughout Clark County also experienced significantly enhanced hourly PM_{10} concentrations but were not regulatorily significant. The widespread impact on PM_{10} concentrations in Clark County indicates that this was a regional dust event. The exceedances at the three regulatorily significant sites affect the PM_{10} attainment designation for Clark County during the 2021-2023 design value period.

Due to drought conditions in the Sonoran and Mojave Deserts, strong winds created by the outflow boundary lofted, entrained, and transported dust into Clark County, arriving in the morning on July 31, 2023, which caused significantly enhanced concentrations of PM_{10} throughout the day. The U.S. Environmental Protection Agency (EPA) Exceptional Event Rule (EER) (U.S. Environmental Protection Agency, 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 Sonoran and Mojave Desert source regions coincide with the outflow boundary 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 July 31, 2023, PM_{10} concentrations at the three regulatorily significant sites ranks above the 99th percentile for all 2019-2023 PM_{10} events in Clark County and is clearly exceptional compared to typical PM_{10} conditions. Windblown dust from the Sonoran and Mojave Deserts 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 Sonoran and Mojave Deserts region of northern Mexico, southwestern Arizona, and southeastern California, with the enhanced PM_{10} concentrations measured at all sites in Clark County, Nevada – designating the July 31, 2023, event as a High-Wind Dust Exceptional Event.

Key narrative evidence and timeline elements are shown below and expanded on in **Section 3**:

Pre-Event Climatological Context

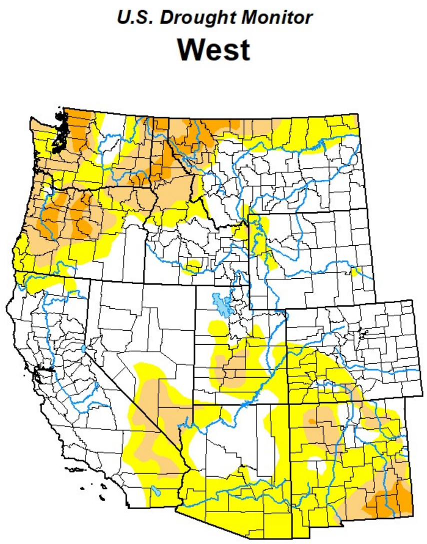


Figure 2.2-6

The Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California, as well as Clark County, Nevada, were under abnormal-to-moderate drought conditions on and before the July 31, 2023, event. Temperatures were above normal, and precipitation was below normal compared to climatology. The barren land cover of the Sonoran Desert and Imperial Valley in the southeastern California source region, was primed for significant dust production during the high-wind event.

See **Section 2.2.**

Inciting High-Wind Event

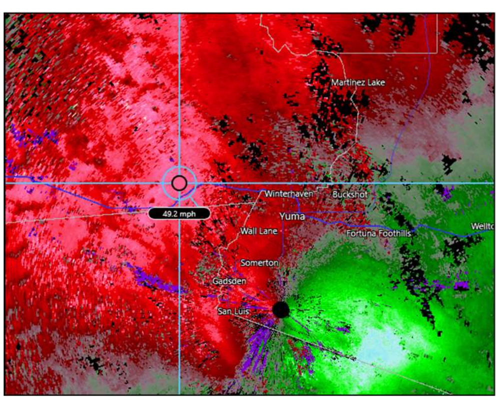


Figure 3.1-9

A thunderstorm-induced outflow boundary developed in northern Mexico and southwestern Arizona between 22:00 on July 30, 2023, and 02:00 PST on July 31. The outflow boundary produced high winds, in excess of 40 mph, in the Sonoran Desert area in southwestern Arizona and southeastern California. These high winds and the associated lofted dust pushed northward through the Mojave Desert during the early morning on July 31. This caused the transport of PM_{10} from the source regions into Clark County. Meteorological and PM_{10} analyses, as well as radar images of this event, show the outflow boundary passage (and associated dust) entering Clark County, Nevada, at 06:00-07:00 PST on July 31.

See **Section 3.1.**

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

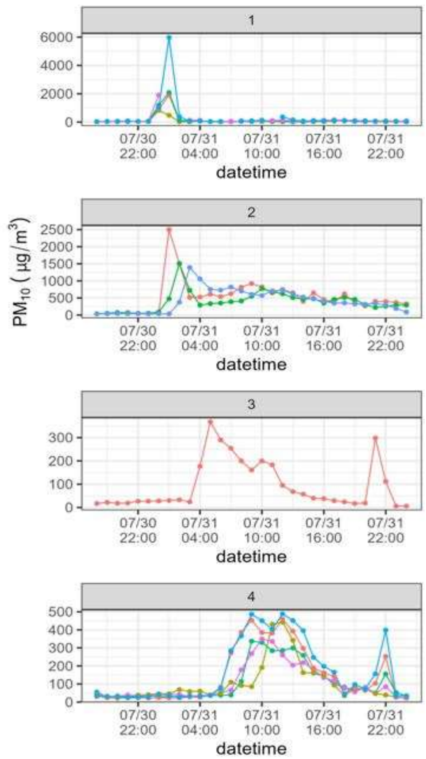


Figure 3.2-1

Meteorological and PM_{10} data along the outflow boundary passage confirm the Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California (located to the south of Clark County) as the source regions for the high-wind dust event. The frontal passage pushed northward through the source regions enroute to Clark County, Nevada, in less than 12 hours of the exceedance.

See Section 3.2.

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

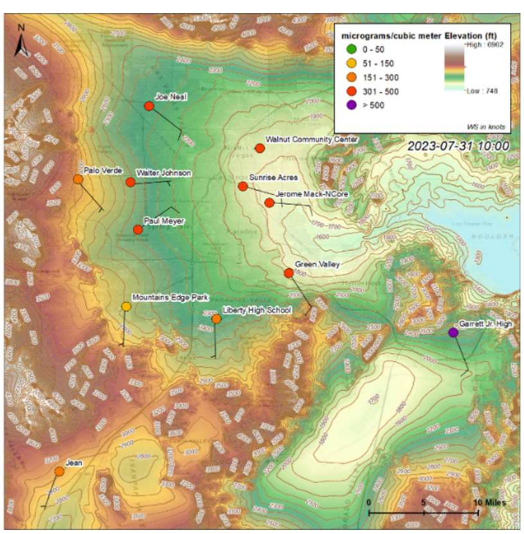


Figure 3.2-7

Enhanced PM_{10} concentrations arrived in Clark County beginning at 06:00-07:00 PST on July 31, 2023, with peak concentrations occurring between 09:00 and 12:00 PST. Concentrations remained enhanced through 18:00 PST. High PM_{10} concentrations at all sites across Clark County coincided with the outflow boundary circulation through the Las Vegas Valley. 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

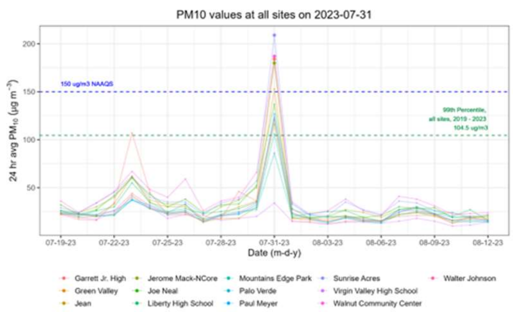


Figure 3.3-4

Four PM_{10} monitoring sites exceeded the NAAQS on July 31, 2023; three sites experienced exceedances that were regulatorily significant, while one experienced an exceedance that was not regulatorily significant. A total of 11 sites within Clark County experienced PM_{10} concentrations above the five-year 99th percentile. The widespread high PM_{10} concentrations concur with a regional high-wind exceptional event.

See Section 3.3.

Media Coverage and Ground-based Evidence

Figure 3.3-2

Multiple news outlets reported on the high winds and dusty conditions related to thunderstorms on July 30-31, 2023, that occurred in southwestern Arizona and southeastern California. Visibility in Las Vegas dropped to 6 miles and ground-based images show dust rolling into the valley between 07:00 and 12:00 PST on July 31.

See Section 3.3.

Comparison with Historical Data

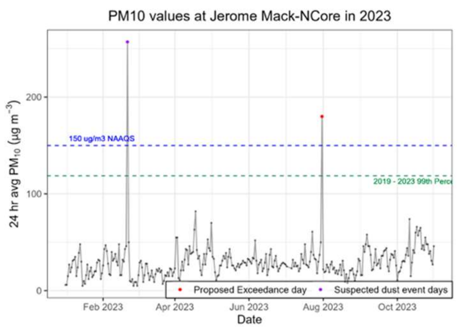


Figure 3.4-2

PM_{10} concentrations at the three sites that experienced regulatorily significant exceedances were above the five-year 99th percentile and the NAAQS on July 31, 2023. These PM_{10} concentrations are also significantly outside typical seasonal and monthly ranges. 30-year climatology analyses show wind speeds associated with the outflow boundary in the Sonoran and Mojave Desert source regions were significantly outside of the historical normal on the event date.

See Section 3.4.

Not Reasonably Controllable or Preventable

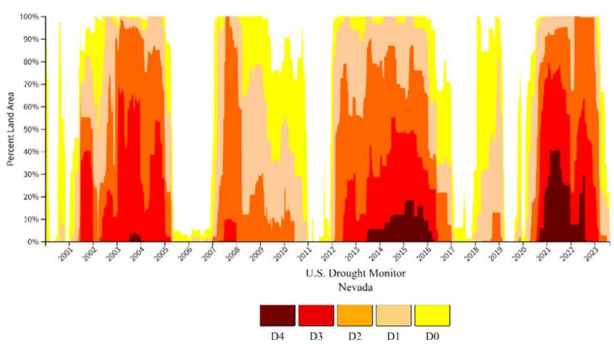


Figure 4.3-3

Based on the abnormally dry conditions in the source regions and the high winds from the thunderstorm-induced outflow boundary, control measures for PM_{10} concentrations within Clark County were quickly overwhelmed and unable to prevent an exceedance event. Significant evidence shows high winds lofted, entrained, and transported PM_{10} from natural undisturbed lands, and indicates that this event was natural and not reasonably controllable or preventable (nRCP).

See Sections 4 and 5.

2. Background

2.1 Demonstration Description

2.1.1 PM_{10} Exceptional Event Rule Summary

The U.S. EPA EER (U.S. Environmental Protection Agency, 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 the EER, exceptional events such as high-wind dust events that affect PM_{10} concentrations can be excluded 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 (U.S. Environmental Protection Agency, 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 July 31, 2023, met the 25-mph sustained wind speed threshold in the Sonoran and 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" (U.S. Environmental Protection Agency, 2016) 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) trajectories from the source area or source-specific emissions inventories.

Table 2.1-1. High-wind PM_{10} exception 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 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 July 31, 2023, qualifies for Tier 2 analysis and may be referred to as a high-wind dust event with sustained winds at or above the high-wind threshold of 25 mph. On July 31, 2023, resultant hourly average wind speeds greater than the 25-mph threshold were observed at several AQS measurement sites in the Sonoran and Mojave desert source regions.

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 (Section 3.3.1) and ground images during the event (Sections 3.3.4). 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. Section 2.2.1 and 2.2.2 discuss the dust source for the event on July 31, natural, undisturbed lands southwest of Las Vegas, including 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 3.2.2 (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	Timeline of event	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 July 31, 2023. 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,
- 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 regions 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 July 31, 2023, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at the Jerome Mack (Monitor AQS ID 32-003-0540, POC 1), Sunrise Acres (Monitor AQS ID 32-003-0561, POC 1), and Walnut Community Center (Monitor AQS ID 32-003-2003, POC 1) sites. 24-hour PM_{10} exceedance values are listed in Table 2.1-3.

Table 2.1-3. 24-hour PM_{10} concentrations recorded at the sites that experienced an exceedance of the NAAQS on July 31, 2023.

Monitor AQS ID - POC	Site Name	24-hour PM_{10} Exceedance Concentration (µg/m^3)
32-003-0540-1	Jerome Mack	180
32-003-0561-1	Sunrise Acres	209
32-003-2003-1	Walnut Community Center	187

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 in Clark County between 2021 and 2023. Table 2.1-4 shows the 2021-2023 design values at each of these three 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 July 31, 2023, and other suspected events qualify as exceptional events.

Monitor Site Name	Design Value Without EPA Concurrence	Design Value With EPA Concurrence
Jerome Mack	3.7	0.3
Sunrise Acres	3.0	0.3
Walnut Community Center	4.0	1.0

Further details on the design values with and without the event date, as well as monitor completeness, may be found in the Initial Notification Summary Information (INI) submitted by the Clark County Department of Environment and Sustainability (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 July 31, 2023, 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 Regions 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 Sonoran Desert, which encompasses southeastern California and southwestern Arizona in the U.S., as well as northern Baja, and northwestern Sonora in Mexico (Figure 2.2-1). Additionally, the southern Mojave Desert also experienced high winds during this event and can be classified as part of the source region. The primary land classifications in these regions, shown by the Sentinel-2 Land Use/Land Cover map, are bare ground and rangeland, with small pockets of crops and 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 land in the source regions primarily has little to no vegetation cover with natural sources of dust that are predisposed to high-wind events.

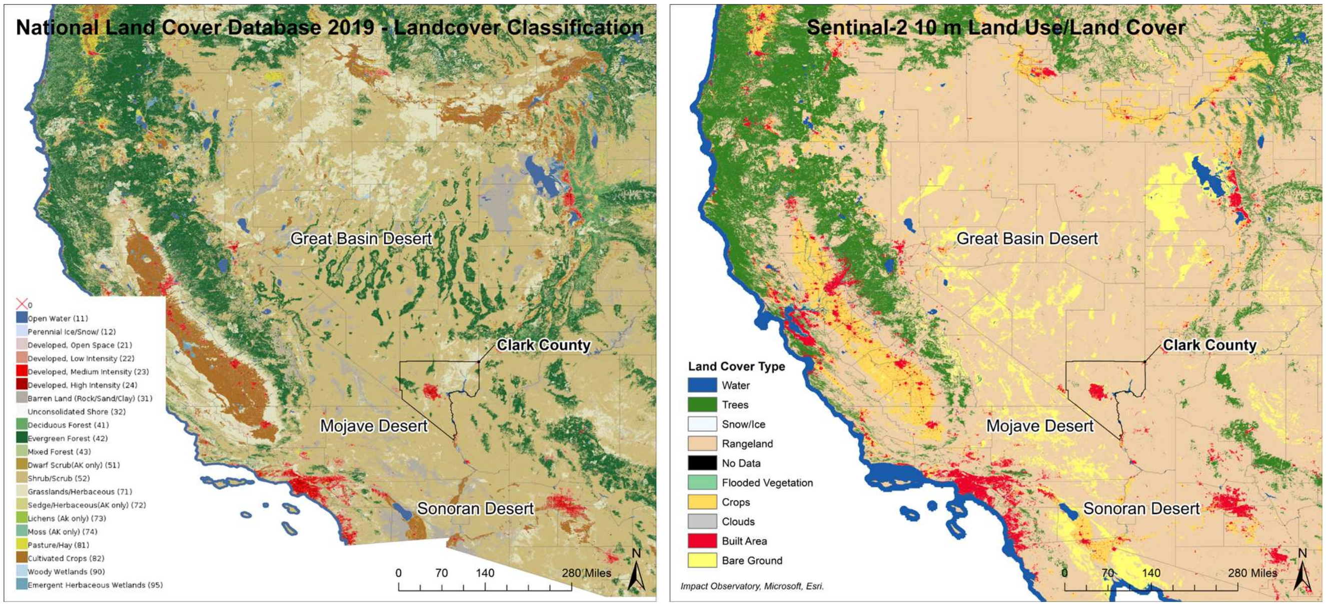


Figure 2.2-1. Land cover type for the western U.S. from (left) the National Land Cover Database-2019 and (right) Sentinel-2 satellite.

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.

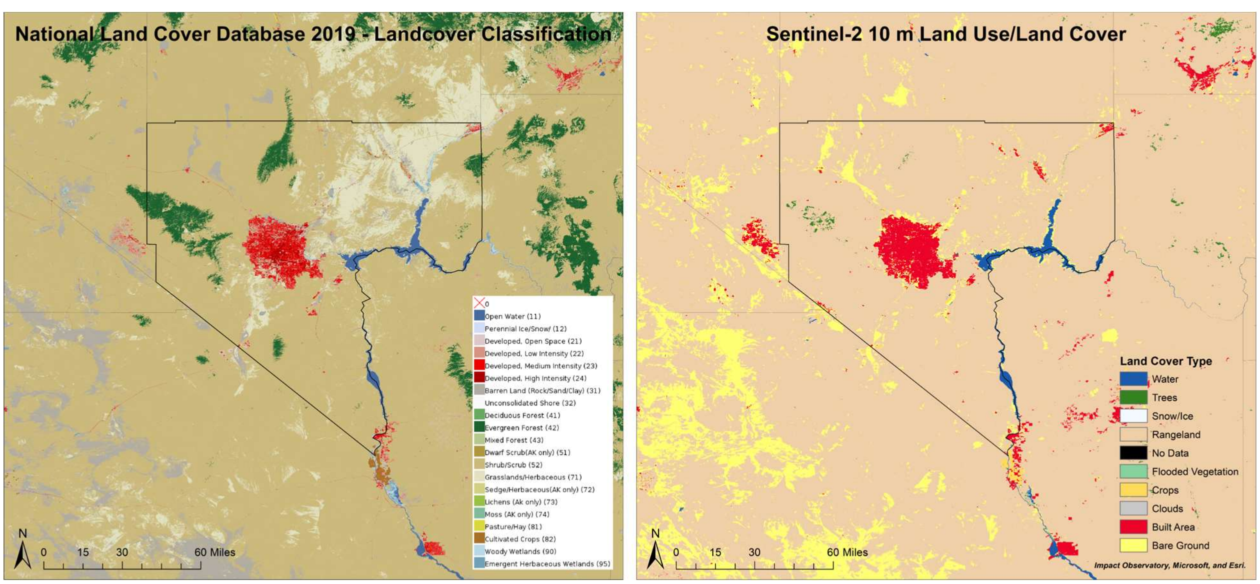


Figure 2.2-2. Land cover type for Clark County, Nevada, and surrounding area from the (left) the National Land Cover Database-2019 and (right) Sentinel-2 satellite.

2.2.2 Climatology for Source Regions and Clark County

The source regions of (1) the Sonoran Desert in southeastern California, southwestern Arizona, and northwestern Mexico, and (2) the southern Mojave Desert in southern California intersect portions of several Omernik Level III Ecoregions, primarily including the Mojave Basin and Range and the Sonoran Basin and Range (Omernik 1987; U.S. Environmental Protection Agency, 2013; Griffith et al. 2014). The Mojave Basin and Range ecoregion 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 borders 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). The ecoregion includes the Mojave Desert, as well as 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.

The Sonoran Basin and Range ecoregion spans approximately 116,364 km^2 of desert landscape in southeastern California, southwestern Arizona, and northwestern Mexico. The ecoregion is characterized by discontinuous mountain ranges separated by wide alluvial plains. Elevations range from 66 to 6,000 ft (20 to 1,830 m). The climate is warm and arid. In the summer months, temperatures can exceed 100 °F (38 °C). Annual precipitation varies from 3 to 17 inches (7.5 to 43 cm) and features a gradient of increasing precipitation from west to east; the western portion of the ecoregion receives most of its precipitation in the winter, and the eastern portion receives most of its precipitation in the summer due to monsoon rains (Calzia and Wilson, 2012; Griffith et al. 2014).

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.

Compared to the long-term climate record in the Las Vegas Area, the days leading up to the July 31, 2023, exceedance experienced normal to above-normal maximum daily temperatures. Concurrently, precipitation accumulation for the Las Vegas area was below normal by late July (**Figure 2.2-3** and **Figure 2.2-4**).

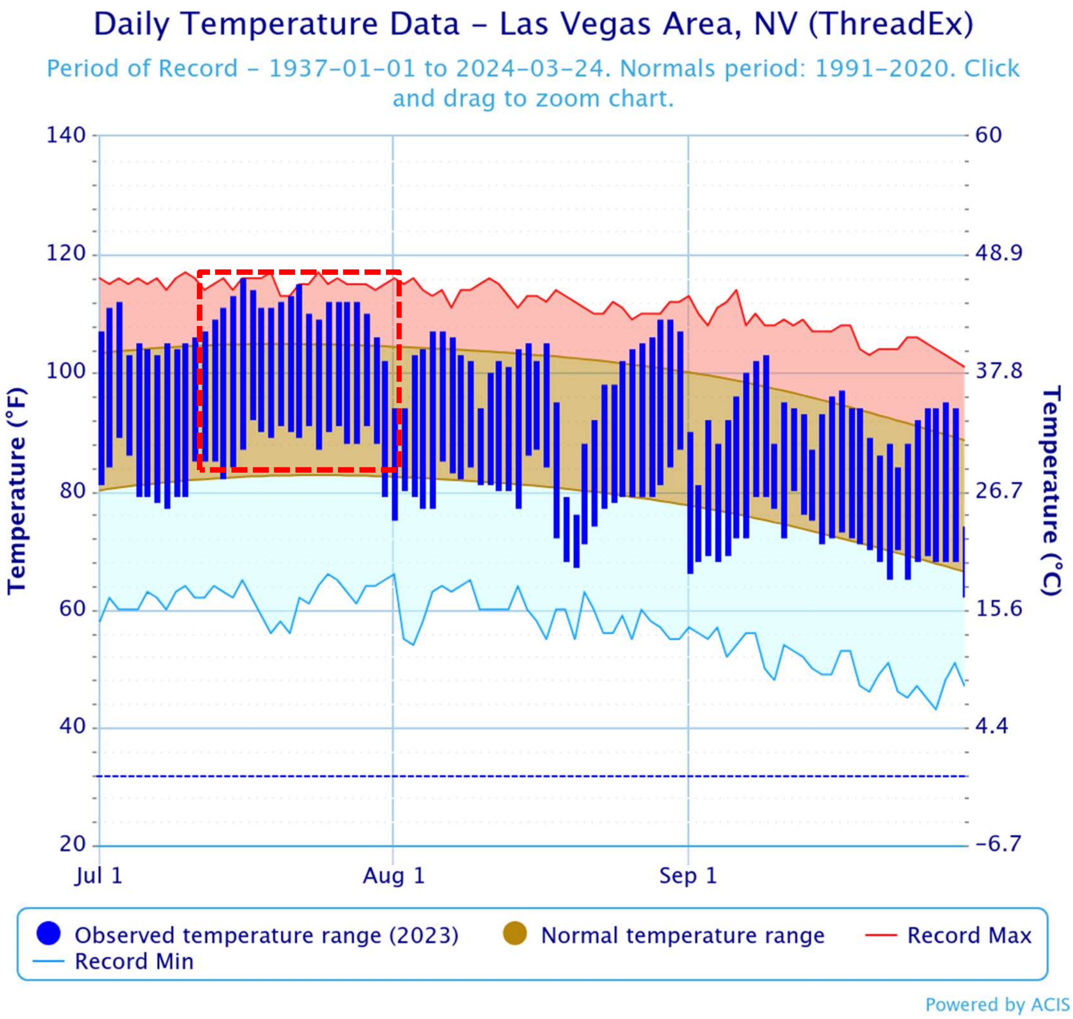


Figure 2.2-3. The temperature records for the Las Vegas area in Nevada from January 1, 1937, through March 3, 2023, by day including (dark blue) observed temperature range 2023, (brown) normal temperature range, (red) record maximum, and (light blue) record minimum. The red box indicates the dates of above normal temperatures before the July 31, 2023, event. Data from NWS: https://www.weather.gov/wrh/Climate?wfo=vef.

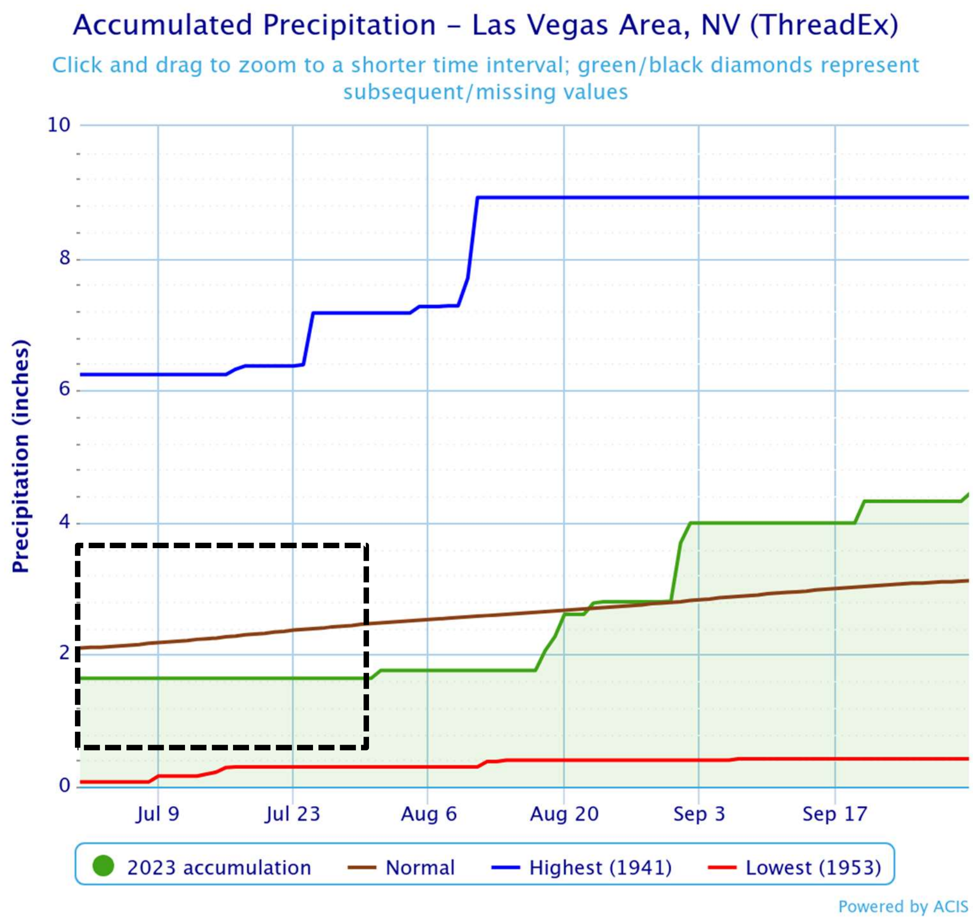


Figure 2.2-4. The precipitation records the Las Vegas area in Nevada by day, including (green) accumulation in 2023, (brown) normal, (blue) record maximum, and (red) record minimum. The black box indicates the period of low accumulated precipitation before the July 31, 2023, event. Data from NWS: https://www.weather.gov/wrh/Climate?wfo=vef.

While temperatures were above normal and precipitation was below normal for much of the western U.S., parts of both Nevada and California experienced progressively decreasing drought conditions in both area and severity in the months before the PM_{10} exceedance, according to the Palmer Drought Severity Index (PDSI) (Figure 2.2-5) that is produced by the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Protection (NCEP).

Despite improving drought conditions in parts of the western U.S., by July 25, 2023, southern Nevada, southeastern California, and southwestern Arizona were under an abnormal-to-moderate drought (Figure 2.2-6 and Figure 2.2-7).

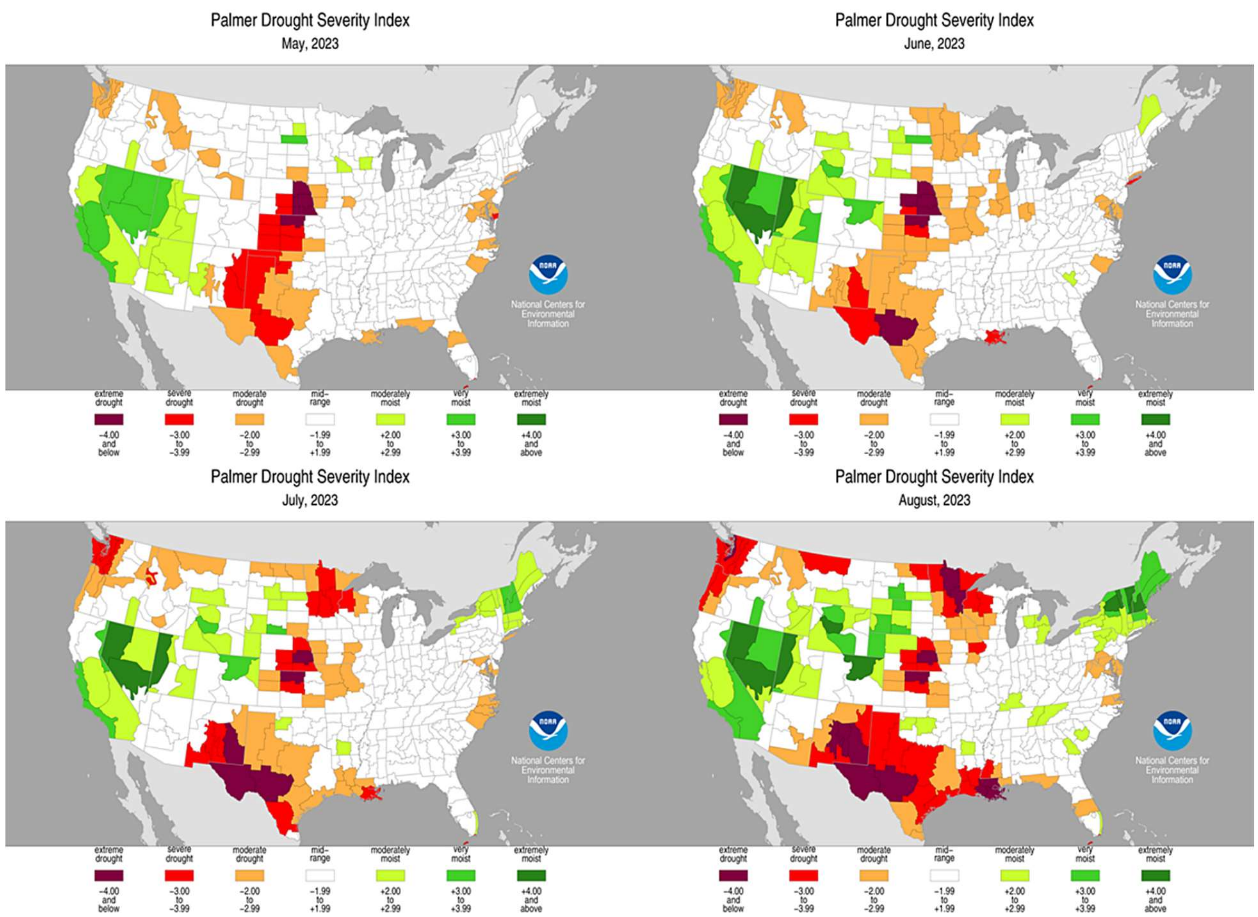
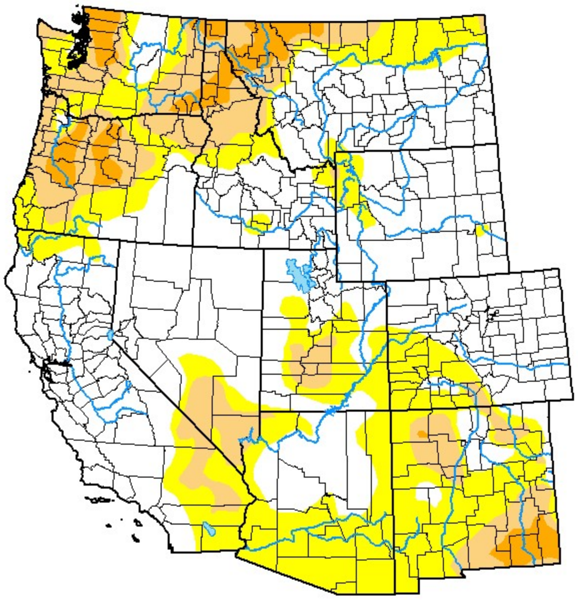


Figure 2.2-5. Palmer Drought Severity Index for May 2023 to August 2023.

U.S. Drought Monitor
West



July 25, 2023
(Released Thursday, Jul. 27, 2023)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	54.87	45.13	17.67	4.25	0.00	0.00
Last Week *07-18-2023*	61.10	38.90	15.31	2.99	0.00	0.00
3 Months Ago *04-25-2023*	46.88	53.12	25.70	6.25	1.40	0.06
Start of Calendar Year *01-03-2023*	12.08	87.92	62.42	38.84	12.41	0.27
Start of Water Year *09-27-2022*	3.89	96.11	73.90	47.71	19.37	2.63
One Year Ago *07-26-2022*	16.72	83.28	72.69	55.74	29.12	6.51

Intensity:
- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

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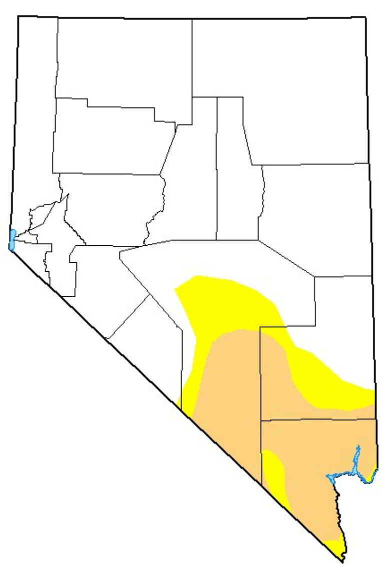
National Drought Mitigation Center

USDA NDMC NOAA

droughtmonitor.unl.edu

Figure 2.2-6. U.S. Drought Monitor values for the western U.S. on July 25, 2023.

U.S. Drought Monitor
Nevada



July 25, 2023
(Released Thursday, Jul. 27, 2023)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	78.45	21.55	14.11	0.00	0.00	0.00
Last Week *07-18-2023*	78.45	21.55	14.11	0.00	0.00	0.00
3 Months Ago *04-25-2023*	33.42	66.58	22.11	2.78	0.00	0.00
Start of Calendar Year *01-03-2023*	0.00	100.00	100.00	78.45	24.45	0.00
Start of Water Year *09-27-2022*	0.00	100.00	100.00	99.52	45.85	0.00
One Year Ago *07-26-2022*	0.00	100.00	100.00	99.52	63.55	29.80

Intensity:
- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

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National Drought Mitigation Center

USDA NDMC NOAA

droughtmonitor.unl.edu

Figure 2.2-7. U.S. Drought Monitor values for Nevada on July 25, 2023.

There are several Automated Surface Observing Systems (ASOS) weather measurement sites in the wind-blown dust source regions 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 regions on July 30 and 31 (1993 – 2022). The median maximum daily temperature varies in the source region, but ranges from approximately 96 °F to 115 °F.

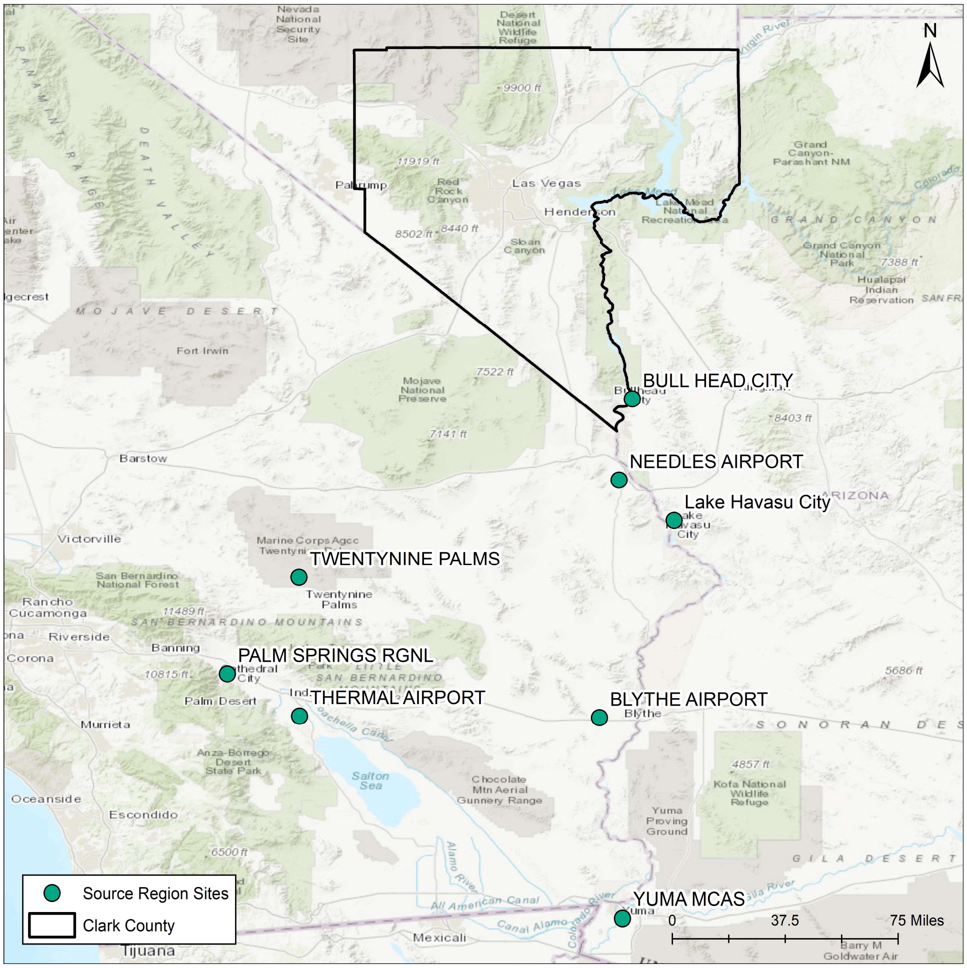


Figure 2.2-8. Location of ASOS measurement sites in the wind-blown dust source region.

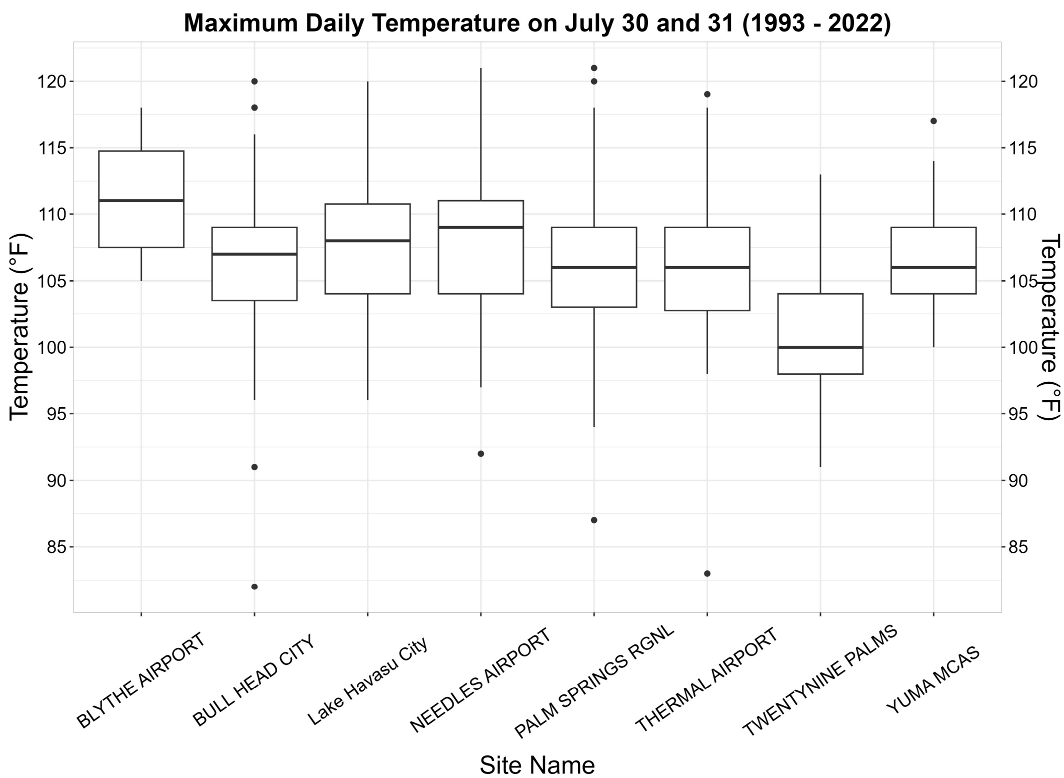


Figure 2.2-9. Maximum daily temperature on July 30 and July 31 from 1993 through 2022 at each measurement site.

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.

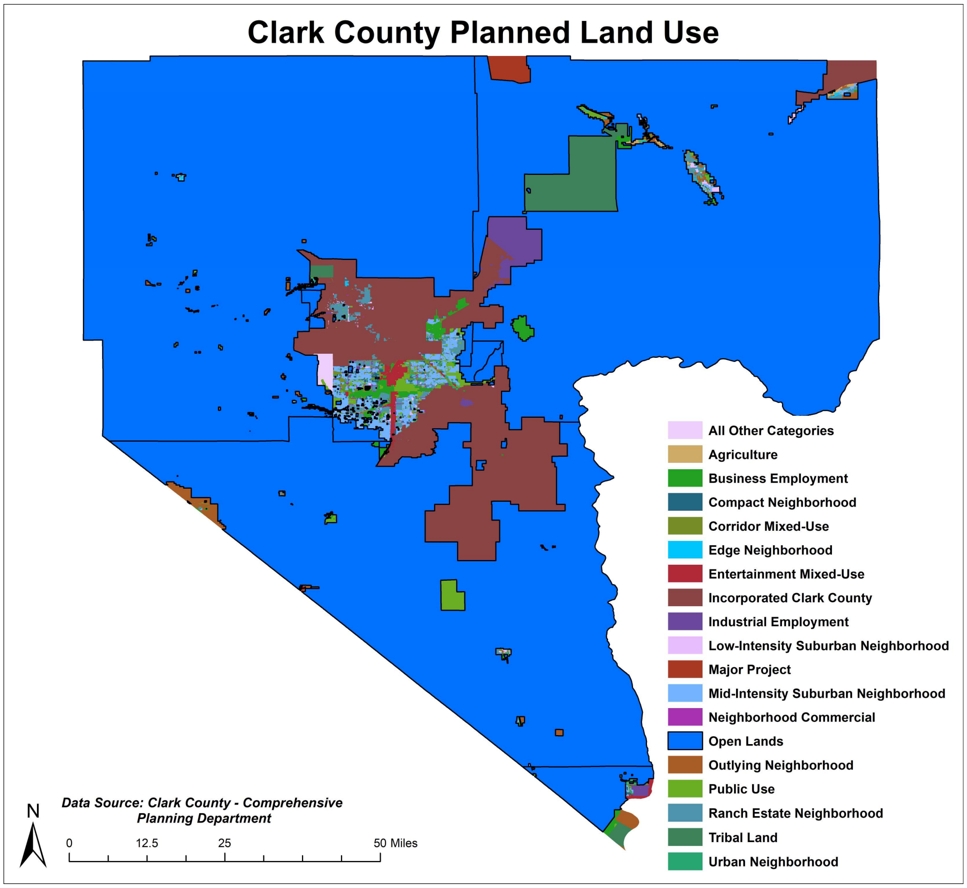


Figure 2.2-10. Planned land use boundaries of Clark County.

Planned land use around the Garret Jr. High site is comprised entirely of incorporated land (Figure 2.2-11). The site is in the center of a block that contains a large sports complex with grassy sports fields, open grassy fields, tracks, tennis courts, and the Garret Junior High School. The immediate area surrounding the block consists of suburban neighborhoods with little exposed dirt or gravel.

Figure 2.2-11. Planned land use boundaries in the area around the Garrett Jr High 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 consisting of parking lots and roads, with little exposed dirt or gravel.

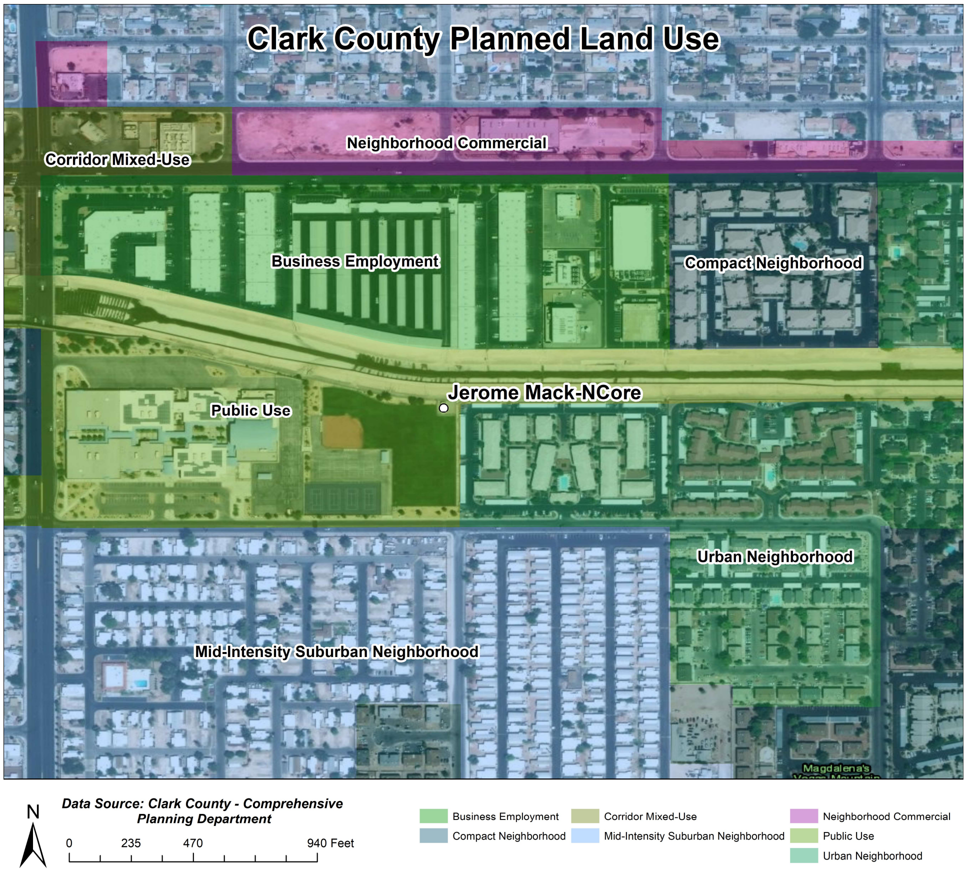


Figure 2.2-12. Planned land use boundaries in the area around the Jerome Mack station.

Planned land use around the Sunrise Acres site is comprised mostly of incorporated land (Figure 2.2-13). Residential areas are also present to the south, including compact neighborhoods, mid-intensity suburban neighborhoods, and commercial neighborhoods. Much of the surrounding area is comprised of buildings and paved surfaces, including parking lots and roads, with little exposed dirt or gravel. A vacant, undeveloped lot and a baseball field are present nearby, which may contribute to local dust during high-wind events.

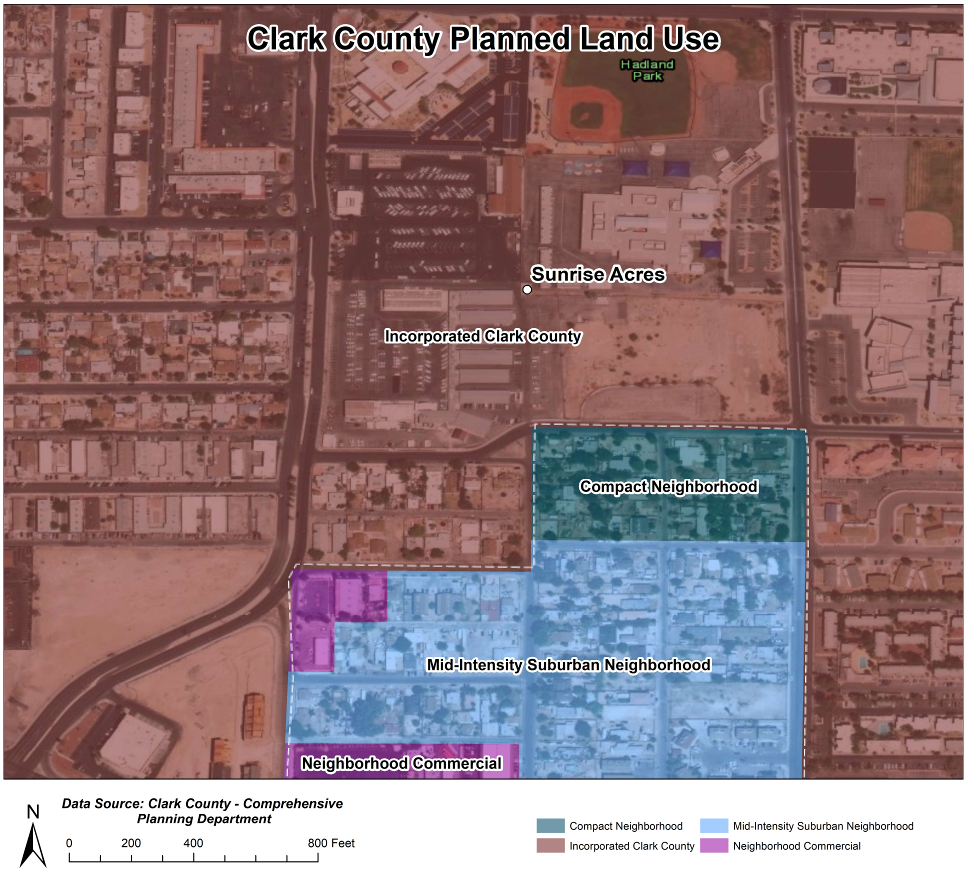


Figure 2.2-13. Planned land use boundaries in the area around the Sunrise Acres station.

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 in the area around the Walnut Community Center station.

Figure 2.2-15 shows the 2023 National Emissions Inventory (NEI) PM_{10} point sources around the affected sites. The size of the point source marker is proportional to the total annual PM_{10} emissions, and the map shows that most sites are not near major point sources. For example, there are no PM_{10} point sources within approximately 2 miles of the Jerome Mack site, and the closest point sources emit less than 3 tons of PM_{10} annually. The Green Valley site is approximately 3 miles from the nearest point sources, which includes 3 sites to the east emitting up to 8-18 tons of PM_{10} annually, and 1 site to the north that emits 4-7 tons of PM_{10} annually.

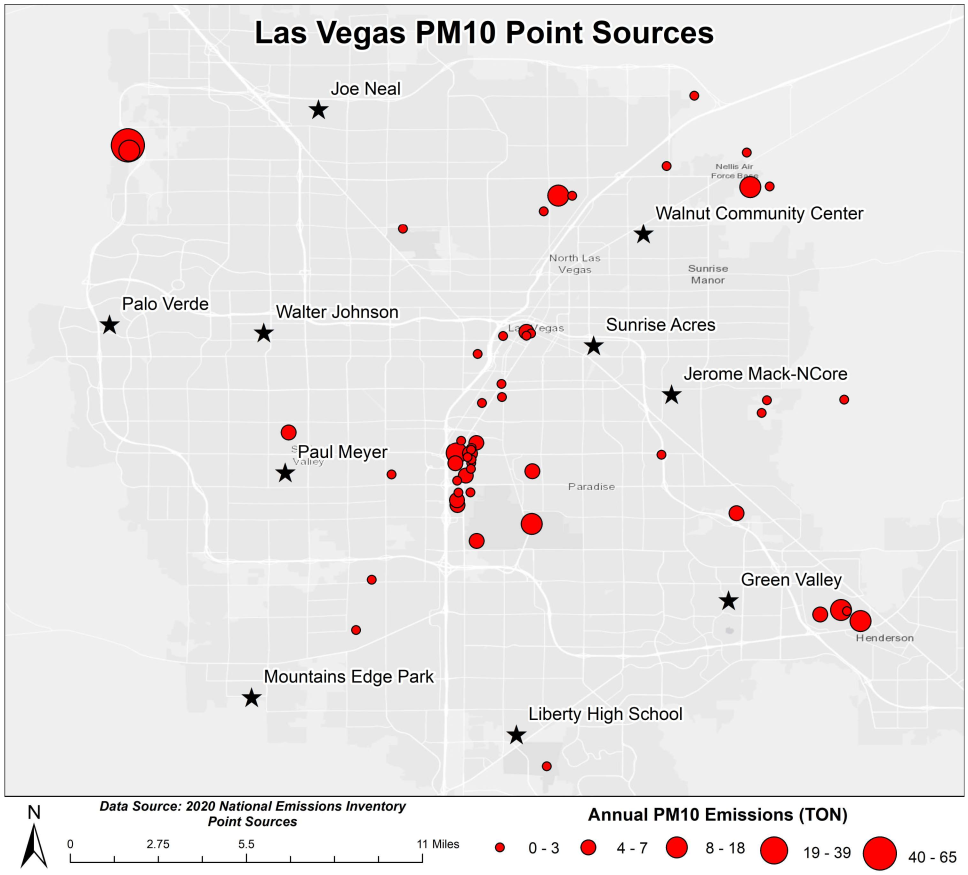


Figure 2.2-15. 2023 National Emissions Inventory (NEI) point sources of PM_{10}.

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 July 31, 2023, 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, wind erosion from construction, paved roads, and other sources has made an increasingly significant contribution to total emissions. As shown in Figure 2.2-10 through Figure 2.2-14, many sites are not near major paved roads. For example, 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). Thus, paved roads and on-road emissions likely did not contribute to the July 31, 2023, exceedance. The Sunrise Acres site is approximately 530 feet from the nearest major paved road source (N Eastern Ave), so these emissions may be more likely to impact this site.

Since this dust event was generated by the outflow boundary from a thunderstorm, forecasting the dust impacts in advance was not possible. Therefore, no Construction Notices or Dust Alerts were issued.

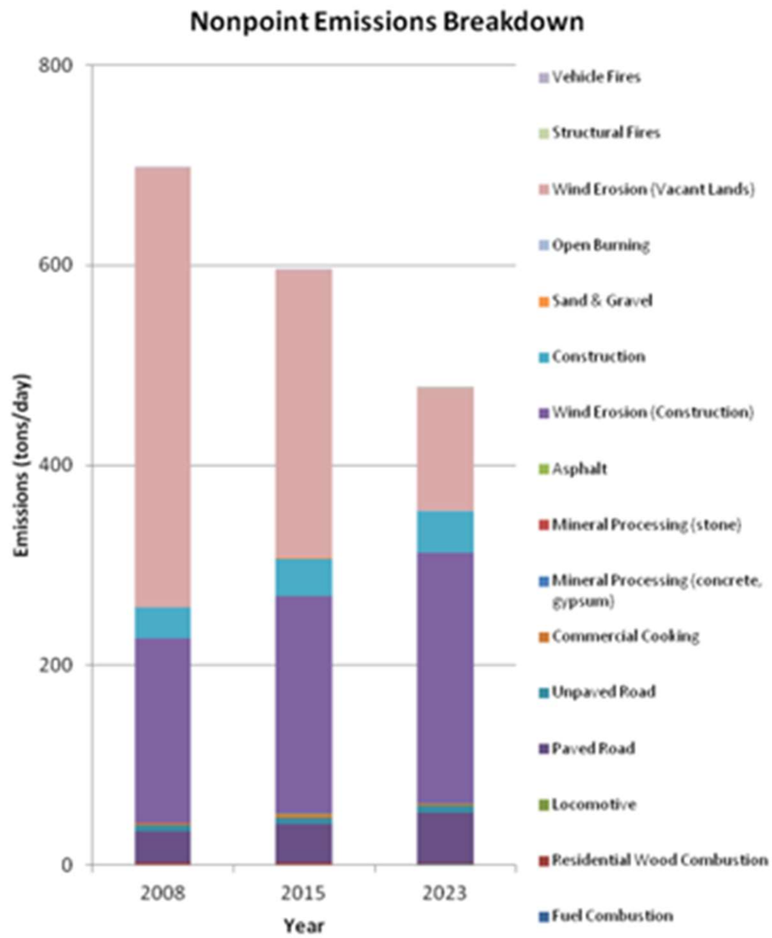


Figure 2.2-16. Nonpoint emissions inventory breakdown from the 2012 'Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})" document.

2.2.4 Historical Analysis of PM_{10} in Clark County

The 24-hour average PM_{10} values recorded on the event day ranged from 180 µg/m^3 at the Jerome Mack site to 188 µg/m^3 at the Sunrise Acres site. Table 2.2-1 displays the statistical summary of 24-hour average PM_{10} concentrations from the five years preceding the event (2019-2023) at all affected sites. The Garrett Jr. High and Walnut Community Center sites do not have a full five years of data collection, and summary statistics are therefore shown for the data available. Although not regulatorily significant, the table includes statistics for the Garrett Jr. High monitoring site to examine the regional effect of the high-wind dust event. The median concentration ranges from 16 µg/m^3 at the Garrett Jr. High site to 35 µg/m^3 at the Walnut Community Center site. The 99th percentile values were at or below 177 µg/m^3. Therefore, the 24-hour average PM_{10} values recorded on the event day exceeded seasonal averages and the 99th percentile for most of the individual sites.

Table 2.2-1 Five-year* (2019-2023) statistical summaries of 24-hour average PM_{10} concentration at affected sites. *Sites with less than five years of available data are indicated, and summary statistics are shown for available data.

Statistic (µg/m^3)	Jerome Mack	Sunrise Acres	*Garrett Jr. High	*Walnut Community Center
Count	1735	1747	937	883
Mean	34	36	22	39
Median	30	32	16	35
Mode	31	29	16	36
St. Dev	26	26	24	32
Minimum	4	4	1	6
95th percentile	63	71	49	68
99th percentile	119	110	140	177
Maximum	445	468	350	470
Range	441	464	349	464
Exceedances (> 150 µg/m^3)	14	13	7	12
24-hour average on 7/31/2023	180	209	184	187

Seasonal and monthly trends in the 24-hour average PM_{10} data at all affected sites for the five years preceding the event (2019-2023) are shown in boxplots in Figure 2.2-17 and Figure 2.2-18 (note that data is limited for several newer sites, as described in Table 2.2-1). The interquartile range is represented by the lower (25th percentile) and upper (75th percentile) edges of the box, 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 outlying and have been removed for monthly and seasonal trend clarity (Section 3.4.2 will present the same box plots but include the outliers). Interquartile ranges across the seasons show significant overlap, with median 24-hour average PM_{10} values lowest in spring (25 µg/m^3) and highest in autumn (35 µg/m^3). For July, the interquartile range is 23-36 µg/m^3, with a median value of 29 µg/m^3.

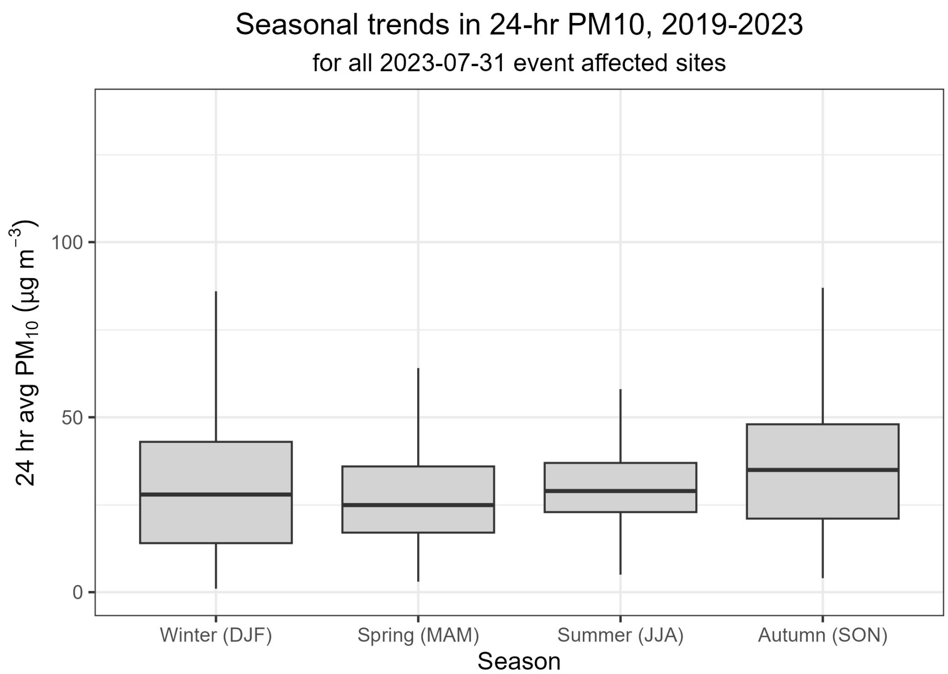


Figure 2.2-17. Seasonal trends in values of PM_{10} from 2019-2023 (outliers have been removed for trend clarity).

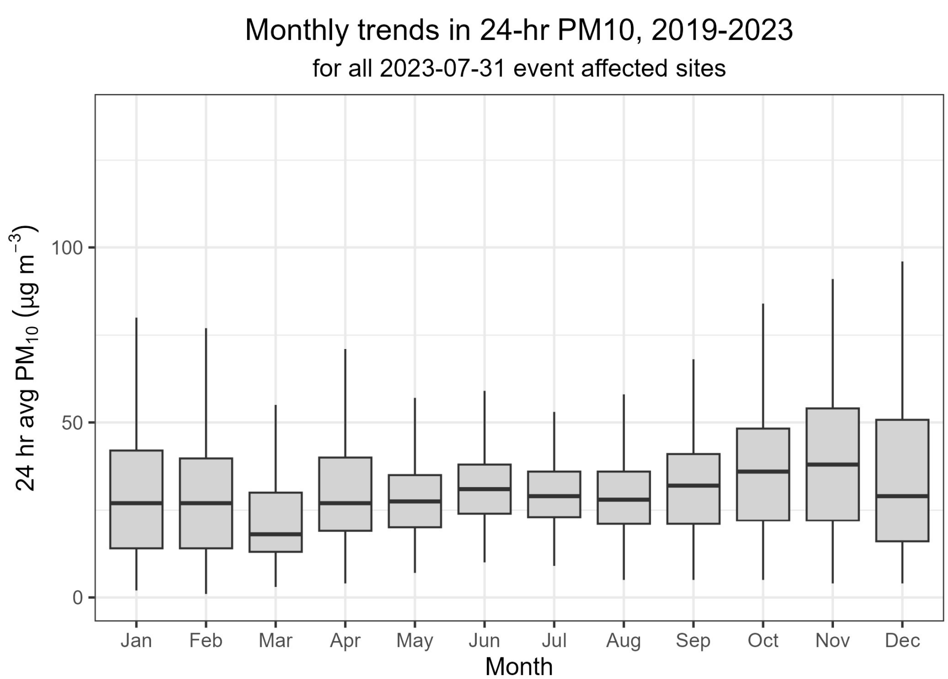


Figure 2.2-18. Monthly trends in values of PM_{10} from 2019-2023 (outliers have been removed for trend clarity).

3. Clear Causal Relationship

During late July 2023, a thunderstorm-induced outflow boundary caused high winds to develop through the Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California driving a windblown dust event that transported PM_{10} and increased concentrations in Clark County, Nevada, on July 31. Strong sustained winds in the source regions were greater than 40 mph. The winds associated with the outflow boundary lofted, entrained, and transported dust from the source regions to Clark County starting at 06:00-07:00 PST on July 31, and lasted through 18:00 PST. The drought conditions affecting the source region, as shown in **Section 2.2**, created an ample source of dust from friable soils. The evidence that support the high-wind dust event claim includes (1) transport from the Sonoran and Mojave Deserts to Clark County is clearly evident via meteorological analyses, radar images, and hour-by-hour progression of PM_{10} concentrations, (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 regions with the outflow boundary, evidence of transport from the source regions to Clark County via meteorological and PM_{10} analyses, and evidence of impacts of the high-wind dust event at the surface in Clark County. We also provide additional statistical evidence to compare this dust event with historical PM_{10} concentrations in Clark County.

3.1 High-Wind Event Origin

On the evening of July 30, 2023, and into the early morning hours of July 31, an area of thunderstorms developed across southern Arizona and northwestern Mexico, propagating northwestward toward southeastern California. An initial outflow boundary ahead of these storms produced strong southeasterly winds and blowing dust as it moved through southwestern Arizona and southeastern California. That outflow boundary also triggered additional thunderstorm development in southwestern Arizona and a subsequent new outflow boundary that combined with the initial outflow as it headed northward. Although wind speeds decreased as the combined outflows approached Clark County from the south, sustained winds as high as 44 mph and gusts up to 66 mph in the source regions of the Sonoran Desert and Mojave Desert of southeastern California were significant enough to produce a large area of blowing and lofted dust that propagated northward into Clark County behind the weakening outflow boundary. Radar imagery, surface wind observations, and PM_{10} concentrations confirm the arrival of the outflow and associated dust in the Las Vegas area between 05:00-07:00 PST on July 31. Once the dust reached Las Vegas, light cyclonic surface winds in the Las Vegas Valley recirculated dust around the city through the afternoon hours. The dust began to decrease at 18:00 PST on July 31, before another brief period of blowing dust occurred during the late evening hours from storms closer to Las Vegas. Radar imagery and hourly surface wind observations from the morning and evening storms confirm the generation of strong outflow winds, while hourly surface winds and regional trends in PM_{10} concentrations show the transport of dust from the source regions and into the Las Vegas area.

3.1.1 Meteorological Analysis

Several weather factors contributed to thunderstorm development and subsequent outflow winds and dust in the Las Vegas region on July 31, 2023. To assess the meteorological conditions that contributed to this dust event, observational data was analyzed from the following sources:

- Upper-air geopotential heights and vorticity
- Mesoanalysis of Convective Available Potential Energy (CAPE) and Downdraft Convective Available Potential Energy (DCAPE)
- Doppler radar imagery
- Hourly surface wind speed and direction
- Hourly regional PM_{10} concentrations

The following sections detail evidence from each of the above sources regarding the generation of blowing dust and its transport into Las Vegas. For completeness, this analysis examines the period between the evening of July 30, 2023, through the evening of July 31.

Upper-level Dynamics

One contributor to the July 31, 2023, high-wind dust event was an inverted upper-level trough of low pressure moving to the northwest across northern Mexico on the evening of July 30. A cluster of thunderstorms developed just ahead of the trough near a cyclonic vorticity maximum. If cyclonic vorticity, also known as positive vorticity, is increasing with height, it can induce upward vertical motion (Bluestein, 1992), which can support thunderstorm development in an unstable environment. In this case, the area of Positive Vorticity Advection (PVA) was downwind (to the northwest) of the inverted trough, and especially downwind of the vorticity maximum (see **Figure 3.1-1**). This PVA contributed directly to thunderstorm development, while the southeasterly mid-level winds helped steer the storms toward southeastern California.

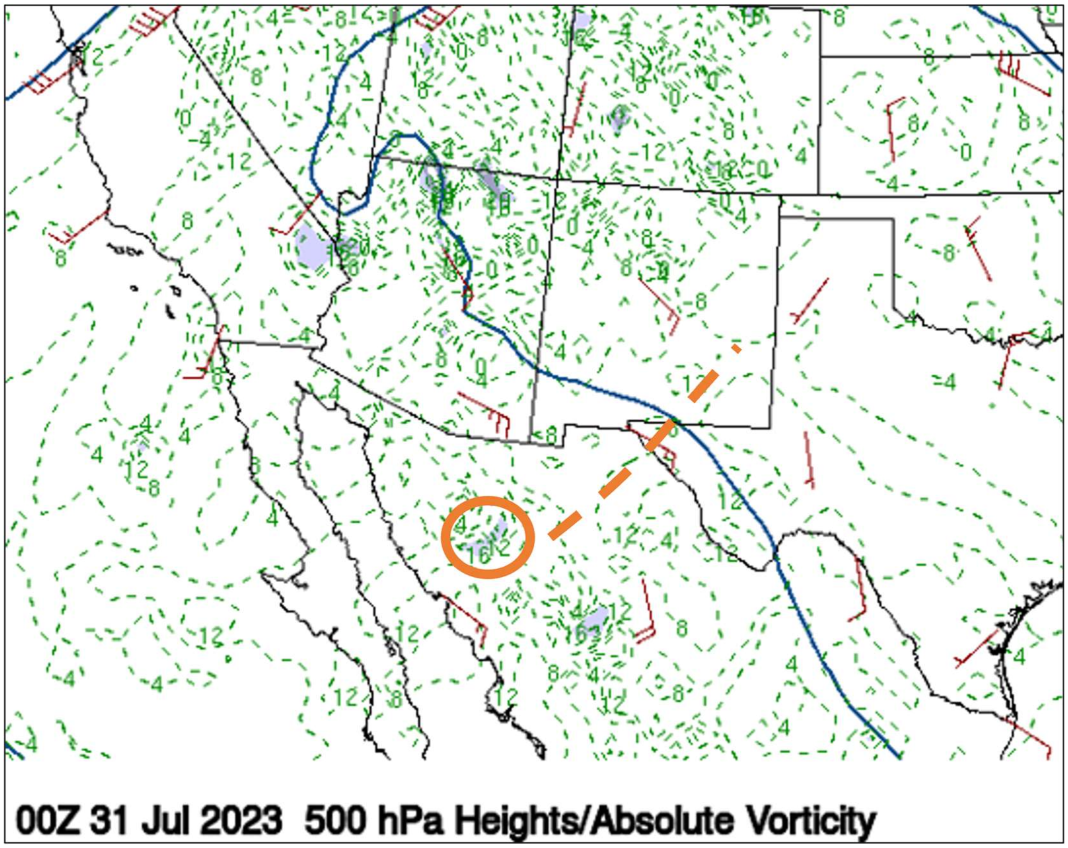


Figure 3.1-1. 500 hectopascal (hPa) heights/absolute vorticity values from 16:00 PST on July 30, 2023. The dashed orange line indicates the axis of an inverted trough of low pressure moving to the northwest. The orange circle shows the cyclonic vorticity maximum analyzed near a developing cluster of thunderstorms. Source: University of Wyoming.

Thermodynamics

Another key factor in the July 31, 2023, dust event was the thermodynamic environment ahead of the trough and vorticity maximum, shown in **Figure 3.1-2**. If the atmosphere is unstable thermodynamically, it can support strong updrafts and downdrafts. One measure of the strength of potential updrafts is CAPE. CAPE is a measure of the potential kinetic energy an air parcel can gain through buoyancy. If a parcel of air remains warmer than its environment, it is buoyant and can accelerate upward. CAPE values are usually considered small when less than 1,000 Joules/kilogram (J/kg), and large when greater than 2,500 J/kg (Markowski and Richardson, 2010). On this day, the Storm Prediction Center's (SPC) mesoanalysis archive indicates CAPE values in the most unstable portion of the atmosphere were near 2,000 J/kg, with some pockets greater than 2,500 J/kg across northwestern Mexico ahead of the approaching trough of low pressure.

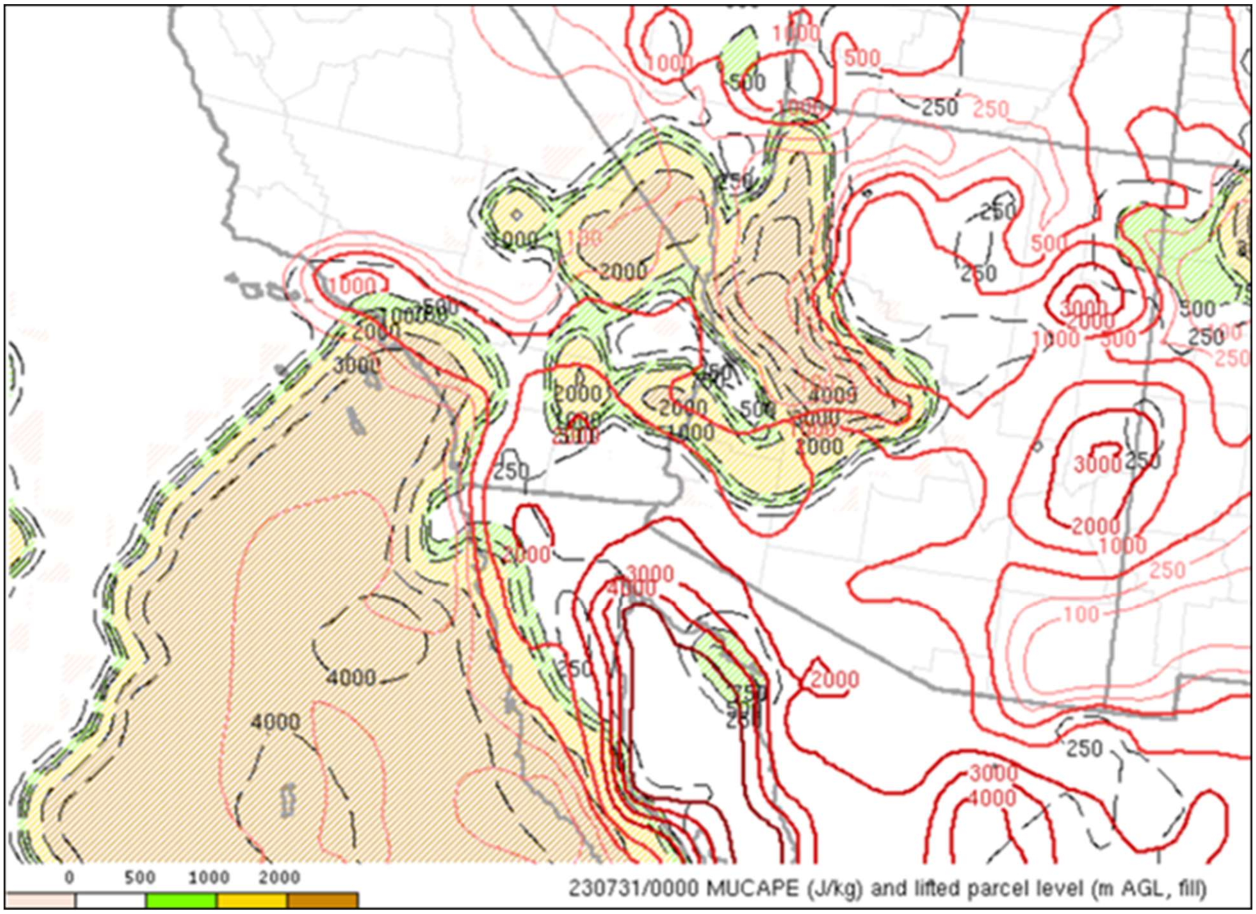


Figure 3.1-2. Most unstable CAPE (MUCAPE) and lifted parcel level (m) values at 16:00 PST on July 30, 2023. Red contours depict estimated MUCAPE, and filled lifted parcel levels indicate areas where instability is rooted aloft. Source: NOAA SPC.

The axis of instability extended into southeastern California, and pockets of CAPE over 2,000 J/kg were still being analyzed at 23:00 PST on July 30 (see Figure 3.1-3). A strong gradient in CAPE values was analyzed north of the Imperial Valley, with instability quickly decreasing to the north. This pattern supported continued thunderstorm development into southeastern California, but did not support thunderstorms continuing northward into Las Vegas during the night.

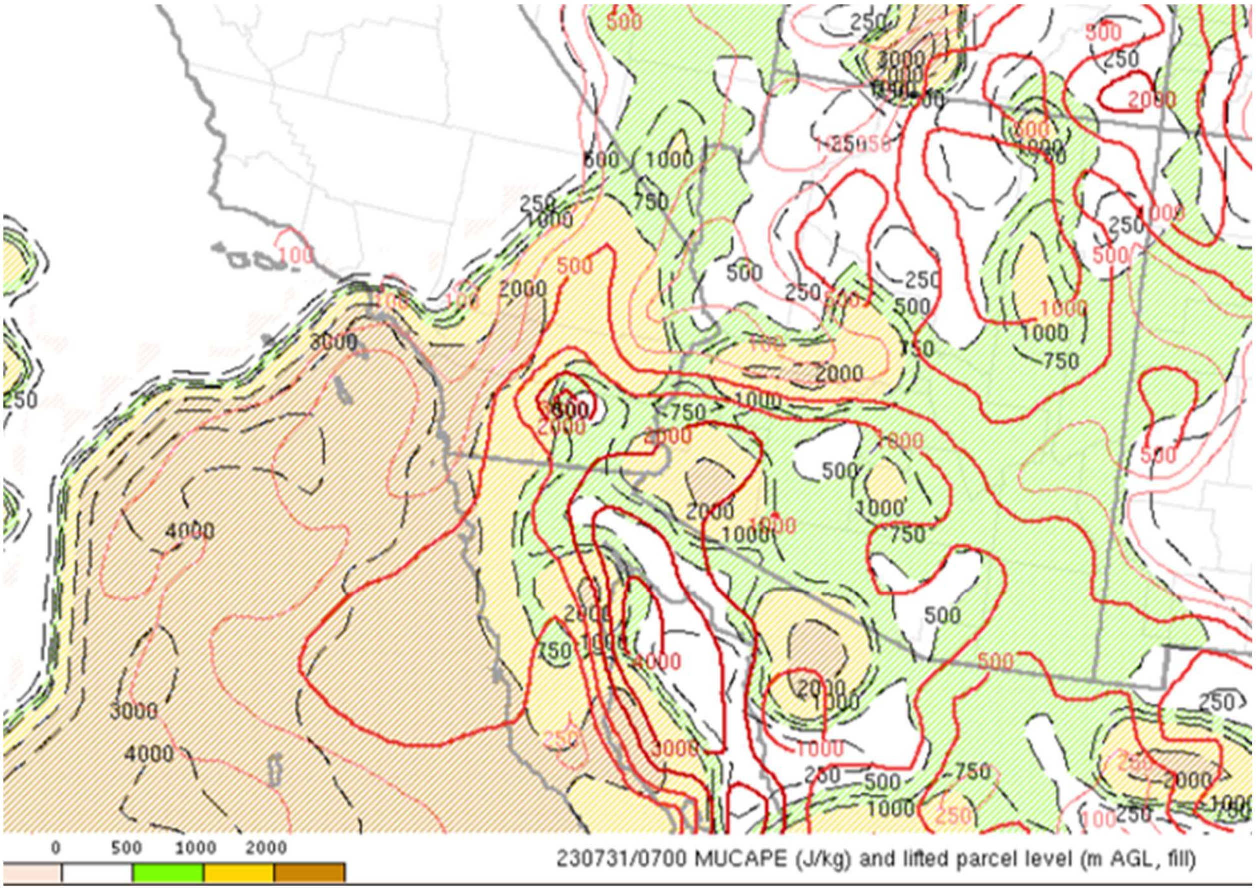


Figure 3.1-3. MUCAPE and lifted parcel level at 23:00 PST on July 30, 2023. Red contours depict estimated MUCAPE, and filled lifted parcel levels indicate areas where instability is rooted aloft. Source: NOAA SPC.

In addition to the upward directed instability of CAPE, another measure of instability, DCAPE, indicates the potential for parcels of air to accelerate downward toward the surface in the downdraft region of a thunderstorm. DCAPE can be greater in environments with low relative humidity in the boundary layer as the dry atmosphere promotes greater evaporative cooling, which can result in stronger downdrafts and outflow winds (Markowski and Richardson, 2010). Relative humidity was low in the boundary layer on this day; sounding measurements taken in Tucson, Arizona, at 16:00 PST on July 30, show a deep layer of dry air near the surface (see **Figure 3.1-4**).

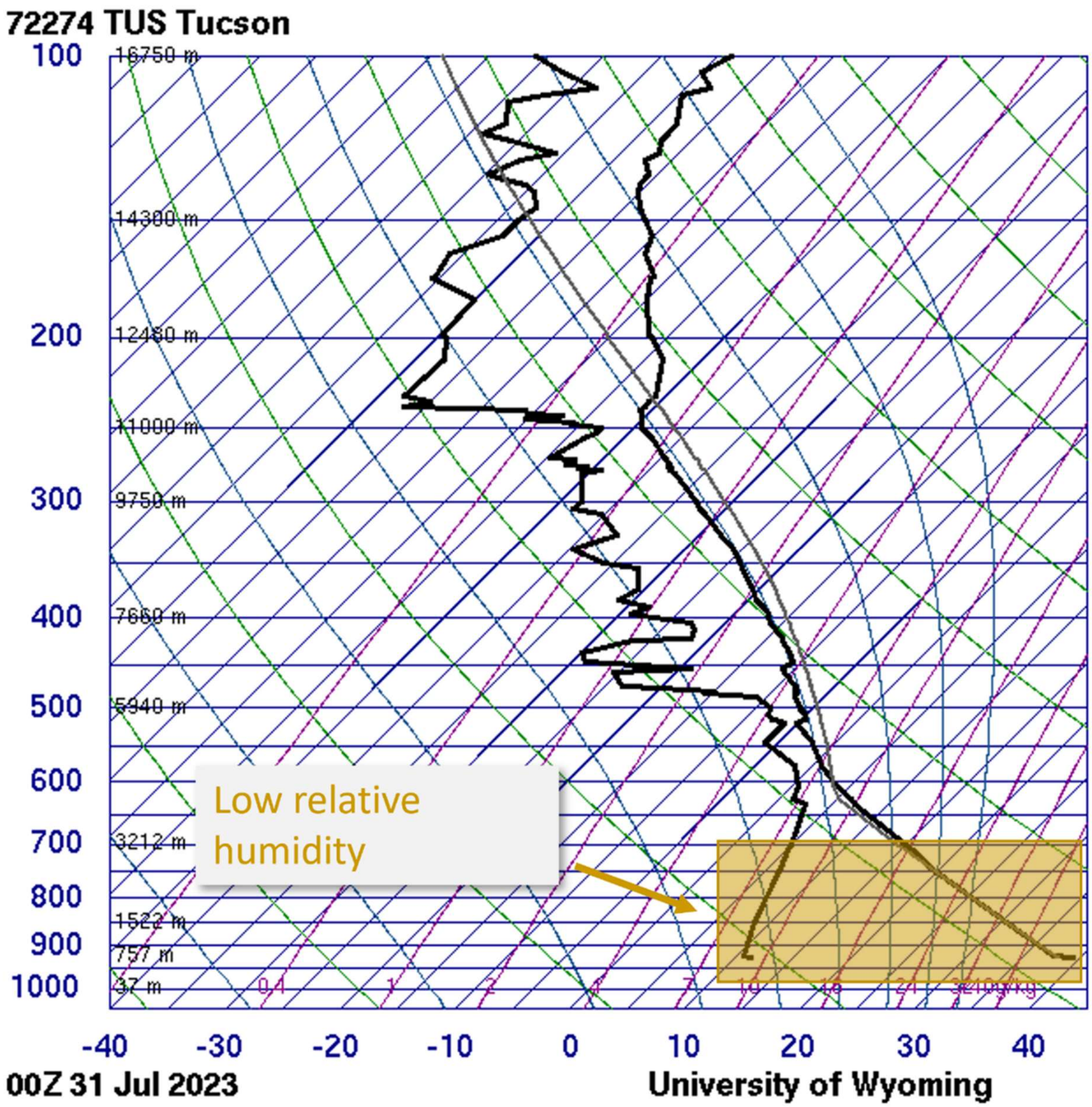


Figure 3.1-4. Sounding measurements taken in Tucson, Arizona, at 16:00 PST on July 30, 2023, showing low relative humidity in the lowest portions of the boundary layer. The left black line is the dewpoint temperature (°C), while the right black line is temperature (°C). The vertical axis is atmospheric pressure in hPa. Source: University of Wyoming.

National Weather Service guidance on DCAPE is that the potential for strong downdrafts and outflow winds increase with DCAPE values greater than 1,000 J/kg. The SPC's mesoanalysis from July 30, taken at 16:00 and 23:00 PST, show a large area of DCAPE values greater than 1,000 J/kg over the region, with maximum values near 1,600 J/kg (see Figure 3.1-5), indicating the potential for strong outflow winds from southern Arizona into southeastern California.

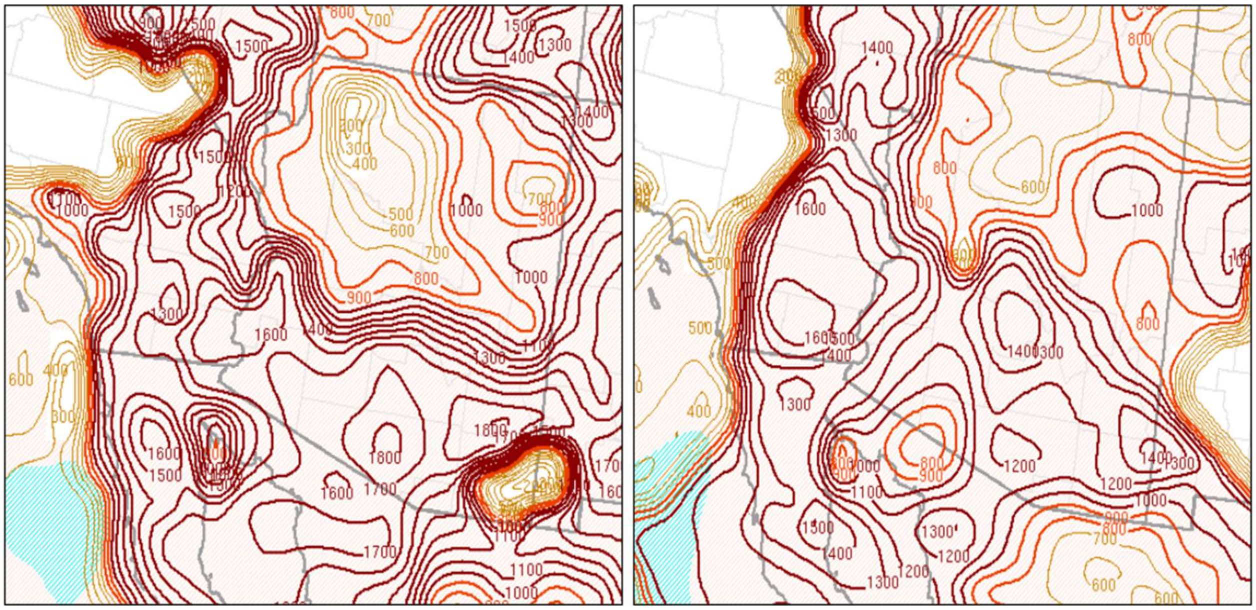


Figure 3.1-5. SPC mesoanalysis DCAPE on July 30, 2023, at 16:00 PST (left) and 23:00 PST (right), indicate potential for strong downdrafts and outflow winds. The minimum of 800 J/kg recorded near southwestern Arizona is due to the atmosphere stabilizing where thunderstorms and outflows were already occurring at 23:00 PST. Source: NOAA SPC.

In summary, weather conditions supported the development of thunderstorms on July 30, 2023, due to the trough of low pressure aloft and associated PVA moving into an unstable environment. In addition, high values of DCAPE due to low relative humidity conditions in the boundary layer supported the development of strong downdrafts and outflow winds. Regional doppler radars were well-positioned to sample the storms and outflow boundaries, providing further evidence of the blowing dust that led to high concentrations of PM_{10} in Las Vegas on July 31.

Doppler Radar Evidence of Strong Outflow Winds

Doppler radar imagery can be useful for analyzing outflow winds. Fine lines on base reflectivity often indicate the leading edge of gusty outflow winds ahead of a complex of thunderstorms. Base velocity is also useful, particularly when diagnosing winds that are perpendicular to the radar beams, as the radar can best measure winds that are directly inbound and outbound near the radar site. That was the case for this event, as some of the initial outflow winds went directly across the doppler radar located in Yuma, Arizona, KYUX.

Radar imagery from the evening of July 30, 2023, shows a cluster of thunderstorms developing northwestward from southeastern into southcentral Arizona and northwestern Mexico. A fine line on base reflectivity coinciding with an outflow boundary appears ahead of this complex of thunderstorms and progresses toward southwestern Arizona, and approaches KYUX near 23:00 PST on July 30 (see **Figure 3.1-6**).

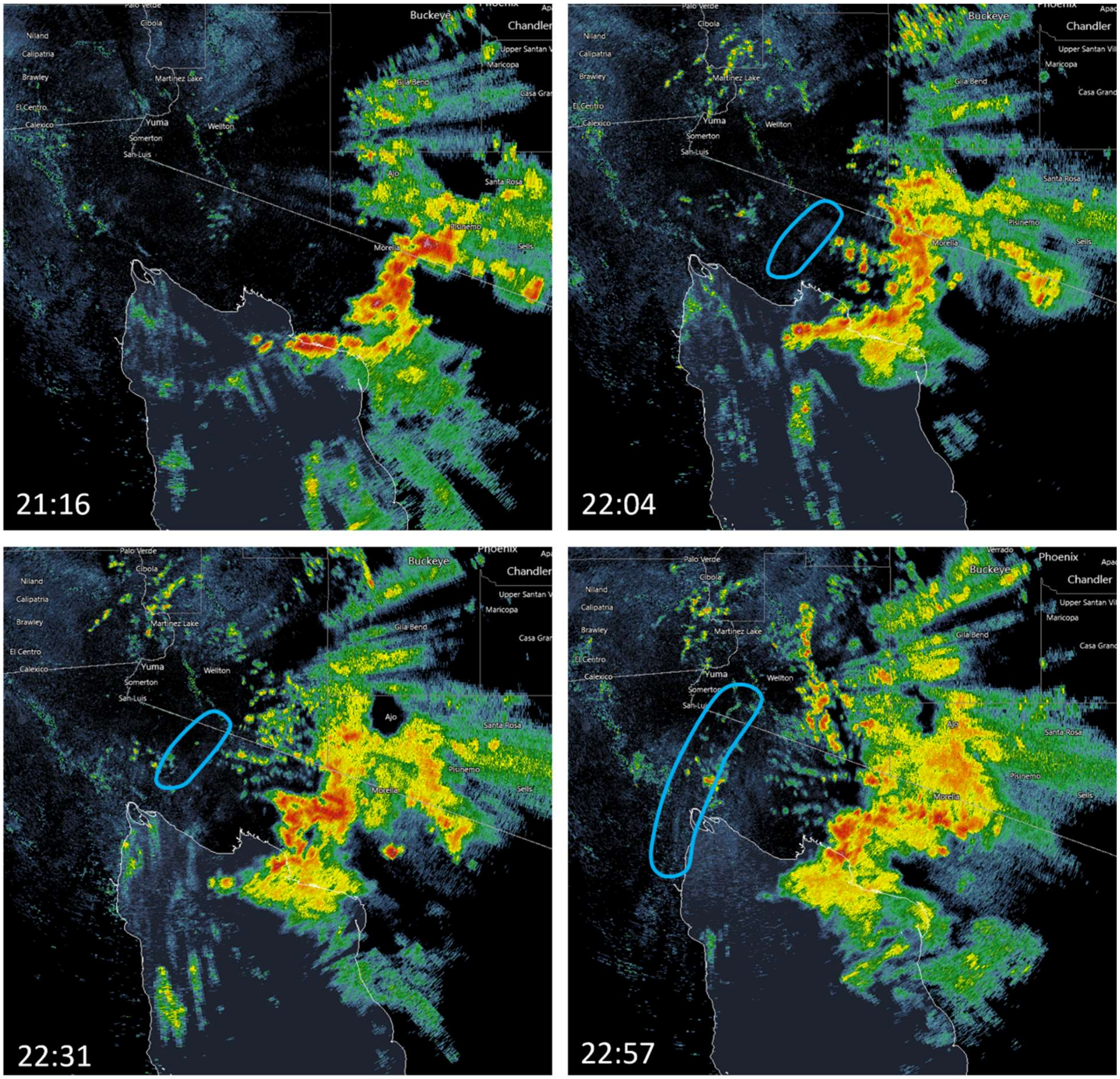


Figure 3.1-6. Doppler radar imagery between 21:16 and 22:57 PST on July 30, 2023, showing a cluster of thunderstorms and an associated outflow boundary moving toward Yuma, Arizona. Blue contour indicates the approximate position of the leading edge of outflow winds. Source: RadarScope.

An area of increasing southeasterly winds is visible along the outflow boundary on the high-resolution base velocity data, approaching KYUX from the southeast (see **Figure 3.1-7**). As the boundary passed over KYUX, radar measurements estimated near surface winds were between 40-45 mph, and PM_{10} concentrations peaked at 3,040 ug/m^3 at the Yuma Supersite. It should be noted that this value is marked with an "AN - Machine Malfunction" null code in AQS, likely due to extremely high PM_{10} concentrations (above the manufacturer's operating specifications). The next hour in Yuma shows a PM_{10} concentration of 486.0 µg/m^3 and is qualified with "IJ – High Winds" null code in AQS, providing evidence of the high-wind dust event affecting the Yuma area.

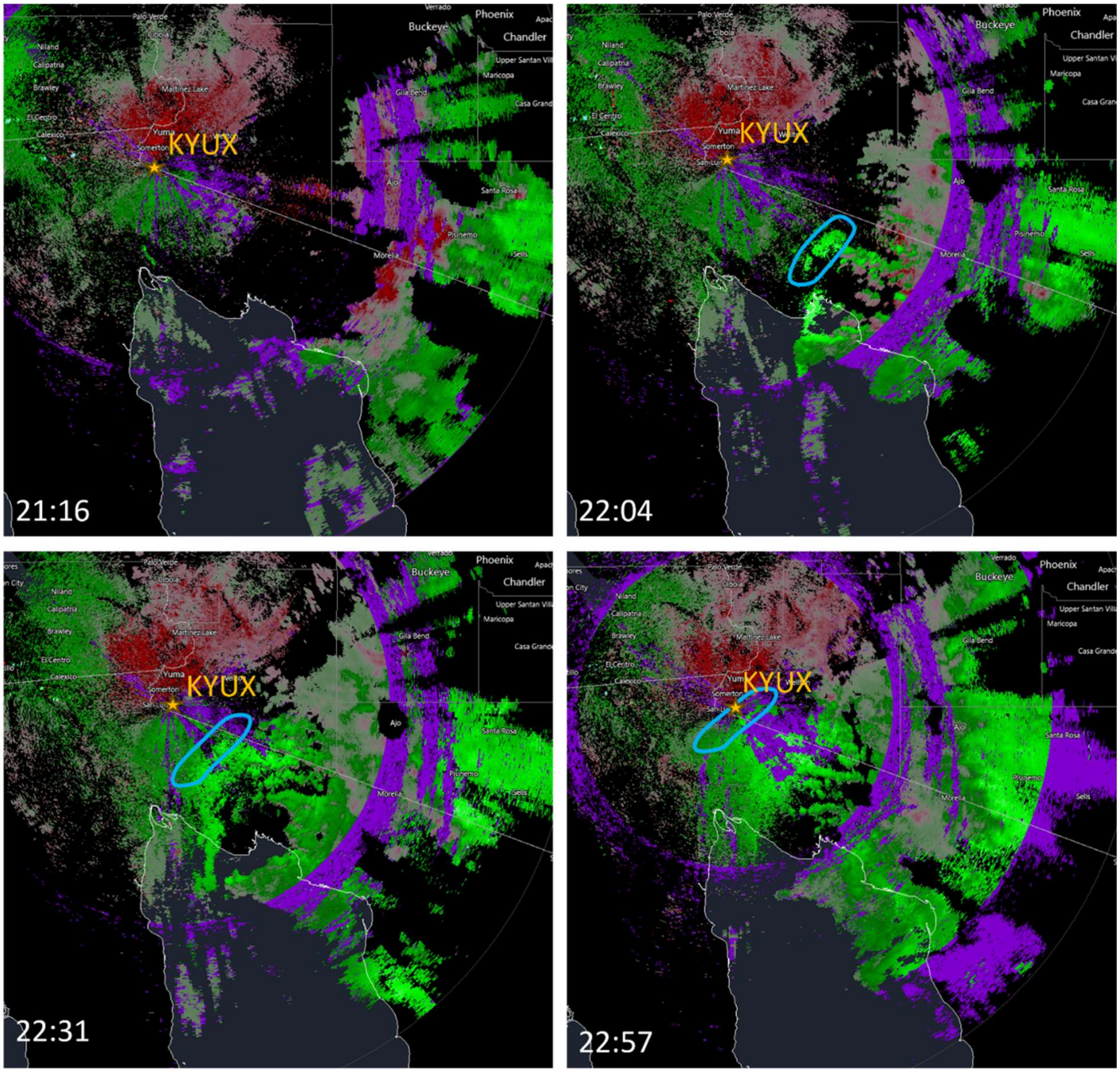


Figure 3.1-7. Base velocity between 22:04 and 22:57 PST on July 30, 2023, showing increasing southeasterly winds towards Yuma, Arizona, correlated with the approach of the fine line on base reflectivity shown in Figure 3.1-6. Green pixels indicate winds that are inbound toward the radar, and red pixels indicate winds that are outbound from the radar. Blue contour shows the approximate location of the leading edge of outflow winds. Purple pixels denote regions of range-folding. The KYUX doppler radar in Yuma is marked with a star. Source: RadarScope.

The outflow boundary proceeded northwest of KYUX and into the Imperial Valley of southeastern California just before midnight (labelled A in Figure 3.1-8). Meanwhile, additional thunderstorms developed across southwestern Arizona (labelled B in Figure 3.1-8). These storms developed near the area of maximum DCAPE shown in Figure 3.1-5. Outflow winds from the additional thunderstorms reinforced and intensified the existing outflow winds, with a more clearly defined outflow boundary moving northward toward southern Nevada by 00:27 PST on July 31, 2023 (see bottom panel in Figure 3.1-8).

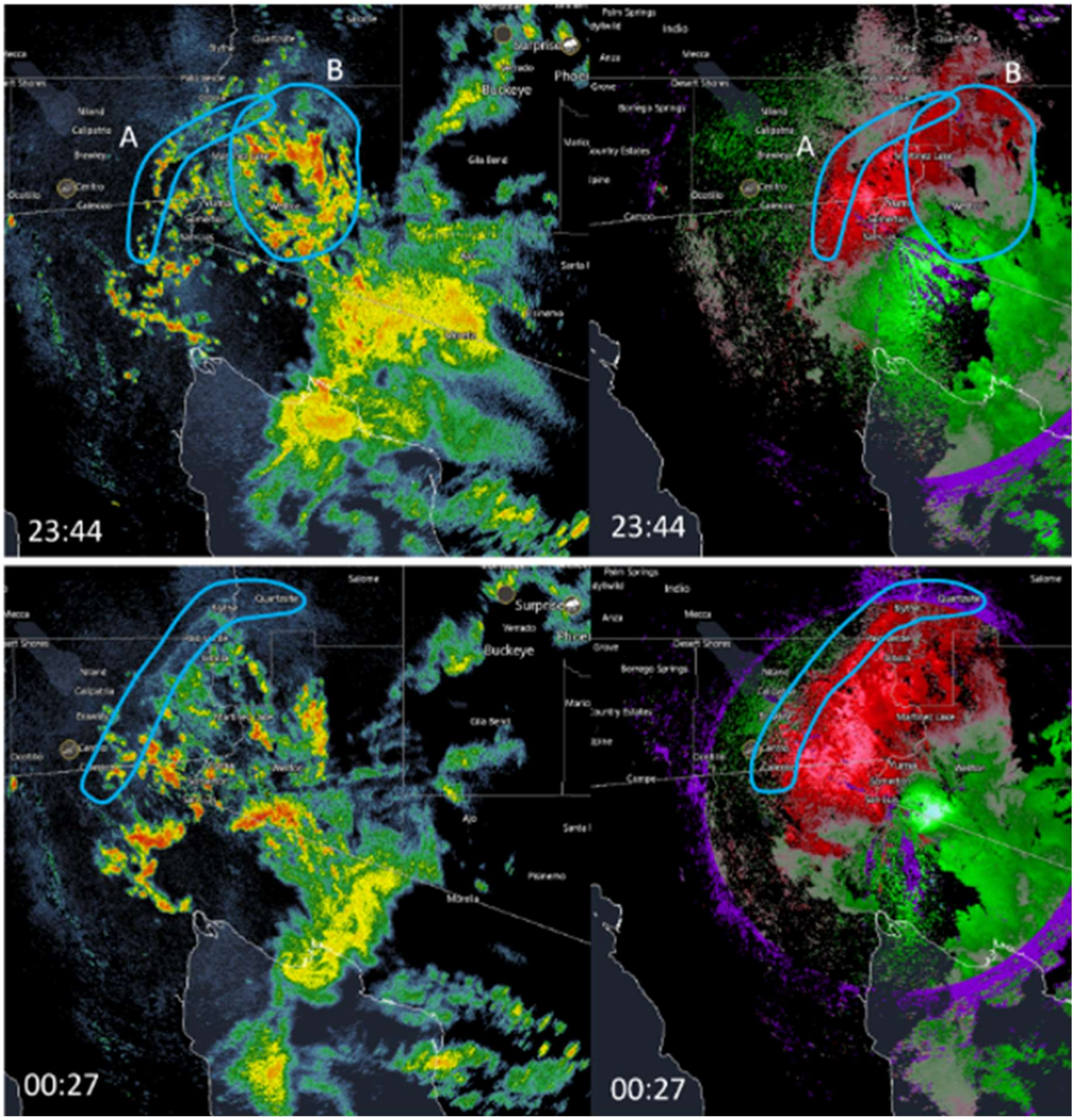


Figure 3.1-8. Radar base reflectivity (left) and base velocity (right) measurements taken over southwestern Arizona. The initial outflow (A) combines with a new outflow (B) generated by storms over the region at around 23:44 PST on July 30, 2023. By 00:27 PST on July 31, a distinct outflow boundary is moving to the north and northwest from KYUX. Source: RadarScope

Wind speeds across southern Imperial County in California were estimated near 50 mph by KYUX at 00:27 PST on July 31, 2023. Radar estimated near-surface winds are shown in **Figure 3.1-9**.

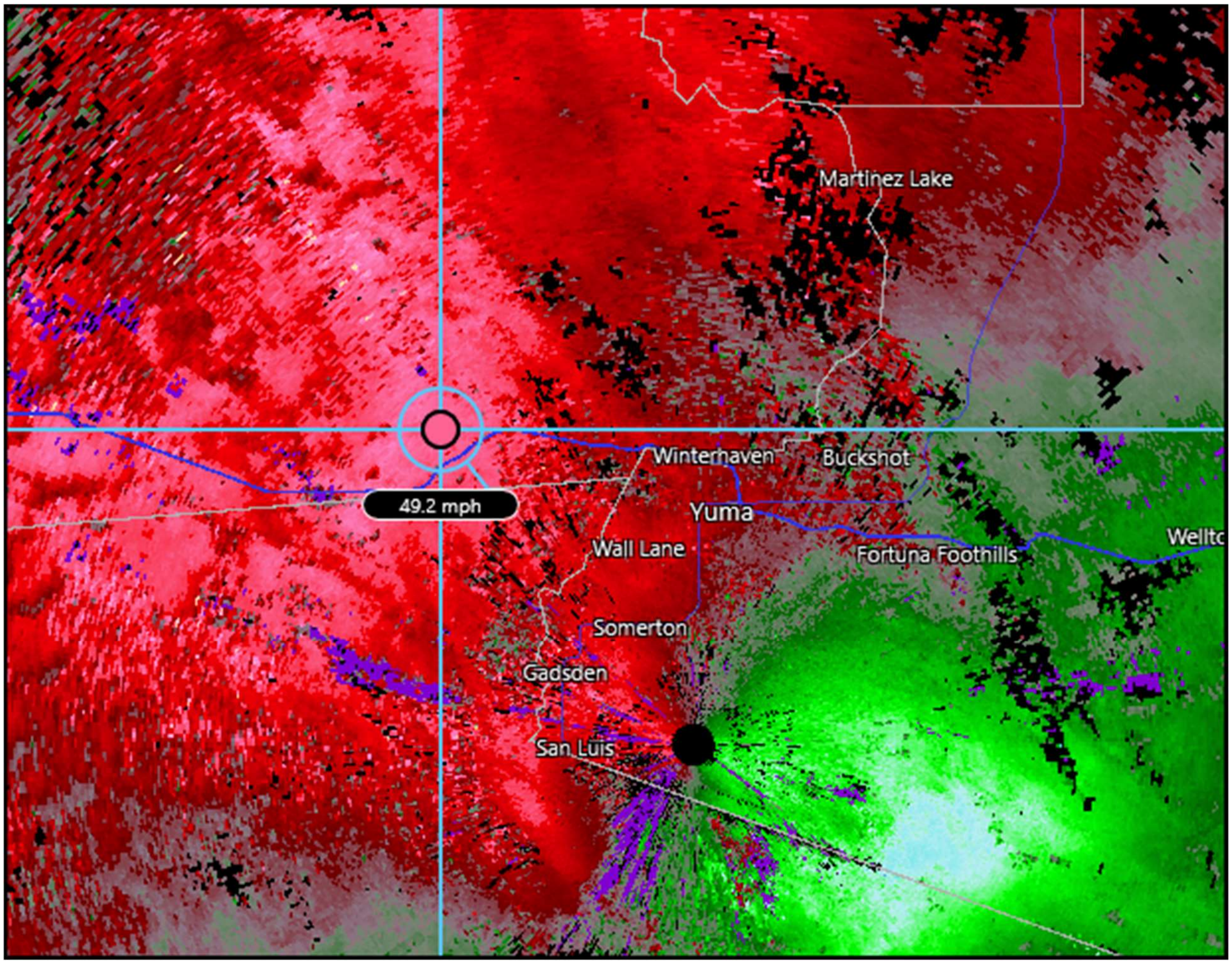


Figure 3.1-9. Doppler radar base velocity estimates of outflow winds over southeastern California at 00:27 PST on July 31, 2023. Pink hues indicate a broad area of outflow southeasterly near-surface winds close to 50 mph. Source: RadarScope.

Radar estimated winds were verified by storm reports from SPC (see **Figure 3.1-10**).

0903	59	2 NNE Seeley	Imperial	CA	3282	11567	Measured wind gust of 51 kts at KNJK from thunderstorm outflow winds. (PSR)
0925	66	1 WSW Imperial	Imperial	CA	3283	11558	Measured wind gust of 57 kts at KIPL (Imperial Airport) from thunderstorm outflow winds. (PSR)
							Corrects previous tstm wnd dmg report from 2 SW Coachella.

Figure 3.1-10. Storm reports from Imperial County measured wind gusts of 51-57 kts (59-66 mph). Source: NOAA SPC.

Sustained winds exceeded 25 mph regionally, and the 66 mph gust recorded at the Imperial County Airport (KIPL) was the regional maximum gust (see **Figure 3.1-11** and **Figure 3.1-12**).

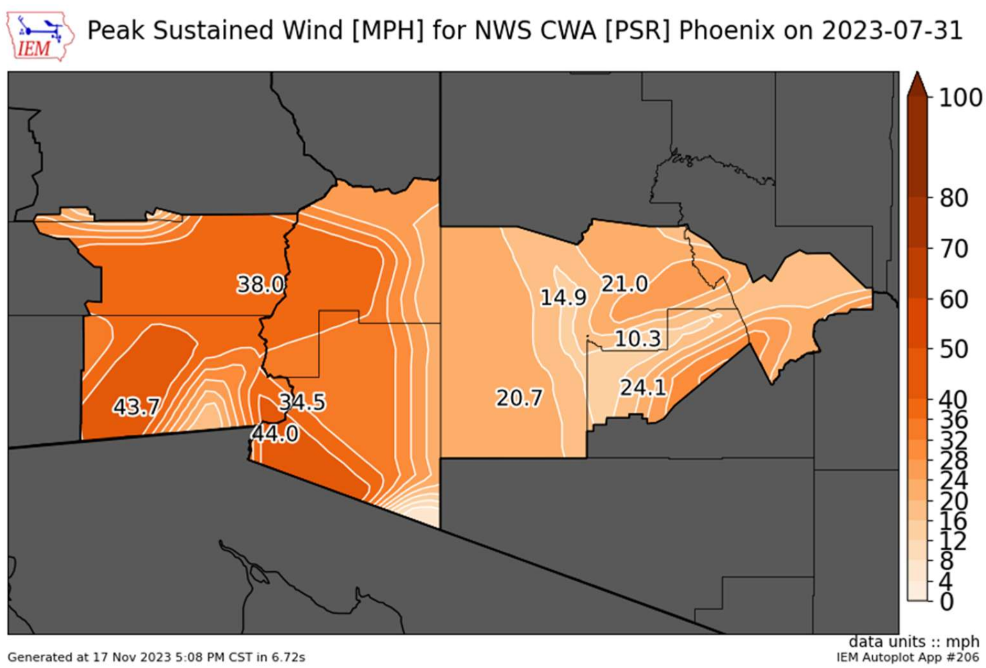


Figure 3.1-11. Peak sustained winds (mph) for NWS Phoenix on July 31, 2023. Source: Iowa State University.

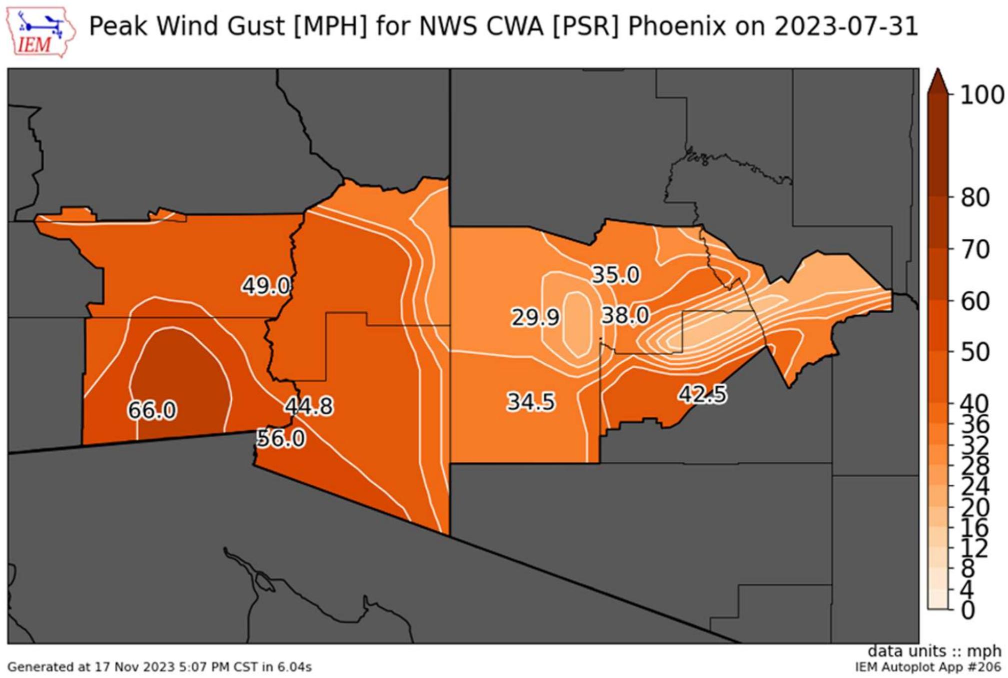


Figure 3.1-12. Peak wind gusts (mph) for NWS Phoenix on July 31, 2023. Source: Iowa State University.

The thunderstorms and strong winds did not maintain their strength as the outflow advanced into the Las Vegas region from the south, due in part to the lack of significant instability in that region as shown in Figure 3.1-3. However, winds remained strong enough to transport the lofted dust into the Las Vegas area. A distinct wind shift is shown on the base velocity data from the radar site KESX southeast of Las Vegas as the outflow boundary moves through. At 3:04 PST on July 31, 2023, winds closest to the surface at KESX were light southwesterly, with some weak returns on radar approaching from the south-southeast above the outflow boundary (see **Figure 3.1-13**). Additional evidence that this radar signature corresponds with the outflow boundary is shown in **Figure 3.1-16**, with PM_{10} concentrations increasing in Bullhead City, Arizona, between 3:00-4:00 PST.

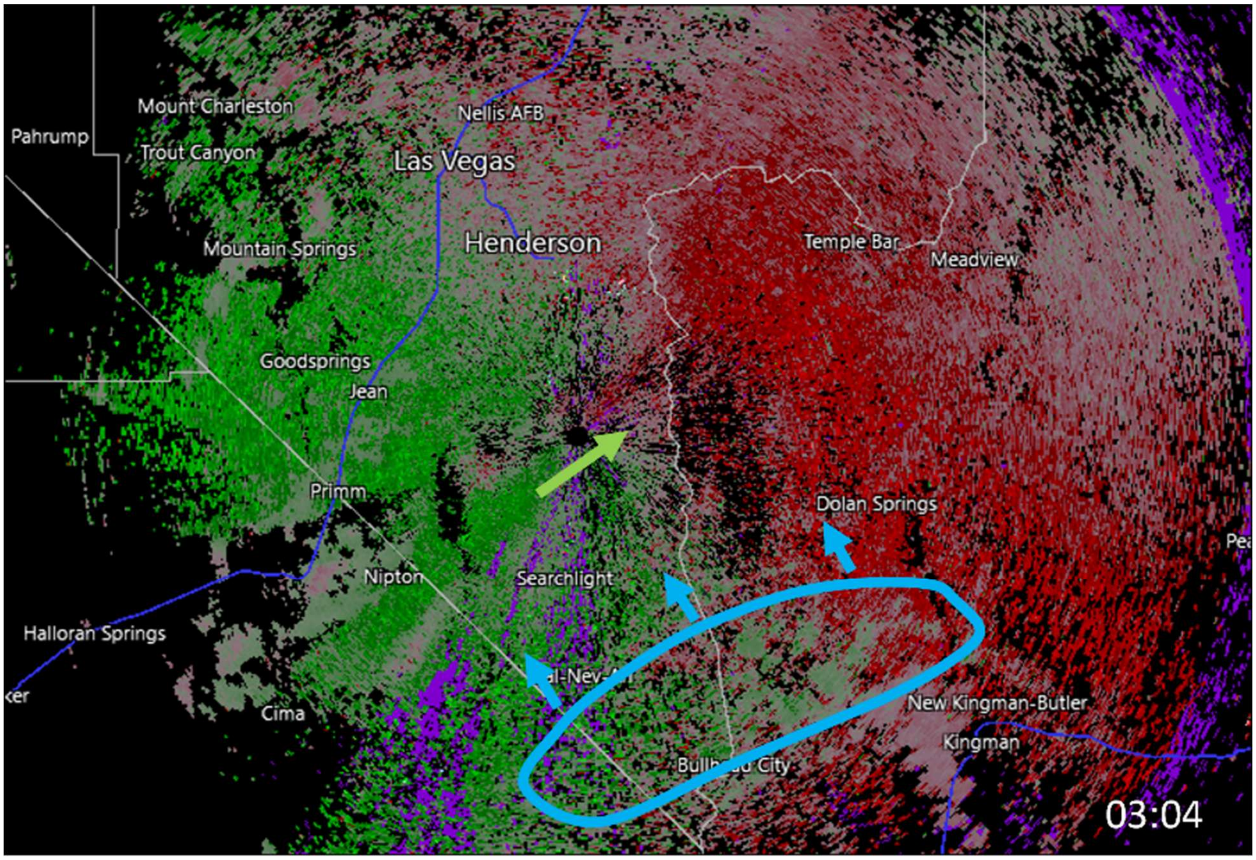


Figure 3.1-13. Base velocity measured at KESX at 03:04 PST on July 31, 2023. The green arrow indicates the direction of near surface winds close to the radar. The blue contour shows an area of weak radar returns approaching from the south-southeast above the outflow boundary. The boundary has passed Bullhead City, Arizona, by this time. Source: RadarScope.

By 03:57 PST on July 31, 2023, surface winds measured at KESX had increased to around 20 mph and shifted to south-southeasterly as the outflow boundary moved toward Las Vegas. (see **Figure 3.1-14**)

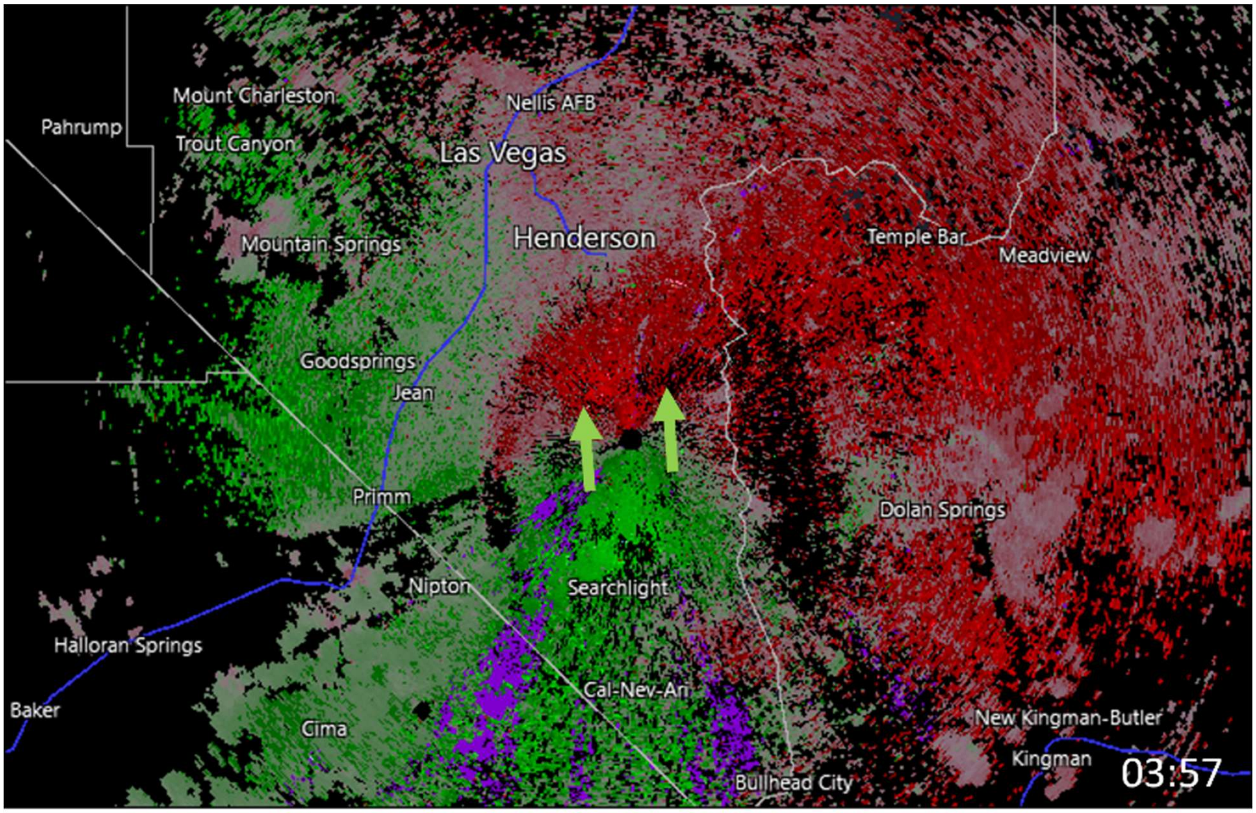


Figure 3.1-14. Radar estimated winds measured at 03:57 PST on July 31, 2023. Winds had shifted to southerly and increased to around 20 mph, indicating the passage of the outflow boundary from the south. The green arrows indicate the approximate wind direction at the surface. Source: RadarScope.

Surface Wind and PM_{10} Measurements

The movement and timing of the outflow boundary depicted by radar imagery closely matches the progression of southerly outflow winds as they moved northward on hourly surface wind observations, as well as the progression of increasing PM_{10} concentrations from the source regions into Las Vegas during the morning of July 31, 2023. The following series of images, **Figure 3.1-15 to Figure 3.1-20** show the hourly evolution of surface winds and PM_{10} concentrations across the region. The brown line added to each figure indicates the estimated leading edge of southerly winds and blowing dust at each time step.

Figure 3.1-15 shows the impacts of increasing southeasterly winds in Imperial County, California, as the initial thunderstorm outflow arrived in that region. Wind speeds increased from 10-15 mph to 20-25 mph, with gusts increasing from around 20 mph to near 50 mph from 00:00-01:00 PST on July 31, 2023. PM_{10} concentrations also increased from 00:00-02:00 PST on July 31; the Westmorland PM_{10} monitor recorded maximum concentrations near 2,000 µg/m^3 from 00:00-01:00 PST, and the Niland PM_{10} monitor recorded maximum concentrations near 6,000 µg/m^3 from 01:00-2:00 PST.

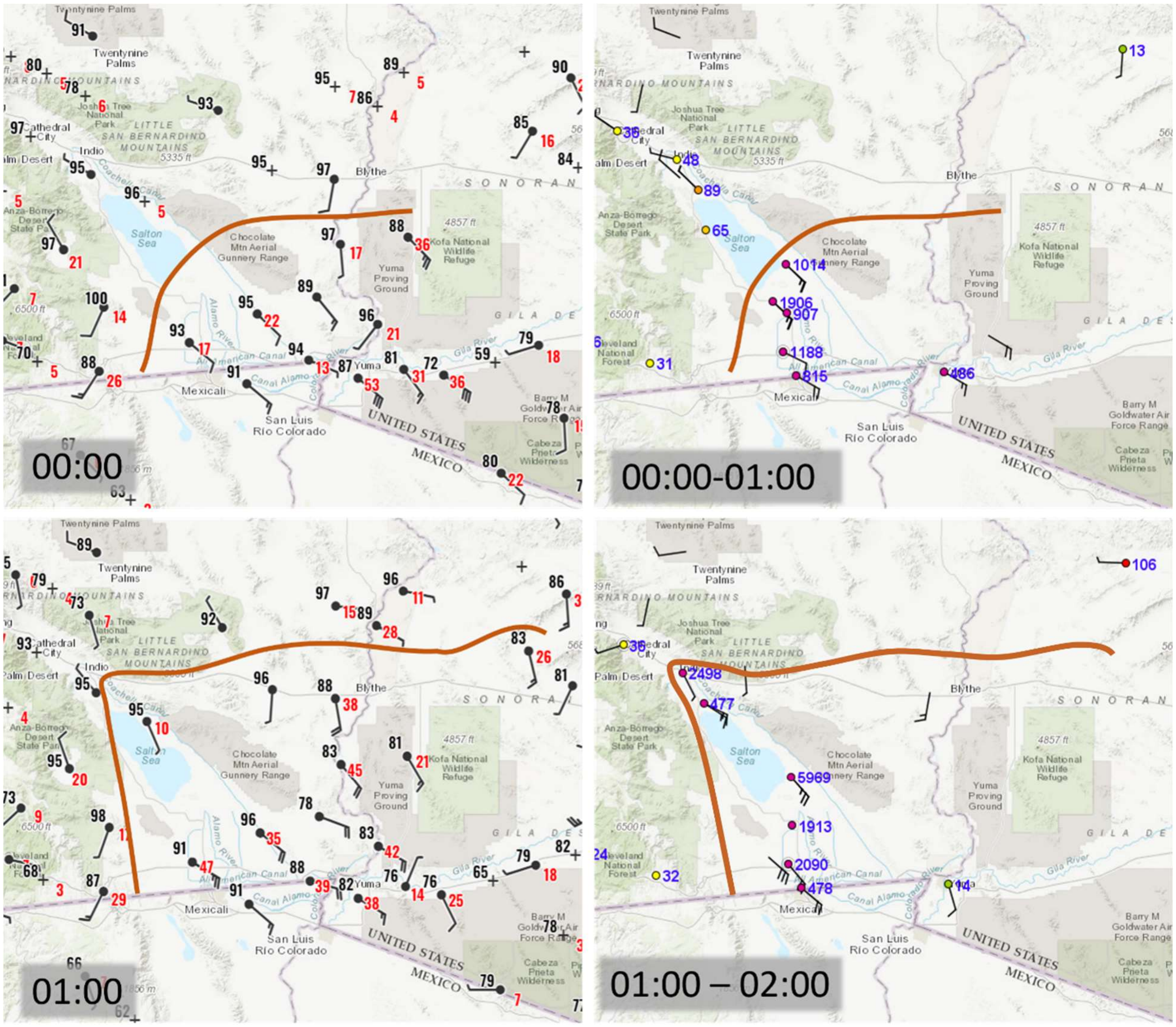


Figure 3.1-15. Increasing winds (left) and PM_{10} concentrations (right) recorded from 00:00-02:00 PST on July 31, 2023, due to outflow boundary passage. Sources: National Weather Service/AirNow-Tech.

Winds that were initially calm to easterly north of the boundary shifted to southerly as the boundary moved northward across southeastern California and into southern Nevada. Simultaneously, PM_{10} concentrations in Bullhead City, Arizona, increased from 24 µg/m^3 at 3:00 PST to 177 µg/m^3 by 4:00 PST (see Figure 3.1-16).

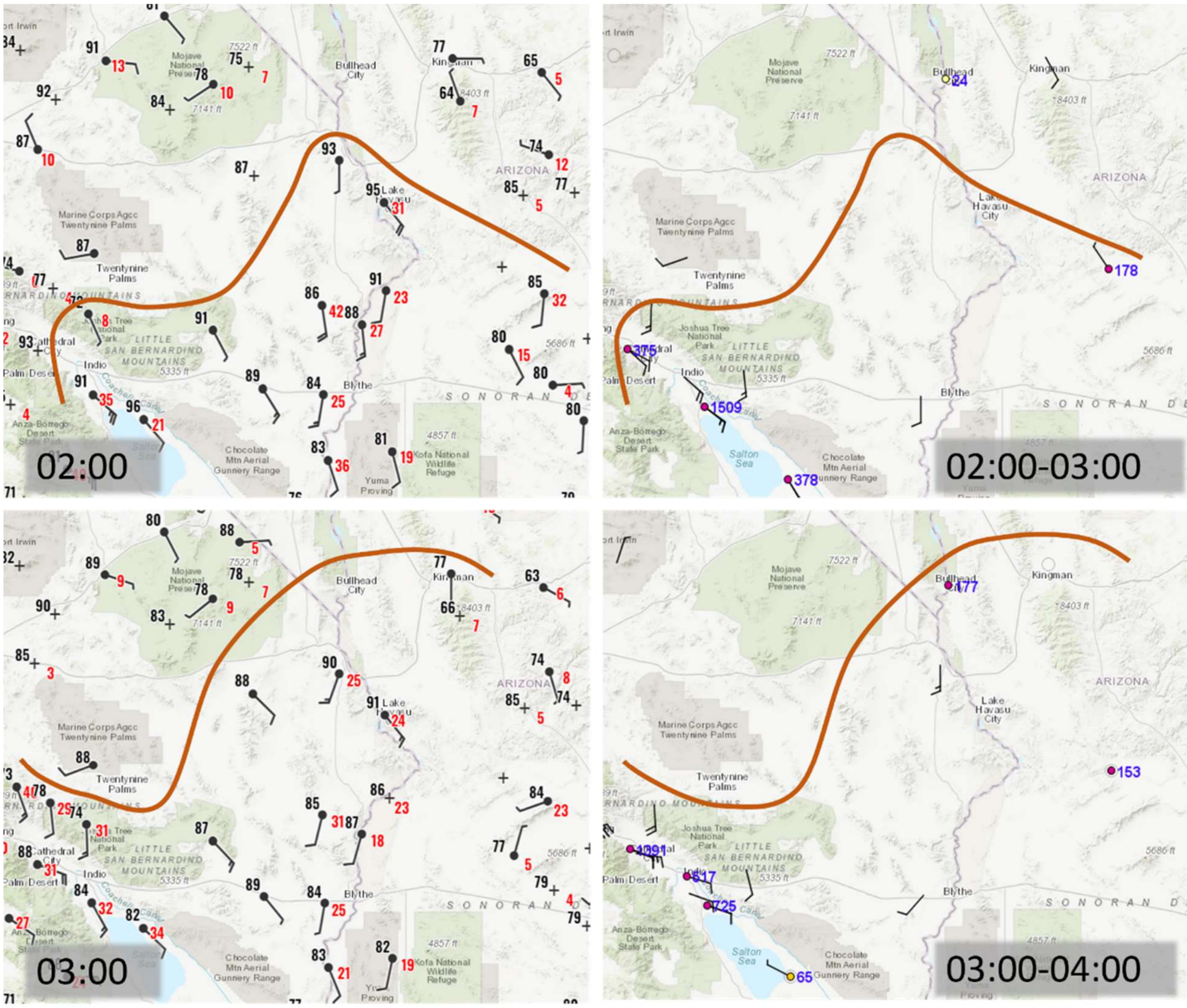


Figure 3.1-16. Winds shift to southerly across southeastern California and western Arizona from 02:00-03:00 PST on July 31, 2023, as the outflow boundary shifts northward. Additionally, PM_{10} concentrations begin increasing in Bullhead City, Arizona, south of Las Vegas, Nevada, between 03:00-04:00 PST on July 31. Sources: National Weather Service/AirNow-Tech.

The outflow boundary continued to gradually advance northward from 04:00 to 06:00 PST on July 31, 2023; in Henderson, Nevada, northeasterly winds recorded at 04:00 PST shifted to southerly by 05:00 PST. PM_{10} concentrations also increased in Henderson, from 18 µg/m^3 recorded at 04:00-05:00 PST to 168 µg/m^3 from 05:00-06:00 PST. Meanwhile, PM_{10} concentrations remained high in Bullhead City, Arizona, with 368 µg/m^3 observed from 04:00-05:00 PST, and 260 µg/m^3 observed from 05:00-06:00 PST, showing the large extent of the plume of dust as it continued to move northward (see Figure 3.1-17).

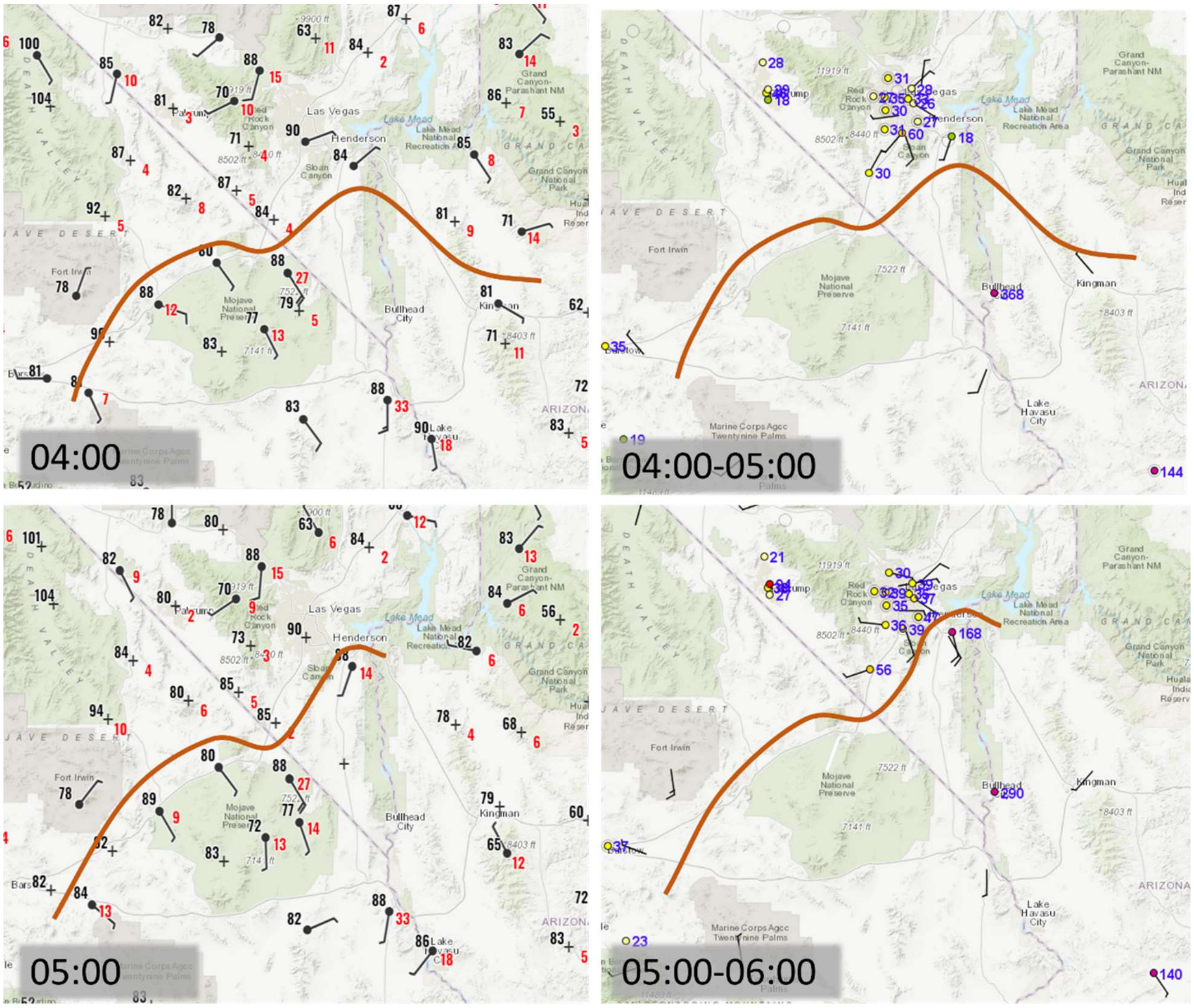


Figure 3.1-17. The large plume of dust gradually shifted northward into Henderson, Nevada, just southeast of Las Vegas by 05:00-06:00 PST on July 31, 2023, as winds shifted to the south behind the outflow boundary. Sources: National Weather Service/AirNow-Tech

As the outflow boundary continued into Las Vegas, a weak cyclonic circulation developed over the area, with dust initially raising PM_{10} concentrations across the eastern portions of the city, before eventually wrapping into the remainder of Las Vegas from the northeast by 12:00 PST (**Figure 3.1-18 through Figure 3.1-20**)

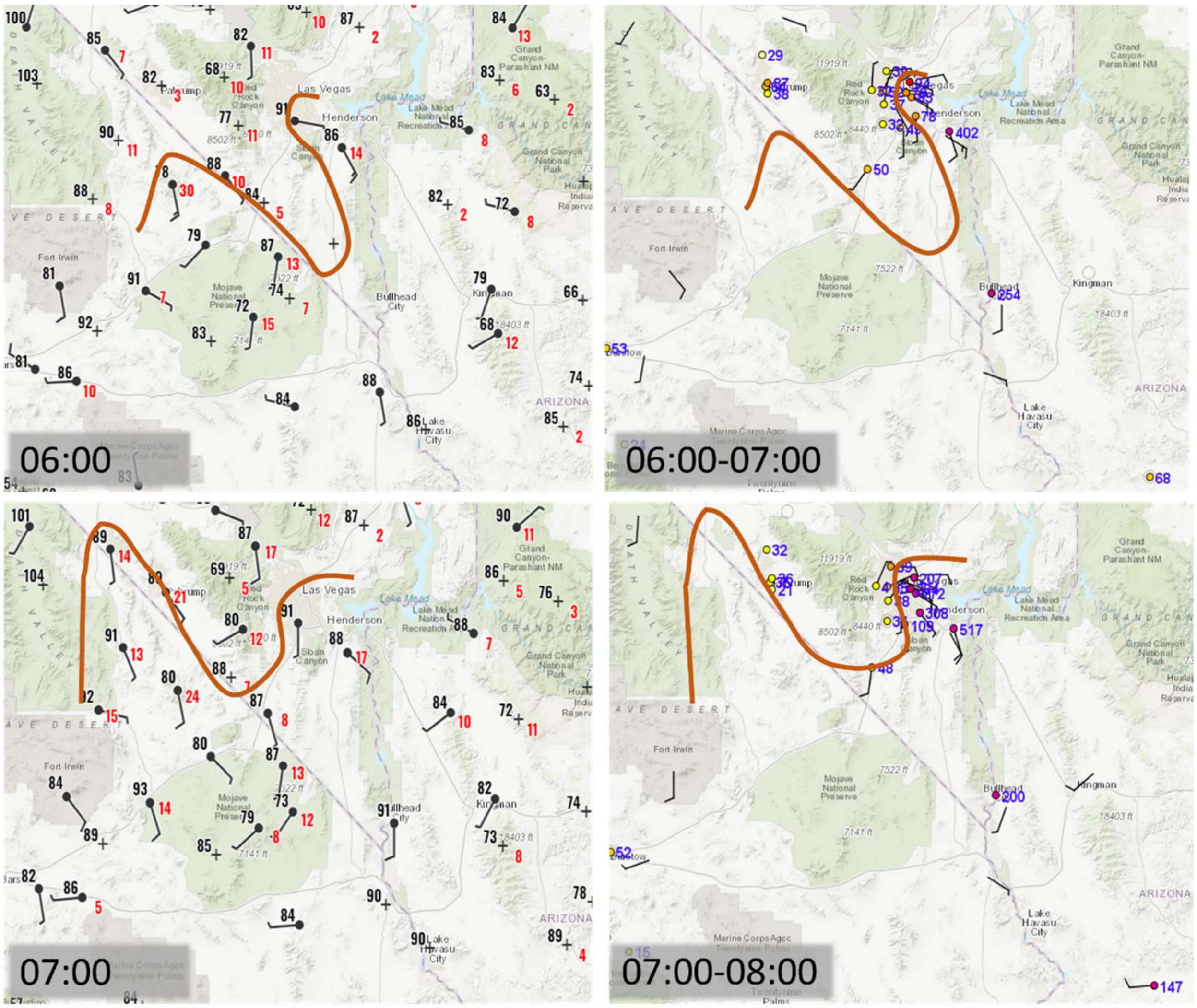


Figure 3.1-18. Dust slowly moved into the eastern portions of Las Vegas, Nevada, between 06:00-08:00 PST on July 31, 2023. Elevated concentrations continued in Bullhead City, Arizona, as the large plume of dust continued northward. Sources: National Weather Service/AirNow-Tech.

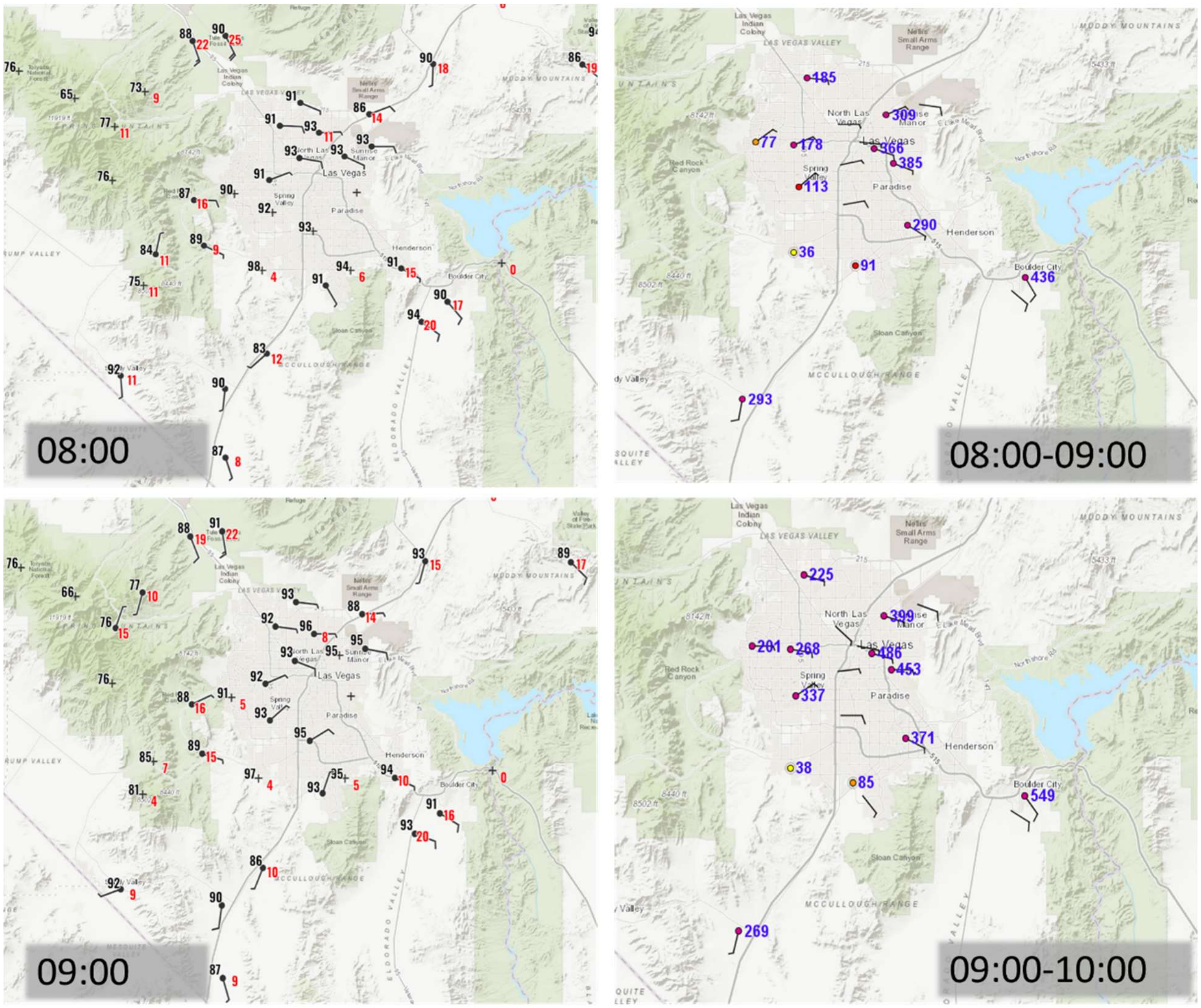


Figure 3.1-19. A weak cyclonic wind pattern developed over Las Vegas, Nevada, circulating dust across the city from the east and northeast. Sources: National Weather Service/AirNow-Tech.

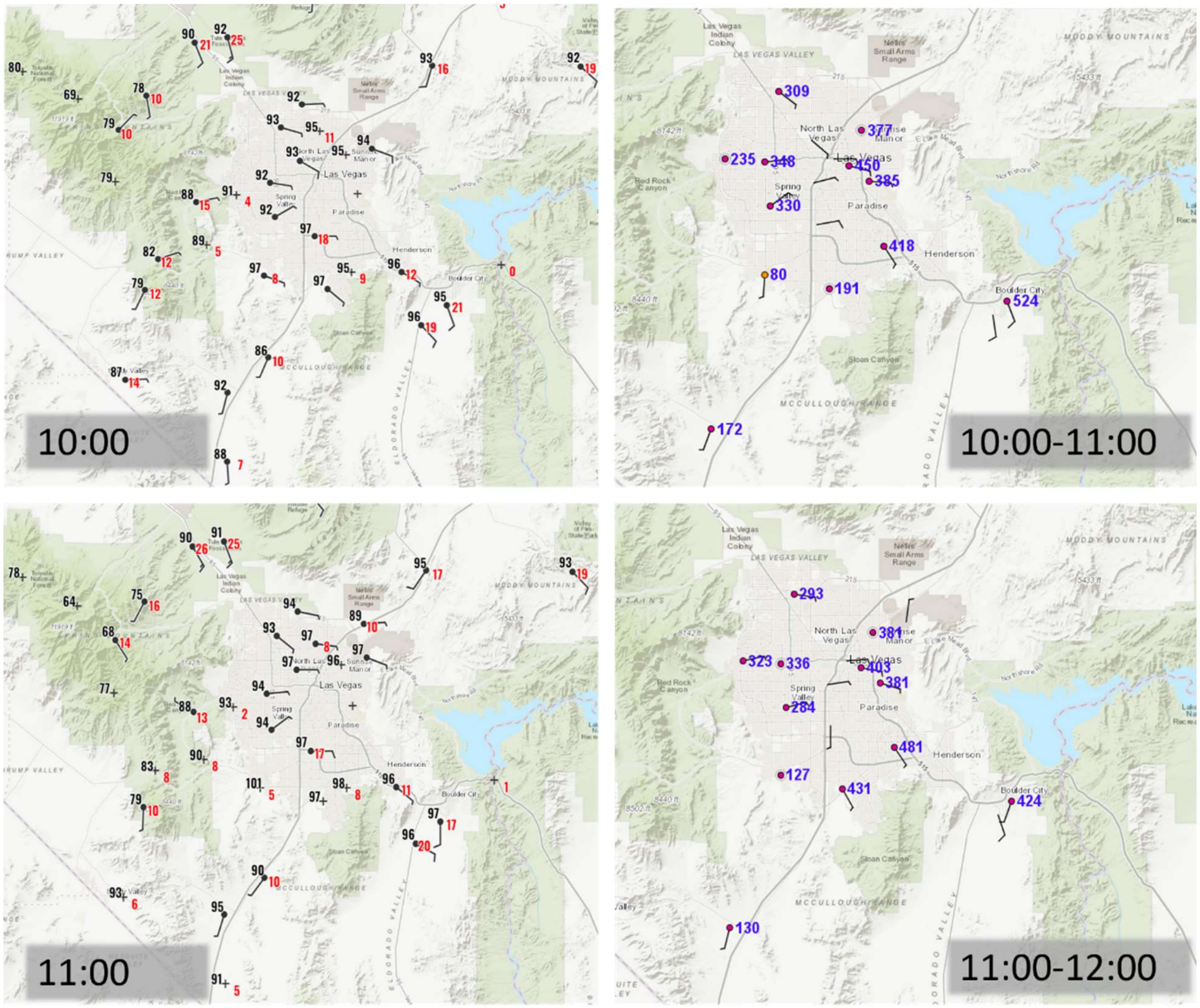


Figure 3.1-20. Dust impacted all PM_{10} monitors in the Las Vegas, Nevada, region by 12:00 PST on July 31, 2023. Sources: National Weather Service/AirNow-Tech.

High concentrations of PM_{10} continued through the afternoon of July 31, 2023, before decreasing between 18:00-19:00 PST. A few additional weaker outflows were observed on radar from the mid-afternoon and into the early evening hours. However, winds did not appear strong enough with these storms to produce additional dust in Las Vegas. The final significant outflow boundary of the day resulted from additional stronger thunderstorms northeast of the area, which produced another brief period of blowing dust in Las Vegas during the late evening hours. The peak PM_{10} concentrations with this final outflow boundary occurred between 22:00-23:00 PST (see **Figure 3.1-21**).

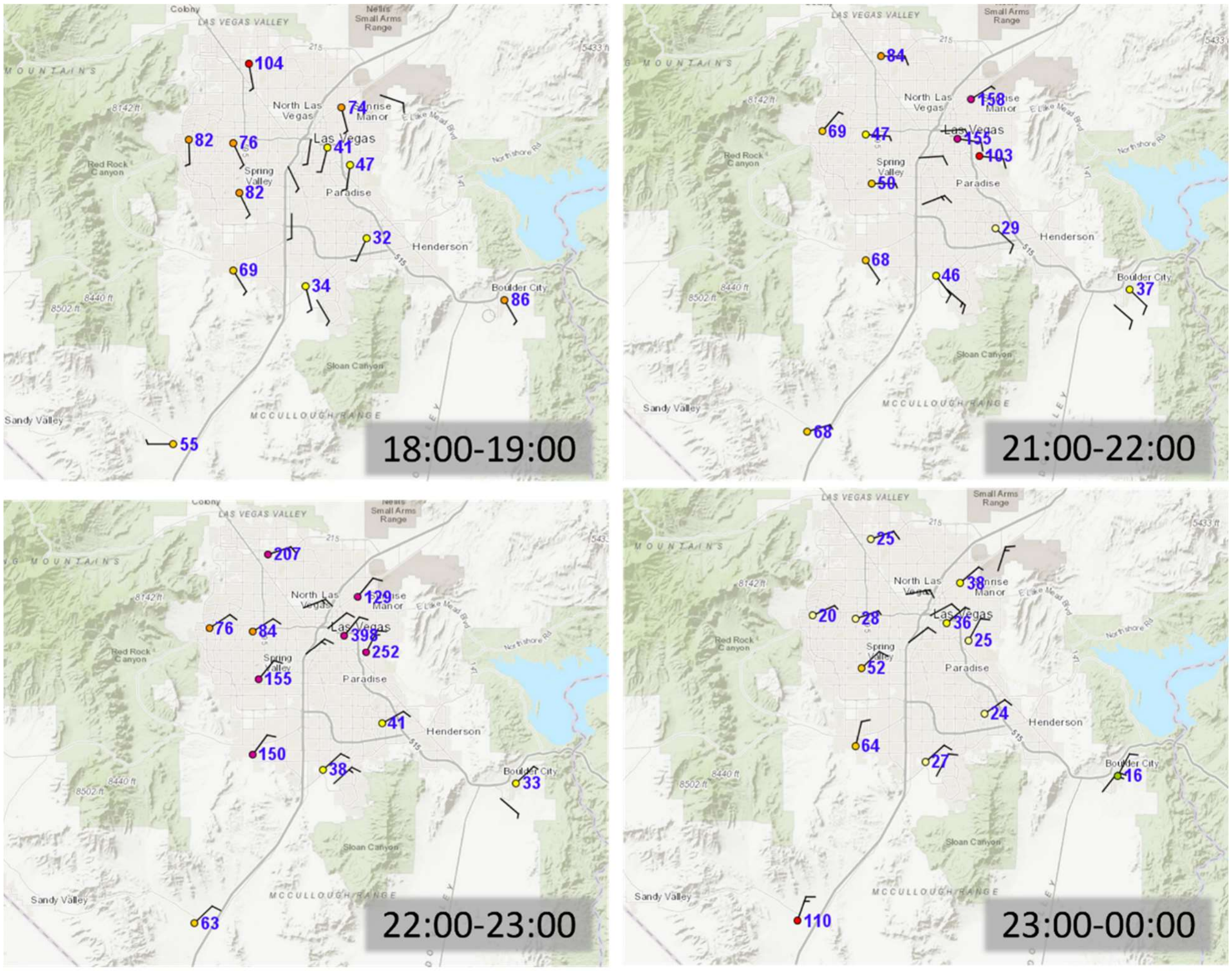


Figure 3.1-21. PM_{10} concentrations in the Las Vegas, Nevada, area began to lower between 18:00-19:00 PST on the evening of July 31, 2023, but quickly increased again between 21:00-23:00 PST as an additional outflow boundary arrived from the northeast. Sources: National Weather Service/AirNow-Tech.

Radar imagery from KESX and the terminal doppler weather radar TLAS show the thunderstorms northeast of Las Vegas producing a fine line on base reflectivity along a southward moving outflow boundary during the evening of July 31, 2023. Gusty northeasterly winds developed along and behind this boundary, which showed up as outbound winds from TLAS (see Figure 3.1-22). Radar estimated wind speeds were near 30 mph. Surface wind observations confirm the radar estimates, with winds of 15-25 mph and gusts of up to 35 mph in Las Vegas at 22:00 PST (see Figure 3.1-23). This second event was over quickly, and much lower PM_{10} concentrations were observed from 23:00 PST on July 31 to 00:00 PST on August 1.

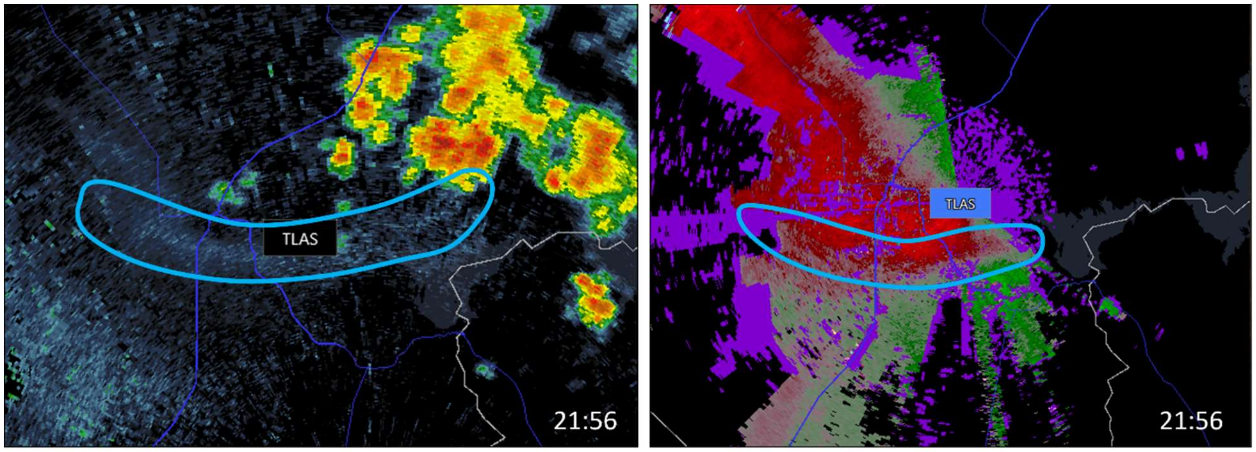


Figure 3.1-22. Thunderstorms northeast of Las Vegas, Nevada, produced an additional outflow boundary in the evening. Base reflectivity (left) is from KESX, and base velocity (right) is from TLAS, with observations from both products taken at 21:56 PST on July 31, 2023. Source: RadarScope.

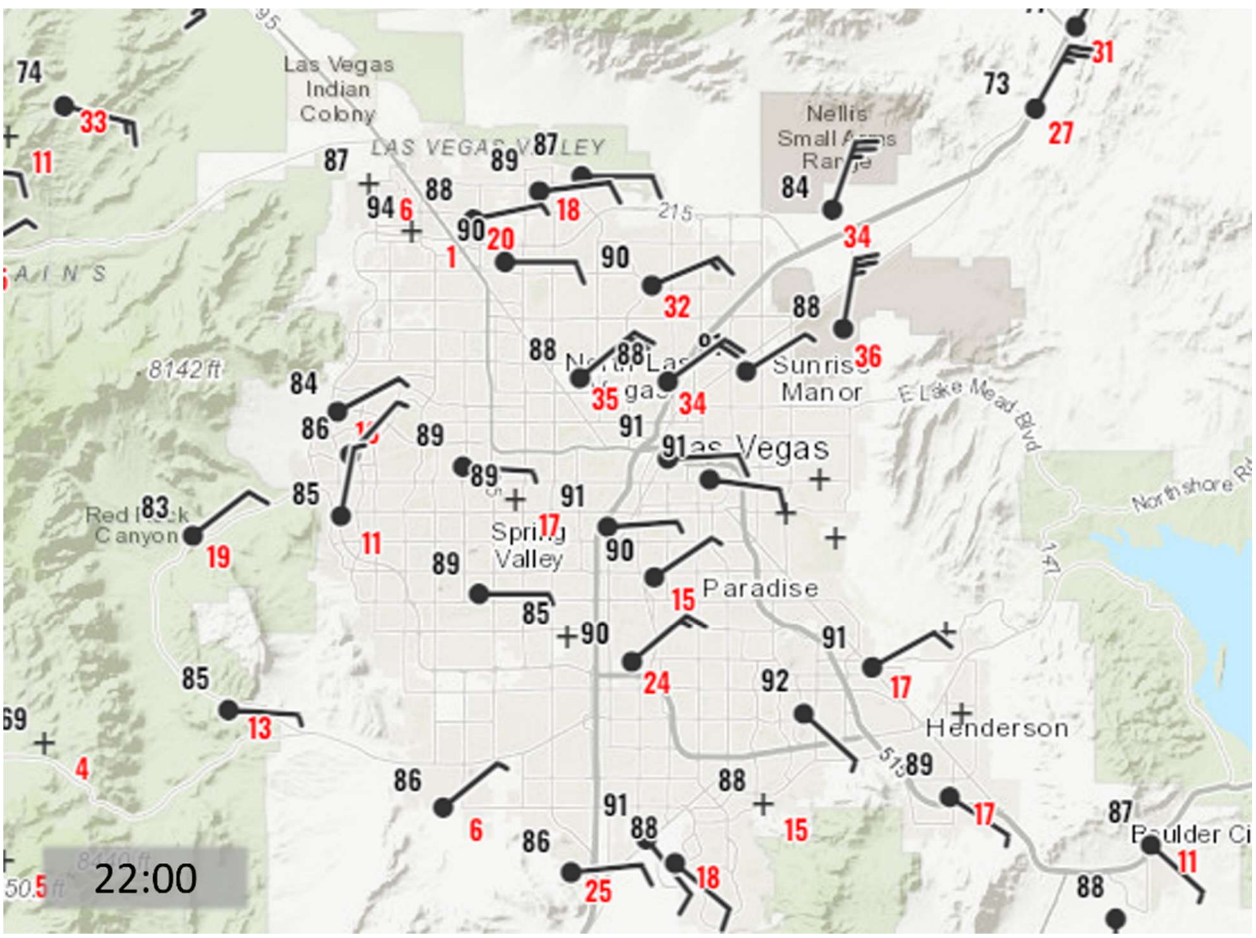


Figure 3.1-23. Surface observations of gusty northeasterly winds with the second brief blowing dust event recorded at 22:00 PST on July 31, 2023. Source: National Weather Service.

The combined effect of (1) the main dust event from the long-range transport of the large dust plume from northern Mexico, southwestern Arizona, and southeastern California during the morning and afternoon of July 31, 2023, and (2) the additional brief period of blowing dust during the evening of July 31, resulted in 24-hour average PM_{10} concentrations above the PM_{10} NAAQS at four monitors in the Las Vegas Valley.

3.1.2 Supporting Ground-Based Data

We were unable to find ground-based images in the source regions due to the event occurring at night.

Peak sustained wind speed data from the Sonoran Desert (southwestern Arizona and 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 3.1-24 and Figure 3.1-25** show the peak sustained wind speeds recorded in the southwestern Arizona and southeastern California region of the Sonoran Desert of 41-44 mph on July 31, 2023. These peak sustained wind speeds were well above the 25-mph threshold in the source regions and could easily loft, entrain, and transport PM_{10} downwind quickly to Clark County.

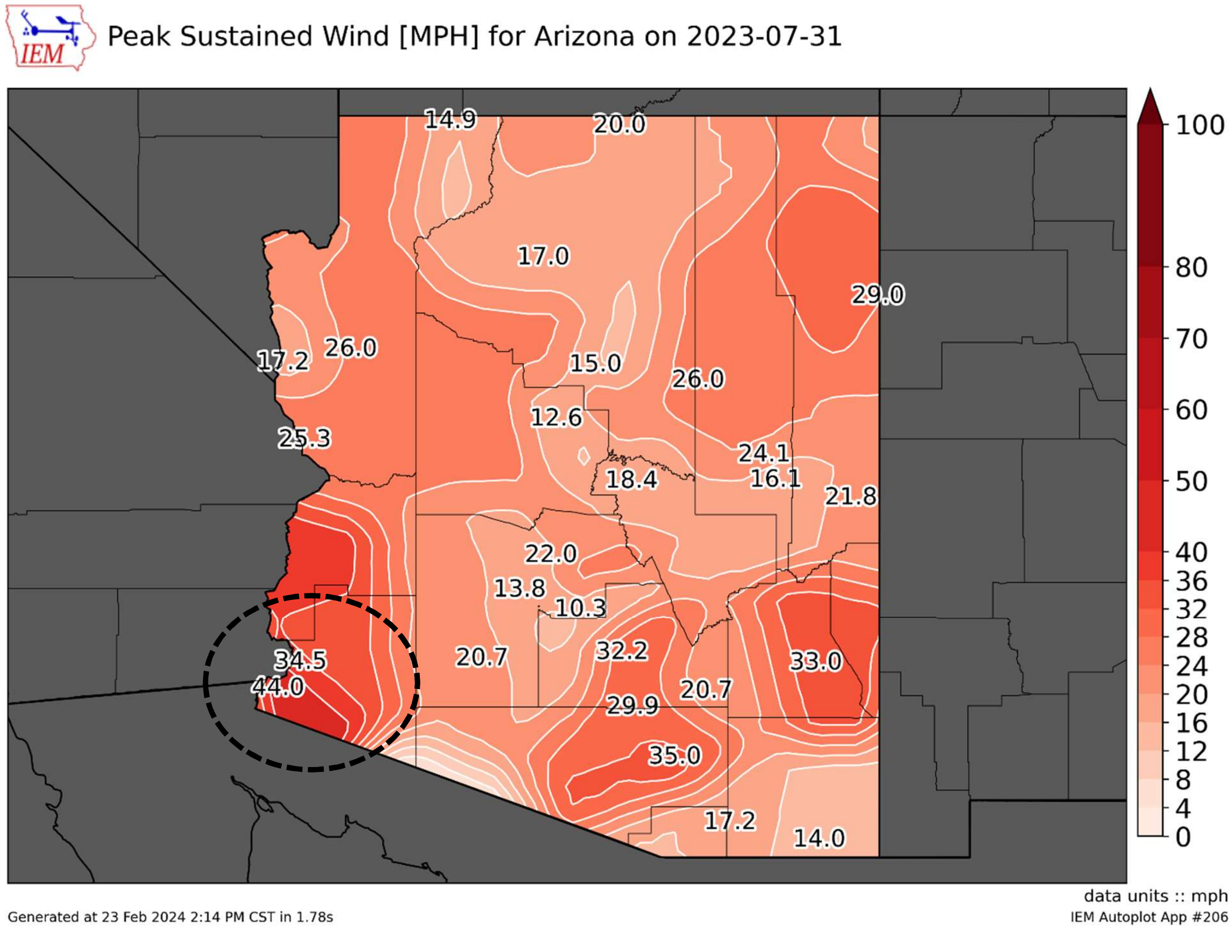


Figure 3.1-24. Peak sustained winds in Arizona on July 31, 2023. One of the source regions, shown approximately by the black dashed line, is located in southwestern Arizona (the Sonoran Desert region). Data source: https://mesonet.agron.iastate.edu/plotting/auto/.

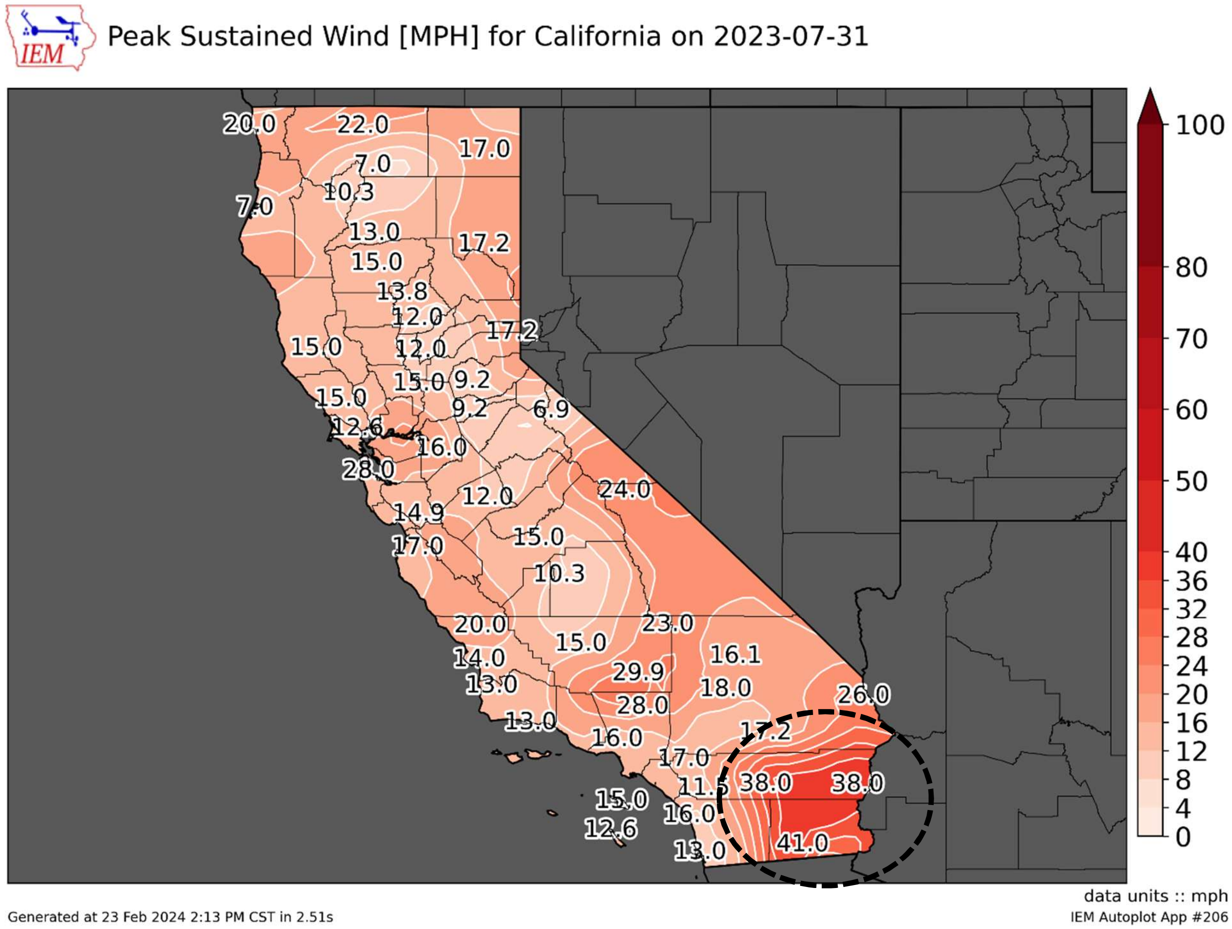


Figure 3.1-25. Peak sustained winds in California on July 31, 2023. One of the source regions, shown approximately by the black dashed line, is located in southeastern California (the Sonoran Desert region). Data source: https://mesonet.agron.iastate.edu/plotting/auto/.

Figure 3.1-26 shows the distribution of maximum daily temperatures recorded at several sites in the wind-blown source regions on July 30 and 31 (1993-2022), and the maximum daily temperatures recorded on July 30 and 31, 2023. The site locations are shown in Figure 2.2-8. Maximum daily temperatures recorded at all sites were at or above the median in the dust region and along the transport path compared to maximum daily temperatures from 1993-2022. Maximum daily temperatures recorded at all sites on July 31, 2023, the day of the PM_{10} exceedance, were above the median. The maximum daily temperatures recorded on July 30 and 31, 2023, provide evidence that the wind-blown dust source regions in the Sonoran source region were abnormally hot on the day before the PM_{10} exceedance.

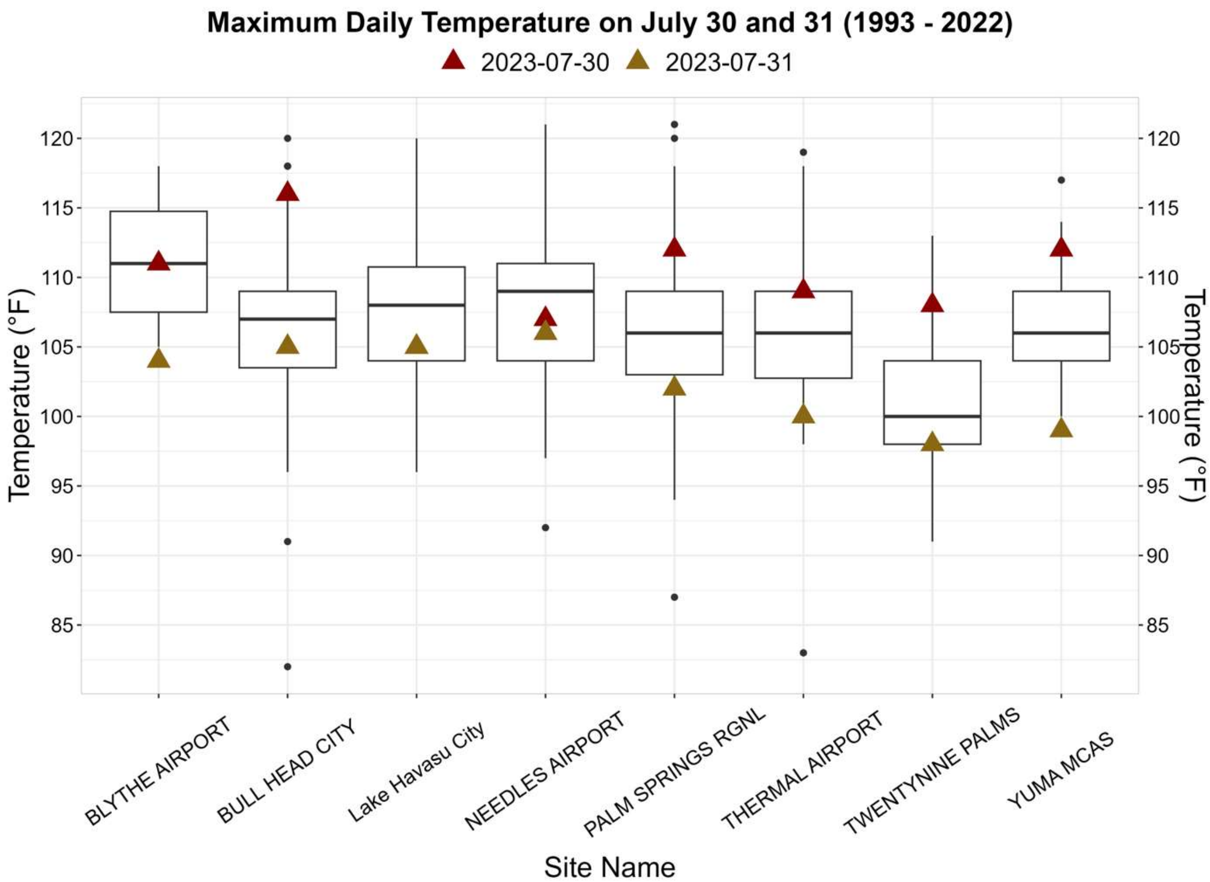


Figure 3.1-26. Maximum daily temperature on July 30 and 31, 2023, compared to the 1993-2022 distribution at each site.

Overall, we find overwhelming evidence that PM_{10} was very likely lofted, entrained, and transported from the Sonoran Desert region of northern Mexico, southwestern Arizona, and southeastern California in the late evening of July 30 through the early morning hours of July 31, 2023, due to outflow boundary winds from multiple thunderstorms. The evidence corroborating this assertion includes (1) the meteorological analysis that shows conditions were consistent with a high-wind event in the Sonoran Desert, including high instability and downdraft potential leading to high winds, (2) radar images from Yuma, Arizona, and Las Vegas, Nevada, showing the progression of winds moving across the Sonoran Desert and into the Clark County area, (3) hour-by-hour progression of high winds and high PM_{10} concentrations from the source regions moving into Clark County, (4) ground-based measurements of high temperatures in the Sonoran Desert region before the event on July 31, and (5) aggregated measurements of high winds in the Sonoran Desert source region on July 31, 2023.

3.2 Transport to Clark County

3.2.1 HYSPLIT Analysis

The complex mesoscale process over the intricate terrain posed challenges in accurately representing the transport to Clark County. Both the North American Mesoscale (NAM) model at 12-km horizontal resolution and the High-Resolution Rapid Refresh (HRRR) model at 3-km horizontal resolution were unable to replicate the outflow boundary process and the associated transport as shown by observations (stations and radar) in **Section 3.1.1**. Due to the inconsistencies between the forecast models and the observed event, we do not include HYSPLIT analyses in this narrative, as the model-driven HYSPLIT runs did not accurately represent the transport for this particular case.

3.2.2 High-Wind Event Timeline

The wind-blown dust event that occurred on July 21, 2023, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at three measurement sites (with one additional site experiencing NAAQS exceedances that were not regulatorily significant) in Clark County, and caused a maximum 24-hour PM_{10} concentration of 209 µg/m^3 at the Sunrise Acres site. Concentrations of PM_{10} at measurement sites throughout Clark County began to rise at 06:00 to 07:00 PST, reached a peak between 09:00 to 12:00 PST, and remained enhanced through 18:00 PST.

In addition to the meteorological evidence of the approach of the outflow boundary presented in **Section 3.1.1**, timeseries graphs and a map showing PM_{10} concentrations and hourly average wind speeds in the source regions are also provided in **Figure 3.2-1 and Figure 3.2-2**. An initial, intense perturbation of dust along California's southern border occurred in the first hours of July 31 and this lofted dust was transported towards Clark County over the next 7-13 hours. Figure 3.2-1 shows PM_{10} concentrations measured at AQS sites between the source regions and Clark County. PM_{10} concentrations peaked in the source region, labelled 1 in Figure 3.2-1, between 00:00-01:00 on July 31, 2023. Concentrations reached a maximum of 6,000 µg/m^3 at the Nilad-English Road site in southern California and exceeded 1,900 µg/m^3 at three other source-region sites. Figure 3.2-2 shows that hourly average wind speeds recorded between 00:00-01:00 exceeded 25 mph in the source region (labelled 1 in Figure 3.2-2), 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). The intensity of this short-lived wind event is better captured by shorter-averaged wind measurements, shown in **Figure 3.2-3**. Five-minute ASOS measurements from the El Centro Naval Air Facility (NJK) and Imperial County Airport (IPL) monitoring sites in the source region show that sustained winds reached 40 mph and wind gusts exceeded 60 mph as the gust front passed through the region. PM_{10} concentrations in region 2 (Figure 3.2-1 and Figure 3.2-2), north of the Salton Sea, peaked between 01:00-03:00, shortly after the peak recorded in region 1 as the outflow boundary moved northward. PM_{10} concentrations greater than 1,000 µg/m^3 were measured by the Palm

Springs/Jacqueline Cochran Regional Airport (TRM) monitoring stations in region 2 (Figure 3.2-1 and Figure 3.2-2) concurrently with wind gusts over 50 mph(Figure 3.2-3). Over the next 2-3 hours, the dust lofted from the source region continued to move northward and eastward along the outflow boundary, and reached Bullhead City, Arizona (region 3 in Figure 3.2-1) between 03:00-05:00. The nearby ASOS station at the Needles Airport (EED) in California measured gusts near 40 mph during peak PM_{10} concentrations, though the sustained winds did not exceed 25 mph. Finally, lofted dust entered Clark County, Nevada, starting around 06:00 to 07:00 PST on July 31. Enhanced PM_{10} concentrations in Clark County lasted for most of the afternoon and reached a peak concentration near 500 µg/m^3. Wind speeds in Clark County were modest during the peak PM_{10} concentrations, rising only to 12 mph at the Harry Reid International Airport (LAS) (Figure 3.2-3); no wind gusts were recorded at LAS on this date. This provides evidence that an outside source contributed to the enhanced PM_{10} concentrations in Clark County on July 31, 2023. Further evidence is provided by the difference in peak PM_{10} concentrations between the source regions and Clark County; it is expected that a portion of the dust first lofted in the source regions would settle across the 300-mile transport path between Imperial County and Clark County. A secondary, short-lived PM_{10} event was observed in Las Vegas at the end of the day on July 31, further enhancing 24-hour PM_{10} averages. This second high-wind dust event was due to a short-lived outflow event from a thunderstorm northeast of the Las Vegas Valley, as discussed in Section 3.1.1. While both events lead to a PM_{10} NAAQS at four sites throughout the Las Vegas Valley, the Sonoran and Mojave Desert event is responsible for the overwhelming majority of the PM_{10} exceedance concentrations.

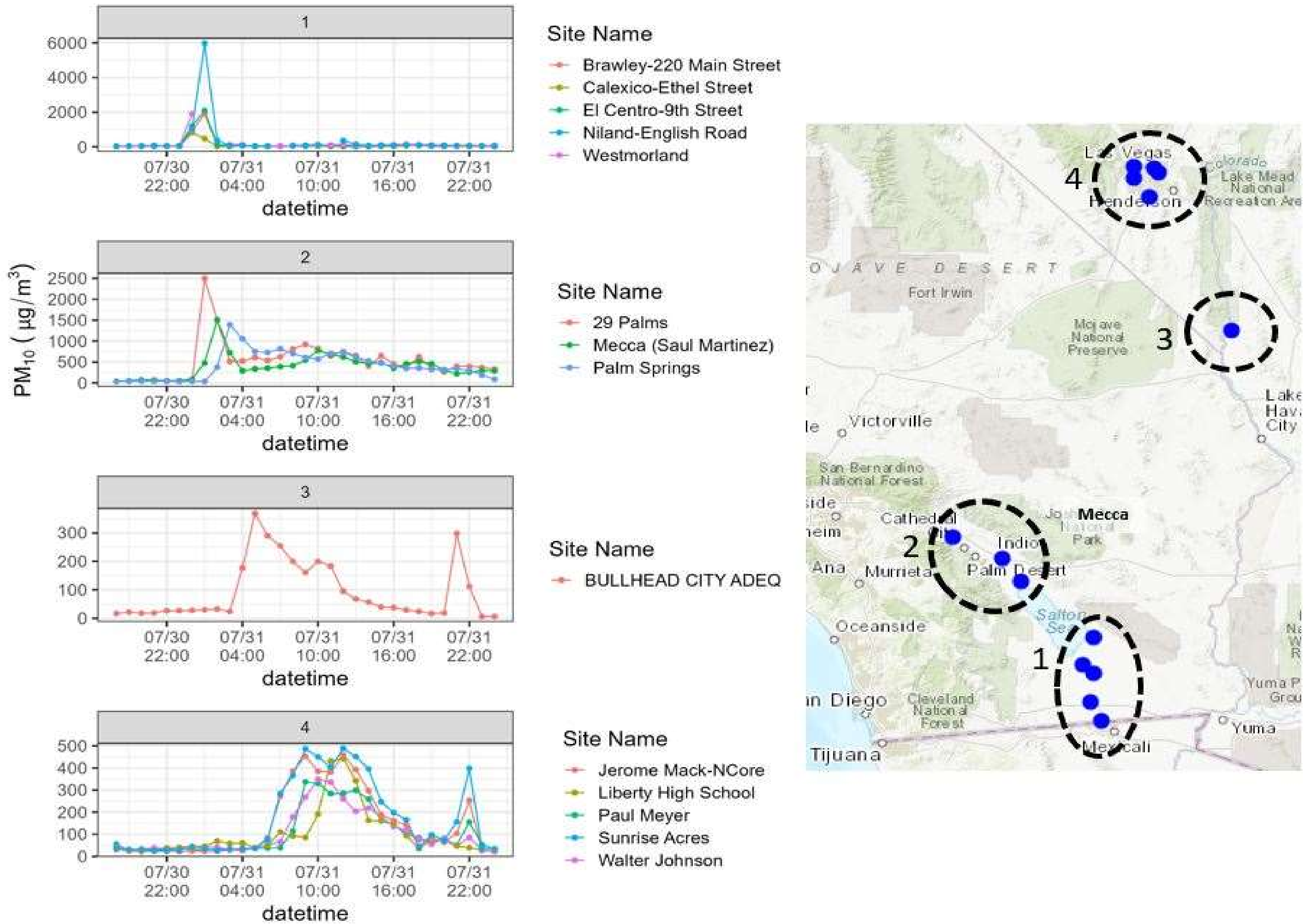


Figure 3.2-1. Timeseries of PM_{10} concentrations (left) along the movement of a gust front associated with thunderstorms. Data are included from AQS sites in Imperial County, CA (Region 1), Riverside County, CA (Region 2), Mojave County, AZ (Region 3) and Clark County, NV (Region 4). Site locations are mapped and circled by region (right). Numbering on the map corresponds to numbering in the time series figures on the left.

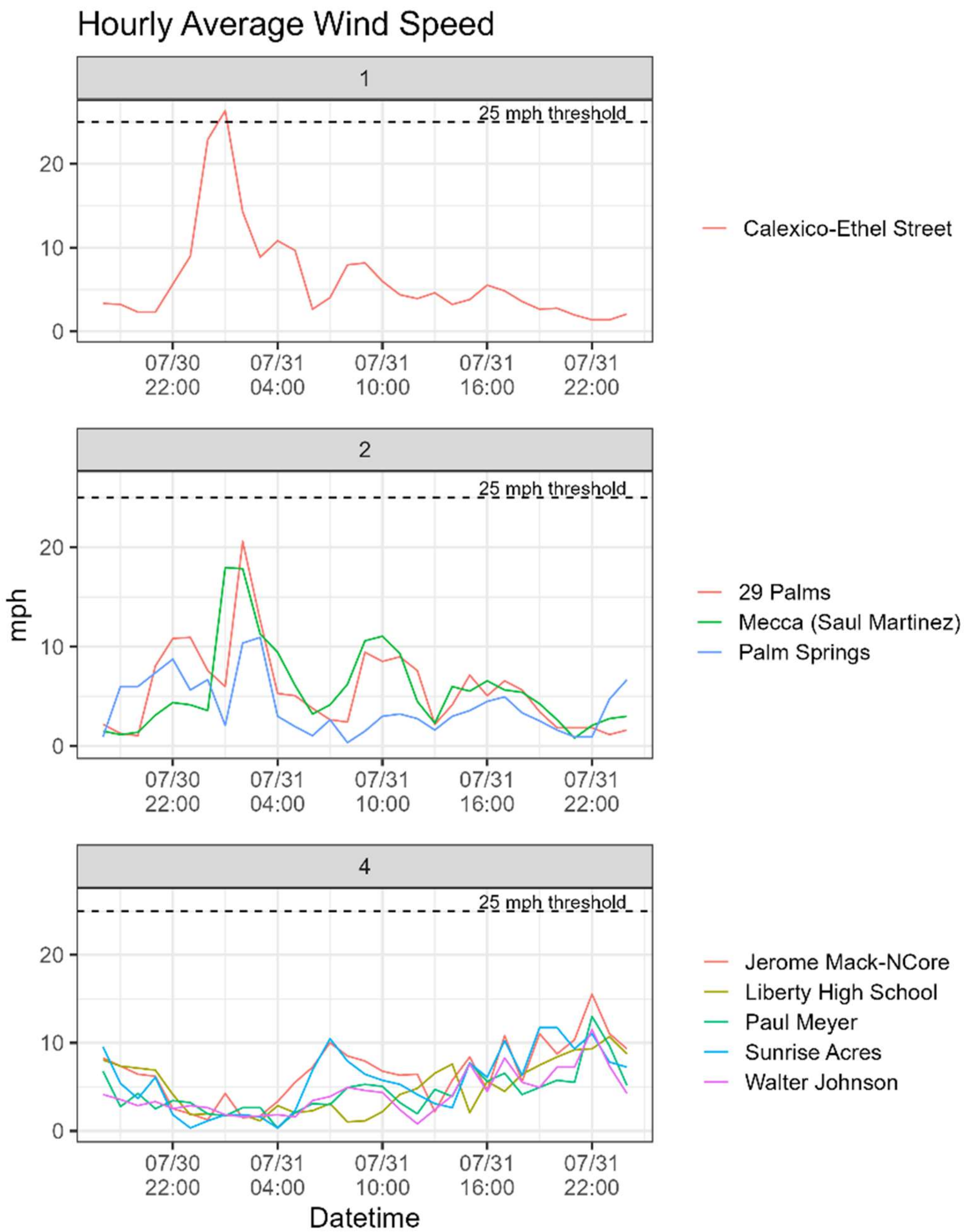


Figure 3.2-2. Timeseries of hourly average wind speed along the movement of a gust front associated with thunderstorms. Data are included from Imperial County, CA (Region 1), Riverside County, CA (Region 2), and Clark County, NV (Region 4). Site locations are mapped and circled by region in Figure 3.2-4.

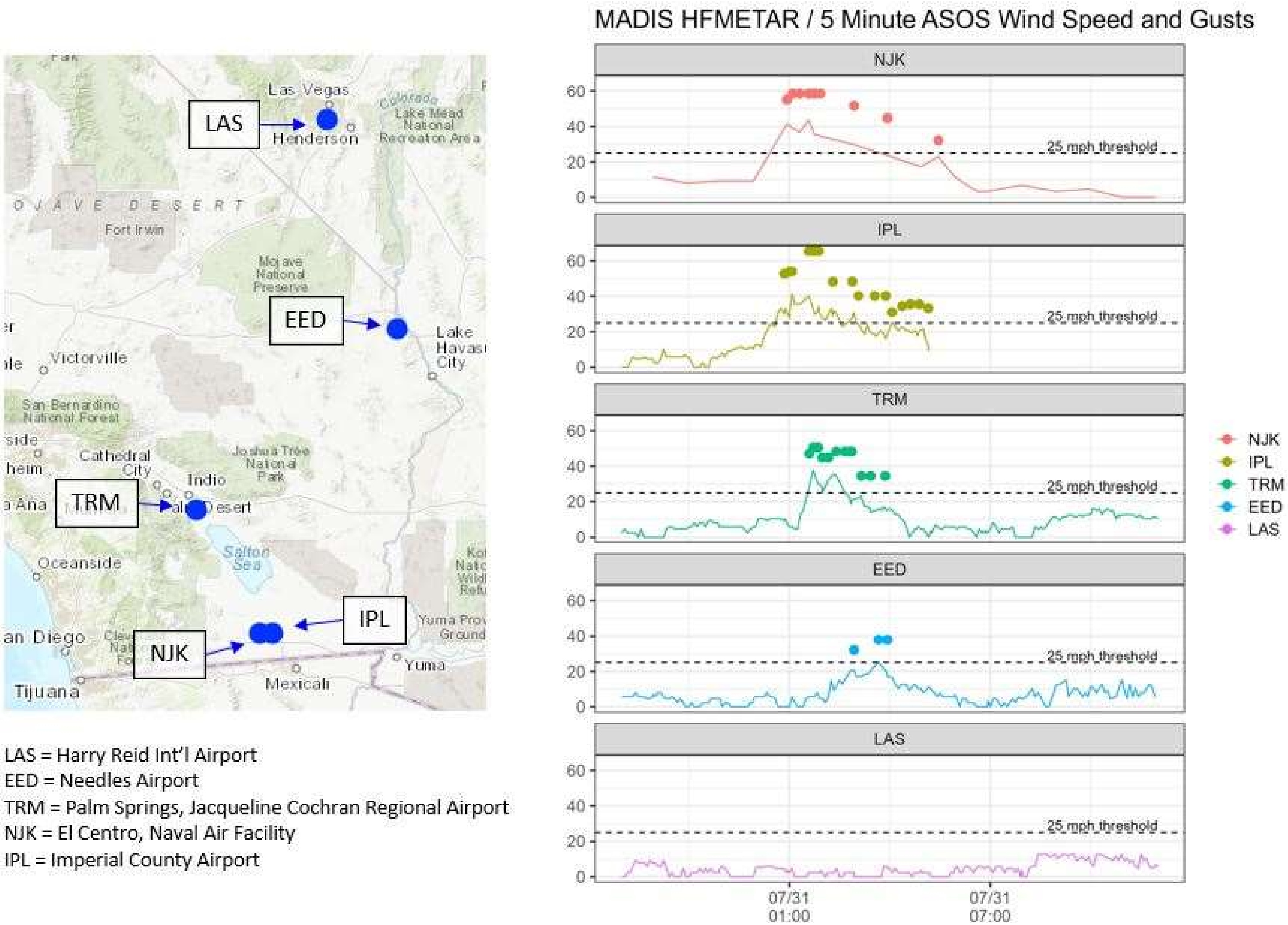


Figure 3.2-3. MADIS HFMETAR/5-minute ASOS wind measurements from weather stations along the outflow boundary. Sustained wind speeds are displayed as lines, and gusts are displayed as points.

The rise in PM_{10} concentrations in the Las Vegas Valley began around 06:00-07:00 PST, coinciding with the approach of the outflow boundary. Figure 3.2-4 shows a rise in surface wind speeds in Las Vegas from 5 to 15 mph as PM_{10} concentrations began to increase. PM_{10} concentrations reached a maximum between 09:00-12:00 PST, with many affected sites exceeding a PM_{10} concentration of 400 $\mu g/m^3$.

Wind speed, direction, and PM_{10} concentrations across Clark County, Nevada, were also consistent with an outflow boundary from the southeast of the county (shown in Figure 3.2-5 through Figure 3.2-11). High concentrations of PM_{10} first affected the southeastern part of the Las Vegas Valley (i.e., the Garrett Jr. High monitoring site) due to the direction of the outflow boundary approach (i.e., from the southeast). The eastern and low elevation sites in the Valley were next affected between 06:00-07:00 PST. As stated in Section 3.1.1, weak cyclonic motion within the Valley then spread the dust event to the northwestern sites, and then to the southwestern sites between 07:00-12:00 PST. PM_{10} concentrations declined throughout the day and into the early evening. The eastern sites experienced the highest 24-hour concentrations of PM_{10} due to their longer exposure to the high-wind dust event.

Enhanced PM_{10} concentrations at the affected sites were likely caused by a high-wind event in the source regions 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 PM_{10} concentrations. Further, the fact that enhanced PM_{10} concentrations were recorded at all sites in the Las Vegas Valley indicates a regional high-wind dust event. While it is possible that some portions of planned land use, such as the dirt-covered lot to the southeast of the Sunrise Acres site, may have contributed to local dust during the high-wind event, evidence of high winds over the natural, undisturbed desert regions upwind of Clark County is clearly the main driver of this dust event. As shown by the timeline of events, high winds from a thunderstorm-induced outflow boundary lofted PM_{10} in the Sonoran Desert in northern Mexico, southwestern Arizona, and southeastern California, and movement of the outflow boundary through southern Mojave Desert caused a regional dust event that extended 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 July 31, 2023.

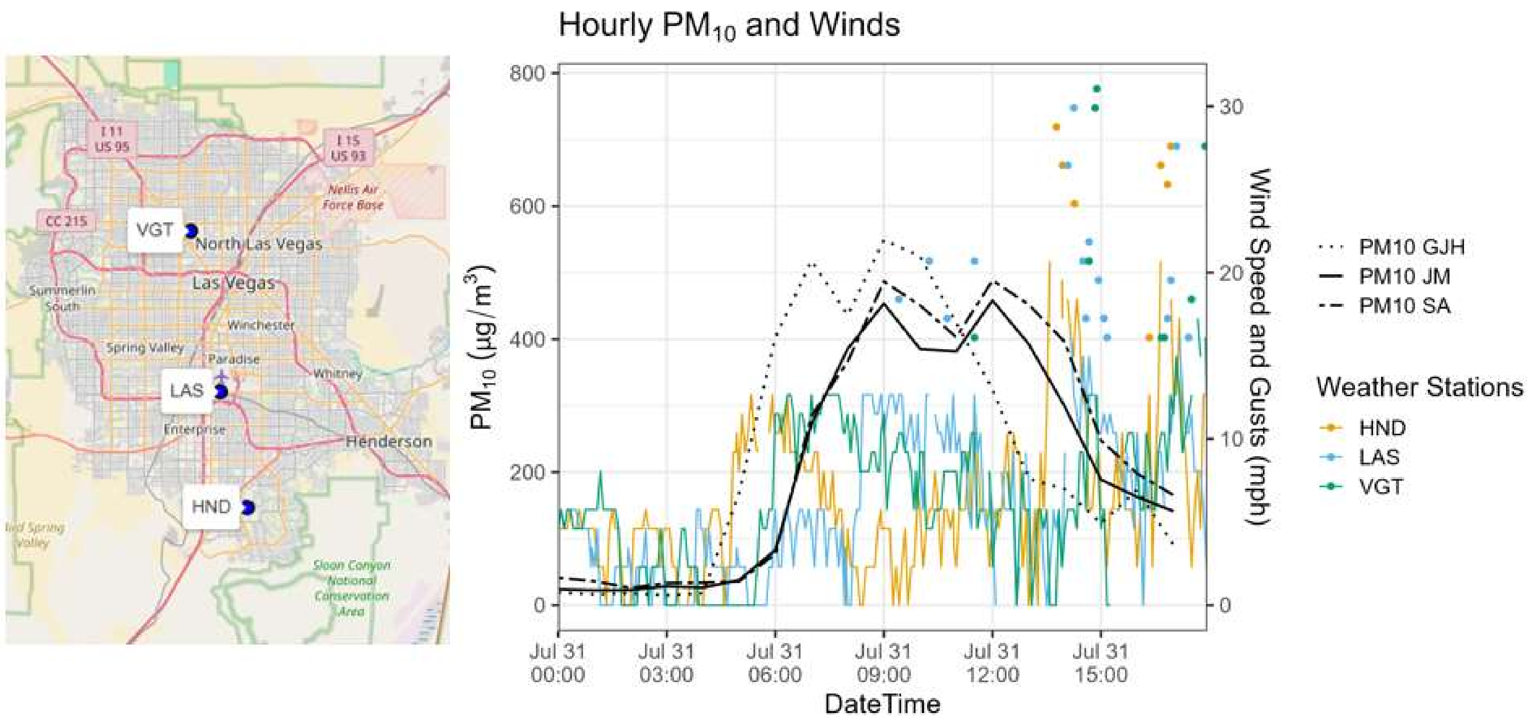


Figure 3.2-4. Hourly PM_{10} concentrations (µg/m^3) at the Jerome Mack (JM), Garrett Jr. High (GJH), and Sunrise Acres (SA) monitoring sites, and wind speed (lines) and wind gusts (dots) from the HND (Henderson Executive Airport), LAS (Harry Reid International Airport) and VGT (North Las Vegas Airport) ASOS weather stations on July 31, 2023, between 00:00 and 18:00 PST.

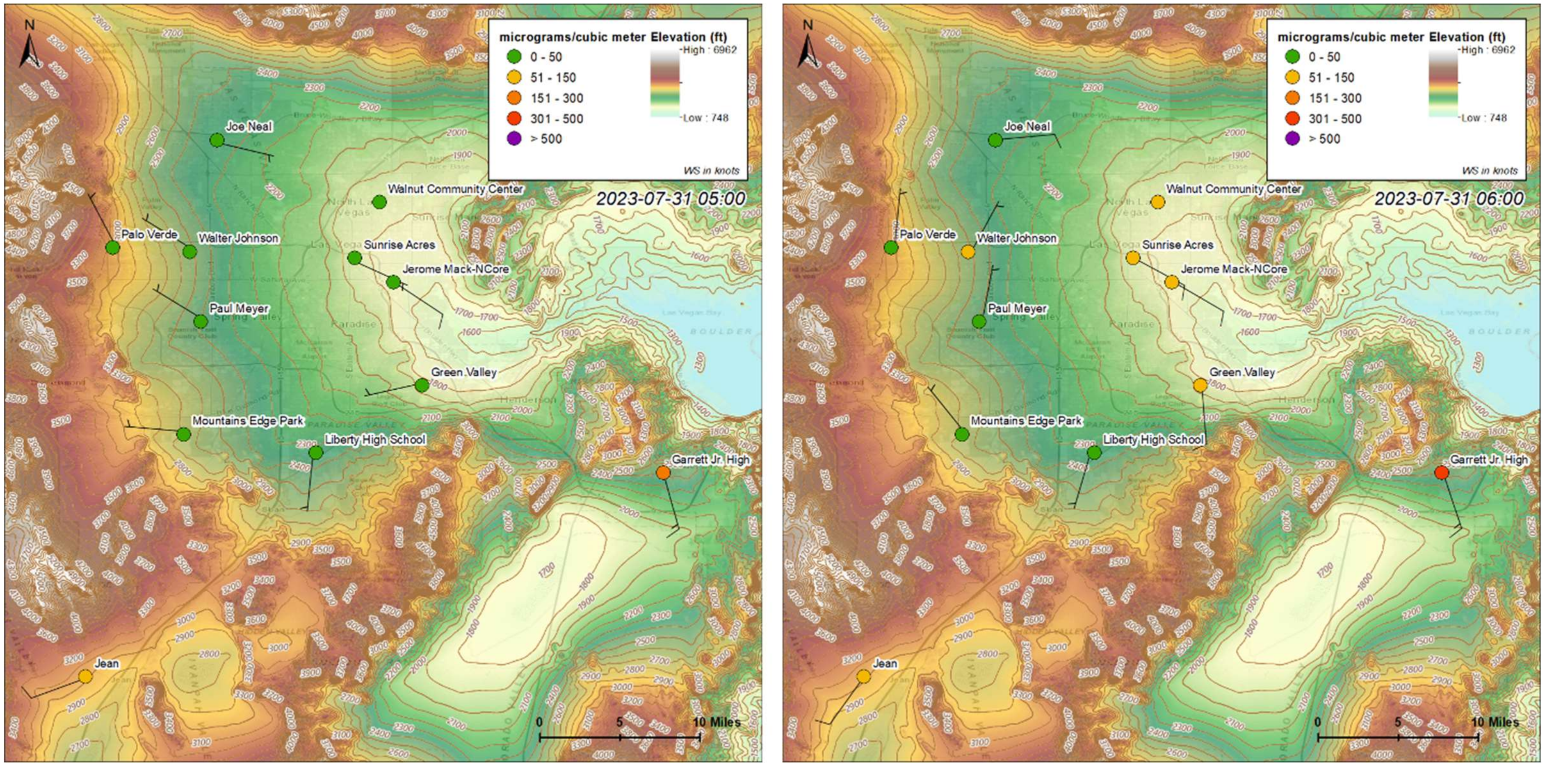


Figure 3.2-5. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 05:00 PST to 06:00 PST.

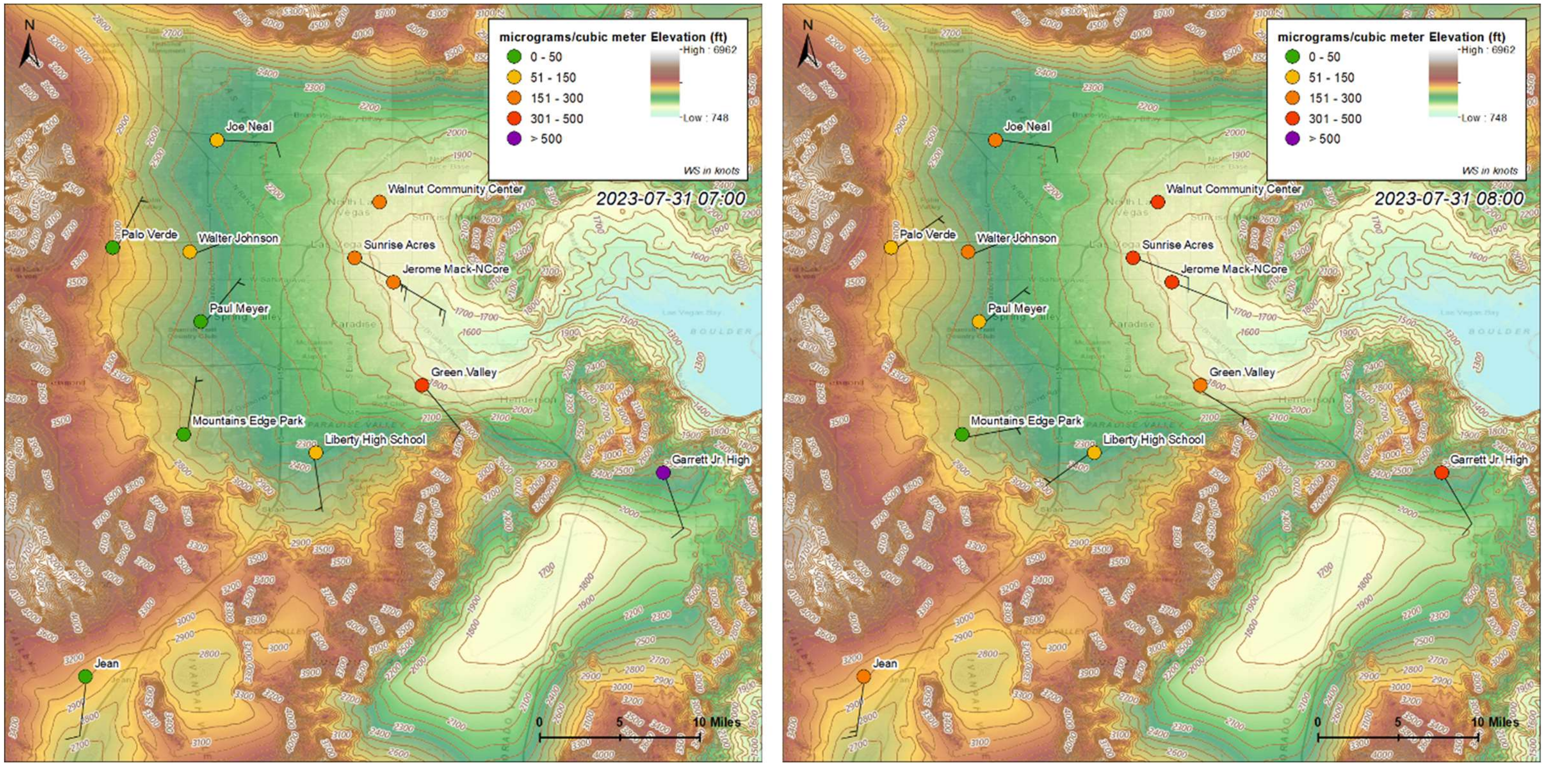


Figure 3.2-6. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 07:00 PST to 08:00 PST.

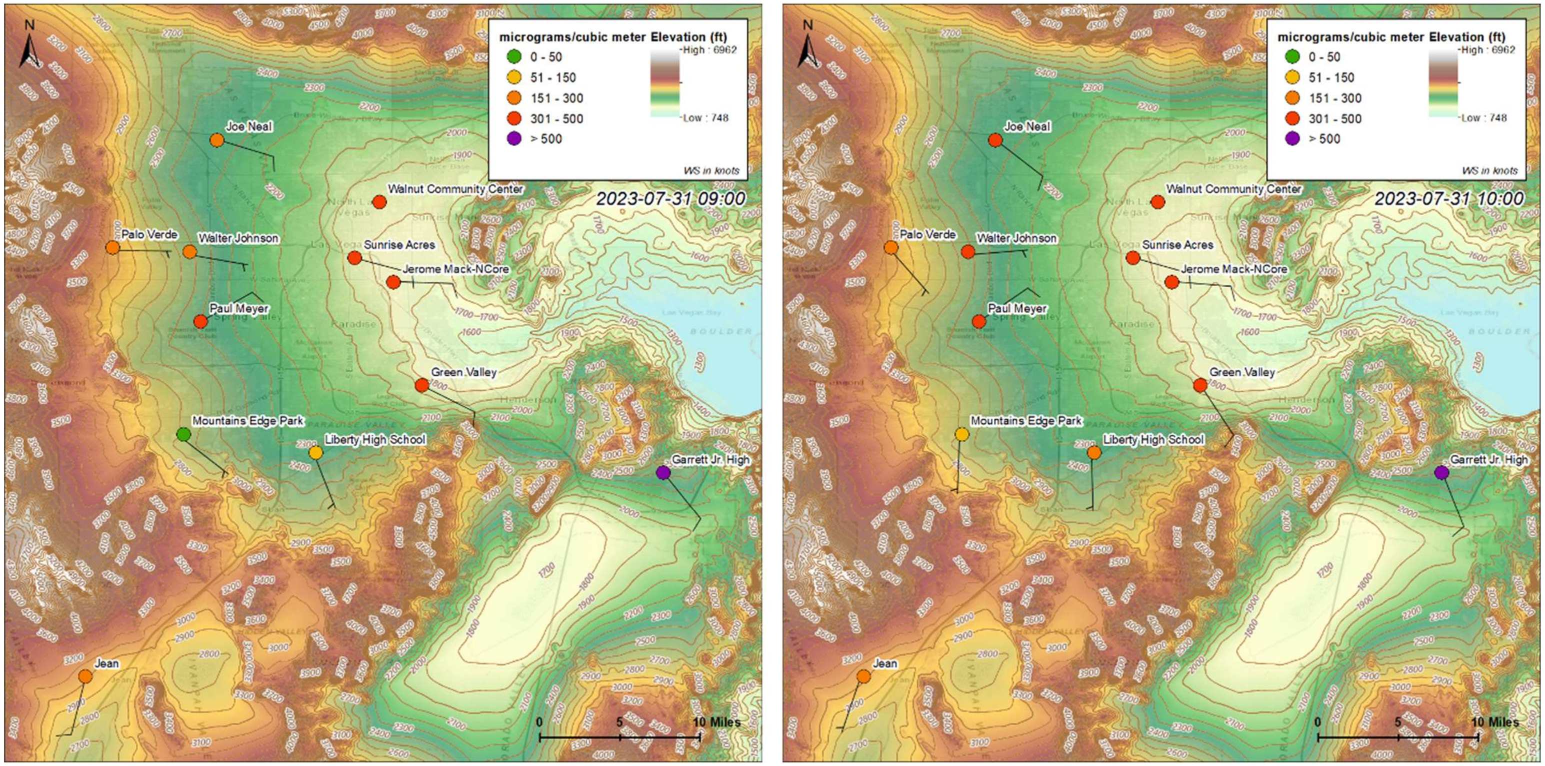


Figure 3.2-7. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 09:00 PST to 10:00 PST.

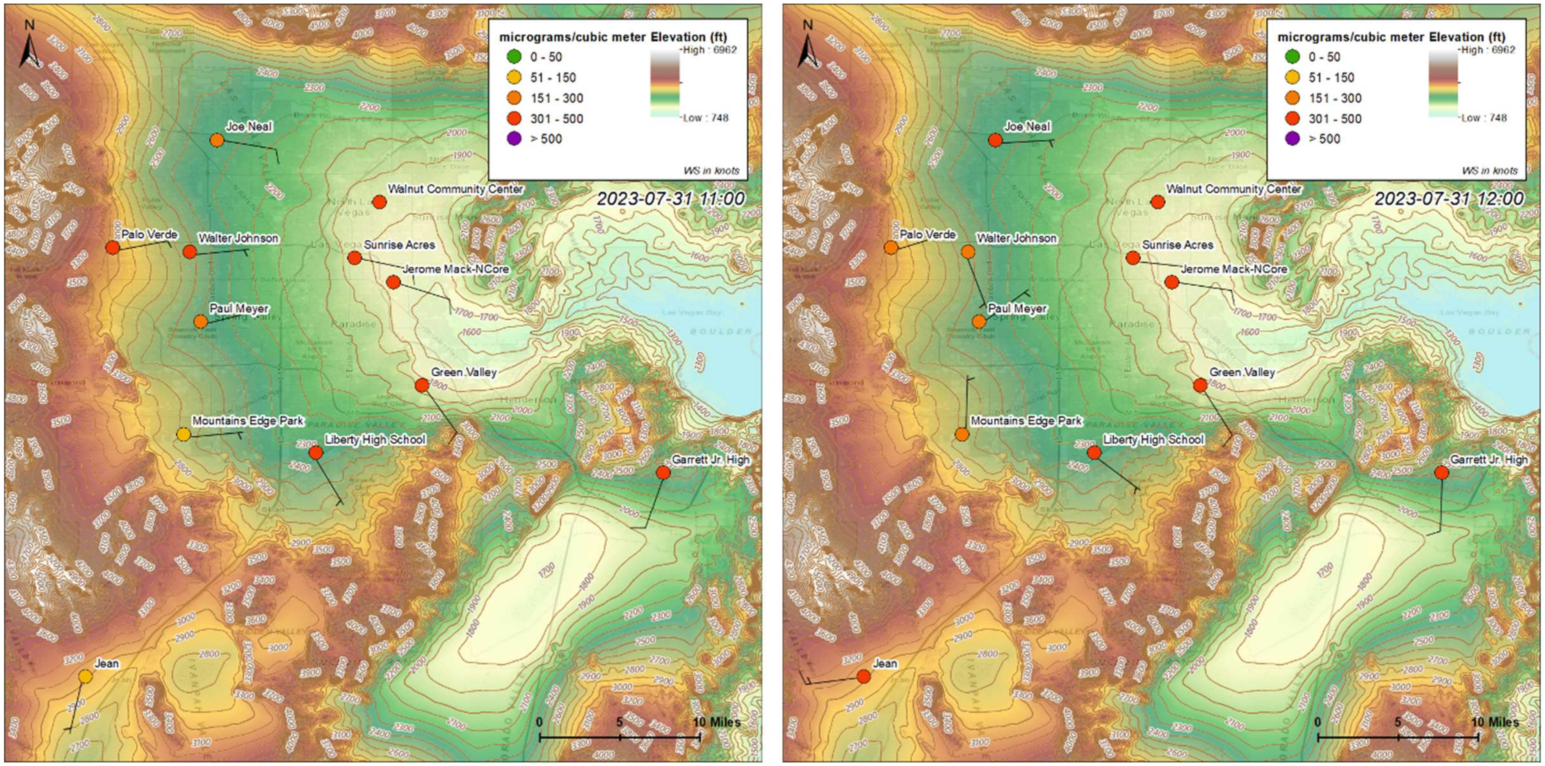


Figure 3.2-8. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 11:00 PST to 12:00 PST.

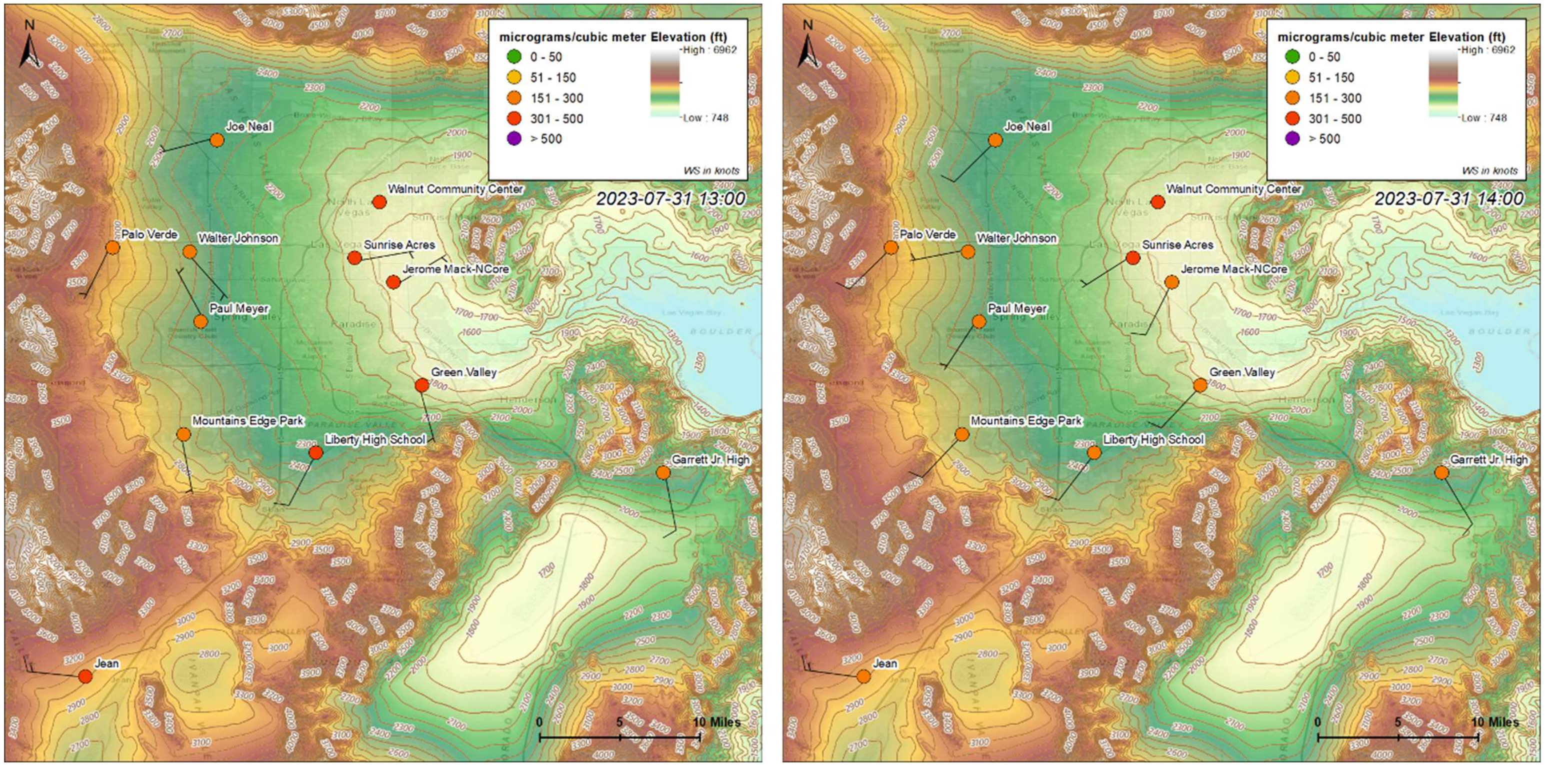


Figure 3.2-9. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 13:00 PST to 14:00 PST.

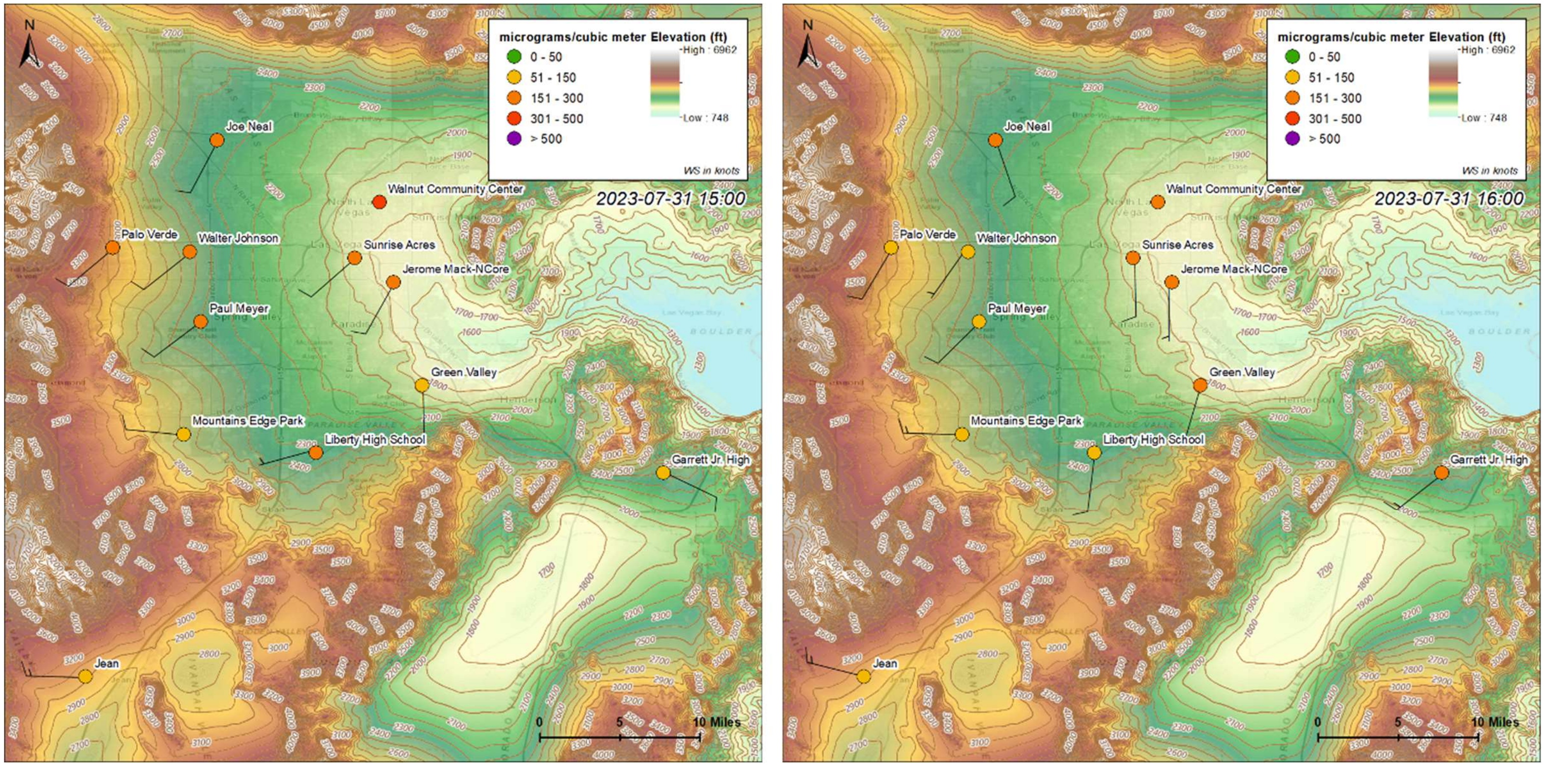


Figure 3.2-10. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 15:00 PST to 16:00 PST.

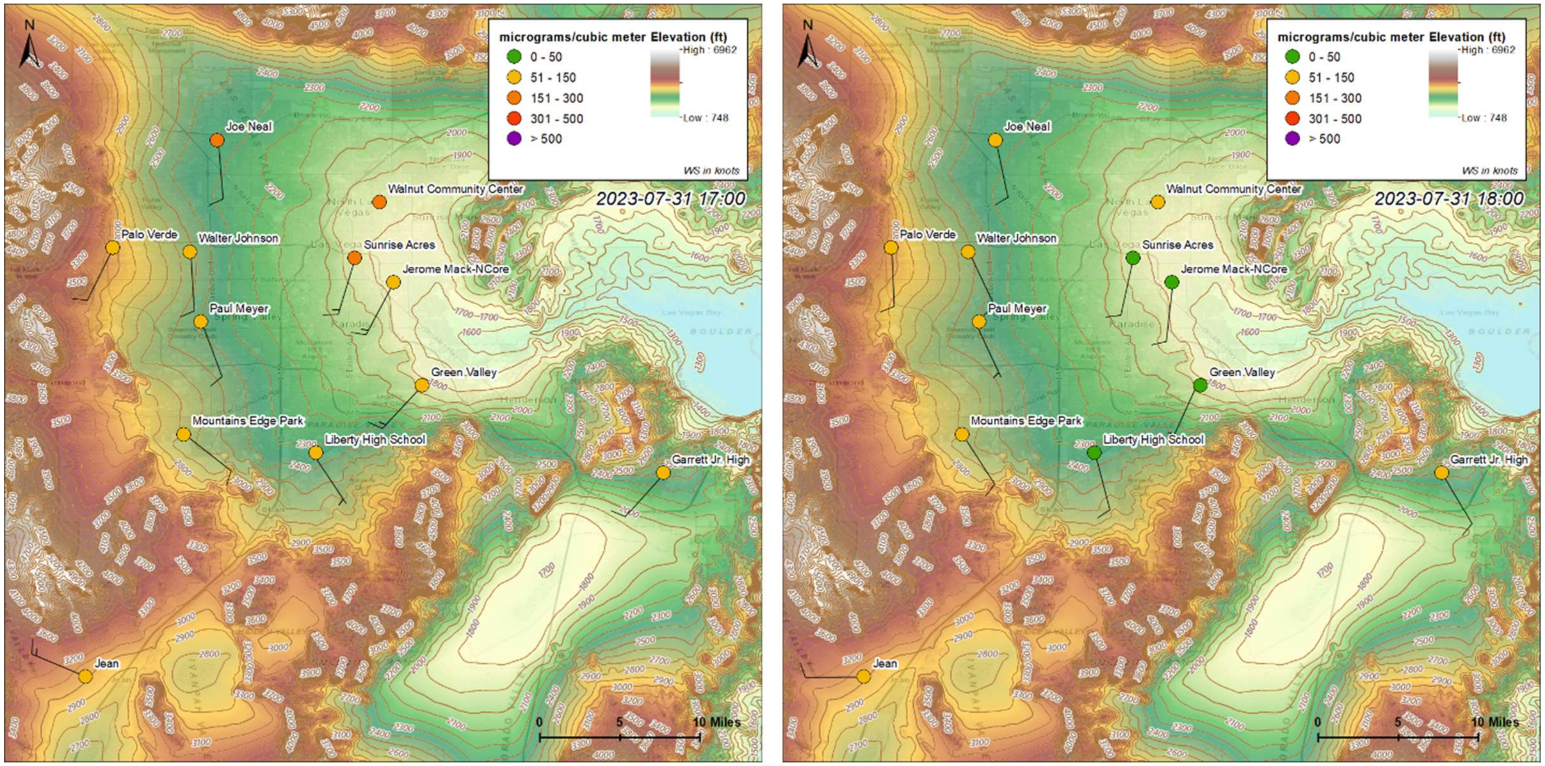


Figure 3.2-11. Topographical map showing surface observations of wind speed, wind direction, and hourly PM_{10} concentrations from each measurement site in Clark County, Nevada, for July 31, 2023, from 17:00 PST to 18:00 PST.

Overall, we find overwhelming evidence that PM_{10} was transported by thunderstorm-induced outflow boundary winds from the Sonoran Desert and through the Mojave Desert in the late evening of July 30 through the early morning on July 31, 2023. Hourly average and 5-minute wind speeds in the source regions and along the transport path show sustained speeds greater than 25 mph, the high-wind threshold. PM_{10} concentrations from monitors along the outflow boundary passage also show the lofted dust from the Sonoran Desert in southeastern California and moving up through the Mojave Desert. The evidence corroborating this assertion includes (1) changes in wind speed along the transport path, (2) enhanced PM_{10} concentrations from monitoring sites along the transport path, and (3) ground-based observation of PM_{10} and wind speed/direction in Clark County that corroborate the PM_{10} event time of arrival.

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

3.3.1 Media Coverage

Multiple news sources, including National Public Radio (NPR), News Channel 3, Patch.com, and NBC Palm Springs reported on the dust event near the source regions from July 30-31, 2023. Screenshots of news articles referenced in this section are included in **Appendix A**.

NPR reported that the Phoenix area had an increased chance of cooling monsoon thunderstorms on July 30, 2023, that could include damaging winds and blowing dust. The heat wave in the southwestern United States throughout July 2023 was starting to decline due to monsoon rains (**https://www.npr.org/2023/07/30/1190968178/historic-hitwave-hit-american-southwest-cool-a-little**).

News Channel 3 reported on a powerful haboob and the aftermath that Indio, California, faced on the morning of July 31, 2023. The storm brought damaging winds, lightning, and lightning-induced fires into the region. Some residents commented on the dust impact across Indio, and mentioned that they have not seen a sandstorm like this in the four years that they lived there. The haboob brought dust and caused damage, with downed trees causing minor accidents. A large amount of sand and dust was lofted into in the air from the outflow of thunderstorms in the region leading to air quality concerns (**https://kesq.com/news/2023/07/31/overnight-haboob-causes-damage-throughout-the-coachella-valley/**).

Patch.com (**Figure 3.3-1**) reported on the monsoonal conditions and the expected elevated amounts of dust in the air for the Imperial and Coachella Valleys. They mentioned the Dust Advisory that went into effect on July 31, 2023, due to the high winds in the Pass Area and Coachella Valley. The South Coast Air Quality Management District (SCAQMD) warned people in the areas impacted by the high levels of dust or dust to limit their time outdoors to avoid exposure (**https://patch.com/california/banning-beaumont/dust-storms-monsoonal-moisture-hit-banning-beaumont-ie**).

Dust Storms, Monsoonal Moisture Hit Banning, Beaumont, IE

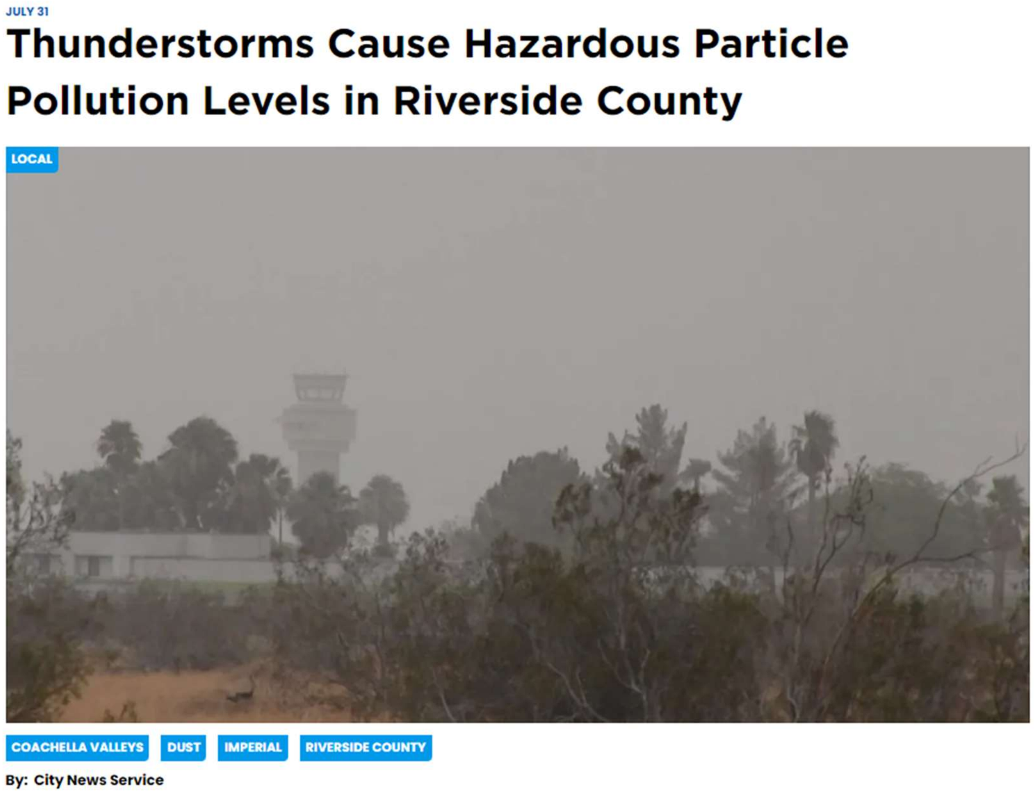
August would sweep in with monsoons and dust storms, the National Weather Service predicted. Still hot weather remains across much of RivCo.

Ashley Ludwig, Patch Staff

Posted Mon, Jul 31, 2023 at 3:15 pm PTUpdated Mon, Jul 31, 2023 at 3:18 pm PT

Figure 3.3-1. Patch.com reported on dust storms and monsoonal moisture on July 31, 2023, in Riverside County and the Imperial and Coachella Valleys area of California.

NBC Palm Springs (**Figure 3.3-2**) reported on the high pollution levels caused by thunderstorms in the Imperial and Coachella Valleys. Air quality regulators issued a dust advisory in areas of Riverside County on July 31, 2023. Pollution levels in the San Gorgonio Pass and the Coachella Valley increased due to the thunderstorms, and the report noted that particle pollution levels were expected to decrease later in the day. The SCAQMD advised that the public should run air conditioners or air purifiers and avoid using anything that would bring outside air inside (**https://nbcpalmsprings.com/2023/07/31/thunderstorms-cause-hazardous-particle-pollution-levels-in-riverside-county/**).



JULY 31

Thunderstorms Cause Hazardous Particle Pollution Levels in Riverside County

LOCAL

COACHELLA VALLEYS DUST IMPERIAL RIVERSIDE COUNTY

By: City News Service

Figure 3.3-2. NBC Palm Springs reported on thunderstorms and high pollution levels in Riverside County on July 31, 2023.

A Dust Storm Warning was also issued for Riverside County, also along the outflow boundary path, for 03:00-05:00 PDT on July 31, 2023. This notice is available in Appendix A.

3.3.2 Pollutant and Diurnal Analysis

Figure 3.3-3 illustrates the timeline of PM_{10} concentrations recorded on July 31, 2023, showing the 1-hour average PM_{10} concentrations for the affected sites. The figure includes a shaded region showing the five-year site-specific 5th - 95th percentile of PM_{10} concentrations, and data points have been colored red if they exceeded the 95th percentile. On July 31, beginning near 05:00 PST, the hourly PM_{10} concentrations surpassed the five-year 95th percentile at the affected sites. The event maintained maximum values throughout the day before dropping within the 5th - 95th percentile near 18:00 PST. Several sites in the northeastern part of the Las Vegas Valley (i.e., the Jerome Mack and Sunrise Acres sites) also saw a second peak near 22:00 PST due to a smaller, short-lived high-wind dust event from a thunderstorm outflow boundary northeast of the valley.

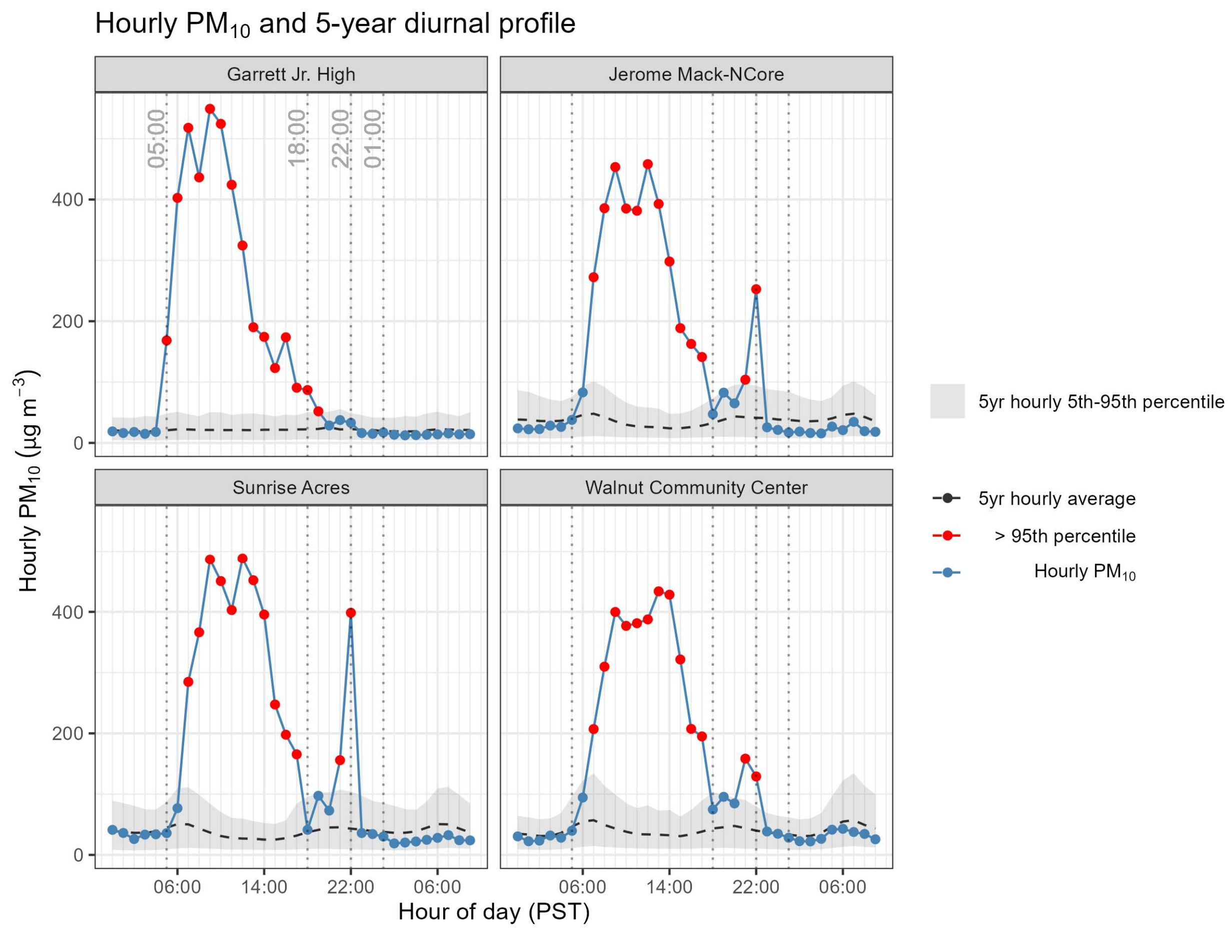


Figure 3.3-3. Hourly PM_{10} concentrations recorded on July 31, 2023; measurements are colored red if they exceeded the five-year (2019-2023), site-specific, hourly 95th percentile.

During the event, 24-hour average PM_{10} concentrations reached over 200 µg/m^3, exceeding both the five-year, combined-site 99th percentile, as well as the NAAQS 150 µg/m^3 threshold (**Figure 3.3-4**) at affected sites. The 24-hour average PM_{10} values immediately before and after July 31 were significantly below the 99th percentile. The episodic and simultaneous increase in PM_{10} concentrations across the monitoring sites suggests a regional source of PM_{10} in line with a wind-blown dust event.

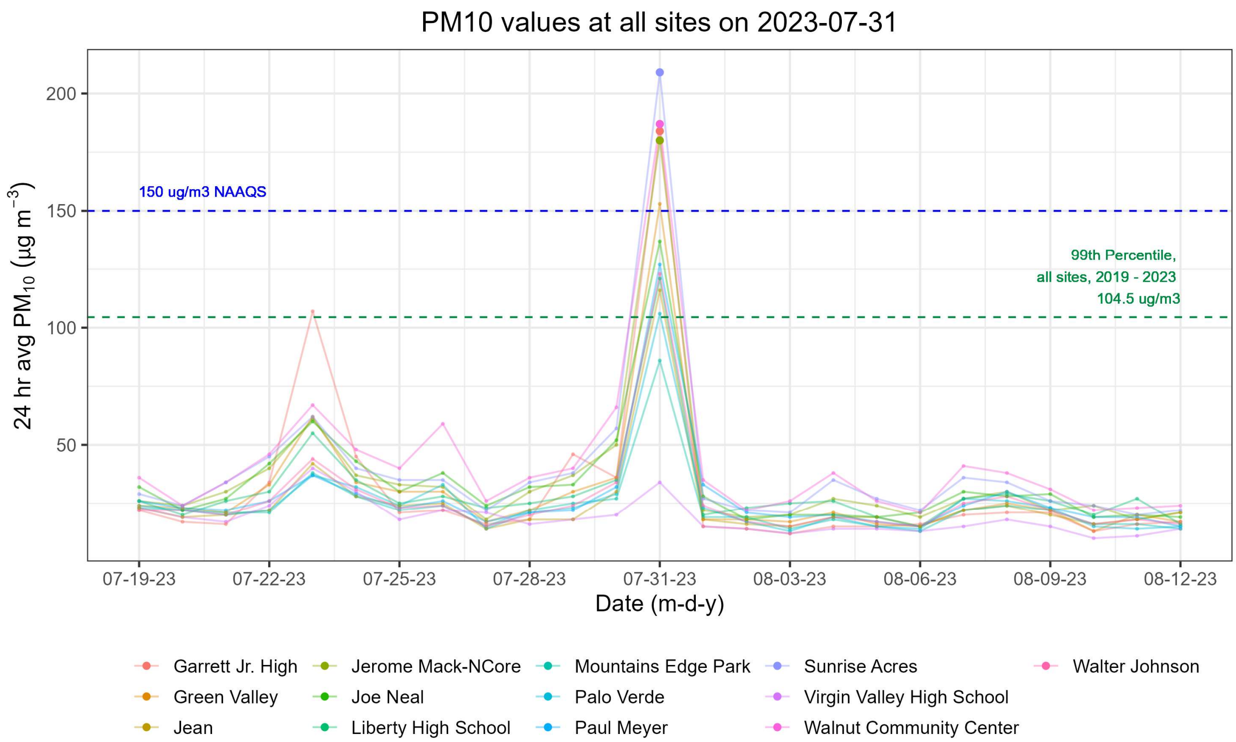


Figure 3.3-4. PM_{10} values in Clark County, Nevada, in July-August 2023, with the NAAQS threshold (blue dash) and five-year 99th percentile (green dash) indicated. The 99th percentile is calculated from 2019-2023 values for all sites combined.

3.3.3 Particulate Matter Analysis

Before the high-wind dust event on July 31, 2023, the hourly $PM_{2.5}/PM_{10}$ ratio is approximately average at all sites based on the 2019-2023 ratio data (Figure 3.3-5). During the mid-morning on July 31, the hourly $PM_{2.5}/PM_{10}$ ratio dropped at all sites to a low value of approximately 0.1 and stayed below the 5th percentile for the rest of the day. The low value of less than 0.1 is consistent with values from dust events reported in studies (Jiang et al., 2018). The decrease in the $PM_{2.5}/PM_{10}$ ratio observed during the mid-morning is also consistent with the increase in hourly PM_{10} concentrations, as described in Section 3.2.2; $PM_{2.5}/PM_{10}$ ratios rise later in the day of the exceedance. Another dip in the $PM_{2.5}$ /PM_{10} ratios occur at the northeastern sites in the Las Vegas Valley (i.e., the Jerome Mack and Sunrise Acres sites) late in the day on July 31 due to a smaller, short-lived dust event caused by a thunderstorm outflow boundary northeast of the valley.

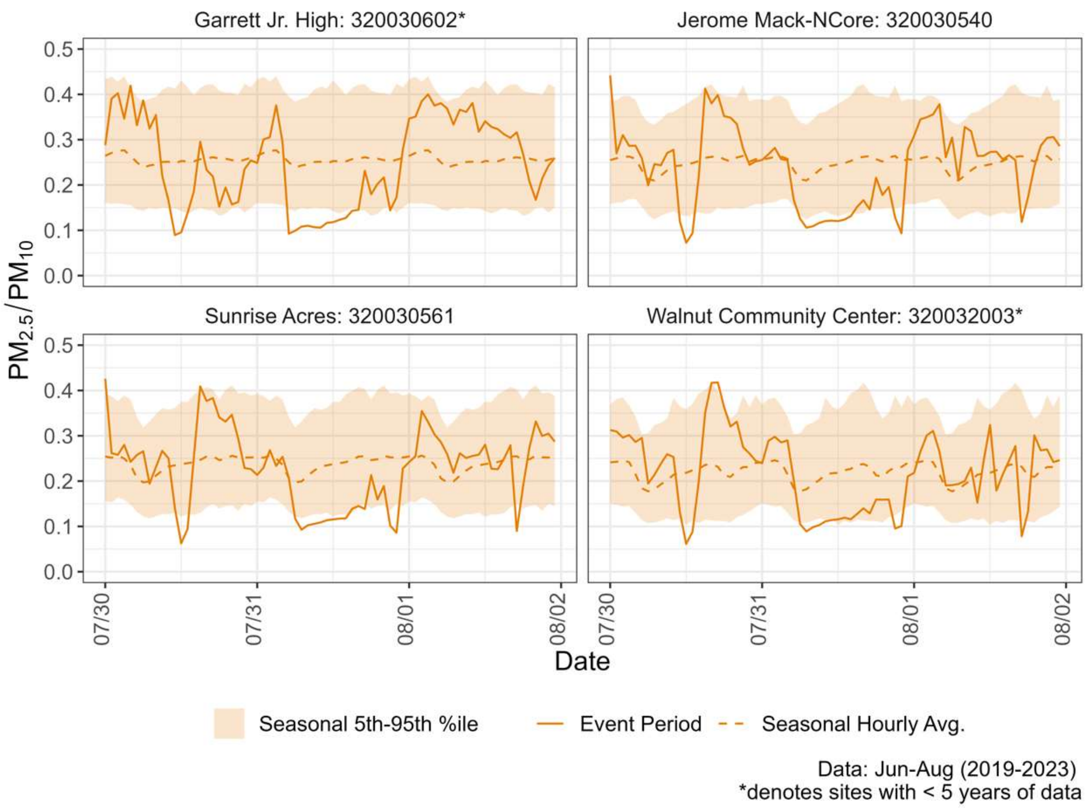


Figure 3.3-5. Ratio of $PM_{2.5}/PM_{10}$ concentrations at the Garret Jr. High, Jerome Mack, Sunrise Acres, and Walnut Community Center sites before, during, and after the July 31, 2023, PM_{10} exceedance event. The five-year average $PM_{2.5}/PM_{10}$ diurnal ratio is displayed as a dotted line, and the 5th to 95th percentile range is shown as a shaded ribbon. The average and 5th - 95th percentile ratio is calculated across June-August of 2019-2023.

3.3.4 Visibility/Ground-Based Images

Visibility data are available from airport monitoring sites through the NWS Weather and Hazards Data Viewer. Figure 3.3-6 shows visibility observations on July 31, 2023 at LAS in Las Vegas. Concurrent with the increasing PM_{10} concentrations, visibility decreases between 09:00-16:00 PST. This is confirmed by camera images in the Las Vegas Valley (Figure 3.3-7 through Figure 3.3-11), which show intensification of dusty and low visibility conditions between 09:00-13:00 PST on July 31, 2023.

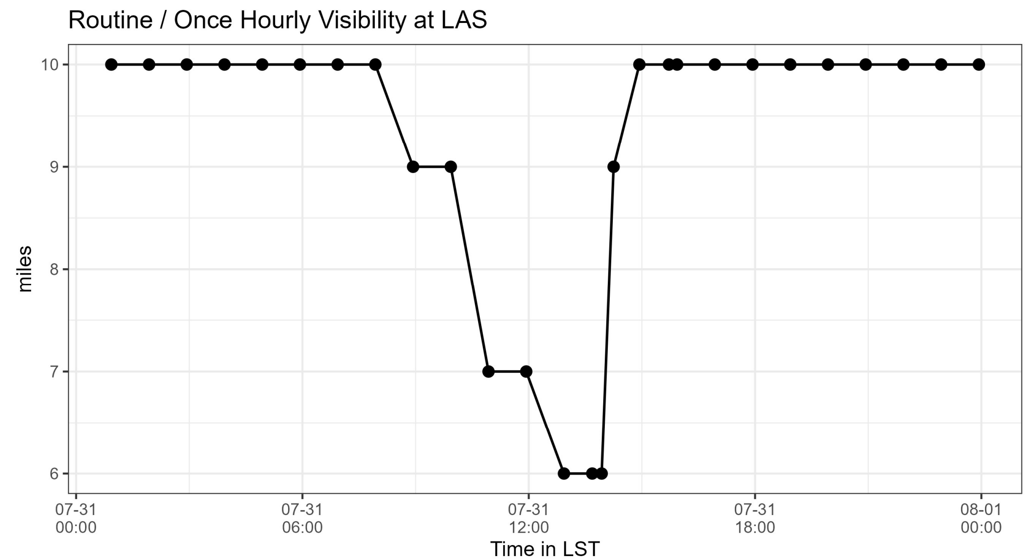


Figure 3.3-6. Visibility in miles on July 31, 2023, recorded at the Harry Reid International Airport (LAS). Visibility data is sourced from the Iowa Environmental Mesonet (https://mesonet.agron.iastate.edu/).

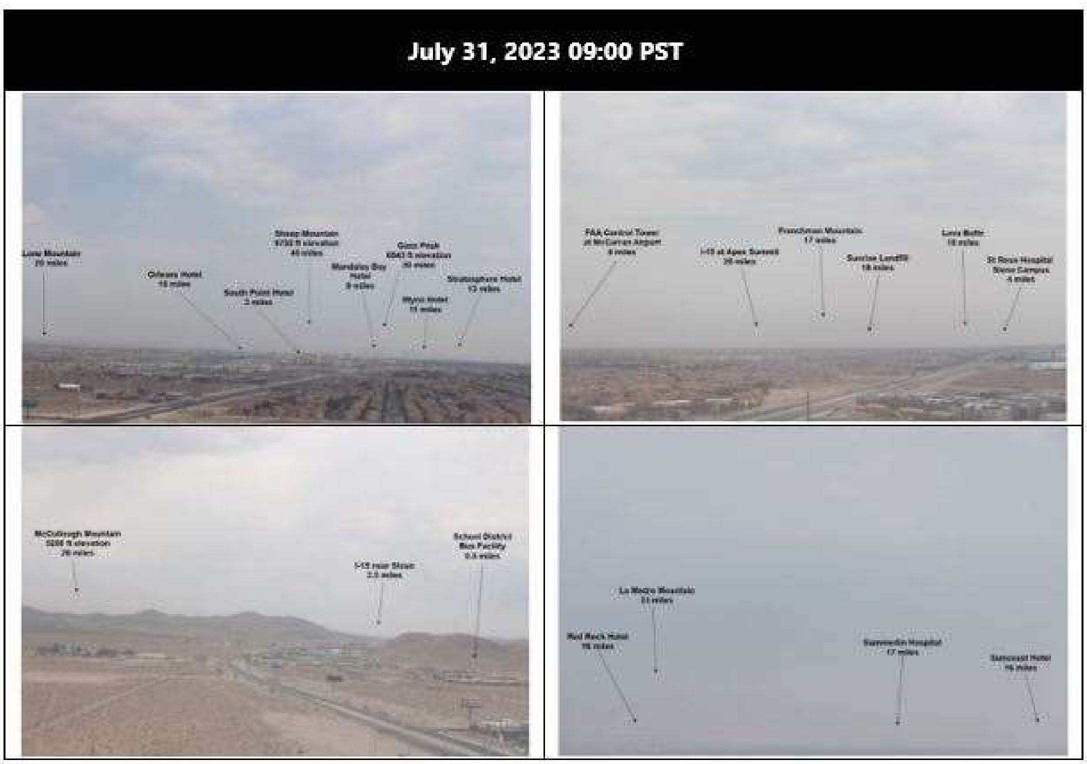


Figure 3.3-7. Camera images for the north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on July 31, 2023, at 09:00 PST.

Figure 3.3-8. Camera images for the north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on July 31, 2023, at 10:00 PST.

Figure 3.3-9. Camera images for the north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on July 31, 2023, at 11:00 PST.

Figure 3.3-10. Camera images for the north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on July 31, 2023, at 12:00 PST.

Figure 3.3-11. Camera images for the north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on July 31, 2023, at 13:00 PST.

Overall, we find overwhelming evidence that on July 31, 2023, PM_{10} was transported from the Sonoran Desert in southwestern Arizona and southeastern California, through the Mojave Desert in southeastern California, and finally reached Clark County by approximately 06:00-07:00 PST. PM_{10} concentrations increased as the outflow boundary entered the Clark County area at approximately 06:00 PST on July 31, with PM_{10} concentrations peaking at 09:00-12:00 PST. This suggests that Clark County was impacted by a regional high-wind dust event originating in the Sonoran Desert. The evidence corroborating this assertion includes (1) media coverage in the source regions and surrounding areas, which provided evidence of a high-wind dust event; (2) an abrupt 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) decreased visibility at the LAS airport corresponding with the PM_{10} event time of arrival; and, (5) ground-based images from the M Resort Hotel in Las Vegas showing extreme dusty conditions on July 31. All pieces of evidence suggest a significant impact from windblown dust at the surface in Clark County on the event date.

3.4 Comparison of Exceptional Event with Historical Data

3.4.1 Percentile Ranking

The 24-hour average PM_{10} concentration observed on the event day ranked in the top 10 and above the 99th percentile of all concentrations observed in the five-year period from 2019-2023 at all affected sites (**Table 3.4-1**). A total of 12 unique days from the five-year period ranked at a higher percentile than the event day across the sites. These 12 days were given a preliminary evaluation for evidence of also being dust events, the results are summarized in **Table 3.4-2**. All 12 days were associated with dust events, wildfire events, or a combination of the two. Full demonstrations supporting exceptional events on these days have been prepared for 10 of the 12 days and can be referenced for further evidence. The other two days showed preliminary evidence of atypical events that should be taken into consideration in their rankings; this preliminary evidence is summarized on the Clark County DEQ website (**https://desaqmonitoring.clarkcountynv.gov/Events**).

Table 3.4-1. Five-year* (2019-2023) rank and percentile of PM_{10} values at affected sites on the July 31, 2023, event date. *Newer sites with less than five years of available data are indicated, and summary statistics are shown for available data.

Date	Site	Rank	Percentile	24-hour PM_{10} (µg/m^3)
7/31/2023	Garrett Jr. High	4	99.9	184
7/31/2023	Jerome Mack	10	99.5	180
7/31/2023	Sunrise Acres	8	99.6	209
7/31/2023	Walnut Community Center	8	99.2	187

Table 3.4-2. Summary of unique days with higher PM_{10} percentile rankings than the July 31, 2023, event day.

Date	Full Exceptional Event Demonstration Prepared?	Preliminary Evidence of Atypical Event?	Summary of Event
9/8/2020	Yes	Yes	Combination of smoke and frontal passage, high winds
7/11/2021	No	Yes	Dust from passing thunderstorms and regional smoke
8/7/2021	No	Yes	Regional wildfire smoke resulting in PM_{10}, $PM_{2.5}$, and ozone exceedances
2/21/2022	Yes	Yes	High wind dust event
4/11/2022	Yes	Yes	High wind dust event
5/8/2022	Yes	Yes	Dust event
5/28/2022	Yes	Yes	Dust event
5/29/2022	Yes	Yes	Dust event
9/8/2022	Yes	Yes	Passing thunderstorm dust event
9/9/2022	Yes	Yes	Passing thunderstorm dust event
10/22/2022	Yes	Yes	Dust event
7/31/2023	Yes	Yes	Combination of nearby wildfire and thunderstorm generated dust event

The following figures provide additional comparisons of the July 31, 2023, event day to the normal range of values:

- Annual time series graphs of 24-hour average PM_{10} concentrations for each affected site are provided in Figure 3.4-1 through Figure 3.4-4. Observations on the event day were above the five-year 99th percentile at all sites. It was also the highest value observed in 2023 for the Garrett Jr. High site, and the second highest value in 2023 for the other affected sites.

- Five-year time series graphs of 24-hour average PM_{10} concentrations for each affected site are provided in Figure 3.4-5 through Figure 3.4-8.

In these figures, other exceedances of the 150 µg/m^3 NAAQS threshold (shown by the blue dashed line) that were further investigated for potential dust event-evidence, as described in Table 3.4-2, are indicated as 'suspect dust event days.'

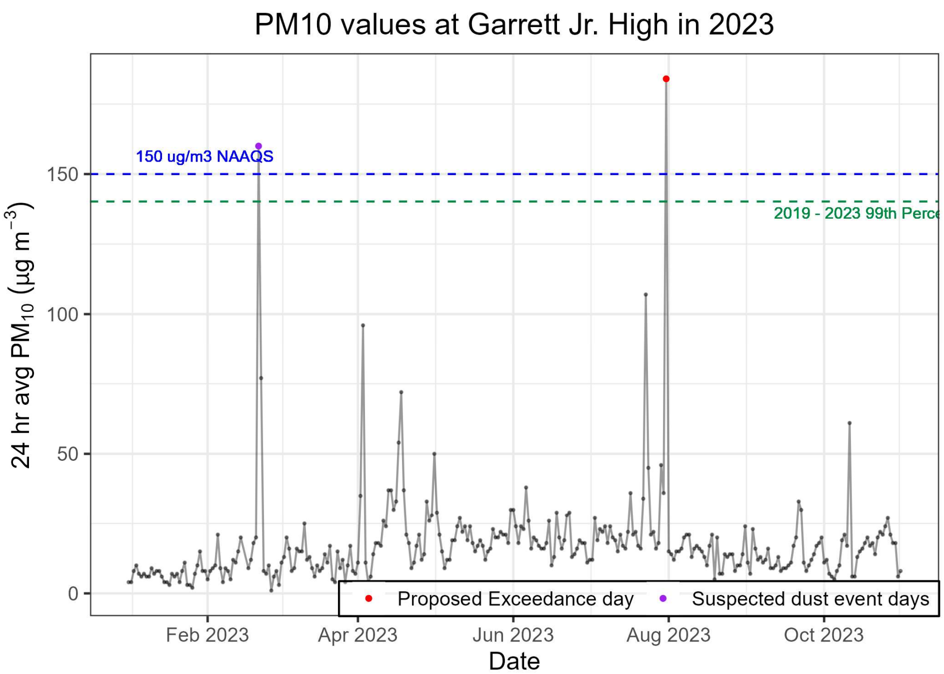


Figure 3.4-1. Garrett Jr. High monitoring site 24-hour PM_{10} measurement in µg/m^3 for 2023, with the (green dash) 2019-2023 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

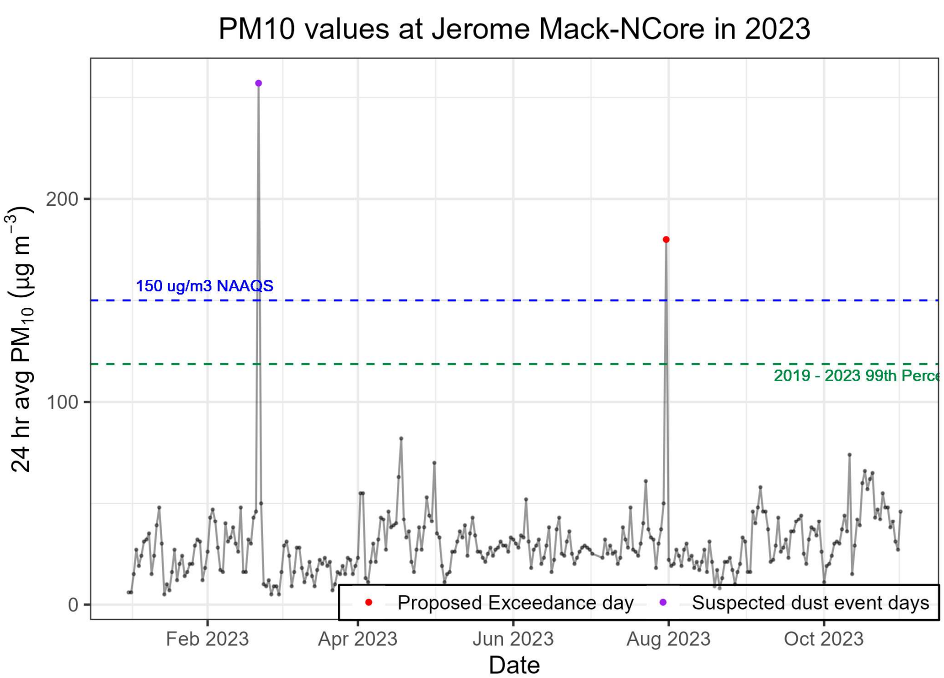


Figure 3.4-2. Jerome Mack monitoring site PM_{10} measurement in µg/m^3 for 2023, with the (green dash) 2019-2023 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

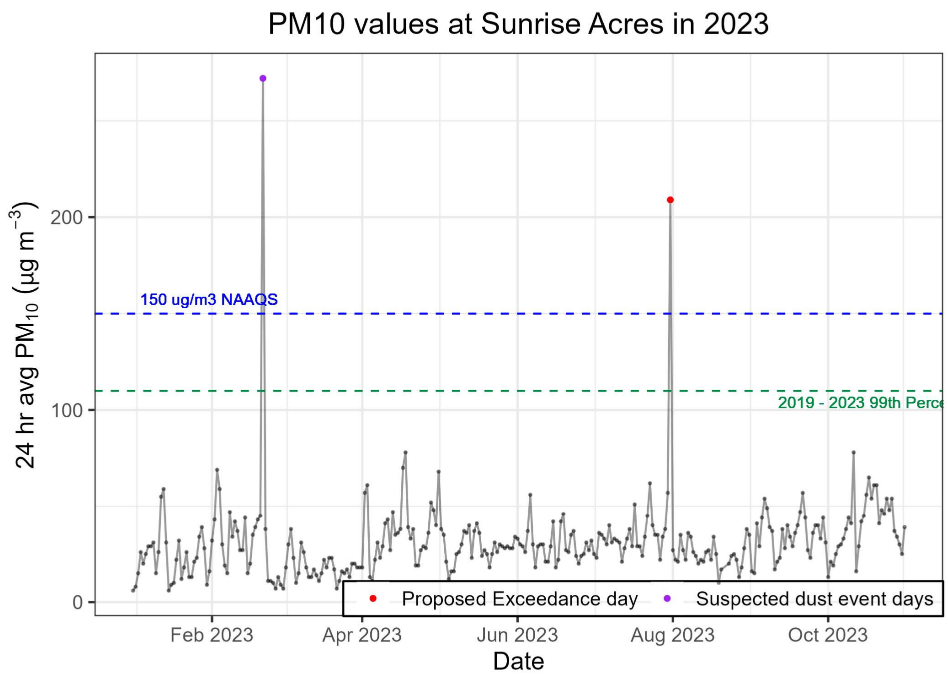


Figure 3.4-3. Sunrise Acres monitoring site PM_{10} measurement in µg/m^3 for 2023, with the (green dash) 2019-2023 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

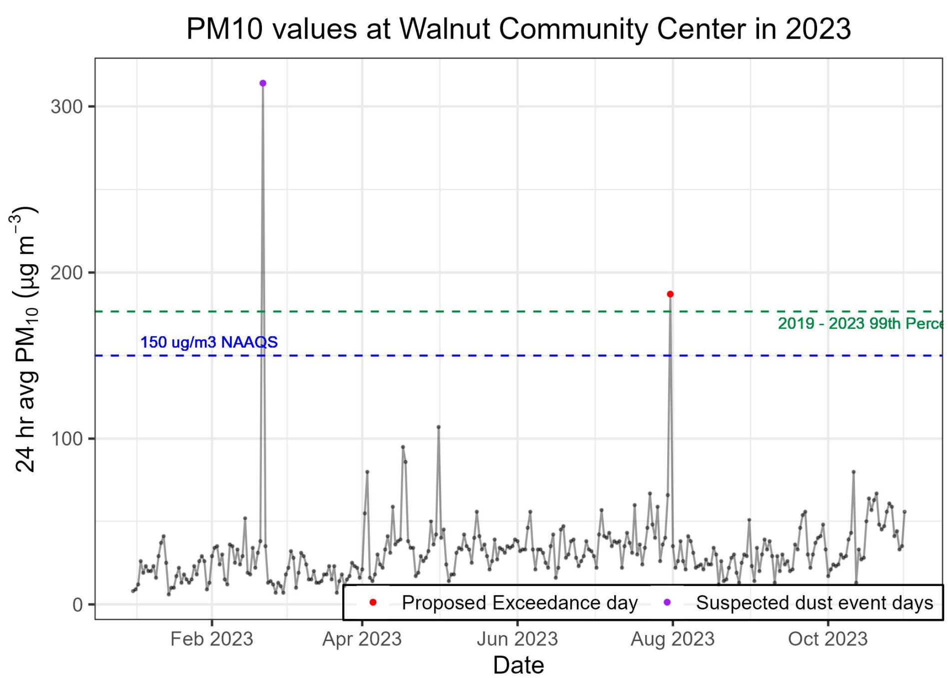


Figure 3.4-4. Walnut Community Center monitoring site PM_{10} measurement in µg/m^3 for 2023, with the (green dash) 2019-2023 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

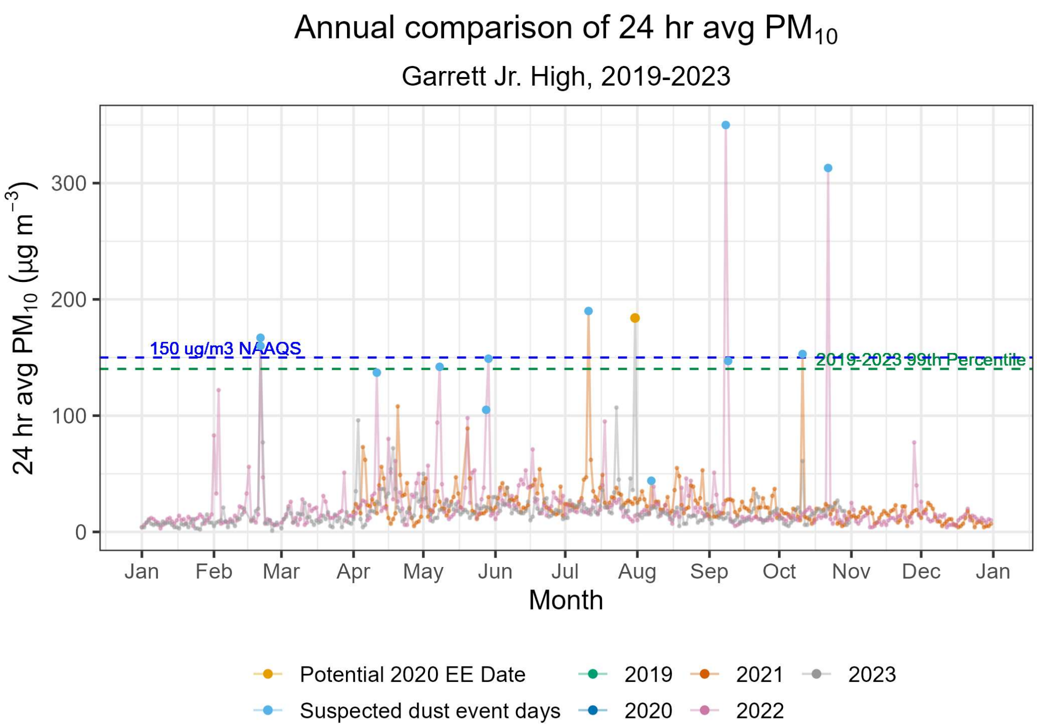


Figure 3.4-5. Garrett Jr. High monitoring site 24-hour PM_{10} measurements in µg/m^3 from 2019-2023 by month with the 99th percentile (green dash) and (grey dash) NAAQS indicated.

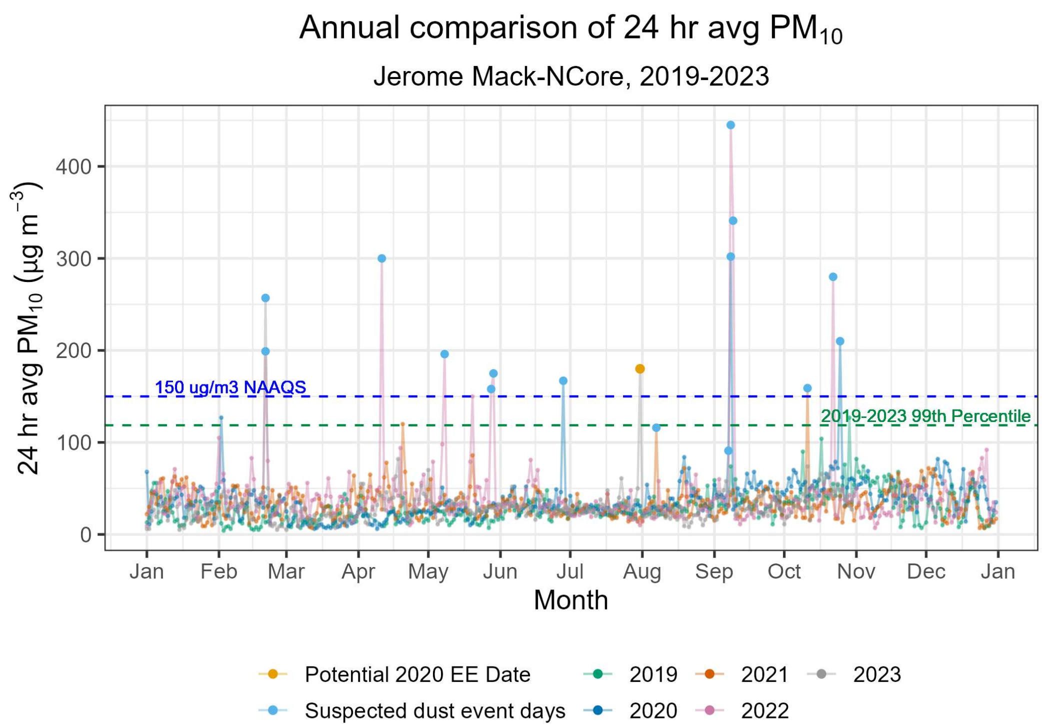


Figure 3.4-6. Jerome Mack monitoring site 24-hour PM_{10} measurements in µg/m^3 from 2019-2023 by month with the 99th percentile (green dash) and (grey dash) NAAQS indicated.

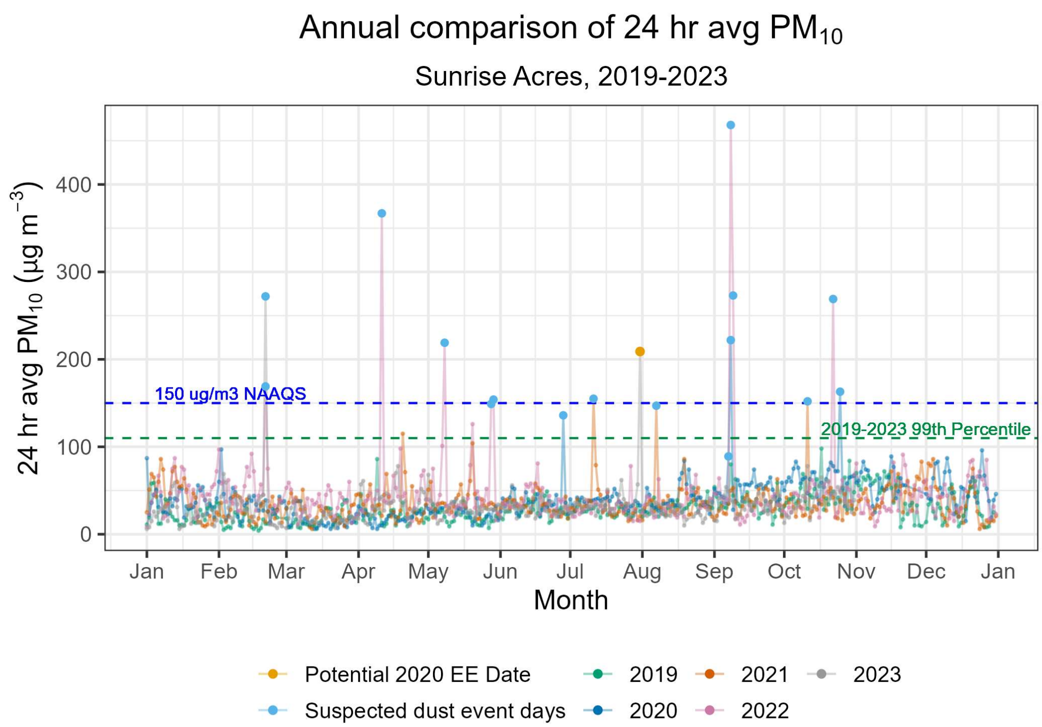


Figure 3.4-7. Sunrise Acres monitoring site 24-hour PM_{10} measurements in µg/m^3 from 2019-2023 by month with the 99th percentile (green dash) and (grey dash) NAAQS indicated.

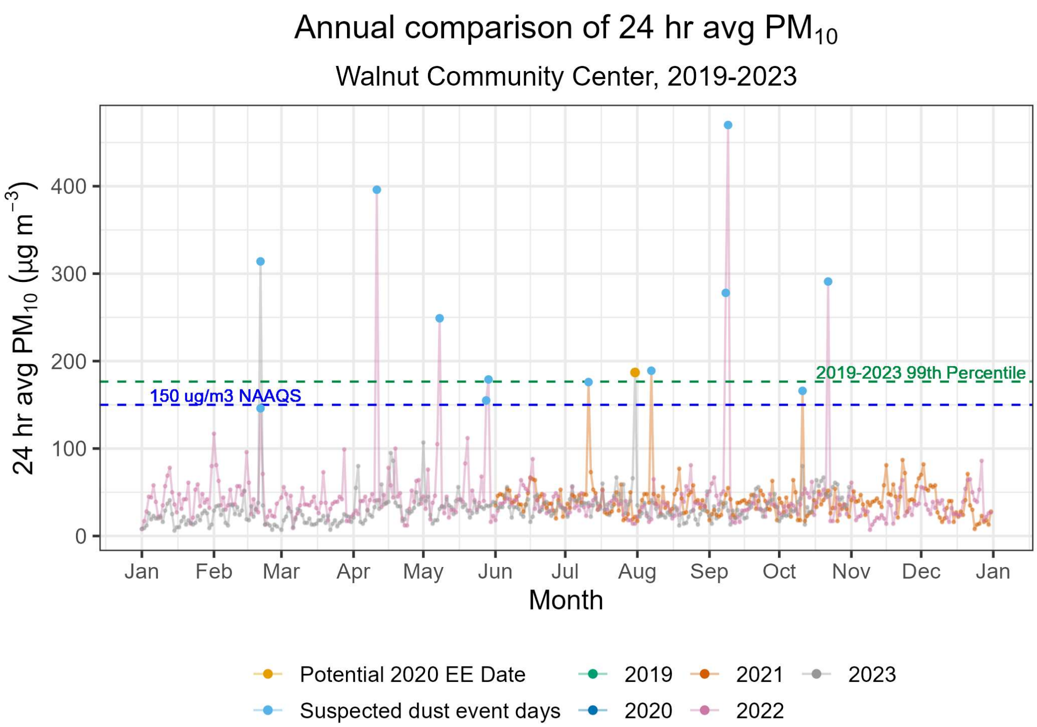


Figure 3.4-8. Walnut Community Center monitoring site 24-hour PM_{10} measurements in µg/m³ from 2019-2023 by month with the 99th percentile (green dash) and (grey dash) NAAQS indicated.

3.4.2 Event Comparison with Diurnal/Seasonal Patterns

The hourly PM_{10} concentrations were compared to five-year (2019-2023) hourly averages. A summary of the maximum value observed compared to the five-year, site-specific 95th percentile is shown in Table 3.4-3, and time series graphs are shown in Figure 3.3-3. At the Garrett Jr. High site, for example, the event reached a maximum of 549.1 µg/m³ at 09:00 PST, 11 times the 95th percentile value of 50.5 µg/m³. Similar trends were seen across the other sites.

Table 3.4-3. Summary of max hourly PM_{10} measurements on the event date compared to five-year, site-specific hourly PM_{10} 95th percentiles.

Site Name	Time of Hourly PM_{10} Max (PST)	Max Hourly PM_{10} (µg/m^3)	Five-Year Hourly PM_{10} 95th Percentile (µg/m^3)	Ratio of Max to Five-Year 95th Percentile
Garrett Jr. High	7/31/2023 9:00	549.1	50.5	11
Jerome Mack	7/31/2023 12:00	458.2	58.2	8
Sunrise Acres	7/31/2023 12:00	488.4	59.5	8
Walnut Community Center	7/31/2023 13:00	433.8	72.8	6

The 24-hour average PM_{10} concentrations were also compared to five-year (2019-2023) monthly and seasonal averages, shown in boxplots Figure 3.4-9 and Figure 3.4-10. The concentrations recorded on the event day are shown to be the highest recorded outliers for the month of July and the summer seasons during the entire five-year period.

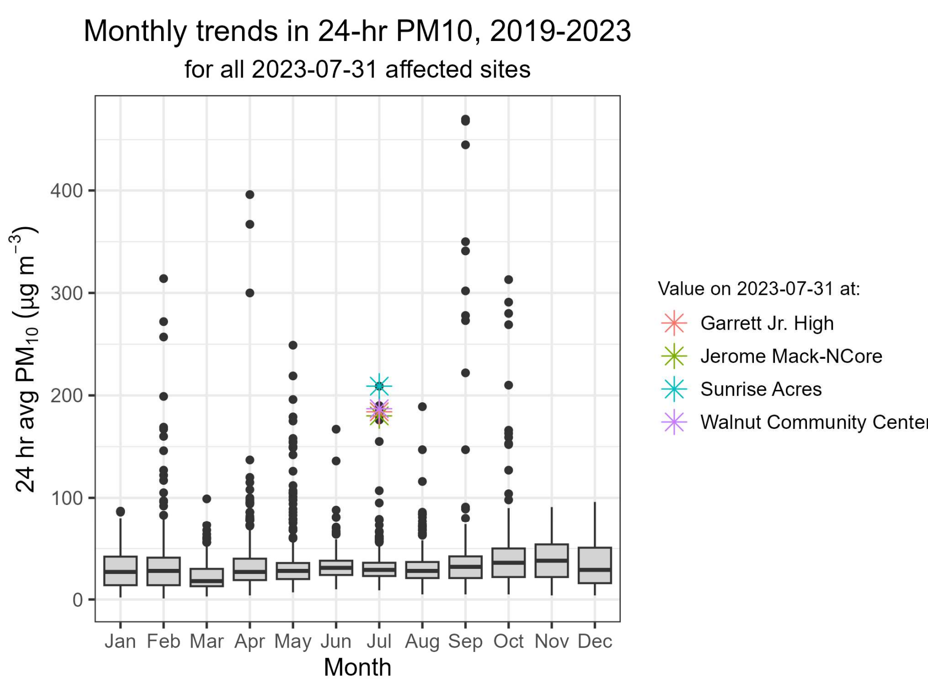


Figure 3.4-9. Monthly trend in 24-hour PM_{10} concentrations for 2019-2023, including outliers, and highlighting the potential exceedance event day.

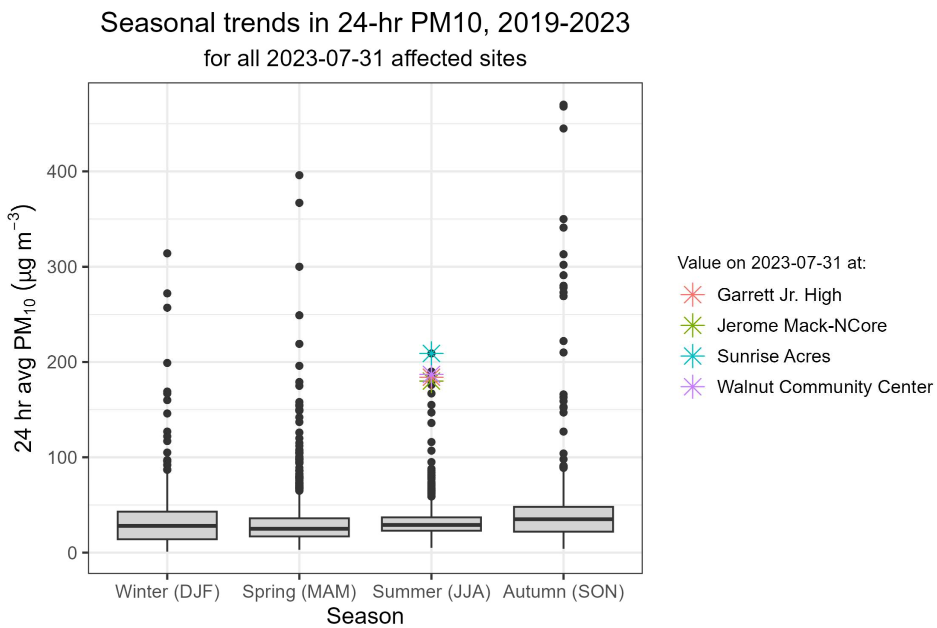


Figure 3.4-10. Seasonal trend in 24-hour PM_{10} concentrations for 2019-2023, including outliers, and highlighting the potential exceedance event day.

Thirty-year seasonal climatology was created using European Environment Agency (ERA5) reanalysis at 0.25° x 0.25° horizontal resolution from 1994 through 2023 for both of the source regions 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 regions and Clark County. This analysis shows the seasonal (June, July, and August) thirty-year average for each variable in the top panel and the event date departure from the seasonal climatology in the bottom panel. Figure 3.4-11 shows the climatology compared with the event date for the source region. On the event date, the source regions of the Sonoran and Mojave Deserts showed higher soil moisture, cooler temperatures, and increased wind speeds, indicative of rain/storms and consistent with the meteorological analysis in Section 3.1.1.

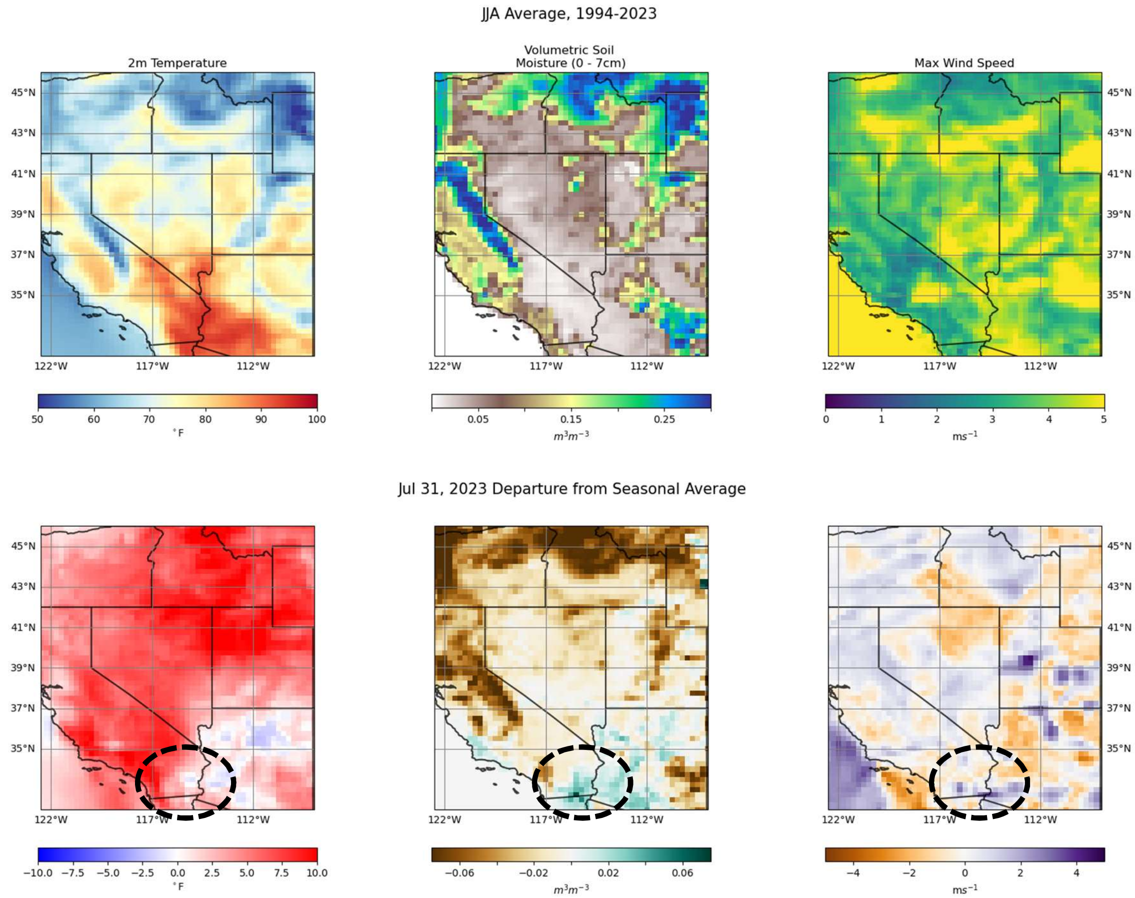


Figure 3.4-11. The thirty-year June-July-August seasonal climatological average based on ERA5 reanalysis for (top row) 2-meter temperature, volumetric soil moisture of the first 7 centimeters, and maximum 10-meter wind speed, and (bottom row) the daily departure for July 31, 2023, from the 30-year average. The source regions are circled.

Figure 3.4-12 shows the climatology compared with the event date for Clark County. On the event date, Clark County experienced a gradient of ground-level temperatures that were largely above the long-term average in the west of the county, and near-to-below normal to the east of the county. Soil moisture and wind speeds were both near to or slightly lower than normal for the event date. This climatological evidence further supports the idea that storms played a key role in triggering the dust event, as indicated by the meteorological analysis.

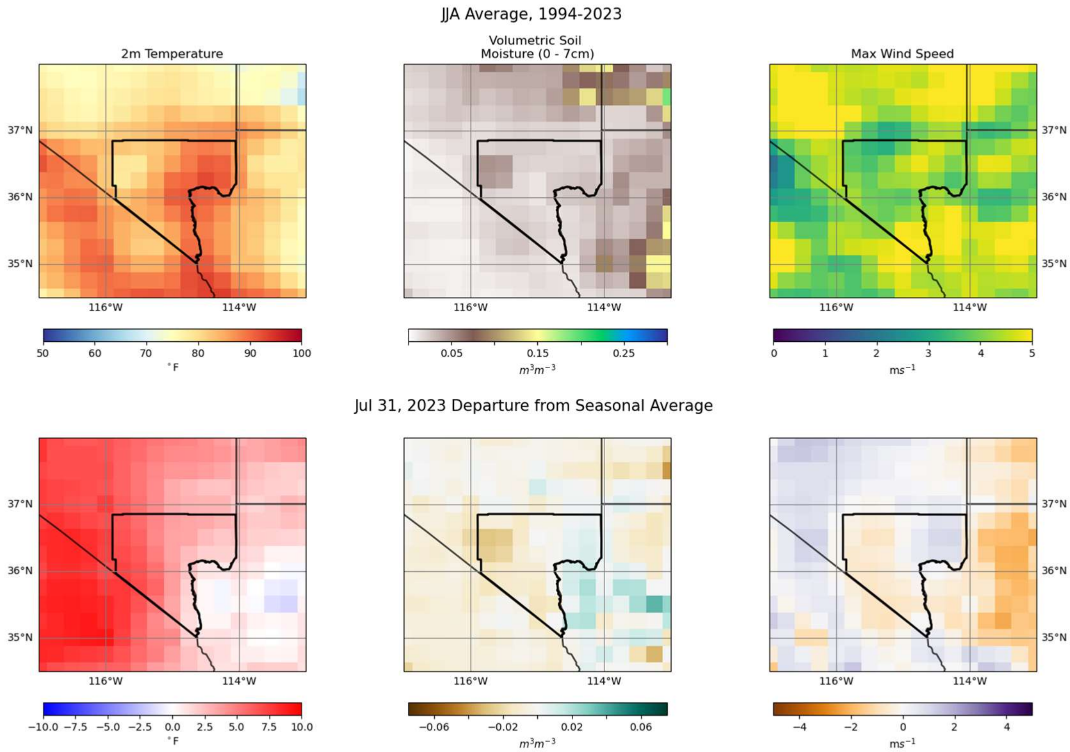


Figure 3.4-12. The thirty-year June-July-August seasonal climatological average for Clark County based on ERA5 reanalysis for 2-meter temperature, volumetric soil moisture of the first 7 centimeters, and maximum 10-meter wind speed (top row) and the daily departure for July 31, 2023, from the 30-year average (bottom row). Clark County is outlined in black.

Overall, we find overwhelming evidence that the July 31, 2023, high-wind dust event in Clark County was well outside normal conditions and impacted by an exceptional event. The evidence corroborating this assertion includes (1) the event rank for PM_{10} concentrations was at or above the 99th percentile at both the 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 concentration was well outside the typical monthly or seasonal norms; and, (4) thirty-year climatology records are consistent with thunderstorms in the source regions and associated higher winds compared with climatological averages.

3.5 Meteorological Similar Analysis

We do not provide a meteorological similar analysis for this date because it is not accurate to compare this event, which was produced by a local-scale, short-term outflow boundary, to other large-scale high-wind events or high PM_{10} dates without high-wind 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 Jerome Mack, Walnut Community Center, and Sunrise Acres monitoring sites of PM_{10} that could have contributed to the July 31, 2023, exceedance. As shown in Section 3.2, however, the main source of PM_{10} is (1) the Sonoran Desert in northern Mexico, southwestern Arizona, and southeastern California, and (2) the southern Mojave Desert, which are 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 July 31, 2023, 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 B**.

The 2012 Maintenance Plan also identified the Natural Events Action Plan for High-Wind Events: Clark County, Nevada 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 Exceptional Events Rule (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. 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 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, which 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 exceed the

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

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 B), 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.

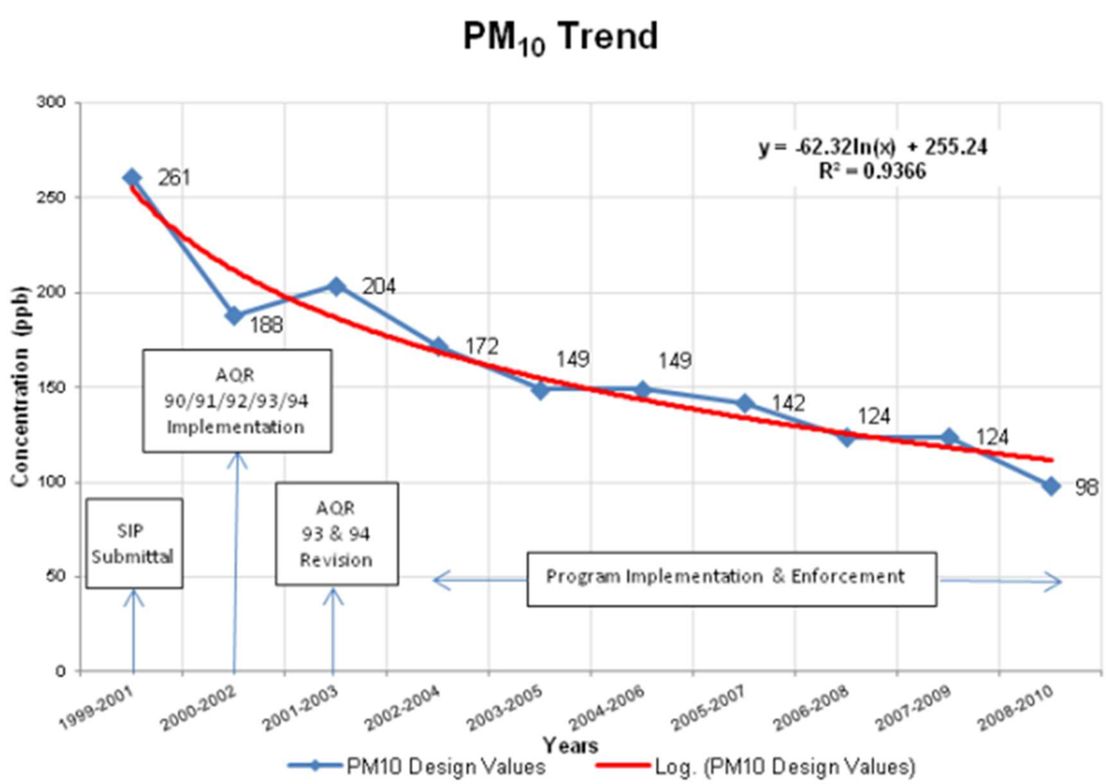


Figure 4.3-1. PM_{10} trends from the 2012 Maintenance Plan.

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.

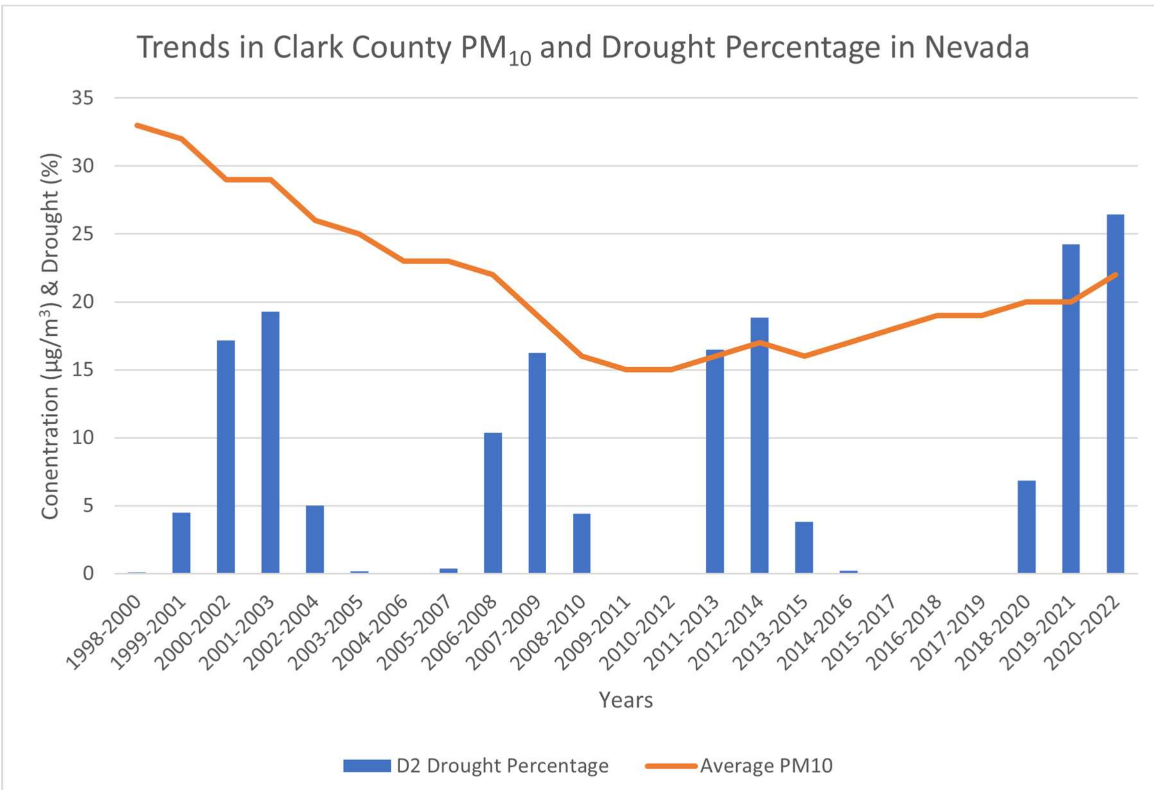


Figure 4.3-2. Three-year running average of PM_{10} concentrations (µg/m^3) at the long-running Paul Meyer monitoring site (AQS: 32-003-0043) (orange line) and the D2 (severe) drought percentage of Nevada (blue bars). Source: **https://www.drought.gov/states/nevada**.

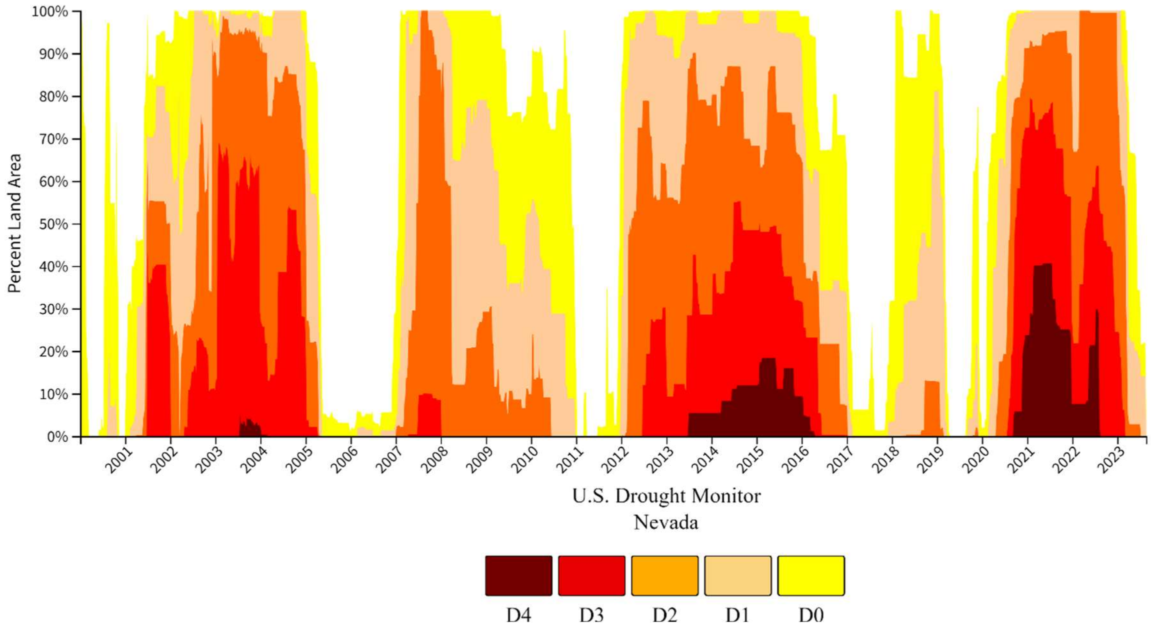


Figure 4.3-3. Drought statistics for Nevada from 2000-2023, colored by drought severity for D0 to D4. Source: **https://www.drought.gov/states/nevada**.

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 sites 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.

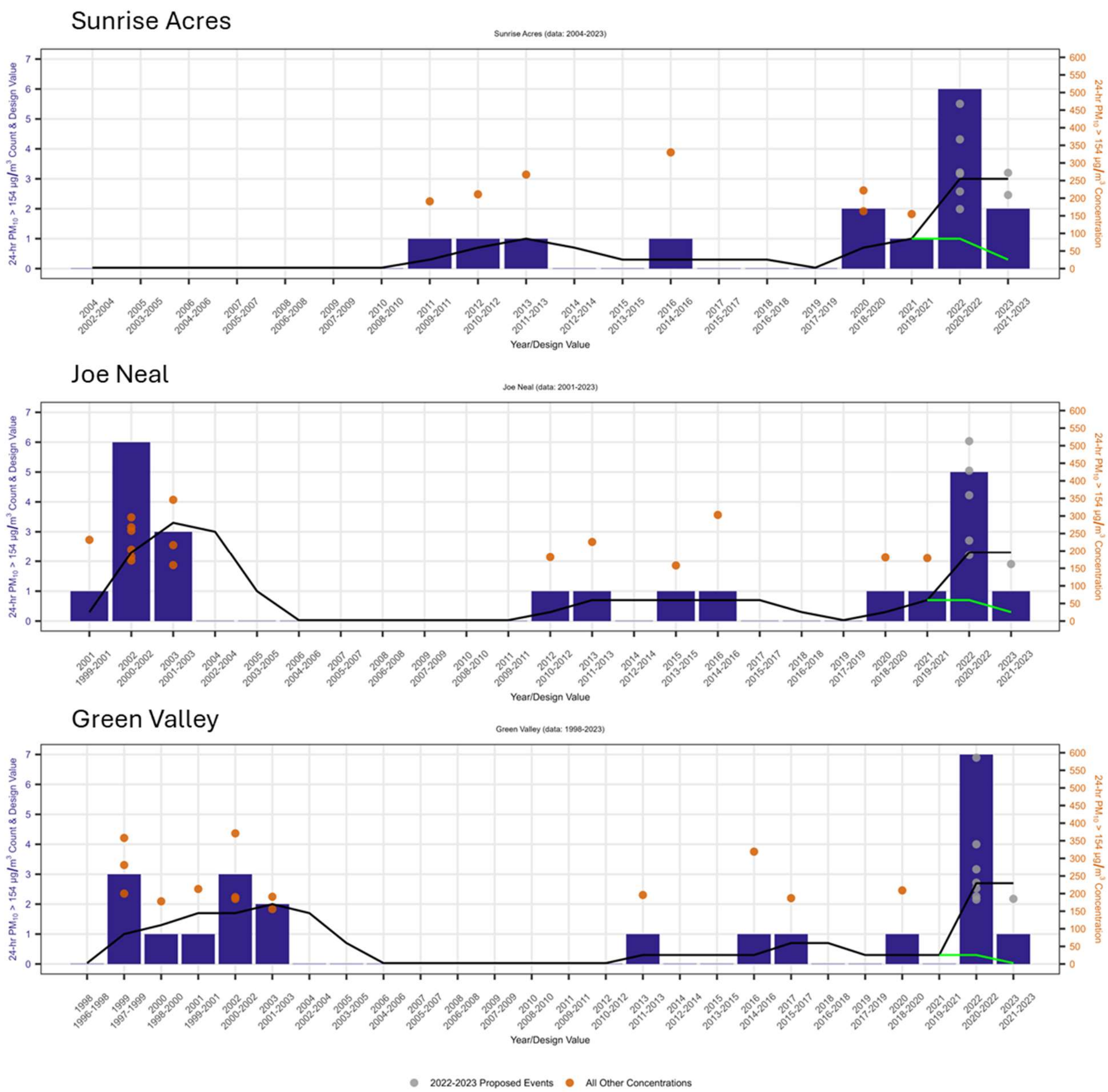


Figure 4.3-4. Historical 24-hour PM_{10} exceedance count (purple bars) and concentration (orange dots) per year/design value period at the Sunrise Acres, Joe Neal, and Green Valley monitoring sites (AQS: 32-003-0561; 32-003-0075; 32-003-0298). The gray dots represent the proposed 2022-2023 PM_{10} exceptional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

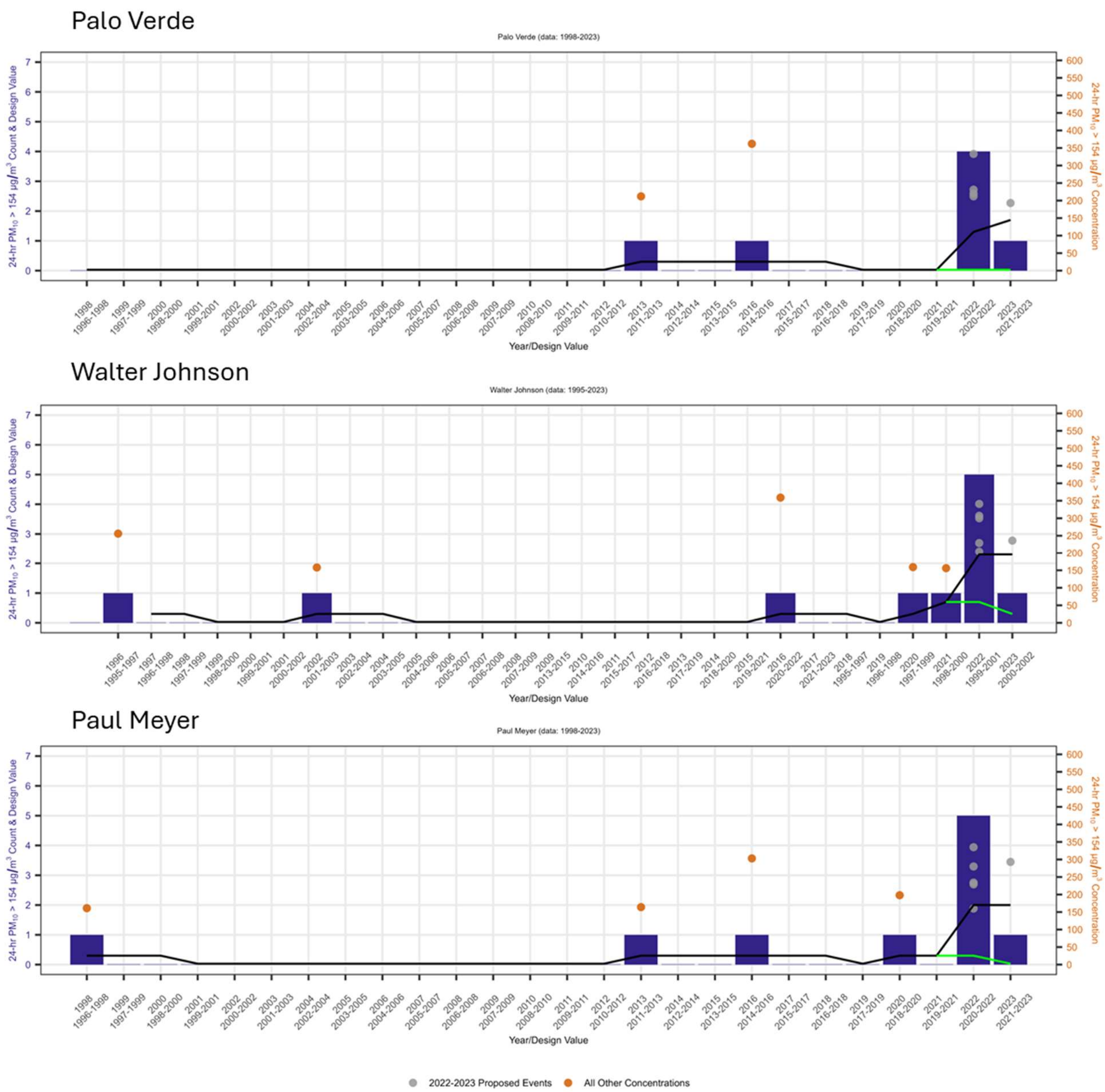


Figure 4.3-5. Historical 24-hour PM_{10} exceedance count (purple bars) and concentration (orange dots) per year/design value period at the Palo Verde, Walter Johnson, and Paul Meyer monitoring sites (AQS: 32-003-0073; 32-003-0071; 32-003-0043). The gray dots represent the proposed 2022-2023 PM_{10} 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 details 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 July 31, 2023, a thunderstorm in northern Mexico and southwestern Arizona created an outflow boundary with associated high-speed winds. The outflow boundary passage through the Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California into the Las Vegas region drove a windblown dust event that increased PM_{10} concentrations in Clark County, Nevada, on July 31. Strong winds in the northern Mexico, southwestern Arizona, and southeastern California source regions were well above 25 mph from the outflow boundary passage, which lofted, entrained, and transported dust from the source regions to Clark County. The hourly PM_{10} concentrations detailed in **Section 3.2.2** show a northerly/northwesterly progression of high PM_{10} concentrations and wind speeds consistent with the direction of travel of the outflow boundary. The outflow boundary pushed through the south/southeastern part of the Las Vegas Valley and first impacted the Jerome Mack, Sunrise Acres, and Walnut Community Center monitoring sites on the eastern side of the Las Vegas Valley; by 07:00 PST on July 31, PM_{10} concentrations above 300 µg/m^3, were recorded at these three sites, while most sites to the west recorded concentrations below 150 µg/m^3. In the following few hours, cyclonic flow in the Valley circulated the high PM_{10} concentrations to all western sites, which recorded concentrations above 400 µg/m^3. Ground-based evidence, including particulate matter analysis (**Section 3.3.3**) and visibility monitors (**Section 3.3.4**), provide additional strong evidence that PM_{10} control measures within Clark County were overwhelmed and unable to prevent an exceedance event on July 31, 2023. The timeline shown in this exceptional event demonstration highlights the progression of extremely high concentrations of PM_{10} from the source regions 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 outflow boundary lofted, entrained, and transported dust from the Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California, this source regions 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

[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

ensure BACM are being implemented, and any observed violation may receive a Notice of Non-Compliance or a Notice of Violation.

Since this dust event was generated by the outflow boundary from a thunderstorm, forecasting the dust impacts in advance was not possible. This and other Clark County public-facing alerts indicate the implementation of BACM and other enforcement procedures. Since it was not possible to forecast the July 31 event, **Appendix C** provides the regularly scheduled construction site inspections performed on these dates by the Compliance and Enforcement Department. Appendix C also provides an example of information that is representative of what inspectors might produce to document their efforts when responding to a Construction Notice or Dust Advisory.

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 D**. 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 July 31, 2023, PM_{10} event were not reasonably controllable or preventable.

5. Natural Event

The July 31, 2023, event is the result of a thunderstorm-induced outflow boundary over the Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California source region; this outflow boundary produced winds that lofted, entrained, and transported dust 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, **Section 4.2**, during the high-wind dust event. Therefore, we conclude 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 July 31, 2023, were caused by a high-wind dust event where dust was lofted, entrained, and transported from the dry Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California. Key elements and evidence associated with the event timeline include:

1. A thunderstorm-induced outflow boundary caused a sharp rise in southeasterly wind speeds across the extremely dry desert source region in the Sonoran Desert in northern Mexico, southwestern Arizona, and southeastern California, to the south/southeast of Clark County between 22:00 on July 30 and 02:00 PST on July 31, 2023. With this outflow boundary, dust from the source region was lofted, entrained, and transported to Clark County across the Mojave Desert by 06:00 to 07:00 PST on July 31. Although winds recorded in the immediate Las Vegas area were below the 25-mph threshold, meteorological measurements in the source region and along the transport path show both hourly and 5-minute wind speeds greater than the 25-mph threshold.

2. Meteorological data along the outflow boundary confirm the Sonoran and Mojave Deserts as the source regions for the high-wind dust event. An initial outflow boundary ahead of these thunderstorms produced strong southerly-southeasterly winds blowing dust as it moved through the source region. This outflow boundary triggered additional thunderstorms in southwestern Arizona and a subsequent new outflow boundary that combined with the initial outflow boundary as it headed northward to Clark County. Meteorological data and visibility measurements all align to confirm event transport from the source region south/southeast of Clark County. PM_{10} measurements along the outflow boundary decreased as winds pushed through Imperial, Riverside, then San Bernardino Counties in California and Clark County in Nevada, confirming the high PM_{10} concentrations along the timeline and trajectories established.

3. Associated with the outflow boundary, PM_{10} was extremely enhanced, visibility measurements indicate dusty conditions, and $PM_{2.5}/PM_{10}$ ratios dropped (indicating windblown dust).

4. PM_{10} concentrations increased in the southeastern part of the Las Vegas Valley first, as the outflow boundary pushed into Clark County starting at approximately 06:00-07:00 PST on July 31, 2023. Cyclonic winds circulated PM_{10} throughout the valley and caused all sites to experience peak PM_{10} concentrations by 09:00-12:00 PST on July 31. 24-hour PM_{10} concentrations were above the NAAQS threshold of 150 $\mu g/m^3$ at 4 sites (regulatory significance at the Jerome Mack [180 $\mu g/m^3$], Sunrise Acres [209 $\mu g/m^3$], and Walnut Community Center [187 $\mu g/m^3$] monitoring sites). Hourly PM_{10} concentrations at some sites in Clark County peaked above 400 $\mu g/m^3$ through the event on July 31. Eleven sites within

the Las Vegas Valley (all sites except for Mountain's Edge) experienced PM_{10} concentrations above the 99th percentile. The concurrent rise in PM_{10} at all sites around Clark County indicates a regional dust event.

5. All sites of regulatory significance exceeded the five-year 99th percentile and the NAAQS on February 21, 2023. Hourly PM_{10} concentrations are also significantly outside typical diurnal, monthly, and seasonal ranges.

6. Clark County, Nevada, and the source regions were under abnormal to moderate drought conditions on and before the July 31, 2023, event. The 30-year climatology shows that wind speeds in the source region were above normal. The barren land cover in the source regions of the Sonoran and Mojave Deserts in northern Mexico, southwestern Arizona, and southeastern California were 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 July 31, 2023. Dust lofted and transported from this natural, undisturbed area experiencing severe drought is considered to be a natural and not reasonable or controllable event.

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 E**).

The high-wind dust event that occurred on July 31, 2023, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at the Jerome Mack (Monitor AQS ID 32-003-0540, POC 1), Sunrise Acres (Monitor AQS ID 32-003-0561, POC 1), and Walnut Community Center (Monitor AQS ID 32-003-2003, POC 1) monitoring sites. On July 31, 2023, the 24-hour PM_{10} concentration reached 180 $\mu g/m^3$ at the Jerome Mack site, 209 $\mu g/m^3$ at the Sunrise Acres site, and 187 $\mu g/m^3$ at the Walnut

Community Center site. Seven additional suspected wind-blown dust events occurred between 2021 and 2023. Without EPA concurrence that the wind-blown dust event on July 31, 2023, and the other suspected events qualify as an exceptional event, the 2021-2023 design value is 3.7 at the Jerome Mack site, 3.0 at the Sunrise Acres site, and 4.0 at the Walnut Community Center site. This is outside of the attainment standard of 1.0. With EPA concurrence on July 31, 2023, and the other seven suspected events, the 2021-2023 design value is 0.3 at the Jerome Mack site, 0.3 at the Sunrise Acres site, and 1.0 at the Walnut Community Center site, all 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 July 31, 2023, and agree to exclude the event from regulatory decisions regarding PM_{10} attainment.

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