ENCLOSURE: TECHNICAL SUPPORT DOCUMENT FOR EPA NONCONCURRENCE ON O_3 EXCEEDANCES MEASURED IN CLARK COUNTY, NEVADA ON MAY 6, 2020 AS AN EXCEPTIONAL EVENT

On July 1, 2021, Clark County Department of Environment and Sustainability (CCDES) submitted an exceptional events demonstration for seven exceedances of the 2015 8-hour ozone (O_3) National Ambient Air Quality Standards (NAAQS) of 0.070 parts per million (ppm) that occurred at the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean and Apex monitoring sites on May 6, 2020.[1,2] The demonstration submitted by CCDES stated that the exceedances measured on May 6, 2020 were caused by a stratospheric ozone intrusion (SOI) over the northwestern United States (U.S.) and eastern Pacific Ocean (SOI source region) that transported O_3-rich air to Clark County, Nevada.[3] Under the Exceptional Events Rule, air agencies can request the exclusion of event-influenced data, and the EPA can agree to exclude these data, from the data set used for certain regulatory decisions, if the EPA determines that the agencies have demonstrated that the event meets the rule criteria and requirements.

As described further in this document, the EPA has concluded that this event does not meet the requirements in the Exceptional Events Rule because the demonstration has not sufficiently shown a clear causal relationship between the specific event and the monitored exceedances. This conclusion was based on review of the extensive evidence presented in the demonstration, including satellite imagery and atmospheric models, trajectory analysis, skew-T diagrams, vertical O_3 profiles, meteorological information, ground level monitoring data, matching day analysis, and statistical modeling analysis. The data and analyses presented in the demonstration, though extensive and supportive that an SOI occurred in the SOI source region, do not support that stratospheric air from the SOI source region was transported to the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean and Apex monitoring sites and impacted air quality so as to cause exceedances of the NAAQS. As a result, the EPA is nonconcurring on this exceptional event demonstration.

The remainder of this document summarizes the Exceptional Events Rule requirements, the event that is the subject of the submitted demonstration, the EPA's review process, and the bases for the EPA's determinations regarding the event.

EXCEPTIONAL EVENTS RULE REQUIREMENTS

The EPA promulgated the Exceptional Events Rule in 2007, pursuant to the 2005 amendment of Clean Air Act (CAA) Section 319. In 2016, the EPA finalized revisions to the Exceptional Events Rule. The 2007 Exceptional Events Rule and 2016 Exceptional Events Rule revisions added sections 40 CFR §50.1(j)-(r); §50.14; and §51.930 to title 40 of the Code of Federal Regulations (CFR). These sections contain definitions, criteria for EPA approval, procedural requirements, and requirements for air agency demonstrations. The EPA reviews the information and analyses in the air agency's demonstration package using a weight of evidence approach and

[1] "Exceptional Event Demonstration for Ozone Exceedances in Clark County, Nevada – May 6, 2020 (July 2021)" ("demonstration").
[2] While submitted by CCDES, the demonstration was prepared by Sonoma Technology under contract with CCDES.
[3] See demonstration, p. ES-1.

decides to concur or not concur. The demonstration must satisfy all of the Exceptional Events Rule criteria for the EPA to concur with excluding the air quality data from regulatory decisions. If any one of the criteria are not met, the EPA will nonconcur with the demonstration.

Under 40 CFR §50.14(c)(3)(iv), the air agency demonstration to justify exclusion of data must include:

A. "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);"

B. "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;"

C. "Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times" to support requirement (B) above;

D. "A demonstration that the event was both not reasonably controllable and not reasonably preventable;" and

E. "A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event."[4]

In addition, the air agency must meet several procedural requirements, including:

1. submission of an Initial Notification of Potential Exceptional Event and flagging of the affected data in the EPA's Air Quality System (AQS) as described in 40 CFR §50.14(c)(2)(i),

2. completion and documentation of the public comment process described in 40 CFR §50.14(c)(3)(v), and

3. implementation of any relevant mitigation requirements as described in 40 CFR §51.930.

For data influenced by exceptional events to be excluded from use in initial area designations, air agencies must also meet the initial notification and demonstration submission deadlines specified in Table 2 to 40 CFR §50.14. We include below a summary of the Exceptional Events Rule criteria, including those identified in 40 CFR §50.14(c)(3)(iv).

Regulatory Significance

The 2016 Exceptional Events Rule includes regulatory language that applies the provisions of CAA section 319 to a specific set of regulatory actions. As identified in 40 CFR §50.14(a)(1)(i),

[4] A natural event is further described in 40 CFR §50.1(k) as "an event and its resulting emissions, which may recur at the same location, in which human activity plays little or no direct causal role. For purposes of the definition of a natural event, anthropogenic sources that are reasonably controlled shall be considered to not play a direct role in causing emissions."

these regulatory actions include initial area designations and redesignations; area classifications; attainment determinations (including clean data determinations); attainment date extensions; findings of State Implementation Plan (SIP) inadequacy leading to a SIP call; and other actions on a case-by-case basis as determined by the Administrator. Air agencies and the EPA should discuss the regulatory significance of an exceptional events demonstration during the Initial Notification of Potential Exceptional Event prior to the air agency submitting a demonstration for the EPA's review.

Narrative Conceptual Model

The 2016 Exceptional Events Rule directs air agencies to submit, as part of the demonstration, a narrative conceptual model of the event that describes and summarizes the event in question and provides context for analyzing the required statutory and regulatory technical criteria. Air agencies may support the narrative conceptual model with summary tables or maps. For SOI events, the EPA recommends that the narrative conceptual model also discuss the local geography/topography, the meteorological conditions that led to the intrusion, how the O_3-containing stratospheric air created elevated ground-level O_3 concentrations at the affected monitor(s), and the chemistry of typical photochemical O_3 formation in the area, and, under 40 CFR §50.14(a)(1)(i), must describe the regulatory significance of the proposed data exclusion.[5]

Clear Causal Relationship and Supporting Analyses

The EPA considers a variety of evidence when evaluating whether there is a clear causal relationship between a specific event and the monitored exceedance or violation. The EPA has published a guidance document for SOIs that outlines the analyses that should be included to establish the clear causal relationship criterion within an air agency's exceptional events demonstration.[6] For SOI events, air agencies should compare the O_3 data requested for exclusion with seasonal historical concentrations at the air quality monitor. In addition to providing this information on the historical context for the event-influenced data, air agencies should include analyses to establish a clear causal relationship between the event and monitored data. As part of the EPA's strategy to ensure air agencies can "right size" demonstrations and manage resources associated with preparing demonstrations, the EPA intends to use a two-tiered approach to evaluate demonstrations for SOI events. The two tiers are delineated based on an event's potential for influencing O_3 concentrations at a given monitor and the history of non-event O_3 concentrations at the affected monitor(s). This approach recognizes that some intrusion events may clearly stand out from normally occurring O_3 concentrations and, thus, may need less supporting evidence to satisfy the rule requirements, particularly for the clear causal relationship element. Within these two tiers of demonstrations, Tier 1 demonstrations are the simplest and least resource-intensive, and may be sufficient for stratospheric intrusion events that cause obvious O_3 impacts during periods in which O_3 concentrations are typically low and meteorological patterns are suggestive of potential transport from the stratosphere. Tier 2 demonstrations should be used when the relationship between the subject intrusion and the influenced O_3 concentrations is complex and not fully elucidated with the simpler Tier 1

[5] Guidance on the Preparation of Exceptional Events Demonstrations for Stratospheric Ozone Intrusions, EPA-457/B-18-001 (November 2018) ("SOI guidance document"), p. 7.
[6] SOI guidance document.

demonstrations. The guidance discusses the types of analyses that could be included within each tier.

Not Reasonably Controllable or Preventable

The Exceptional Events Rule requires that air agencies establish that the event be both not reasonably controllable and not reasonably preventable at the time the event occurred. This requirement applies to both natural events and events caused by human activities; however, it is presumed that SOI events satisfy both factors of the "not reasonably controllable or preventable" element unless evidence in the record clearly demonstrates otherwise.[7]

Natural Event

According to the CAA and the Exceptional Events Rule, an exceptional event must be "an event caused by human activity that is unlikely to recur at a particular location *or* a natural event" (emphasis added). The 2016 Exceptional Events Rule preamble acknowledges that SOIs are natural events. Once an agency provides evidence that an SOI occurred and demonstrates that there is a clear causal relationship between the measurement under consideration and the event, the EPA expects minimal documentation to satisfy the "human activity that is unlikely to recur at a particular location or a natural event" element.

EPA REVIEW OF EXCEPTIONAL EVENTS DEMONSTRATION

On November 30, 2020, CCDES submitted an Initial Notification of a potential Exceptional Event for numerous exceedances of the 2015 8-hour O_3 NAAQS that occurred at monitoring sites within Clark County, Nevada during 2018 and 2020.[8] On July 1, 2021, CCDES submitted an exceptional events demonstration for seven exceedances of the 2015 8-hour O_3 NAAQS that occurred at the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean and Apex monitoring sites within Clark County, Nevada on May 6, 2020.[9]

Regulatory Significance

The EPA determined that data exclusion of some of the exceedances referenced in the Initial Notification may have a regulatory significance for an attainment date extension or determination of attainment by the Marginal area attainment date for the Las Vegas, Nevada (NV) nonattainment area (NAA) for the 2015 8-hour O_3 NAAQS, and worked with CCDES to identify the relevant exceedances and monitoring sites affected.[10] Table 1 summarizes the exceedances that CCDES included in the demonstration.

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[7] According to 40 CFR §50.14(b)(6), "Where a State demonstrates to the Administrator's satisfaction that emissions from stratospheric intrusions caused a specific air pollution concentration in excess of one or more national ambient air quality standard at a particular air quality monitoring location and otherwise satisfies the requirements of this section, the Administrator will determine stratospheric intrusions to have met the requirements identified in paragraph (c)(3)(iv)(D) of this section regarding the not reasonably controllable or preventable criterion and shall exclude data from use in determinations of exceedances and violations."

[8] See email from Araceli Pruett, CCDES, to multiple staff at EPA Region 9, dated November 30, 2020.

[9] See letter from Marci Henson, CCDES, to Elizabeth Adams, EPA Region 9, dated July 1, 2021.

[10] See letters from Elizabeth Adams, EPA Region 9, to Michael Sword, CCDES, dated January 26, 2021, and to Marci Henson, CCDES, dated April 26, 2021 and May 4, 2021.

Table 1: 2015 8-hour O_3 NAAQS Exceedance Summary

Exceedance Date	Monitoring Site Name	AQS ID	2015 8-hour Avg. (ppm)
May 6, 2020	Apex	32-003-0022	0.076
	Paul Meyer	32-003-0043	0.077
	Walter Johnson	32-003-0071	0.078
	Joe Neal	32-003-0075	0.076
	Green Valley	32-003-0298	0.072
	Jerome Mack	32-003-0540	0.073
	Jean	32-003-1019	0.075

Narrative Conceptual Model

The demonstration submitted by CCDES provided a narrative conceptual model in Section 1.4 of the demonstration to describe how O_3-containing stratospheric air was transported from over the northwestern United States and eastern Pacific Ocean into the troposphere and caused the O_3 exceedances at the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean and Apex monitoring sites.[11] Additional information addressing narrative conceptual model components was also presented in the Executive Summary and Sections 2 and 3. The narrative conceptual model included characteristics of the Clark County area, such as descriptions of typical O_3 formation, the ambient O_3 monitoring network, meteorology, geography, topography, emissions, and seasonal O_3 variations.[12] The demonstration incorrectly identified that the exceedances at the Walter Johnson, Paul Meyer, Joe Neal, and Green Valley sites could lead to an O_3 nonattainment designation for the Clark County area;[13] in fact, the portion of Clark County containing the four monitors is currently designated as the Las Vegas, NV Marginal NAA for the 2015 O_3 NAAQS. The demonstration and the conceptual model did not identify the regulatory action for which this event is significant, which is a determination whether the area attained the 2015 O_3 NAAQS by the Marginal area attainment date or qualifies for an attainment date extension.

Section 2 of the demonstration provided: a) a regional description of Clark County and the surrounding area, with respect to topography and climatology; b) an overview of CCDES' monitoring network, including parameters measured and location of the monitors; c) characteristics of non-event historical O_3 formation during the O_3 season as compared to characteristics for the May 6, 2020 SOI event; d) a description of SOI events in general and characteristics specific to the May 6, 2020 SOI event.[14] The demonstration provided results of a comparison of the six-year (2015-2020) historical record and seasonality of maximum daily 8-hour average (MDA8) O_3 concentrations at the Jerome Mack, Green Valley, Walter Johnson, Paul Meyer, Joe Neal, Apex, and Jean monitoring sites compared to May 6, 2020. In the demonstration, "non-event" was defined as all days other than the May 6, 2020 event day. CCDES had identified 15 possible exceptional event days for the year 2018, and 13 possible exceptional event days for the year 2020. These possible exceptional events days were color-

[11] See demonstration, pp. 1-9 to 1-10.
[12] See demonstration, pp. 2-1 to 2-26.
[13] See demonstration, p. ES-1.
[14] See demonstration, pp. 2-1 to 2-26.

coded in the aforementioned six-year historical comparisons. The demonstration also provided an analysis of COVID restrictions' potential effects on O_3 concentrations.[15]

Section 3 of the demonstration contained analysis intended to demonstrate the Clear Causal Relationship portion of the demonstration.[16]

The demonstration cited the 2017 Fires, Asian, and Stratospheric Transport-Las Vegas Ozone Study (FAST-LVOS) as evidence that SOIs can cause exceedances of the O_3 NAAQS in Clark County.[17] More specifically, the demonstration cited a paper by Zhang et al.[18] that evaluated stratospheric and other source contributions to O_3 for "two exemplary SOI events" on April 23 and May 13, 2017. As part of the EPA's review of the demonstration's narrative conceptual model, the EPA reviewed data from AQS for the Clark County O_3 monitors for April 23 and May 13, 2017, and May 6, 2020. This data can be found in Appendix A to this Technical Support Document (TSD). As can be seen from Table A1 in Appendix A of this TSD, on April 23, 2017 the highest observed MDA8 at any monitor in Clark County was 67 parts per billion (ppb), and the highest on May 13, 2017 was 68 ppb; neither of these 2017 events resulted in measured exceedances of the 2015 O_3 NAAQS in Clark County. Table A2 from the Appendix A of this TSD shows the maximum one-hour average O_3 was 71 ppb on April 23, 2017 and 75 ppb on May 13, 2017; the maximum one-hour average O_3 was 98 ppb on May 6, 2020. This highlights the potential relative importance of local contributions, *i.e.*, while there might have been enhanced background O_3 levels due to SOI in the 2017 events, the two intrusions discussed in the Zhang et al. paper were on days with maximum one-hour average O_3 concentrations over 20 ppb lower than that measured on May 6, 2020, and did not result in any monitored exceedances of the O_3 NAAQS in Clark County.

The demonstration asserted that "[t]ypical SOI events in Clark County occur under similar meteorological conditions as those on May 6, 2020."[19] However, there are important differences in the meteorological conditions for the April 23 and May 13, 2017 events from the FAST-LVOS study compared to the May 6, 2020 event. As part of the EPA's review of the demonstration's narrative conceptual model, the EPA reviewed North Las Vegas Airport data (not part of the demonstration) for April 23 and May 13, 2017, and May 6, 2020.[20] This data can be found in Appendix A to this TSD. As can be seen in Appendix A, Table A3 of this TSD, high wind speeds of up to 26 miles per hour (mph) were measured on April 23, 2017, with ten hours measuring wind speeds of 15 mph or above. On May 13, 2017, high wind speeds of up to 29 mph were measured, with eight hours measuring wind speeds of 15 mph or above. In contrast, during the morning hours until the mid-afternoon, the wind speeds on May 6, 2020 were less than 10 mph, reaching a peak speed of 13 mph at 10:53 PM. High wind speeds are typical of an SOI event because high winds can be associated with deep convective mixing and transport of

[15] See demonstration, pp. 2-26 to 2-35.
[16] See demonstration, pp. 3-1 to 3-103.
[17] See demonstration, p. 2-6.
[18] Zhang et al., Characterizing sources of high surface ozone events in the southwestern US with intensive field measurements and two global models, Atmospheric Chemistry & Physics., Volume 20, issue 17, pp. 10379–10400, published September 8, 2020, https://acp.copernicus.org/articles/20/10379/2020/acp-20-10379-2020.pdf.
[19] See demonstration, p. 2-6.
[20] https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2017-4-23.
https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2017-5-13.
https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2020-5-6.

O_3 from the free troposphere to the surface. High wind speeds can also disperse and dilute local emissions of O_3 precursors and thus reduce the local photochemical production of O_3. The evidence from the Zhang paper presented in the demonstration is not convincing that the meteorological conditions on May 6, 2020 were similar to those on April 23 and May 13, 2017. On May 6, 2020, high average temperature (approximately 85 degrees Fahrenheit)[21] and low wind speeds indicate conditions that were conducive to standard photochemistry and more similar to non-SOI event days.

The demonstration provided results from atmospheric transport models: Global Forecast System (GFS), Whole Atmosphere Community Climate Model (WACCM), and Real-time Air Quality Modeling System (RAQMS) for isentropic potential vorticity (IPV), water vapor, and carbon monoxide (CO) concentrations as evidence for a stratospheric intrusion event that injected ozone-rich stratospheric air into the upper troposphere over the Pacific Ocean west of northern California on May 4, 2020, at 00:00 Universal Time Coordinated (UTC) (May 3 at 16:00 Pacific Standard Time (PST)). While the SOI guidance document acknowledges that "[t]here are a variety of possible products that can help demonstrate that the first stage of an intrusion (stratosphere to FT [free troposphere]) occurred,"[22] it also states that "[a]ny demonstrations that use modeled representations of air quality to show stratospheric transport into the PBL [planetary boundary layer] should provide some evidence that the model is well fit for making that determination: those models that are systematically evaluated daily (and demonstrate relatively low levels of bias and error) are preferable, as are those that assimilate actual air quality data into the simulations."[23] The guidance also states that "[p]rognostic or retrospective air quality models may be used to provide evidence that stratospheric material reached the surface, but these analyses must be accompanied by robust model performance evaluations that support their use for this purpose and the horizontal and vertical grid resolution of the model should be appropriate for capturing an event."[24] The coarse grid global models used in the demonstration do not have adequate spatial resolution needed for urban O_3 modeling compared to rural O_3 and thus are not expected to perform well for urban O_3. The models alone are not sufficient to establish that stratospheric O_3 reached the surface and caused the exceedances. Additional analysis of the surface monitoring data and meteorological data is needed to establish that the O_3 rich layer extended to the surface layer and caused the O_3 exceedances.

In many instances, O_3 rich tropospheric air is not mixed into the PBL and does not reach surface monitoring sites. For example, research field studies including the 2013 Las Vegas Ozone Study (LVOS)[25] and the 2017 FAST-LVOS study[26] identified multiple events in which SOI layers were observed in the free troposphere above Las Vegas but did not reach the surface or contributed minimally to surface layer O_3 after mixing with transported plumes that contained enhanced O_3 concentrations from wildfires or international transport. While air quality models can be useful as weight of evidence analysis for supporting the possibility that stratospheric O_3-rich air

[21] See demonstration, p. 3-82.
[22] See SOI guidance document, p. 19.
[23] See SOI guidance document, p. 25.
[24] See SOI guidance document, p. 30.
[25] A. Langford, Las Vegas Ozone Study (LVOS), Final Report (MOU #CBE 602948-13), Clark County Department of Air Quality, July 25, 2014.
[26] A. Langford and C. Senff, Fires, Asian, and Stratospheric Transport-Las Vegas Ozone Study (FAST-LVOS), Report Contract No. CBE 6043188-16) for Clark County Department of Air Quality, December 1, 2019.

impacted the surface, the global scale models cited in the demonstration have very coarse scale resolution and large uncertainty in simulating both vertical mixing and surface concentrations of O_3. As discussed below, the analysis of surface monitoring data also does not support the conclusion that the O_3 exceedance was caused by mixing of stratospheric O_3 to the surface.

Although the demonstration stated that the Cajon Pass and I-15 corridor is an important atmospheric transport pathway from the Los Angeles Basin into the Las Vegas Valley (LVV),[27] the demonstration did not provide analysis of monitors' concentrations along this corridor on May 6, 2020 (and days prior), nor did it provide a comparison of the conditions on May 6, 2020 (and days prior) to non-event days that had significant transport impact. Moreover, the demonstration stated that meteorological conditions on May 6 suggest that local and regional O_3 production from surface pollutant precursors should be relatively high[28] but did not demonstrate that SOI, and not this local regional O_3 production, caused the monitored exceedances.

The demonstration information referenced above includes several analyses that were located outside of the demonstration's stated narrative conceptual model and within the detailed technical sections addressing other rule criteria. The SOI guidance document states that narrative conceptual models are expected to "help readers and the reviewing EPA Regional office understand the event formation and the event's influence on monitored pollutant concentrations before the reader reaches the portion of the demonstration that contains the technical evidence to support the requested data exclusion."[29] The detail provided in Section 1.4 did not clearly or completely outline the conceptual model of the event formation and influence on monitored pollutant concentrations; rather, it presented the conceptual model as a summary of the clear causal relationship evidence. The conceptual model section also did not include the types of information outlined in the SOI guidance document. Additional information that reflected the conceptual model requirements was included elsewhere in the demonstration and is described above; however, this information should have been included or specifically referenced in the conceptual model portion at the beginning of the demonstration to clearly outline the demonstration's overall characterization of how the event led to the observed exceedances.

Overall, the demonstration contained the elements required for inclusion in the conceptual model portion of the exceptional events demonstration.

Table 2: Documentation of the Narrative Conceptual Model

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
May 6, 2020	Executive Summary: p. ES-1 Section 1.4: pp. 1-9 to 1-10 Section 2: pp. 2-1 to 2-26 Section 3: pp. 3-1 to 3-82	Sufficient	Yes

Clear Causal Relationship

The demonstration included several analyses intended to support a clear causal relationship between the SOI event and the monitored exceedances. These analyses are presented in Section

[27] See demonstration, p. 2-1.
[28] See demonstration, p. 2-25.
[29] See SOI guidance document, p. 7.

3: a) comparison of the SOI event concentrations to historical concentrations; b) analyses addressing stratospheric-tropospheric exchange: satellite imagery and atmospheric models; c) analyses addressing stratospheric air reaching the surface: Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) trajectory analysis, measurements of tropospheric mixing shown in skew-T diagrams, vertical O_3 profiles, and meteorological maps; d) analyses addressing impacts of the SOI at the surface: analysis of absolute humidity (AH), temperature, and measured concentrations of O_3, nitric oxide (NO) and nitrogen dioxide (NO_2); e) a matching day analysis; and f) Generalized Additive Model (GAM) statistical modeling.[30] The EPA reviewed the event and the tiering information provided in the SOI guidance document and determined that the appropriate tier for this event is Tier 2.[31] As stated in the SOI guidance document for a Tier 2 demonstration: "More complex relationships between the subject stratospheric intrusion and the influenced ozone concentrations will typically require additional detail to satisfy the clear causal relationship element (i.e., a Tier 2 demonstration). This additional evidence can either show the relative contribution estimates to the exceedance from local and transported anthropogenic pollutants compared to the intrusion contribution (i.e., quantification and apportionment) or show that meteorological conditions were not conducive to local photochemical production of ozone and that the demonstrated intrusion best explains the elevated ozone concentration(s)."[32] As part of the EPA's review of the demonstration's clear causal relationship information, the EPA produced additional figures and tables that were not included in the demonstration. These figures and tables can be found in Appendix A to this TSD.

Comparison with historical concentrations

The demonstration included a comparison with historical concentrations, as required by 40 CFR §50.14(c)(3)(iv)(C). The demonstration compared the exceedances to six years of historical data (2015-2020) at the seven affected monitoring sites.[33] The data was presented in graphs as well as tables. The graphs show that the seven monitoring sites measured maximum 8-hour O_3 concentrations equal to or above the 99th percentile when using six years of year-round data. When comparing to percentiles calculated only for the five-year history (2015-2019) from the week before and after the exceedance day, the concentrations measured at Apex, Jean, Jerome Mack, Joe Neal, Paul Meyer, and Walter Johnson on May 6, 2020 were at or above the 99th percentile value and the concentration at Green Valley was below the 99th percentile value. Rank-ordered O_3 concentrations show that the May 6, 2020 exceedance value fell within the top five O_3 concentrations in 2020 for each of the seven monitoring sites included in the demonstration. Four of the seven sites measured other exceedances during the six-year period historical data that were higher in magnitude than those measured on May 6, 2020.

Overview of the event and evidence that stratospheric-tropospheric exchange occurred

The demonstration provided an overview of the event, including a description of stratospheric-tropospheric exchange (STE).[34] The demonstration included analysis of satellite data for May 4-7, 2020 to identify possible signatures of a stratospheric intrusion event, such as O_3-rich and extremely dry air in the free troposphere. These analysis products include maps of true color visible imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments

[30] See demonstration, pp. 3-1 to 3-103.
[31] See demonstration, pp. 1-3 to 1-4. The demonstration was completed as a Tier 2 analysis.
[32] See SOI guidance document, p. 31.
[33] See demonstration, pp. 2-9 to 2-15 and 3-1 to 3-11.
[34] See demonstration, pp. 3-12 to 3-39.

onboard the Terra satellite, water vapor imagery from Geostationary Operational Environmental Satellite (GOES)-East, and total column O_3 from the Ozone Mapping and Profiling Suite (OMPS) Nadir-Mapper (NM) instrument onboard the Suomi National Polar-orbiting Partnership (NPP) satellite and from Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2). The demonstration acknowledged water vapor was present over the eastern Pacific Ocean from May 4 to May 7 (Figures 3-11 through 3-14) in the same regions that showed enhanced tropospheric column O_3 (Figure 3-15), which could weaken the case for an SOI having occurred over the eastern Pacific Ocean. The demonstration hypothesized that the moisture-rich air over the eastern Pacific Ocean was at lower altitude in the troposphere than the SOI layer,[35] but did not provide evidence to support this hypothesis. The total column O_3 data in Figures 3-15 and 3-16 support the possibility that an SOI extended into the free troposphere over the eastern Pacific Ocean, Oregon and northern California and Nevada on May 4.

The demonstration presented modeling analysis results from atmospheric transport models as evidence of stratosphere-to-troposphere mixing, including RAQMS, GFS, WACCM, and MERRA-2 data for O_3, carbon monoxide (CO) and IPV levels.[36] Stratospheric air is characterized by high IPV, high concentrations of O_3, and low concentrations of CO compared to tropospheric air; these characteristics can therefore act as tracers for the mixing of stratospheric air into the troposphere. Demonstration Figures 3-17 (GFS model) and 3-21 (WACCM model) show elevated IPV and elevated O_3 respectively at 0:00 UTC on May 4 (16:00 PST May 3) in the vicinity of the SOI source region. Demonstration Figures 3-30 (RAQMS model) and 3-31 (WACCM model) show reduced CO levels at 0:00 UTC on May 4 (16:00 PST May 3) in the vicinity of the SOI source region.

The visible water vapor, ozone satellite imagery, and meteorological data as well as model results for IPV, ozone, and CO levels presented in the demonstration provide some evidence that STE occurred in the SOI source region over the eastern Pacific Ocean west of northern California.

<u>Evidence that stratospheric air reached the surface</u>
The demonstration further presented evidence to support that O_3-containing stratospheric air was able to penetrate to the lowest levels of the atmosphere, including HYSPLIT trajectory modeling,[37] radiosonde skew-T plots showing vertical profiles of temperature and relative humidity,[38] vertical column measurements of O_3 in the troposphere at Boulder, Colorado,[39] and meteorological maps to indicate transport of vertically mixed air from the SOI source region to Clark County.[40]

The demonstration presented various types of HYSPLIT trajectory modeling:

- 72-hour backward trajectories from May 4 to May 7, 2020 00:00 UTC (May 3 - May 6, 2020 16:00 PST), at elevations of 50 meters (m) and 1000 m above ground level (AGL), from three starting points: a point in the LVV, the Apex monitor site, and the Jean

[35] See demonstration, p. 3-15.
[36] See demonstration, pp. 3-19 to 3-39.
[37] See demonstration, pp. 3-39 to 3-51.
[38] See demonstration, pp. 3-52 to 3-61.
[39] See demonstration, pp. 3-62 to 3-64.
[40] See demonstration, pp. 3-64 to 3-68.

monitor site. Demonstration Figures 3-37 and 3-38 (starting points in the LVV and Apex monitor site, respectively) show backward trajectories passing from Las Vegas through northern California to the SOI source region. However, demonstration Figure 3-39 (starting point at the Jean monitor site) shows a backward trajectory passing from Las Vegas through southern California, up through northern California and then to the SOI source region.[41] This difference in trajectories was not discussed or explained in the demonstration.

- A matrix of 72-hour backward trajectories from May 4 to May 7, 2020 00:00 UTC (May 3 - May 6, 2020 16:00 PST), at elevation of 1,000 m AGL, with starting locations on an evenly spaced grid covering Las Vegas, Nevada. Although demonstration Figure 3-40 shows trajectories passing from Las Vegas through northern California to the SOI source, it also shows multiple trajectories that pass from Las Vegas through southern California to the Pacific Ocean south of the SOI source region.[42] This difference in trajectories was not discussed or explained in the demonstration.
- Frequency-weighted back trajectory analysis was presented in demonstration Figures 3-41 through 3-43, with starting points in the LVV, the Apex site, and Jean site, at an elevation of 50 m AGL for the period of May 3, 2020 06:00 UTC to May 7, 2020 00:00 UTC (May 2, 2020 22:00 PST to May 6, 2020 16:00 PST).[43] Demonstration Figure 3-41 (starting point in LVV) shows trajectories passing through northern California. Figure 3-42 (starting point at Apex site) shows trajectories passing through northern California, as well as a percentage of trajectories passing through central California, and others through Utah; demonstration Figure 3-43 (starting point at Jean site) shows some trajectories passing through northern California, as well as a percentage of trajectories passing through southern California, and others north into Utah and northern Nevada. This difference in trajectories was not discussed or explained in the demonstration.
- Matrix forward trajectories were run to show air parcel transport patterns from the SOI region at a height of 5,000 m AGL from the SOI source region to the Las Vegas area. Demonstration Figure 3-44 shows some trajectories passing through northern California and others passing through southern California before arriving at Nevada.[44]

Although the importance of O_3 transport from southern California to Clark County was mentioned in several sections of the demonstration, the demonstration did not discuss the differences between the HYSPLIT trajectories shown in Figures 3-38 (starting point at the Apex site) and 3-39 (starting point at the Jean site), which show markedly different trajectories.[45] The frequency-weighted back trajectories provided in the demonstration show that air masses impacting Las Vegas on May 6, 2020 were largely local in origin as the highest frequencies are located directly over Las Vegas and nearby in southern Nevada. These trajectories suggest a very low probability that air from northern California and northern Nevada significantly impacted Las Vegas. These frequency-weighted back trajectories are consistent with the high temperatures and low winds experienced in Las Vegas on May 6, 2020.

[41] See demonstration, p. 3-44.
[42] See demonstration, p 3-46.
[43] See demonstration, pp. 3-48 to 3-50.
[44] See demonstration, p. 3-51.
[45] See demonstration, pp. 3-43 to 3-44.

Section 3.3.2 of the demonstration provided measurements of tropospheric mixing via skew-T diagrams.[46] A skew-T diagram from the National Weather Service (NWS) office in Medford, Oregon was presented in demonstration Figure 3-48 for May 4, 2020 00:00 UTC (May 3, 2020 16:00 PST). Skew-T diagrams from the NWS office in Oakland, California were presented in demonstration Figure 3-49 for May 4 and 5, 2020 00:00 UTC (May 3 and 4, 2020 16:00 PST). Skew-T diagrams from the NWS office in Reno, NV were presented in demonstration Figure 3-50 for May 5, 2020 00:00 UTC (May 4, 2020 16:00 PST), May 5, 2020 12:00 UTC (May 5, 2020 4:00 PST), and May 6, 2020 00:00 UTC (May 5, 2020 16:00 PST). Skew-T diagrams from the NWS office in Las Vegas, NV were presented in demonstration Figure 3-51 for May 6, 2020 12:00 UTC (4:00 PST) and May 7, 2020 00:00 UTC (May 6, 2020 16:00 PST).

Figure 3-46 of the demonstration shows skew-T diagrams for a 2017 stratospheric intrusion event over Grand Junction, Colorado in April 2017. This 2017 Grand Junction event was discussed in the SOI guidance document. Figure 3-46 shows a thick layer of very dry air that penetrated deep into the lower troposphere, to within about 4,000 meters above the surface with a dew point of -30 degrees C. The soundings in Figure 3-49 at the Oakland NWS office on May 4 and 5 are more similar to the example for Grand Junction from the guidance, and they do show layers of very dry air with significant vertical depth close to the ground. However, layers of dry air in the sounding alone are not sufficient evidence that a stratospheric ozone intrusion was the source of the dry air or that a stratospheric intrusion occurred, and in fact, the surface level ozone monitors in northern California show very low levels of ozone on May 4 and 5, 2020. Demonstration Figures 3-50 (Reno, NV) and 3-51 (Las Vegas, NV) do not show an unusually dry layer of air near the surface. The air mass in Figure 3-46 for the Grand Junction 2017 event was both drier and had greater vertical depth compared to the plot shown in demonstration Figure 3-51. The skew-T soundings in the demonstration do not provide compelling evidence of O_3-rich air from the SOI source region reached the surface.

Section 3.3.2 of the demonstration also provided a vertical profile of O_3 measured by the Tunable Optical Profiler for Aerosol and Ozone (TOPAZ) Light Detection and Ranging (LIDAR) instrument at Boulder, Colorado for May 7, 2020 (the day after the May 6 event in Clark County) showing that a layer of very high O_3 (concentrations over 100 ppb) was observed between 4 and 8 kilometers (km) and that concentrations in the range of 70-80 ppb reached as low as 2 km above sea level (ASL) over Boulder, Colorado.[47] The EPA notes that this alone is not sufficient to show that O_3 reached the surface at Boulder, Colorado, nor does it address whether this air mass reached the surface in Clark County, NV, 960 km to the southwest, and at an elevation of 0.6 km ASL.[48] This shows that stratospheric-tropospheric exchange may have occurred in the SOI source region over the northwestern U.S. and eastern Pacific Ocean; it does not demonstrate that O_3-rich stratospheric air was transported from the SOI source region over the northwestern United States (U.S.) and eastern Pacific Ocean to Nevada, and that it reached the surface in Clark County, NV. At any location, baseline stratospheric contribution is the result of the sum of many minor STE events. Some STE will have been minor and shallow, while some will have been deep stratospheric intrusions. STE events that are deep and coherent cause large deviations from "baseline" stratospheric contributions. However, a deep STE intrusion

[46] See demonstration, pp. 3-52 to 3-61.
[47] See demonstration, pp. 3-62 to 3-64.
[48] United States Geological Survey national map viewer, https://apps.nationalmap.gov/viewer/

sufficiently far from a surface monitor will likely have been sufficiently dispersed (due to mixing with other air parcels) and processed (chemical losses and physical deposition) such that it is not a coherent event when air parcels from the STE intrusion arrive at the surface monitor. Evidence that the SOI air parcel reached the area, reached the surface, and caused the exceedances at the monitors is critical to support the conceptual model, and a clear causal relationship in such instances.

Section 3.3.3 of the demonstration provided daily upper and daily surface meteorological maps of the U.S. for May 4 – 6, 2020, and PBL contour maps of southwestern U.S. for May 5 and 6, 2020.[49] According to the demonstration, the upper meteorological maps indicate that air from the SOI source region moved into Oregon on May 4, and the surface meteorological maps show indicators on May 4 for strong vertical mixing between the upper free troposphere and the surface over Oregon and Washington. The demonstration did not make a similar statement regarding indicators for strong mixing over Clark County for May 5 and 6, only stating that "surface low pressure, as seen on May 6, can induce vertical mixing between the surface and upper levels."[50] The demonstration commented that the PBL maps indicate a deep mixed layer over Oregon on May 5; a deep mixed layer over Oregon, Nevada, and Arizona on May 6; with the PBL over Clark County on May 6 being 2 – 3 km in altitude. This section of the demonstration concluded that "stratospheric ozone-rich air originating near the coastal California Oregon border was transported eastward to Oregon on May 4 and may have become well-mixed within the planetary boundary layer on May 5, then transported at the lower level to Clark County, Nevada, on May 6. Although photochemical production of ozone occurred on May 6, this analysis provides evidence that meteorological conditions were favorable for vertical mixing of ozone to the surface on May 6 in the Las Vegas area."[51] The meteorological maps presented in the demonstration do not provide compelling evidence that the O_3-rich stratospheric air from the SOI source region reached the surface in the LVV. The meteorological maps and qualitative interpretation describe a complex atmospheric transport pathway, including two days of near-surface transport. The duration of transport that is qualitatively implied would be better addressed by trajectories that integrate hourly meteorology. The demonstration also did not provide evidence of enhanced background O_3 levels along the path from the SOI source region through Oregon, northern California to Nevada during the period of May 4-6, 2020 when the intrusion event is to have occurred. Evidence of such could indicate mixing between the free troposphere and PBL and impacts at surface monitor sites. While the demonstration did present evidence of unhealthy levels of O_3 progressing eastward from southern California, it did not include analyses showing a similar progression from the SOI source region to Las Vegas.[52] Further, the two-day transport near the surface would also imply depletion of any stratospheric ozone both by surface deposition and chemical reaction losses during the transport period, processes that would require a chemical transport model to quantify. The PBL analysis does not clearly indicate that the stratospheric air reached the monitors on the ground in Clark County. We also note that as stated earlier, the frequency-weighted back trajectories provided in the demonstration show that air masses impacting Las Vegas on May 6, 2020 were largely local in

[49] See demonstration, pp. 3-64 to 3-68.
[50] See demonstration, p. 3-65.
[51] See demonstration, p. 3-68.
[52] See demonstration, p. 3-76.

origin and indicate a very low probability that air from northern California and northern Nevada significantly impacted Las Vegas.

To further evaluate trajectories for the May 6, 2020 exceedances in Clark County, the EPA performed additional analyses of wind rose data, additional HYSPLIT forward trajectories, and review of air quality information in areas of southern California. The figures produced in this analysis can be found in Appendix A of this TSD. Figure A1 shows wind roses representing the average wind speed and wind direction for the LVV for the entire 24-hour period of May 6, 2020. The light blue colors illustrate lighter winds with a strong northwesterly, westerly, and southwesterly component.

TSD Table A3 shows that wind speeds measured at the North Las Vegas Airport weather station (7 km southeast of the Joe Neal site and 7 km northeast of the Walter Johnson site) ranged from 0 to 13 mph on May 6, 2020, with no winds over 10 mph until 3:53 PM. During the ten hour period from 9:53 AM to 6:53 PM, wind speeds ranged from 0 to 12 mph. TSD Table A4 shows that the May 6, 2020 MDA8 O_3 concentrations for the Apex, Paul Meyer, Walter Johnson, Joe Neal, and Green Valley sites occurred at 11:00 AM (i.e., reflecting hourly concentrations from 11:00 AM through 6:00 PM), and at 10:00 AM (i.e., reflecting hourly concentrations from 10:00 AM through 5:00 PM) at Jerome Mack and Jean. As discussed earlier in this TSD, the low wind speeds experienced on May 6, including those that occurred in the morning through the period the exceeding monitors measured their maximum 8-hour concentration values, are more characteristic of conditions conducive to local photochemical O_3 production rather than an SOI event.

HYSPLIT forward trajectories were computed using data from the North American Mesoscale Forecast System (NAM) 12 km resolution model for multiple heights (50 m, 1000 m, and 1500 m) starting on May 5, 2020 4:00 am PST from various areas in southern California. These forward trajectories, shown in TSD Figure A2, depict air parcels moving from southern California northeast into Nevada with several transecting the LVV. Demonstration Figure 3-40 presents HYSPLIT back trajectories.[53] Although Figure 3-40 from the demonstration shows back trajectories from the potential SOI region to the LVV, there are also a significant number of trajectories from southern California to the LVV as well. This, as well as the TSD Figure A1 wind roses indicating some winds from the southwest, supports potential transport of pollutants from southern California to the LVV contributing to the elevated O_3 concentrations. The meteorology in the Las Vegas area (low winds and high temperatures) and frequency-weighted back trajectories (very high air mass residence time in the Las Vegas area) indicate most of the air in the area was local in origin, also suggesting local production as a substantial source of O_3.

In the days leading up to May 6, 2020, southern California was experiencing a heat wave and high O_3 Air Quality Index (AQI) values as depicted in Figures 3-64 and 3-65 in the demonstration.[54] South Coast Air Quality Management District (AQMD) released an announcement on May 5, 2020 noting an impending heat wave and unhealthy values of ground-level O_3, shown in Figure A3 of this TSD. This region had several days of excessive heat warnings and heat advisories from the NWS; the weather advisories are included in the South Coast AQMD announcement. O_3 AQI levels for southern California on May 4, 2020 were in the

[53] See demonstration, p. 3-46.
[54] See demonstration, pp. 3-75 to 3-76.

moderate to unhealthy for sensitive groups range but began to build in the region. The O_3 AQI values in southern California reached the unhealthy range from May 5-6, 2020 as shown in Figures 3-64 and 3-65 in the demonstration. Demonstration Figure 3-64 shows the southern California to Las Vegas region was experiencing unhealthy for sensitive groups to unhealthy AQI levels on May 6, 2020.

The unhealthy for sensitive groups values in Clark County, Nevada were forecasted by the CCDES via their Twitter feed as shown in Figure A4 of this TSD. The "Unhealthy for Sensitive Groups" AQI category has a range of 8-hour average O_3 from 71-85 ppb. The values measured in the LVV on May 6, 2020 occurred within this forecasted range. In the CCDES tweet, high O_3 values were attributed to transport from southern California, consistent with the wind rose and HYSPLIT trajectory evidence discussed above. This evidence points to potential transport of O_3 from areas of southern California contributing to the Clark County O_3 exceedances on May 6, 2020; the frequency-weighted back trajectories, low wind speeds measured at the North Las Vegas Airport weather station, and high temperatures on May 6, 2020 indicate conditions conducive to local O_3 production as opposed to SOI.

Overall, the evidence presented in the demonstration does not support that stratospheric air from the SOI source region reached the surface in Las Vegas. Demonstration HYSPLIT trajectories show that some air parcels may have originated from the SOI source region and arrived at Las Vegas. However, the HYSPLIT trajectories presented in the demonstration, as well those generated by the EPA (Appendix A of this TSD) also show air parcels from the SOI source region passing over portions of southern California that were experiencing a heat wave and high AQI values of O_3 prior to reaching the LVV. The impact of the air parcels passing over a potential source of high O_3 and O_3 precursors was not discussed in the demonstration. The evidence presented in the demonstration from the TOPAZ LIDAR instrument at Boulder, Colorado was insufficient to show that stratospheric O_3 reached the surface at Boulder, Colorado or Clark County, NV, 960 km miles to the southwest. The meteorological maps presented in the demonstration do not provide compelling evidence for strong mixing between the upper free troposphere and the surface over Clark County for May 5 and 6.

<u>Evidence showing the impacts of the intrusion at the surface</u>
The demonstration included evidence intended to support that the resultant impacts from the intrusion on O_3 concentrations at the surface caused the O_3 exceedances at the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean and Apex monitoring sites.

The demonstration presented O_3 concentrations, AH (i.e., water vapor), and temperature from the Jerome Mack site, comparing May 6, 2020 diurnal data to 5th and 95th percentile data from May 2015 – 2019.[55] Figure 3-58 of the demonstration shows that on May 6, 2020, AH values were lower than the five year (2015-2019) May average, with values dipping below the lowest 5th percentile of the five year May data through much of the day. On May 6, AH values were below 1 gram per cubic meter for much of the afternoon. The peak MDA8 values on May 6, 2020 occurred in the mid to late morning for the seven sites that exceeded. The AH data presented in the demonstration show 95th percentile five-year May values reaching as high as 10 grams per cubic meter and 5th percentile five-year May values dipping below 2.5 grams per cubic meter during the afternoon hours. The demonstration did not discuss AH values for other days in May

[55] See demonstration, p. 3-68 to 3-69.

2020, including for days in May prior to May 6, to show if there was a noticeable effect on the diurnal pattern before and during the period of presumed transport of O_3-rich stratospheric air from the SOI source region.

Demonstration Figure 3-59 shows O_3, NO, and NO_2 concentrations measured at Jerome Mack on May 6, 2020 superimposed over the average, 5th, and 95th percentile data for May for the 2015-2019 years when available; demonstration Figure 3-60 shows the same measurements for O_3 and NO_2 at Joe Neal.[56] In demonstration Figures 3-59 and 3-60, the NO_2 concentration changes do not strongly coincide with the AH temporal changes shown in demonstration Figure 3-58. In TSD Figures A9 (for Joe Neal) and A11 (for Jerome Mack), we see a regular diurnal pattern of decreasing NO_2 from the early morning to low values in the afternoon in the days prior to and following May 6. The demonstration noted that NO_2 concentrations at Jerome Mack and Joe Neal, and NO concentrations at Jerome Mack were approximately average relative to the seasonal average. If air parcels from the SOI source region (with very low NO_2) had arrived at the LVV monitors, one would expect for there to be a noticeable effect. The shapes of the AH, O_3, and NO_2 profiles shown in demonstration Figures 3-58, 3-59, and 3-60 generally follow the same diurnal shape as the May 2015-2019 data. While AH from early morning through the rest of the day on May 6, 2020 is lower than the 5th percentile data for May for years 2015-2019, the demonstration did not provide sufficient evidence to show that the lower than average AH values were due to the arrival of O_3-rich (with low NO_2 and low water vapor) SOI air rather than other meteorological conditions on that day.

The demonstration presented diurnal O_3 data for May 6, 2020 with five-year 5th to 95th percentile data from the five exceeding sites in the LVV.[57] As noted in Section 2.3 of the demonstration, mobile sources comprise most of the emissions of total oxides of nitrogen (NO_x), ($NO_x = NO + NO_2$) during the O_3 season, so one would expect for there to be variation due to weekday/weekend patterns. A comparison of May 6, 2020 (a Wednesday) to comparable days of the week was not provided in the demonstration. If O_3-rich air had been transported from the SOI source region to the monitors in the LVV, one should see a contemporaneous decrease in NO_2 with increase in O_3 that is not explainable by the normal diurnal NO_2/O_3 pattern. This is not evident in Figure 3-59 or Figure 3-60. While these figures show O_3 concentrations peaking above the 95th percentiles from hour 12 to hour 16 at Jerome Mack, and from hour 12 to hour 14 at Joe Neal, no contemporaneous decrease in NO_2 occurs in the afternoon hours of May 6, 2020. The May 6, 2020 NO_2 at both sites generally follows the multi-year average diurnal pattern. While May 6, 2020 NO_2 concentrations at Joe Neal are below the five year average for the majority of the day, the NO_2 measured at Jerome Mack on May 6, 2020 is above the site's multi-year average in the early morning, and then tracks closely with the average values the remainder of the day. The demonstration did not discuss the difference in NO_2 measured at these two sites, simply stating that afternoon concentrations were average relative to the seasonal average.[58] Overall, the demonstration did not provide evidence that decreases in NO_2 were inconsistent with the normal diurnal pattern or that the NO_2 decreases were due to SOI.

[56] NO_2 data was available for Jerome Mack from 2017-2020 and for Joe Neal from 2015-2020; NO data was available for Jerome Mack from 2015-2020. See demonstration, p. 3-69.
[57] See demonstration, pp. 3-69 to 3-74.
[58] See demonstration, p. 3-70.

The demonstration presented a map (Figure 3-64) of observed MDA8 O_3 concentrations that shows elevated O_3 levels throughout southern California (from Los Angeles east into the Mojave Desert Air Basin, and south in San Diego County), and southern Nevada within the Clark County border. The demonstration also presented maps (Figure 3-65) of daily O_3 AQI for May 4 to 6, 2020, that show moderate and unhealthy AQI values across the southwestern U.S.[59] Demonstration Figure 3-64 shows the highest elevated O_3 levels (orange and red dots) in California to be concentrated in southern California. Demonstration Figure 3-65 shows air quality becoming worse around Los Angeles and San Diego and the level of unhealthy O_3 expanding from southern California to the northeast into the LVV, from May 4 to 6. Poor air quality is not shown in Oregon or along the Oregon/California border. The demonstration consistently describes the path of the O_3-rich air from the SOI source region to be through Oregon, northern California, and then to Nevada. While SOI can impact ground level monitors across a wide region, meteorological conditions that are conducive to photochemical O_3 production can similarly cause O_3 exceedances across a wide region, and it is common for O_3 exceedances caused by photochemical O_3 episodes to occur in areas in the southwest, including southern California, the Central Valley, and Clark County. Many of these areas where regionally high O_3 occurs are also O_3 NAAs where exceedances are common during favorable meteorology. In assessing the possibility of stratospheric O_3 impacting surface monitors, one should review if O_3 exceedances had occurred in both urban and rural areas and at higher elevation monitoring sites that do not typically have O_3 exceedances. As noted in the FAST-LVOS paper, "... the high average elevation of the Southwest and Intermountain West increase the likelihood that descending O3-rich air will reach the surface."[60] The AQI plot on May 6 could more reasonably be interpreted to indicate high photochemical production of O_3 in Clark County, as well as areas in Los Angeles and San Diego due to favorable meteorological conditions, and subsequent regional transport of O_3 and precursors from southern California to Clark County, rather than transport of stratospheric O_3 from the SOI source region.

To further understand and evaluate the air monitoring and meteorological data during the event, the EPA conducted additional analyses which are presented as tables and figures in Appendix A to this TSD. TSD Table A4 shows the MDA8 O_3 exceedances on May 6, 2020 at the O_3 monitoring sites in Clark County (with the six monitoring sites in the LVV noted), as well as the hours that contribute to the MDA8 O_3. The corresponding MDA8 O_3 hours at each exceeding monitoring site occurred either at 10:00 AM or 11:00 AM on May 6, 2020. TSD Table A5 shows the MDA8 O_3 at four National Park Service (NPS) O_3 monitors surrounding the LVV on both May 5 and 6, 2020. TSD Figure A17 shows the locations of the O_3 monitoring sites listed in TSD Tables A4 and A5. The high values shown in TSD Table A5 measured at the Mojave National Preserve (MNP) on both May 5 and 6 support potential transport from southern California impacting the remote MNP monitor and the LVV area. Additionally, Figure A5 shows hourly O_3 concentrations for the exceeding monitors (except for Joe Neal) and O_3 monitors in the surrounding areas to the west and southwest of the LVV. The exceeding monitors show strong diurnal signatures, as do O_3 monitoring sites northeast of Los Angeles, consistent with local photochemical production as a primary contributor to high O_3 concentrations.

[59] See demonstration, pp. 3-75 to 3-76.
[60] Langford et al, p. 21.

A review of the hourly O_3 data in Clark County on May 6 indicates that there were strong gradients in the observed O_3 across the County. For example, as shown in TSD Table A1, of the six O_3 monitors in the LVV (Paul Meyer, Walter Johnson, Palo Verde, Joe Neal, Green Valley, and Jerome Mack), the MDA8 O_3 on May 6, 2020 ranged from 78 ppb at Walter Johnson to 68 at Palo Verde. TSD Table A2 shows the maximum 1-hour O_3 for the LVV O_3 monitors ranging from 98 at Walter Johnson to 76 at Green Valley. The Palo Verde monitor is 6.5 km to the west of the Walter Johnson monitor, while the Green Valley monitor is 23 km to the southeast of the Walter Johnson monitor. If there had been a substantial contribution of stratospheric O_3 in Clark County on May 6, one would expect to observe less variability in O_3 across the County.

A study of O_3 in the LVV found that the highest O_3 concentrations occur seasonally in May and June and are typically measured in the western portion of the Valley.[61] Figure A6 shows locations of the Joe Neal, Walter Johnson, and Paul Meyer monitoring sites in the LVV (the three highest O_3 monitors on May 6, 2020). These three sites are all in the western portion of the LVV, following typical seasonal patterns for this region (minus the Apex monitor, which tied for third highest with a value of 76 ppb and is roughly 20 miles northeast of Las Vegas, outside of the Las Vegas NAA).

TSD Figure A7 includes O_3, NO, NO_2, and meteorological parameter data from AQS collected at the Jerome Mack NCore monitoring site in early May 2020. There is a substantial amount of NO_x present on May 6 at the Jerome Mack monitoring site prior to violating O_3 concentrations that occurred later that day. This is consistent with local photochemical production of O_3 due to local emissions of O_3 precursors or potentially transport of O_3 precursors from other source areas. As shown in TSD Figures A8 to A11, NO_2 values from AQS are elevated in the late evening hours of May 5th and the early morning hours of May 6th at the Jerome Mack monitoring sites and precede the elevated O_3 values; NO_2 values at Joe Neal do not appear to be elevated during these times. The demonstration states that during the afternoon of May 6, 2020, NO_2 concentrations were "approximately average relative to the seasonal average."[62] If stratospheric air was infiltrating the LVV, it is expected that both sites would be similarly affected, and that NO_2 values would be lower outside of typical commuting hours as stratospheric air has low concentrations of CO, NO_x, particulate matter and water vapor.[63] In addition to NO_2, local meteorological parameters measured at the sites in question suggest conditions were conducive for local production of O_3. A review of weather data from Weather Underground (wunderground.com) shows that both maximum and daily average temperatures in the Las Vegas area were 10-15 degrees above the historical average for May 6; the maximum temperature on May 6, 2020 was 99 degrees Fahrenheit, only four degrees lower than the historical record high and 10 degrees lower than the maximum temperature measured in May 2020.[64] At the Joe Neal monitoring site (see TSD Figure A8), O_3 values closely trend with temperature. TSD Figures A12 to A16 show that other Clark County monitoring sites (Walter Johnson, Paul Meyer, Green Valley, Jean, and Apex) all follow a similar diurnal pattern for O_3 and temperature with O_3 and

[61] Xian and Crane, The study of ozone variations in the Las Vegas metropolitan area using remote sensing information and ground observations, 86th AMS Annual Meeting, p. 4, 2006, https://pubs.er.usgs.gov/publication/70035659.
[62] See demonstration, p. 3-70.
[63] See SOI guidance document, p. 4.
[64] https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2020-5-6, https://www.wunderground.com/history/monthly/us/nv/north-las-vegas/KVGT/date/2020-5.

temperature values closely trending with each other. In addition, winds were light (less than 10 mph) in the LVV during the morning of May 6, 2020.

The evidence presented in the demonstration for low water vapor (i.e., AH), high O_3, and typical NO_x concentrations is insufficient to demonstrate impacts from an SOI on the monitors. Low water vapor, regionally high O_3, and typical NO_x concentrations are not conclusive indicators of a clear causal relationship between an exceedance of the NAAQS and a stratospheric intrusion, especially for southern Nevada where low humidity is common, regionally high O_3 can be associated with regionally favorable meteorology for local O_3 production and O_3 transport from major source regions in California, and photochemical production of O_3 does occur at typical NO_x concentrations. The data presented in the demonstration appear consistent with substantial local photochemical O_3 and are not sufficient to demonstrate a clear causal relationship between the exceedances and a stratospheric intrusion.

Additional analyses

The demonstration included two additional analyses not discussed in the SOI guidance document. These types of analyses are outlined in the EPA's guidance document for wildfire O_3 events[65] and are intended to provide a numerical estimation of the quantity of O_3 that can be attributed to an event, *e.g.*, a wildfire, by evaluating the expected O_3 concentration for a day based on typical meteorology and transport patterns. We refer to the wildfire O_3 guidance document as needed later in this section to outline how to evaluate the information presented from these analyses.

The demonstration included an analysis of data from days that were meteorologically similar to the exceedance day.[66] The demonstration identified that on May 6, 2020, maximum temperature was in the 40th percentile, mixing layer mixing ratio was in the 15th percentile, and average wind speed was in the 2nd percentile, as compared to the 30-day period surrounding May 6 over a seven-year period.[67] Matching dates were selected based on synoptic and local meteorological conditions. HYSPLIT trajectories were used to cluster dates with similar transport patterns, and then meteorological parameters were used to determine the best matching dates among those in the same cluster. The parameters included daily average wind speed, resultant wind direction and speed, geopotential height, relative humidity, and temperature at elevations corresponding to 1000 millibars (mb) and 500 mb and daily average atmospheric pressure, maximum temperature, and minimum temperature at the surface. The subset of candidate matching days was further filtered by comparing to meteorological maps at the surface and 500 mb, as well as local meteorological data. The formal analysis only considered the daily statistics and did not analyze information on a more refined time scale (e.g., wind speeds during peak O_3 hours).

A selection of nine days was provided in the demonstration, with three of the nine days highlighted as especially valuable comparisons to the exceedance event, as the exceedance event and these three days all fell when COVID-19 restrictions were occurring. The days selected had O_3 concentrations ranging from 41 to 74 ppb at the sites that exceeded on May 6, 2020. The demonstration found that concentrations on the identified matching days were below the level of the NAAQS and below the concentrations measured on the event day, with the exception of one

[65] "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations" (September 2016) ("wildfire O_3 guidance document").
[66] See demonstration, pp. 3-76 to 3-83.
[67] See demonstration, p. 3-79.

historical day (May 8, 2018), which measured two exceedances at Jerome Mack and Green Valley that were higher than the exceedances measured on May 6, 2020. The demonstration noted that concentrations on this historical day (May 8, 2018) were highest on the eastern side of the LVV, indicative of local photochemical production, while concentrations on May 6, 2020 were higher on the western side of the LVV upwind of the downtown area. The demonstration went on to state that this difference in spatial pattern between May 6, 2020 and May 8, 2018 indicated that the elevated O_3 concentrations on May 6, 2020 were due to a regional event, rather than a local photochemical event (such as that which occurred on May 8, 2018).[68] In addition, on May 6, 2020, Apex (located roughly 20 miles northeast of Las Vegas) tied for the third highest concentration of the LVV monitors. It should be noted that the monitoring sites with the highest design values for this area historically are those on the western side of the LVV[69], suggesting that such a pattern is in fact common under typical local photochemical and meteorological conditions, and while the patterns of highest concentrations on the two days do not match, this pattern mismatch does not clearly point to a non-photochemical source being present on May 6, 2020. The demonstration specifically noted that wind speeds on May 6, 2020 were low (2nd percentile), and that wind speed was prioritized over wind direction for selection of matching days since the winds were likely highly variable as indicated by low average and resultant wind speeds.[70] It is therefore possible that the matching days might have different atmospheric flow patterns during peak O_3 hours, resulting in a different pattern of exceedances on each day.

The matching day analysis did not consider several factors in selecting similar days for comparison, such as ambient NO_x concentrations, weekday/weekend effects, O_3 concentrations on the preceding days, and evaluation of timing of wind speeds in the context of O_3 formation. For example, O_3 can build up gradually over several days; wind speeds in the late morning and early afternoon hours, when O_3 production is typically highest, may factor more strongly into the determination of daily maximum 8-hour average concentrations of O_3. The effects of these potential factors were not discussed, weakening the conclusions drawn in the matching day analysis. Additionally, of the nine matching days selected, all but one of the days had measured concentrations above 62 ppb for at least one of the five sites analyzed in the demonstration, while four of the days had measured concentrations at or above 65 ppb, suggesting that even if the matching days themselves did not measure exceedances, the conditions observed were favorable to O_3 concentrations near the NAAQS, and small differences in meteorology between the event day and the selected matching days could be responsible for the higher O_3 values observed on the event day.

While the demonstration did compare May 6, 2020 to other meteorologically similar days, the nine comparison days only included one day with measured exceedances. An analysis of how the exceedance day compared to non-event exceedance days to determine if there were differences between those exceedance days and May 6, 2020, was not included. As noted previously in this TSD, the event day had high temperatures and low wind speeds, conditions conducive to local O_3 formation. There is also information supporting transport from southern California. The matching day analysis presented in the demonstration does not show that conditions on the event day were notably different than conditions on non-event exceedance days, nor that the event day

[68] See demonstration, pp. 3-80 to 3-83.
[69] Xian and Crane, The study of ozone variations in the Las Vegas metropolitan area using remote sensing information and ground observations, 86th AMS Annual Meeting, p. 4, 2006, https://pubs.er.usgs.gov/publication/70035659.
[70] See demonstration, pp. 3-80 to 3-83.

meteorology in the presence of local area emissions alone was insufficient to cause the measured exceedances on the event day. The demonstration referred to a matching day analysis included as part of an Arizona Department of Environmental Quality (ADEQ) exceptional events demonstration that was concurred on by the EPA and stated that the analysis presented in this demonstration is an expansion of that type of work;[71] however, unlike the demonstration reviewed here, the referenced ADEQ demonstration included a more extensive analysis, including a comprehensive review of exceedance days to show how the event day was unusual in comparison.[72]

To further address the assertion that the SOI caused the O_3 exceedances, the demonstration included information on and analysis of output from a GAM analysis that was developed for monitors in the LVV.[73] GAMs are statistical models intended to allow for prediction of a response (in this case, MDA8 O_3 concentrations) based on linear and non-linear effects from multiple input variables. The GAM described in the demonstration used 16 separate input variables, primarily meteorological in nature, to predict O_3 concentrations each day at eight monitors in the LVV.

The demonstration provided several analyses to evaluate the GAM performance. An analysis of GAM residuals (*i.e.*, the difference between the observed concentration and the predicted concentration) found that residuals were close to zero (less than 0.5 ppb) when averaged across the dataset, and similarly when considering all days that were not flagged as exceptional events.[74] The flagged day residuals were larger; average residuals across all 2018 and 2020 flagged days ranged between 6-9 ppb for the five sites within the Las Vegas NAA, and were higher (over 12 ppb) for the sites within Clark County but outside of the NAA.[75] Values for sites outside of the NAA were based on a much smaller number of dates (2-4 as opposed to 11-22) as the monitors outside of the NAA did not exceed on most of the flagged days. As demonstrated by the R^2 values ranging from 0.55 to 0.61 for the various sites, the data presented also show that there is a large amount of variability in concentrations that remains after considering the variables selected.

The wildfire O_3 guidance document states: "Users of regression models should consider the uncertainties in the model's prediction abilities, specifically at high concentrations, before making conclusions based on the modeled results. A key question when considering model uncertainty is whether the model predicts O_3 both higher and lower than monitored values at high concentrations (above 65 or 70 ppb) or whether the model displays systematic bias on these high monitored days."[76] The analysis included in the demonstration attempts to address this concern. The demonstration included a calculation of the average residual of points not flagged as exceptional events with measured concentrations at or above 60 ppb. The average residuals of

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[71] See demonstration, p. 3-83.

[72] "Addendum to: State of Arizona Exceptional Event Documentation for Wildfire-Caused Exceedances on June 20, 2015 in the Maricopa Nonattainment Area – September 2016; Additional Evidence that Ozone and Ozone Precursor Emissions From the Lake Fire Reached and Affected Ozone Monitors Within the Maricopa Nonattainment Area" (May 2018), pp. 21-28.

[73] See demonstration, pp. 3-83 to 3-101.

[74] See demonstration, p. 3-89.

[75] Of the sites included in the GAM analysis, the sites that fall within the Las Vegas NAA boundaries are Green Valley, Jerome Mack, Joe Neal, Paul Meyer, and Walter Johnson. The GAM analysis also included three sites (Jean, Indian Springs, and Boulder City) which are operated by CCDES and fall outside of the NAA boundaries but are still within Clark County, and are located to the southwest, northwest, and southeast of the NAA, respectively. Refer to p. 2-3 of the demonstration for a map showing the relative locations of the monitors.

[76] See wildfire O_3 guidance document, p. 28.

these higher concentration points were higher than the average of all residuals and the non-flagged day residuals, in the range of 3-5 ppb for all sites. This suggests that at least some of the 6-9 ppb average residuals reported for the flagged dates at the Las Vegas NAA sites can be explained by the performance of the statistical model at high concentrations, since the flagged dates are typically among the highest concentrations measured. This is common in regression models; points considered for exceptional events demonstrations are typically among the highest observed concentrations at the monitor, and selecting points with high observed concentrations, whether exceptional events or not, will not result in a selection that is normally distributed around the mean of the regression model. Therefore, a positive residual is expected for data with high observed concentrations, even considering the typical performance of the model. In other words, the positive residual is not itself indicative of an unusual source of O_3 affecting the monitors.

The demonstration also included a case study analysis of days not flagged as exceptional events where most monitors measured concentrations above 60 ppb, to evaluate the model performance at higher concentrations.[77] The median residuals across all monitors for each day ranged from 0.24 ppb to 3.89 ppb. The demonstration also gave the range (minimum and maximum) of residuals for individual monitors on each case study day. On every case study day, the highest residual for an individual monitor was between 3 ppb and 7 ppb. This further supports that a positive residual of several ppb is common for any individual monitor on higher O_3 days outside of any potential exceptional events impact. In addition, on the case study days selected, the highest concentration measured by any monitor was 72 ppb; residuals might be higher on days that measured higher concentrations.

In order to account for the normal variability inherent in the statistical model, the wildfire O_3 guidance document states that the proper calculation to estimate the contribution from an atypical source of O_3 is to compare the sum of the predicted O_3 concentration and the 95th percentile of the residuals for the model to the observed concentration, rather than a direct comparison of the predicted O_3 concentration to the observation.[78] The demonstration showed the residuals for the individual days but did not present a calculation using the 95th percentile values of the residuals.[79] As the positive 95th quantile value for each monitor is presented in Table 3-17, this can be used to determine the potential contribution for each monitor per the method described in the wildfire O_3 guidance document (by subtracting the positive 95th quantile value for the monitor in Table 3-17 from the reported residual for the monitor in Table 3-19). Using this method, a potential SOI contribution of 2 ppb for Paul Meyer, 5 ppb for Walter Johnson, 2 ppb for Joe Neal, 0 ppb for Green Valley, 5 ppb for Jerome Mack, and 7 ppb for Jean can be calculated. (No GAM calculations were presented for Apex.) When this potential SOI contribution is subtracted from the observed concentration, Jerome Mack and Jean fall below the level of the NAAQS, but the values for Paul Meyer, Walter Johnson, Joe Neal, and Green Valley on May 6, 2020 are still above the level of the NAAQS (75 ppb for Paul Meyer, 74 ppb for Joe Neal, 73 ppb for Walter Johnson, and 72 ppb for Green Valley). Based on the information presented in the demonstration, the model does not support that an unusual O_3 source affected monitors in the Las Vegas NAA on May 6, 2020 sufficiently to cause exceedances of the

[77] See demonstration, p. 3-92.
[78] See wildfire O_3 guidance document, p. 28.
[79] See demonstration, p. 3-100.

NAAQS; exceedances fall within the range of expected concentrations based on the performance of the statistical model.

Section 2.5 of the demonstration provided an analysis of the possible impact of COVID restrictions on O_3 from decreases in NO_x and volatile organic compounds (VOC) emissions from mobile sources.[80] Daily traffic count data from March to June was presented for 2019 and 2020. Focusing on the month of May, daily MDA8 O_3 during May 2020 was compared to MDA8 O_3 during May for the previous five years for the Paul Meyer, Walter Johnson, Joe Neal, Jean, Green Valley, and Jerome Mack sites. The demonstration concluded that "the observations do not suggest a month-long high ozone effect due to COVID emission precursor changes."[81] The analysis went on to compare the historical distribution of daily MDA8 O_3 during the month of May with May 2020. The demonstration concluded that, "although precursor NO_x emissions decreased during May 2020 due to COVID restrictions, MDA8 ozone concentrations were not statistically higher than previous years and the EE days cannot be attributed to a consistent month-long increase in ozone concentrations due to the COVID shutdown."[82] Lastly, the COVID impact discussion looked at the GAM analysis (demonstration Section 3.5.2), focusing particularly on May 2020 GAM residuals.[83] The demonstration concluded that high residuals indicate an unknown source of O_3, and suggested this supported the impacts of an SOI. However, as discussed above, high residuals are at least partially an artifact of selection bias and the inherent uncertainly in the model. In addition, given the nonlinear response of O_3, lower NO_x associated with COVID could result in different impacts on O_3 concentrations during high and low days. Therefore, a month-long average increase would not necessarily be expected even if lower NO_x was causing increased O_3 on higher O_3 days. In general, showing lack of significant difference between different years' means is not sufficient to conclude that there was no COVID effect on high O_3 days.

Overall, the results from the matching day analysis and the GAM model analysis do not support that an unusual source, such as an SOI, caused the O_3 exceedances measured at monitoring sites in the Las Vegas NAA on May 6, 2020.

<u>Conclusion regarding the clear causal relationship criterion</u>
The analyses included in the demonstration do not sufficiently demonstrate a clear causal relationship between the emissions generated by the SOI event and the exceedances measured at the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean and Apex monitoring sites on May 6, 2020. Specifically, the demonstration provided some evidence that stratospheric-tropospheric exchange may have occurred in an area over the Pacific Ocean west of northern California. However, other evidence presented was inadequate to demonstrate a clear causal relationship between the suggested SOI and the exceedances measured at the LVV monitoring sites. The evidence was insufficient to show transport of such air from the aforementioned region to Clark County. Evidence presented in the demonstration shows that some HYSPLIT trajectories may have originated from the SOI source region, but trajectories and other meteorological information suggest a complex atmospheric transport pathway, including two days of near-surface transport, which would also imply depletion of any stratospheric ozone

[80] See demonstration, pp. 2-26 to 2-35.
[81] See demonstration, p. 2-29.
[82] See demonstration, p. 2-29.
[83] See demonstration, p. 3-83.

both by surface deposition and chemical reaction losses during the transport period. Other trajectory analyses in the demonstration and in this TSD show transport from southern California (which was experiencing a heat wave and high levels of O_3) to the LVV and shows that air masses were also largely local in origin. AQI maps of the southwestern U.S. included in the demonstration show increasing levels of high O_3 expanding from regions in southern California to the LVV from May 4 to 6. Skew-T plots from the NWS Las Vegas Office did not show an unusually dry layer of air near the surface. TOPAZ LIDAR measurements did not show O_3 reaching the surface at Boulder, Colorado and cannot be extrapolated to show O_3 reached the surface in Clark County, NV.

Analyses presented to demonstrate SOI impacted the exceeding monitors also did not show a clear causal relationship. Although AH values in the afternoon of May 6, 2020 were lower than the five year (2015-2019) May seasonal averages, NO_2 concentrations at the Jerome Mack and Joe Neal sites did not show a clear temporal coincidence with the low AH values. Rather, the NO_2 profiles on May 6, 2020 generally follow the diurnal NO_2 profiles for the five year (2015-2019) May seasonal data. Review of the MDA8 O_3 concentrations for the O_3 monitors in Clark County for May 6, 2020 shows significant variation between the monitors in the LVV, which would not be expected if a regional event such as an SOI had occurred. Additional evidence of an unusual source of O_3 (*i.e.*, matching day analysis and GAM modeling results) did not indicate that an SOI caused the exceedances at the monitors. In addition, meteorological conditions on May 6, 2020 were conducive to local photochemical production from typical sources in the nonattainment area and transport from areas experiencing high O_3 in southern California. A review of the hourly O_3 data in Clark County on May 6 indicates that there was substantial local photochemical O_3 production, with strong gradients in the observed O_3 across the County. The EPA's review of the demonstration evidence and additional analysis by the EPA (presented in Appendix A of this TSD) indicate that meteorological conditions on May 6, 2020 were conducive to local photochemical production from typical sources in the nonattainment area and that there was likely transport of O_3 from areas experiencing high O_3 in southern California to the LVV. Any potential SOI impact would be difficult to distinguish from these larger anthropogenic contributions and would likely have a comparatively minimal effect. The demonstration did not provide evidence or analysis to make this distinction and failed to demonstrate that the SOI event specifically caused the exceedances that were as much as 8 ppb over the standard. Insufficient evidence was presented to establish that, following the SOI over the Pacific Ocean west of northern California, the stratospheric O_3-rich air was transported to Clark County and then caused the exceedances at the ground level monitors.

Table 3: Documentation of the Clear Causal Relationship criterion

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
May 6, 2020	Section 1: p. 1-4 Section 2: pp. 2-1, 2-6, 2-9 to 2-26 Section 3: pp. 3-1 to 3-103	Insufficient	No

Not Reasonably Controllable or Preventable

The Exceptional Events Rule presumes that SOI events are not reasonably controllable or preventable [40 CFR §50.14(b)(6)]. Through the analyses provided to address the clear causal relationship criterion, the demonstration established that an SOI occurred northwest of the LVV,

although the O_3 exceedances in the LVV did not meet the clear causal relationship criterion and were most likely due to anthropogenic pollutants, local photochemistry, and transport from southern California. Therefore, the documentation provided sufficiently demonstrates that the SOI event itself was not reasonably controllable and not reasonably preventable.

Table 4: Documentation of the Not Reasonably Controllable or Preventable criterion

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
May 6, 2020	Section 5: p 5-1	Sufficient	Yes

Natural Event

The 2016 Exceptional Events Rule preamble acknowledges that SOIs are natural events. The demonstration established the occurrence of an SOI that originated over the northwest United States and eastern Pacific Ocean, although it did not adequately demonstrate the transport of ozone-rich air from the SOI origin to the LVV which subsequently caused the exceedances that were the subject of the demonstration. Thus, the demonstration has therefore shown that the SOI event itself was a natural event.

Table 5: Documentation of the Natural Event criterion

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
May 6, 2020	Section 4: p 4-1	Sufficient	Yes

Schedule and Procedural Requirements

In addition to technical demonstration requirements, 40 CFR §50.14(c) and 40 CFR §51.930 specify schedule and procedural requirements an air agency must follow to request data exclusion. Table 6 outlines the EPA's evaluation of these requirements.

Table 6: Schedules and Procedural Criteria

	Reference	Demonstration Citation	Criterion Met?
Did the agency provide prompt public notification of the event?	40 CFR §50.14 (c)(1)(i)	August 11, 2021 Letter; Addendum to "Exceptional Event Demonstration for Ozone Exceedances in Clark County, Nevada – May 6, 2020"[84]	No. Notifications were for elevated levels of O_3, but not specific to this event.
Did the agency submit an Initial Notification of Potential Exceptional Event and flag the affected data in the EPA's Air Quality System (AQS)?	40 CFR §50.14 (c)(2)(i)	November 30, 2020 email[85]	Yes

[84] Letter from Marci Henson, CCDES, to Elizabeth Adams, EPA Region 9, dated August 11, 2021.
[85] Email from Araceli Pruett, CCDES, to multiple staff at EPA Region 9, dated November 30, 2020.

	Reference	Demonstration Citation	Criterion Met?
Did the initial notification and demonstration submittals meet the deadlines for data influenced by exceptional events for use in initial area designations, if applicable? Or the deadlines established by the EPA during the Initial Notification of Potential Exceptional Events process, if applicable?	40 CFR §50.14 Table 2 40 CFR §50.14 (c)(2)(i)(B)	July 1, 2021 Letter[86]	Yes
Was the public comment process followed and documented? • Did the agency document that the comment period was open for a minimum of 30 days? • Did the agency submit to the EPA any public comments received? • Did the state address comments disputing or contradicting factual evidence provided in the demonstration?	40 CFR §50.14 (c)(3)(v)	August 11, 2021 Letter; Appendix H, "Documentation of Public Comment Process May 6, 2020 Demonstration"[87]	Yes
Has the agency met requirements regarding submission of a mitigation plan, if applicable?	40 CFR §51.930 (b)	NA	NA

Conclusion

The EPA has reviewed the documentation provided by CCDES to demonstrate that O_3-containing stratospheric air was transported into the troposphere and that this O_3-rich air reached the ground-level monitors and caused exceedances of the 2015 8-hour O_3 NAAQS at the Walter Johnson, Paul Meyer, Joe Neal, Jerome Mack, Green Valley, Jean, and Apex monitoring sites on May 6, 2020. The EPA has determined that the flagged exceedances at these monitoring sites on this day do not satisfy the exceptional events criteria. Specifically, although the demonstration presented evidence that an SOI may have occurred in an area over the northwestern United States and eastern Pacific Ocean, and that SOI meets the requirement that the event be not reasonably controllable or preventable and a natural event, the demonstration failed to show that there exists a clear causal relationship between the event and the monitored exceedances. This conclusion was based on the review of evidence presented in the demonstration, including meteorological information, atmospheric modeling output, satellite data, HYSPLIT trajectories, ground level monitoring data, analysis of meteorologically similar days, and statistical modeling analysis, as well as review of additional information by the EPA as presented in this TSD. The exceedance day experienced conditions favorable to local O_3 production and transport of anthropogenic O_3 from southern California within the normal summer O_3 season. The weight of evidence, taking into consideration the data and analyses in the demonstration and this TSD, does not support that O_3-rich stratospheric air was transported to the monitors in the LVV and impacted monitors there sufficiently to cause exceedances of the NAAQS. As the weight of evidence does not support a clear causal relationship between the SOI event and the May 6, 2020

[86] Letter from Marci Henson, CCDES, to Elizabeth Adams, EPA Region 9, dated July 1, 2021.
[87] Letter from Marci Henson, CCDES, to Elizabeth Adams, EPA Region 9, dated August 11, 2021.

monitored exceedances at O_3 monitors in the Las Vegas NAA, the EPA is nonconcurring on this exceptional events demonstration.

APPENDIX A: Supplemental figures and analysis prepared by the EPA.

Figure A1: Wind roses for the LVV on May 6, 2020 (AirNowTech).

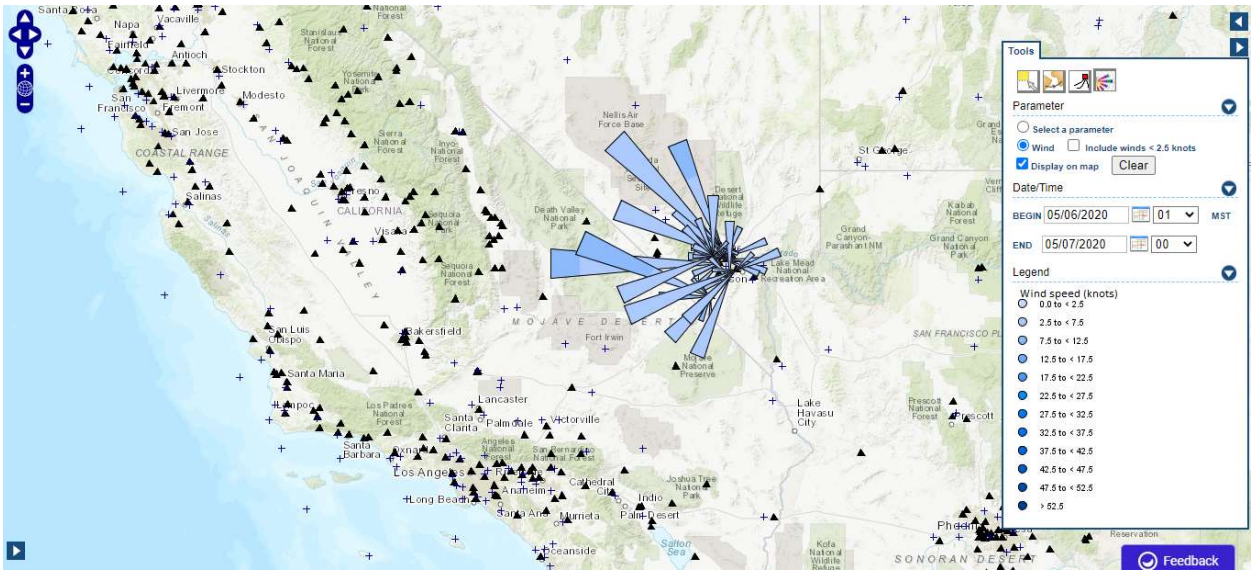


Figure A2: HYSPLIT 72-hour forward trajectories from southern California beginning May 5, 2020 at 4:00 am PST using the NAM 12 km for height levels 50 m, 1000 m, and 1500 m (using the AirNowTech Navigator).

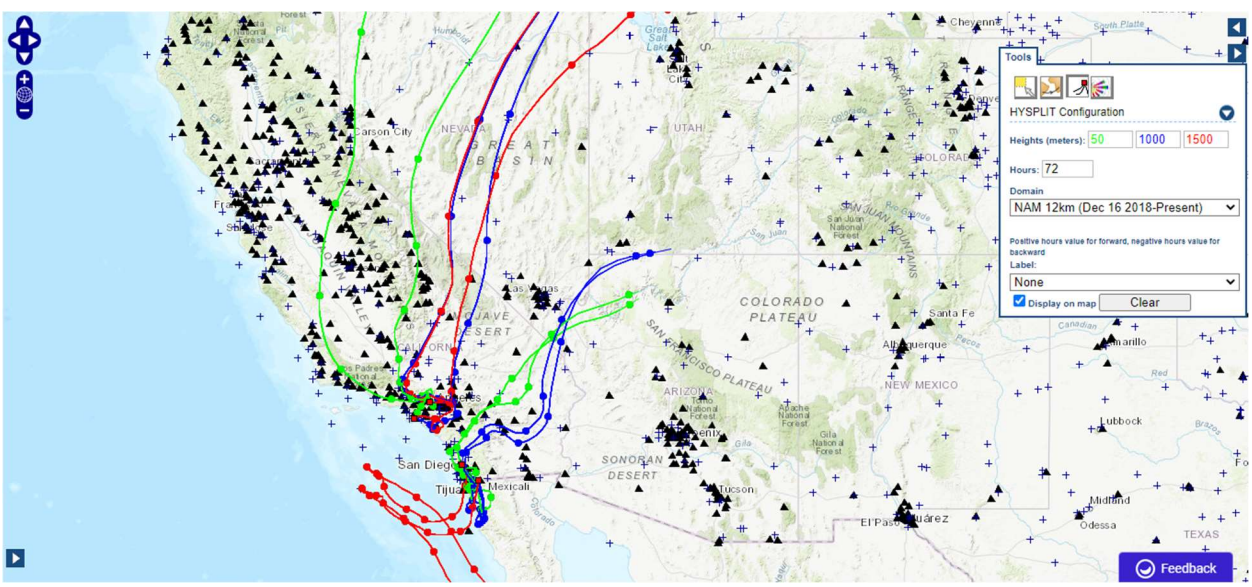


Figure A3. South Coast AQMD O_3 advisory, valid from May 5 to May 8, 2020.

FOR IMMEDIATE RELEASE: May 5, 2020
MEDIA CONTACT:
Bradley Whitaker, (909) 396-3456, Cell: (909) 323-9516
Nahal Mogharabi, (909) 396-3773, Cell: (909) 837-2431
press@aqmd.gov

South Coast AQMD Issues Ozone Advisory Due to Heat Wave

Valid: Tuesday, May 5, 2020 through Friday, May 8, 2020

This advisory is in effect through Friday afternoon. South Coast AQMD will issue an update if additional information becomes available.

High temperatures are expected to persist over the next several days throughout the South Coast Air Basin and the Coachella Valley, increasing the likelihood of poor air quality in many areas.

Levels of ground-level ozone (smog) – the predominant summertime pollutant – are likely to reach the **Unhealthy** or higher Air Quality Index (AQI) levels in the Santa Clarita Valley, the San Gabriel Mountains, the San Gabriel Valley, the Inland Empire and the San Bernardino Mountains.

The National Weather Service (NWS) is predicting a heat wave over southern California that will last through Friday. This is due to an upper air high pressure system located over Baja California. As of Tuesday afternoon, the NWS has issued a heat advisory for the Inland Empire area of San Bernardino and Riverside Counties and the Orange County inland areas, which is in effect from 10 am Tuesday until 9 pm on Friday. A heat advisory has also been issued for Los Angeles County and is in effect from 10 am Wednesday through 9 pm on Thursday. The NWS has issued an excessive heat warning for the Coachella Valley and the San Gorgonio Pass, which is in effect from 10 am Tuesday until 9 pm on Friday. For information regarding the NWS warnings and the most current weather information, visit the NWS San Diego (https://www.weather.gov/sgx/) and Los Angeles (https://www.weather.gov/lox/) websites. Elevated temperatures, which enhance ozone formation rates, coupled with predicted atmospheric inversions that trap pollution near the surface may cause unusually high and persistent levels of ozone pollution.

Figure A4. A tweet dated May 6, 2020 from Clark County, Nevada Department of Environment and Sustainability with their air quality forecast for the next five days, including May 6, 2020.

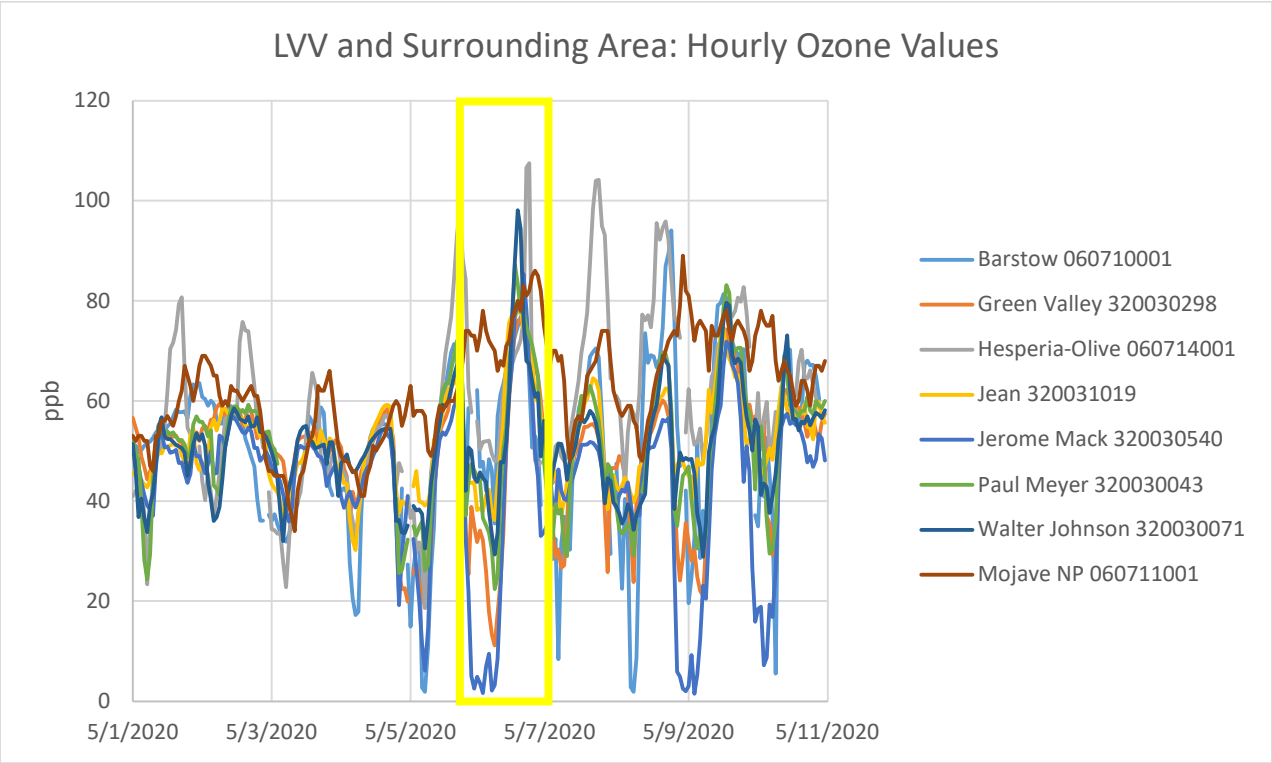
Environment & Sustainability @SustainClarkCty · May 6, 2020

#AirQuality today will reach the UNHEALTHY FOR SENSITIVE GROUPS level for ozone. Weather patterns + pollutant transport from SoCal is increasing ground-level ozone in #Vegas. Conditions should begin settling down tomorrow. Go to our Forecast page for more: bit.ly/2vrSuTv

	Ozone	PM_{10}	$PM_{2.5}$
Wed (5/6/2020)	UNH-SG	Good	Good
Thu (5/7/2020)	Moderate	Good	Good
Fri (5/8/2020)	Moderate	Good	Good
Sat (5/9/2020)	Moderate	Good	Good
Sun (5/10/2020)	Moderate	Good	Good

1

Figure A5: Hourly O_3 concentrations* at LVV and surrounding areas from May 1 through May 10, 2020.



* Values from the EPA's Air Quality System (AQS) database, AMP350 report pulled 3/18/2022

Figure A6. Location of the Joe Neal, Walter Johnson, and Paul Meyer monitoring sites in the LVV.

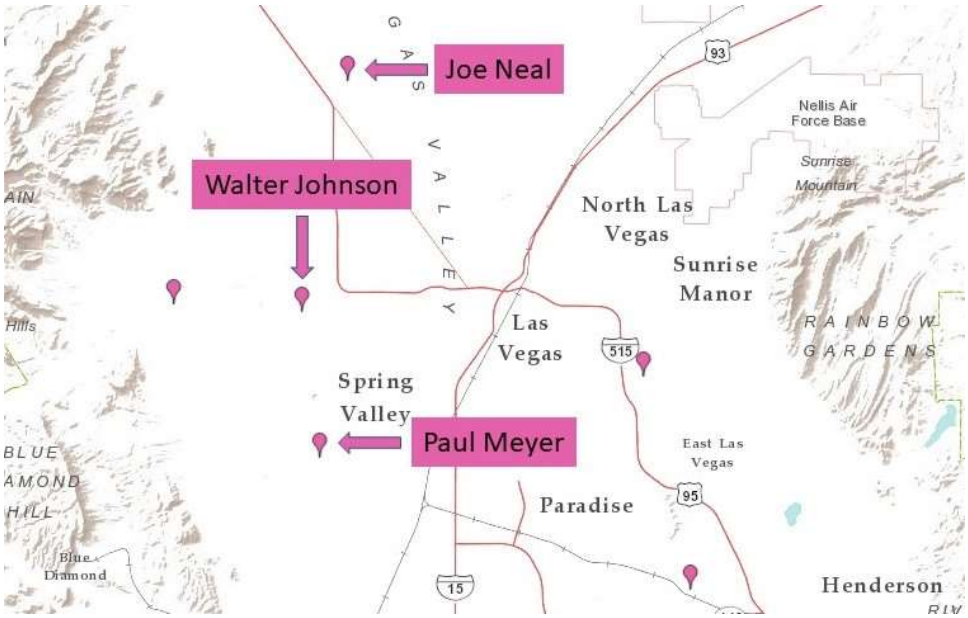
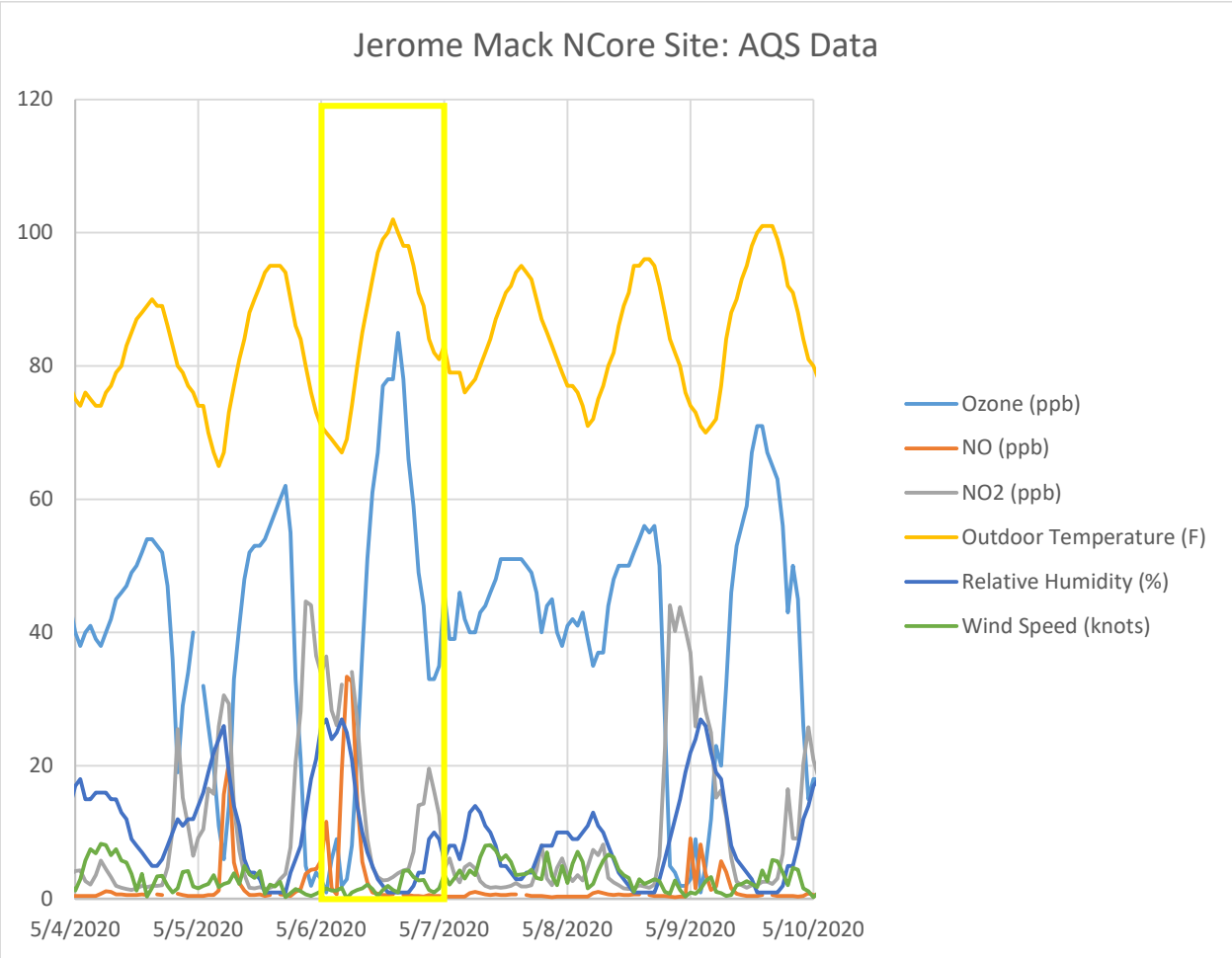
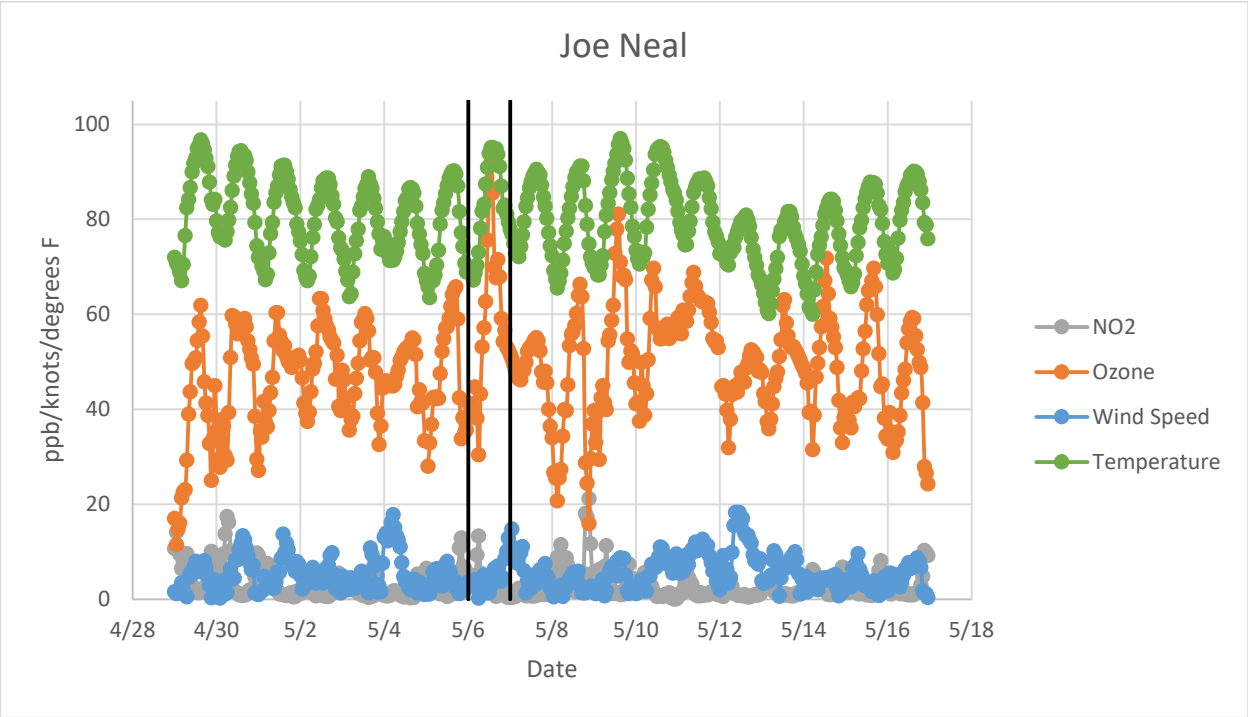


Figure A7: O_3, NO, NO_2, and meteorological monitoring values from AQS* for the Jerome Mack NCore monitoring site.



* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/3/2021

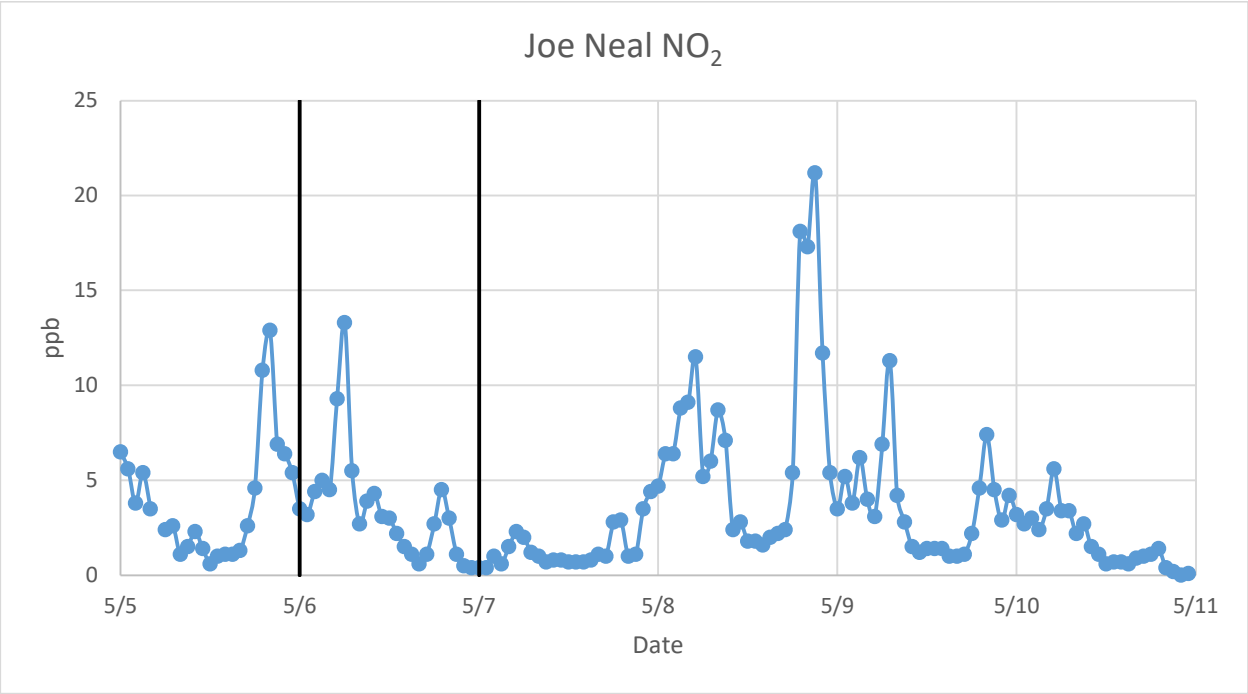
Figure A8: Hourly NO_2, O_3, wind speed, and temperature values from AQS* for the Joe Neal monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 at 12:00 am and May 7, 2020 at 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/3/2021

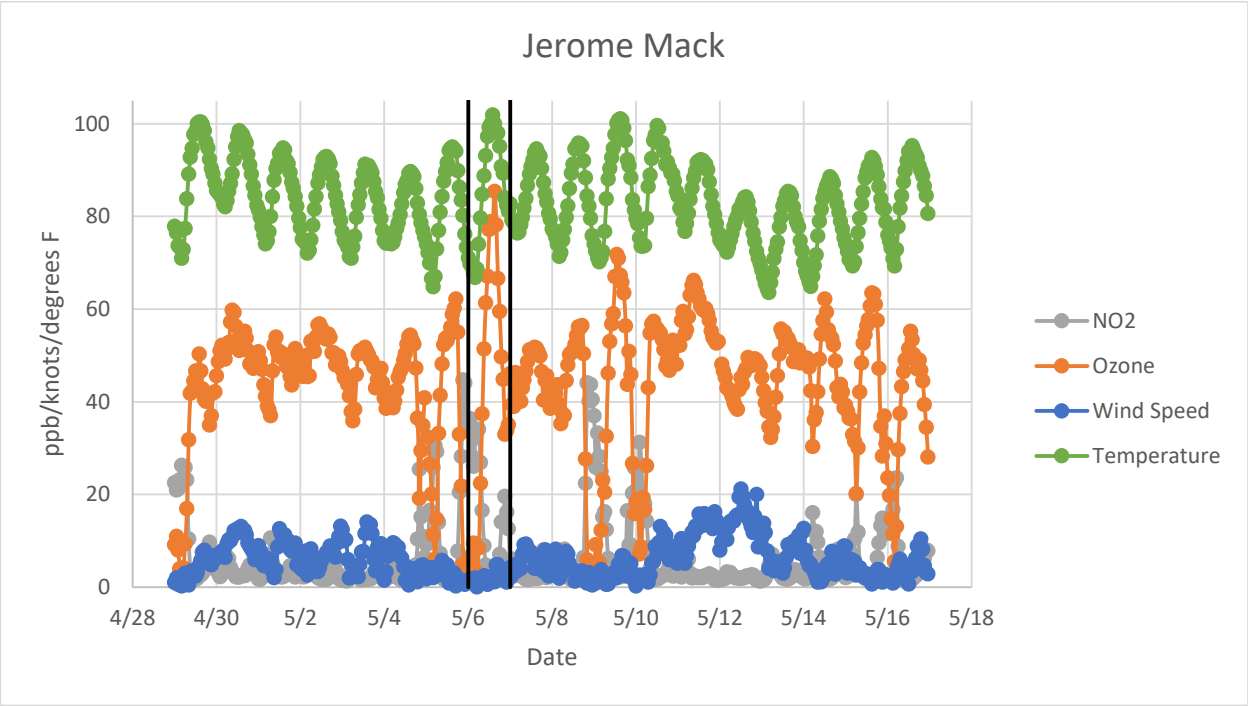
Figure A9. Hourly NO_2 values from AQS * for the Joe Neal monitoring site from May 5, 2020 through May 10, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/3/2021

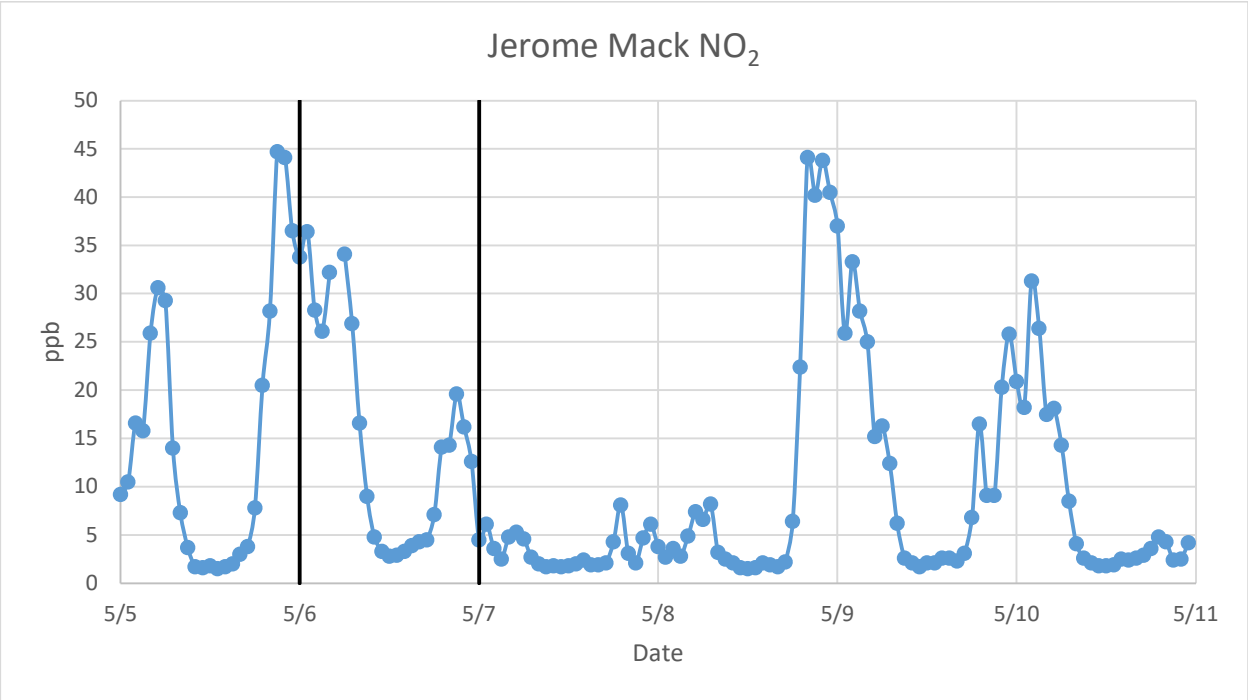
Figure A10: Hourly NO_2, ozone, wind speed, and temperature values from AQS* for the Jerome Mack monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/3/2021

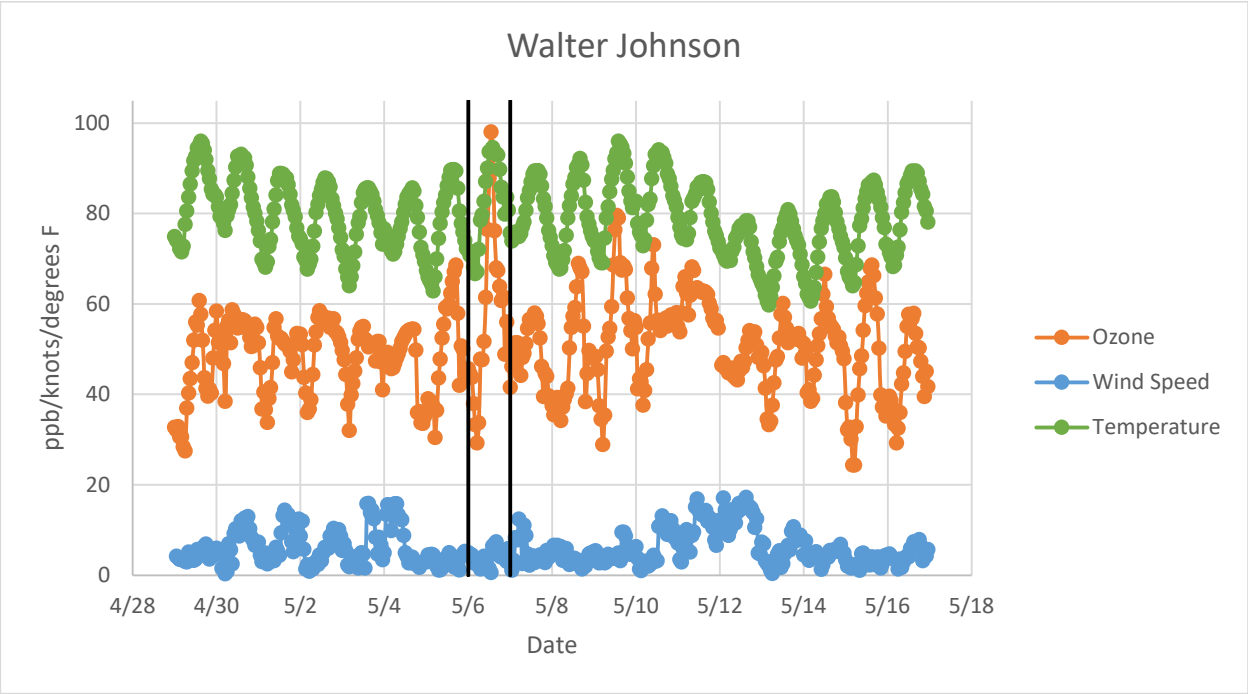
Figure A11. Hourly NO_2 values from AQS* for the Jerome Mack monitoring site from May 5, 2020 through May 10, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/3/2021

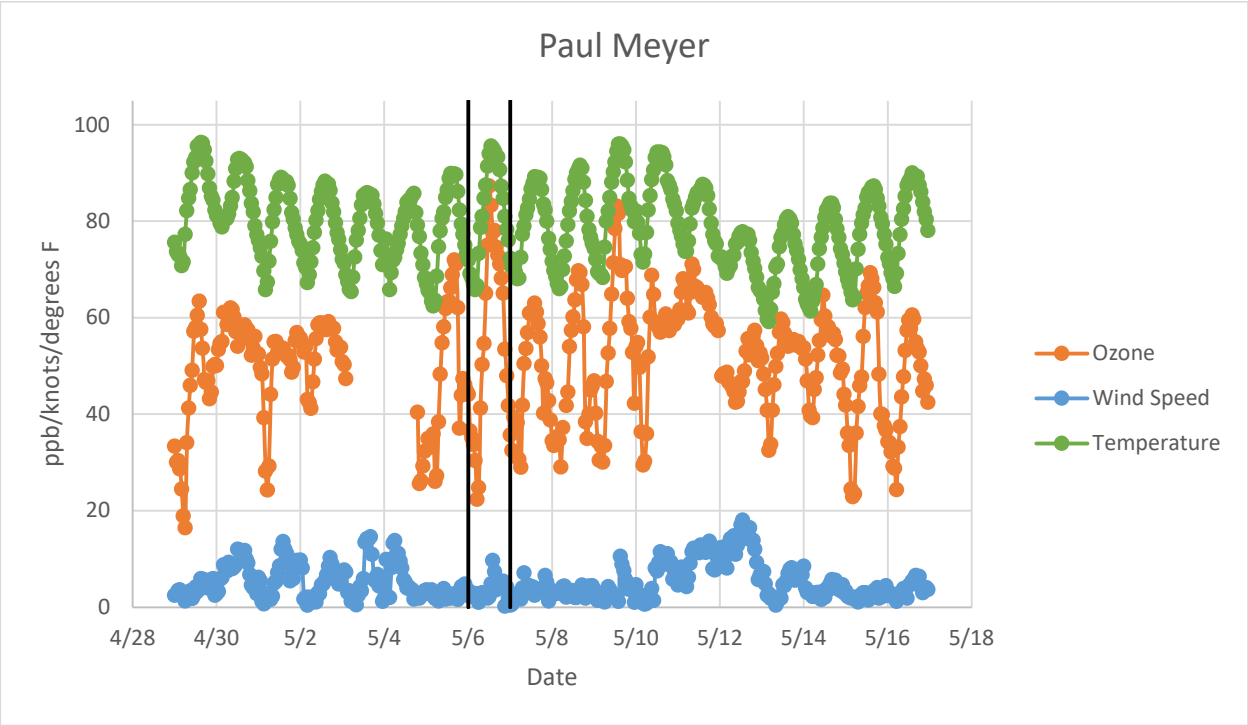
Figure A12: Hourly O_3, wind speed, and temperature values from AQS* for the Walter Johnson monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 7/29/2021

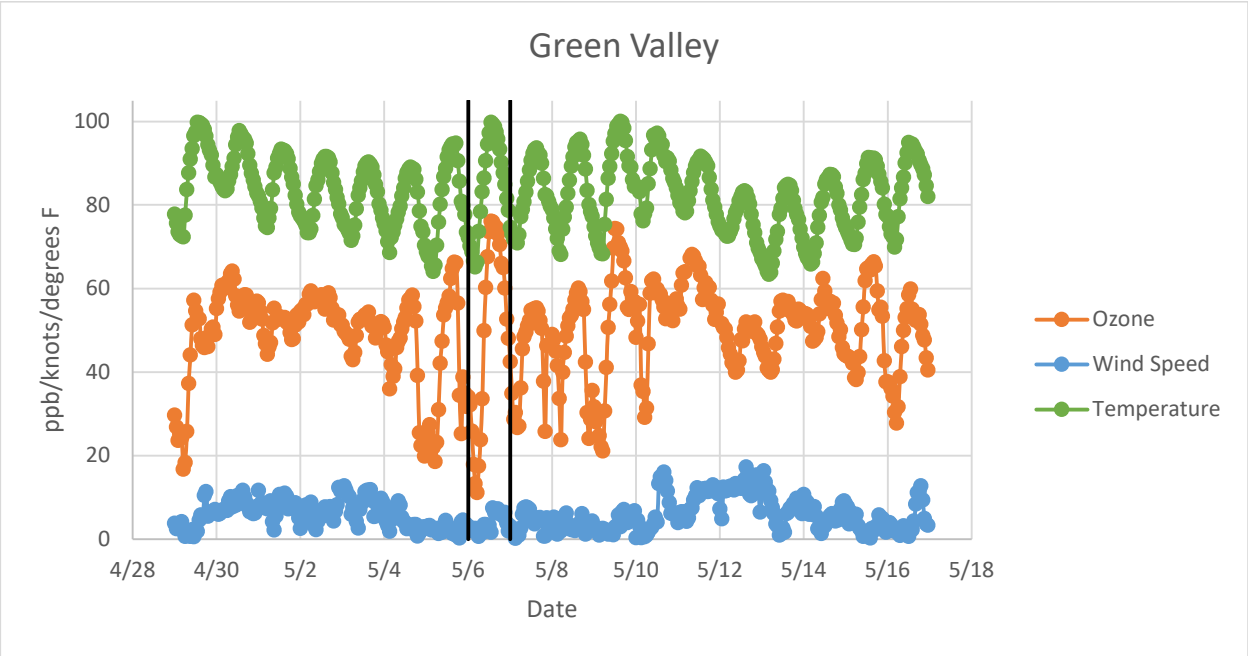
Figure A13: Hourly O_3, wind speed, and temperature values from AQS* for the Paul Meyer monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/3/2021

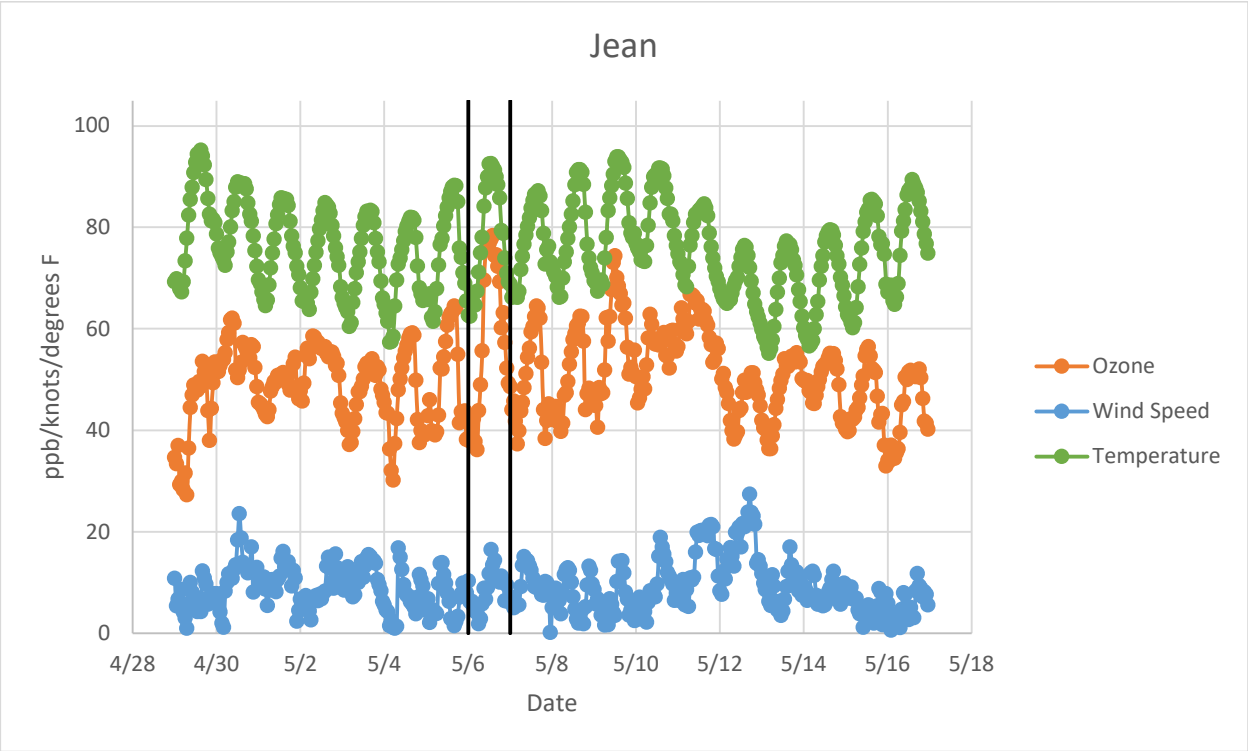
Figure A14: Hourly O_3, wind speed, and temperature values from AQS* for the Green Valley monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/5/2021

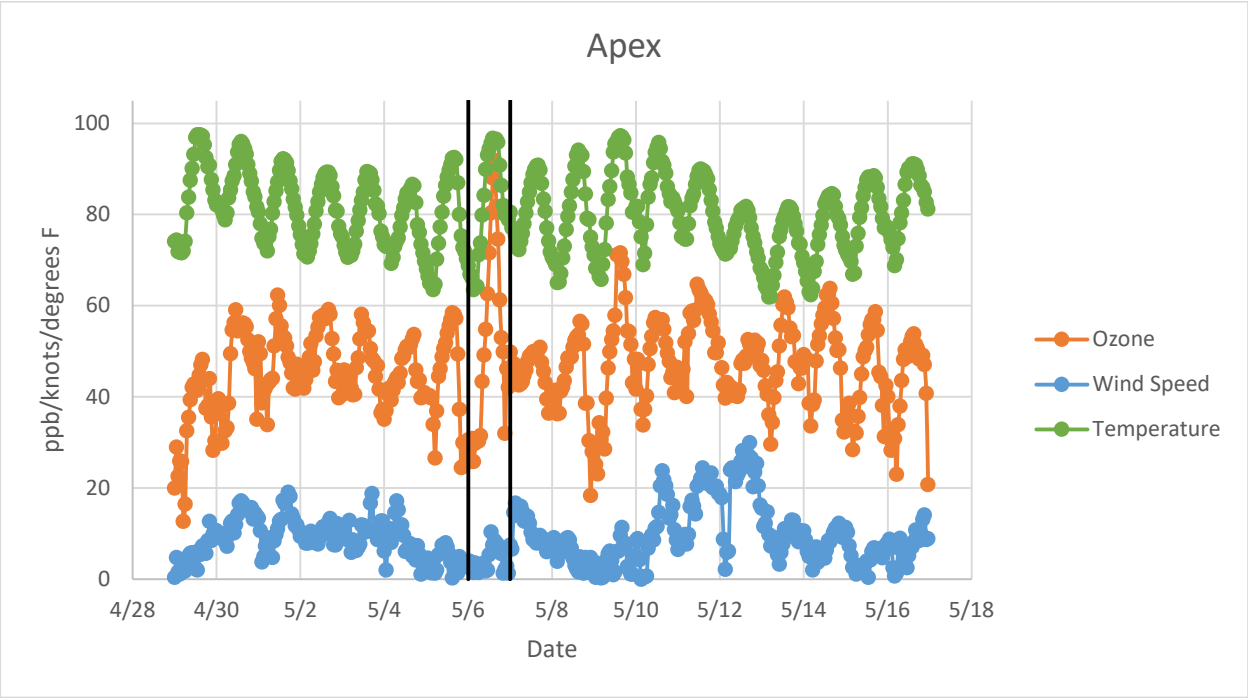
Figure A15: Hourly O_3, wind speed, and temperature values from AQS* for the Jean monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/5/2021

Figure A16: Hourly O_3, wind speed, and temperature values from AQS* for the Apex monitoring site from April 29, 2020 through May 16, 2020.



The two black vertical lines represent May 6, 2020 12:00 am and May 7, 2020 12:00 am, respectively.

* Values from the EPA's Air Quality System (AQS) database, AMP501 report pulled 8/5/2021

Figure A17: O_3 Monitoring Sites In and Around the LVV.

Table A1: MDA8 O_3 (ppb) at Clark County O_3 Monitors for April 23 and May 13, 2017, and May 6, 2020.

Monitor	Name	In LVV	April 23, 2017 MDA8*	May 13, 2017 MDA8*	May 6, 2020 MDA8 *
32-003-0022	Apex		66	63	76
32-003-0023	Mesquite		63	62	60
32-003-0043	Paul Meyer	X	65	65	77
32-003-0071	Walter Johnson	X	67	66	78
32-003-0073	Palo Verde	X	65	65	68
32-003-0075	Joe Neal	X	65	63	76
32-003-0298	Green Valley	X	67	63	72
32-003-0540	Jerome Mack	X	62	63	73
32-003-0601	Boulder City		67	68	69
32-003-1019	Jean		64	58	75
32-003-7772	Indian Springs		65	57	63

* Values from the EPA's Air Quality System (AQS) database, AMP350NW reports pulled 7/8/2021 and 1/14/2022

Table A2: Maximum 1-hour O_3 (ppb) at Clark County O_3 Monitors for April 23 and May 13, 2017, and May 6, 2020.

Monitor	Name	In LVV	April 23, 2017 Max 1-hour*	May 13, 2017 Max 1-hour*	May 6, 2020 Max 1-hour*
32-003-0022	Apex		70	71	91
32-003-0023	Mesquite		63	62	65
32-003-0043	Paul Meyer	X	67	73	87
32-003-0071	Walter Johnson	X	70	75	98
32-003-0073	Palo Verde	X	69	70	82
32-003-0075	Joe Neal	X	67	69	92
32-003-0298	Green Valley	X	70	68	76
32-003-0540	Jerome Mack	X	66	70	85
32-003-0601	Boulder City		71	72	75
32-003-1019	Jean		67	60	78
32-003-7772	Indian Springs		68	60	72

* Values from the EPA's Air Quality System (AQS) database, AMP350 reports pulled 1/19/2022 and 2/10/2022

Table A3: Comparison of Wind Speeds (WS)* – April 23 and May 13, 2017; May 6, 2020.

Time	WS (mph) 4/23/2017	WS (mph) 5/13/2017	WS (mph) 5/6/2020
12:53 AM	3	14	5
1:53 AM	0	17	7
2:53 AM	0	29	3
3:53 AM	6	24	6
4:53 AM	0	13	6
5:53 AM	0	23	6
6:53 AM	8	25	0
7:53 AM	9	23	0
8:53 AM	16	20	5
9:53 AM	18	18	5
10:53 AM	22	8	0
11:53 AM	20	3	0
12:53 PM	23	5	3
1:53 PM	22	3	9
2:53 PM	13	9	10
3:53 PM	26	8	12
4:53 PM	18	0	8
5:53 PM	16	5	9
6:53 PM	13	9	8
7:53 PM	15	8	9
8:53 PM	13	3	6
9:53 PM	10	0	0
10:53 PM	3	10	13

miles per hour (mph)

* data for North Las Vegas Airport Station, from Weather Underground

https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2017-4-23
https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2017-5-13
https://www.wunderground.com/history/daily/us/nv/north-las-vegas/KVGT/date/2020-5-6

Table A4: MDA8 O_3 (ppb) at Clark County Monitoring Sites for May 6, 2020.

Clark County O_3 Monitors					
Monitor	**Name**	**Date (2020)**	**In LVV**	**MDA8 (ppb)***	**MDA8 Hours***
32-003-0022	**Apex**	5/6		76	1100-1800
32-003-0023	Mesquite	5/6		60	1000-1700
32-003-0043	**Paul Meyer**	5/6	X	77	1100-1800
32-003-0071	**Walter Johnson**	5/6	X	78	1100-1800
32-003-0073	Palo Verde	5/6	X	68	1100-1800
32-003-0075	**Joe Neal**	5/6	X	76	1100-1800
32-003-0298	**Green Valley**	5/6	X	72	1100-1800
32-003-0540	**Jerome Mack**	5/6	X	73	1000-1700
32-003-0601	Boulder City	5/6		69	1400-2100
32-003-1019	**Jean**	5/6		75	1000-1700
32-003-7772	Indian Springs	5/6		63	1000-1700

Yellow highlight indicates an MDA8 O_3 exceedance $\geq$70 ppb

Monitors in **bold** included in 5/6/2020 demonstration

* Values from the EPA's Air Quality System (AQS) database, AMP350NW report pulled 7/8/2021

Table A5: MDA8 O_3 (ppb) at NPS O_3 Monitors Surrounding the LVV, for May 5 and 6, 2020.

Surrounding Area O_3 Monitors Outside of LVV					
Monitor	Name	Date (2020)		MDA8 (ppb)*	MDA8 Hours*
32-033-0101	Great Basin NP	5/5	NE of LVV	56	1000-1700
32-033-0101	Great Basin NP	5/6	NE of LVV	60	1100-1800
06-027-0101	Death Valley NP	5/5	W of LVV	55	1300-2000
06-027-0101	Death Valley NP	5/6	W of LVV	60	1100-1800
06-071-1001	Mojave Nat Pres.	5/5	SW of LVV	73	1600-2300
06-071-1001	Mojave Nat Pres.	5/6	SW of LVV	82	1400-2100
04-005-8001	Grand Canyon NP	5/5	E of LVV	54	1400-2100
04-005-8001	Grand Canyon NP	5/6	E of LVV	68	1600-2300

Yellow highlight indicates an MDA8 O_3 exceedance $\geq$70 ppb

* Values from the EPA's Air Quality System (AQS) database, AMP350NW report pulled 9/7/2021