APPENDIX D

System Modification Requests

SYSTEM MODIFICATION REQUEST

Carbon Monoxide Network Reduction.

Background

The carbon monoxide (CO) monitoring network has been an integral part of the criteria pollutant monitoring program since before the establishment of South Coast AQMD. Over time, air quality priorities have shifted, and CO concentrations in the South Coast Air Basin have consistently remained below the National Ambient Air Quality Standards (NAAQS), achieving maintenance status for both the 1-hour and 8-hour standards.

Per 40 CFR Part 58, Appendix D, Section 4.2, the general design criteria require that at least one CO monitor be collocated with a required near-road nitrogen dioxide (NO_2) monitor. If a Core-Based Statistical Area (CBSA) has multiple required near-road NO_2 monitors, only one CO monitor must be collocated within that CBSA. To meet this minimum monitoring requirement, South Coast AQMD actively operates CO monitors at the Anaheim Near-Road and Ontario Etiwanda Near-Road monitoring sites, along with 17 area wide CO monitors as shown in Figure 1.

The U.S. EPA Regional Administrator, in collaboration with state and local agencies, has not mandated additional CO monitors beyond the minimum federal requirements.

In March 2022, Antelope Valley Air Pollution Control District (AVAPCD) advised South Coast AQMD they were to discontinue CO monitoring at the Lancaster Air Monitoring Station (AMS) and proposed a shared CO monitoring responsibility for the Los Angeles-Long Beach-Anaheim Metropolitan Statistical Area (MSA) (CBSA 31080). South Coast AQMD concurs with this approach and agrees to coordinate CO monitoring responsibilities accordingly.

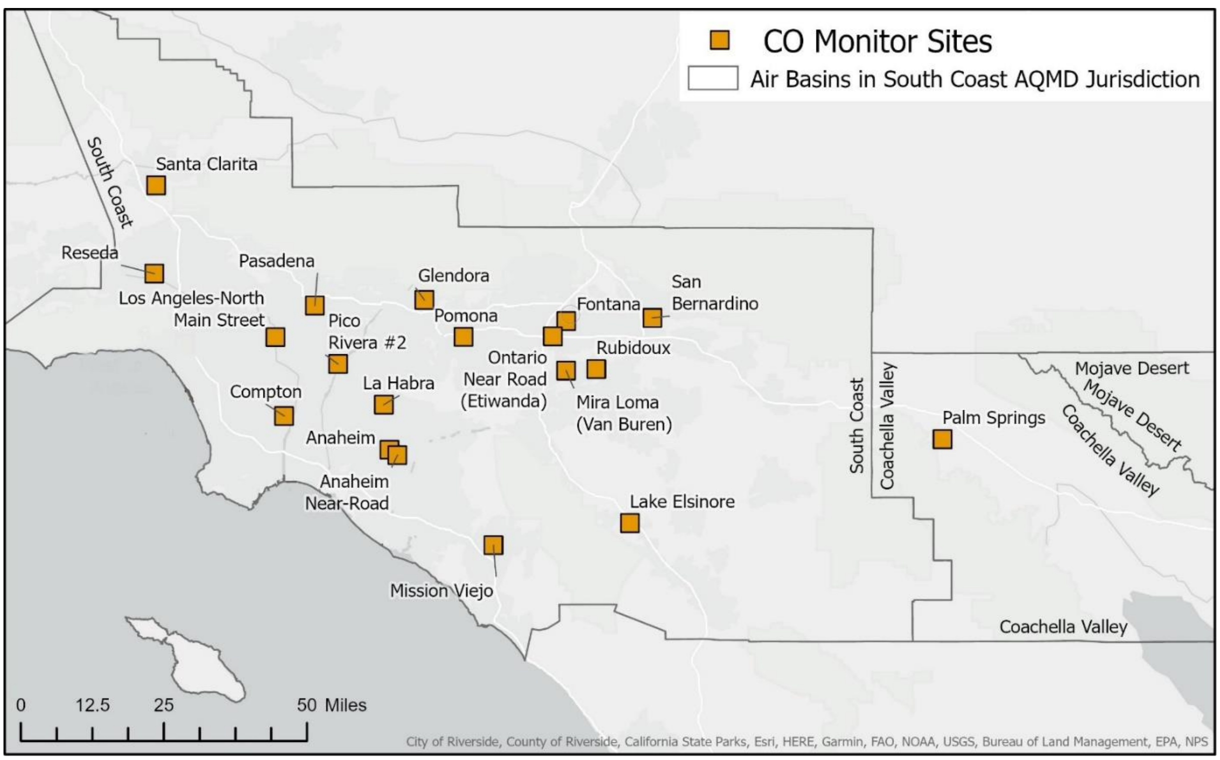


Figure 1 Carbon Monoxide Monitoring Network

South Coast AQMD meets the requirement for near road monitors and exceeds the minimum monitoring requirements for area-wide CO monitoring as shown in Table 1.

Regulatory Compliance and Minimum Monitoring Requirements

Table 1 Minimum Monitoring Requirements for CO
(Note: Refer to section 4.2 of Appendix D of 40 CFR Part 58.)

CBSA	Population & Census Year	Required Near Road Monitors	Active Near Road Monitors	Required Area Wide Monitors	Active Area Wide Monitors
31080	12,927,614 2024	1	1	0	11
40140	4,744,214 2024	1	1	0	6

In support of System Modification Request (SMR) to discontinue CO monitoring, South Coast AQMD has provided the following data summary as outlined in 40 CFR Part 58.14 (c). For years listed with no data in the various links on the EPA's Air Trends webpage, Air Quality Design Values, https://www.epa.gov/air-trends/air-quality-design-values#report, South Coast AQMD utilized data from the AQS AMP480 Design Value Report which reports DV concentrations with validity flag indicators (Y and N). This was done to satisfy the five year requirement in order for the student t-test value to be correct for the calculation being performed.

Data Analysis and Evaluation

Carbon Monoxide Trends

CO is currently measured at 19 sites within the South Coast AQMD criteria pollutant monitoring network. The CO monitors proposed for closure have not exceeded the CO National Ambient Air Quality Standards (NAAQS) for CO. The five-year DV metric for 8-hour and 1-hour pass the 80% of applicable NAAQS statistics and qualify for closure under the 40 CFR Part 58 (c)(1) conditions for closure as shown in Tables 2 through 5.

In addition to the active site requests to discontinue CO monitoring, South Coast AQMD is also seeking retroactive approval to discontinue CO monitoring at sites that have been discontinued due to circumstances beyond the control of South Coast AQMD. Some of these sites are in the process of being relocated, however, CO monitoring will not be continued at the new locations.

Table 2 – CO NAAQS: 8 – Hour

Site Name	Site	Year 1 Design Value (ppm)	Year 2 Design Value (ppm)	Year 3 Design Value (ppm)	Year 4 Design Value (ppm)	Year 5 Design Value (ppm)	Average Design Value (ppm)	Std. Dev *S*	Student's *t* value (90% confidence)	Number of Data Values (*n*)	90% Upper CI (ppm)	80% of 9ppm NAAQS	Test
		2020	2021	2022	2023	2024							
Anaheim	060590007	1.7	1.5	1.4	1.6	2.4	1.716	0.388	2.132	5	2.086	7.2	PASS
Los Angeles Main (Trace)	060371103	1.4	1.5	1.4	1.2	1.6	1.4124	0.137	2.132	5	1.543	7.2	PASS
Compton	060371302	3.1	3.7	3.0	2.6	3.1	3.09	0.394	2.132	5	3.466	7.2	PASS
Elsinore	060659001	0.7	0.8	0.6	0.7	1.0	0.76	0.152	2.132	5	0.905	7.2	PASS
Fontana	060712002	1.2	1.4	1.0	1.0	1.1	1.142	0.167	2.132	5	1.301	7.2	PASS
Glendora	060370016	1.9	0.9	0.6	0.6	1.1	1.02	0.536	2.132	5	1.531	7.2	PASS
La Habra	060595001	1.2	1.3	1.4	1.1	1.6	1.316	0.185	2.132	5	1.493	7.2	PASS
Mira Loma Van Buren	060658005	1.5	1.6	1.2	1.2	1.3	1.36	0.182	2.132	5	1.533	7.2	PASS
Pasadena	060372005	2.2	1.6	1.3	1.0	1.1	1.444	0.479	2.132	5	1.901	7.2	PASS
Pico Rivera	060371602	1.7	1.5	1.5	1.3	1.5	1.496	0.142	2.132	5	1.631	7.2	PASS
Palm Springs	060655001	0.5	0.4	0.5	0.8	1.1	0.66	0.288	2.132	5	0.935	7.2	PASS
Pomona	060371701	1.1	1.3	1.1	1.3	1.2	1.2	0.100	2.132	5	1.295	7.2	PASS
Reseda	060371201	1.7	1.9	1.8	1.7	1.8	1.78	0.084	2.132	5	1.860	7.2	PASS
Rubidoux	060658001	1.5	1.8	1.2	1.2	1.4	1.42	0.249	2.132	5	1.657	7.2	PASS
Rubidoux (Trace)	060658001	1.4	1.7	1.1	1.2	1.4	1.36	0.230	2.132	5	1.580	7.2	PASS
Santa Clarita	060376012	0.8	0.7	0.6	0.6	0.7	0.68	0.084	2.132	5	0.760	7.2	PASS
San Bernardino	060719004	1.4	1.6	1.4	1.2	2.9	1.7	0.686	2.132	5	2.354	7.2	PASS

Table 3– Formerly Active CO NAAQS: 8 – Hour

Site Name	Site	Year 1 Design Value (ppm)	Year 2 Design Value (ppm)	Year 3 Design Value (ppm)	Year 4 Design Value (ppm)	Year 5 Design Value (ppm)	Average Design Value (ppm)	Std. Dev *S*	Student's *t* value (90% confidence)	Number of Data Values (*n*)	90% Upper CI (ppm)	80% of 9ppm NAAQS	Test
PAST CO (5 Years)													
Azusa (2018-2022)	060370002	1.0	1.1	2.0	1.4	0.9	1.28	0.444	2.132	5	1.703	7.2	PASS
West LA (2017-2021)	060370113	1.2	1.3	1.2	1.2	1.0	1.18	0.110	2.132	5	1.284	7.2	PASS
Los Angeles Main (2019-2023)	060371103	1.6	1.6	1.6	1.5	1.1	1.48	0.217	2.132	5	1.687	7.2	PASS
LAX Hastings (2017-2021)	060375005	1.6	1.5	1.3	1.3	1.3	1.4	0.141	2.132	5	1.535	7.2	PASS
Costa Mesa (2013-2017)	060591003	2.0	1.9	2.2	1.7	1.4	1.84	0.305	2.132	5	2.131	7.2	PASS
Upland (2019-2023)	060711004	1.1	1.1	1.1	0.8	0.7	0.96	0.195	2.132	5	1.146	7.2	PASS
Mission Viejo (2018-2022)	060592002	0.9	0.8	0.8	0.8	1.0	0.86	0.089	2.132	5	0.945	7.2	PASS

Table 4 - CO NAAQS: 1 - Hour

Site Name	Site	Year 1 Design Value (ppm)	Year 2 Design Value (ppm)	Year 3 Design Value (ppm)	Year 4 Design Value (ppm)	Year 5 Design Value (ppm)	Average Design Value (ppm)	Std. Dev *S*	Student's *t* value (90% confidence)	Number of Data Values (*n*)	90% Upper CI (ppm)	80% of 35ppm NAAQS	Test
		2020	2021	2022	2023	2024							
Anaheim	060590007	2.3	2.1	2.4	2.5	2.8	2.414	0.248	2.132	5	2.650	28	PASS
Los Angeles Main (Trace)	060371103	1.8	1.9	1.6	1.4	1.8	1.71	0.199	2.132	5	1.900	28	PASS
Compton	060371302	4.5	4.3	3.4	3.2	3.5	3.78	0.581	2.132	5	4.333	28	PASS
Elsinore	060659001	0.9	0.9	0.9	1.3	1.8	1.16	0.397	2.132	5	1.539	28	PASS
Fontana	060712002	1.7	1.9	1.6	1.5	1.6	1.656	0.154	2.132	5	1.803	28	PASS
Glendora	060370016	2.3	1.4	0.9	0.8	1.4	1.36	0.594	2.132	5	1.926	28	PASS
La Habra	060595001	2.1	2.3	2.5	2.1	2.0	2.192	0.211	2.132	5	2.393	28	PASS
Mira Loma Van Buren	060658005	1.8	2.0	1.6	1.7	1.6	1.742	0.165	2.132	5	1.900	28	PASS
Pasadena	060372005	2.6	1.9	1.6	1.3	1.4	1.768	0.516	2.132	5	2.260	28	PASS
Pico Rivera	060371602	3.1	1.8	1.6	1.8	1.9	2.04	0.602	2.132	5	2.614	28	PASS
Palm Springs	060655001	0.8	0.8	1.1	0.9	3.4	1.4	1.125	2.132	5	2.472	28	PASS
Pomona	060371701	1.5	1.7	1.6	1.5	1.7	1.6	0.100	2.132	5	1.695	28	PASS
Reseda	060371201	2.0	2.6	2.2	2.3	2.2	2.262	0.218	2.132	5	2.470	28	PASS
Rubidoux	060658001	1.8	2.1	3.3	1.4	1.8	2.07	0.731	2.132	5	2.767	28	PASS
Rubidoux (Trace)	060658001	1.9	2.1	1.6	1.4	1.8	1.747	0.271	2.132	5	2.005	28	PASS
Santa Clarita	060376012	1.2	1.0	1.5	1.1	1.2	1.202	0.187	2.132	5	1.380	28	PASS
San Bernardino	060719004	1.9	2.0	1.7	1.6	3.8	2.2	0.908	2.132	5	3.066	28	PASS

Table 5 – Formerly Active CO NAAQS: 1 - Hour

Site Name	Site	Year 1 Design Value (ppm)	Year 2 Design Value (ppm)	Year 3 Design Value (ppm)	Year 4 Design Value (ppm)	Year 5 Design Value (ppm)	Average Design Value (ppm)	Std. Dev *S*	Student's *t* value (90% confidence)	Number of Data Values (*n*)	90% Upper CI (ppm)	80% of 9ppm NAAQS	Test
PAST CO (5 Years)													
Azusa (2018-2022)	060370002	1.4	1.6	2.4	1.5	1.3	1.64	0.439	2.132	5	2.059	28	PASS
West LA (2017-2021)	060370113	2.0	1.6	1.9	2.0	1.5	1.8	0.235	2.132	5	2.024	28	PASS
Los Angeles Main (2019-2023)	060371103	2.0	2.1	2.0	1.7	1.3	1.82	0.327	2.132	5	2.132	28	PASS
LAX Hastings (2017-2021)	060375005	2.1	1.8	1.8	1.6	1.7	1.8	0.187	2.132	5	1.978	28	PASS
Costa Mesa (2013-2017)	060591003	2.4	2.7	3.0	2.1	1.7	2.38	0.507	2.132	5	2.863	28	PASS
Upland (2019-2023)	060711004	1.5	1.5	1.3	1.1	1.0	1.28	0.228	2.132	5	1.497	28	PASS
Mission Viejo (2018-2022)	060592002	1.2	1.0	1.7	1.0	1.2	1.22	0.286	2.132	5	1.493	28	PASS

System Modification Request Justification

South Coast AQMD requests U.S. EPA approval to discontinue CO monitoring at the AMS listed in Tables 2 through 5, in accordance with 40 CFR Part 58.14(c)(1). The CO monitors at these sites meet all applicable discontinuation criteria. Sites proposed for discontinuation include Anaheim, Los Angeles Main Street (trace), Compton, Lake Elsinore, Fontana, Glendora, La Habra, Mira Loma Van Buren, Pasadena, Pico Rivera, Palm Springs, Pomona, Reseda, Rubidoux (trace), Santa Clarita, and San Bernardino.

In addition, South Coast AQMD requests retroactive approval to discontinue CO monitoring at Azusa, West Los Angeles, Los Angeles Main (non-trace), LAX Hastings, Costa Mesa, Upland, Mission Viejo, and Perris. These monitors were discontinued due to circumstances beyond the agency's control, such as lease terminations. In cases where sites are being relocated, CO monitoring is not continuing at the new locations.

All monitors proposed for discontinuation have demonstrated attainment of the CO National Ambient Air Quality Standards (NAAQS) over the past five years. Furthermore, based on observed levels, trends, and variability, each site exhibits less than a 10 percent probability of exceeding 80 percent of the applicable standard over the next three years.

The CO monitors are not specifically required by any attainment or maintenance plans. Although the monitors are located within a CO maintenance area, the most recent State Implementation Plan (SIP) maintenance plan approved by U.S. EPA does not include a contingency measure triggered by monitored air quality concentrations. Additionally, the monitors proposed for discontinuation are not the only State and Local Air Monitoring Stations (SLAMS) operating within the maintenance area.

Approval of this request will allow South Coast AQMD to continue meeting the minimum CO monitoring requirements by continuing operation of the two near road CO monitors as demonstrated in the minimum monitoring requirements Table 1.

SYSTEM MODIFICATION REQUEST

Exide Rehrig Pb Source Monitor
AQS Site Code 06-037-1405

Background

In 1990, the U.S. EPA requested that South Coast AQMD begin collecting ambient air particulate samples at the Exide battery recycling facility in Vernon, California. In response, source-oriented lead (Pb) monitoring was established at the ATSF site. In 2007, Exide installed five fenceline Pb monitors as a condition of its permit, which operated on a daily schedule (Figure 1).

Anticipating U.S. EPA's revisions to the National Ambient Air Quality Standards (NAAQS) for Pb, South Coast AQMD established a Pb monitor at the Rehrig site in 2007. The Rehrig monitor was initially operated on a six-day sampling schedule and later transitioned to daily monitoring. These actions were taken in preparation for the November 12, 2008 revision to the Pb NAAQS, which required source-oriented monitoring at facilities emitting more than 1.0 tons per year (TPY) of Pb or at airports emitting more than 0.5 TPY of Pb, as identified in the National Emissions Inventory (NEI).

In March 2015, the California Department of Toxic Substances Control (DTSC) ordered the cessation of operations at Exide and mandated the permanent closure of the facility. On October 22, 2020, DTSC established the Vernon Environmental Response Trust (VERT) to oversee the environmental cleanup and ensure continued monitoring until site remediation was completed. As of 2025, remediation activities at the Exide facility have been completed. In parallel, mandated facility air monitoring required under South Coast AQMD's permit is expected to be discontinued in 2025. Public updates are available on the DTSC Exide webpage, and air monitoring data remain accessible through the South Coast AQMD Exide Monitoring page.

South Coast AQMD Monitoring at the Rehrig site ceased on August 17, 2024, due to the sale of the property by Rehrig Pacific Company to BNSF Railway. As a result of the property transfer, continued operation of the Pb monitor at this location was no longer feasible. Therefore, South Coast AQMD requests retroactive approval through the established U.S. EPA System Modification Request (SMR) process to formally discontinue Pb monitoring at the Rehrig site as of that date.

Furthermore, Exide no longer exceeds U.S. EPA's minimum emissions threshold for source-oriented Pb monitoring, as defined under the 2010 Pb NAAQS. The most recent Design Value (DV) for 2020–2024 has remained below the NAAQS limit, as shown in Table 1. The site's historical data, permanent facility closure, completed remediation, and expected termination of permit-required air monitoring provide strong justification for formally discontinuing Pb monitoring at this location.

Figure 1 Locations of South Coast AQMD and Exide VERT Pb monitors

Regulatory Compliance and Minimum Monitoring Requirements

Table 1 Source Oriented Pb Monitoring

(Note: Refer to section 4.5 of Appendix D of 40 CFR Part 58.)

Source Name	Address	Pb Emissions[4] (lbs. per year)	Emission Inventory Source[2] & Data Year	Max 3-Month DV[1] [ug/m3]	DV Date (third month, year)
Exide Technologies[3] (Rehrig)	4010 E. 26th Street Vernon, CA 90058	0.0	NEI, 2020	0.04	4, 2022

[1]Consider data from past three years.
[2]Using latest NEI Data 2020 most recent available at https://www.epa.gov/air-emissions-inventories/national-emissions-inventory
[3]Exide facility is currently closed.

Table 2 Source Pb FRM Monitor Minimum Sampling Frequency

	Location	AQS No.	Type	Required Sampling Frequency
2	Rehrig (Exide)	060371405	Source	1-in-6

Note: Sampling frequency requirement per 58.12 (b)

Data Analysis and Evaluation

Lead Trends

Pb is measured at two source locations in the South Coast AQMD jurisdiction. During the last five years of operation there were no exceedances of the Pb National Ambient Air Quality Standards (NAAQS) at the Rehrig site. The 40 CFR Part 58 (c)(1) metric for the 3-month rolling average DV pass the 80% of NAAQS statistic, however in 2020 the data did not meet the minimum threshold of 75% and therefore do not qualify for closure under the 40 CFR Part 58.14 (c)(1) conditions for closure.

Rehrig Pb Monitor	
Year	3-Month Rolling Average DV ($\mu g/m^3$)
2020	.02[1]
2021	.06
2022	.06
2023	.06
2024	.04[1]
5 Yr. DV Avg.	.05
40 CFR Part 58 (c)(1) Metric	0.02
80% of NAAQS	0.12 ug/m^3
Test	Pass

[1] DV not valid due to < 75% completeness.

System Modification Justification
South Coast AQMD requests U.S. EPA approval to retroactively discontinue Pb monitoring at the Rehrig site, consistent with the provisions of 40 CFR Part 58.14. The justification for discontinuation is outlined below.

Lead Monitoring Discontinuation
The Rehrig Pb monitor does not qualify for discontinuation under 40 CFR 58.14(c)(1) due to the presence of an "N" validity flag. However, South Coast AQMD is requesting retroactive approval to discontinue Pb monitoring at this location under the general and discretionary provisions of 40 CFR 58.14, which allow for case-by-case approval when:

- The discontinuation does not compromise data collection needed for implementation of a NAAQS; and
- The requirements of Appendix D to Part 58 continue to be met.

Although the monitor is located in a designated nonattainment area, it is not specifically required by any active State Implementation Plan (SIP), maintenance plan, or related contingency provision. The most recent SIP revision adopted by the State and approved by U.S. EPA does not rely on this site to meet or maintain the Pb standard, nor does it include contingency measures tied to concentration levels at this location.

Monitoring data from the past five years show that Pb concentrations at the Rehrig site have remained well below 80% of the applicable NAAQS threshold. The probability of exceedance is less than 10 percent based on historical levels, observed trends, and data variability. In addition, data collected at the site support closure under 40 CFR Part 58 Appendix D, Section 4.5(ii), which allows discontinuation where emissions do not contribute to a maximum Pb concentration exceeding 50% of the NAAQS.

Furthermore, Exide no longer exceeds U.S. EPA's minimum emissions threshold for source-oriented Pb monitoring, as defined under the 2010 Pb NAAQS. The most recent Design Value (DV) for 2020–2024 has remained below the NAAQS limit, as shown in Table 1. The site's historical data, permanent facility closure, completed remediation, and expected termination of permit-required air monitoring in 2025 provide strong justification for formally discontinuing Pb monitoring at this location.

The Rehrig Pb monitor is not the Design Value site for the region, and South Coast AQMD continues to meet or exceed the minimum required Pb monitoring network design criteria. Regional Pb air quality trends remain adequately represented by other active monitors.

Monitoring at Rehrig ceased on August 17, 2024, due to the sale of the property by Rehrig Pacific Company to BNSF Railway, which eliminated access for continued operation. Given the completed cleanup of the Exide facility and the forthcoming termination of permit-required monitoring, South Coast AQMD formally requests retroactive approval through the System Modification Request (SMR) process to discontinue Pb monitoring at the Rehrig site as of August 17, 2024.

Summary

The Rehrig Pb monitor has demonstrated compliance for over five years, with a probability of less than 10% exceeding 80% of the NAAQS in the next three years. The most recent Design Value for 2020–2024 remains well below the standard, and Exide no longer exceeds U.S. EPA’s threshold for source-oriented Pb monitoring under the 2010 Pb NAAQS. The current SIP does not include contingency measures based on monitored concentrations, and the site is not identified as the regional DV location. Furthermore, remediation at the Exide facility is complete, permit-required monitoring is expected to end in 2025, and alternative monitoring stations continue to represent regional trends. Given that South Coast AQMD exceeds the minimum Pb monitoring requirements and the Rehrig monitor ceased operation on August 17, 2024, due to property sale and loss of access, we formally request U.S. EPA approval to retroactively discontinue Pb monitoring at the Rehrig site.

SYSTEM MODIFICATION REQUEST

Perris Monitoring Site
AQS Site Codes 06-065-6001

Background

The Perris Air Monitoring Station (AMS), located at 237.5 North D Street, Perris, CA 91702, has been operational since May 1973. The site was originally established to monitor ozone (O_3) and particulate matter (PM_{10}) to assess pollutant trends and ozone formation in the region.

Over time, the area surrounding the site has undergone significant changes, potentially compromising data representativeness. During the 2020 Network Assessment, the site was identified as low value due to compromised probe and monitoring path siting criteria as specified in 40 CFR Part 58, Appendix E. Additionally, the City of Perris formally requested site discontinuation on March 30, 2022, as the building was being repurposed, increasing activities that further compromised siting criteria.

South Coast AQMD requests retroactive approval through the established U.S. EPA System Modification Request (SMR) process to discontinue criteria pollutant monitoring at the Perris AMS. The location of the site is shown in Figure 1.

Figure 1 Perris Riverside County Facility

Site Performance and Regional Comparisons

In 2021, the last complete year of data, for the Perris site, Redlands recorded the highest 8-hour O_3 Design Value (DV) in the Ontario-Riverside-San Bernardino Metropolitan Statical Area (MSA) (CBSA 31080) with a DV of 110 ppb. By comparison, Perris's 8-hour O_3 DV for 2021 was 92 ppb.

Also in 2021, The Mecca Saul Martinez AMS recorded the 24-hour PM_{10} DV concentration of 182 µg/m³ in the Ontario-Riverside-San Bernardino MSA. By comparison, Perris' 24-hour DV PM_{10} concentration was 58.7 µg/m³.

Between 2017 and 2021, no PM_{10} standard exceedances were observed at the Perris AMS. South Coast AQMD also continues to exceed the minimum monitoring requirements for both pollutants, as detailed in Tables 1 and 2.

Regulatory Compliance and Minimum Monitoring Requirements

Table 1 Minimum Monitoring Requirements for Ozone

(Note: Refer to section 4.1 and Table D-2 of Appendix D of 40 CFR Part 58)

MSA \CBSA	Counties	Population & Census Year	8-hr DV (ppb) & Years	DV AMS (name & AQS ID)	Monitors Required	Monitors Active	Monitors Needed
40140	San Bernardino Riverside	4,744,214 2024	110 2019-2021	Redlands 060714003	3	11	0

Population – 2024 is the most recent Census year available Metropolitan and Micropolitan Statistical Areas Totals: 2020-2024 (census.gov)
DV Years – The three years over which the DV was calculated (AMP 480).

Table 2 Minimum Monitoring Requirements for PM_{10}

(Note: Refer to section 4.3 of Appendix D of 40 CFR Part 58)

MSA \CBSA	Counties	Population & Census Year	Daily DV [ug/m3]	DV Site (Name, AQS ID)	Required Monitors	Active Monitors	Additional Monitors Needed
40140	San Bernardino Riverside	4,744,214 2024	182 2019-2021	Mecca (Saul Martinez) 060658005	1	13	0

Max AADT Counts – 2021 latest data available from CA DOT; https://dot.ca.gov/programs/traffic-operations/census

To support the system modification request, South Coast AQMD has presented a comprehensive data summary in accordance with the guidelines specified in 40 CFR Part 58.14 (c)(1). For years where no data is available in the provided links on the EPA's Air Trends webpage (https://www.epa.gov/air-trends/air-quality-design-values#report), South Coast AQMD has employed data sourced from the AQS AMP480 Design Value (DV) Report.

This report includes DV concentrations along with validity flag indicators (Y and N). The utilization of this data from the AQS AMP480 DV Report is essential for meeting the five-year requirement, ensuring the accuracy of the student t-test value in the calculation process. This meticulous approach ensures the integrity of the data used in evaluating the requested system modifications.

Data Analysis and Evaluation

Ozone Trends

Ozone is measured at eleven AMS in the Ontario-Riverside-San Bernardino MSA, and the Perris AMS has never been the Design Value (DV) site for the MSA.

Perris AMS	
Year	O3 8-Hour DV (ppb)
2017	93
2018	93
2019	93
2020	94
2021	92
5 Yr. DV Avg.	93
40 CFR Part 58.14 (c)1 Metric	94
80% of 70ppb NAAQS	56
Test	FAIL

The 40 CFR Part 58.14 (c)(1) metric is 93.7 ppb, with 80% of the 70 ppb NAAQS threshold at 56.0 ppb. Perris' O_3 monitor fails this test.

PM_{10} Trends

PM_{10} is measured at eight AMS in the Ontario-Riverside-San Bernardino MSA, and the Perris AMS has not been designated as the DV site. Over the last five years of operation, no exceedances of the PM_{10} NAAQS have been observed.

Perris AMS			
Year	PM_{10} 24-Hour Maximum µg/m³	DV Report Observed Exceedances	DV Report Estimated Exceedances
2017	75	0	0
2018	64	0	0
2019	97	0	0
2020	92	0	0
2021	77	0	0
5 Yr. Avg.	81		
40 CFR Part 58.14 (c)1 Metric	94		
80% of 150 ppb NAAQS	120		
Test	PASS		

PM_{10} FRM San Bernardino/Riverside County Maximum 24 hour Concentration vs Perris

Year	Maximum 24 Hr. Concentration µg/m³	Perris Maximum 24 Hr. Concentration µg/m³
2017	477	75
2018	421	64
2019	232	97
2020	680	92
2021	334	77

The Perris AMS PM_{10} monitor has remained below the 80% threshold of the applicable NAAQS and passes the student's t-test for statistical significance. The 40 CFR Part 58.14(c)(1) metric for PM_{10} is 94 µg/m³, compared to the 80% NAAQS threshold of 120 µg/m³ (based on 80% of the 150 µg/m³ 24-hour standard). Perris' PM_{10} monitor passes this test for closure.

It is noteworthy that the Perris PM_{10} monitor has consistently measured lower concentrations than the DV site each year.

System Modification Request Justification

South Coast AQMD requests U.S. EPA approval to retroactively discontinue both O_3 and PM_{10} monitoring at the Perris AMS. The justification for each pollutant is provided below, consistent with the requirements of 40 CFR Part 58.14.

Ozone Monitoring Discontinuation

The Perris O_3 monitor does not qualify for discontinuation under 40 CFR 58.14(c)(1), as the DV does not pass the student's t-test criteria and exceeds the 80% threshold of the O_3 NAAQS. However, South Coast AQMD requests retroactive approval to discontinue O_3 monitoring at this location under the general provisions of 40 CFR 58.14, which allow for case-by-case consideration if:

- The discontinuation does not compromise data collection needed for implementation of a NAAQS; and
- The requirements of Appendix D to Part 58 continue to be met.

Perris is not the O_3 DV site for the relevant MSA, and South Coast AQMD continues to exceed the minimum monitoring requirements for O_3, as detailed in Table 1. In addition, the Perris O_3 monitor is not specifically required by any attainment or maintenance plan. The area is designated as a maintenance area, but the most recent EPA-approved plan does not rely on contingency measures triggered by monitored concentrations. Importantly, Perris is not the only SLAMS site within the maintenance area, and regional air quality trends remain well represented without it.

PM_{10} Monitoring Discontinuation

The Perris AMS PM_{10} monitor has remained below the 80% threshold of the applicable NAAQS and passes the Student's t-test for statistical significance. The 40 CFR Part 58.14(c)(1) metric for PM_{10} is 94 µg/m³, compared to the 80% NAAQS threshold of 120 µg/m³ (based on 80% of the 150 µg/m³ 24-hour standard). Perris' PM_{10} monitor passes this test for closure. Therefore, South Coast AQMD formally requests an SMR to retroactively discontinue PM_{10} monitoring at Perris under 40 CFR 58.14(c)(1).

In addition, under the general provisions of 40 CFR 58.14, the discontinuation is further justified because:

- The discontinuation does not compromise data collection needed for implementation of a NAAQS; and
- The requirements of Appendix D to Part 58 continue to be met.

Perris is not the PM_{10} Design Value (DV) site for the relevant MSA, and South Coast AQMD continues to exceed the minimum PM_{10} monitoring requirements as detailed in Table 2. The Perris PM_{10} monitor is also not specifically required by any attainment or maintenance plan. The area is designated as a maintenance area, and the most recent EPA-approved plan does not include contingency measures triggered by monitored concentrations. Importantly, Perris is not the only SLAMS site within the maintenance area, and regional air quality trends remain well represented without it.

Summary

In accordance with 40 CFR Part 58.14, South Coast AQMD formally requests a System Modification Request (SMR) to discontinue O_3 and PM_{10} monitoring at the Perris AMS. The Perris PM_{10} monitor meets the requirements for discontinuation under 40 CFR 58.14(c)(1), having remained below the 80% NAAQS threshold, with a 40 CFR 58.14(c)(1) metric of 94 µg/m³ compared to the 120 µg/m³ threshold, and passing the Student's t-test for statistical significance.

While the O_3 monitor does not qualify for discontinuation under 40 CFR 58.14(c)(1) through (c)(5) due to elevated design values and not passing the Student's t-test, South Coast AQMD is requesting its closure under the general provisions of 40 CFR 58.14. The discontinuation of both monitors is justified because:

- The discontinuations do not compromise data collection needed for implementation of a NAAQS; and
- The requirements of Appendix D to Part 58 continue to be met.

Perris AMS is not the Design Value (DV) site for either pollutant within the relevant MSA, and its data is not specifically required by any attainment or maintenance plan. The area is designated as a maintenance area, and the most recent EPA-approved plans do not include contingency measures triggered by monitored concentrations at this location. In addition, nearby SLAMS monitors provide adequate spatial and scale representation of regional air quality trends, and South Coast AQMD continues to meet or exceed the minimum monitoring requirements for both O_3 and PM_{10}.

Approval of this request will support the continued refinement and efficiency of the South Coast AQMD air monitoring network.

SYSTEM MODIFICATION REQUEST

Pomona Air Monitoring Station
AQS Site Code 06-037-1701

Background

The Pomona Air Monitoring Station (AMS), located at 924 N. Garey Avenue in Pomona, is situated between a residential and commercial area along a heavily trafficked roadway.

Originally, the AMS was established for microscale carbon monoxide (CO) monitoring. Although CO is currently measured at the Pomona site, a separate System Modification Request (SMR) is submitted to discontinue CO monitoring. Over time, as ozone (O_3) became a pollutant of concern, O_3 and nitrogen dioxide (NO_2) measurements were added. The NO_2 monitor was initially classified as neighborhood scale; however, increasing traffic along the thoroughfare has shifted its classification to middle scale, while O_3 monitoring remains at the neighborhood scale.

Since the AMS inception, significant changes in the surrounding area have potentially compromised data representativeness. During a 2020 Technical Systems Audit (TSA), the U.S. EPA determined that the Pomona AMS no longer meets probe and monitoring path siting criteria outlined in 40 CFR Part 58, Appendix E and recommended its closure.

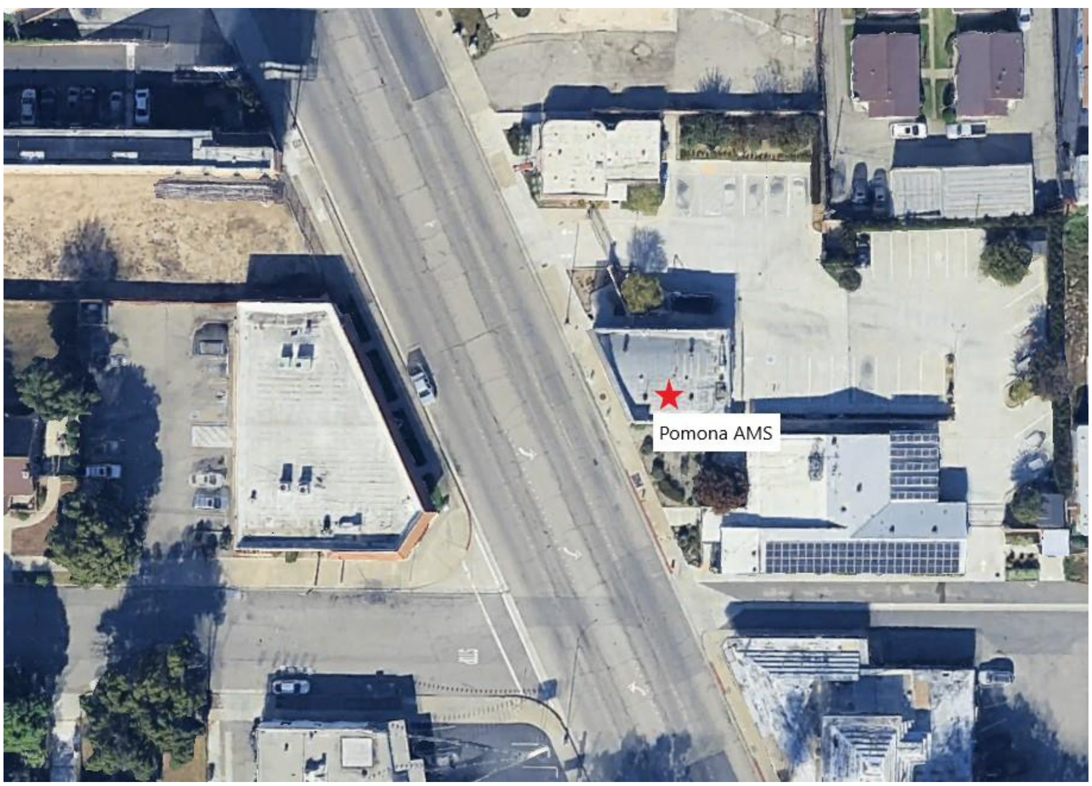


Figure 2 Pomona Air Monitoring Station

Site Performance and Regional Comparisons

In 2024, Glendora recorded the highest 8-hour O_3 Design Value (DV) in the Los Angeles-Long Beach-Anaheim Metropolitan Statistical Area (MSA) (CBSA 31080) with a DV of 101 ppb. By comparison, Pomona's 8-hour O_3 DV for 2024 was 94 ppb.

Also in 2024, the Los Angeles Main St. AMS reported the highest 1-hour NO_2 concentration in the Los Angeles-Long Beach-Anaheim MSA at 80 ppb. Long Beach 710 recorded the highest Annual Arithmetic Mean (AAM) for NO_2 at 20.5 ppb. In contrast, Pomona's maximum 1-hour NO_2 concentration was 68.9 ppb, with an AAM concentration of 17.1 ppb.

Notably, from 2020 to 2024, Pomona did not serve as the DV site for either O_3 or NO_2, and no exceedances of the National Ambient Air Quality Standards (NAAQS) for NO_2 were observed at the Pomona AMS. Additionally, South Coast AQMD continues to meet or exceed the minimum monitoring requirements for both O_3 and NO_2, as detailed in Tables 1 and 2.

Regulatory Compliance and Minimum Monitoring Requirements

Table 1 Minimum Monitoring Requirements for Ozone

(Note: Refer to section 4.1 and Table D-2 of Appendix D of 40 CFR Part 58)

MSA \CBSA	Counties	Population & Census Year [1]	8-hr DV (ppb) & Years [2]	DV Site (Name, AQS ID)	Monitors Required	Monitors Active	Monitors Needed
31080	Los Angeles Orange	12,927,614 2024	101 2022-2024	Glendora 060370016	4	14	0
40140	San Bernardino Riverside	4,744,214 2024	108 2022-2024	Redlands 060714003	3	11	0

Population – 2024 is the most recent Census year available Metropolitan and Micropolitan Statistical Areas Totals: 2020-2024 (census.gov)

DV Years – The three years over which the DV was calculated (AMP 480).

Table 2 Minimum Monitoring Requirements for Nitrogen Dioxide

(Note: Refer to section 4.3 of Appendix D of 40 CFR Part 58)

CBSA	Population & Census Year	Max AADT Counts (2019)	Required Near Road Monitors	Active Near Road Monitors	Additional Near Road Monitors Needed	Required Area Wide Monitors	Active Area Wide Monitors	Additional Area wide Monitors Needed
31080	12,927,614 2024	386,600 2022	2	2	0	1	13	0

Max AADT Counts – 2022 latest data available from CA DOT; https://dot.ca.gov/programs/traffic-operations/census

To support the system modification request, South Coast AQMD has presented a comprehensive data summary in accordance with the guidelines specified in 40 CFR Part 58.14 (c)(1). For years where no data is available in the provided links on the EPA's Air Trends webpage (https://www.epa.gov/air-trends/air-quality-design-values#report), South Coast AQMD has employed data sourced from the AQS AMP480 Design Value (DV) Report.

This report includes DV concentrations along with validity flag indicators (Y and N). The utilization of this data from the AQS AMP480 DV Report is essential for meeting the five-year requirement, ensuring the accuracy of the student t-test value in the calculation process. This meticulous approach ensures the integrity of the data used in evaluating the requested system modifications.

Data Analysis and Evaluation

Ozone Trends

Ozone is measured at fourteen AMS in the Los Angeles–Long Beach–Anaheim MSA, and the Pomona AMS has not been the DV site for the MSA.

Pomona AMS	
Year	O_3 8-Hour DV (ppb)
2020	88
2021	90
2022	94
2023	90
2024	94
5 Yr. DV Avg.	91
40 CFR Part 58.14 (c)(1) metric	94
80% of 70ppb NAAQS	56
Test	FAIL

The 40 CFR Part 58.14 (c)(1) metric is 93.8 ppb, with 80% of the 70 ppb NAAQS threshold at 56.0 ppb. Perris' O_3 monitor fails this test.

Nitrogen Dioxide Trends

Nitrogen Dioxide is measured at seventeen stations in MSA and the NO_2 monitor at the Pomona AMS has not been the DV for the MSA.

Pomona AMS	
Year	NO2 1-Hour DV (ppb)
2020	59
2021	58
2022	55
2023	53
2024	54
5 Yr. DV Avg.	55
40 CFR Part 58.14 (c)(1) metric	58
80% of 100ppb NAAQS	80
Test	PASS

The 40 CFR Part 58.14 (c)(1) metric is 58.3 ppb, with 80% of the 100 ppb NAAQS threshold at 80 ppb. Pomona's NO_2 passes this test.

Pomona AMS	
Year	NO2 Annual DV (ppb)
2020	18.3
2021	17.9
2022	16.9
2023	16.5
2024	17.1
5 Yr. DV Avg.	17.3
40 CFR Part 58.14 (c)(1) metric	18.1
80% of 53ppb NAAQS	42.4
Test	PASS

The 40 CFR Part 58.14 (c)(1) metric is 18.1 ppb, with 80% of the 53 ppb NAAQS threshold at 42.4 ppb. Pomona's NO_2 passes this test.

Over the past five years, no exceedances of the NO_2 NAAQS have been recorded at the Pomona air monitoring station. The DVs for both the 1-hour and annual NO_2 standards remain below 80% of the applicable NAAQS, qualifying the site for discontinuation under the closure criteria outlined in 40 CFR Part 58.14(c)(1).

It is also noteworthy that the Pomona NO_2 monitor has consistently recorded lower concentrations than the DV site each year within the Los Angeles–Long Beach–Anaheim MSA.

System Modification Request Justification

South Coast AQMD requests U.S. EPA approval to discontinue both O_3 and NO_2 monitoring at the Pomona AMS. The justification for each pollutant is provided below, consistent with the requirements of 40 CFR Part 58.14.

Ozone Monitoring Discontinuation

Pomona's O_3 monitor does not qualify for discontinuation under 40 CFR 58.14(c)(1), as the DV does not pass the Student's t-test criteria and exceeds the 80% threshold of the O_3 NAAQS. However, South Coast AQMD requests approval to discontinue O_3 monitoring at this location under the general provisions of 40 CFR 58.14, which allow for case-by-case consideration if:

- The discontinuation does not compromise data collection needed for implementation of a NAAQS; and
- The requirements of Appendix D to Part 58 continue to be met.

Pomona is not the DV site for the relevant O_3 MSA, and South Coast AQMD continues to exceed the minimum monitoring requirements for O_3, as detailed in Table 1. In addition, the Pomona O_3 monitor is not specifically required by any attainment or maintenance plan. The area is designated as a maintenance area, and the most recent EPA-approved plan does not rely on contingency measures triggered by monitored concentrations. Importantly, Pomona is not the only SLAMS site within the maintenance area, and regional air quality trends remain well represented without it.

Nitrogen Dioxide Monitoring Discontinuation

South Coast AQMD requests to discontinue NO_2 monitoring at Pomona in accordance with 40 CFR 58.14(c)(1). Pomona's NO_2 data:

- Passes the Student's t-test,
- Has maintained concentrations well below 80% of the applicable 1-hour and annual NAAQS over the past five years, and

- Demonstrates a less than 10% probability of exceeding 80% of the NAAQS in the next three years, based on an evaluation of trends, levels, and variability.

From 2020 to 2024, Pomona did not serve as the DV site for NO_2, and no exceedances of the NO_2 NAAQS were observed. The monitor is not mandated by an attainment or maintenance plan, and South Coast AQMD continues to meet or exceed minimum monitoring requirements for NO_2, as shown in Table 2.

Summary

In accordance with 40 CFR Part 58.14, South Coast AQMD is formally submitting a SMR to discontinue O_3 and NO_2 monitoring at the Pomona AMS. The NO_2 monitor qualifies for removal under §58.14(c)(1), while the O_3 monitor does not meet the criteria under §58.14(c)(1) through (c)(5) due to historical exceedances. However, South Coast AQMD requests a waiver to discontinue the O_3 monitor on a case-by-case basis, as permitted under §58.14, given that the closure does not compromise data collection needed for NAAQS implementation and the network continues to meet the requirements of Appendix D.

The Pomona O_3 monitor presents persistent logistical challenges beyond the agency's control, and nearby sources limit the site's representativeness for regulatory comparison. During the most recent U.S. EPA TSA, in which the Pomona site was visited, EPA auditors recommended its closure based on siting constraints and limited value to the broader network. Additionally, Pomona has consistently recorded lower O_3 concentrations than DV sites in the surrounding region, and nearby the nearby Glendora AMS offer equivalent spatial and scale representation. South Coast AQMD continues to meet or exceed minimum monitoring requirements, and approval of this request will support the continued refinement and efficiency of the air monitoring network.

SYSTEM MODIFICATION REQUEST

Upland Monitoring Site
AQS Site Codes 06-071-1004

Background

The Upland Air Monitoring Station (AMS), located at 1350 San Bernardino Road, #62, Upland, CA 91786, has been operational since March 1973. The site was originally established to monitor ozone (O_3) carbon monoxide, (CO), nitrogen dioxide, NO2, and particulate matter (PM_{10}) to assess pollutant trends and O_3 formation in the region. Although CO was measured at the Upland site, a separate System Modification Request (SMR) is being submitted for CO.

Over time, the area surrounding the site has undergone significant changes, potentially compromising data representativeness. The site was originally established by CARB in a trailer park. The park managers, Upland Cascade, terminated the lease and the last sampling day was March 31, 2023. South Coast AQMD is searching for a replacement site to characterize O_3 along the foothills. Considering the sites history of O_3 measurements, relocating as close as possible is a priority. South Coast AQMD will work with U.S. EPA once a site has been identified to gain concurrence on the new location. South Coast AQMD requests retroactive approval through the established U.S. EPA System Modification Request (SMR) process to discontinue criteria pollutant monitoring at the Upland AMS. The location of the site is shown in Figure 1.

Figure 1 Upland Cascade Trailer Park

Site Performance and Regional Comparisons

In 2022, Redlands recorded the highest 8-hour O_3 Design Value (DV) concentration of 113 ppb in the Ontario-Riverside-San Bernardino Metropolitan Statistical Area (MSA) (31080 CBSA). By comparison Upland's 8-hour O_3 concentration for the same period was 103 ppb.

Additionally, in 2022, Ontario Near Road Route 60 reported the highest 1-hour NO_2 concentration in the Ontario-Riverside-San Bernardino MSA at 85 ppb and also recorded the highest Annual Arithmetic Mean (AAM) for NO_2 at

29 ppb. In contrast, Upland's maximum 1-hour NO_2 concentration was 53 ppb, with an AAM concentration of 15 ppb.

Also in 2022, Mecca recorded the maximum 24-hour PM_{10} concentration in the Ontario-Riverside-San Bernardino MSA at 380 µg/m³, while Upland's maximum 24-hour PM_{10} concentration was 77 µg/m³.

Notably, from 2018 and 2022, Upland did not serve as the DV site for either O_3 NO_2, or PM_{10} and no exceedances of the National Ambient Air Quality Standards (NAAQS) for NO_2 were observed at the Upland AMS. Additionally, South Coast AQMD continues to meet or exceed the minimum monitoring requirements for O_3, NO_2 and PM_{10}, as detailed in Tables 1 and 2.

Regulatory Compliance and Minimum Monitoring Requirements

Table 1 Minimum Monitoring Requirements for O_3

(Note: Refer to section 4.1 and Table D-2 of Appendix D of 40 CFR Part 58)

MSA/ CBSA	Counties	Population & Census Year	8-hr DV (ppb) & Years[1]	DV AMS (name & AQS ID)	Monitors Required	Monitors Active	Monitors Needed
31080	Los Angeles Orange	12,927,614 2024	101 2022-2024	Glendora 060370016	4	14	0

Population – 2024 is the most recent Census year available Metropolitan and Micropolitan Statistical Areas Totals: 2020-2024 (census.gov)
DV Years – The three years over which the DV was calculated (AMP 480).

Table 2 Minimum Monitoring Requirements for NO_2

(Note: Refer to section 4.3 of Appendix D of 40 CFR Part 58.)

MSA/CBSA	Population & Census Year	Max AADT Counts (2019) [1]	Required Near Road Monitors	Active Near Road Monitors	Additional Near Road Monitors Needed	Required Area Wide Monitors	Active Area Wide Monitors	Additional Area wide Monitors Needed
31080	12,927,614 2024	386,000 2021	2	2	0	1	13	0

[1]Max AADT Counts – 2021 latest data available from CA DOT; https://dot.ca.gov/programs/traffic-operations/census

Table 3 Minimum Monitoring Requirements for PM_{10}

(Note: Refer to section 4.3 of Appendix D of 40 CFR Part 58)

MSA/CBSA	Counties	Population & Census Year	Daily DV [ug/m3]	DV Site (Name, AQS ID)	Required Monitors	Active Monitors	Additional Monitors Needed
31080	Los Angeles Orange	12,927,614 2024	380 2022-2024	Mecca (Saul Martinez) 060658005	4-8 Med Conc.	7	0

Max AADT Counts – 2024 latest data available from CA DOT; https://dot.ca.gov/programs/traffic-operations/census

To support the system modification request, South Coast AQMD has presented a comprehensive data summary in accordance with the guidelines specified in 40 CFR Part 58.14 (c)(1). For years where no data is available in the provided links on the EPA's Air Trends webpage (https://www.epa.gov/air-trends/air-quality-design-values#report), South Coast AQMD has employed data sourced from the AQS AMP480 Design Value (DV) Report.

This report includes DV concentrations along with validity flag indicators (Y and N). The utilization of this data from the AQS AMP480 DV Report is essential for meeting the five-year requirement, ensuring the accuracy of the student t-test value in the calculation process. This meticulous approach ensures the integrity of the data used in evaluating the requested system modifications.

Data Analysis and Evaluation

Ozone Trends

Ozone is measured at eleven AMS in the Ontario-Riverside-San Bernardino MSA, and the Upland AMS has not been designated as the DV site for the MSA.

Upland AMS	
Year	O_3 8-Hour DV (ppb)
2018	109
2019	105
2020	106
2021	103
2022	103
5 Yr. DV Avg.	105
40 CFR Part 58.14 (c)(1) metric	108
80% of 70 ppb NAAQS	56
Test	FAIL

The 40 CFR Part 58.14 (c)(1) metric is 108 ppb, with 80% of the 70 ppb NAAQS threshold at 56.0 ppb. Upland' O_3 monitor fails this test.

Nitrogen Dioxide Trends

Nitrogen Dioxide is measured at seventeen stations in the Ontario-Riverside-San Bernardino MSA and the NO_2 monitor at the Upland AMS has not been the DV for the MSA. During the last five years of operation there were no exceedances of the NO_2 NAAQS. The 5-year DV metric for 1-hour and Annual standards pass the 80% of applicable NAAQS statistics and qualify for closure under the 40 CFR Part 58 (c)(1) conditions for closure.

Upland AMS	
Year	NO_2 1-Hour DV (ppb)
2018	51
2019	48
2020	47
2021	47
2022	47
5 Yr. DV Avg.	48
40 CFR Part 58.14 (c)(1) metric	50
80% of 100 ppb NAAQS	80
Test	PASS

Upland AMS	
Year	NO_2 Annual DV (ppb)
2018	15
2019	14
2020	14
2021	15
2022	15
5 Yr. DV Avg.	15
40 CFR Part 58.14 (c)(1) metric	15
80% of 53 ppb NAAQS	42
Test	PASS

Is also noteworthy that the Upland NO_2 monitor has consistently measured lower concentrations than the DV site each year in the Ontario-Riverside-San Bernardino MSA.

PM_{10} Trends

PM_{10} is measured at eight stations in the Ontario-Riverside-San Bernardino MSA, and the Upland AMS has not been designated as the DV site. Over the last five years there were exceedances of the PM_{10} NAAQS, however Upland was not the DV site for the MSA.

Upland AMS			
Year	PM_{10} 24-Hour Maximum µg/m³	DV Report Observed Exceedances	DV Report Estimated Exceedances
2018	156*	1	1.5
2019	125	0	0
2020	174*	1	1.1
2021	123	0	0
2022	144	0	0
5 Yr. Avg.	144		
40 CFR Part 58.14 (c)1 Metric	165		
80% of 150 ppb NAAQS	120		
Test	FAIL		

*Exceedance of PM_{10} Standard

PM_{10} FRM San Bernardino/Riverside County Maximum Concentration vs Upland

Year	Maximum 24 Hr. Concentration µg/m³	Upland Maximum 24 Hr. Concentration µg/m³
2018	421	156
2019	232	125
2020	680	174
2021	334	123
2022	432	144

The Upland AMS PM_{10} monitor does not pass the 40 CFR Part 58.14(c)(1) metric for PM_{10} which is 165 µg/m³, compared to the 80% NAAQS threshold of 120 µg/m³ (based on 80% of the 150 µg/m³ 24-hour standard). Additionally, Upland exceeded the PM_{10} standard in 2018 and 2020.

It is noteworthy that the Upland PM_{10} monitor has consistently measured lower concentrations than the DV site each year.

System Modification Request Justification

South Coast AQMD respectfully requests U.S. EPA approval to discontinue O_3, NO_2, and PM_{10} monitoring at the Upland AMS, based on the following justifications:

NO_2 Closure under 40 CFR Part 58.14(c)(1):

The Upland NO_2 monitor qualifies for discontinuation under 40 CFR Part 58.14(c)(1). Over the past five years (2018–2022), the monitor has consistently recorded concentrations well below 80% of both the 1-hour and annual NO_2 National Ambient Air Quality Standards (NAAQS) without any exceedances. Statistical trend analyses confirm that the monitor passes the required Student's t-test metrics, verifying stable attainment and supporting removal under regulatory provisions.

O_3 and PM_{10} Closure through Case-by-Case Consideration:

The Upland O_3 and PM_{10} monitors do not meet the statistical requirements for discontinuation under 40 CFR Part 58.14(c)(1), having failed the 5-year trend test metrics. However, South Coast AQMD respectfully requests discontinuation of these monitors under case-by-case consideration, as authorized by 40 CFR Part 58.14, based on the following circumstances:

- Upland AMS is not the Design Value (DV) site for either O_3 or PM_{10} within the Ontario–Riverside–San Bernardino MSA.
- The most recent EPA-approved maintenance plans do not depend on Upland AMS data for contingency measures or air quality plan implementation.
- Regional air quality will continue to be adequately represented by nearby monitors, including Mira Loma (6.82 miles away) and Rubidoux (9.92 miles away), ensuring network coverage is maintained in compliance with Appendix D of 40 CFR Part 58.
- Importantly, continued operation of the Upland AMS became infeasible due to circumstances beyond South Coast AQMD's control. In 2023, the property management company, Upland Cascade, terminated the site lease agreement, forcing cessation of all monitoring activities at the location effective March 31, 2023. Despite efforts to maintain the site and secure continued operation, the lease termination made continued monitoring impossible. South Coast AQMD is actively seeking a new monitoring site to maintain ozone coverage along the foothills.

Given these factors, South Coast AQMD respectfully requests U.S. EPA approval to discontinue:

- NO_2 monitoring under 40 CFR Part 58.14(c)(1); and
- O_3 and PM_{10} monitoring under case-by-case consideration as permitted by 40 CFR Part 58.14, based on site access loss and supporting network assessments.

Summary

South Coast AQMD respectfully requests U.S. EPA approval to discontinue O_3, NO_2, and PM_{10} monitoring at the Upland AMS.

The Upland NO_2 monitor qualifies for discontinuation under 40 CFR Part 58.14(c)(1), having demonstrated stable attainment of the 1-hour and annual NO_2 NAAQS over the past five years, with no recorded exceedances and successful completion of statistical trend analyses.

For the Upland O_3 and PM_{10} monitors, South Coast AQMD requests discontinuation under case-by-case consideration authorized by 40 CFR Part 58.14, as the monitors do not meet the statistical trend requirements of 58.14(c)(1). Key factors supporting case-by-case approval include:

- Neither O_3 nor PM_{10} monitors serve as DV sites for the MSA;
- The most recent maintenance plans do not rely on data from Upland AMS for contingency measures.
- Regional monitoring coverage remains robust, with nearby sites at Mira Loma and Rubidoux ensuring continued spatial representation.
- And critically, monitoring operations were forcibly discontinued due to the termination of the site lease by Upland Cascade, a circumstance beyond South Coast AQMD’s control.

Approval of this request will maintain compliance with federal monitoring regulations, ensure continued network integrity, and support ongoing efforts to realign monitoring resources to regional air quality priorities.

SYSTEM MODIFICATION REQUEST

Santa Clarita Monitoring Site
AQS Site Codes 06-037-6012

Background and Monitoring Objectives

In February 2023, the City of Santa Clarita proposed relocating the South Coast Air Quality Management District (South Coast AQMD) Santa Clarita (SCLR) Air Monitoring Station (AMS) due to planned roadway construction at the existing site. By August 2024, the city identified a suitable new location approximately 190 feet southwest of the current site at the Newhall-Valencia Mini-Storage facility.

Operational since May 2001, the Santa Clarita AMS is one of South Coast AQMD's longest-standing air monitoring sites in Los Angeles County. Initially established to monitor ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), and particulate matter (PM_{10}) to characterize regional air quality, the site expanded its measurements in October 2008 to include continuous fine particulate matter ($PM_{2.5}$).

The monitoring instruments are housed in a temperature-controlled shelter, with meteorological sensors mounted on a 10-meter light radio tower attached to the shelter. All equipment is installed in accordance with U.S. EPA guidelines and will be relocated as depicted in Figure 1.

Figure 1: Map view of existing site area and major cross streets. Existing AMS is outlined in red and proposed new site is outlined in yellow. The blue dot represents the proposed air sensor deployment location, with the two sites being 190 feet apart.

Site Relocation Assessment and Ozone Comparison Study

In consultation with U.S. EPA Region 9, South Coast AQMD evaluated the suitability of the proposed relocation site for the Santa Clarita air monitoring station. A two-month study was conducted from October 16 to December 18, 2024, using Aeroqual AQY-R sensors to measure ozone O_3, $PM_{2.5}$, and meteorological parameters at both the current and proposed sites, approximately 200 feet apart.

Ozone

Analysis of both 1-hour and maximum daily 8-hour rolling average O_3 concentrations showed strong agreement between the current and proposed sites. Most lines of analysis indicate that differences are minimal and likely within ± 5%. Specifically:

- The maximum daily 8-hour rolling average O_3 concentrations at the new site were approximately 2% higher than at the current site, with similar distributions across quartiles and means.
- A Welch two-sample t-test found no statistically significant difference in maximum daily 8-hour O_3 values (p-value = 0.7952), further supporting the comparability between sites.
- Time series, scatterplots, and violin plots also showed high correlation and similar concentration patterns.

These results suggest that the proposed relocation is unlikely to impact the integrity of O_3 monitoring data, including peak values relevant to NAAQS assessments.

$PM_{2.5}$

While both sensors showed close tracking, $PM_{2.5}$ concentrations at the new site were slightly elevated, likely due to its closer proximity to a roadway and railroad tracks. Notable findings include:

- The mean $PM_{2.5}$ concentration at the proposed site was about 5% higher than at the current site.
- A Welch two-sample t-test indicated this difference was statistically significant; however, the absolute difference was modest (0.2 to 0.8 $\mu g/m^3$).
- Median and 25th percentile values were elevated by 5.8% and 7.9%, respectively.

Though statistically significant, these differences remain relatively small and are within an expected range given the new site's location characteristic.

This analysis supports the conclusion that the proposed relocation site provides comparable air quality data, particularly for O_3, the pollutant for which the site carries a design value. The relocation is necessary due to infrastructure changes at the current site and is being fully funded by the City of Santa Clarita. Full documentation is provided in Attachment A of the System Modification Request (SMR).

Proposed Relocation Site Details

The proposed relocation site consists of a 50' x 20' asphalt area, reinforced with concrete piers to support the monitoring shelter. The site is securely fenced and designed to accommodate:

- A criteria pollutant shelter
- Particulate monitoring

A 200-amp electrical service meter will supply power to a 30' monitoring platform, with infrastructure provisions for additional monitors.

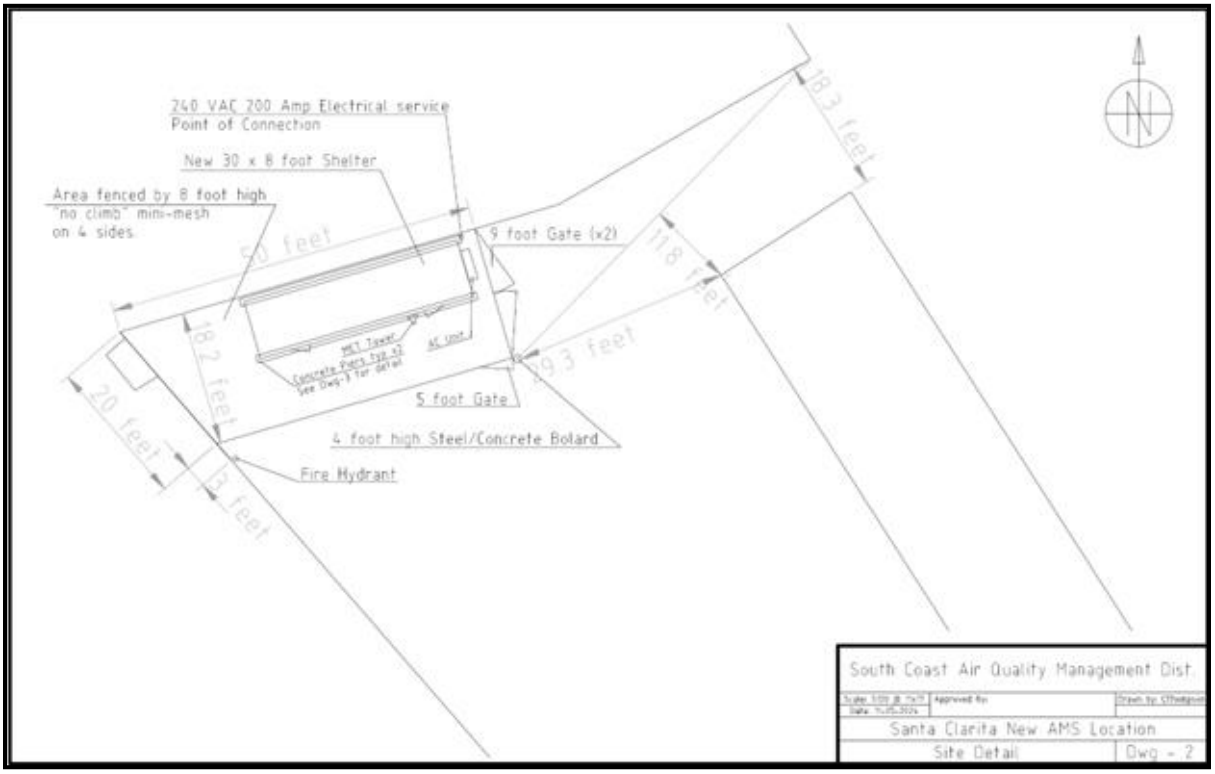


Figure 2 Santa Clarita Relocated Site Detail

Regulatory Compliance and Siting Criteria

The proposed Santa Clarita AMS proposed relocation aligns with 40 CFR Part 58, Appendix E siting requirements, as outlined in Table 1.

Table 1 Santa Clarita Selected Site Information

Pollutants – O_3, NO_2, PM_{10}, $PM_{2.5}$	Scale of Representativeness	Distance	Meets minimum requirement (yes/no)
Distance from Sources	Neighborhood	50 meters	Yes
Distance from Roadway	Neighborhood	70 meters (36,000 AADT max capacity)	Yes
Distance from obstructions (building)	Neighborhood	10 meters (meets 2x height requirement)	Yes
Spacing from Trees	Neighborhood	17 meters	Yes

Request for Relocation

South Coast AQMD requests U.S. EPA Region 9 concurrence to proceed with relocating the Santa Clarita AMS and initiating monitoring operations at the new site by January 1, 2026. The relocated site will continue to measure O_3, NO_2, PM_{10}, and $PM_{2.5}$, maintaining the same monitoring objectives and ensuring data continuity.

Summary of System Modification Request

Due to circumstances beyond South Coast AQMD's control, the Santa Clarita AMS must be relocated. Accordingly, we formally request approval to relocate monitoring activities for O_3, NO_2, PM_{10}, and $PM_{2.5}$ under 40 CFR Part 58.14(c) to the new Newhall-Valencia Mini-Storage site.

The new location, situated 190 feet from the existing AMS, fully complies with 40 CFR Part 58, Appendix E siting criteria and maintains a comparable scale of representativeness. Air quality measurements at the new site will remain consistent with those from the previous location, ensuring continued compliance with federal air monitoring standards.

ATTACHMENT A

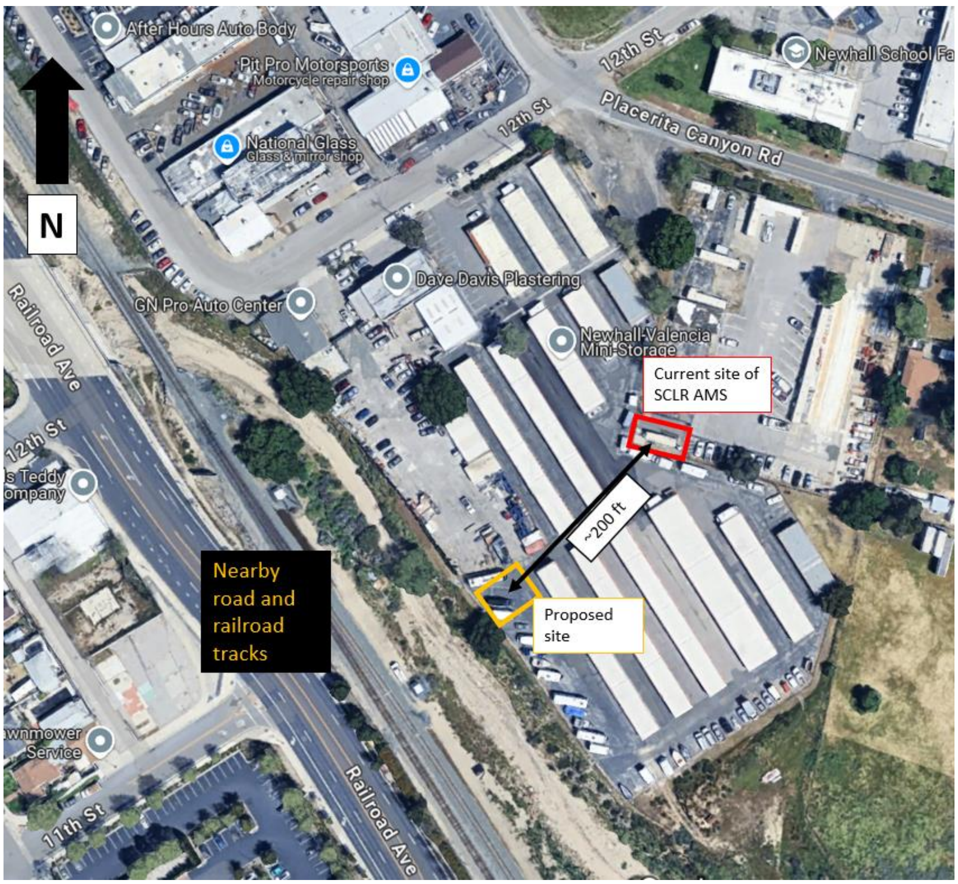
Santa Clarita Air Monitoring Station Relocation Study

Final Report on Air Pollutant Concentration Differences Between Current and Proposed New Site

Updated 12/24/2024 by the Air Quality Sensor Performance Evaluation Center (AQ-SPEC) at South Coast AQMD

Background

The existing South Coast AQMD Santa Clarita (SCLR) air monitoring station (AMS) will need to be relocated due to the future construction of a road through the current site. The new proposed site is about 200 feet southwest of the current site and closer to a roadway and railroad tracks (see figure below). This report discusses preliminary findings in air pollutant concentration differences between the current and proposed sites using air quality sensors during a limited investigation period.



Methods

Reference Data

The pollutants of interest in this study are ozone (O_3) and mass of particles smaller than 2.5 micrometers in diameter ($PM_{2.5}$). The reference-grade air monitoring equipment at SCLR AMS includes a Teledyne T400 O_3 monitor providing

1-minute time resolution data and a Met One Beta Attenuation Monitor (BAM) 1020 $PM_{2.5}$ monitor providing 1-hour time resolution data.[1]

Sensor Data

Air quality sensors (hereafter referred to as "sensors") can potentially provide high-quality air monitoring data, typically at lower cost. In addition, sensors are usually compact, lightweight, feature low power consumption, and are therefore more readily deployable than regulatory-grade air monitors. The AQ-SPEC program has evaluated many sensors[2] and has the competency to carry out an air monitoring project with sensors to obtain credible data. Aeroqual AQY-R sensors were employed in this study, as they measure $PM_{2.5}$, PM_{10}, O_3, and nitrogen dioxide (NO_2), as well as meteorological data such as temperature (T), relative humidity (RH), and dewpoint (DP) at 1-minute time resolution. These sensors measure particle mass concentration using optical scattering techniques.

Sensor Calibration

An essential component of obtaining high quality data from sensors is the co-location of sensors with trusted reference monitors to obtain a set of training data with which to correct the sensor data. Ideally, the co-location period would be long enough to capture a wide range of environmental conditions that would be observed when sensors are deployed to a new location.

The investigation period allowed for at least a 1-month co-location period of the sensors on the current SCLR AMS rooftop. Afterwards, one of the sensors was relocated to the new proposed site to collect measurements for 2 months (10/16/2024 to 12/18/2024), while another sensor was retained on the current SCLR AMS rooftop. The sensor unit IDs are as follows:

- **AQYR266** remained on the current SCLR AMS rooftop for both the co-location period and the subsequent 2-month deployment period
- **AQYR270** monitored from the current SCLR AMS rooftop for just the co-location period and was then deployed at the new proposed site for the subsequent 2-month period

Data treatment measures of note:

- SCLR reference measurements: removal of negative values, and removal of records flagged with internal South Coast AQMD quality control or operator codes.
- Sensor measurements: negative values from the co-location period were retained because they are useful for developing the sensor calibration models (i.e., removing negative sensor values from the sensor co-location data could have removed diurnal minima that would have been otherwise considered valid if a simple offset were applied to the entire sensor data set – this is usually more evident in gas-phase sensor data). However, the post-colocation analysis is performed with negative sensor data removed.

For the co-location period, SCLR AMS reference monitor data was paired with sensor data to develop a multiple linear regression model (i.e., all possible explanatory factors were incorporated into the model without consideration of p-value significance to reduce to a parsimonious model) to calibrate the sensor. Calibration models were developed for each sensor and for each pollutant measured (see Appendix). After the co-location period, all sensor data from that point forward was corrected with the respective calibration model. Note that since the reference $PM_{2.5}$ monitor reports only at hourly frequency, the 1-minute sensor $PM_{2.5}$ data was resampled to hourly frequency (with a 75% data completeness threshold necessary for hourly resampling) in this study.

[1] http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-monitoring-network-plan/aaqmnp-santaclarita.pdf?sfvrsn=16

[2] http://www.aqmd.gov/aq-spec/evaluations/criteria-pollutants

From the 2-month deployment period, the sensor data from AQYR270 (the sensor that was moved to the new proposed site; the sensor on the left pole mount in the photo below) was compared against both the SCLR AMS reference monitor data and AQYR266 (the sensor that remained at the current SCLR AMS).

Results

Visual Comparisons

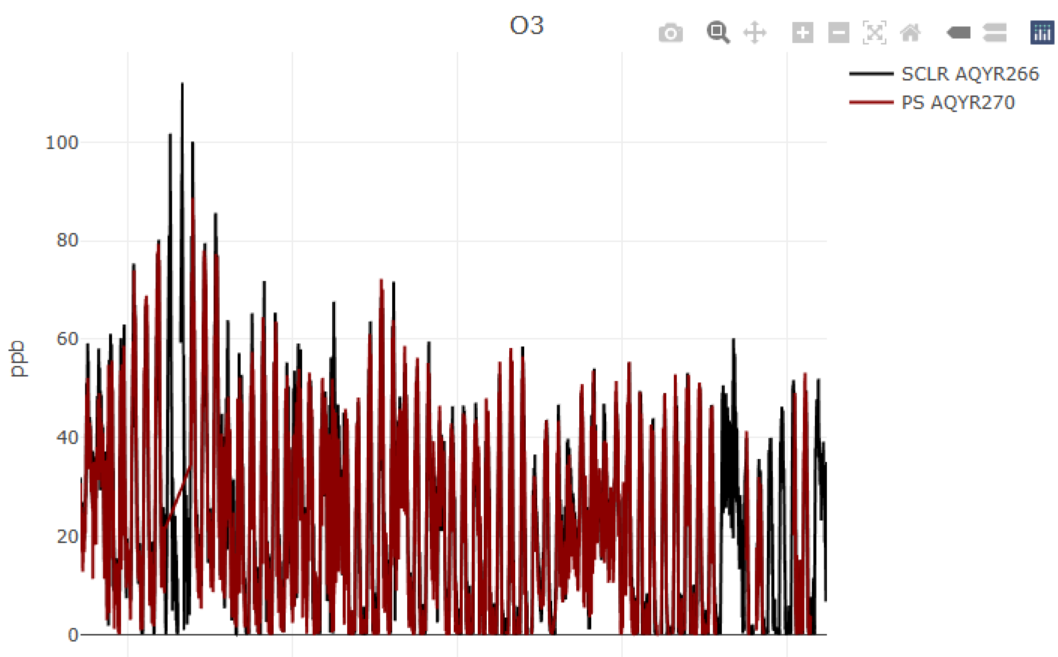
Three visuals are shown to compare the readings from sensor AQYR270 deployed at the new proposed site (PS) to the reference monitor at SCLR AMS and the sensor AQYR266 that remained at SCLR AMS:

- Timeseries show pollutant readings as a function of time during the 2-month deployment period. This visual allows for the discernment of whether the pollutant levels at the PS and the current SCLR AMS follow the same diurnal trends. This visual also allows for estimation of the difference in signal amplitudes.
- Correlograms are a multi-layered correlation visual, and in this report they show scatterplots, distributions, and correlation coefficients between the reference monitor and the sensors. This visual allows for discernment of the strength of the linear relationship between the pollutant concentrations reported by the various instruments.
- Violin plots provide more insight into the pollutant concentration distributions reported by the various instruments during the 2-week deployment period. This visual contains a traditional box and whisker plot that shows measures of central tendency (mean, median), quartiles, outliers – but it also contains an overlaid probability distribution curve of the underlying population distribution of the measurements.

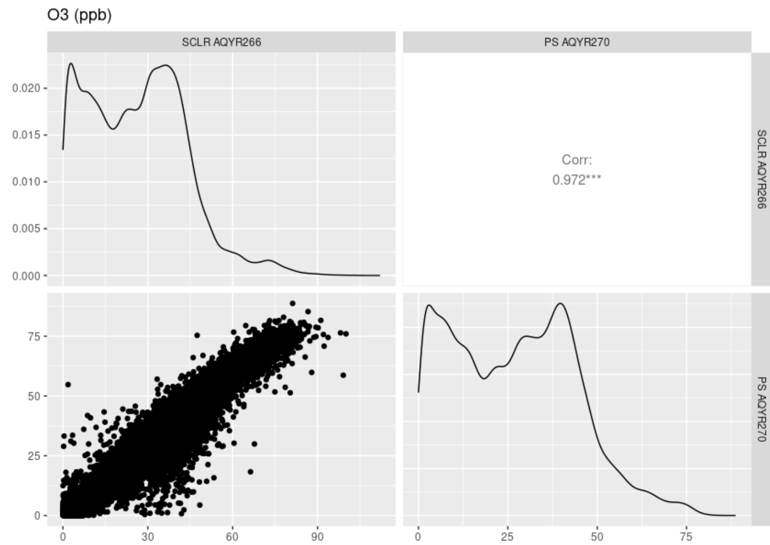
The visuals provided in this section alone are not sufficient to determine if there is a statistically significant difference in air pollutant concentrations obtained at the current SCLR AMS site and the new proposed site – however these visuals are provided to aid a general audience with understanding the magnitude of differences. Other metrics are explored after the visual analysis section.

Visual Analysis: O_3

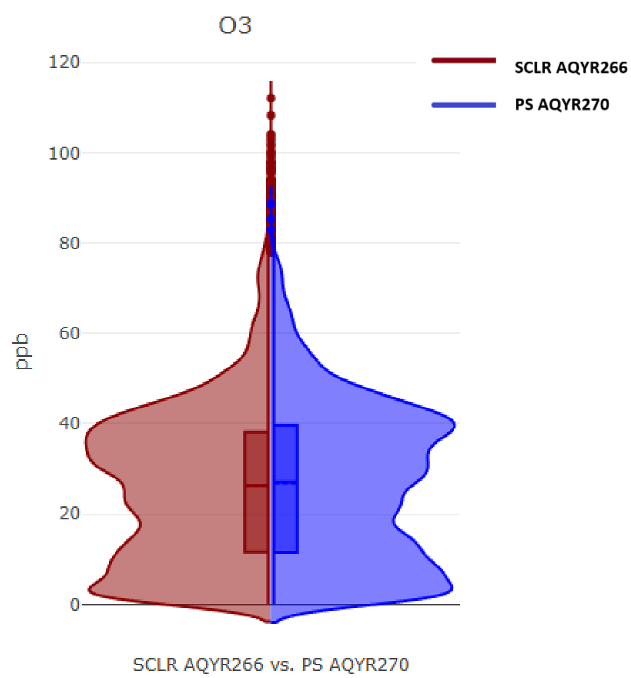
The O_3 timeseries indicates that both sensors tracked each other closely.



The correlogram shows a high degree of correlation between the two sensors' O_3 readings. The plots along the diagonal show the distribution of O_3 measurements from each sensor.

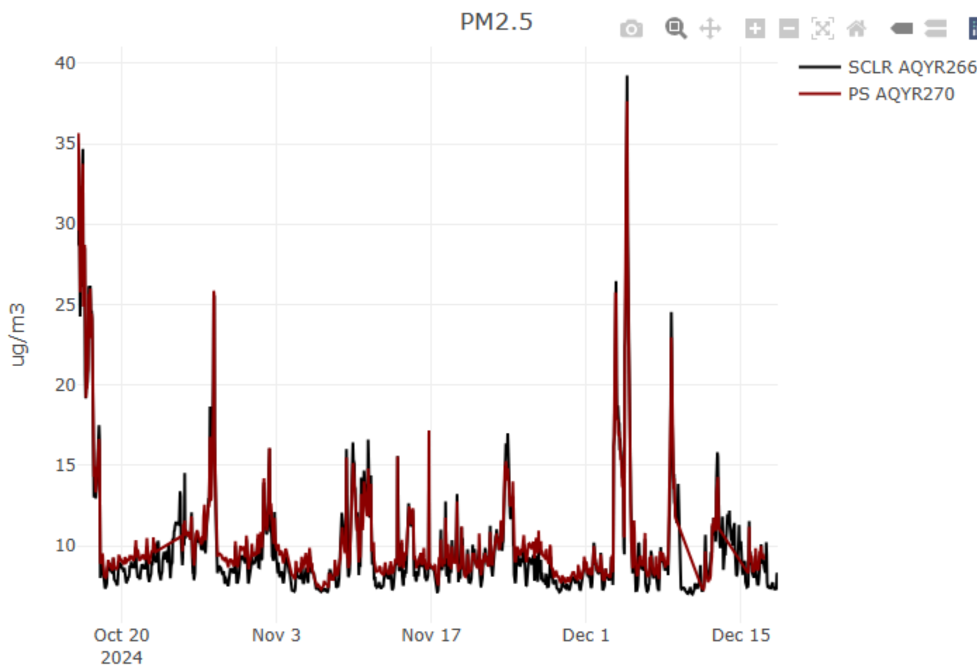


The violin plot shows that the distribution of O_3 measurements between both sensors were very similar to each other, but there may be slightly higher O_3 concentrations at the new proposed site compared to the current SCLR AMS site.

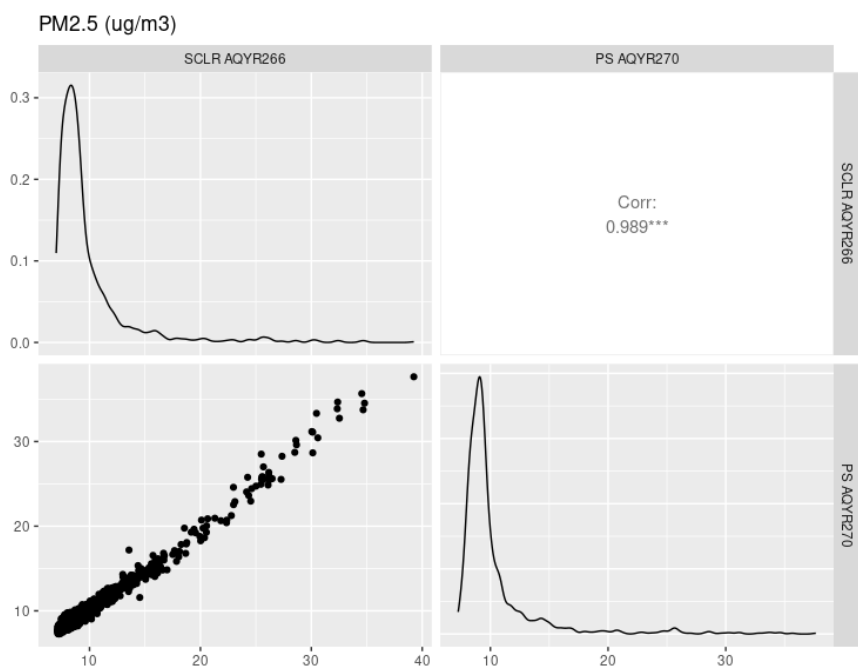


Visual Analysis: $PM_{2.5}$

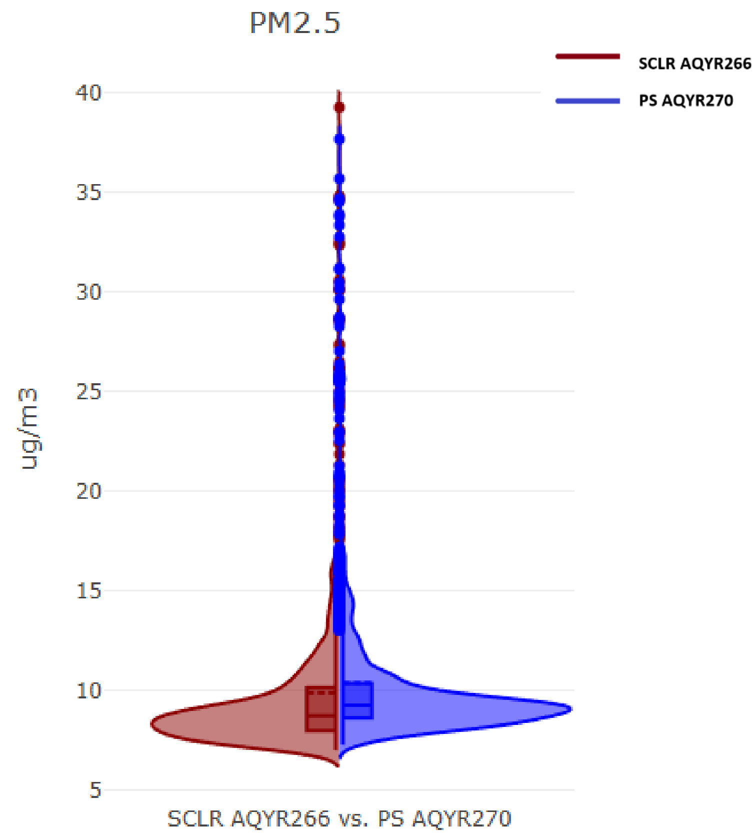
The $PM_{2.5}$ timeseries indicates that both sensors tracked each other closely, though the PM2.5 concentrations from the AQYR270 sensor at the new proposed site tended to be slightly higher than those from the AQYR266 sensor remaining at the current SCLR site.



The correlogram shows a high degree of correlation between the sensors' $PM_{2.5}$ readings. The plots along the diagonal show the distribution of $PM_{2.5}$ measurements from each sensor.



The violin plot shows that the distribution of $PM_{2.5}$ measurements appears to be similar between the two sensors, however the readings from the AQYR270 sensor at the new proposed site were shifted slightly to higher concentrations, especially at the lower concentrations of the distribution. The distributions suggest there may be higher $PM_{2.5}$ concentrations at the new proposed site compared to the current SCLR AMS site.


PM2.5
SCLR AQYR266
PS AQYR270
ug/m3
40
35
30
25
20
15
10
5
SCLR AQYR266 vs. PS AQYR270

Statistical Analysis: O_3

The AQYR270 sensor deployed at the new proposed site did not show more than a ±5% difference in mean, median, or quartile values for O_3 when compared to the AQYR266 sensor retained at the SCLR AMS. While the maximum values between the two sensors differed by about 21%, it should be noted that potential outliers can cause misleading impressions of differences between the two sites. The table below suggests there may not be any meaningful impact on O_3 measurements at the new proposed site when looking at measures of central tendency (quartiles and means).

O_3			
	SCLR AQYR266 (ppb)	**PS AQYR270 (ppb)**	**(% difference)**
Min	0.0	0.0	
Q1	11.6	11.5	-0.8%
Median	26.3	27.1	3.1%
Mean	26.3	26.8	1.8%
Q3	38.2	39.7	4.1%
Max	112.1	88.7	-20.9%

A Welch two-sample t-test was also performed on the data. Note that a Welch t-test is used instead of a Student's t-test because we do not assume that the data from the sensors have the same variance.

Below is the output of a Welch t-test between the x = SCLR AQYR266 and y = PS AQYR270:

```
t = -5.1751, df = 132545, p-value = 2.282e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.6647376 -0.2995341
sample estimates:
mean of x mean of y
 26.31159  26.79373
```

The t-test result between the AQYR270 sensor at the new proposed site had a p-value below 0.05 when tested against the sensor at the current SCLR AMS, indicating that there is a *statistically* significant difference between the mean O_3 values measured at the current SCLR AMS reference and the proposed new site sensor during this limited investigation. However, this O_3 difference is likely less than 0.66 ppb, which is less than 2.5% of the average O_3 concentration measured at either site.

Statistical Analysis: $PM_{2.5}$

The AQYR270 sensor deployed at the new proposed site did not show more than a ±5% difference in the minimum, mean, 75th percentile, or maximum values for $PM_{2.5}$ when compared to the AQYR266 sensor retained at the SCLR AMS. However, AQYR270 readings had an 7.9% greater 25th percentile concentration and a 5.8% greater median concentration compared to AQYR266. The table below suggests there may be $PM_{2.5}$ concentrations at the new proposed site greater than ~5% compared to the current SCLR AMS site, however the *mean* $PM_{2.5}$ concentration difference does not exceed 5%.

$PM_{2.5}$			
	SCLR AQYR266 (µg/m³)	**PS AQYR270 (µg/m³)**	**(% difference)**
Min	7.0	7.3	3.8%
Q1	8.0	8.6	7.9%
Median	8.7	9.2	5.8%
Mean	9.9	10.4	5.0%
Q3	10.1	10.3	2.0%
Max	39.2	37.7	-4.1%

Below is the output of a Welch t-test between the x = SCLR AQYR266 and y = PS AQYR270:

```
t = -3.4521, df = 2765.9, p-value = 0.0005645
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.7751660 -0.2135656
sample estimates:
mean of x mean of y
 9.874146 10.368511
```

The t-test result between the two sensors had a p-value <0.05 and so the difference between the two sensors' mean $PM_{2.5}$ readings was *statistically* significantly different. This indicates that the proposed site likely experiences higher $PM_{2.5}$ mean concentration values, and this increase is likely in the range of 0.2 to 0.8 µg/m³.

Conclusions

- For O_3: most lines of analysis suggest that there is little difference, and likely not in exceedance of ±5% difference, in concentrations measured at the current SCLR AMS site and the new proposed site.
- For $PM_{2.5}$: some lines of analysis suggest that there may be a nontrivial difference in $PM_{2.5}$ concentrations at the new proposed site compared to the current SCLR AMS site. Possible contributing factors may be the new proposed site's closer proximity to a roadway and railway tracks. While the mean concentration difference at the two locations was found to be statistically significant, this difference did not exceed 5% during this study.

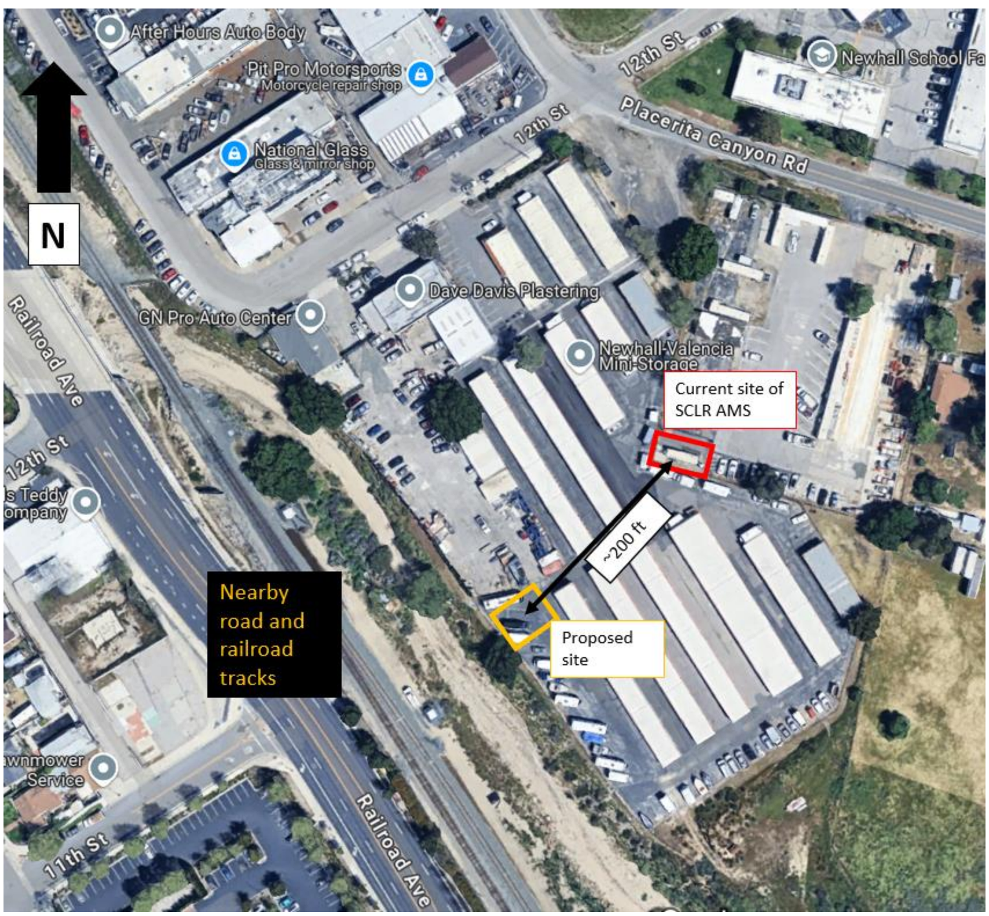
Santa Clarita Air Monitoring Station Relocation Study (Addendum)

This 4/2/2025 Addendum is for the 12/24/2024 Final Report on Air Pollutant Concentration Differences Between Current and Proposed New Site *by the Air Quality Sensor Performance Evaluation Center (AQ-SPEC) at South Coast AQMD*

Background

The existing South Coast AQMD Santa Clarita (SCLR) air monitoring station (AMS) will need to be relocated due to the future construction of a road through the current site. The new proposed site is about 200 feet southwest of the current site and closer to a roadway and railroad tracks (see figure below). This addendum discusses the maximum daily 8-hour rolling average ozone (O_3) concentrations observed between Aeroqual AQY-R sensors that were deployed in a 2-month study (10/16/2024 to 12/18/2024), as follows:

- **AQYR266** was deployed on the current SCLR AMS rooftop
- **AQYR270** was deployed at the new proposed site (PS)



Methods

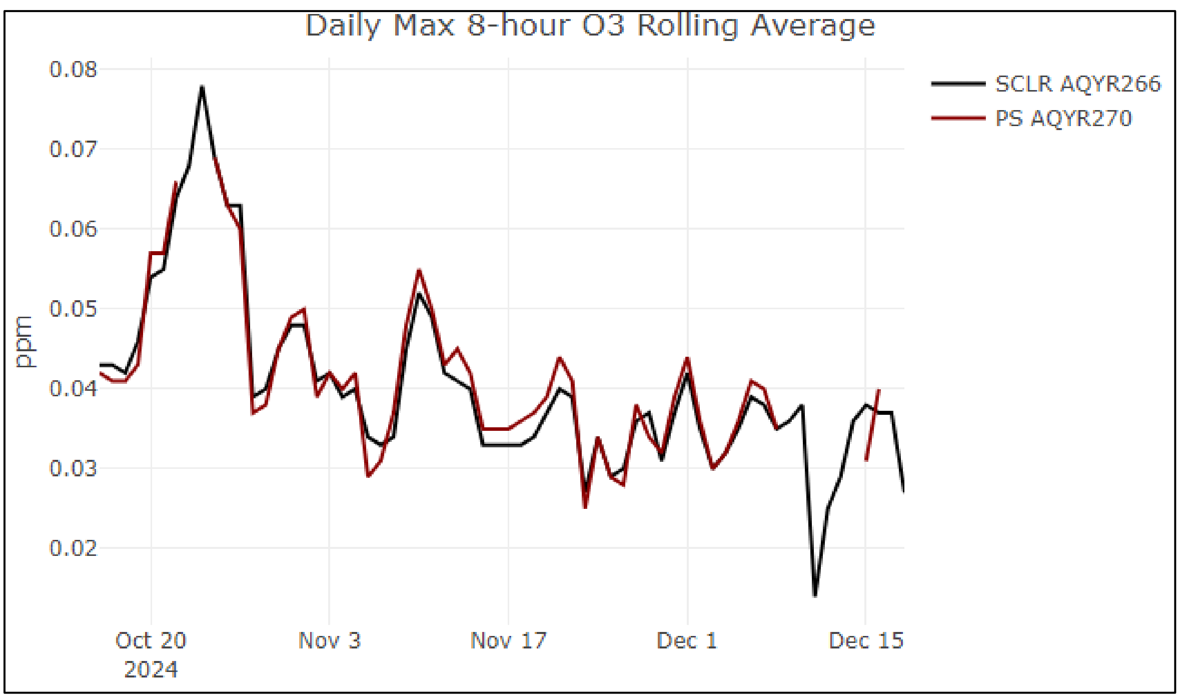
For this addendum, the 1-minute sensor data was resampled to hourly averages with consideration of a 75% data validity threshold and then truncated to 3 decimal places, expressed in ppm. Then for each hour, a rolling 8-hour average was calculated using that and the following 7 hours' averages, with consideration of a 75% data validity threshold, and again truncated to 3 decimal places. This method is in accordance with 40CFR50 Appendix I:

> 2. ***Primary and Secondary Ambient Air Quality Standards for Ozone.***
>
> 2.1 ***Data Reporting and Handling Conventions.***
>
> 2.1.1 ***Computing 8-hour averages.*** Hourly average concentrations shall be reported in parts per million (ppm) to the third decimal place, with additional digits to the right being truncated. Running 8-hour averages shall be computed from the hourly ozone concentration data for each hour of the year and the result shall be stored in the first, or start, hour of the 8-hour period. An 8-hour average shall be considered valid if at least 75% of the hourly averages for the 8-hour period are available. In the event that only 6 (or 7) hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using 6 (or 7) as the divisor. (8-hour periods with three or more missing hours shall not be ignored if, after substituting one-half the minimum detectable limit for the missing hourly concentrations, the 8-hour average concentration is greater than the level of the standard.) The computed 8-hour average ozone concentrations shall be reported to three decimal places (the insignificant digits to the right of the third decimal place are truncated, consistent with the data handling procedures for the reported data.)

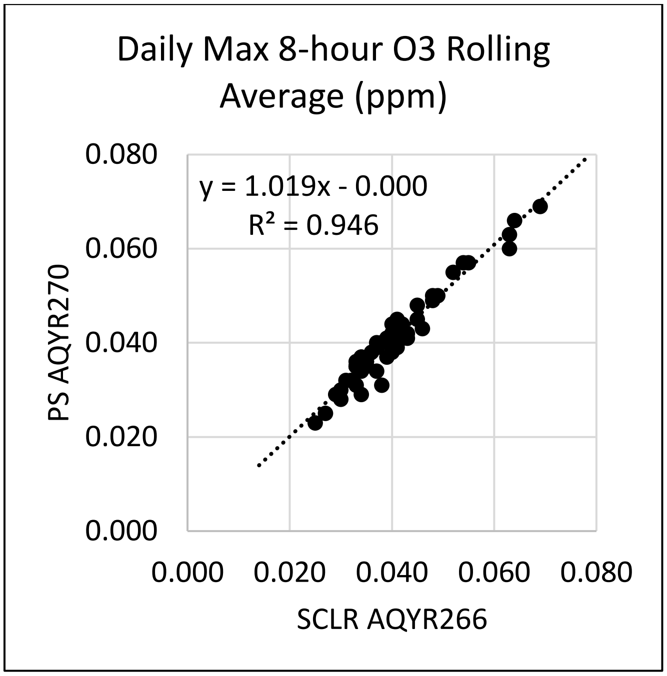
Results

All results are of the maximum daily 8-hour rolling average O_3 concentrations.

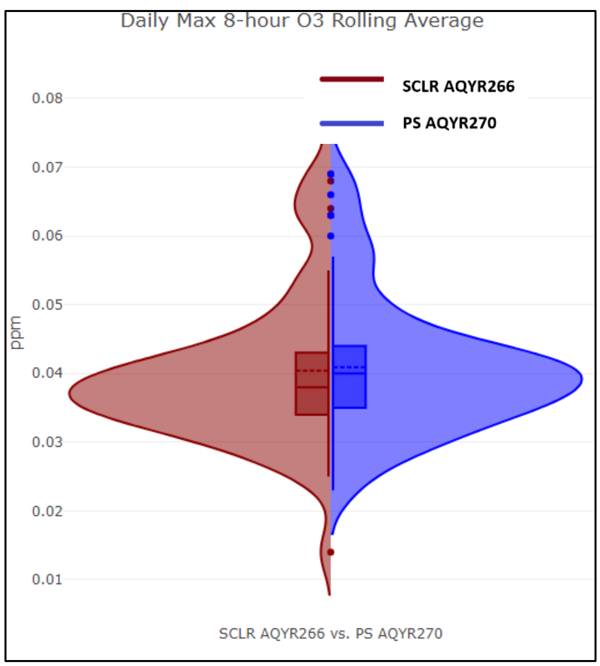
The O_3 timeseries indicates that both sensors tracked each other closely.



The scatterplot shows a high degree of correlation between the two sensors' maximum daily 8-hour rolling average O_3 readings. In addition, the regression equation shows a slope near unity and an intercept of zero. The slope indicates that in general the maximum daily 8-hour rolling average O_3 readings at the new proposed site are about 2% higher than those at the existing site.



The violin plot shows that the distribution of maximum daily 8-hour rolling average O_3 concentrations between both sensors were very similar to each other, but there may be slightly higher maximum daily 8-hour rolling average O_3 concentrations at the new proposed site compared to the current SCLR AMS site.



The AQYR270 sensor deployed at the new proposed site did not show more than a ±5% difference in 1st quartile, mean, or 3rd quartile values for the maximum daily 8-hour rolling average O_3 concentrations when compared to the AQYR266 sensor retained at the SCLR AMS; the median value at the new proposed site was higher than the existing site by 5.3%. While the max-maximum between the two sensors differed by about 11.5%, it should be noted that potential outliers or the short study period can cause misleading impressions of differences between the two sites. The table below suggests there may not be any meaningful impact on maximum daily 8-hour rolling average O_3 concentrations at the new proposed site when looking at measures of central tendency (quartiles and means).

Daily Max 8-hour O_3 Rolling Average			
	SCLR AQYR266 (ppm)	PS AQYR270 (ppm)	(% difference)
Min	0.014	0.023	
Q1	0.034	0.035	2.9%
Median	0.038	0.040	5.3%
Mean	0.040	0.040	0.0%
Q3	0.043	0.044	2.3%
Max	0.078	0.069	-11.5%

A Welch two-sample t-test was also performed on the maximum daily 8-hour rolling average O_3 concentrations. Note that a Welch t-test is used instead of a Student's t-test because we do not assume that the data from the sensors have the same variance.

Below is the output of a Welch t-test between the x = SCLR AQYR266 and y = PS AQYR270:

```
t = -0.2601, df = 116.97, p-value = 0.7952
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.004331536  0.003325855
sample estimates:
 mean of x  mean of y
0.04040625 0.04090909
```

The t-test result between the sensors had a p-value well above 0.05, indicating that there is no *statistically* significant difference between the maximum daily 8-hour rolling average O_3 concentrations O_3 values measured at the current SCLR AMS reference and the proposed new site sensor during this limited investigation.

Conclusion

- For O_3: most lines of analysis suggest that there is little difference, and likely not in exceedance of ±5% difference, in maximum daily 8-hour rolling average O_3 concentrations measured at the current SCLR AMS site and the new proposed site. There was no statistically significant difference demonstrated.

WAIVER REQUEST

Central San Bernardino Mountains Air Monitoring Station
AQS Site Code 06-071-0005

Background

The Central San Bernardino Mountains air monitoring station (AMS) has been operational since October 1973. This site is located adjacent to Lake Gregory in the City of Crestline within San Bernardino County Regional Parks property. The surrounding area is mixed-use residential and recreational and is characterized by heavy tree coverage. Despite the proximity of trees to the monitoring equipment, the site remains a critical ozone (O_3) $PM_{2.5}$ (non-FEM) and PM_{10} monitoring location with a long history as the O_3 Design Value (DV) site for the region.

The South Coast Air Quality Management District (South Coast AQMD) requests a waiver from the 10-meter minimum distance requirement from trees as stipulated in 40 CFR Part 58, Appendix E. The attached sensor study (Attachment 1) demonstrates that despite tree proximity, O_3 measurements at the Central San Bernardino Mountains AMS remain representative of regional air quality trends. Additionally, the site continues to support continuous $PM_{2.5}$, PM_{10}, and meteorological monitoring, which are essential for air quality assessments.

Figure 3 Central San Bernardino Mountains AMS Satellite View.

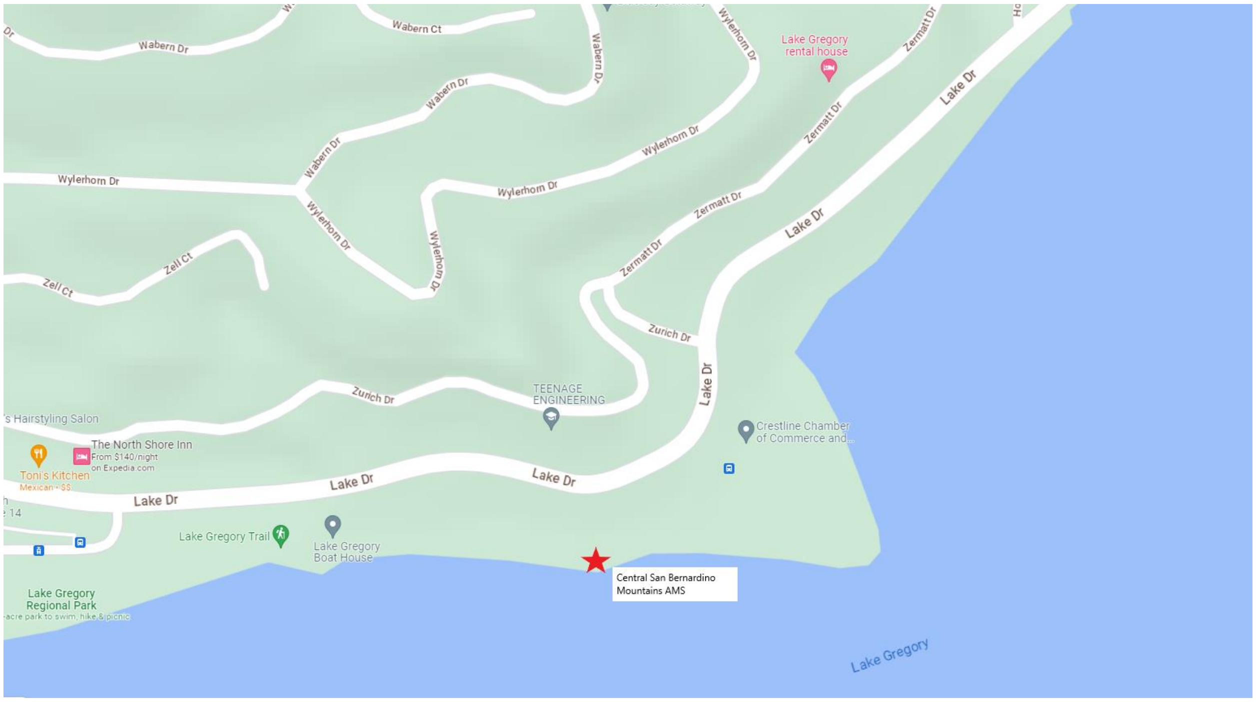


Figure 4 Central San Bernardino Mountains AMS Street Map.

Figure 3 Area surrounding the monitoring site.

Justification for Waiver Request

Regulatory Basis for Waiver

According to 40 CFR Part 58, Appendix E, a waiver may be granted for existing sites if either of the following conditions is met:

1. The site is as representative of the monitoring area as it would be if the siting criteria were met (Section 4.1.1).
2. The probe cannot reasonably be relocated to meet siting criteria due to physical constraints (Section 4.1.2).

This waiver request satisfies both conditions:

- Representativeness: The attached sensor study (Attachment 1) confirms that O_3 concentrations at Central San Bernardino Mountains AMS remain consistent with regional trends and are not significantly affected by tree proximity.
- Physical Constraints: The inability to relocate the monitoring site to a location where trees are not within 10 meters and/or present an obstruction is due to the surrounding dense forest area, as well as the proximity of roadways and other obstructions that further compromise siting criteria. Additionally, the site is located on San Bernardino County land, where it has operated under a no-cost lease since 1973. The expected cost to relocate the site is prohibitive and would disrupt historical data continuity that is invaluable for long-term trend analysis.

Central San Bernardino Mountains AMS Data Evaluation

Ozone Trends and Design Value Status

The Central San Bernardino AMS has served as the DV site, or the second highest site for O_3, providing critical data for NAAQS compliance

Central San Bernardino Mountains AMS	
Year	O_3 8-Hour DV (ppb)
2020	109
2021	110
2022	109
2023	106
2024	107
5 Yr. DV Avg.	108

Supporting Technical Findings

Sensor Study and Airflow Analysis

A sensor study (Attachment 1) conducted at Crestline AMS confirms that O_3 readings remain accurate and representative despite the tree proximity. The study includes:

- Comparative O_3 concentration analysis from alternative probe locations.
- Airflow modeling results demonstrating that trees do not significantly obstruct air circulation.
- Correlation studies between the Central San Bernardino Mountains AMS and other monitoring sites, validating its continued importance.
- Findings showing that O_3 values measured at Central San Bernardino AMS are similar to other regional sites.

Summary of Study Findings

The sensor study evaluated O_3 concentrations at the Central San Bernardino Mountains AMS in comparison to other monitoring locations to determine whether tree proximity significantly impacts data quality. The findings indicate:

- Ozone measurements at Central San Bernardino Mountains AMS closely align with regional O_3 trends, demonstrating that tree proximity does not introduce systematic bias.
- Airflow modeling shows adequate atmospheric mixing, confirming that O_3 samples are representative of ambient conditions.
- Alternative monitoring locations in the area would face similar siting challenges due to dense forestation, making relocation impractical.
- Maintaining the existing monitoring site preserves historical data continuity, which is essential for long-term air quality trend analysis and regulatory compliance.

Conclusion and Waiver Request

Key Findings Supporting the Waiver

1. Central San Bernardino Mountains AMS remains representative of the monitoring area, meeting 40 CFR Part 58, Appendix E, Section 4.1.1.
2. Physical constraints prevent probe relocation, as the site is in a dense forested area, and there are no feasible alternative locations that meet siting criteria.
3. Central San Bernardino Mountains AMS has been the region's DV site for O_3, making its continued operation critical for regulatory and scientific purposes.
4. The cost-benefit analysis supports maintaining the site at its current location, given that it operates on a no-cost lease from San Bernardino County and relocation would be cost-prohibitive.
5. The attached sensor study (Attachment 1) confirms that O_3 data quality is not compromised by tree proximities, and that measured O_3 values remain consistent with other monitoring locations in the region.

Request for Waiver

South Coast AQMD formally requests a waiver from the 10-meter tree distance and obstruction requirements for the Central San Bernardino Mountains AMS, allowing continued monitoring of O_3.

Per 40 CFR Part 58, Appendix E, Section 4.3, this waiver will be subject to renewal every five years and documented in the Annual Monitoring Network Plan as required under 40 CFR Part 58.10.

Attachment 1

sensors

MDPI

Article

Development of a Network of Accurate Ozone Sensing Nodes for Parallel Monitoring in a Site Relocation Study

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Abstract: Recent technological advances in both air sensing technology and Internet of Things (IoT) connectivity have enabled the development and deployment of remote monitoring networks of air quality sensors. The compact size and low power requirements of both sensors and IoT data loggers allow for the development of remote sensing nodes with power and connectivity versatility. With these technological advancements, sensor networks can be developed and deployed for various ambient air monitoring applications. This paper describes the development and deployment of a monitoring network of accurate ozone (O_3) sensor nodes to provide parallel monitoring in an air monitoring site relocation study. The reference O_3 analyzer at the station along with a network of three O_3 sensing nodes was used to evaluate the spatial and temporal variability of O_3 across four Southern California communities in the San Bernardino Mountains which are currently represented by a single reference station in Crestline, CA. The motivation for developing and deploying the sensor network in the region was that the single reference station potentially needed to be relocated due to uncertainty that the lease agreement would be renewed. With the implication of siting a new reference station that is also a high O_3 site, the project required the development of an accurate and precise sensing node for establishing a parallel monitoring network at potential relocation sites. The deployment methodology included a pre-deployment co-location calibration to the reference analyzer at the air monitoring station with post-deployment co-location results indicating a mean absolute error (MAE) < 2 ppb for 1-h mean O_3 concentrations. Ordinary least squares regression statistics between reference and sensor nodes during post-deployment co-location testing indicate that the nodes are accurate and highly correlated to reference instrumentation with R^2 values > 0.98, slope offsets < 0.02, and intercept offsets < 0.6 for hourly O_3 concentrations with a mean concentration value of 39.7 ± 16.5 ppb and a maximum 1-h value of 94 ppb. Spatial variability for diurnal O_3 trends was found between locations within 5 km of each other with spatial variability between sites more pronounced during nighttime hours. The parallel monitoring was successful in providing the data to develop a relocation strategy with only one relocation site providing a 95% confidence that concentrations would be higher there than at the current site.

Keywords: ozone; sensor network; sensor node; mountain community monitoring; parallel monitoring; site relocation study

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1. Introduction

1.1. Ozone Pollution

Ozone (O_3) is a highly reactive gas that is comprised of three oxygen atoms. In the stratosphere (10–50 km above the earth's surface), O_3 is generated naturally and provides a protective layer that shields the earth from harmful ultraviolet (UV) rays emitted by the sun. In the troposphere (0–10 km above earth's surface), O_3 is considered an air pollutant and harmful to public health and the environment. The effects of O_3 on human health include reducing lung function and irritation of the respiratory system. Increases in exposure to O_3 have been associated with increases in school absenteeism [1–3] and increases in the risk of death from respiratory causes [4–7]. In a long-term study on children, reductions in air pollutants have been associated with statistically significant decreases in bronchitis symptoms like asthma [8,9]. High concentrations of O_3 have been recognized as a phytotoxic threat to forests, crops, and vegetation [10,11].

Tropospheric O_3 or ground-level O_3 is formed by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) that occur in the presence of sunlight. This process is known as the photolytic cycle and is shown in Equations (1)–(3) [12]. Prime conditions for generating O_3 typically occur during the summer months when intense sunlight is coupled with mobile and stationary sources emitting carbon monoxide (CO), VOC, and NO_x. Without sunlight, photolysis of nitrogen dioxide (NO_2) in Equation (1) ceases and Equation (3) leads to the removal of O_3 from the atmosphere when fresh emissions of NO are present. Commuter traffic in the late afternoon and early evening typically provides a source of fresh NO emissions leading to O_3 titration. In rural communities, fewer sources of NO may cause less titration of O_3 by NO which may lead to higher nighttime O_3

concentrations than nearby urban environments [13].

$$NO_2 + h\nu \rightarrow NO + O^{\cdot} \quad (1)$$

$$O^{\cdot} + O_2 \rightarrow O_3 \quad (2)$$

$$O_3 + NO \rightarrow NO_2 + O_2 \quad (3)$$

1.2. Regulation

In the United States, O_3 concentration levels are regulated by the United States Environmental Protection Agency (U.S. EPA) under the Clean Air Act (CAA). The U.S. EPA establishes National

Ambient Air Quality Standards (NAAQS) for criteria pollutants which include CO, lead (Pb), NO_2, O_3, particulate matter (PM), and sulfur dioxide (SO_2). The State of California further regulates these pollutants with the California Ambient Air Quality Standards (CAAQS) established by the California Air Resources Board (CARB). These standards are designed to protect public health and the environment. The latest federal and state standards for O_3 are shown in Table 1.

Table 1. Federal and State standards for ozone (obtained September 2019).

Standard for Ozone	1-h Average	8-h Average (Year Established)
National Ambient Air Quality Standard	120 ppb (1979)	70 ppb (2015) 75 ppb (2008) 80 ppb (1997)
California Ambient Air Quality Standard	90 ppb	-

1.3. Ozone Levels in the South Coast Air Basin and Monitoring in the San Bernardino Mountains

The South Coast Air Quality Management District (South Coast AQMD) is the air pollution agency for the South Coast Air Basin (SCAB) which is in Southern California and includes all of Orange County and the urban portions of Los Angeles, Riverside, and San Bernardino Counties. In order to determine regional attainment for ambient air quality standards, South Coast AQMD operates a network of air monitoring stations (AMS) equipped with EPA approved instrumentation that measures criteria air pollutants across the basin. South Coast AQMD operates 29 Federal Equivalent Method (FEM) O_3 instruments. Significant improvement has been achieved in reducing O_3 while population, vehicle miles traveled, economic activity, and goods movement in the region has been increasing. Large emissions of O_3 precursors (NO_x and VOCs) along with the topography and meteorology of the region lead to some of the worst O_3 pollution in the nation [14]. The San Bernardino Mountain (SBM) Communities (SBMCs) are especially at risk for severe O_3 episodes as polluted air travels inland with onshore wind from Los Angeles. Regional-scale temperature inversions that occur below the heights of the mountain crests lead to stagnant air conditions while clear skies and abundant sunlight provide conditions conducive for O_3 formation [15]. In 2015, one or more of the South Coast AQMD's O_3 reference analyzers exceeded the most current federal standard (2015 8-h NAAQS: 70 ppb) on 113 days. Of the top ten monitoring sites in the nation for most frequently exceeding the 8-h standard, seven are located within the SCAB. Monitoring sites within the San Bernardino County exceeded this standard 102 times in 2015 with the Central San Bernardino Mountains air monitoring site (Crestline AMS) exceeding the 8-h O_3 standard 86 times; more than any other O_3 monitoring location in the basin. The maximum 8-h average O_3 concentration recorded in the SCAB in 2015 was measured at the Crestline AMS at 127 ppb (AQMP, 2016).

The main goal of this study is to determine if a relocation site in a nearby community would experience the same or similar O_3 profile to the current monitoring site by testing the hypothesis that O_3 concentrations in nearby communities are consistent spatially and temporally. While O_3 is a secondary pollutant that is formed by reactions between primary pollutants (NO_x and VOC) in the presence of sunlight and is often considered a regional pollutant, a recent community level O_3 monitoring campaign in Riverside, CA found that O_3 concentrations vary spatially across a community [16]. In early 2017, South Coast AQMD was faced with the potential need to relocate the Crestline AMS due to uncertainty that the lease agreement would be renewed. If the lease was terminated, circumstances may prevent the option to perform parallel monitoring or perform parallel monitoring during the high O_3 season, typically occurring from July through September. At a minimum, parallel monitoring must be conducted during the season when maximum concentrations are expected [17]. Since this monitoring station experiences some of the highest O_3 concentrations in the basin, parallel monitoring at the current and potential relocation monitoring sites was determined to be necessary to develop an appropriate relocation strategy. While parallel monitoring is not required via statute or regulation when relocating a monitoring site, not performing parallel monitoring may have regulatory consequences if the relocation site does not meet the same monitoring objectives of the current monitoring location. Parallel monitoring provides a mechanism to determine if the relocation site can meet the current monitoring objectives.

The current monitoring objectives of the Crestline AMS include evaluation of ambient air quality data, protection of public health, development and evaluation of control plans, and air quality research. The evaluation of ambient air quality provides data to determine the attainment of ambient air quality standards (NAAQS and CAAQS), assess progress in achieving standards, and track long term trends. The protection of public health is achieved through communicating the Air Quality Index (AQI) results to the public in a timely manner and documenting population exposure to air pollutants [18]. Data used for research involves long-term trend analysis and tracking impacts on the environment and the public health effects of air pollutants. Parallel monitoring can also provide insights into the continuity of measurements between an old and new monitoring site. Continuity of measurements in one location is ideal for tracking long term trends for assessing progress in achieving and maintaining national and state standards, developing and evaluating State Implementation Plans (SIP) for attaining the standards, and providing long term data repositories for answering questions posed by researchers. The South Coast AQMD has been monitoring O_3 in Crestline, California since 1973 and maintaining the continuity of measurements is ideal for long-term trend analysis [19].

This study aims to investigate the spatial and temporal variability between Crestline and the three potential relocation sites by parallel monitoring during the high O_3 season. With the expected results impacting the relocation strategy of a monitoring site with high O_3 concentrations, the monitoring project required an accurate, precise, and reliable O_3 sensor that could be deployed in remote mountain locations with power and connectivity versatility.

1.4. Evaluation of Ozone Sensing Technology

In 2014, the South Coast AQMD established the Air Quality Sensor Performance Evaluation Center (AQ-SPEC) to evaluate the performance of consumer and research-grade sensors against federally approved instrumentation. AQ-SPEC evaluates gas-phase and particle-phase sensors under both ambient field and controlled laboratory conditions. Results from these performance evaluations are publicly available on the AQ-SPEC website at www.aqmd.gov/aq-spec. The methodology of low-cost sensors that measure O_3 is typically categorized as either metal-oxide or electrochemical methods. The performance of low-cost gas-phase sensors can be impacted by changing environmental factors

(e.g., temperature and humidity), long-term drift, and interfering pollutants [20–23]. Electrochemical sensors for O_3 detection often experience inference from other oxidizing gases commonly found in ambient environments [20]. When deployed for ambient air monitoring, the electrochemical O_3 sensors are often coupled with a NO_2 sensor in order to subtract out interference from local NO_2 concentrations. While metal-oxide O_3 sensors are selective to O_3, previous deployments of this technology have shown reduced sensitivity to O_3 concentrations over time in extended field deployment studies [24,25].

AQ-SPEC evaluated the 2B Tech Personal O_3 Monitor (POM, 2B Technologies, Boulder, CO, USA) with the field and laboratory evaluation results indicating that the POM is capable of accurate and precise O_3 measurements. The POM is a miniature UV-absorption based monitor that uses a folded optical path ("U" shaped) to achieve a path length similar to that used in a regulatory-grade O_3 instrument that is designated as U.S. EPA FEM [26]. In August of 2015, the UV absorption methodology used in the POM was designated by the U.S. EPA as FEM for O_3: EQOA–0815–227. In the two-month AQ-SPEC field evaluation, the coefficient of determination (R^2) for a triplicate set of POMs was found to be 1.0 with a mean absolute error (MAE) less than 2 ppb [27,28]. In the AQ-SPEC laboratory evaluation, the performance of the POM was found not to be adversely affected by the NO_2 interferent or extreme environmental conditions (i.e., high/low temperature and relative humidity) [28,29]. In a previous study to monitor O_3 for the Hong Kong Marathon, the POM was selected due to its ability to measure O_3 without interferences from common oxidizing pollutants found in ambient air [30].

2. Materials and Methods

2.1. Node Design and Development

Based on project monitoring requirements, the POM was selected as the O_3 sensor to be incorporated into the sensing node. The POM weighs 0.3 kg with dimensions of 10 × 7.6 × 3.8 cm and is shown in the Supplementary Materials Figure S1. The POM is powered by 12-volt direct current (DC) and integrates well into battery, solar, or plugin (AC/DC converter) applications. Particular to this study, the POMs were equipped with a particulate filter at the sample inlet to prevent dust and aerosols from reaching the sensor optics. In contrast to many of the commercially available O_3 sensors that use a fan or passive sampling, the sampling mechanism of the POM is a small pump that controls sample flow through the unit. The pump is one of the factors affecting the commercial price of the device. Since only a small network of three sensors would be deployed, the cost was not a primary concern in sensor selection for this monitoring application. Enough monetary resources or access to loaning such sensors via a sensor library program would be required for other researchers to deploy similar types of sensor networks.

Due to the timeline requirements to build and deploy a network of O_3 monitors in the region during the high O_3 season, the decision was made to build a sensor network that would be easily deployed in contrast to deploying additional monitoring stations that would require constructing, building, and siting three additional ambient air monitoring shelters equipped with FEM O_3 analyzers, zero air generators, and gas calibrators. Constructing, building, and siting additional monitoring stations with required equipment would have been time and cost-prohibitive to meet project timeline requirements to monitor O_3 in the region during the high O_3 season.

The POM is not an "Internet of Things" (IoT) connected device. Out of the box, POM data can be stored internally on the POMs internal memory (limited to ~6 days for 1-min averaged data) and/or data can be transmitted over a USB or serial port for logging data externally with a data acquisition solution. The POM was coupled with an IoT communications device for data acquisition, edge data processing, and data telemetry to a cloud-based platform for data storage and visualization. A remote IoT monitoring solution was selected, which included data acquisition hardware (i.e., model Thiamis 1000 (T1K), Netronix Inc., Philadelphia, PA, USA) and a cloud-based environmental monitoring software with web-based application functionality that provides access to real-time and historical monitoring data (i.e., Environet, Netronix Inc., Philadelphia, PA, USA). The T1K is equipped with both cellular and Wi-Fi data communication, a real-time clock, and 8 GB memory (see Supplementary Materials Figure S2). The real-time clock and internal memory allowed the T1K to continue recording data even if the data connection (Wi-Fi or cellular) was intermittent or unavailable for an extended period. The three POMs were configured to output data every 10 s. The 10-s data was transmitted to the T1K through the serial to 3.5 mm cable provided by 2B Technologies. The T1k recorded and performed edge data processing to average the 10-sec O_3 values to 1-min average O_3 concentrations and thus reduced the data transmission rate to 1/6 of the original data output from the sensor. These 1-min O_3 concentrations were then transmitted from the T1K via a cellular or Wi-Fi network to Environet for data storage and visualization. The 1-min data output was selected for this monitoring network to allow the POM data to be time-matched with the output of the regulatory air monitoring station FEM ozone instrumentation for pre-deployment collocation calibration purposes.

The T1K and the POM were housed in a weatherproof polycarbonate enclosure (Fibox, Glen Burnie, MD, USA) with dimensions of 35.5 × 30.5 × 17.8 cm. The box was fitted with the appropriate backing plate for mounting the components in the enclosure which allowed for easy access to remove hardware from the enclosure for potential repairs or replacement. Two vents were installed in the box for heat dissipation and to ensure that the sampling of the POM was not pumping air into a leak-tight box. The sensor node was powered via a 120/12V AC to DC power converter. The node could be optionally configured for solar power by adding a 12 V battery, 50 W solar panel, and charge controller. The total cost per node is roughly $6500 USD. The bill of materials (BOM) for the sensor node is shown in Table 1. Figure 1 shows the sensing node with the major components labeled. The result of this development was an accurate O_3 sensing node that could be successfully deployed in rural communities with varied access to power and connectivity to transmit real-time data and visualize data remotely.

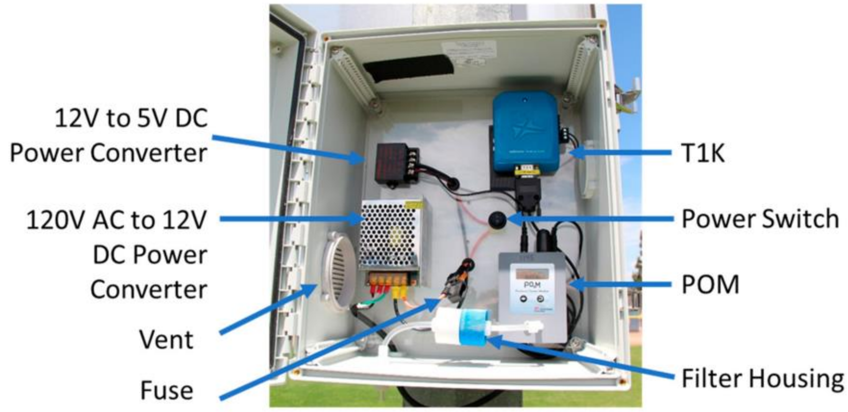

Figure 1. Ozone sensor node with labeled components.

2.2. Nodes' Deployment

Three O_3 sensor nodes were constructed and deployed for this parallel monitoring application. Prior to deployment, the POMs were calibrated against a calibration transfer standard (CTS) at South Coast AQMD headquarters in Diamond Bar, CA. The CTS, Thermo Scientific Model 49i O_3 analyzer, was connected to a manifold along with the three POMs. The manifold was then inundated with varying O_3 concentrations by an O_3 generator. The POMs were calibrated with the in-line particulate filter upstream of the sampling inlets to ensure that the calibration configuration matched the deployment configuration. The initial calibration was a 2-point calibration with a zero and span at 250 ppb of O_3. The calibration parameters, slope (S) and offset (Z), derived from the 2-point calibration were inputted into the POM via the POM's user interface as outlined in the 2B Technology operational manual [31]. After calibration, the POMs were verified against the CTS with ramping O_3 in the following sequence:

0, 250, 200, 150, 100, and 50 ppb (see Supplementary Materials Figure S3a–c). The slopes ranged from 0.98 to 1.00 with R^2 values greater than 0.99. The intercepts ranged from 0.3 to 2.1 ppb. The results of the verification indicate that the POMs accurately and precisely measured O_3 over a wide range of concentrations that were inclusive of ambient levels not exceeding 200 ppb during the study.

The experimental deployment design incorporated three phases: pre-deployment co-location, deployment, and post-deployment co-location. The three phases of deployment are summarized in Table 2. The pre- and post-deployment co-location took place at the Crestline AMS, which is equipped with a FEM O_3 reference analyzer (model 49i, Thermo Scientific, Waltham, MA, USA). The pre-deployment co-location at the AMS allowed for the implementation of an in-situ field calibration of the 3 POMs to the station reference analyzer. The post-deployment co-location at the AMS allowed for a verification of POM performance at the conclusion of the study in order to verify the in-situ field calibration and the deployment results.

Table 2. Deployment dates and number of days per deployment period.

Period	Dates	# of Days
Pre-deployment co-location	7/11/17 to 7/19/17	8
Deployment	7/19/17 to 9/19/17	62
Post-deployment co-location	9/19/17 to 9/29/17	10

The three additional deployment locations were selected based on their potential to serve as a possible relocation site for the current Crestline AMS. The deployment locations are shown on a map of the San Bernardino Mountains in Figure 2 (larger extent map in Supplementary Materials Figure S4). The three additional locations are on the south slope of the San Bernardino Mountains and located near the California State Route 18

(SR-18). SR-18 begins in San Bernardino at State Route 210 (SR-210) and travels to Big Bear City and then out to the high desert region near Victorville and Interstate 15 (I-15). SR-330 which also originates in San Bernardino and merges with SR-18 in Running Springs.

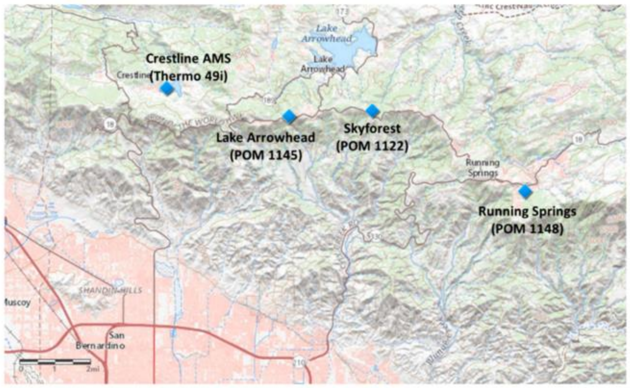

Figure 2. Map of Eastern San Bernardino Mountain Communities and deployment locations.

2.3. Data Processing and Analysis

When examining the POMs during the co-location time periods, ordinary least squares (OLS) regression statistics along with mean bias error (MBE) and MAE were utilized to characterize the POMs performance against the Thermo 49i O_3 measurements from the Crestline AMS. Information on the measurement error calculations and equations for MBE and MAE can be found in the Supplementary Materials Equations (S1) and (S2).

When examining the POMs and the Crestline Thermo 49i during the deployment periods, OLS regression statistics and bias deviations between Crestline and the three alternative locations were utilized to characterize spatial and temporal differences between sites. Equations for mean bias deviation (MBD) and mean absolute deviation (MAD) are found in Supplementary Materials Equations (S3) and (S4). The MBD between the relocation sites and the Crestline location provides a metric that indicates the tendency of a relocation site to either under- or over-estimate O_3 concentrations when compared to the Crestline AMS location. The MBD is a relative measure that can be either positive or negative based on whether the relocation site under- or over-estimates O_3 concentrations when compared to the Crestline location. Care should be taken when examining the MBD since the positive and negative errors will cancel each other out. The MAD provides a better metric for examining the absolute deviations between the Crestline location and potential relocation sites.

The 1-min data collected during the deployment phase was calibrated according to the OLS calibration factors derived from the pre-deployment co-location period. The 1-min data was processed to remove negative and extremely high concentrations (> 250 ppb) from the data set. The 1-min data was then run through a Hampel outlier detection algorithm to remove and replace temporal outliers (see Supplementary Materials Section S7). The rolling Hampel filter compares each data point to a rolling median value of the last 10 consecutive data points in a data series. A threshold of six standard deviations was used to characterize a value as an outlier and replace it with the rolling median value. The cause of the outliers may have been power surges or temporary glitches with the POM or data transmission. Data were then averaged to 1-h mean O_3 concentrations with a requisite of 42 or more

1-min data points to generate a valid 1-h mean O_3 concentration. These 1-h averages for the three POMs and Crestline reference monitor were then matched on date and time to enable the parallel monitoring comparisons between the reference site and three relocation sites. Any row with a missing concentration value for either Crestline or the three relocation sites was removed from the analysis so the four locations could be compared across a complete matching data set.

In following the CARB Air Monitoring Technical Advisory Committee (AMTAC) document providing guidelines for site relocation and parallel monitoring, a data set of high values was created by finding the daily maximum 1-h O_3 concentration for each location and then filtering to keep values that exceed a threshold value. The threshold value was set at 87.4 ppb which represents the top 20% of the prior three years of daily maximum 1-h O_3 concentrations collected at the Crestline AMS. From this data set, MBD could be calculated to determine if a relocation site would be higher or lower than the current monitoring site with calculating the upper and lower limits of the 95% confidence interval (CI) on the MBD. Calculations for the 95% CI on the MBD have been adapted from the CARB's Guidelines for Parallel Monitoring [17] (Supplementary Materials Equations (S5)–(S8)).

3. Results and Discussion

3.1. Pre-Deployment Co-location Period at Crestline

Data collection for the pre-deployment co-location at the Crestline AMS took place from 11 July to 19 July 2017, which provided for nearly eight days of co-location data. During the pre-deployment co-location, ambient temperature ranged from 16 to 30 °C with a mean temperature of 23.4 ± 3.3 °C and ambient relative humidity (RH) ranged from 21% to 70% with a mean RH of 46.4% ± 11.2%, as measured by the AMS meteorological equipment (model HC2-S3, Rotronic, Hauppauge, NY, USA). During these eight days, the range of 1-min O_3 concentration was 110 ppb with a maximum of 141 ppb measured on 15 July, as recorded by the Crestline AMS FEM O_3 instrument. The 1-min datasets from the POMs and FEM were filtered for values < −5 ppb and > 250 ppb. The 1-min data was then time-matched and OLS regression analysis was performed for the POMs against the Thermo 49i reference analyzer to perform an in-situ field calibration. The co-location OLS calibration offsets for the

POMs were small with slope offsets < 0.07 and intercept offsets < 1.6 ppb (see Supplementary Materials

Table S2). The in-situ field calibration is effective in correcting for slope and intercept offsets and reducing the MBE between the POMs and the Thermo 49i. The MAE calculated for the three POMs at the 1-min time interval is <4 ppb. Due to the inherent fluctuations of 1-min data points, the MAE was not effectively reduced by the in-situ field calibration. By averaging to 1-h mean O_3 concentrations, the MAE between the three POMs and the Crestline O_3 monitor was reduced to less than 1 ppb. Figure 3 shows the time-series for the pre-deployment co-location time period with Figure 4 showing the correlation plots of the POMs against the Thermo 49i after the in-situ field calibration was performed. The low measurement error of the POMs against the reference instruments indicates that these units are not adversely affected by weather fluctuations (temperature or RH) or interfering pollutants.

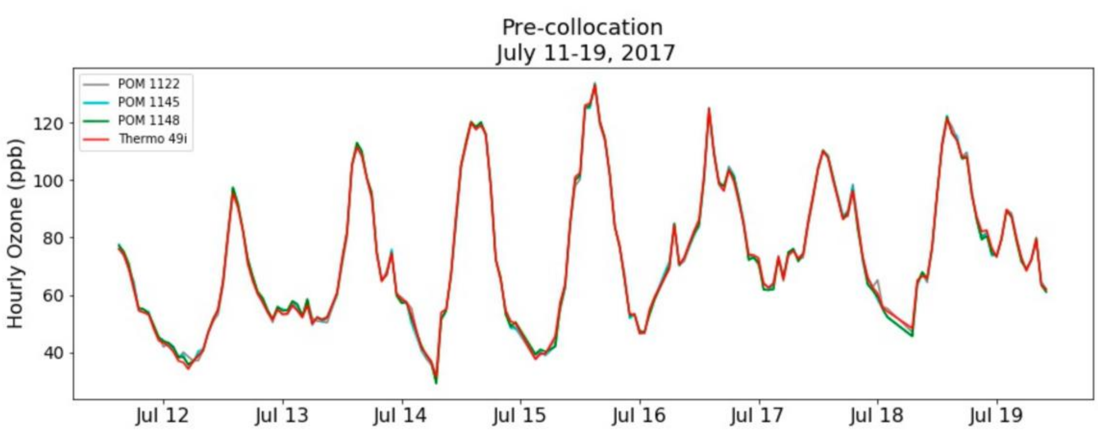

Figure 3. Pre-deployment co-location at Crestline time series for 1-h mean O_3 concentrations after the in-situ field calibration was performed.

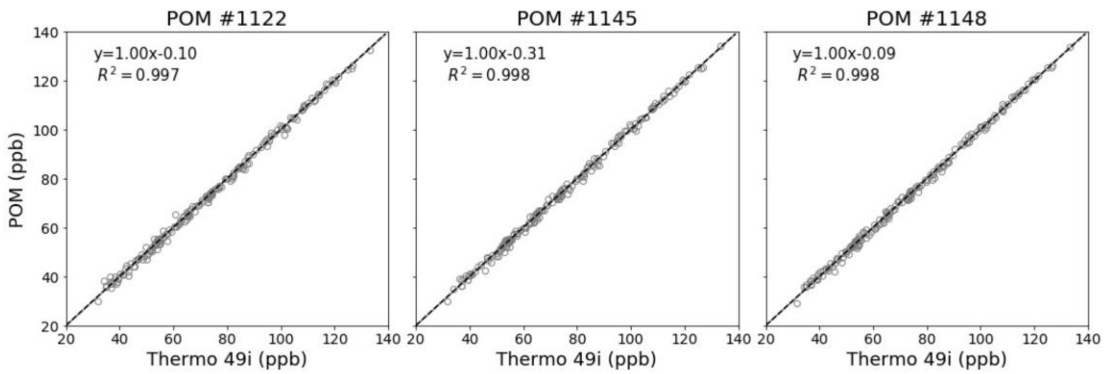

Figure 4. Pre-deployment co-location correlation plots for 1-h O_3 concentrations after the in-situ field calibration was performed.

3.2. Post-Deployment Co-location Period at Crestline

The post-deployment co-location at Crestline AMS took place for 10 days from 19–29 September 2017. The post-deployment co-location results provide a mechanism to verify that the POMs maintained their calibration and collected valid and accurate O_3 measurements throughout the deployment period. Temperature conditions during the pre-deployment co-location ranged between 4 and 25 °C with a mean temperature of 13.3 ± 5.1 °C. The RH ranged between 13% and 99% with a mean RH of

54.3% ± 28.9%. The range for 1-h mean O_3 concentrations experienced in the post-deployment co-location was 86 ppb with a maximum 1-h value of 91.6 ppb measured on September 29th by the Crestline AMS Thermo 49i. For hourly mean concentrations, R^2 values were greater than 0.98 with slopes ranging from 0.98 to 1.02 and intercepts ranging from −0.03 to −0.57. The calculated MAE was less than 2 ppb with MBE calculated at −0.83, −1.24, and 1.30 ppb for POM 1122, 1145, and 1148, respectively. Figure 5 shows the time series for the post-deployment co-location and Figure 6 shows the scatter plots for the POMs vs. the Thermo 49i. These post-deployment co-location results indicate that the individual POMs maintained their calibration throughout the deployment period and collected accurate measurements with MAEs less than 2 ppb. Additionally, the performance was not adversely affected by changing weather conditions, interfering pollutants, or length of deployment.

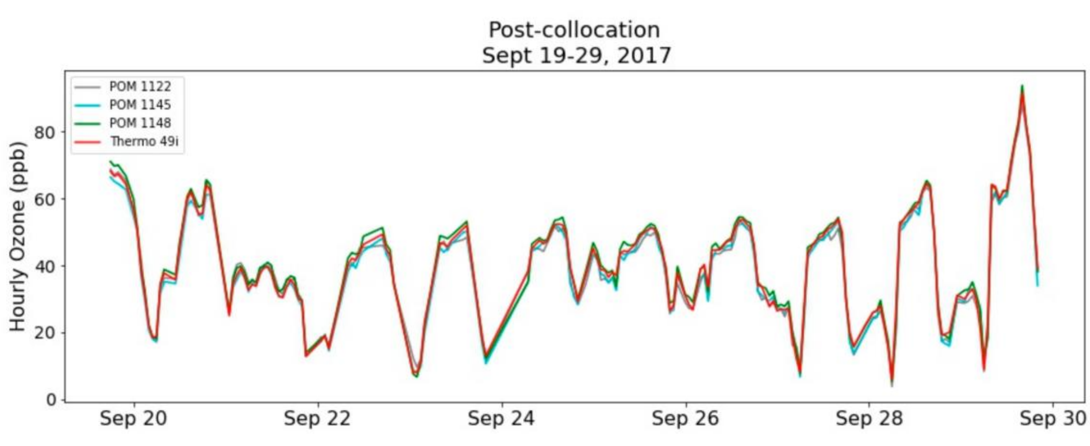

Figure 5. Post-deployment co-location time series for 1-h mean O_3 concentrations.

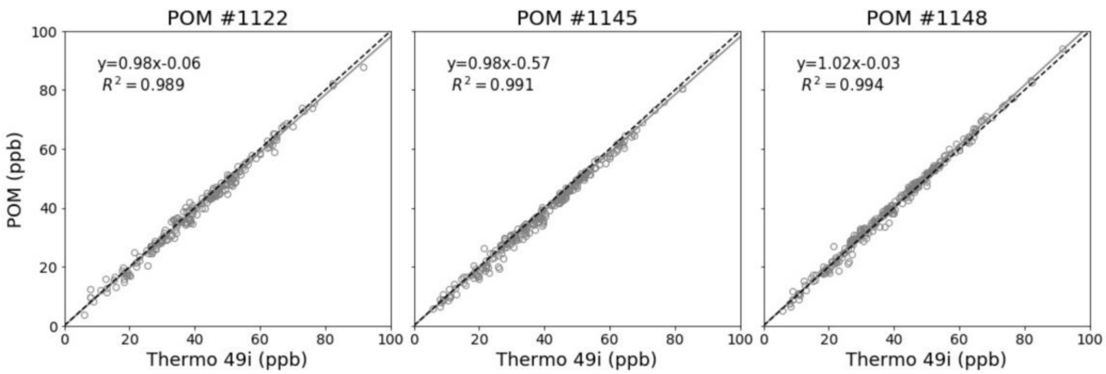

Figure 6. Post-deployment co-location correlation plots for 1-h O_3 concentrations.

3.3. Results from Deployment

The deployment of the sensors across the San Bernardino Mountains took place during the high O_3 season for two months (17 July to 18 September 2017). Performing parallel monitoring during the high O_3 season is critical for obtaining enough high concentration values to examine the relocation sites

with the current monitoring site. Data recovery at the 1-h time average was found to be 99.9%, 96.5%, 73.4%, and 100% for the Thermo 49i, POM 1122, POM 1145, and POM 1148, respectively. POM 1145 in Lake Arrowhead, CA experienced a power outage due to an unforeseen water leak requiring the power outlet supplying the node to be turned off. As a result, data was not collected from 8:00 a.m. on 2 August 2017, to 4:00 p.m. on 18 August 2017, when the unit was outfitted with a solar panel, charge controller, and a 12-volt battery to provide power. Data rows with a missing value for any location were filtered out so a comparison between sites would have the same number of data points. After all rows with a missing value were dropped from further analysis, data recovery for the 1-h matched data was 70.4% (1032 rows) by which the four sites are characterized and compared. Temperature conditions for Crestline AMS during the deployment ranged from 8 to 34 °C with a mean temperature of 21.6 ± 4.8 °C. The RH ranged from 9% to 99% with a mean RH at 49.0% ± 18.5%. Table 3 provides the summary statistics, OLS regression statistics, and the mean measurement deviations calculated for the monitoring locations during the deployment period. The difference in mean O_3 concentration between Crestline (54.2 ppb) and the three locations varied with Skyforest, CA (54.2 ppb) being identical, Running Springs, CA (56.7 ppb) being slightly higher on average, and Lake Arrowhead, CA (64.0 ppb) being about 10 ppb higher on average than the Crestline location. These spatial variations in O_3 concentrations between locations could likely not have been predicted a priori without monitoring, highlighting the importance of developing less-expensive monitoring solutions to supplement the spatial resolution of current monitoring networks. The largest range of O_3 concentrations was seen at the Crestline AMS which had the highest maximum and lowest minimum hourly concentration values. The summary statistics between the four locations are shown in Figure 7 by box plots for each of the sampling locations. The horizontal dotted line and dotted diamond indicate the mean and standard deviation of the sample. Note that the following figures and tables are ordered from left to right by distance from the Crestline AMS.

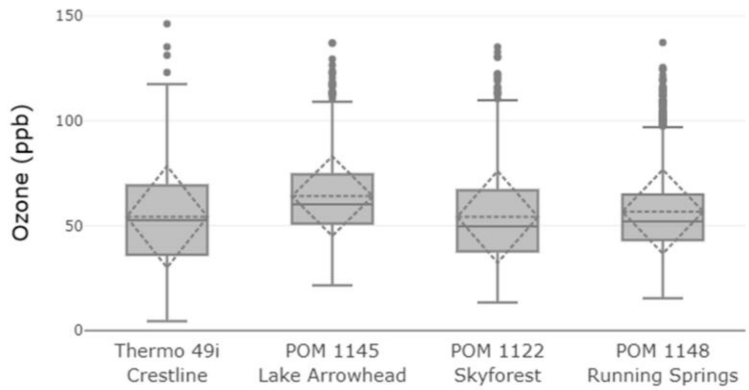

Figure 7. Box plots for the 1-h mean O_3 concentrations for the four deployment locations.

Table 3. Summary information and 1-h statistics for the four monitoring locations.

Location	**Crestline**	**Lake Arrowhead**	**Skyforest**	**Running Springs**	
Instrument	Thermo 49i	POM 1145	POM 1122	POM 1148	Units
Population	10,700	12,400	300	4800	no. residents
Elevation	1390	1753	1733	1858	m
Distance from Crestline AMS	0	5.8	9.5	17.1	km
Statistics (1-h average)					
Mean Ozone Conc.	54.2	64.0	54.2	56.7	ppb
Standard Deviation	24.2	18.9	21.8	20.0	ppb
Minimum Conc.	4.5	21.5	13.4	15.4	ppb
Maximum Conc.	146.2	137.1	135.2	137.3	ppb
Hourly data points	1032	1032	1032	1032	count
Slope	-	0.65	0.81	0.62	-
Intercept	-	28.8	10.5	22.8	-
R_2	-	0.69	0.80	0.57	-
Mean Bias Deviation (MBD)	-	9.8	0.0	2.5	ppb
Mean Absolute Deviation (MAD)	-	11.7	8.3	12.1	ppb
MAD—Daytime		7.1	6.7	8.7	ppb
MAD—Nighttime		16.7	10.0	15.9	ppb

The OLS regression statistics for the 1-h matched data sets compare each of the potential relocation sites (*y*-axis) to the current Crestline AMS (*x*-axis) and provides insights into the similarity between the four locations. Immediately, the large intercept bias between the three locations stands out with intercepts at 28.8, 10.5, and 22.8 for Lake Arrowhead, Skyforest, and Runnings Springs, respectively. This intercept offset is primarily due to the nighttime differences between Crestline and the relocation sites likely caused by varying degrees of available local NO emission to scavenge O_3. Regarding correlation, the three relocation sites correlate with Crestline with R^2 values at 0.69, 0.80, and 0.57 for Lake Arrowhead, Skyforest, and Runnings Springs, respectively. Slope offsets between Crestline and the three relocation sites were found to be 0.65, 0.81, and 0.62 for Lake Arrowhead, Skyforest, and Runnings Springs, respectively. Of the three relocation sites, the Skyforest location most closely matches the Crestline location with the highest correlation and the smallest slope/intercept offset. If finding the location that most closely matches the diurnal trends of the Crestline AMS is required for relocation, then the Skyforest location would be the chosen relocation site as this site was found to have an identical mean O_3

concentration throughout the deployment and regression statistics indicating the strongest commonality between Skyforest and the current monitoring site.

The MBD and MAD of the three locations with respect to Crestline provided insights on the spatial variability in O_3 between locations. The MBD between Crestline and the three alternative locations was found to be 9.8, 0.0, and 2.5 ppb bias for Lake Arrowhead, Skyforest, and Running Springs, respectively. The MAD from Crestline was found to be 11.7, 8.3, and 12.1 ppb for Lake Arrowhead, Skyforest, and Running Springs, respectively. Looking at the MBD, the Skyforest location appears to be the most suitable location for relocation as this location matched the mean of the Crestline location. However,

when examining the MAD, all three sites deviate from Crestline AMS with MAD > 8.0 ppb; indicating spatial variability between Crestline and these relocation sites. When separating the MAD between day and night hours, the predominant deviation between Crestline and the three locations takes place during nighttime hours. The MAD values for nighttime hours are 135%, 50%, and 83% higher than daytime MAD for Lake Arrowhead, Skyforest, and Running Springs, respectively. The cause for the increased nighttime deviation from the Crestline AMS is likely due to local factors affecting the titration of ozone between locations during nighttime conditions. Local factors including topography, populations, and traffic counts are discussed below to better understand these local factors and their impact on the spatial variation of O_3 between Crestline and the relocation sites.

Since the Crestline AMS experiences some of the highest O_3 concentrations in the SCAB, comparing the daily maximum O_3 concentrations between the current monitoring site and the potential relocation sites is important to understand the difference between the locations with regard to daily 1-h maximum concentrations that could lead to exceedances of the 1-h standard. When considering relocating a site that experiences high O_3 concentrations, care needs to be taken to ensure that the relocation site experiences O_3 concentrations as high as or higher than the existing monitoring site. A data set of high values of the daily maximum 1-h O_3 concentration was created and after filtering for the threshold value and missing data, 30 daily maximum values remained with data summarized in Table 4. The mean of the high values in the data set for Crestline, Lake Arrowhead, Skyforest, and Running Springs was 100.8, 106.9, 101.9, and 104.6 ppb, respectively. While each of the relocation sites experienced higher O_3 concentrations than Crestline on average, only the Lake Arrowhead location provides a relocation site with a 95% confidence that the MBD would be greater than Crestline with a positive lower limit of MBD at 2.1 ppb, indicating that this location would likely be at least 2.0% higher than the Crestline AMS. Both Skyforest and Running Springs have negative values for the lower limit of the 95% CI of MBD at −2.6 and −1.5 ppb, respectively. These negative values indicate that these relocation sites, Skyforest and Running Springs, could potentially yield O_3 concentrations lower than the current monitoring site by 2.6% and 1.5% respectively. If the requirement were set that the relocation site must on average experience higher concentrations than the existing site with a 95% CI on the MBD, then the Lake Arrowhead location would be chosen as the relocation site to meet this criterion. The regression statistics of the high values data set (*n* = 30) are similar in nature with the

1-h regression statistics (*n* = 1032) shown in the preceding section. Between the three relocation sites, Skyforest has the highest R^2 value (0.70), slope nearest to one (0.90), and lowest intercept (11.3) which indicates this location most closely matches the diurnal trends experienced at Crestline.

Table 4. Summary Statistics and 95% confidence interval for the daily 1-h maximum O_3 concentration.

Location	**Crestline**	**Lake Arrowhead**	**Skyforest**	**Running Springs**	
Instrument	Thermo 49i	POM 1145	POM 1122	POM 1148	Units
Mean Conc.	100.8	106.9	101.9	104.6	ppb
MBD	-	6.08	1.08	3.81	ppb

SD MBD	-	8.89	8.29	11.93	ppb
Lower limit of MBD (95% CI)	-	2.10	−2.63	−1.53	ppb
Upper Limit of MBD (95% CI)	-	10.05	4.79	9.15	ppb
Lower Limit %	-	2.0	−2.6	−1.5	%
Upper Limit %	-	9.7	4.7	8.9	%
Slope	-	0.61	0.90	0.63	-
Intercept	-	45.7	11.3	41.5	-
R^2	-	0.59	0.70	0.40	-

The temporal differences between locations are shown in the time series plot shown in Figure 8 that is a subset from 21 August to 1 September 2017. The time series indicates that the three locations deviate from Crestline AMS predominantly during nighttime conditions when O_3 concentrations are typically decreasing. The typical wind patterns of the region with daytime onshore winds blowing in from the west/southwest and daytime upslope flow for the mountains provide a steady source of O_3 precursors for the elevated mountain communities. During the day, these upslope air masses are pushed up towards the boundary layer. In Figure 9, the timing of daily peak values between locations differs from the western sites (Crestline and Lake Arrowhead) peaking around 3 p.m. while the more eastern sites (Skyforest and Running Springs) peak an hour later around 4 p.m. During the evening time, wind patterns typically shift to an offshore direction with winds blowing from the northeast. These nighttime wind patterns lead to downslope air movement on the mountain which can lead to potential increases in O_3 concentrations as polluted air masses near the boundary layer fall in elevation and pass through the mountain communities. An example of this can be seen in Figure 9

with O_3 concentrations increasing in nighttime conditions on 25 August at 9 p.m. when hourly O_3 concentrations increase by 10 and 15 ppb from the previous hour at Lake Arrowhead and Skyforest, respectively. A similar trend with regional-scale air flows and increasing nighttime O_3 concentrations in mountain communities has been seen in the Front Range of the Colorado Mountains [32].

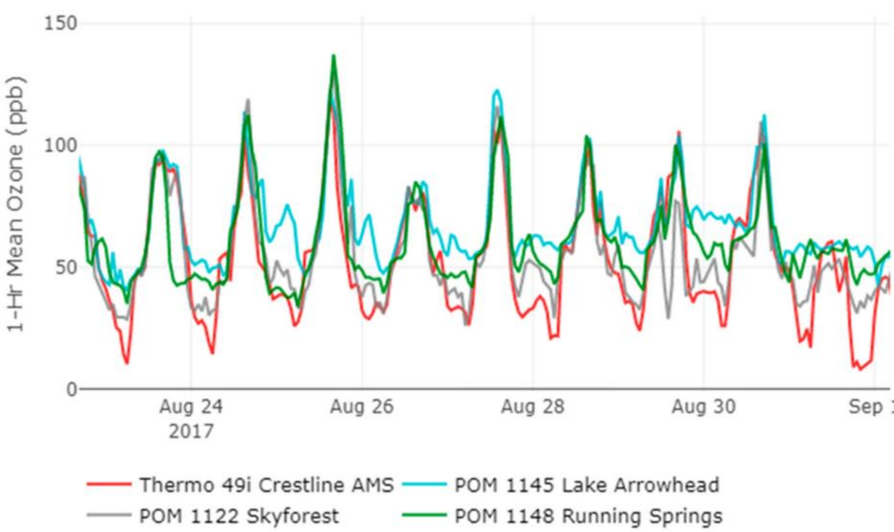

Figure 8. Timeseries for deployment, subset between 22 August and 1 September 2017.

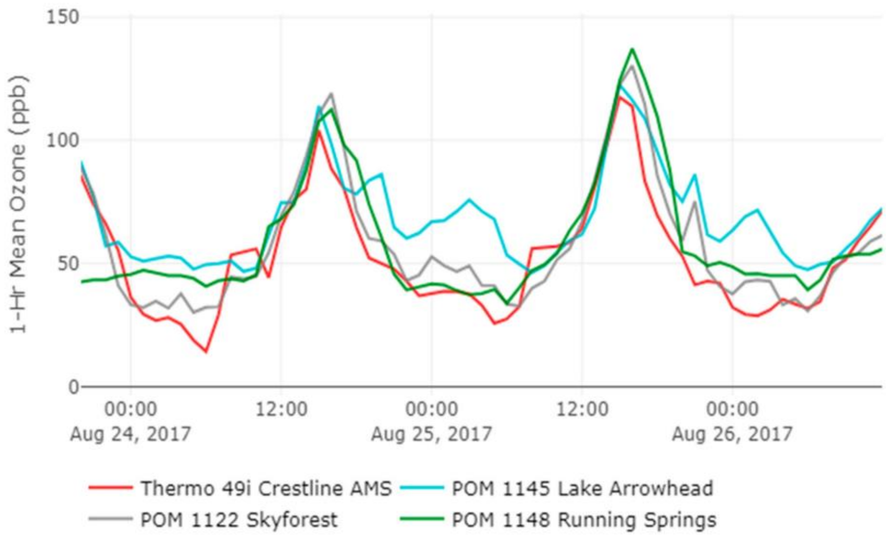

Figure 9. Time series for deployment subset between August 24 and 26, 2017.

Comparing the four locations regarding the number of exceedances of the 2015 U.S. EPA 8-h O_3 standard (70 ppb) provides another way for understanding the spatial variability of O_3 between these locations. For the time-matched deployment data set, the Crestline location exceeded the 8-h O_3 NAAQS standard 35 times while Lake Arrowhead, Skyforest, and Running Springs exceeded the standard 38, 27, and 28 times, respectively (Table 5). In comparison to Crestline, the Arrowhead location experienced six additional exceedance days, while Skyforest and Running Springs had five and four fewer days exceeding the standard, respectively. These differences indicate the spatial variability of O_3 across the San Bernardino Mountains and provide an indication of how relocating the site may impact the number of 8-h exceedances recorded for the region. The O_3 spatial variability with 10 additional days exceeding the standard at Lake Arrowhead in comparison with Skyforest is surprising as these two sites are located less than 5 km apart. This significant difference between locations in close proximity was surprising, not expected prior to monitoring, and could likely not have been predicted by simulation prior to monitoring. Many physical and chemical processes influence ambient O_3 concentrations. Models that predict O_3 concentrations simulate these physical and chemical processes. The simulation of atmospheric processes is challenging with the introduction of errors due to a lack of understanding of the physical and chemical processes, model assumptions, and data limitations [33]. Chemical process simulations include but are not limited to photolytic reactions and radical chemistry, while physical process simulations include but are not limited to emission sources and sinks, dispersion and diffusion, and meteorological conditions. An important physical process for air quality forecasting is the planetary boundary layer (PBL) which is the lowest layer of the atmosphere starting at the earth's surface and capped by a stable layer [34]. The PBL layer height is difficult to predict when frontal boundaries (i.e., mountains) are present or multiple level thermal inversions are formed [35]. When the sun is setting, a second thermal inversion can form with the rapid loss of solar flux at the surface of the earth. This second layer forms the stable nocturnal boundary layer leaving a residual layer above that can potentially trap pollutants aloft. Simulations can be performed at varied spatial (regional to neighborhood) and temporal resolutions (yearly to hourly). The National Weather Service provides a national air quality forecast for the United States hour by hour at a spatial resolution of 12 km for O_3 to provide advance notice of air pollution events [36]. In an active open-source development project, the U.S. EPA has developed the Community Multiscale Air Quality Modeling System (CMAQ) that consists of a suite of programs for creating air quality simulations [37]. The CMAQ model has been used to simulate air quality at finer spatial scales. With the addition of high-resolution input data, ozone concentrations were simulated for the Baltimore/Washington region at a 1 km spatial resolution. The bias between the simulation and surface ozone monitoring sites was found to follow a similar diurnal pattern with a positive mean bias in the early morning hours that decreases throughout the day until sunset when the bias starts increasing [38]. CMAQ was used in more complex topography in the San Joaquin Valley in California at 2–12 km and in the Colorado Front range at 4 km spatial resolution [39]. During O_3 exceedances in Colorado, the simulation was found to capture the timing and rate of the initial rapid O_3 production well, but largely underestimated the persistence of elevated concentrations when compared to surface O_3 measurements. While the model correctly simulated regional O_3 concentrations, verification with the local air monitoring stations revealed under- and over-estimation errors [32]. The spatial variability in O_3 concentrations found between the locations in this study and the potential bias of O_3 simulations indicates the importance of developing accurate sensing nodes and monitoring air pollutants in spatially dense networks to investigate the spatial variability of air pollutants and identify such spatial phenomena. This is especially true for regions with complex topography, meteorology, and atmospheric chemistry.

Table 5. Exceedances of the U.S. EPA 2015 8-h ozone standard of 70 ppb.

Location—Unit	No. of Exceedances (Days)
Crestline—Thermo 49i	32
Skyforest—POM 1122	27
Lake Arrowhead—POM 1145	38
Running Springs—POM 1148	28

The topography and population of the distinct locations may have a factor in the differences in O_3 concentrations between the four monitoring locations. The Crestline community has a population of roughly 10,000 residents with a valley topography with homes distributed around Lake Gregory and the Crestline AMS. The Lake Arrowhead and the Skyforest monitoring locations are at the outer southern edge of the populated Lake Arrowhead region (12,400 population) and are located along the SR-18 highway. Both Lake Arrowhead and the Skyforest location are higher in elevation by an estimated 350 m when compared to the Crestline location and have views looking into the lower San Bernardino County valley communities. This topography with an overlooking view is quite different than the valley topography of the Crestline location. Running Springs has a population of roughly 4800 residents with the monitor located at the southeastern edge of the community near an elementary school. The location of the Crestline AMS in the middle of a mountain community in contrast to the other three monitoring locations may potentially explain the differences in evening O_3 concentrations. As commuters return home in the late afternoon/early evening, vehicle tailpipe emissions of NO titrate O_3 from the Crestline community. Other stationary sources located within a mile of the Crestline AMS that may potentially play a role in O_3 production and/or titration include two gasoline fuel stations, a wastewater treatment plant, and other establishments that may increase local traffic. The Crestline valley topography may also contribute to the stagnation of air which in turn leads to higher maxima during the day and lower minima concentrations at night. Prior research between urban and rural sites show similar trends seen in this work with a nighttime minimum for O_3 more pronounced in urban locations [13]. These differences in topology, population, and siting location provide an explanation for

why nighttime MAD is larger than daytime MAD between Crestline and the potential relocation sites.

The local traffic patterns in the region may also have an impact on O_3 patterns and evening titration of O_3 from the atmosphere. The California Department of Transportation (Caltrans) provides Annual Average Daily Traffic (AADT) estimates for state highways. AADT data for 2017 was retrieved from www.data.ca.gov as a geodatabase (GDB) with shapefiles for AADT which were viewed using ESRI ArcGIS Pro mapping software. Figure 10 shows the AADT estimates for relevant locations within the monitoring region. From the base of the mountains, AADT for California State Route 18 (SR-18) near Waterman Canyon is estimated at 16,800 daily counts. SR-18 is a common route for daily commuters who live in the mountain communities and work in the valley communities below. Roughly 40% of the AADT heading into the mountain communities on SR-18 diverts into Crestline via SR-138 with traffic counts estimated at 6800 counts for SR-138. The remaining 60% of the daily traffic continues along SR-18 towards Arrowhead with AADT estimated at 10,000 counts along SR-18 past Crestline. While Crestline has two significant corridors into the city from SR-18 with SR-138 and Lake Gregory Dr., Lake Arrowhead has four significant corridors into the community with Daley Canyon Rd to SR-189, SR-173, Arrowhead Villa Rd., and Kuffel Canyon Rd. These additional entrance/exit routes serve to spatially spread out the daily commuter traffic and may reduce the impact of the evening commuter traffic emissions scavenging O_3. The SR-330 travels from the valley in San Bernardino and merges with SR-18 in Running Springs. SR-330 is the primary route for commuters heading into Running Springs and one of several routes that lead to the Big Bear region. AADT measured at the base of the mountain at SR-330 and Highland Ave. indicates AADT at the base of the mountain is estimated at 11,500. After the merging of SR-18 and SR-330 in Running Springs, SR-18 has increased traffic counts with AADT estimated at 10,700. This increased traffic flow on SR-18 with the merging with SR-330 in the Running Springs community contrasts with the Crestline monitoring location that is embedded in the community and located away from the SR-18.

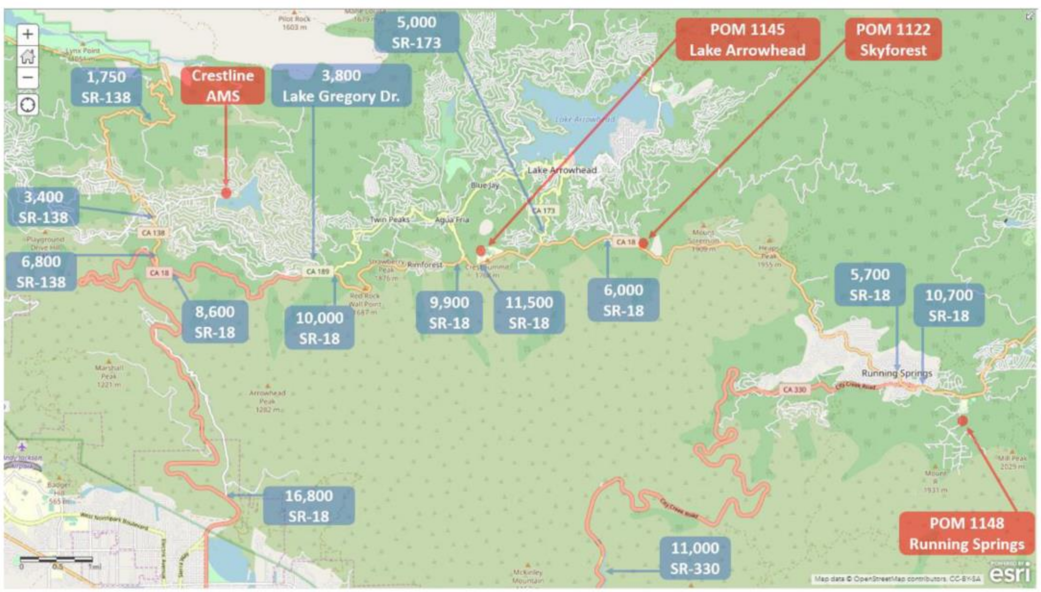

Figure 10. Annual Average Daily Traffic estimates by location for the monitoring region of interest. * SR: State Route.

The spatial scale of the Crestline AMS is considered to be a neighborhood scale monitoring site [19]. A neighborhood scale monitoring station is one that is defined to extend throughout an area of a city with relatively uniform land use with a range of 0.5 to 4.0 km [40]. The spatial variability of O_3 between the Crestline AMS and the three sites (5.8 to 17.1 km from Crestline) supports this scale with the changing topography, population, and local land use between the mountain communities. When relocating a site, the data uses of the current site need to be examined to ensure the relocation site meets the desired data uses. The primary data uses for the Crestline O_3 data are the evaluation of ambient air quality, protection of public health, and scientific research. Since Crestline is a site were high O_3 concentrations are recorded in the SCAB, the evaluation of ambient air quality and determination of the NAAQS and CAAQS stands in the forefront. Therefore, the Lake Arrowhead location, which was the only site with a 95% CI on the MBD to be on at least 2% higher than the current site, would be the best choice for a relocation site. The Lake Arrowhead relocation option with higher O_3 concentrations also suits the monitoring purpose of protecting public health as this location would likely indicate higher calculated AQI values and provide the associated AQI health messaging to warn residents during high O_3 pollution events. Relocating to the Lake Arrowhead site would likely yield O_3 monitoring data between 2.0% and 9.7% higher on average (95% confidence on MBD) than the Crestline AMS. This lack of continuity between measurement locations with higher concentrations at the relocation site would not be beneficial for the tracking of long-term air quality trends. Since the Lake Arrowhead relocation site would likely experience more O_3 exceedances than the Crestline location, assessing the progress in achieving the air quality standards, with regard to regulatory or incentive actions taken to meet the standard, would not be measurable until several years of monitoring data is collected for trend tracking. Data uses involving long-term trend analysis and tracking of impacts on the environment and public health effects are benefited from long-term continuous measurements in one location. With that in mind, other than maintaining the site in Crestline, relocating to the Skyforest location would be the most likely relocation option since this site nearly matches the average concentrations at Crestline and most closely tracks the Crestline diurnal trends with the best regression statistics between the three relocation sites. With protecting public health and welfare as one of the ultimate goals of monitoring air quality, monitoring stations are strategically placed in locations with high population density. The current monitoring site in Crestline is the most strategically located as this location is situated near the center of a mountain community in contrast to the potential relocation sites located at the edges of their respective population centers.

In this study, the sensor nodes were developed to obtain O_3 concentration across a region to determine potential alternative siting locations for an ambient air monitoring station with uncertainty around the renewal of the lease agreement for the current monitoring site. While these sensing nodes were purposely built for parallel monitoring of O_3, the sensing platform could be used in other ambient applications due to the ease of installation, versatility with power and connectivity options, and accuracy of the O_3 monitors. Each of the four locations monitored in this work included areas where the physical activity took place and ranged from water sports activities, high school athletics, biking/mountain biking, ice-skating, and softball/baseball. Two of the locations are adjacent to schools where physical education classes and school sporting events are conducted. Deployment of real-time O_3 sensors in O_3 pollution impacted communities at schools could provide data to school administrators and coaches on their current hyper-local O_3 concentrations that could be used to make determinations on the appropriateness of conducting physical activities. Threshold values based on health and exposure studies could be established to set up alert notifications to inform decision-makers

when O_3 concentrations reach unhealthy or unsafe conditions.

This evaluation of the spatial and temporal ozone trends is limited due to the specific application of this project to determine if a nearby location to the current Crestline AMS could serve a potential relocation site. This study was performed in a relatively tight geographical area and over a 2-month period during the high ozone season. A more comprehensive study to investigate spatial and temporal trends in the region could be designed and would include additional sites (urban/rural) and be performed for a longer duration to include multiple seasons.

4. Conclusions

This paper presents the development and deployment of a small network of highly accurate remote O_3 sensor nodes for performing parallel monitoring to examine three potential relocation sites for a regulatory air monitoring site. The deployment methodology of the three O_3 sensing nodes included a pre-deployment co-location calibration to a reference O_3 analyzer with post-deployment co-location results indicating a MAE for 1-h O_3 concentrations to be less than 2 ppb between the POMs and the O_3 reference instrument at the monitoring site. The O_3 sensing nodes provided accurate, precise, and real-time O_3 measurements that were displayed on an online dashboard for real-time viewing and reporting. The high-level of confidence in the data generated by these sensing nodes allows for investigating the spatial and temporal trends across the distinct locations that could serve as a relocation site for the current regulatory monitoring station in the San Bernardino Mountains. The results indicate that spatial variability exists between these locations with differences more pronounced in the evening hours. When examining exceedances of the 2015 8-h standard at 70 ppb, locations within 5 km from each other differed by more than 10 exceedance days over the deployment period. The parallel monitoring was successful in providing the data to adequately defend a relocation strategy for the current O_3 monitoring site with only one site providing a 95% confidence that concentrations would be higher than the current monitoring location.

Supplementary Materials: The following are available online at http://www.mdpi.com/1424-8220/20/1/16/s1, Figure S1: 2B Tech Personal Ozone (O_3) Monitor (POM), Figure S2: Netronix Thiamis 1000, Table S1: Bill of Materials for O_3 Sensing Node, Figure S3: Calibration Verification of 2B POMs, Figure (S4): Map of Southern California with deployment locations, Data Analysis/Calculations section with Equation (S1): Mean Bias Error (MBE), Equation (S2): Mean Absolute Error (MBE), Equation (S3): Mean Bias Deviation (MBD), and Equation (S4): Mean Absolute Deviation (MBD), a section with Hampel Filter information, High Values Data Set Equations with Equation (S5): Lower Limit of 95% CI (L), Equation (S6): Upper Limit of 95% CI (U), Equation (S7): Lower Limit %, and Equation (S8): Upper Limit %, and Table S2: In-situ collocation calibration offsets based on ordinary least squares regression.

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