

Clean Air Status and Trends Network (CASTNET) Quarterly Data Summary for Second Quarter 2021 (April through June)

Prepared for: U.S. Environmental Protection Agency (EPA), Clean Air Markets Division

EPA Contract No.: 68HERH21D0006, CASTNET Base Program (0003)

Prepared by: Wood Environment & Infrastructure Solutions, Inc. (Wood), Gainesville, Florida

Wood Project No.: 6064216003

Submitted: September 30, 2021

Introduction

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during second quarter 2021. Trends in pollutants measured at eastern and western reference sites are shown. Results from the quality assurance/quality control (QA/QC) program are presented for second quarter data and include completeness and precision of filter concentrations and hourly O₃ concentrations. This report also analyzes data for continuous, trace-level NO_y from eight sites and continuous SO₂ concentrations from three sites. Other QC statistics are given in the CASTNET Second Quarter 2021 Quality Assurance Report (Wood, 2021).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O₃ Concentrations (ppb) through Second Quarter 2021



Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O₃ concentrations measured through second quarter 2021. Two sites in California and the SAN189, NE site exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O₃.

Trends

Trend analyses were performed based on filter pack pollutant concentrations measured in micrograms per cubic meter (µg/m³) of air at the 34 eastern and 16 western reference sites during second quarter. Trends in quarterly mean filter pack and O₃ concentrations are shown using box plots in Figures 2 through 13.

Second Quarter Concentrations

Second quarter mean HNO₃, NO₃⁻, NH₄⁺, total NO₃⁻, SO₂, SO₄²⁻, Ca²⁺, K⁺, Mg²⁺, and Na⁺ concentrations increased at eastern sites in 2021, and Cl⁻ concentrations decreased. All second quarter mean concentrations increased at western sites in 2021.

Quarterly O₃ concentrations were analyzed using box plots constructed by averaging all valid hourly O₃ concentrations within second quarter 2021 by site and then averaging those averages for all eastern and western reference sites (Figure 13). The figure shows an overall reduction in quarterly mean O₃ concentrations at eastern and western sites. Mean O₃ concentrations increased slightly in second quarter 2021. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Second Quarter Mean HNO₃ Concentrations

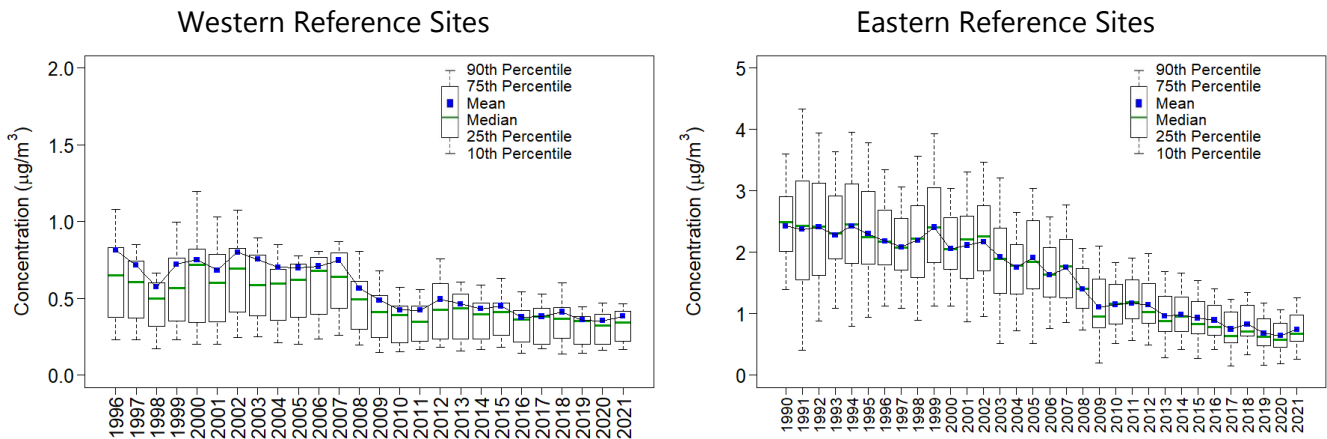


Figure 3. Trends in Second Quarter Mean NO₃⁻ Concentrations

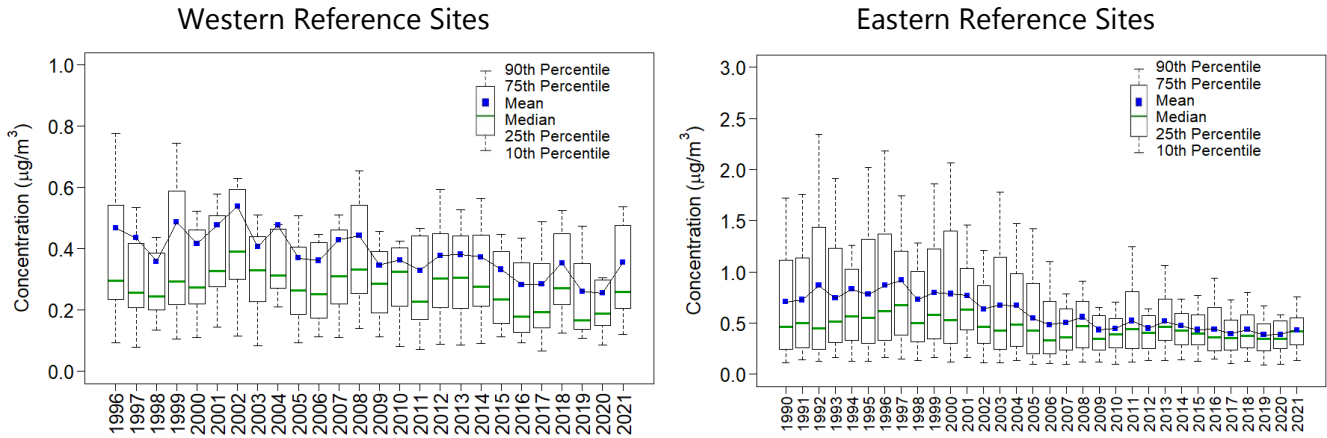


Figure 4. Trends in Second Quarter Mean NH₄⁺ Concentrations

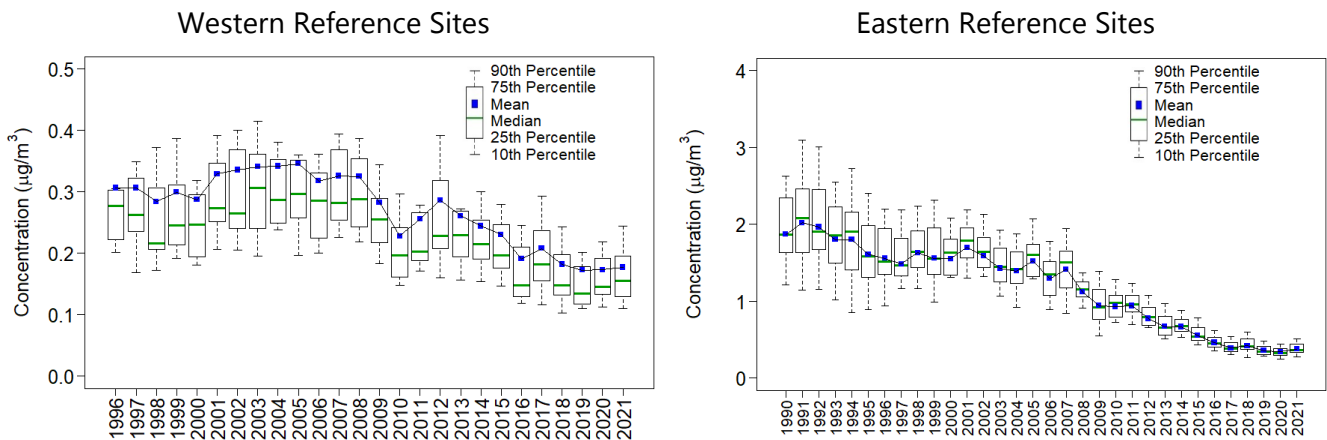


Figure 5. Trends in Second Quarter Mean Total NO₃⁻ Concentrations

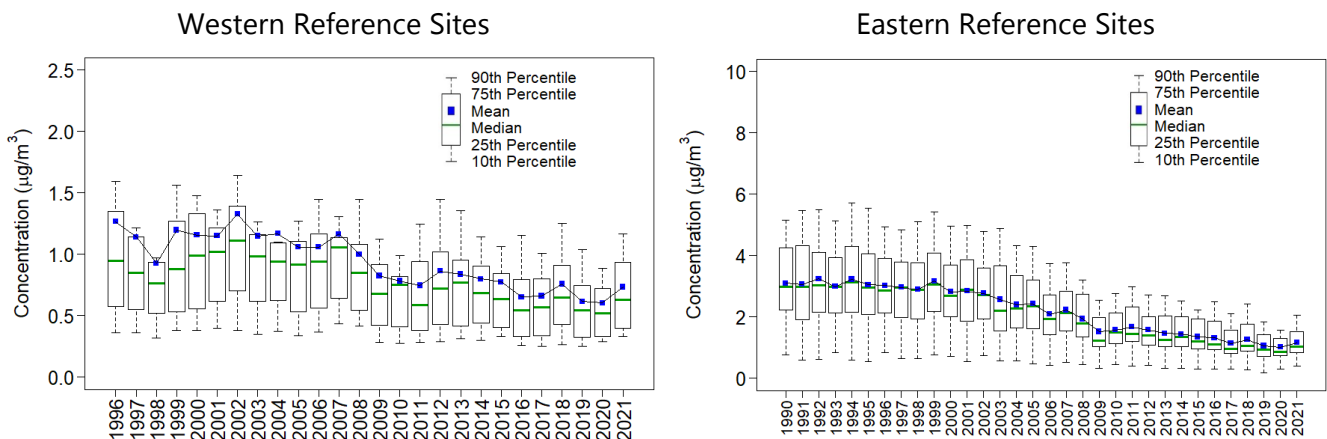


Figure 6. Trends in Second Quarter Mean SO₂ Concentrations

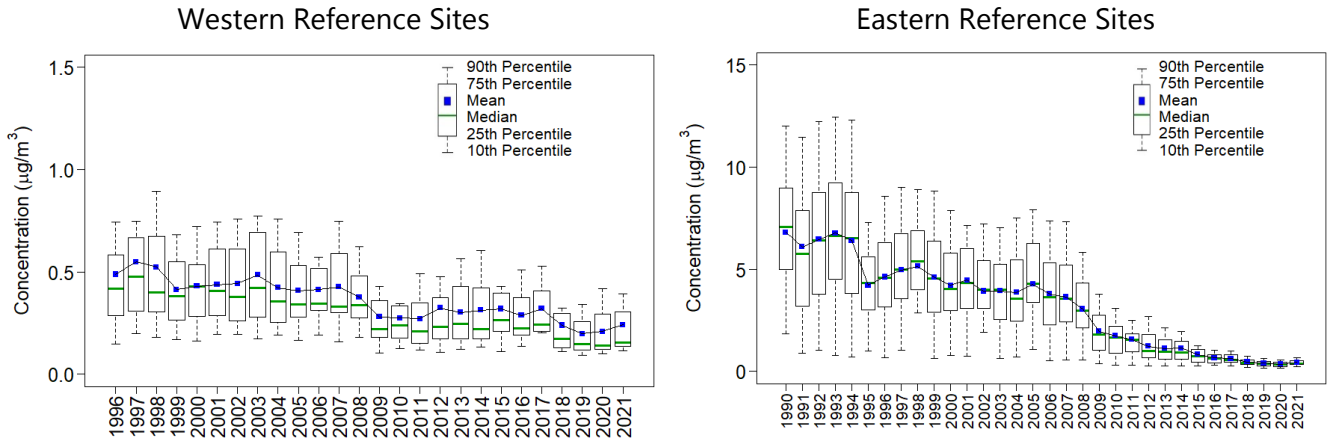


Figure 7. Trends in Second Quarter Mean SO₄²⁻ Concentrations

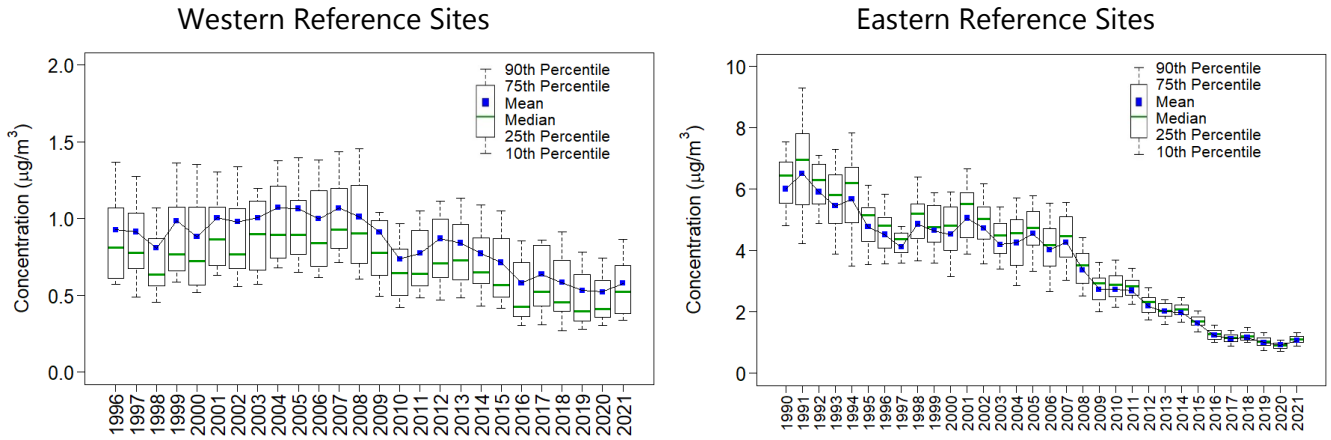


Figure 8. Trends in Second Quarter Mean Cl⁻ Concentrations

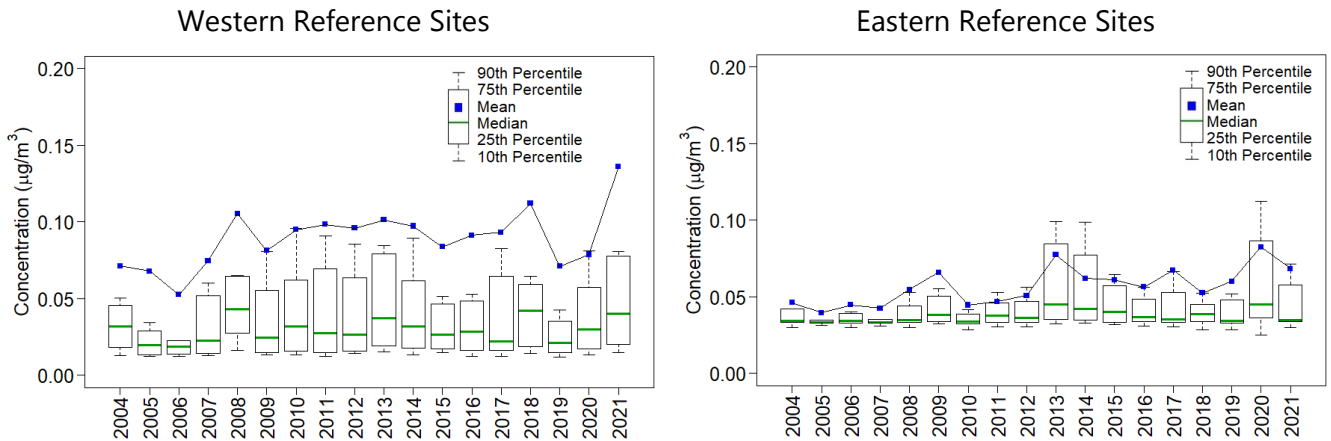


Figure 9. Trends in Second Quarter Mean Ca^{2+} Concentrations

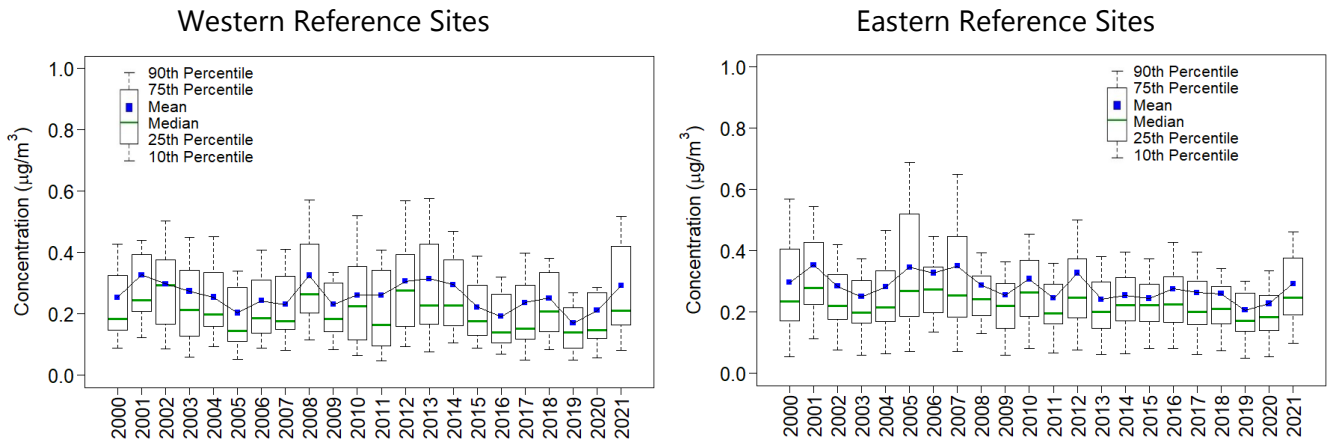


Figure 10. Trends in Second Quarter Mean K^+ Concentrations

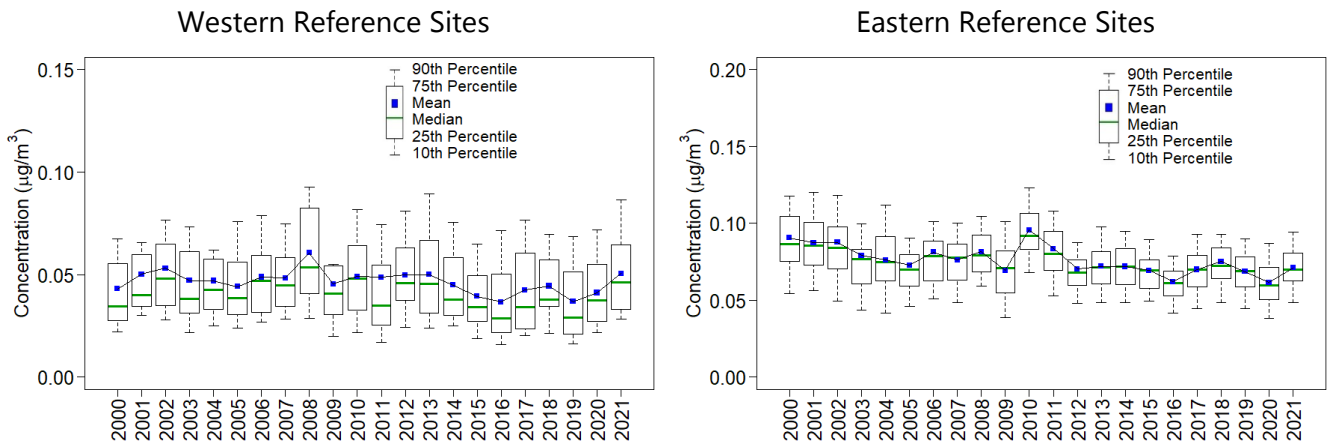


Figure 11. Trends in Second Quarter Mean Mg^{2+} Concentrations

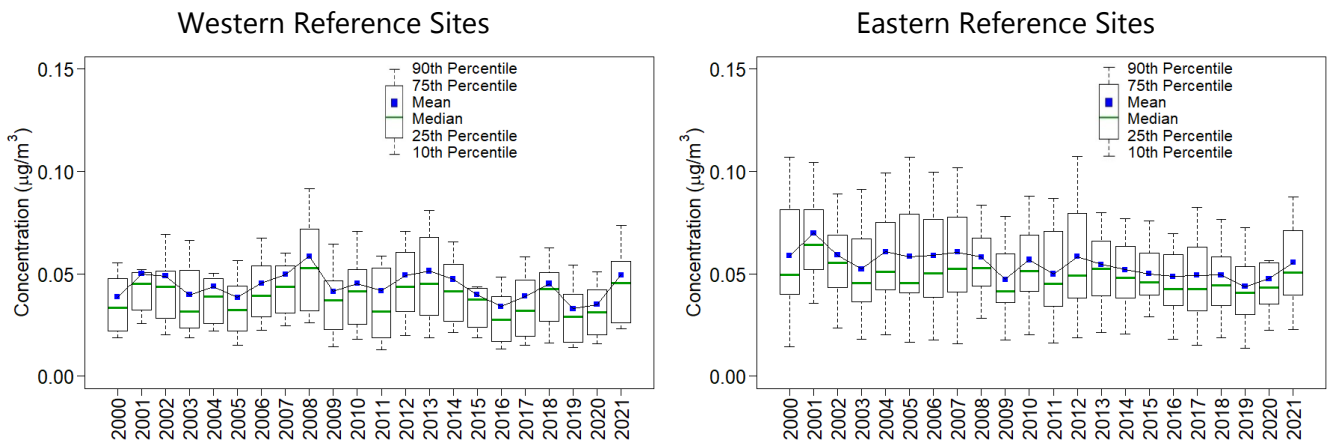


Figure 12. Trends in Second Quarter Mean Na⁺ Concentrations

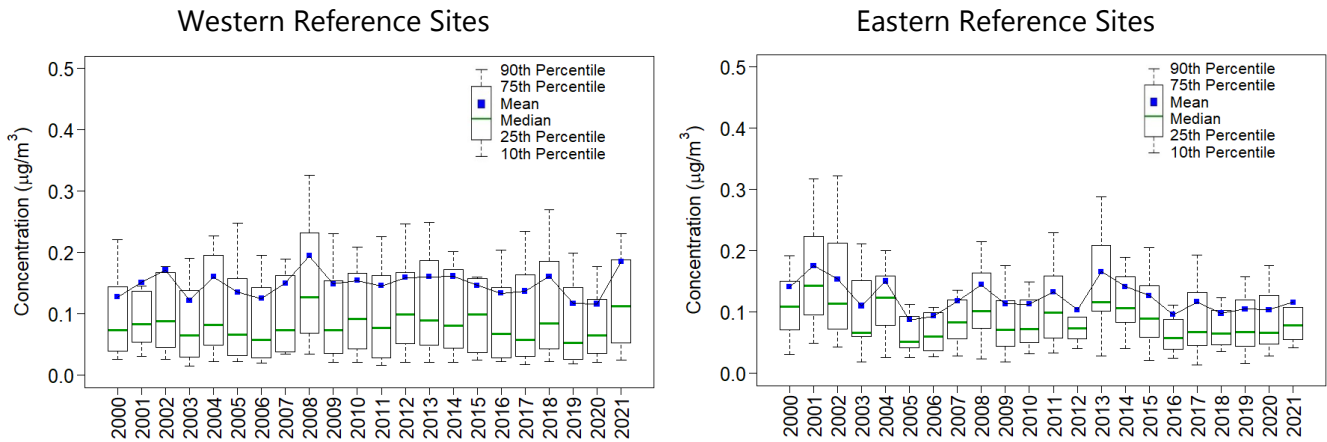
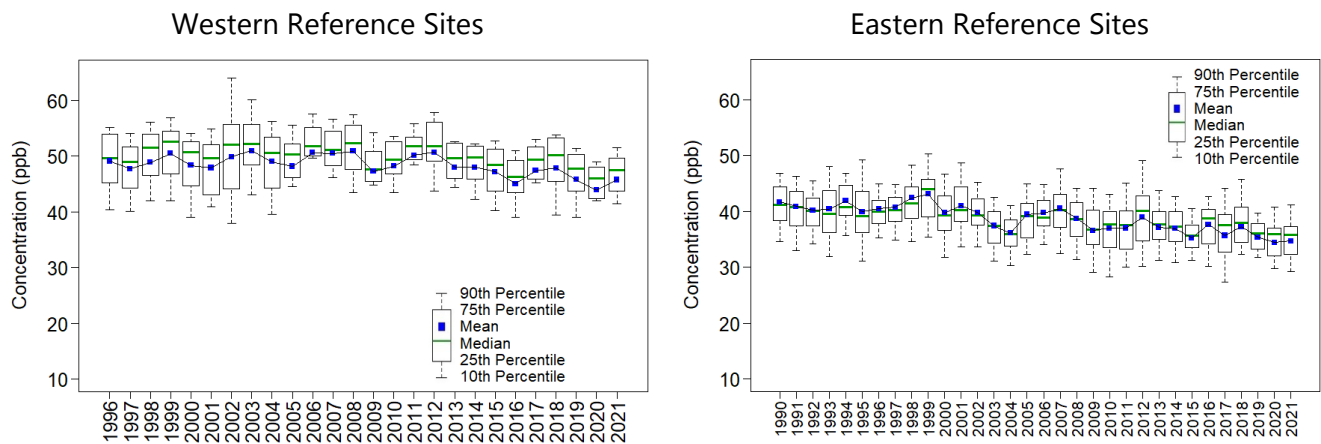


Figure 13. Trends in Second Quarter Mean O₃ Concentrations



Changes in 3-year Average Second Quarter Concentrations

Three-year averages of quarterly mean concentrations of total NO₃⁻, NH₄⁺, SO₂, SO₄²⁻, and O₃ were reduced over the period 1990–1992 through 2019–2021 for eastern reference sites and 1996–1998 through 2019–2021 for western reference sites. Tables 1 and 2 summarize changes in 3-year average second quarter concentrations.

Table 1. Eastern Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O₃ Pollutant Concentrations

	Total NO ₃ ⁻ (µg/m ³)	NH ₄ ⁺ (µg/m ³)	SO ₂ (µg/m ³)	SO ₄ ²⁻ (µg/m ³)	O ₃ (ppb)
1990–1992	3.1	2.0	6.5	6.1	41
2019–2021	1.1	0.4	0.4	1.0	35
Percent Change	-66	-82	-94	-84	-15

Table 2. Western Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O₃ Pollutant Concentrations

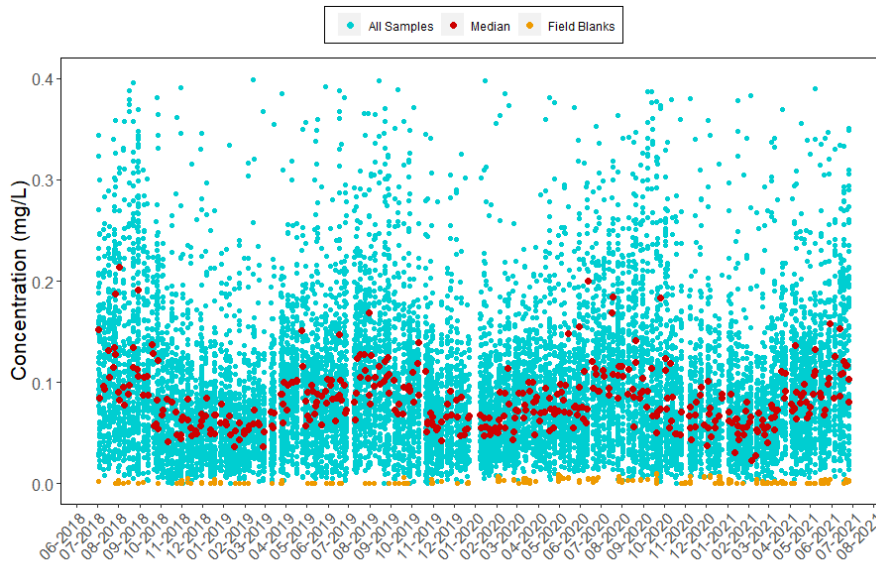
	Total NO ₃ ⁻ (µg/m ³)	NH ₄ ⁺ (µg/m ³)	SO ₂ (µg/m ³)	SO ₄ ²⁻ (µg/m ³)	O ₃ (ppb)
1996–1998	1.1	0.3	0.5	0.9	49
2019–2021	0.7	0.2	0.2	0.5	45
Percent Change	-41	-42	-59	-38	-7

Time Series of Laboratory Analysis Parameters for All Sites

Figures 14 through 24 give time series of laboratory-analyzed concentrations of field samples and field blanks in milligrams per liter (mg/L) of 11 parameters from third quarter 2018 through second quarter 2021. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

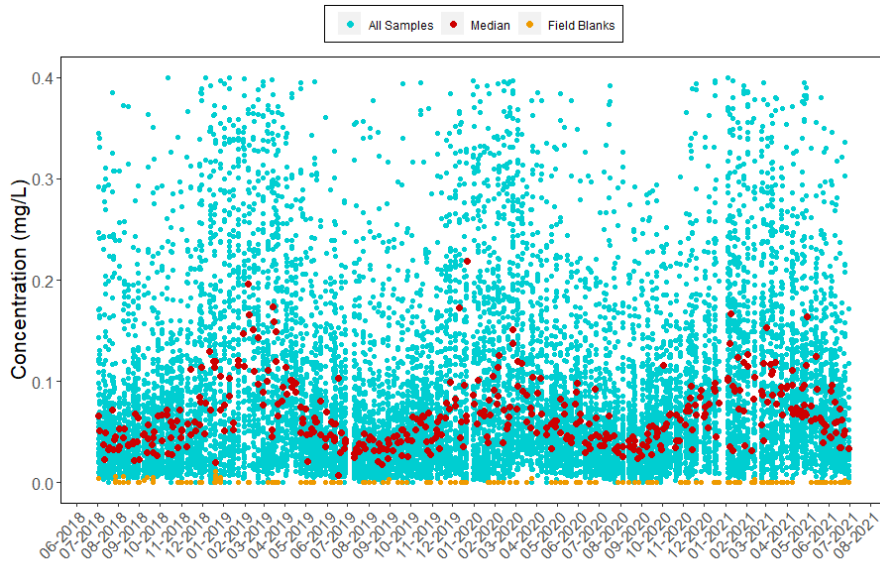
Figure 17 shows unusual results from the cellulose filter field blanks at end of quarter. The eluent from Wood’s established supplier was not available and one from a different supplier was used. The new eluent produced unexpected results, including some elevated field blank data. Another eluent was then purchased from a different provider and utilized. Prior to use, the laboratory tested and approved the replacement eluent. Reanalysis of field blanks confirmed that results with the replacement eluent, which is now in use, were below reporting limits. Preliminary results for reanalysis of field samples indicate the initial analyses were comparable within CASTNET sample replicate criteria.

Figure 14. Concentrations of NO₃⁻ (as N) from Nylon Filters



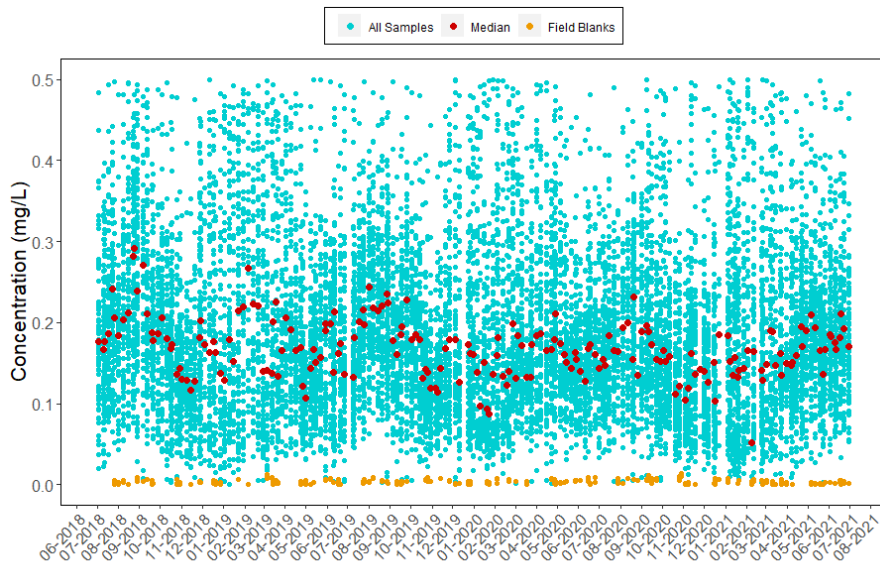
Note: Nominal reporting limit is 0.008 mg/L.

Figure 15. Concentrations of NO_3^- (as N) from Teflon Filters



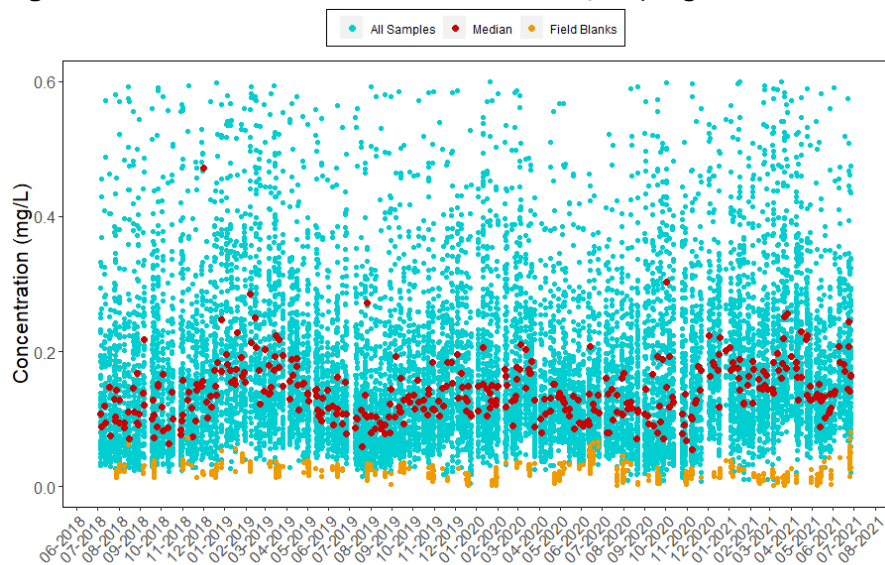
Note: Nominal reporting limit is 0.008 mg/L.

Figure 16. Concentrations of NH_4^+ (as N) from Teflon Filters



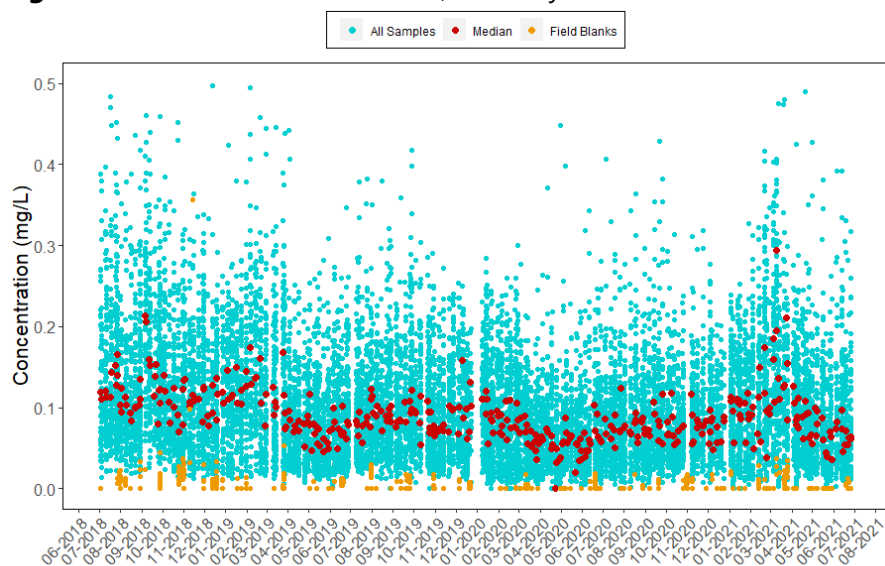
Note: Nominal reporting limit is 0.020 mg/L.

Figure 17. Concentrations of SO₂ from K₂CO₃-impregnated Cellulose Filters



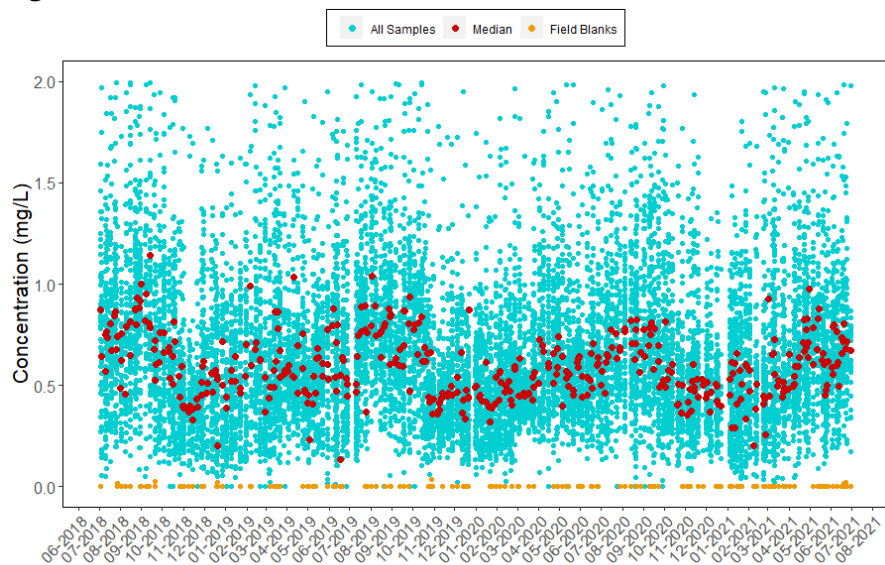
Note: Nominal reporting limit is 0.040 mg/L.

Figure 18. Concentrations of SO₄²⁻ from Nylon Filters



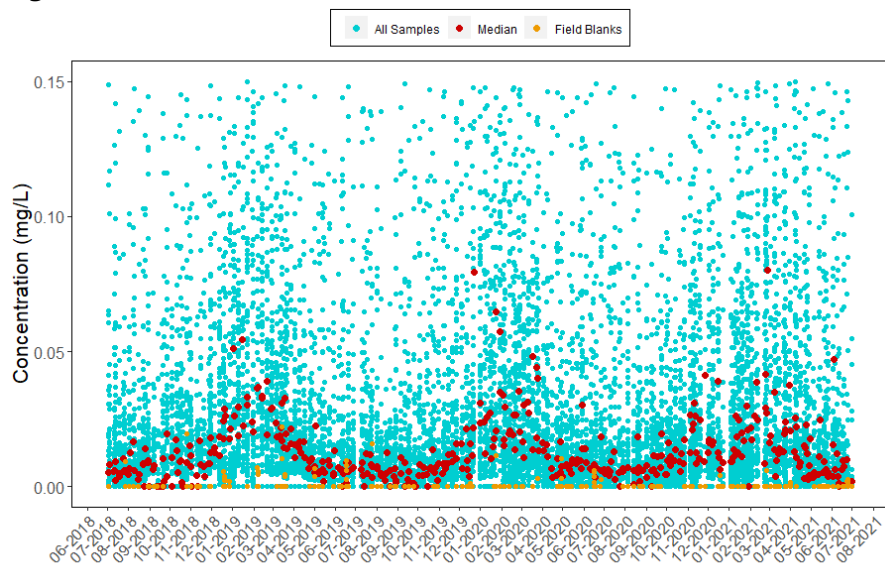
Note: Nominal reporting limit is 0.040 mg/L.

Figure 19. Concentrations of SO_4^{2-} from Teflon Filters



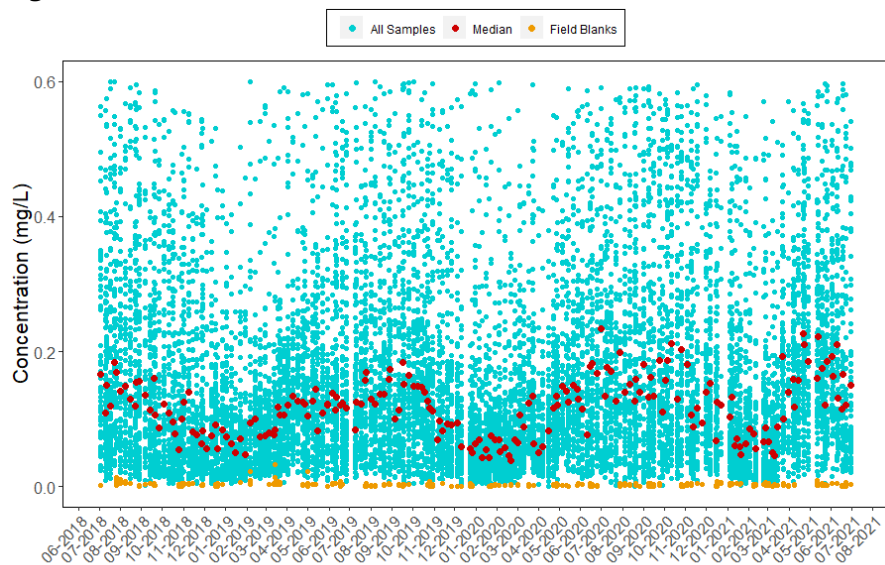
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



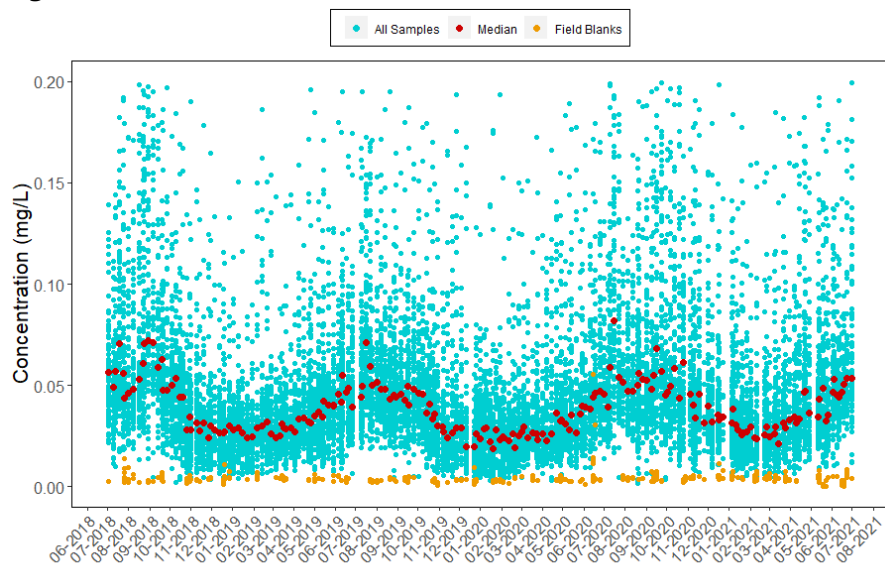
Note: Nominal reporting limit is 0.020 mg/L.

Figure 21. Concentrations of Ca²⁺ from Teflon Filters



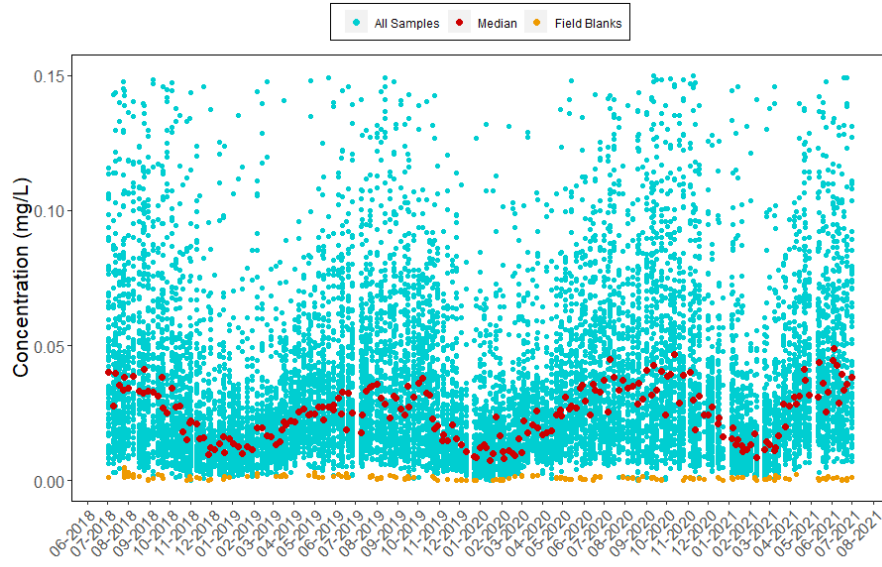
Note: Nominal reporting limit is 0.006 mg/L.

Figure 22. Concentrations of K⁺ from Teflon Filters



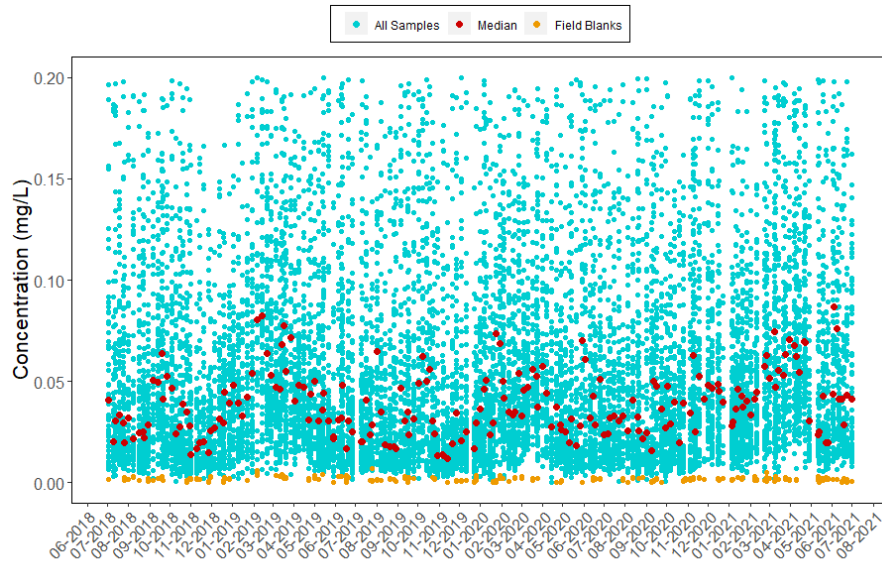
Note: Nominal reporting limit is 0.006 mg/L.

Figure 23. Concentrations of Mg^{2+} from Teflon Filters



Note: Nominal reporting limit is 0.003 mg/L.

Figure 24. Concentrations of Na^{+} from Teflon Filters



Note: Nominal reporting limit is 0.005 mg/L.

Time Series of Concentration Differences from Co-located Sites

Figures 25 and 26 show times series of concentration differences between the two sets of co-located sites. Problems with filter pack flow occurred at MCK231 beginning 6/8/2021 and, consequently, the mass flow controller was replaced on 6/28/2021.

Figure 25. Time Series of Filter Concentration Differences between MCK131 and MCK231, KY

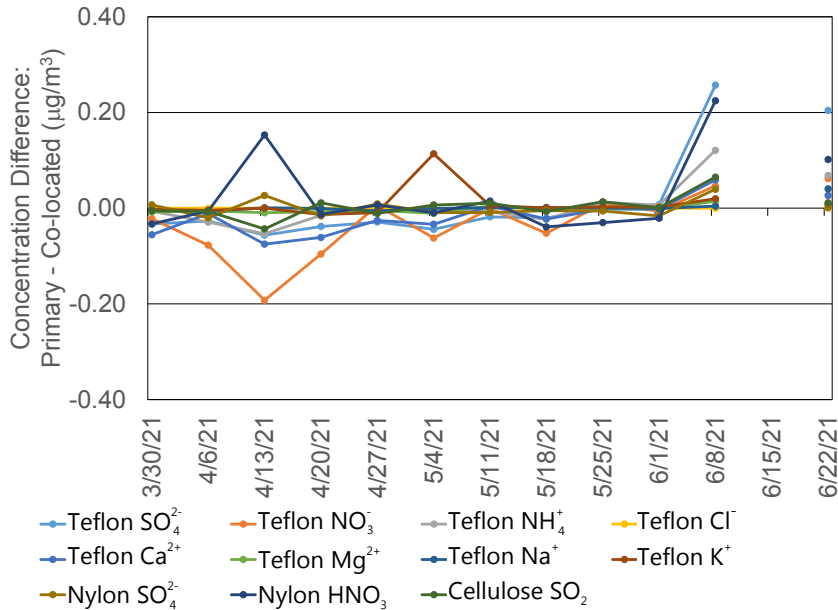
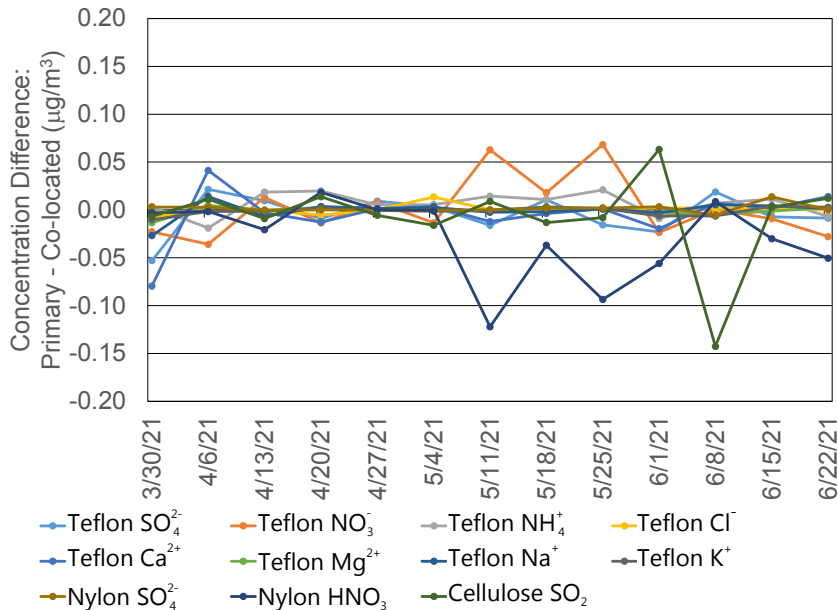


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

Table 3 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231 and ROM406/206 during second quarter 2021. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Second Quarter 2021

	SO ₄ ²⁻	NO ₃ ⁻	NH ₄ ⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	Cl ⁻	HNO ₃	SO ₂	Total NO ₃ ⁻
MCK131/231, KY											
\bar{X} (μg/m ³)	1.14	0.46	0.47	0.27	0.05	0.07	0.09	0.03	0.95	0.43	1.39
\bar{Y} (μg/m ³)	1.12	0.49	0.46	0.29	0.05	0.07	0.08	0.03	0.92	0.42	1.39
MAD	0.06	0.05	0.03	0.03	0.01	0.01	0.02	0.00	0.06	0.02	0.08
MARPD	6.33	10.52	6.52	12.90	13.54	5.91	14.97	0.37	6.27	4.16	6.66
ROM406/206, CO											
\bar{X} (μg/m ³)	0.57	0.42	0.24	0.25	0.03	0.06	0.05	0.02	0.42	0.17	0.84
\bar{Y} (μg/m ³)	0.57	0.42	0.23	0.25	0.04	0.06	0.05	0.02	0.46	0.18	0.88
MAD	0.02	0.03	0.01	0.02	0.00	0.01	0.00	0.00	0.04	0.03	0.04
MARPD	3.61	9.35	6.92	7.86	9.55	14.28	9.48	13.86	9.84	17.58	5.18

Completeness for Filter Pack Concentrations

Table 4 shows CASTNET sites with less than 90 percent completeness for weekly filter pack concentrations. Comments are included to provide information on why these sites experienced low data completeness.

Table 4. Sites with less than 90 Percent Data Completeness for Filter Concentrations for Second Quarter 2021

Site ID	Teflon SO ₄ ²⁻	Teflon NO ₃	Teflon NH ₄ ⁺	Teflon Minor Cations	Teflon Cl ⁻	Nylon HNO ₃	Nylon SO ₄ ²⁻	Cellulose SO ₂	Comment
BBE401, TX	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	A flow system leak affected five samples.
ALC188, TX	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	There were two 2-week samples, one of which was invalidated due to power failures.
PIN414, CA	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	A flow system leak affected two samples.
SAN189, NE	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	There were two 2-week samples.
THR422, ND	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The sampling tower could not be raised due to a broken winch, affecting two samples.

Precision of Ozone Concentrations

Time series of co-located hourly O₃ concentration differences for second quarter 2021 are provided in Figures 27 and 28 for MCK131/231 and ROM406/206, respectively. The figures indicate no consistent bias between the co-located analyzers at these site locations.

Figure 27. Time Series of the Differences in Co-located O₃ Concentrations for MCK131/231, KY

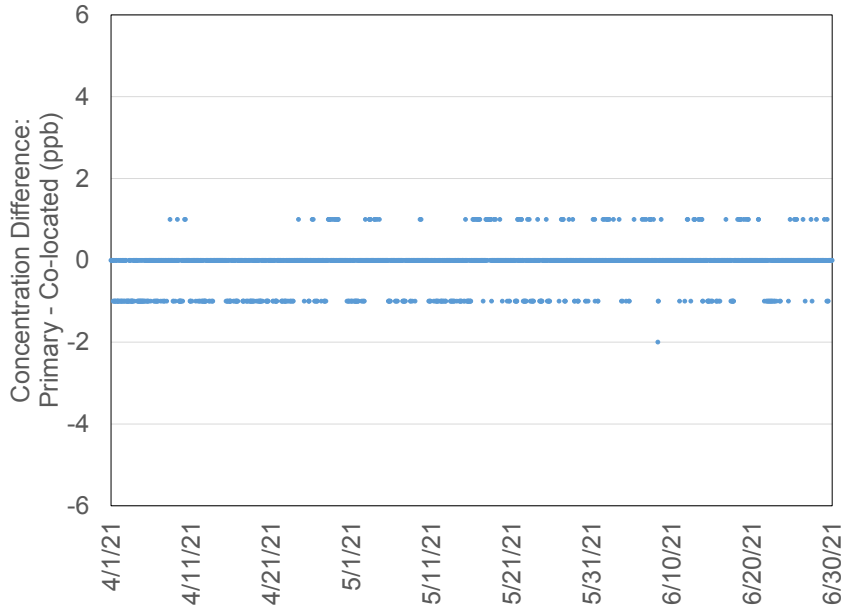


Figure 28. Time Series of the Differences in Co-located O₃ Concentrations for ROM406/206, CO

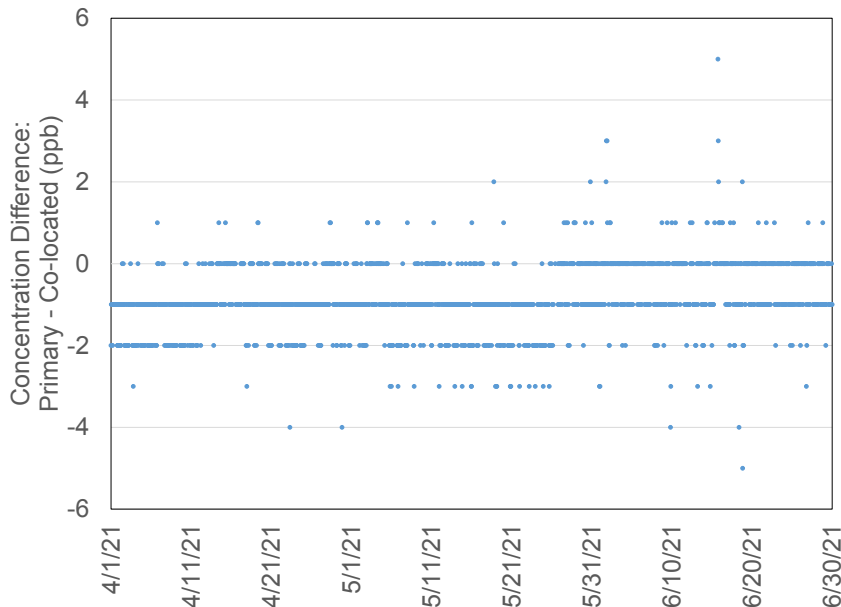


Table 5 gives MARPD data for O₃ data measured at the two co-located sites.

Table 5. Quarterly Precision (MARPD) for Co-located O₃ Concentrations

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	3	7/1/20	1.8	2086
	4	10/1/20	1.5	2069
	1	1/1/21	1.0	2046
	2	4/1/21	0.6	2075
ROM406/206, CO				
	3	7/1/20	1.7	2023
	4	10/1/20	3.3	1996
	1	1/1/21	4.5	2015
	2	4/1/21	1.9	2013

Completeness for O₃ Concentrations

Calculation of an annual O₃ value requires 75 percent completeness. However, calculation of the 3-year design value used for regulatory purposes requires 90 percent completeness. Table 6 shows CASTNET sites with less than 90 percent completeness for DM8A O₃ concentrations. Comments are provided for these sites.

Table 6. Sites with less than 90 Percent Data Completeness for DM8A Concentrations during Second Quarter 2021

Site ID	Percent Completeness	Comments
PSU106, PA	67.0	The analyzer pressure transducer malfunctioned.
PIN414, CA	80.2	On 6/15/2021 the 49iQ analyzer was replaced with a 49i. The replacement analyzer had a bad lamp and was replaced 6/23/2021. In addition, data from 5/11/21 to 5/18/21 were invalidated.
PET427, AZ	83.5	The analyzer power supply failed 6/1/21 and was replaced 6/15/21.
CDZ171, KY	84.6	The communications package power supply failed 3/27/21 and was repaired 4/14.
ALC188, TX	87.9	Power failure affected ozone data collection 5/22/21 to 6/1/21.

Table 7 shows CASTNET sites with less than 90 percent completeness for hourly O₃ concentrations. Comments are provided for these sites. The annual average for each of these sites is included for reference.

Table 7. Sites with less than 90 Percent Data Completeness for O₃ Concentrations

Site ID	Q2 2021	Q3 2020– Q2 2021	Comments
PSU106, PA	67.5	91.2	The analyzer pressure transducer malfunctioned.
PIN414, CA	82.1	92.7	On 6/15/21 the 49iQ analyzer was replaced with a 49i. The replacement analyzer had a bad lamp and was replaced 6/23/21. In addition, data from 5/11/21 to 5/18/21 were invalidated.
PET427, AZ	84.0	95.2	The analyzer power supply failed 6/1/21 and was replaced 6/15/21.
CDZ171, KY	81.8	93.0	The communications package power supply failed 3/27/21 and was repaired 4/14/21.
ALC188, TX	88.6	96.6	Power failure affected ozone data collection 5/22/21 to 6/1/21.

Filter Pack Total Nitrate and Continuous Trace-level NO_y Concentrations at Eight CASTNET Sites

Figures 29 through 36 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO₃⁻ concentrations collected at the eight sites with NO_y measurements. NO_y concentration data were not measured at DUK008 during the quarter. The NO_y concentrations were consistently higher than the total NO₃⁻ levels at all sites with NO_y measurements. The average weekly NO_y levels, the weekly total NO₃⁻ concentrations, and their ratios for the sites with available data are shown in Table 8. Ratios of NO_y to total NO₃⁻ varied from 2.95 at PNF126 to 5.93 at HWF187.

Table 8. Summary of Total NO₃⁻ and NO_y Measurements for Second Quarter 2021

Site ID	Elevation (m)	Total NO ₃ ⁻ (ppb)	NO _y (ppb)	Ratio
DUK008, NC	164*	0.66	-	-
BVL130, IL	213	0.78	4.31	5.14
MAC426, KY	243	0.52	2.04	4.06
HWF187, NY	497	0.17	0.91	5.93
GRS420, TN	793	0.43	1.54	3.66
PNF126, NC	1216	0.37	0.95	2.95
PND165, WY	2386	0.16	0.56	3.50
ROM206, CO	2742	0.26	1.20	4.78

Note: *Enhanced NO_y monitor is located at the top of the 30-m tower.

Figure 29. Comparison of DUK008 Weekly Mean NO_y and Total NO₃⁻ Concentrations

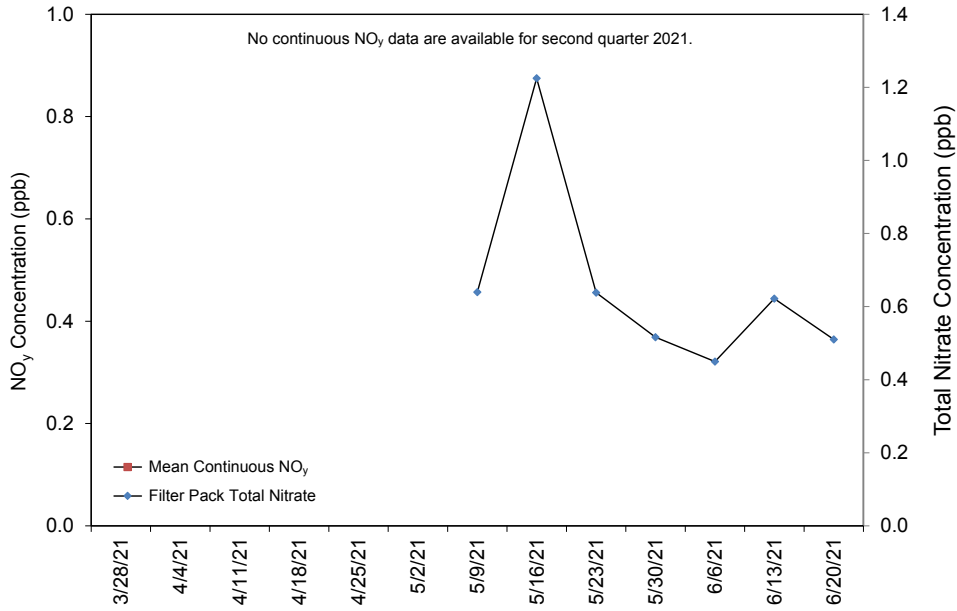


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO₃⁻ Concentrations

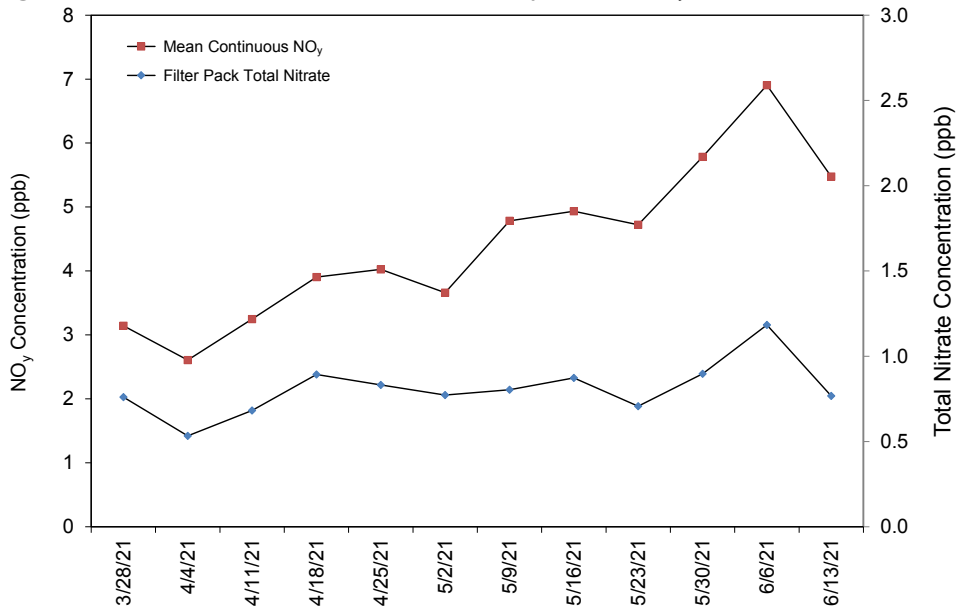


Figure 31. Comparison of MAC426 Weekly Mean NO_y and Total NO_3^- Concentrations

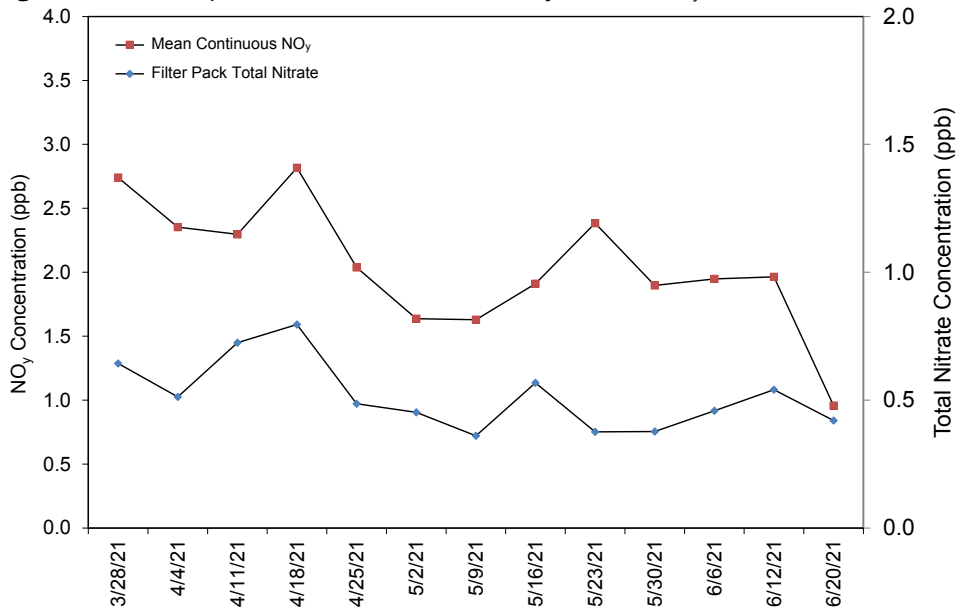


Figure 32. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

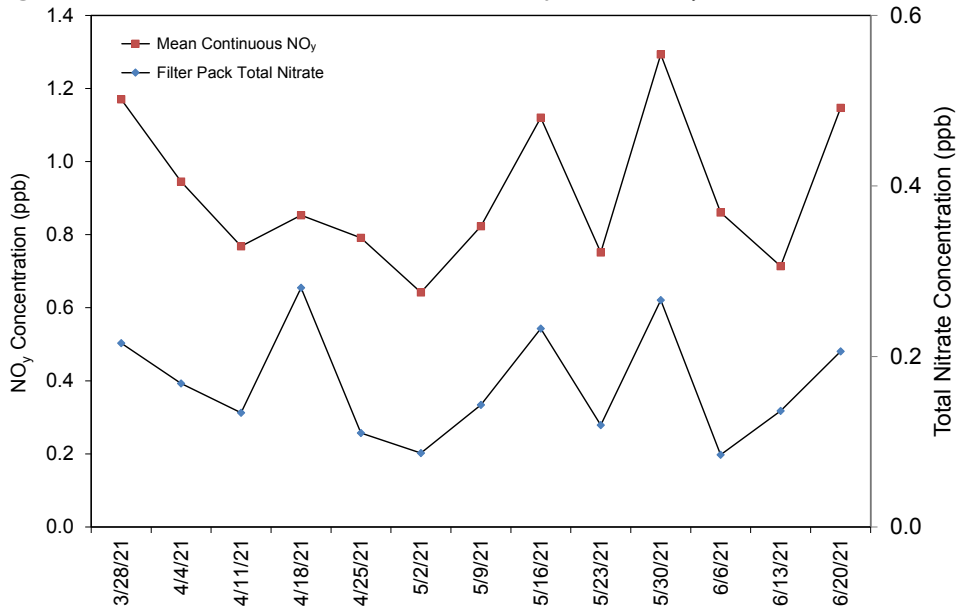


Figure 33. Comparison of GRS420 Weekly Mean NO_y and Total NO_3^- Concentrations

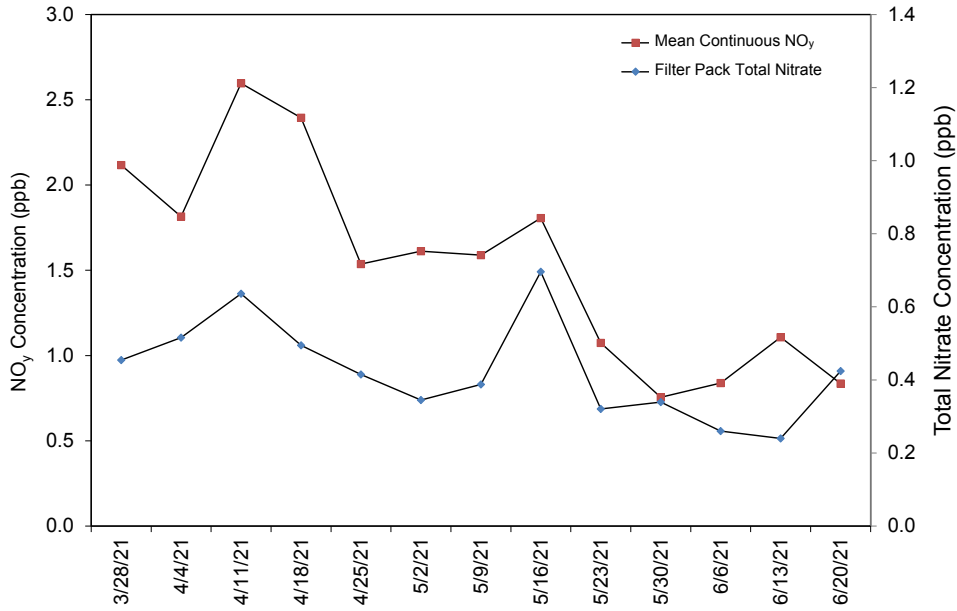


Figure 34. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

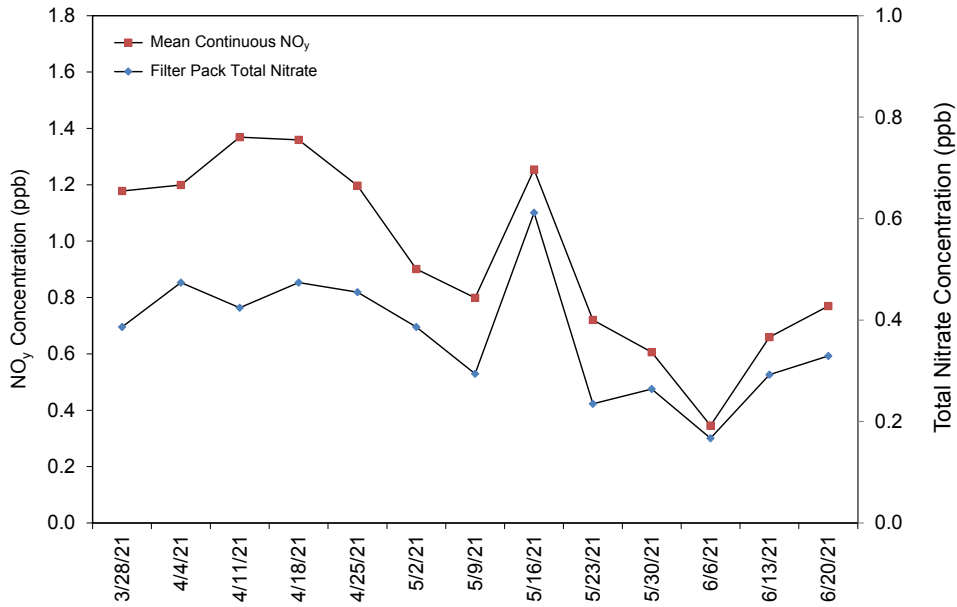


Figure 35. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

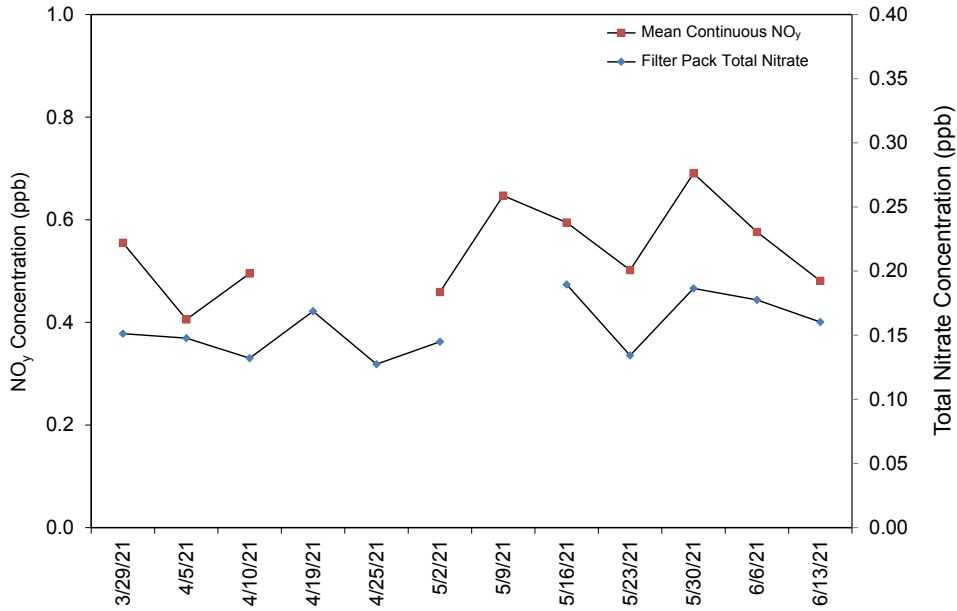
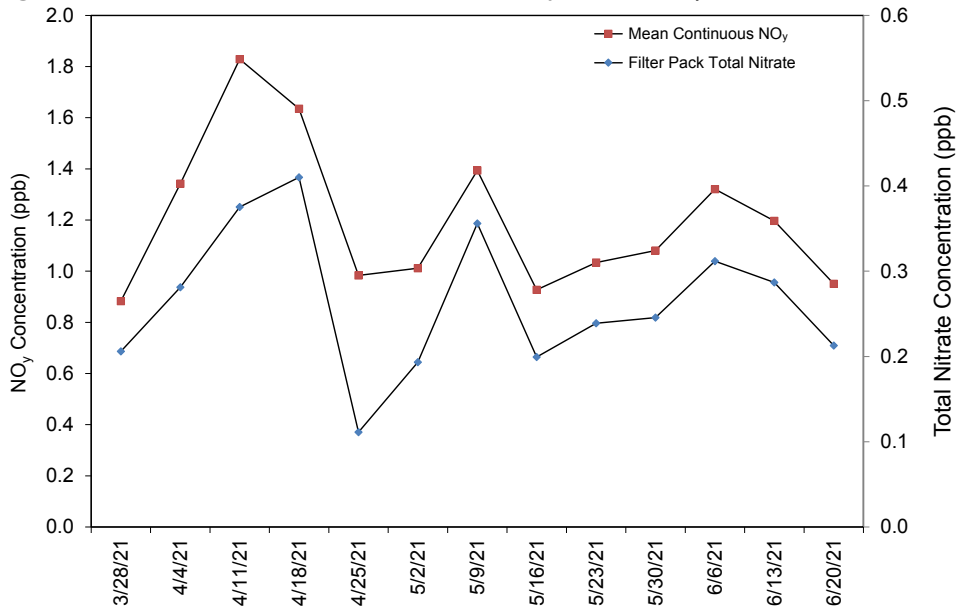


Figure 36. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figures 37 through 39 provide diagrams that compare weekly filter pack SO₂ concentrations with continuous trace-level gas data measured at BVL130, MAC426, and GRS420. The continuously measured trace-level concentrations were higher than filter pack concentrations at BVL130 and were comparable at MAC426 and GRS420.

Figure 37. Comparison of BVL130 Weekly Mean SO₂ Concentrations

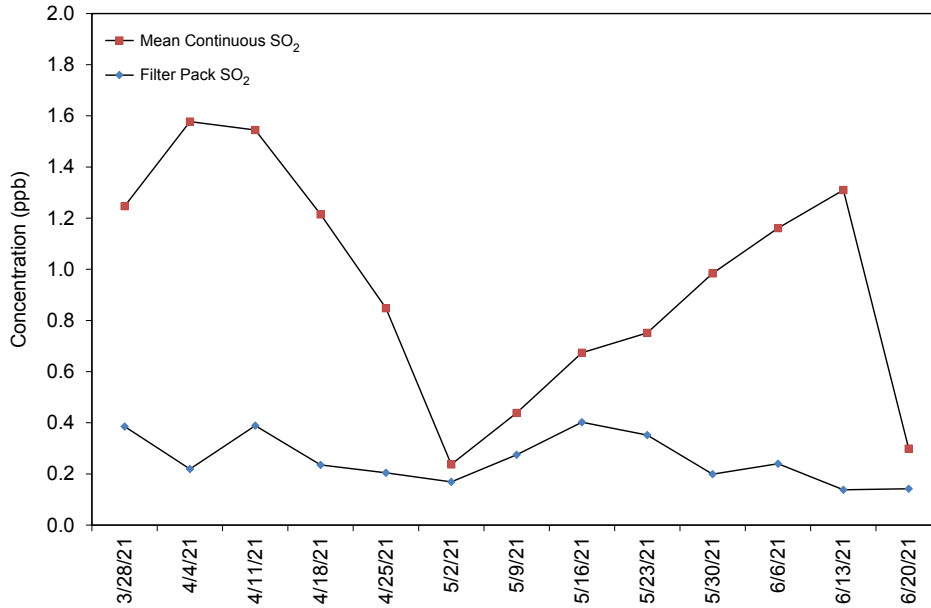


Figure 38. Comparison of MAC426 Weekly Mean SO₂ Concentrations

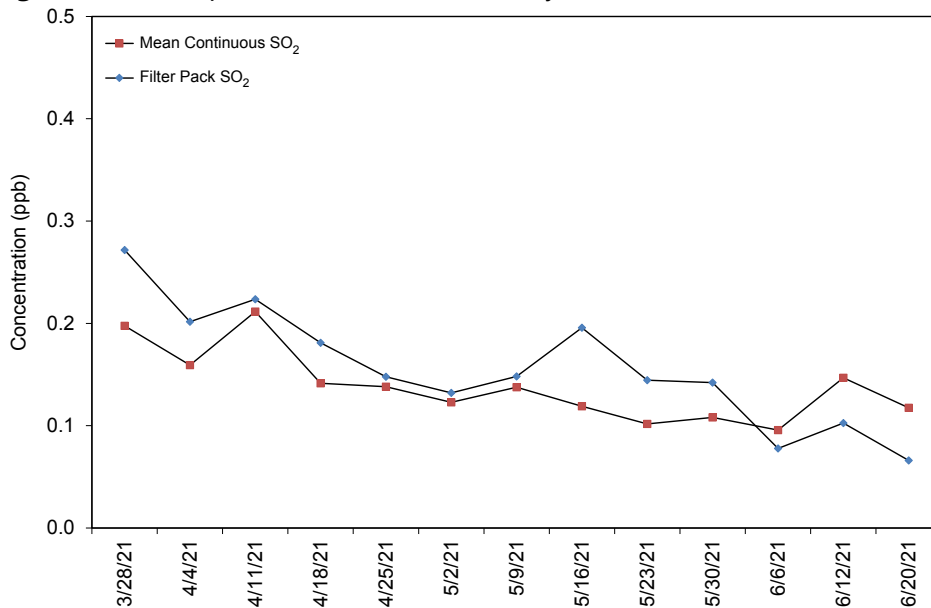
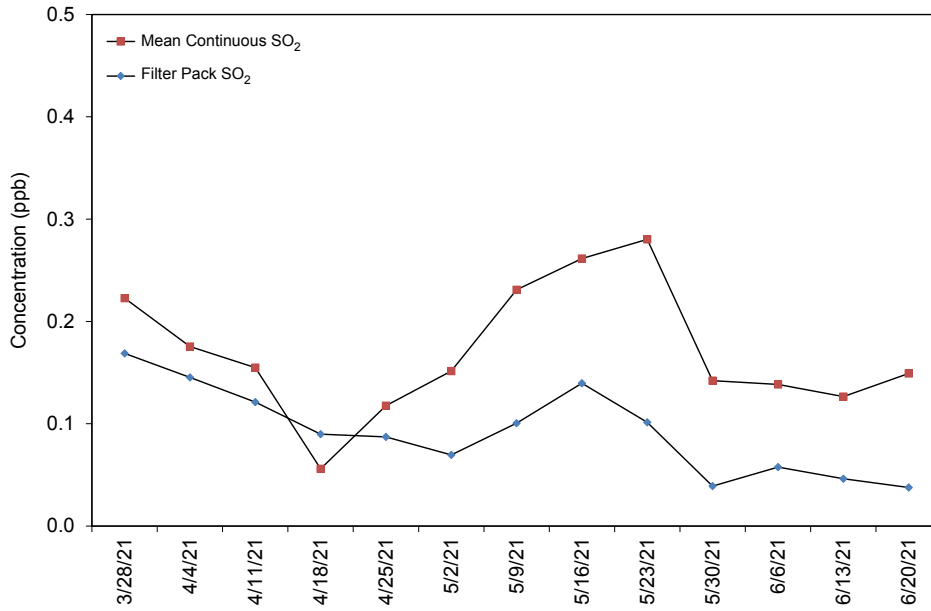


Figure 39. Comparison of GRS420 Weekly Mean SO₂ Concentrations



Completeness for Continuous Trace-level Gas Measurements

Table 9 shows the percent completeness for CASTNET trace-level gas measurements. Comments are provided for sites with less than 90 percent completeness for hourly trace-level gas concentrations during second quarter 2021. The average for third quarter 2020 through second quarter 2021 for each of the sites is included for reference.

Table 9. Percent Data Completeness for Continuous Trace-level Gas Measurements

Site ID	Parameter*	Q2 2021	Q3 2020 – Q2 2021	Comments
BVL130, IL	CO	21	41	The CO analyzer required calibration in April and May.
	NO	95	92	
	NOY	95	92	
	NOYDIF	95	92	The SO ₂ analyzer required calibration in April and June.
	SO ₂ _GA	79	85	
CHC432, NM	NO	97	97	
	NOX	97	97	
	NOXDIF	97	97	
DUK008, NC	HNO ₃	tower down		
	NH ₃	tower down		
	NO	tower down		
	NO ₂ _TRUE	tower down		
	NOX_TRUE	tower down		
	NOY	tower down		
	NOY_MINUS	tower down		
	NOYDIF	tower down		
TNX	tower down			
GRS420, TN	CO	91	94	
	NO	97	95	
	NOY	97	95	
	NOYDIF	97	96	
	SO ₂ _GA	96	97	
HWF187, NY	NO	95	95	
	NOY	95	95	
	NOYDIF	95	95	
MAC426, KY	CO	63	78	CO analyzer data were invalid from 5/25 – 6/23. There were no QC checks during that period because the zero air generator malfunctioned. The “as found” checks failed when the site was visited on 6/23.
	NO	92	95	
	NOY	92	95	
	NOYDIF	92	95	
	SO ₂ _GA	96	96	
PND165, WY	NO	74	83	The analyzer required calibration in May.
	NOY	74	82	
	NOYDIF	74	82	
PNF126, NC	NO	81	80	The analyzer required calibration in May.
	NOY	85	80	
	NOYDIF	81	79	
ROM206, CO	NO	82	89	The analyzer required calibration in May.
	NOY	94	90	
	NOYDIF	82	88	

Note: * See Table 10

The parameters listed in Table 9 are both calculated and measured. Table 10 provides information on how the parameters listed in Table 9 are obtained.

Table 10. CASTNET Trace-level Gas Measurements

Parameter Name	How Obtained	Description of Process
CO	Measured	Gas filter correlation
HNO3	Calculated	NOY minus NOY_MINUS
NH3	Calculated	TNX minus NOY
NO	Measured	Chemiluminescence reaction/no converter used
NO2_TRUE	Calculated	NOX_TRUE minus NO
NOX_TRUE	Measured	Photolytic converter
NOY	Measured	Molybdenum converter at 315° Celsius
NOYDIF	Calculated	NOY minus NO
NOY_MINUS	Measured	Sodium carbonate denuder followed by molybdenum converter at 315° Celsius
NOX	Measured	Molybdenum converter at 325° Celsius
NOXDIF	Calculated	NOX minus NO
SO2_GA	Measured	Ultraviolet fluorescence
TNX	Measured	Platinum/stainless steel converter at 825° Celsius followed by molybdenum converter at 315° Celsius

References

Wood Environment & Infrastructure Solutions, Inc. 2021. *Clean Air Status and Trends Network (CASTNET) Second Quarter 2021 Quality Assurance Report*.
<https://java.epa.gov/castnet/documents.do>