Clean Air Status and Trends Network

Quarterly Data Summary for Second Quarter 2024 (April through June)

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Introduction

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during second quarter 2024. 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 O_3 concentrations. This report also analyzes data for continuous, trace-level NO_y from the five sites that were operational during second quarter and continuous SO_2 concentrations from one site. Other QC statistics are given in the CASTNET Second Quarter 2024 Quality Assurance Report (WSP, 2024).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O_3 Concentrations (ppb) through Second Quarter 2024

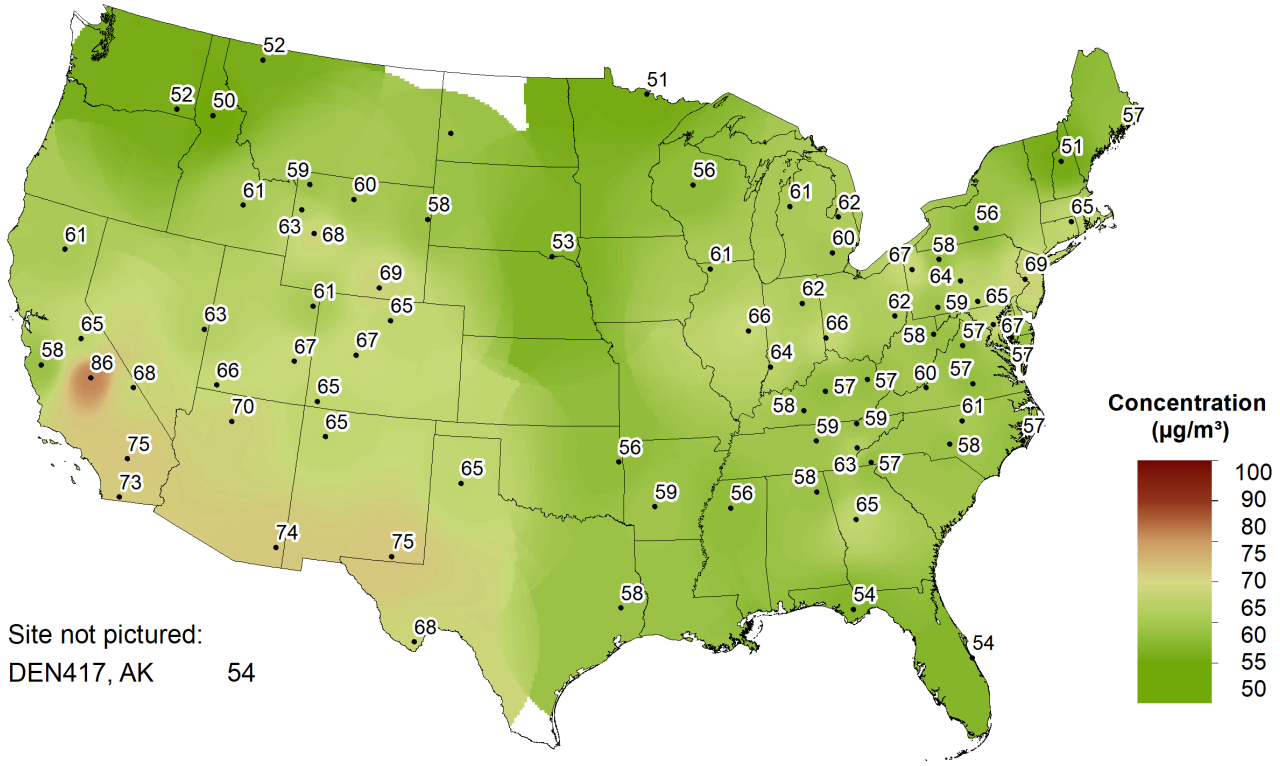


Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O_3 concentrations measured through second quarter 2024. Five sites exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O_3.

Trends

Trend analyses were performed based on filter pack pollutant concentrations measured in micrograms per cubic meter ($\mu g/m^3$) of air at the 27 eastern and 16 western reference sites during second quarter. Trends in quarterly mean filter pack and O_3 concentrations are shown using box plots in Figures 2 through 13.

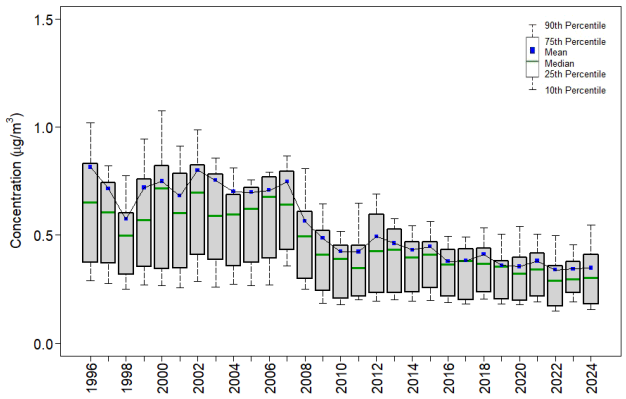
Second Quarter Concentrations

Quarterly mean HNO_3, NO_3^-, NH_4^+, total NO_3^-, SO_2, SO_4^{2-}, Ca^{2+}, Mg^{2+}, and K^+ concentrations decreased at eastern sites in 2024, and Cl^- and Na^+ concentrations increased. Quarterly mean NO_3^-, NH_4^+, total NO_3^-, SO_4^{2-}, and Ca^{2+} concentrations decreased at western sites in 2024 while HNO_3, Cl^-, K^+, Mg^{2+}, and Na^+ concentrations increased. The time series of SO_2 concentrations at the western reference sites is no longer presented.

Quarterly O_3 concentrations were analyzed using box plots constructed by calculating the mean of all valid hourly O_3 concentrations within second quarter 2024 by site and then averaging those means for all eastern and western reference sites (Figure 13). The figure shows an overall reduction in quarterly mean O_3 concentrations at eastern and western sites. Mean O_3 concentrations at eastern sites decreased in second quarter 2024, and concentrations at western sites increased slightly. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Second Quarter Mean HNO_3 Concentrations

Western Reference Sites



Eastern Reference Sites

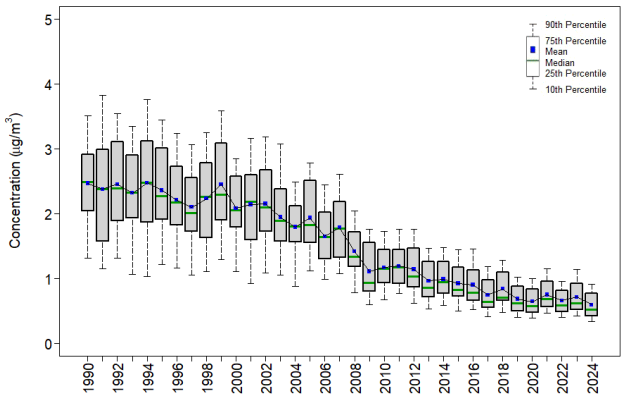
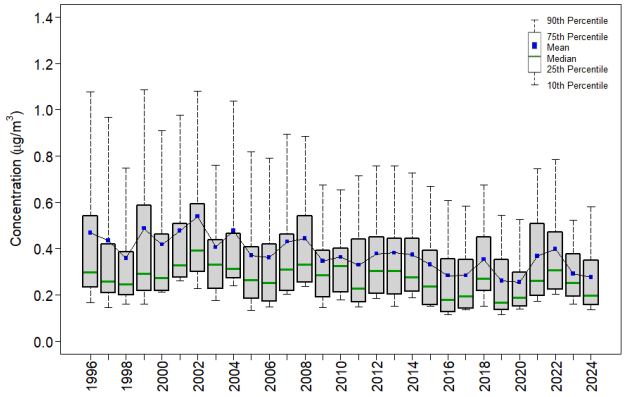


Figure 3. Trends in Second Quarter Mean NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

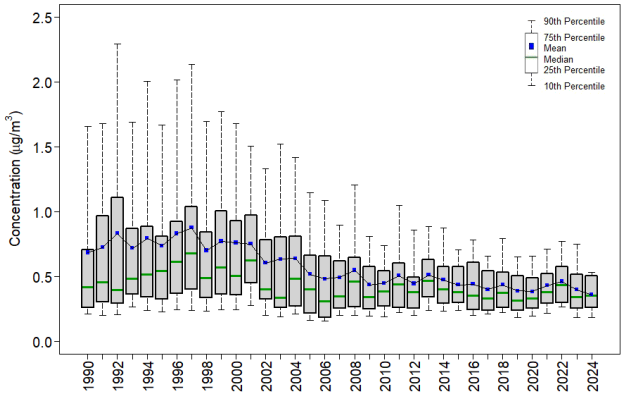
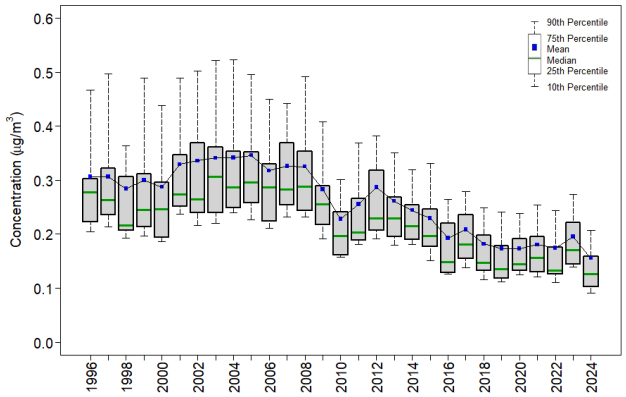


Figure 4. Trends in Second Quarter Mean NH_4^+ Concentrations

Western Reference Sites



Eastern Reference Sites

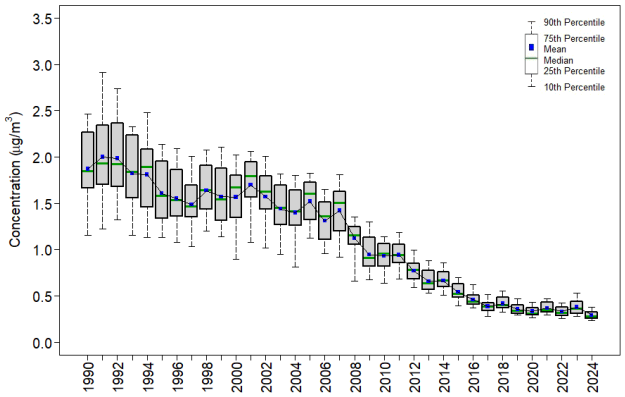
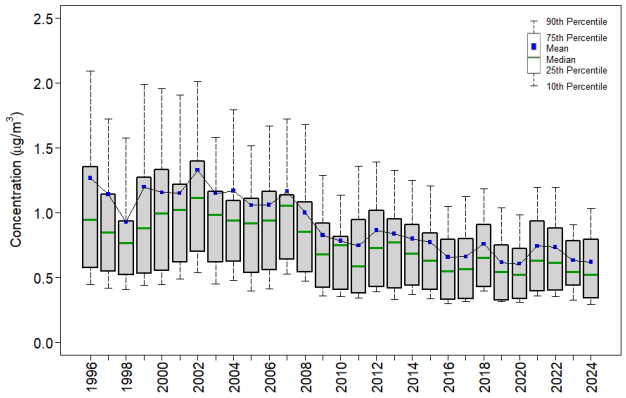


Figure 5. Trends in Second Quarter Mean Total NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

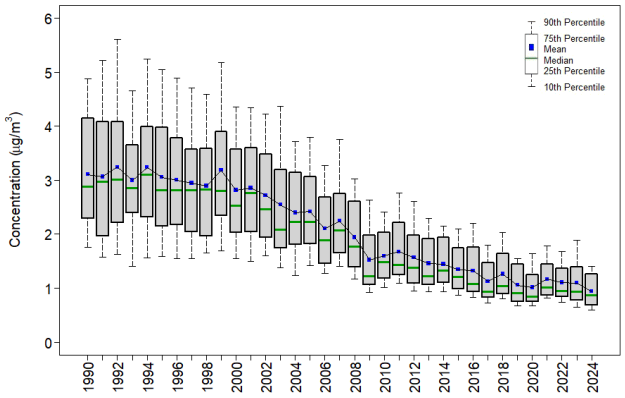


Figure 6. Trends in Second Quarter Mean SO_2 Concentrations

Eastern Reference Sites

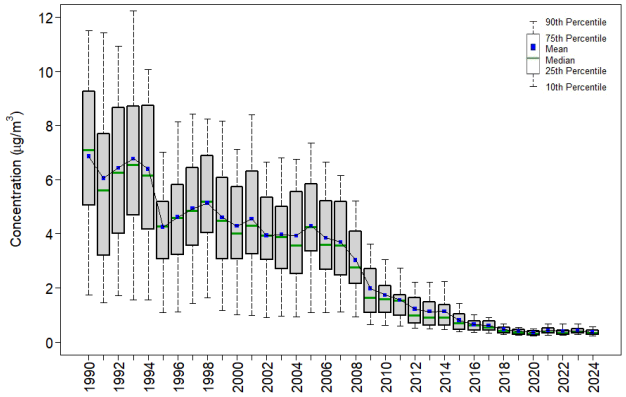
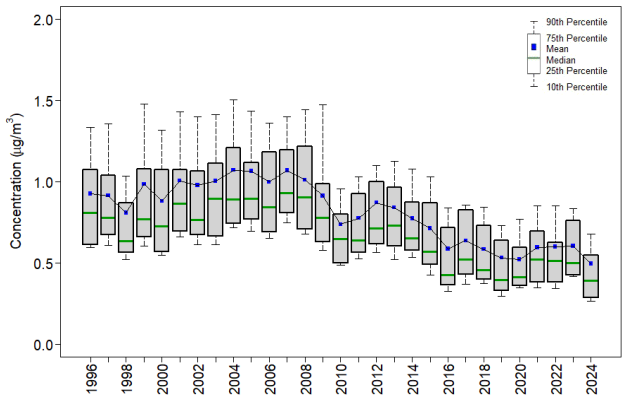


Figure 7. Trends in Second Quarter Mean SO_4^{2-} Concentrations

Western Reference Sites



Eastern Reference Sites

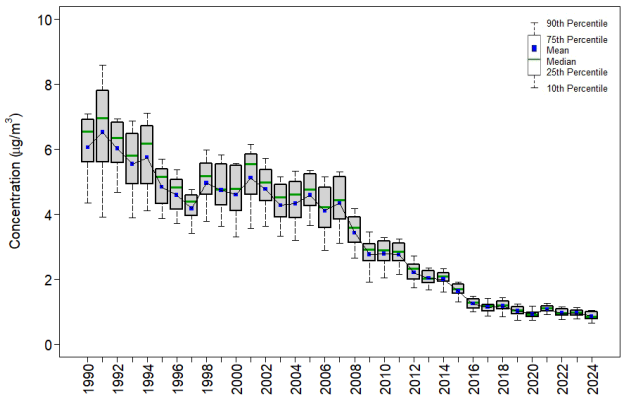
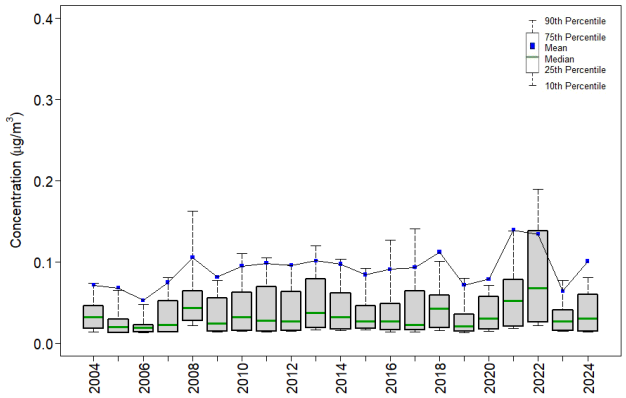


Figure 8. Trends in Second Quarter Mean Cl^- Concentrations

Western Reference Sites



Eastern Reference Sites

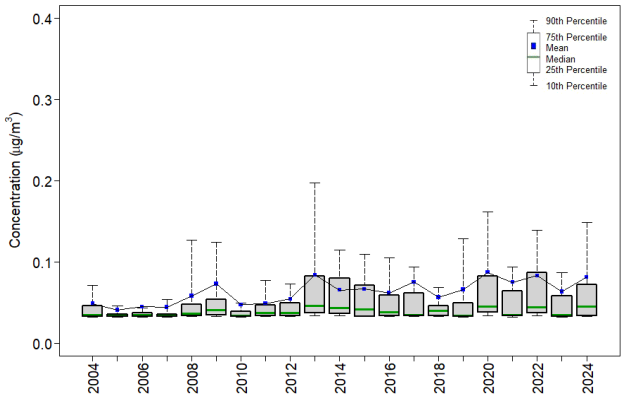
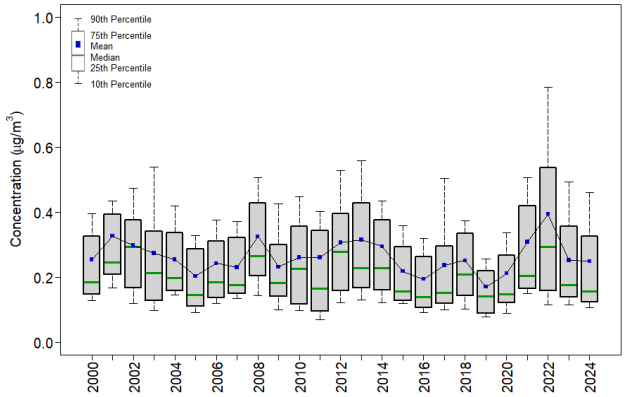


Figure 9. Trends in Second Quarter Mean Ca^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

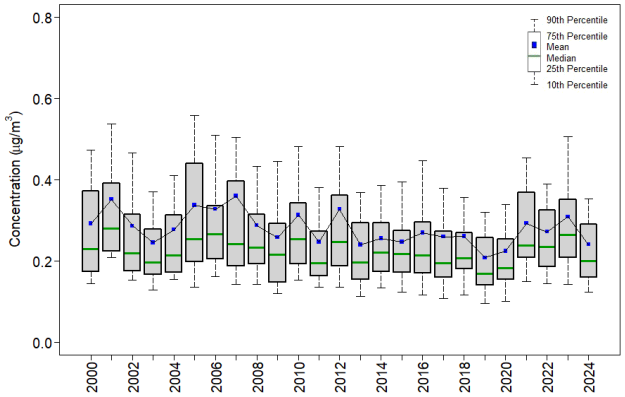
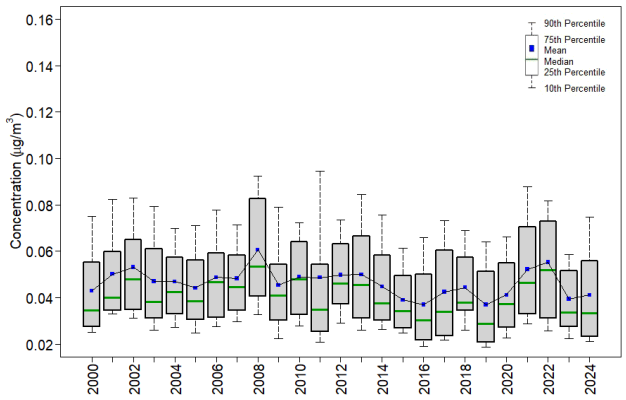


Figure 10. Trends in Second Quarter Mean K^{+} Concentrations

Western Reference Sites



Eastern Reference Sites

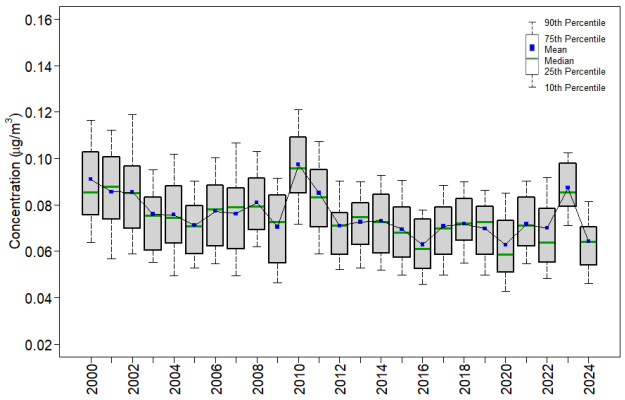
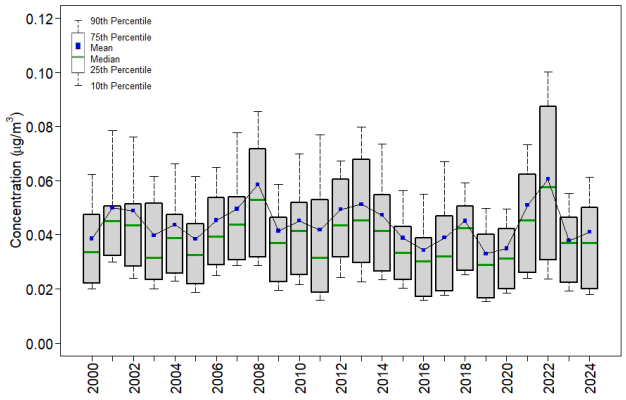


Figure 11. Trends in Second Quarter Mean Mg^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

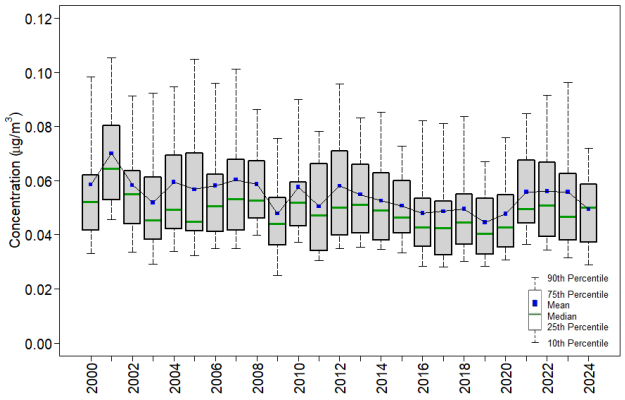
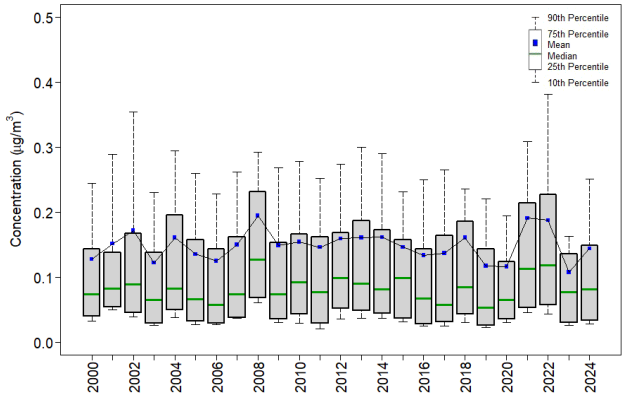


Figure 12. Trends in Second Quarter Mean Na^+ Concentrations

Western Reference Sites



Eastern Reference Sites

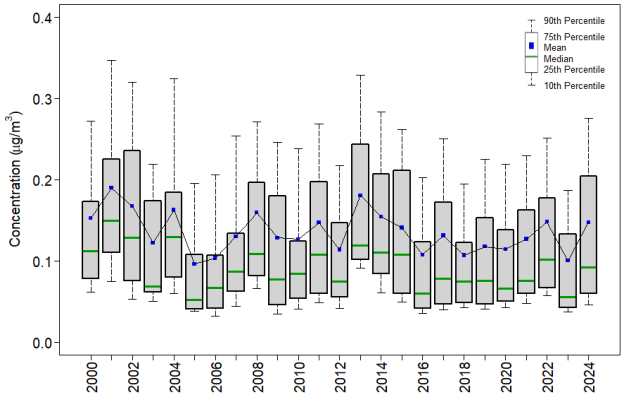
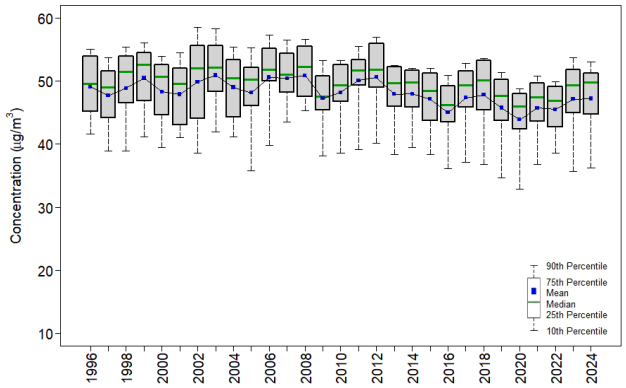
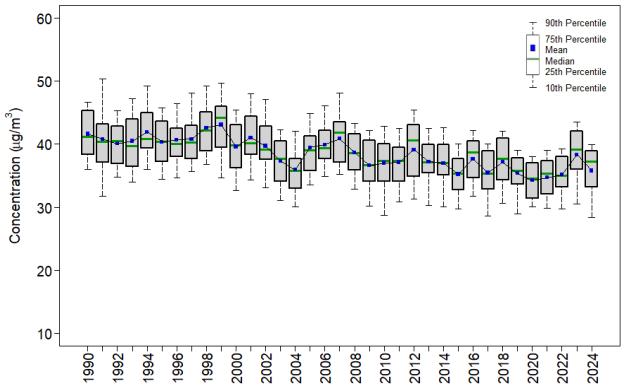


Figure 13. Trends in Second Quarter Mean O_3 Concentrations

Western Reference Sites



Eastern Reference Sites



Changes in 3-Year Average Second Quarter Concentrations

As shown in Table 1 and Table 2, three-year averages of quarterly mean concentrations of total NO_3^-, NH_4^+, SO_2, and SO_4^{2-} were reduced over the period 1990–1992 through 2021–2024 for eastern reference sites and 1996–1998 through 2021–2024 for western reference sites. O_3 concentrations decreased at eastern and western sites. Ca^{2+}, K^+, and Mg^{2+} levels declined at eastern sites from 2004–2006 through 2021–2024. Na^+ and Cl^- values increased. At western sites, base cation concentrations declined and Cl^- concentrations increased.

Table 1. Eastern Reference Sites: 3-Year Mean Values (ppb or µg/m^3)

Parameter	O_3 (ppb)	Total NO_3^-	NH_4^+	SO_2	SO_4^{2-}	Ca^{2+}	K^+	Mg^{2+}	Na^+	Cl^-
1990–1992	41	3.1	2.0	6.4	6.2					
2004–2006						0.31	0.07	0.06	0.12	0.04
2022–2024	32	1.0	0.3	0.4	0.9	0.27	0.07	0.05	0.13	0.08
Percent Change	-22	-67	-83	-94	-85	-13	-1	-7	9	70

Note: Ozone concentrations are given as ppb. Concentrations for all other parameters are in µg/m^3.

Table 2. Western Reference Sites: 3-Year Mean Values (ppb or µg/m^3)

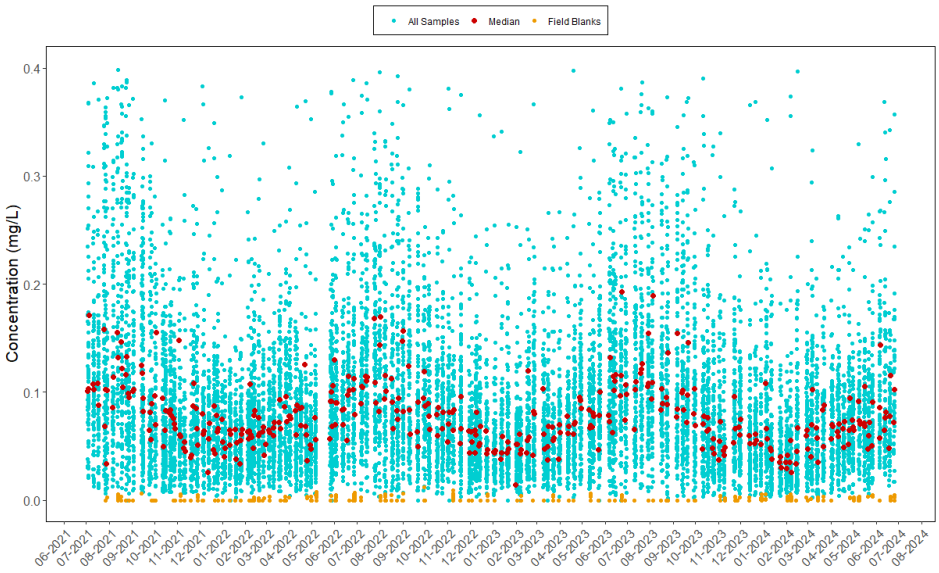
Parameter	O_3 (ppb)	Total NO_3^-	NH_4^+	SO_2	SO_4^{2-}	Ca^{2+}	K^+	Mg^{2+}	Na^+	Cl^-
1996–1998	49	1.1	0.3	0.5	0.9					
2004–2006						0.23	0.05	0.04	0.14	0.06
2022–2024	41	0.4	0.1		0.3	0.15	0.02	0.02	0.07	0.07
Percent Change	-15	-63	-69		-70	-37	-53	-57	-47	12

Note: Ozone concentrations are given as ppb. Concentrations for all other parameters are in µg/m^3.

Time Series of Laboratory Analysis Parameters for All Sites

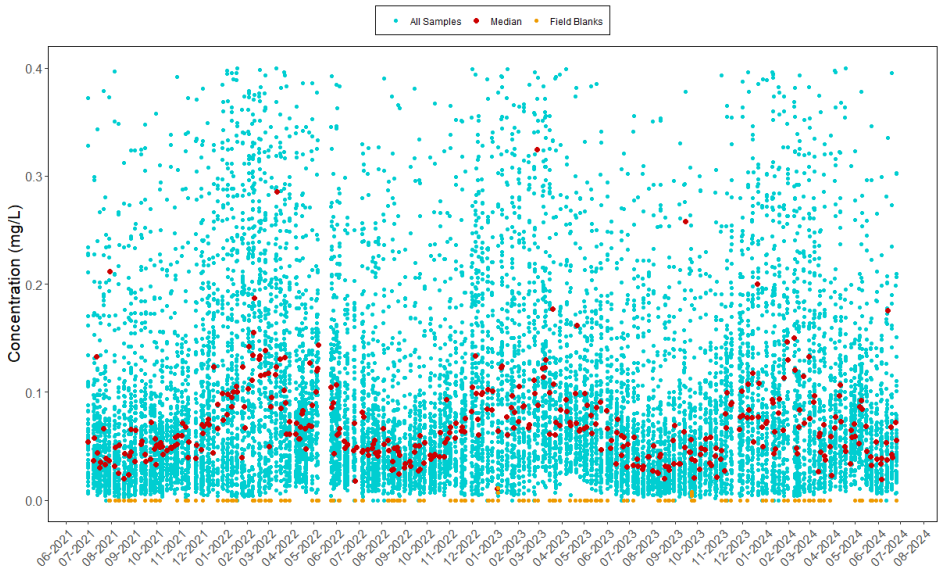
Figures 14 through 24 give time series of laboratory-analyzed concentrations of field samples and field blanks in milligrams per liter (mg/L) of 11 parameters from third quarter 2021 through second quarter 2024. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

Figure 14. Concentrations of NO_3^- (as N) from Nylon Filters



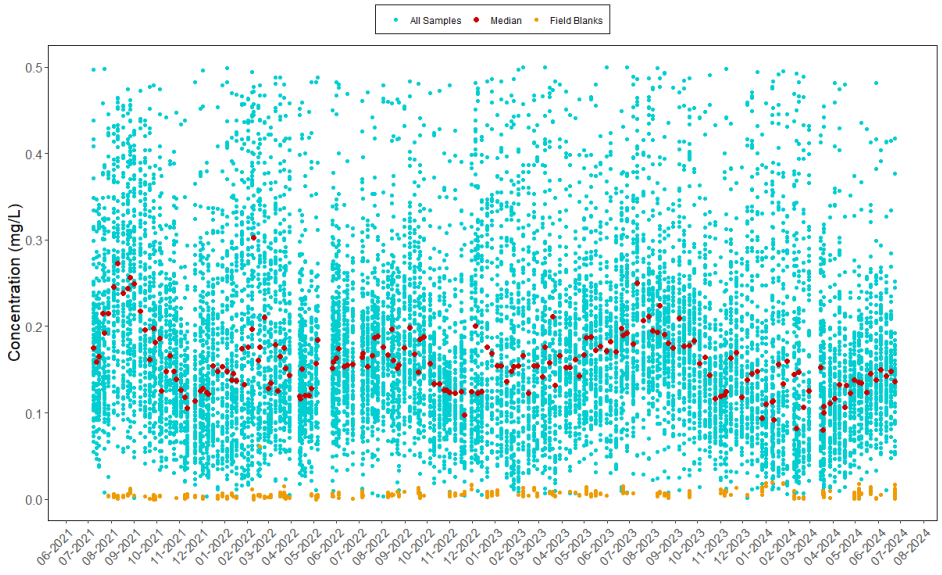
Note: Nominal reporting limit is 0.008 mg/L

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



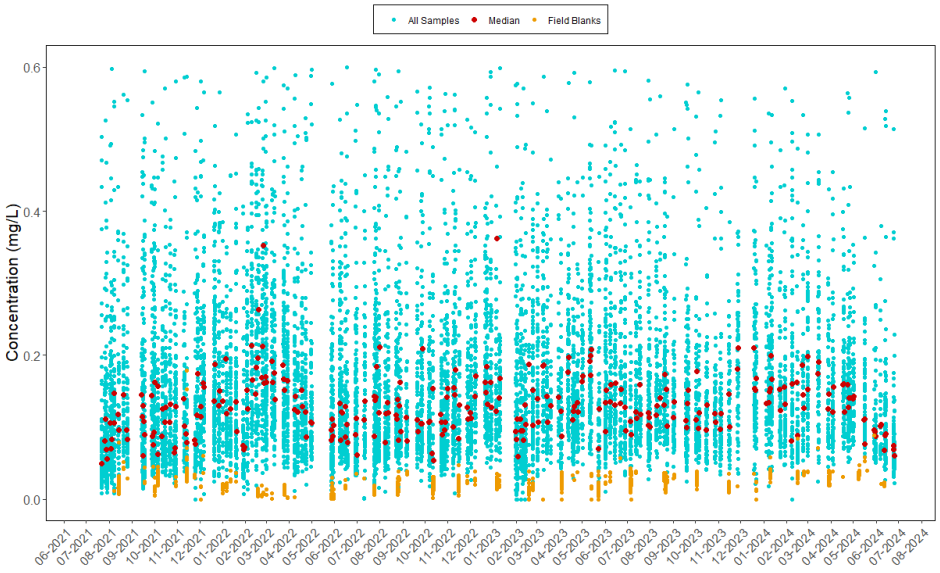
Note: Nominal reporting limit is 0.008 mg/L

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



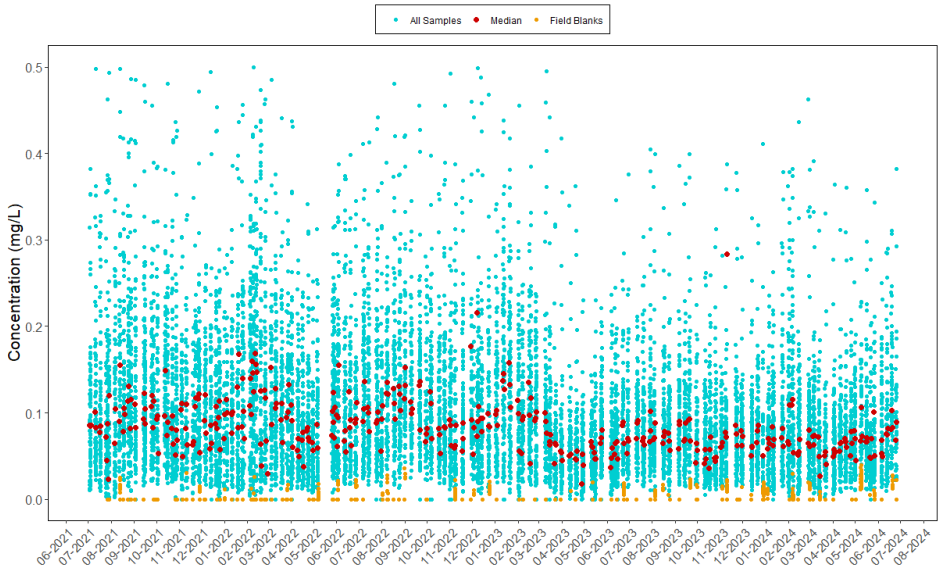
Note: Nominal reporting limit is 0.020 mg/L

Figure 17. Concentrations of SO_2 from K_2CO_3-impregnated Cellulose Filters



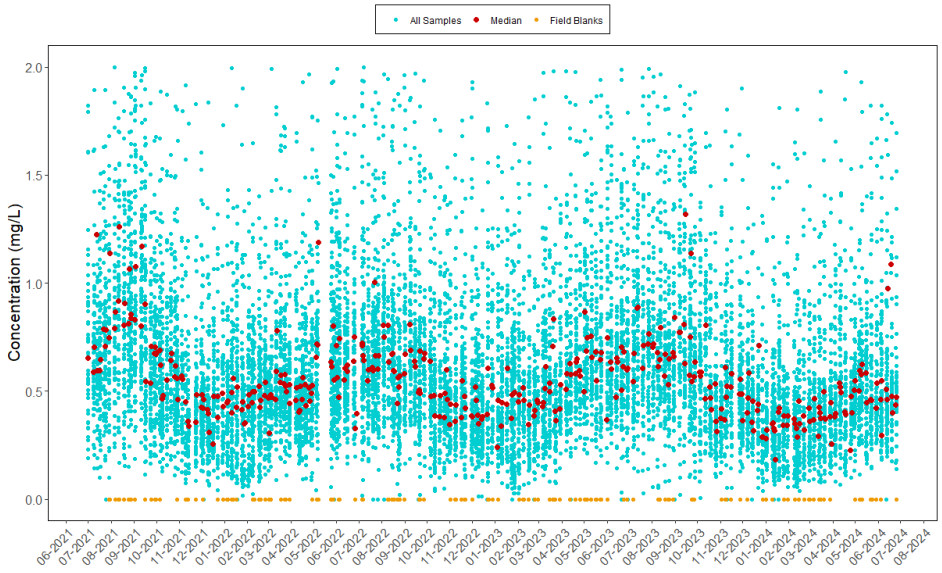
Note: Nominal reporting limit is 0.040 mg/L

Figure 18. Concentrations of SO_4^{2-} from Nylon Filters



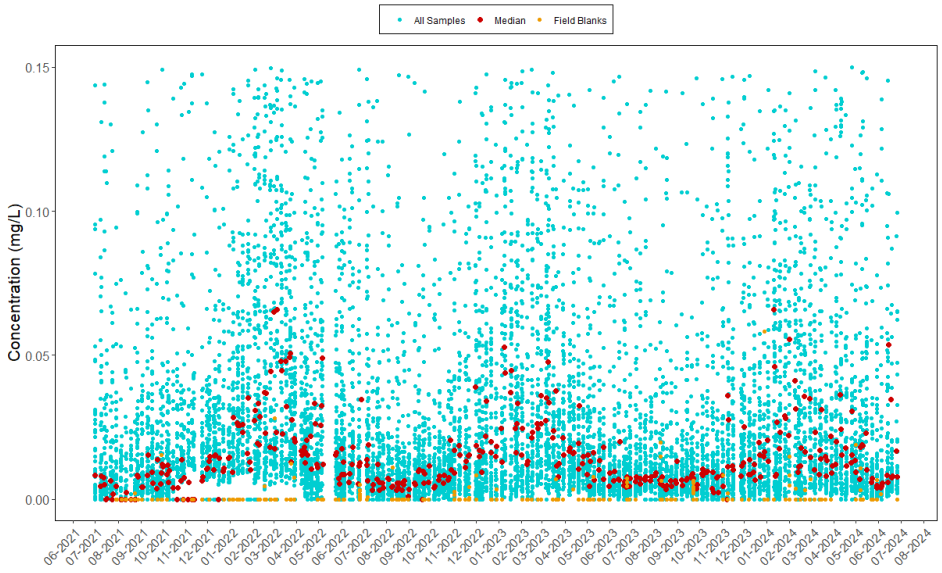
Note: Nominal reporting limit is 0.040 mg/L

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



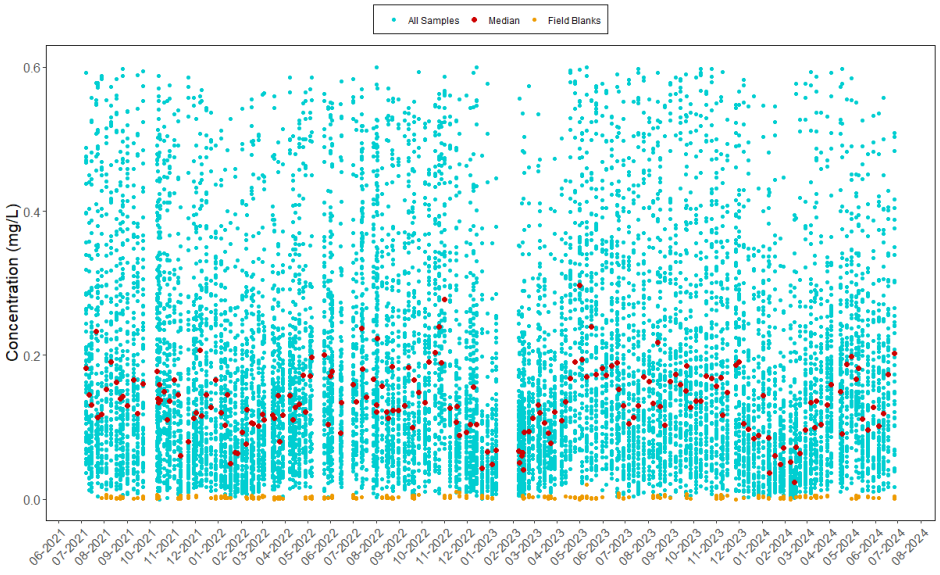
Note: Nominal reporting limit is 0.040 mg/L

Figure 20. Concentrations of Cl^- from Teflon Filters



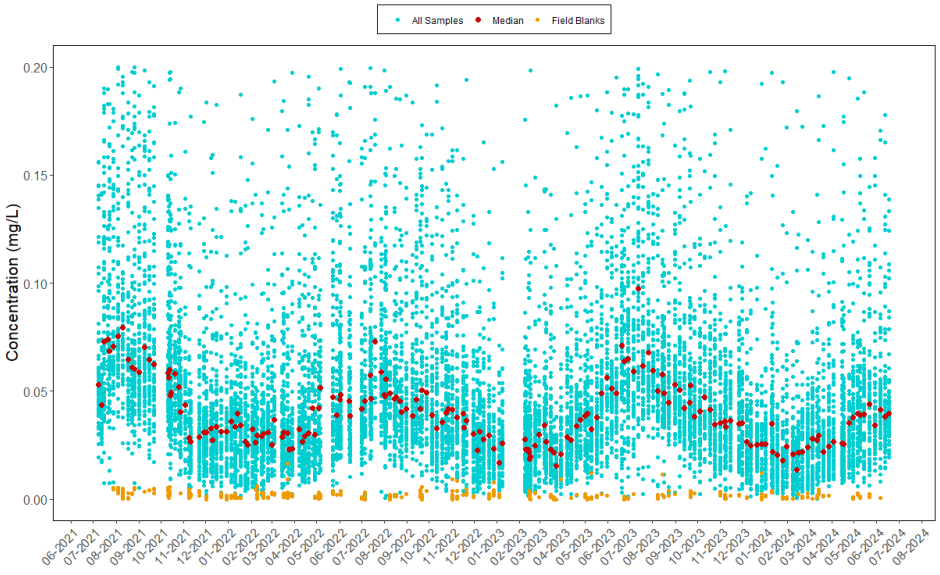
Note: Nominal reporting limit is 0.020 mg/L

Figure 21. Concentrations of Ca^{2+} from Teflon Filters



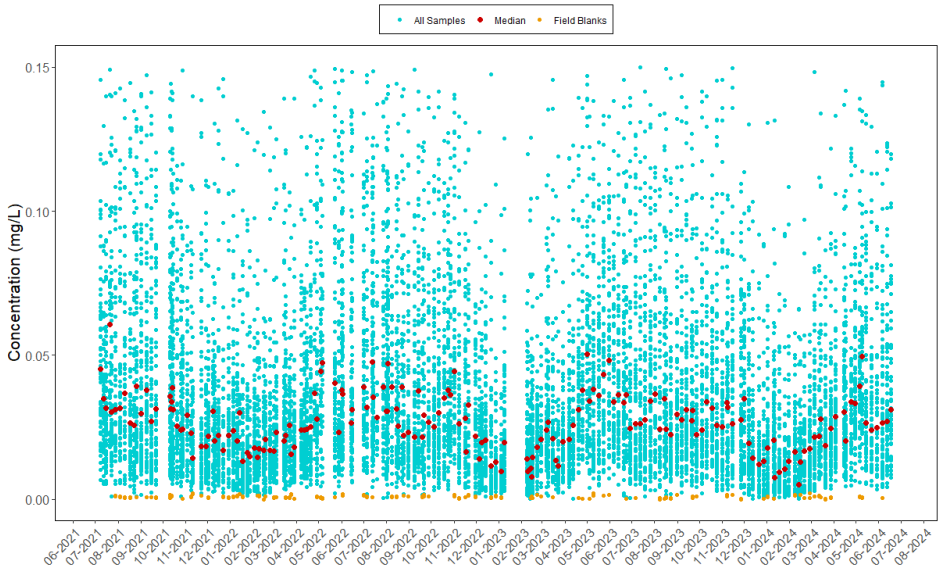
Note: Nominal reporting limit is 0.006 mg/L

Figure 22. Concentrations of K^{+} from Teflon Filters



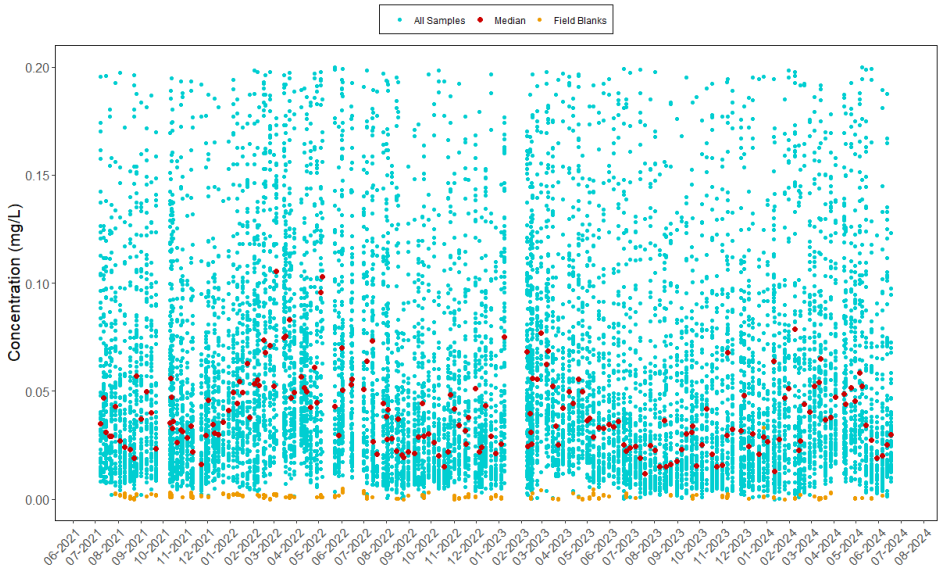
Note: Nominal reporting limit is 0.006 mg/L

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. The data gap in Figure 26 was caused by problems with mass flow controller at ROM206, CO.

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

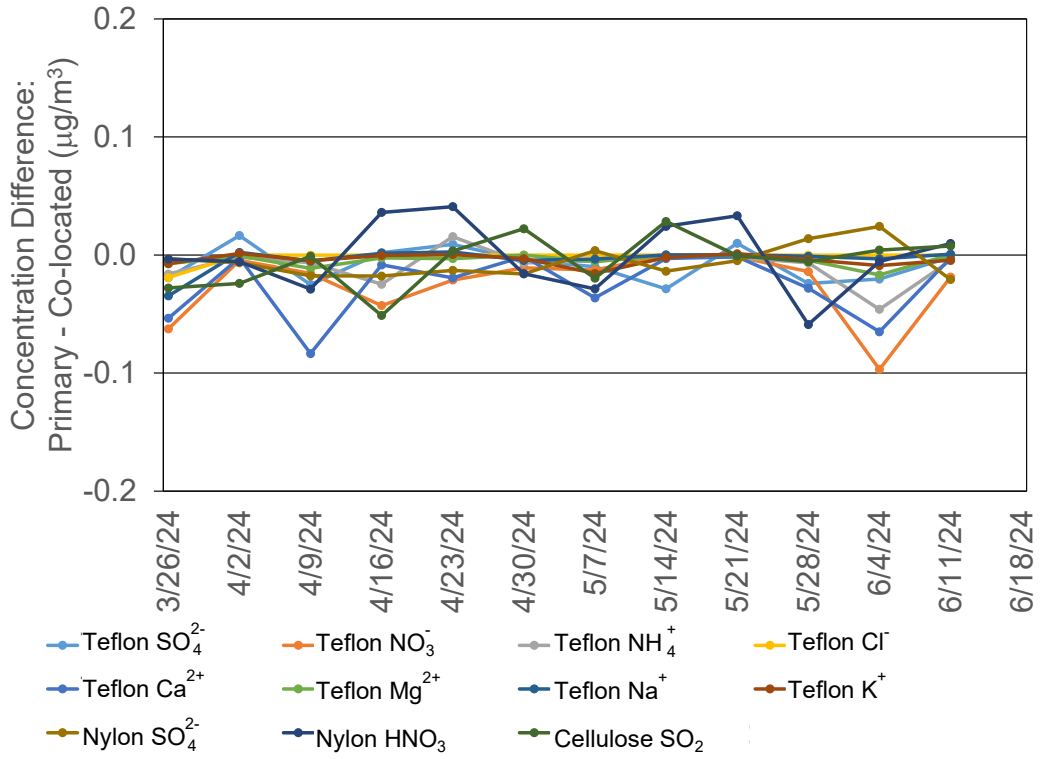
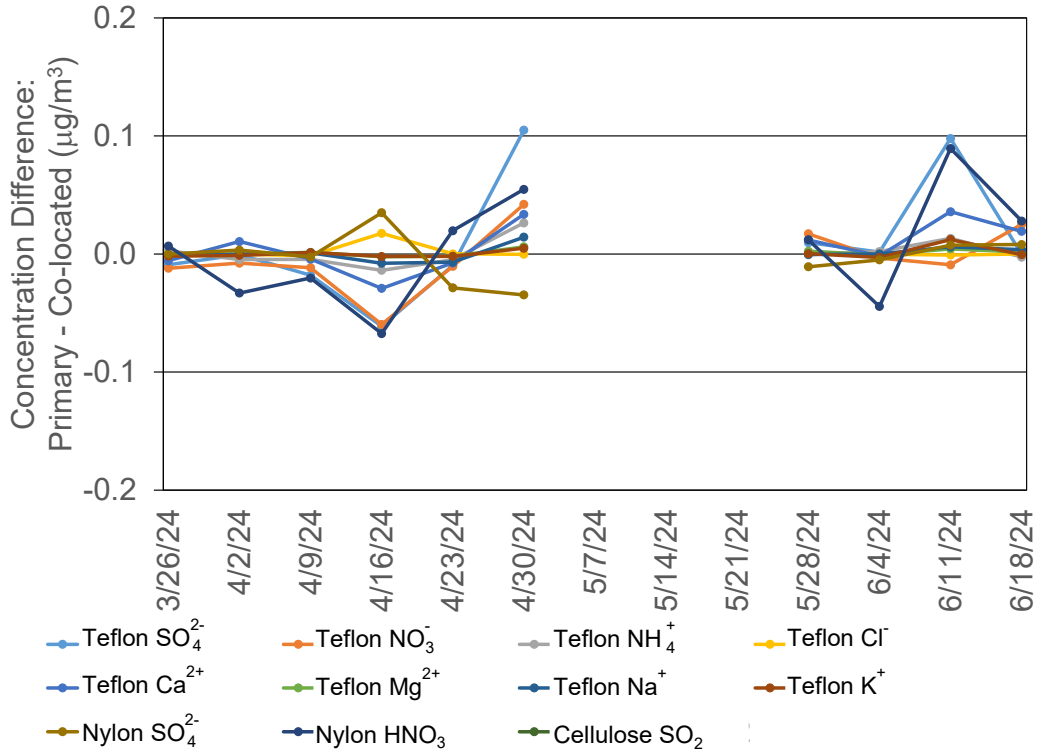


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

Table 3 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231, KY and ROM406/206, CO during second quarter 2024. Note that SO_2 measurements were discontinued at ROM406. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Second Quarter 2024

	Total NO_3^-	HNO_3	NO_3^-	NH_4^+	SO_2	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-
MCK131/231, KY											
$\overline{X}$ ($\mu g/m^3$)	1.04	0.63	0.41	0.35	0.34	0.89	0.26	0.05	0.11	0.07	0.06
$\overline{Y}$ ($\mu g/m^3$)	1.06	0.63	0.44	0.36	0.35	0.90	0.28	0.05	0.12	0.07	0.06
MAD	0.04	0.02	0.03	0.01	0.02	0.01	0.03	0.00	0.00	0.00	0.00
MARPD	3.83	4.08	5.06	3.13	5.23	1.63	7.45	7.76	4.17	6.02	1.11
ROM406/206, CO											
$\overline{X}$ ($\mu g/m^3$)	0.47	0.30	0.17	0.12		0.32	0.14	0.02	0.03	0.02	0.01
$\overline{Y}$ ($\mu g/m^3$)	0.48	0.31	0.18	0.12	0.11	0.31	0.14	0.02	0.03	0.02	0.01
MAD	0.05	0.04	0.02	0.01		0.03	0.02	0.00	0.00	0.00	0.00
MARPD	11.39	12.47	13.41	7.23		10.34	12.94	11.78	15.33	13.21	10.53

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 of Weeks having a Successful Filter Pack Deployment during Second Quarter 2024

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	Comments
MKG113, PA	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	The site operator suffered a broken foot in December 2023 and was unable to perform duties through first quarter 2024. A calibrator technician visited the site on 3/24 and installed a filter pack. The LRL117, PA field site operator (FSO) visited the site on 4/06 and performed normal site visit as did the CTH110, NY FSO on 4/16. A new FSO was trained and began servicing the site on 4/24.
ROM206, CO	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	A mass flow controller malfunction affected 3 samples.
ESP127, TN	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Samples for weeks 21 and 26 were invalidated for suspect values.
LPO010, CA	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	A two-week sample was invalidated due to a failed mass flow controller.
SHE604, WY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two samples were invalidated for suspect data.
SUM156, FL	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two samples were affected by power failure.
YOS404, CA	84.6	84.6	84.6	84.6	84.6	84.6	84.6	N/A	One sample was not received. Another was invalidated for suspect data.

Precision of Ozone Concentrations

Time series of co-located hourly O_3 concentration differences for second quarter 2024 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 Difference in Co-located O_3 Concentrations for MCK131/231, KY

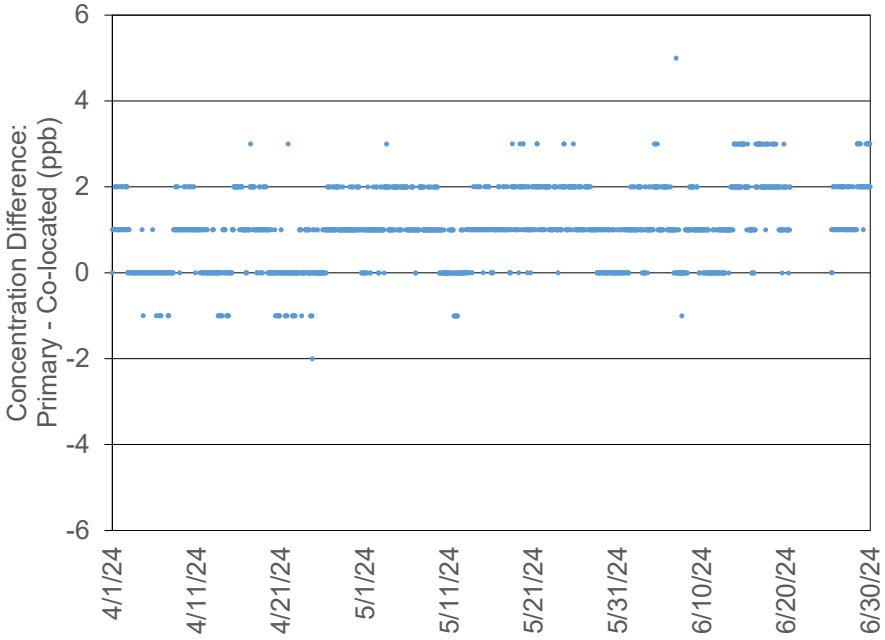


Figure 28. Time Series of the Difference in Co-located O_3 Concentrations for ROM406/206, CO

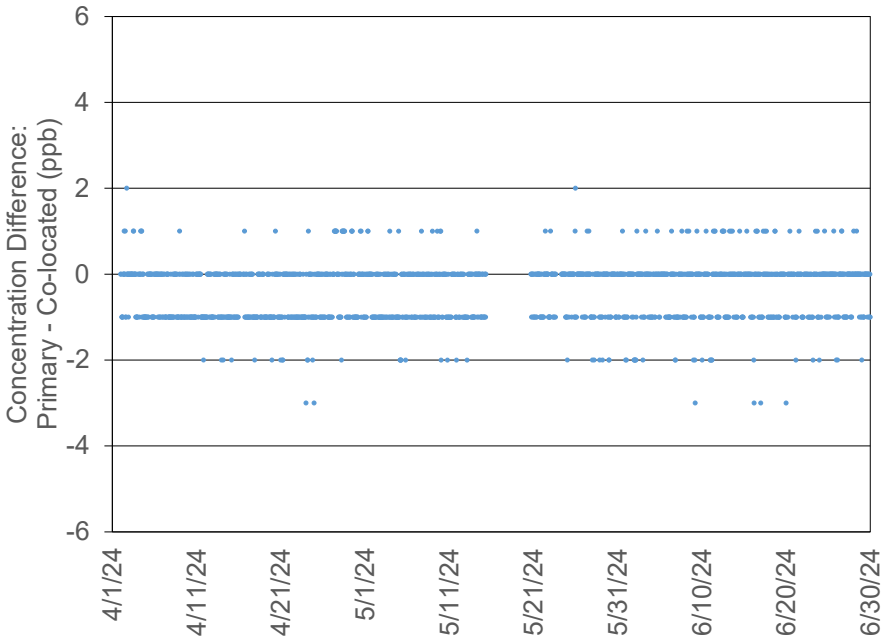


Table 5 gives MARPD data for O_3 data measured at the two co-located sites.

Table 5. Quarterly Precision (MARPD) for Co-located O_3 Concentrations

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	3	7/1/2023	3.6	1912
	4	10/1/2023	2.2	2031
	1	1/1/2024	1.7	2068
	2	4/1/2024	2.8	1963
ROM406/206, CO				
	3	7/1/2023	1.6	2038
	4	10/1/2023	1.2	2072
	1	1/1/2024	1.1	2054
	2	4/1/2024	1.0	1931

Completeness for Ozone Concentrations

Calculation of an annual O_3 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 O_3 concentrations. Comments are provided for these sites.

Table 6. Sites with less than 90 Percent Data Completeness for DM8A Concentrations during Second Quarter 2024

Site ID	Percent Completeness	Comments
SUM156, FL	80	Power failure affected data collection from 4/1/2024 to 4/16/2024.
SHN418, VA	82	There were rolling power outages that caused some data loss from 4/10/2024 through 4/30/2024 due to maintenance by the power company.
BBE401, TX	84	The ozone filter holder was inadvertently broken during the 6/18/2024 site visit. The analyzer was turned off until 6/26/2024 when a new filter holder was installed.
PND165, WY	86	Analyzer bench temperatures were out of criteria during several periods in June.
ESP127, TN	88	The data logger was offline from 6/27/2024 to 7/3/2024. Additionally, there were several hours of bench temperatures that exceeded criteria in early April.
VPI120, VA	89	The data logger lost communication with the analyzer between 5/8/2024 to 5/14/2024. There was also a power failure between 5/25/2024 to 5/27/2024.
CHC432, NM	89	Data were invalid from 6/15/2024 to 6/21/2024 due to a failed sample pump.

Table 7 shows CASTNET sites with less than 90 percent completeness for hourly O_3 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 O_3 Concentrations

Site ID	Q2 2024	Q3 2023 – Q2 2024	Comments
SUM156, FL	81.4	91.4	Power failure affected data collection from 4/1/2024 to 4/16/2024.
BBE401, TX	88.2	94.5	The ozone filter holder was inadvertently broken during the 6/18/2024 site visit. The analyzer was turned off until 6/26/2024 when a new filter holder was installed.

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

Figures 29 through 33 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO_3^- concentrations collected at the five sites with NO_y measurements. The NO_y concentrations were consistently higher than the total NO_3^- levels at all sites. The average weekly NO_y levels, the weekly total NO_3^- concentrations, and their ratios for the five sites with available data are shown in Table 8. Ratios of NO_y to total NO_3^- varied from 3.01 at GRS420, TN to 7.52 at PND165, WY.

Table 8. Summary of Total NO_3^-/NO_y Measurements for Second Quarter 2024

Site ID	Elevation	Total NO_3^- (ppb)	NO_y (ppb)	Ratio
DUK008, NC	164*	0.44	1.94	4.59
BVL130, IL	213	0.64	3.42	5.39
GRS420, TN	793	0.36	1.06	3.01
PND165, WY$^{\phi}$	2386	0.12	0.88	7.52
ROM206, CO$^{\phi}$	2742	0.19	0.91	5.08

Note: *The inlet of the enhanced NO_y monitor is located at the top of the 30-meter tower.

$^{\phi}$The PND165 and ROM206 sites discontinued NO/NO_y measurements as of July 8, 2024 and will not be included in subsequent quarterly reports.

Figure 29. Comparison of DUK008, NC Weekly Mean Continuous NO_y and Total NO_3^- Concentrations

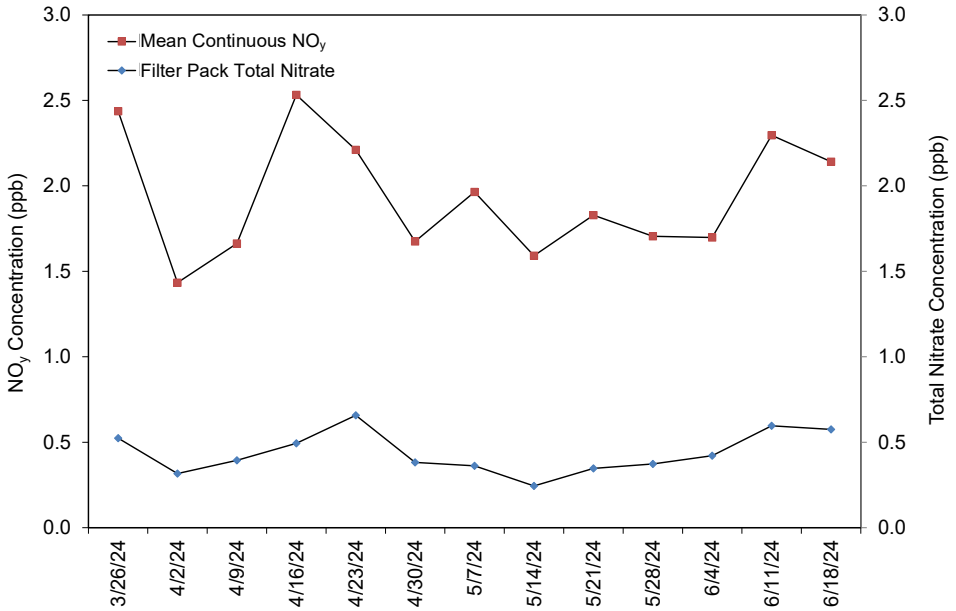


Figure 30. Comparison of BVL130, IL Weekly Mean Continuous NO_y and Total NO_3^- Concentrations

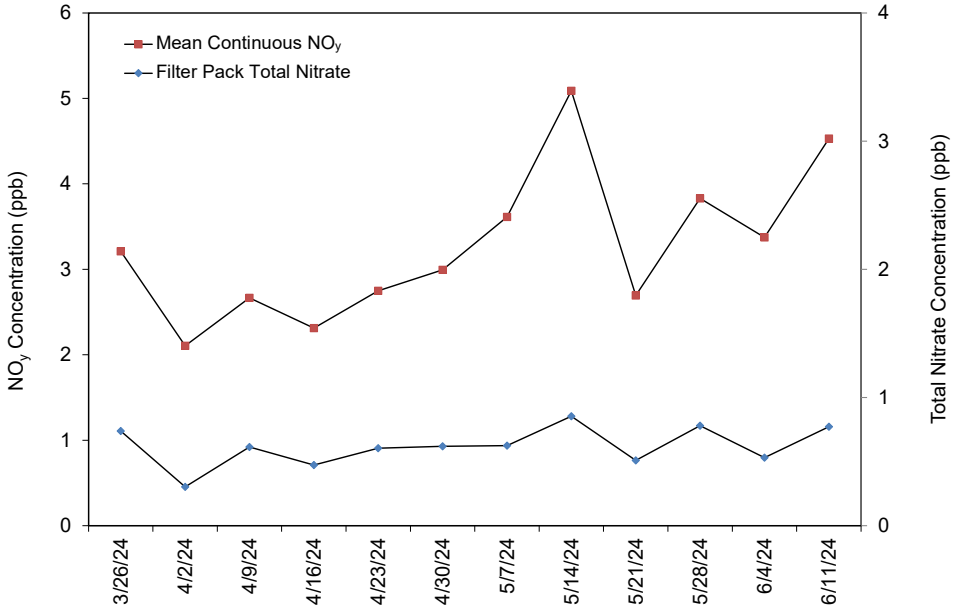


Figure 31. Comparison of GRS420, TN Weekly Mean Continuous NO_y and Total NO_3^- Concentrations

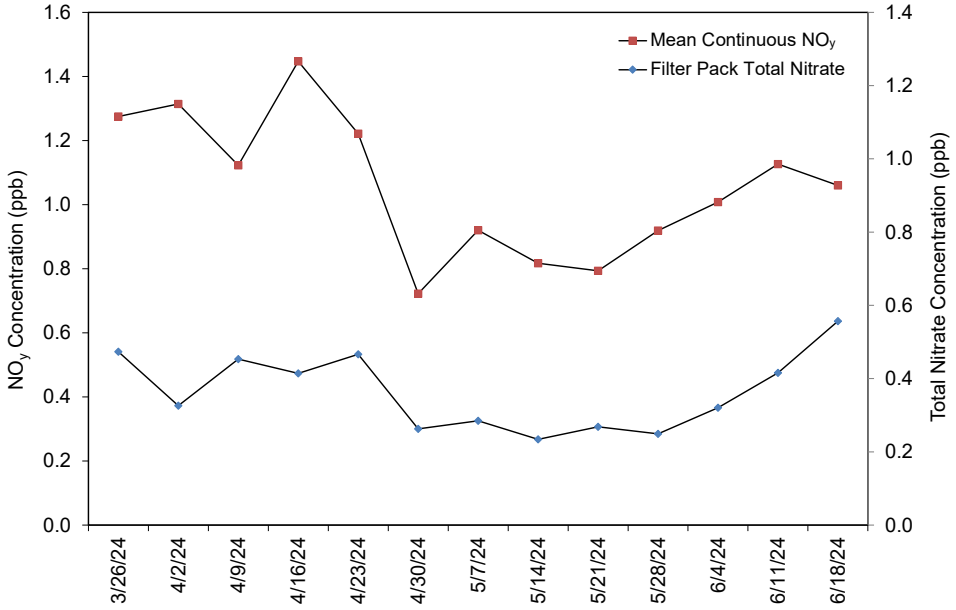


Figure 32. Comparison of PND165, WY Weekly Mean Continuous NO_y and Total NO_3^- Concentrations

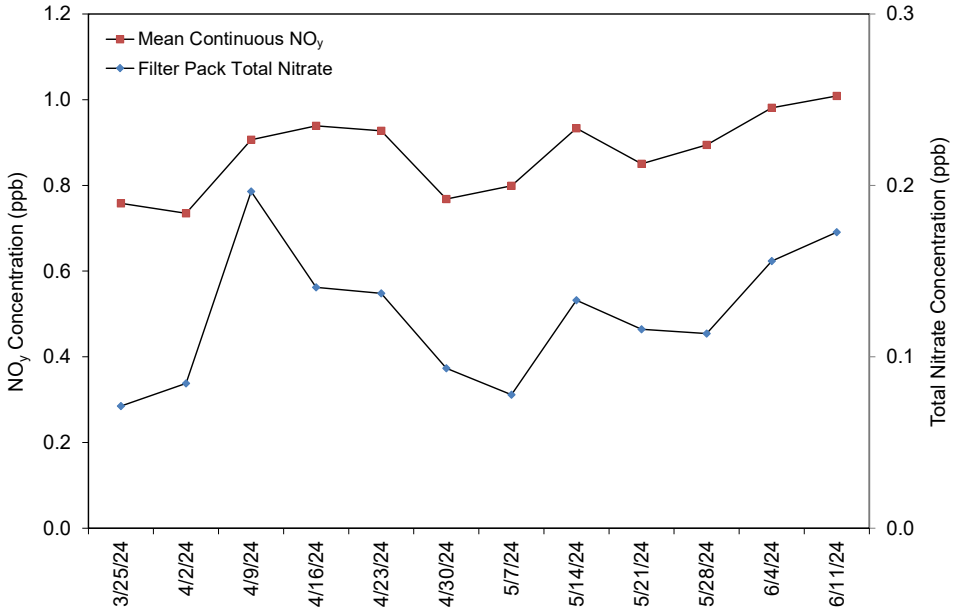
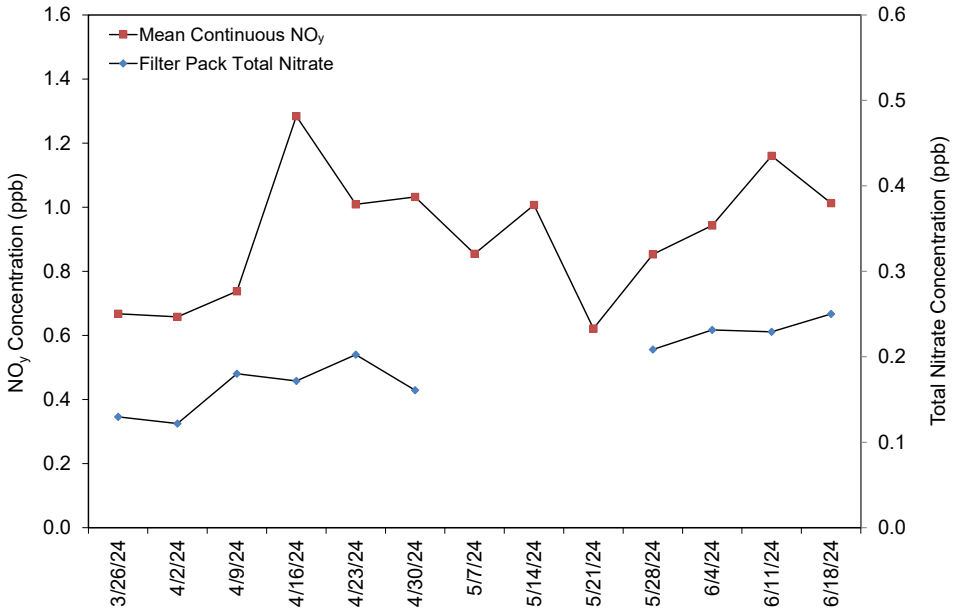


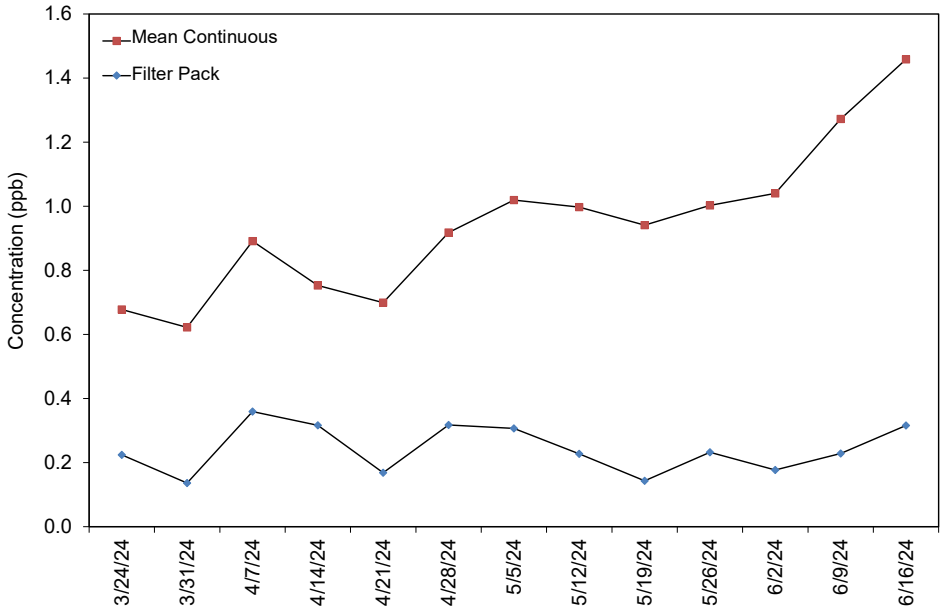
Figure 33. Comparison of ROM206, CO Weekly Mean Continuous NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figure 34 provides diagrams that compare weekly filter pack SO_2 concentrations with continuous trace-level gas data measured at BVL130, IL. The continuously measured trace-level concentrations were higher than filter pack concentrations.

Figure 34. Comparison of BVL130, IL Weekly Mean SO_2 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 2024. The average for third quarter 2023 through second quarter 2024 for each of the sites is included for reference.

Table 9. Percent Data Completeness for Continuous Trace-level Gas Measurements (1 of 2)

Site ID	Parameter	Q2 2024	Q3 2023–Q2 2024	Comments
BVL130, IL	CO	87	89	Low data recovery was caused by sample pump failure in mid-June and calibration drift mid-May.
	NO	96	91	
	NOY	96	90	
	NOYDIF	96	90	
	SO2_GA	83	88	Low data recovery due to sample pump failure in mid-June.

Table 9. Percent Data Completeness for Continuous trace-level Gas Measurements (2 of 2)

Site ID	Parameter	Q2 2024	Q3 2023–Q2 2024	Comments
DUK008, NC	HNO3	94	82	
	NH3	94	83	
	NO	94	82	
	NO2_TRUE	94	82	
	NOX_TRUE	94	82	
	NOY	94	83	
	NOY_MINUS	94	82	
	NOYDIF	94	82	
	TNX	94	83	
GRS420, TN	CO	90	89	
	NO	95	86	
	NOY	95	86	
	NOYDIF	95	88	
	SO2_GA	95	91	
PND165, WY	NO	91	92	
	NOY	91	92	
	NOYDIF	91	92	
ROM206, CO	NO	96	91	
	NOY	96	91	
	NOYDIF	96	91	

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
NH	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

Reference

WSP USA Environment & Infrastructure Inc. 2024. Clean Air Status and Trends Network (CASTNET) Second Quarter 2024 Quality Assurance Report. https://www.epa.gov/castnet/documents-reports