

Clean Air Status and Trends Network

Quarterly Data Summary for Third Quarter 2024 (July through September)

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

EPA Contract No.: 68HERH21D0006

EPA Task Order No.: 68HERH24F0333, CASTNET Base Program (3003)

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WSP Project No.: US-EI-68HERH21D0006.7470

Submitted: December 23, 2024

Introduction

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during third 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 third 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 the five sites that were operational during third quarter. Other QC statistics are given in the CASTNET Third Quarter 2024 Quality Assurance Report (WSP, 2024).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O₃ Concentrations (ppb) through Third Quarter 2024

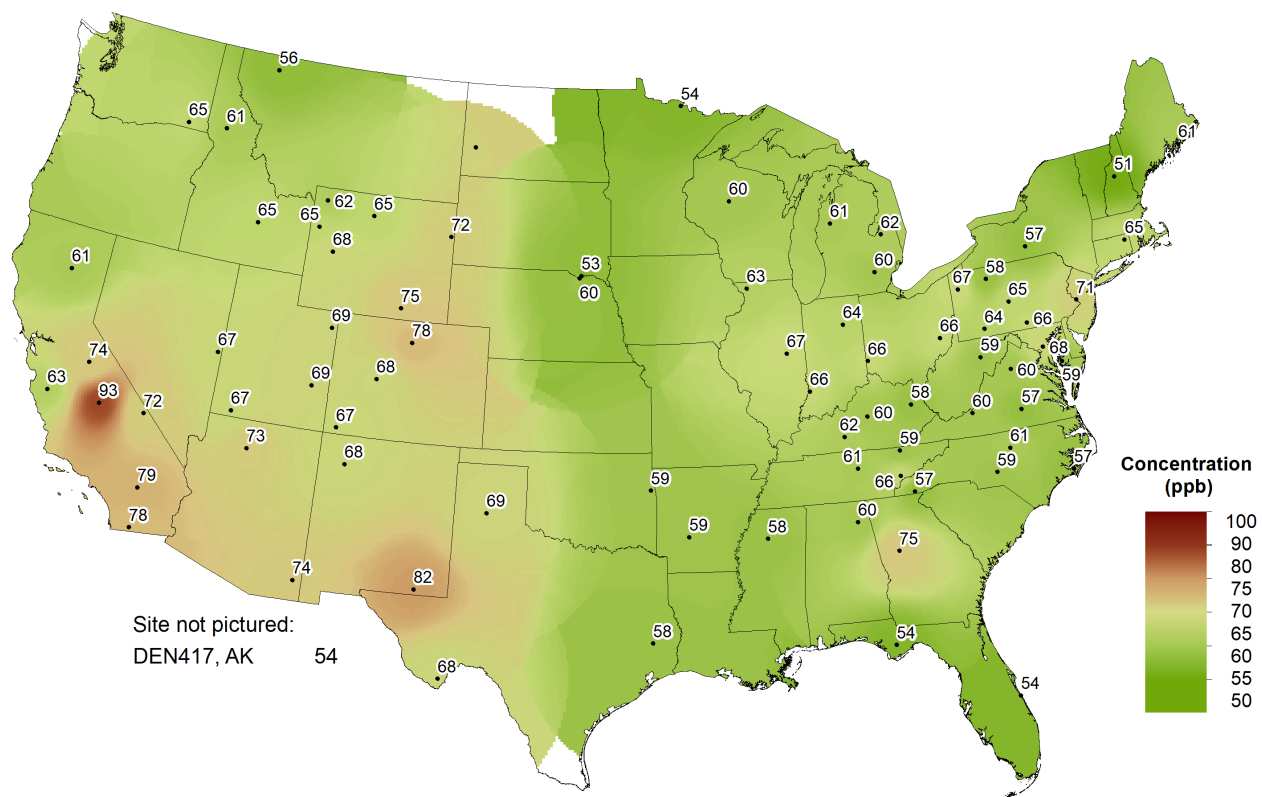


Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O₃ concentrations in parts per billion (ppb) measured through third quarter 2024. Thirteen sites exceeded the 0.070 parts per million (70 ppb in practice) National Ambient Air Quality Standard for O₃.

Trends

Third Quarter Concentrations

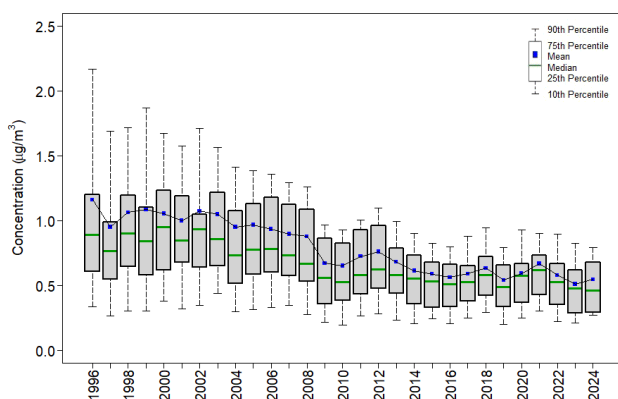
Trend analyses were performed based on filter pack pollutant concentrations measured in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) of air at the 27 eastern and 16 western reference sites during third quarter. Quarterly O₃ concentrations were analyzed using box plots constructed by averaging all valid hourly O₃ concentrations within third quarter 2024 by site and then averaging those averages for all eastern and western reference sites. The percent change in quarterly mean filter pack concentrations and O₃ concentrations at eastern and western reference sites from 2023 to 2024 are shown in Table 1. Trends of pollutants in quarterly mean filter pack and O₃ concentrations are shown using box plots in Figures 2 through 12.

Table 1. Percent Change in Concentrations (ppb or $\mu\text{g}/\text{m}^3$) from Third Quarter 2023 to Third Quarter 2024

	O ₃ (ppb)	Total NO ₃ ⁻	NH ₄ ⁺	SO ₄ ²⁻	Ca ²⁺	K ⁺	Mg ²⁺	Na ⁺	Cl ⁻
Eastern	3	0	-8	-7	-4	0	-2	-12	-18
Western	8	4	-8	-11	14	40	13	-4	-17

Note: Ozone concentrations are given as ppb. Concentrations for all other parameters are in $\mu\text{g}/\text{m}^3$.

Figure 2. Trends in Third Quarter Mean HNO₃ Concentrations
Western Reference Sites



Eastern Reference Sites

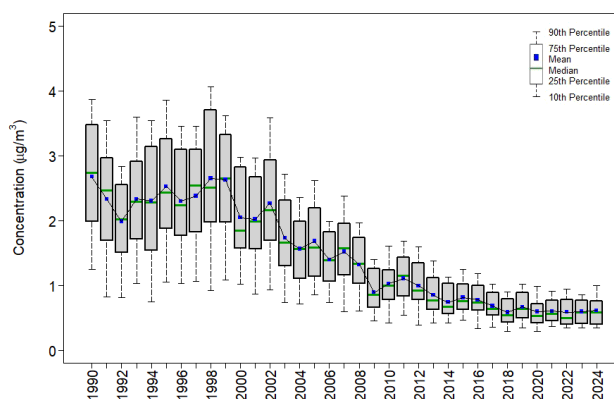
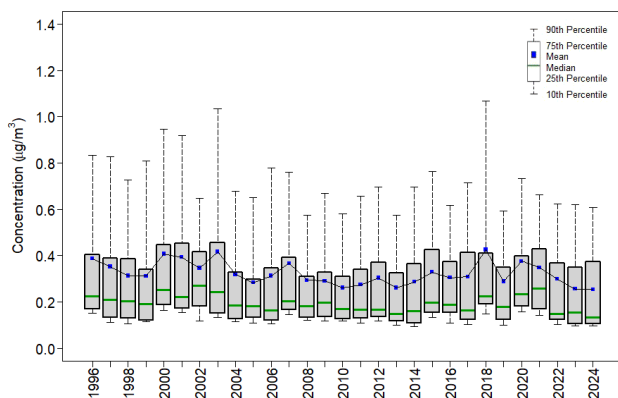


Figure 3. Trends in Third Quarter Mean NO_3^- Concentrations
Western Reference Sites



Eastern Reference Sites

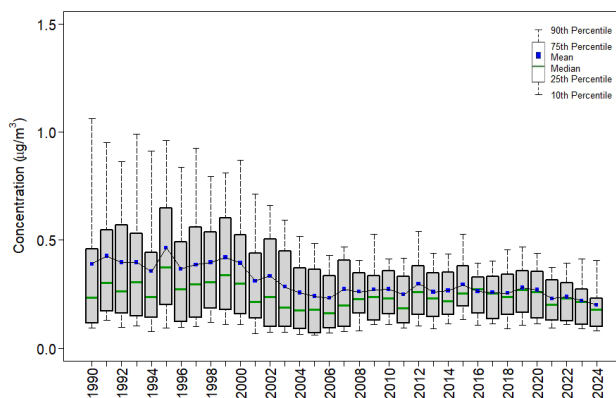
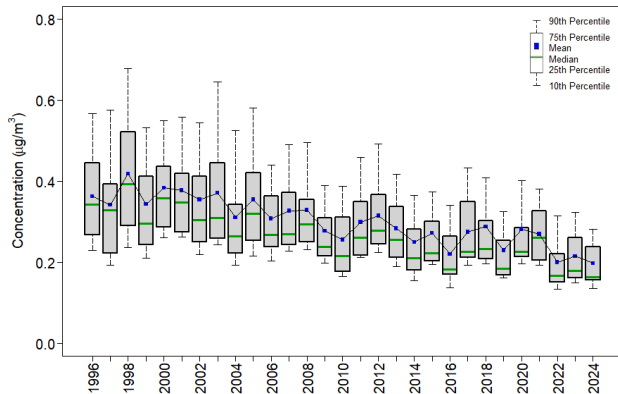


Figure 4. Trends in Third Quarter Mean NH_4^+ Concentrations
Western Reference Sites



Eastern Reference Sites

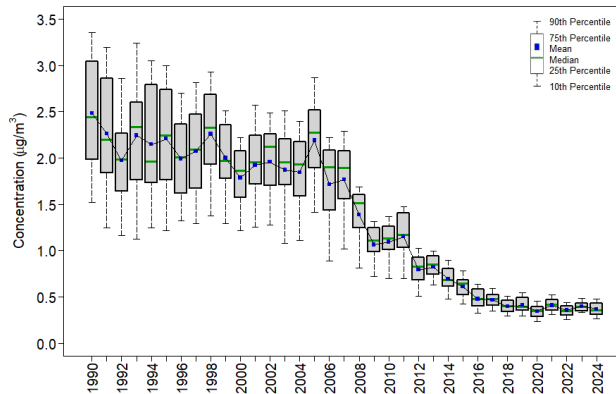
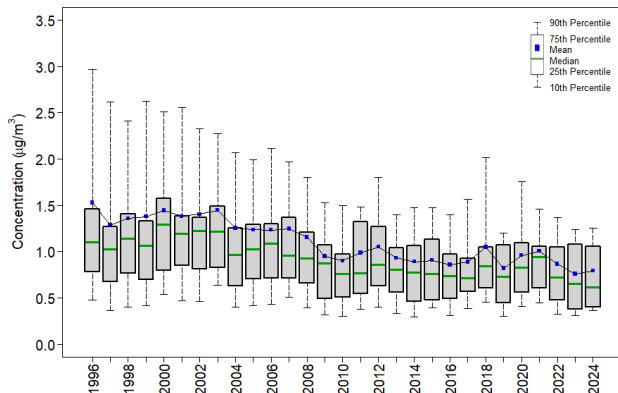


Figure 5. Trends in Third Quarter Mean Total NO_3^- Concentrations
Western Reference Sites



Eastern Reference Sites

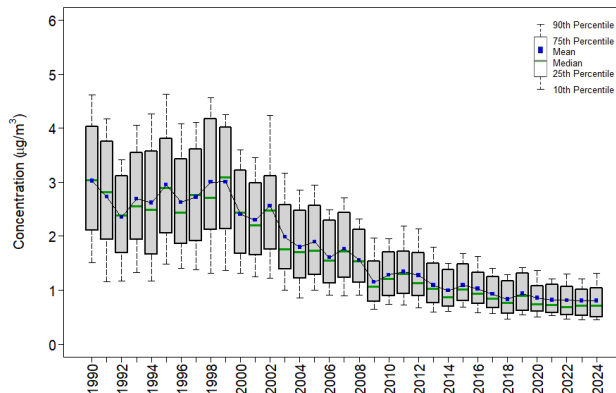
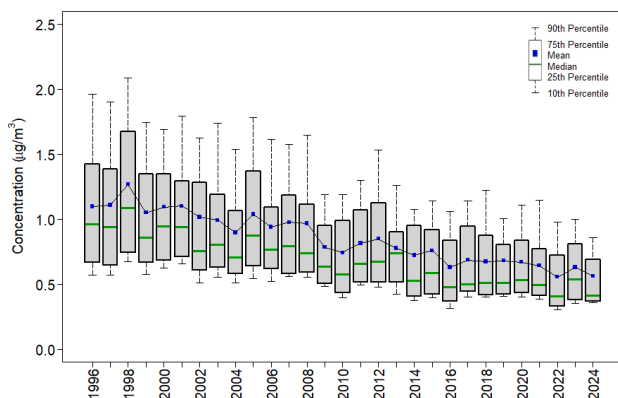


Figure 6. Trends in Third Quarter Mean SO_4^{2-} Concentrations
Western Reference Sites



Eastern Reference Sites

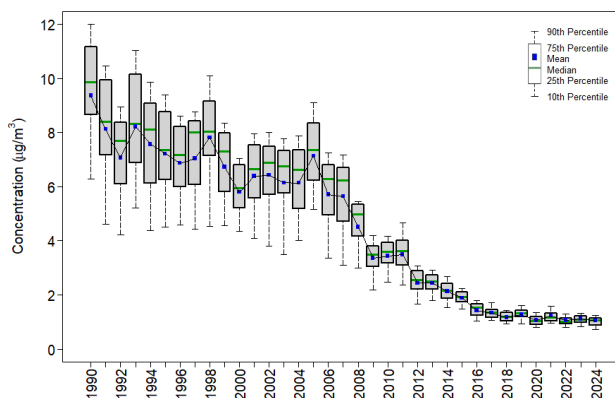
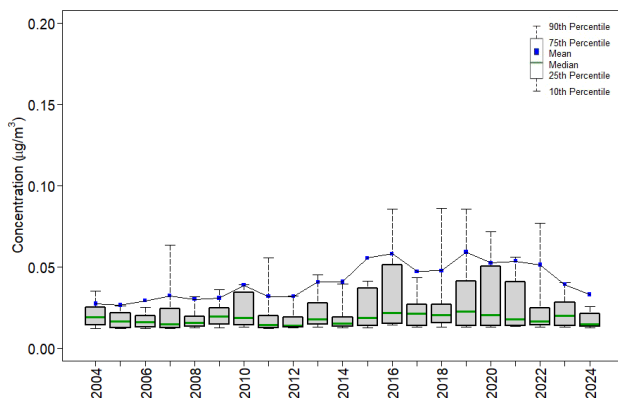


Figure 7. Trends in Third Quarter Mean Cl^- Concentrations
Western Reference Sites



Eastern Reference Sites

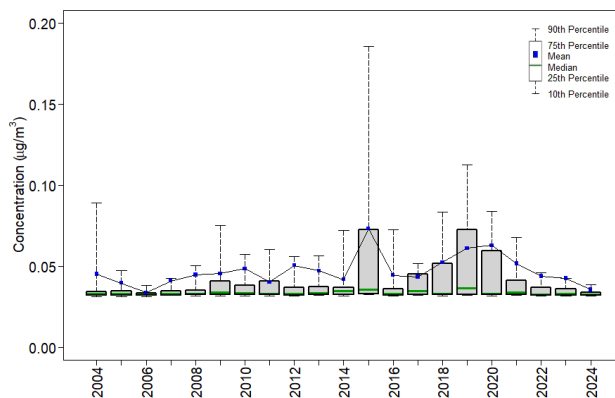
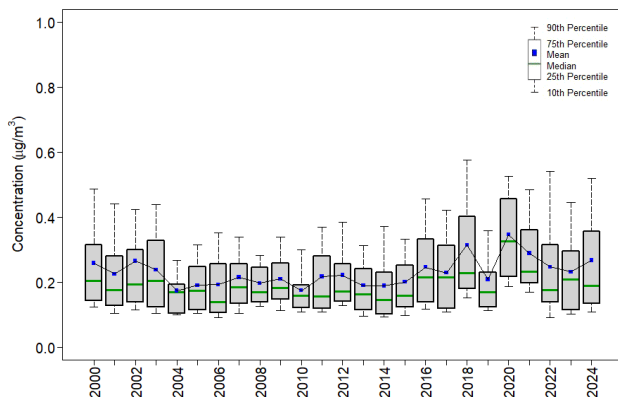


Figure 8. Trends in Third Quarter Mean Ca^{2+} Concentrations
Western Reference Sites



Eastern Reference Sites

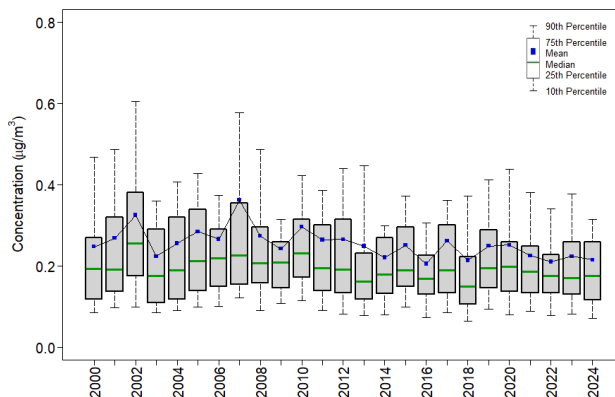
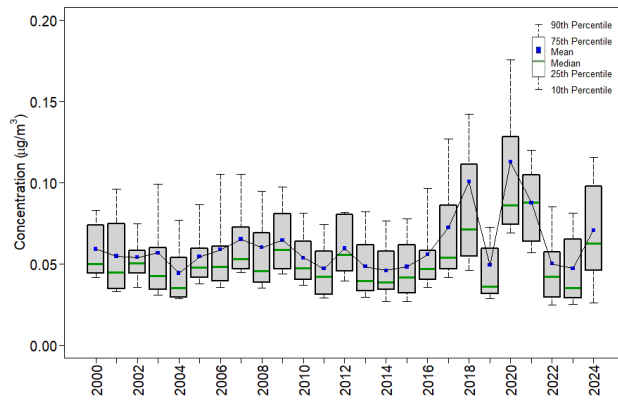
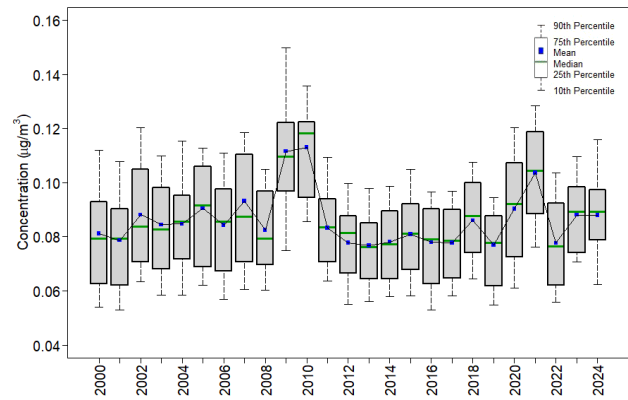
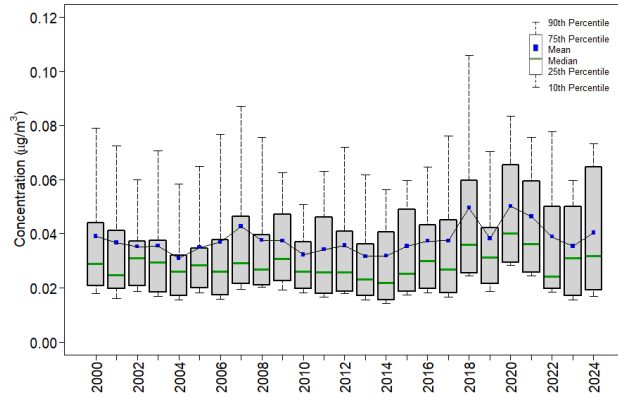
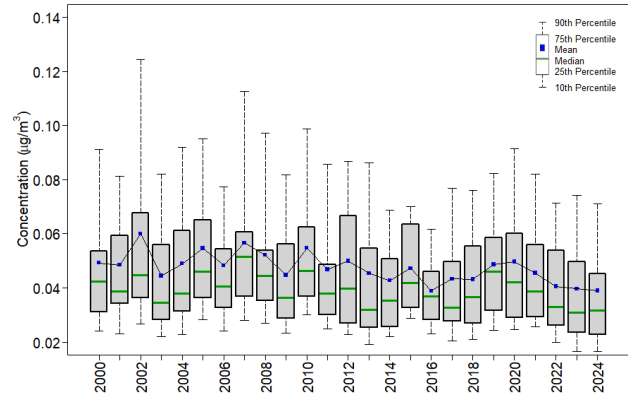
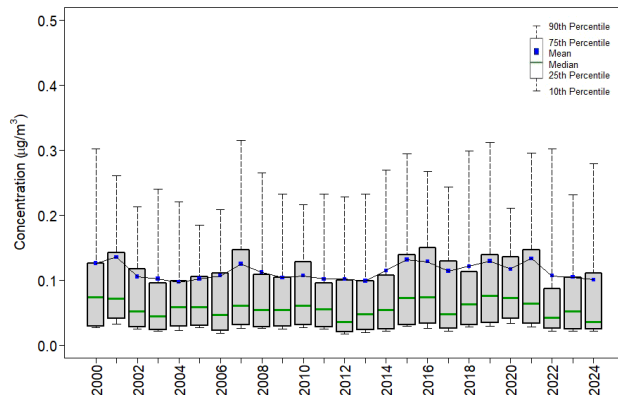


Figure 9. Trends in Third Quarter Mean K^+ Concentrations
Western Reference Sites

Eastern Reference Sites

**Figure 10. Trends in Third Quarter Mean Mg^{2+} Concentrations**
Western Reference Sites

Eastern Reference Sites

**Figure 11. Trends in Third Quarter Mean Na^+ Concentrations**
Western Reference Sites

Eastern Reference Sites

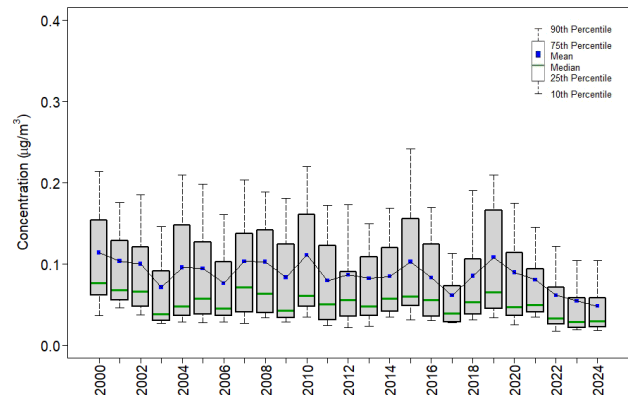
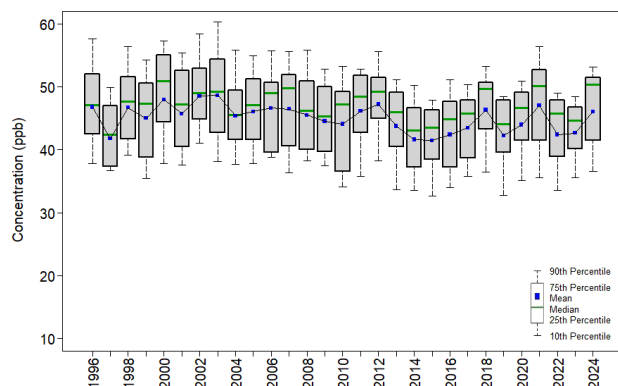
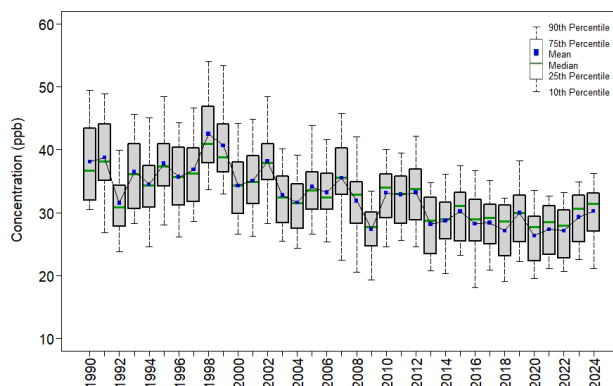


Figure 12. Trends in Third Quarter Mean O₃ Concentrations
Western Reference Sites



Eastern Reference Sites



Changes in Three-Year Average Third Quarter Concentrations

Tables 2 and 3 summarize changes in three-year averages of quarterly mean concentrations of O₃, total NO₃⁻, NH₄⁺, and SO₄²⁻ over the period 1990–1992 through 2022–2024 for the eastern reference sites and 1996–1998 through 2022–2024 for the western reference sites. Changes in Ca²⁺, K⁺, Mg²⁺, Na⁺ and Cl⁻ concentrations are shown from 2004–2006 through 2022–2024.

Table 2. Eastern Reference Sites: Three-Year Mean Values (ppb or µg/m³)

	O ₃ (ppb)	Total NO ₃ ⁻	NH ₄ ⁺	SO ₄ ²⁻	Ca ²⁺	K ⁺	Mg ²⁺	Na ⁺	Cl ⁻
1990–1992	36	2.7	2.2	8.2					
2004–2006					0.27	0.09	0.05	0.09	0.04
2022–2024	29	0.8	0.4	1.1	0.22	0.08	0.04	0.05	0.04
Percent Change	-20	-70	-83	-87	-18	-2	-17	-38	3

Note: Ozone concentrations are given as ppb. Concentrations for all other parameters are in µg/m³.

Table 3. Western Reference Sites: Three-Year Mean Values (ppb or µg/m³)

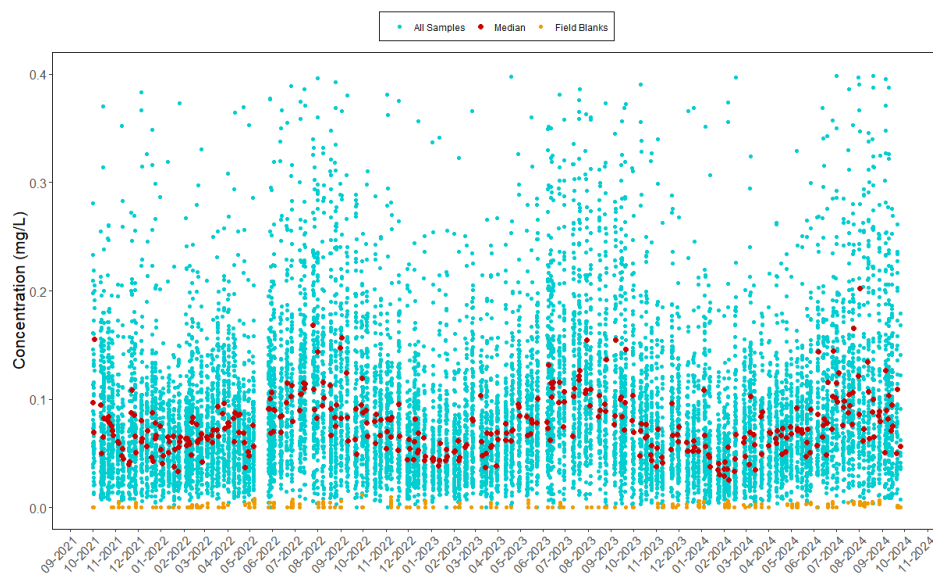
	O ₃ (ppb)	Total NO ₃ ⁻	NH ₄ ⁺	SO ₄ ²⁻	Ca ²⁺	K ⁺	Mg ²⁺	Na ⁺	Cl ⁻
1996–1998	45	1.4	0.4	1.2					
2004–2006					0.19	0.05	0.03	0.10	0.03
2022–2024	44	0.8	0.2	0.6	0.25	0.06	0.04	0.10	0.04
Percent Change	-3	-42	-46	-50	34	7	11	2	49

Note: Ozone concentrations are given as ppb. Concentrations for all other parameters are in µg/m³.

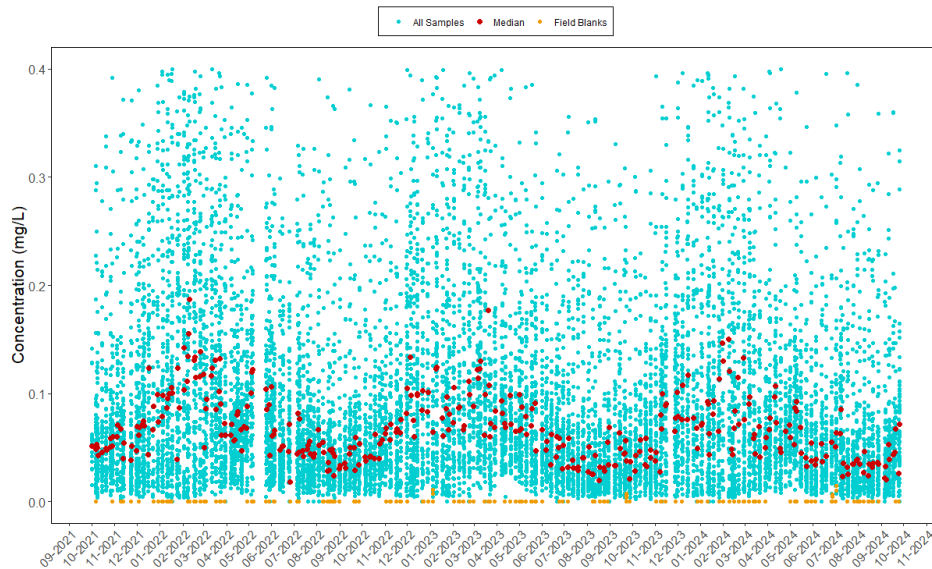
Time Series of Laboratory Analysis Parameters for All Sites

Figures 13 through 23 give time series of laboratory-analyzed concentrations of field samples and field blanks in milligrams per liter (mg/L) of 11 parameters from fourth quarter 2021 through third quarter 2024. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

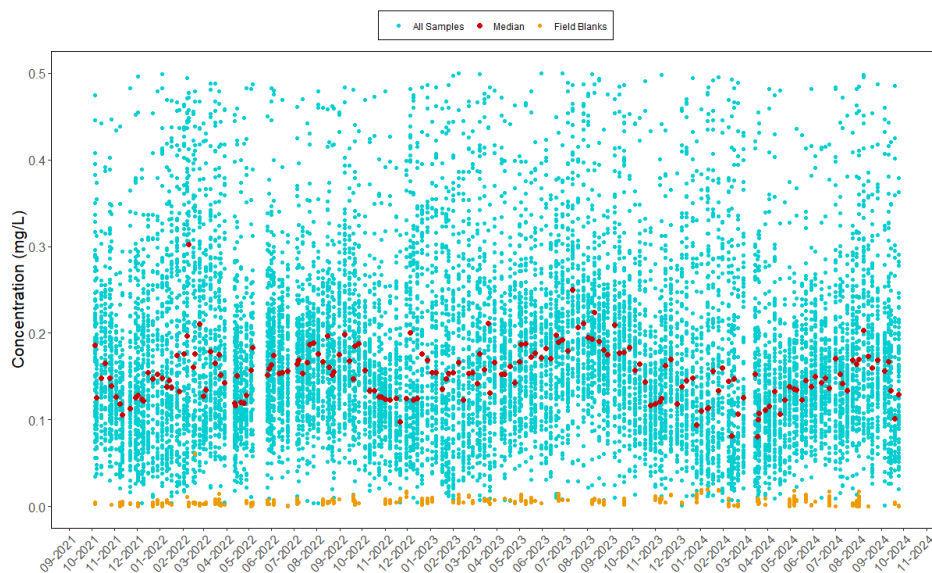
Figure 13. Concentrations of NO_3^- (as N) from Nylon Filters



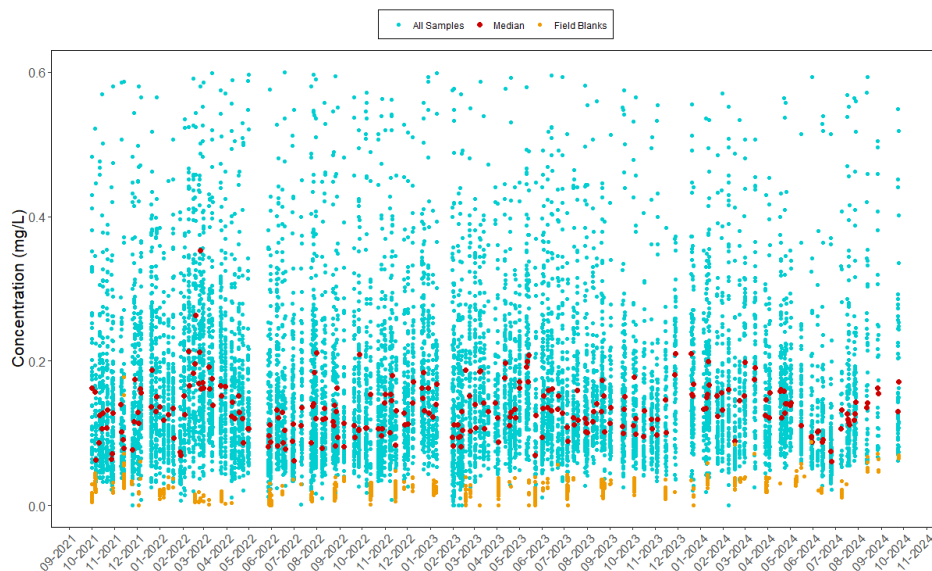
Note: Nominal reporting limit is 0.008 mg/L

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

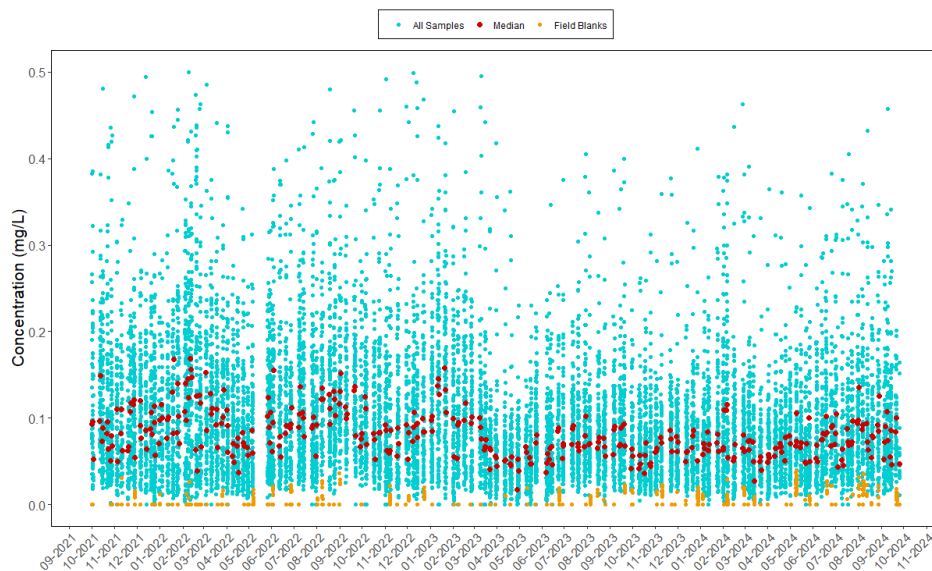
Note: Nominal reporting limit is 0.008 mg/L

Figure 15. Concentrations of NH_4^+ (as N) from Teflon Filters

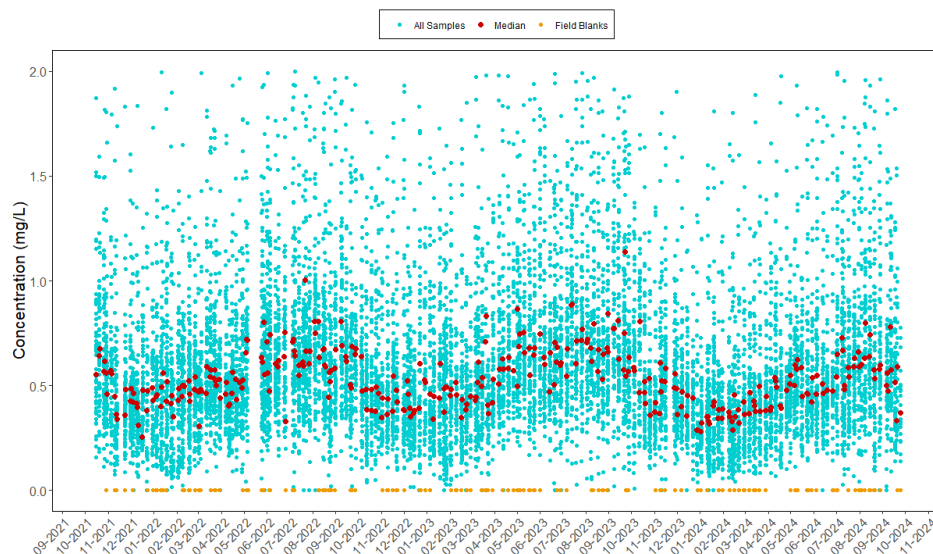
Note: Nominal reporting limit is 0.020 mg/L

Figure 16. Concentrations of SO₂ from K₂CO₃-impregnated Cellulose Filters

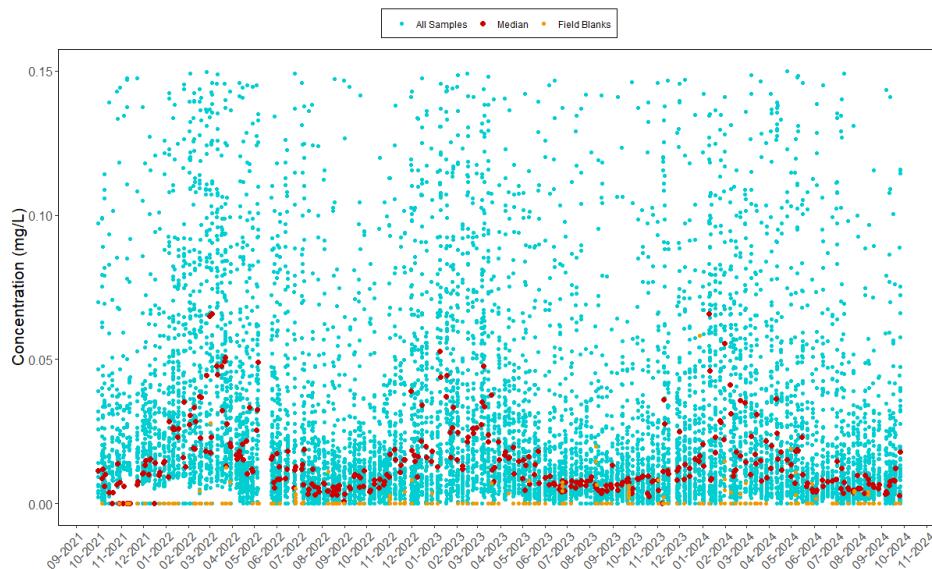
Note: Nominal reporting limit is 0.040 mg/L

Figure 17. Concentrations of SO₄²⁻ from Nylon Filters

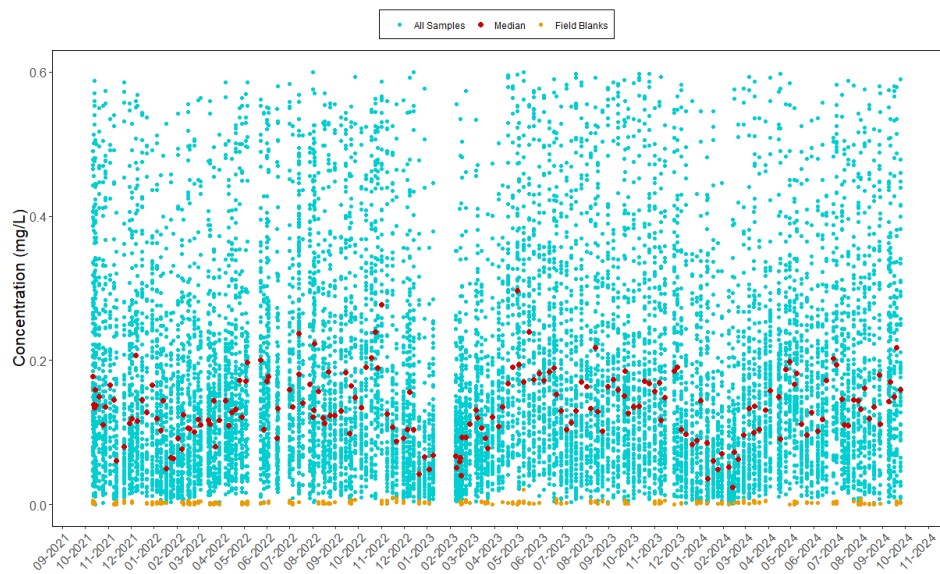
Note: Nominal reporting limit is 0.040 mg/L

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

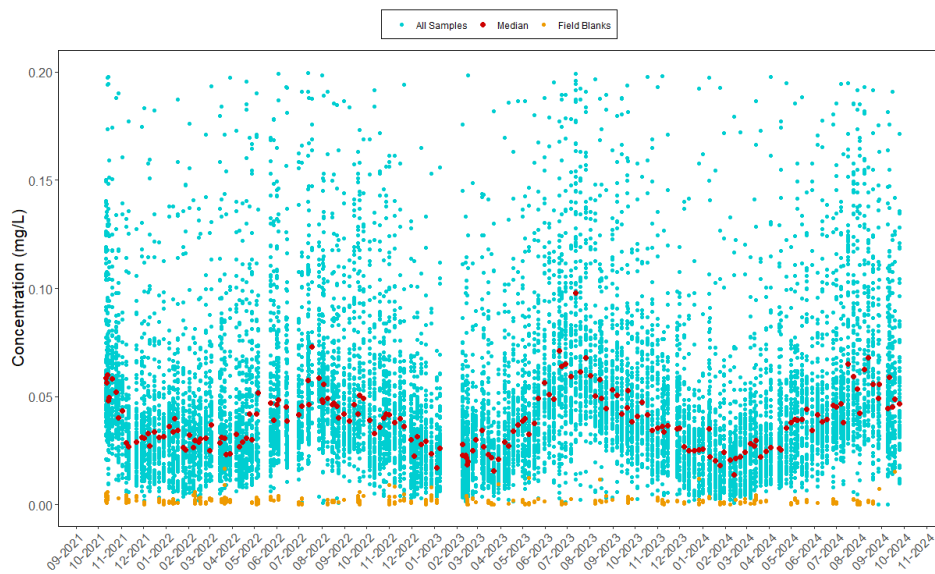
Note: Nominal reporting limit is 0.040 mg/L

Figure 19. Concentrations of Cl^- from Teflon Filters

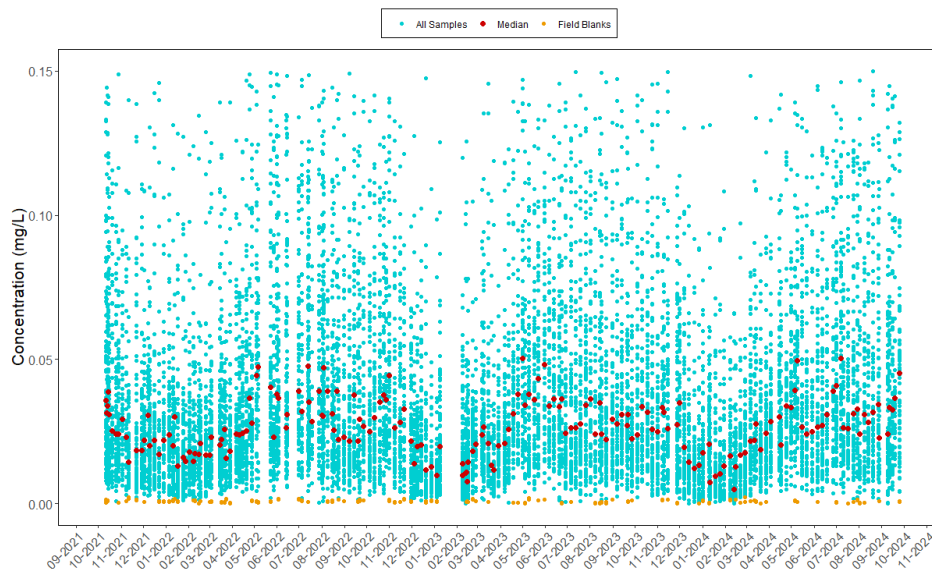
Note: Nominal reporting limit is 0.020 mg/L

Figure 20. Concentrations of Ca^{2+} from Teflon Filters

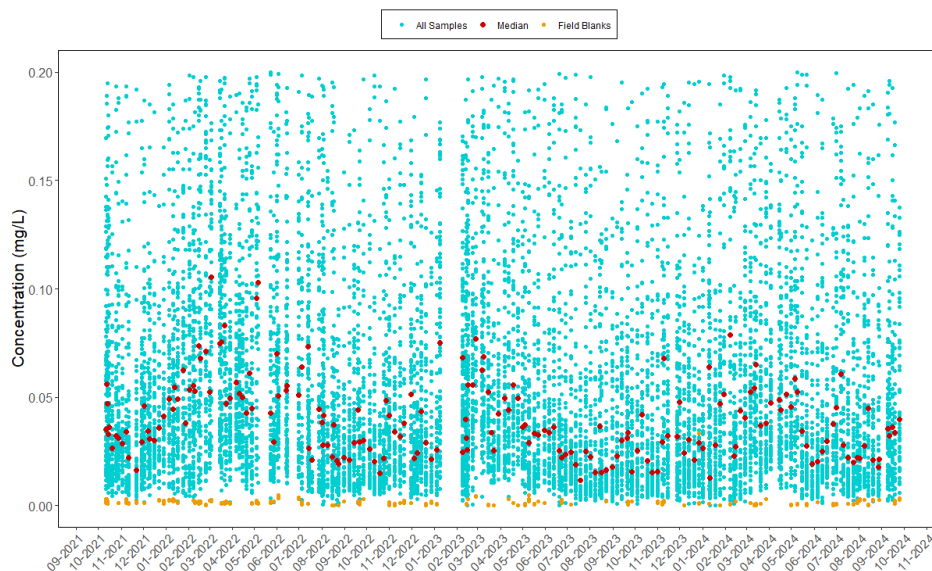
Note: Nominal reporting limit is 0.006 mg/L

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

Note: Nominal reporting limit is 0.006 mg/L

Figure 22. Concentrations of Mg^{2+} from Teflon Filters

Note: Nominal reporting limit is 0.003 mg/L

Figure 23. Concentrations of Na^+ from Teflon Filters

Note: Nominal reporting limit is 0.005 mg/L

Time Series of Concentration Differences from Co-located Sites

A time series of concentration differences between two sets of co-located sites are illustrated in Figures 24 and 25. The anomaly in Figure 24 was caused by suspected contamination of a sample at MCK131, KY. A high Na^+ result from this sample was invalidated, and there remains the possibility of unconfirmed associated contaminants. This sample provides valuable information about the precision of filter pack measurements.

Figure 24. Filter Concentration Differences between MCK131 and MCK231, KY for Third Quarter 2024

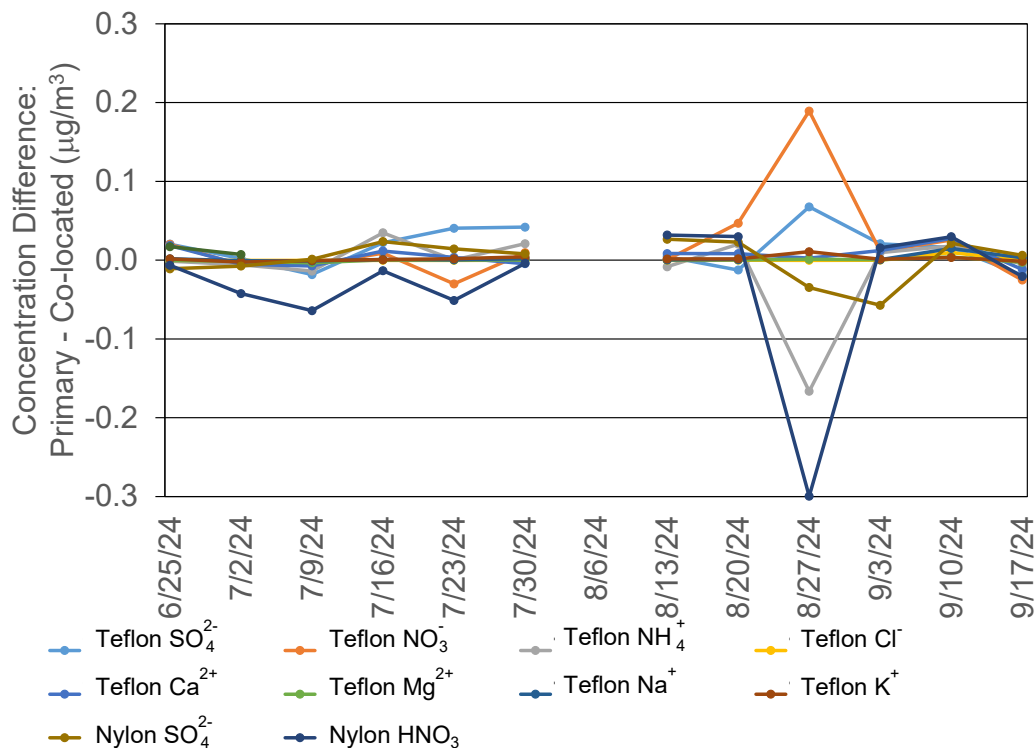
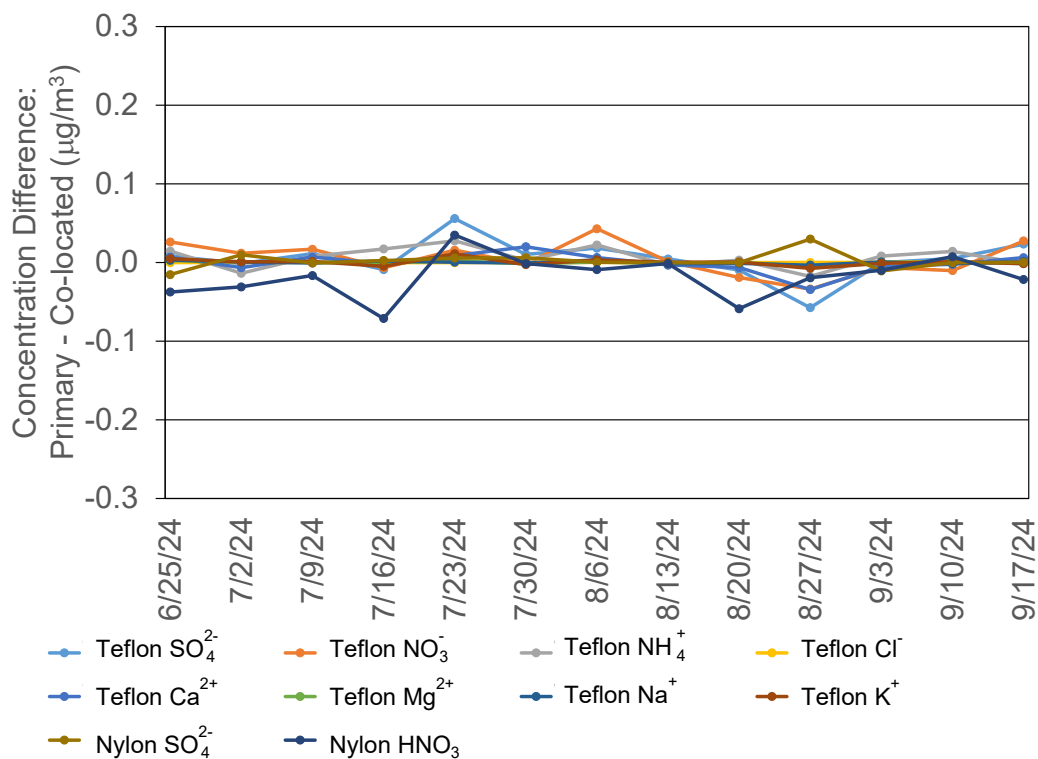


Figure 25. Filter Concentration Differences between ROM406 and ROM206, CO for Third Quarter 2024

Precision of Filter Pack Concentrations

Table 4 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231, KY and ROM406/206, CO during third quarter 2024. The MARPD values met the 20 percent criterion.

Table 4. Precision (MARPD) for Co-located Filter Pack Data during Third Quarter 2024

	Total NO ₃ ⁻	HNO ₃	NO ₃ ⁻	NH ₄ ⁺	SO ₄ ²⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	Cl ⁻
MCK131/231, KY										
\bar{X} (μg/m ³)	1.04	0.63	0.41	0.35	0.89	0.26	0.05	0.11	0.07	0.06
\bar{Y} (μg/m ³)	1.06	0.63	0.44	0.36	0.90	0.28	0.05	0.12	0.07	0.06
MAD	0.04	0.02	0.03	0.01	0.01	0.03	0.00	0.00	0.00	0.00
MARPD	3.83	4.08	5.06	3.13	1.63	7.45	7.76	4.17	6.02	1.11
ROM406/206, CO										
\bar{X} (μg/m ³)	0.47	0.30	0.17	0.12	0.32	0.14	0.02	0.03	0.02	0.01
\bar{Y} (μg/m ³)	0.48	0.31	0.18	0.12	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 5 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 5. Sites with Less than 90 Percent Success in Filter Pack Deployment during Third 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
BBE401, TX	69.2	69.2	69.2	69.2	69.2	69.2	69.2	N/A	The site was damaged by a lightning strike. This affected four samples.
BVL130, IL	76.9	76.9	76.9	76.9	76.9	76.9	76.9	7.7	The Mass Flow Controller (MFC) malfunctioned and was replaced. This affected three samples.
CAT175, NY	76.9	76.9	76.9	76.9	76.9	76.9	76.9	7.7	Two samples were lost in shipping.
CHE185, OK	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The data logger malfunctioned. This affected the flow data for two samples.
CND125, NC	84.6	84.6	84.6	84.6	84.6	84.6	84.6	7.7	The MFC malfunctioned and was replaced. This affected one sample. In addition, there was one 2-week sample.
GRC474, AZ	84.6	84.6	84.6	84.6	84.6	84.6	84.6	N/A	The data logger malfunctioned. This affected flow data for two samples.
LAV410, CA	61.5	61.5	61.5	61.5	61.5	61.5	61.5	N/A	There was a communication issue which affected five samples. Satellite service was down.
PIN414, CA	69.2	69.2	69.2	69.2	69.2	69.2	69.2	N/A	There was one 3-week sample during the quarter. Flow readings were 0.0 liters per minute (LPM) from 9-18-24 to 9-26-24. This affected an additional sample.
SHN418, VA	76.9	76.9	76.9	76.9	76.9	76.9	76.9	N/A	A power outage affected one sample, and a leak in the flow system affected two more.
SPD111, TN	84.6	84.6	84.6	84.6	84.6	84.6	84.6	7.7	There was insufficient flow volume for two samples.
VPI120, VA	84.6	84.6	84.6	84.6	84.6	84.6	84.6	7.7	Power failure affected one sample. Another sample was invalidated for suspect data.

Note: N/A = Filter pack SO₂ concentrations were not measured.

Precision of Ozone Concentrations

Time series of hourly O₃ concentration differences for third quarter 2024 are provided in Figures 26 and 27 for co-located sites MCK131/231 and ROM406/206, respectively.

Figure 26. O₃ Concentration Differences for Co-located sites MCK131 and MCK231, KY for Third Quarter 2024

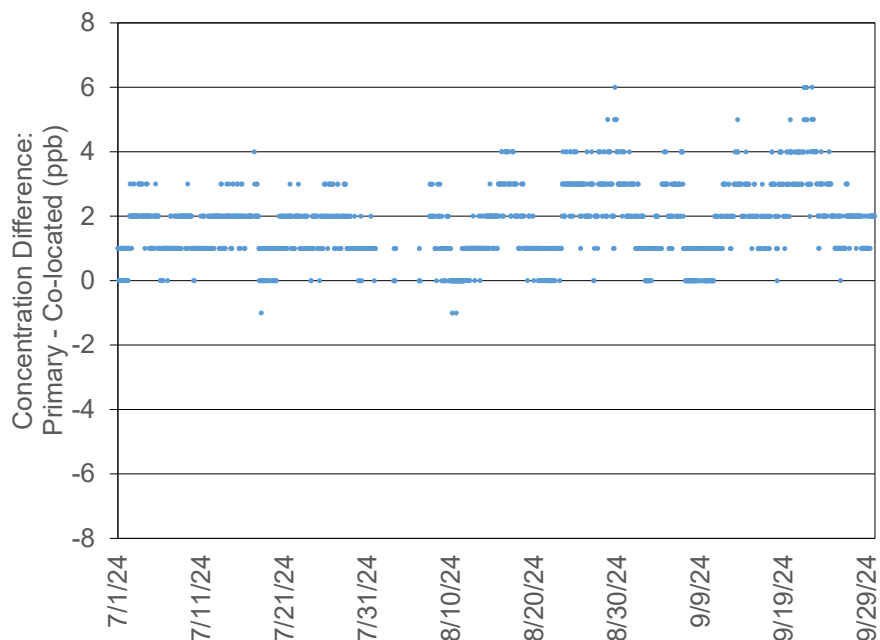


Figure 27. O₃ Concentration Differences for Co-located sites ROM406 and ROM206, CO for Third Quarter 2024

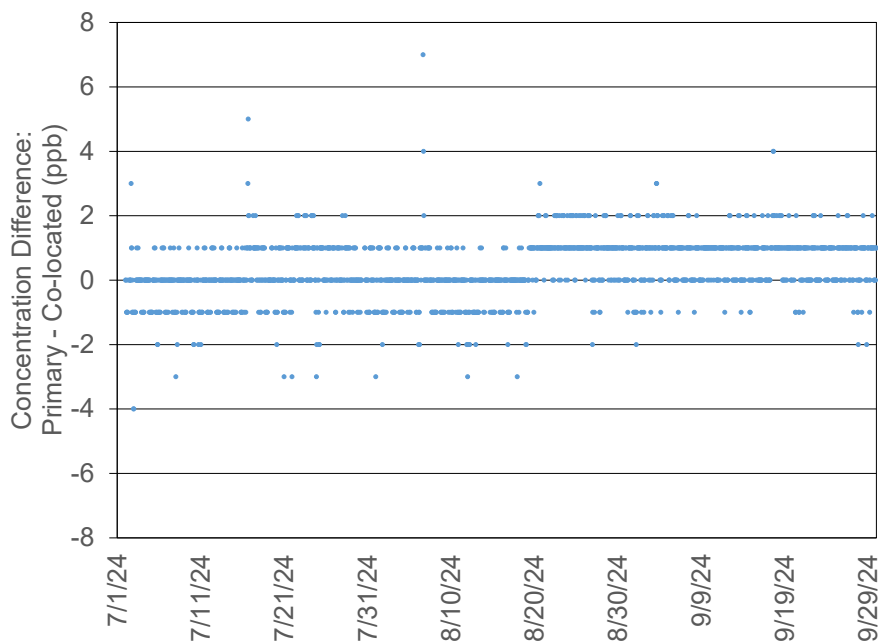


Table 6 gives MARPD data for O₃ data measured at the two co-located sites.

Table 6. Quarterly Precision (MARPD) for Co-located O₃ Concentrations

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	4	10/1/23	2.2	2031
	1	1/1/24	1.7	2068
	2	4/1/24	2.8	1963
	3	7/1/24	5.1	1930
ROM406/206, CO				
	4	10/1/23	1.2	2072
	1	1/1/24	1.1	2054
	2	4/1/24	1.0	1931
	3	7/1/24	1.4	2076

Completeness for Ozone Concentrations

Calculation of an annual O₃ value requires 75 percent completeness. Calculations of the three-year design value used for regulatory purposes, requires 90 percent completeness. Table 7 shows CASTNET sites with less than 90 percent completeness for DM8A O₃ concentrations. Comments are provided for these sites.

Table 7. Sites with less than 90 Percent Data Completeness for DM8A Concentrations during Third Quarter 2024

Site ID	Percent Completeness	Comments
BBE401, TX	33.7	The site was damaged by lightning strike.
LAV410, CA	57.6	There was a communications issue. The satellite service was down.
NPT006, ID	60.9	The site analyzer sample pump failed in late June and was replaced in mid-July.
BEL116, MD	73.9	High shelter temperatures in July resulted in some invalidations. The shelter became hot enough that instruments needed to be shut down until late July. There was also a power failure in September.
GRC474, AZ	76.1	Data logger malfunction
LPO010, CA	77.2	The site analyzer sample pump failed in late July and was replaced in early August.
CAN407, UT	81.5	There were shelter temperature issues in July and August.
CHE185, OK	82.6	Data logger malfunction
SPD111, TN	83.7	There were power failures in August and September.
BWR139, MD	85.9	There was an obstruction in the ozone inlet that affected data from mid to late September.
CRM435, ID	85.9	The ozone sample pump failed. Data were invalid from 8/25 – 9/5.
MCK131, KY	87.0	There were shelter temperature issues in August.
MCK231, KY	87.0	There were shelter temperature issues in August.
CNT169, WY	89.1	There was a sample line leak in August.

Table 8 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 8. Sites with less than 90 Percent Data Completeness for O₃ Concentrations

Site ID	Q3 2024	Q4 2023 – Q3 2024	Comments
BBE401, TX	40.7	80.3	The site was damaged by a lightning strike.
BEL116, MD	82.4	94.2	High shelter temperatures in July resulted in some invalidations. The shelter became hot enough that instruments needed to be shut down until late July. There was also a power failure in September.
BWR139, MD	88.6	96.6	There was an obstruction in the ozone inlet that affected data from mid to late September.
CNT169, WY	89.1	92.4	There was a sample line leak in August.
CRM435, ID	87.0	95.7	The ozone sample pump failed. Data were invalid from 8/25 – 9/5.
GRC474, AZ	82.0	93.8	Data logger malfunction.
LAV410, CA	60.4	87.0	There was a communications issue. The satellite service was down.
LPO010, CA	78.5	92.3	The site analyzer sample pump failed in late July and was replaced in early August.
NPT006, ID	64.3	89.5	The site analyzer sample pump failed in late June and was replaced in mid-July.
SPD111, TN	86.6	92.7	There were power failures in August and September.

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

Figures 28 through 32 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO₃⁻ concentrations collected at the five sites with NO_y measurements. The NO_y concentrations were consistently higher than the total NO₃⁻ levels at all sites. The average weekly NO_y levels, the weekly total NO₃⁻ concentrations, and their ratios for the five sites with available data are shown in Table 9. Ratios of NO_y to total NO₃⁻ varied from 3.23 at GRS420, TN to 6.63 at BVL130, IL.

Table 9. Summary of Total NO₃⁻/NO_y Measurements for Third Quarter 2024

Site ID	Elevation	Total NO ₃ ⁻ (ppb)	NO _y (ppb)	Ratio
BVL130, IL	213	0.53	3.15	6.63
DUK008, NC	164*	0.34	1.96	5.73
GRS420, TN	793	0.30	0.94	3.23
SAN192, NE	386	0.47	2.12	4.25
STK138, IL	281	0.43	1.51	3.87

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

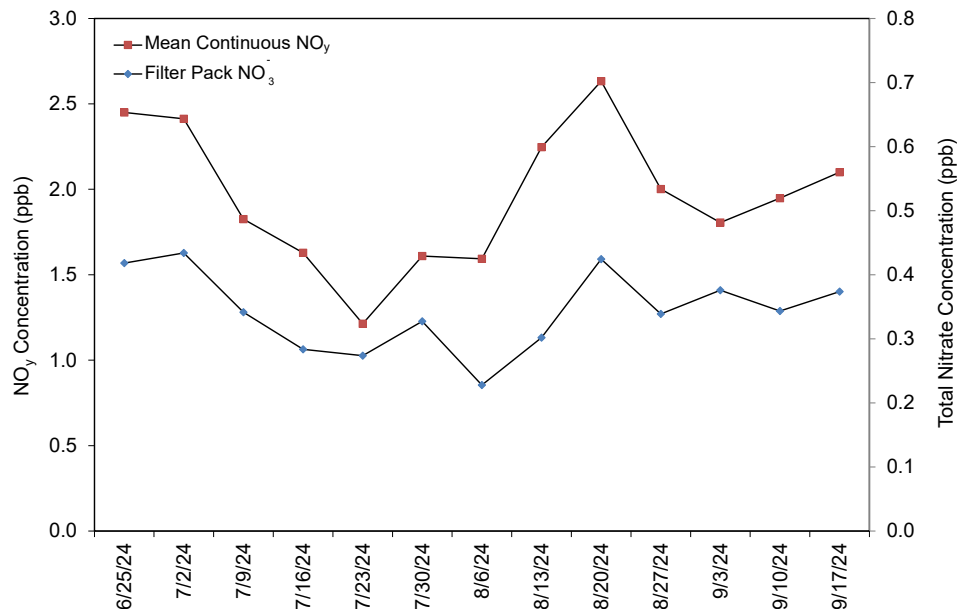
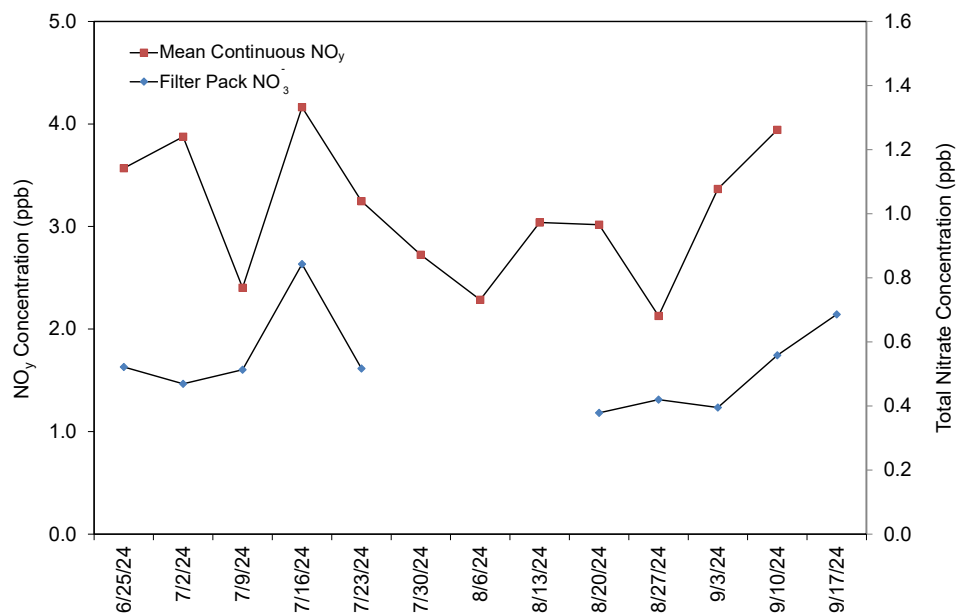
Figure 28. Comparison of DUK008, NC Weekly Mean Continuous NO_y and Total NO_3^- Concentrations**Figure 29.** Comparison of BVL130, IL Weekly Mean Continuous NO_y and Total NO_3^- Concentrations

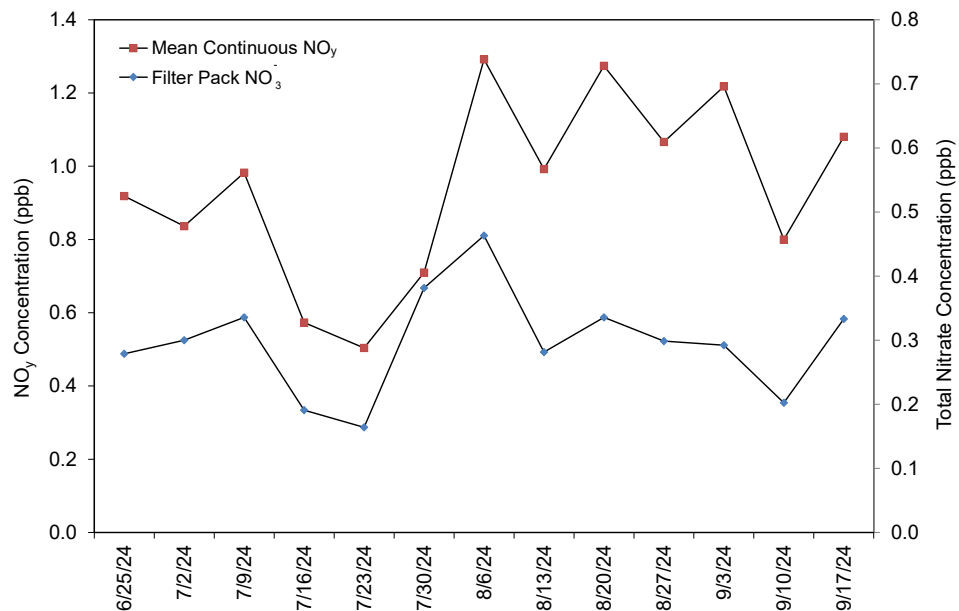
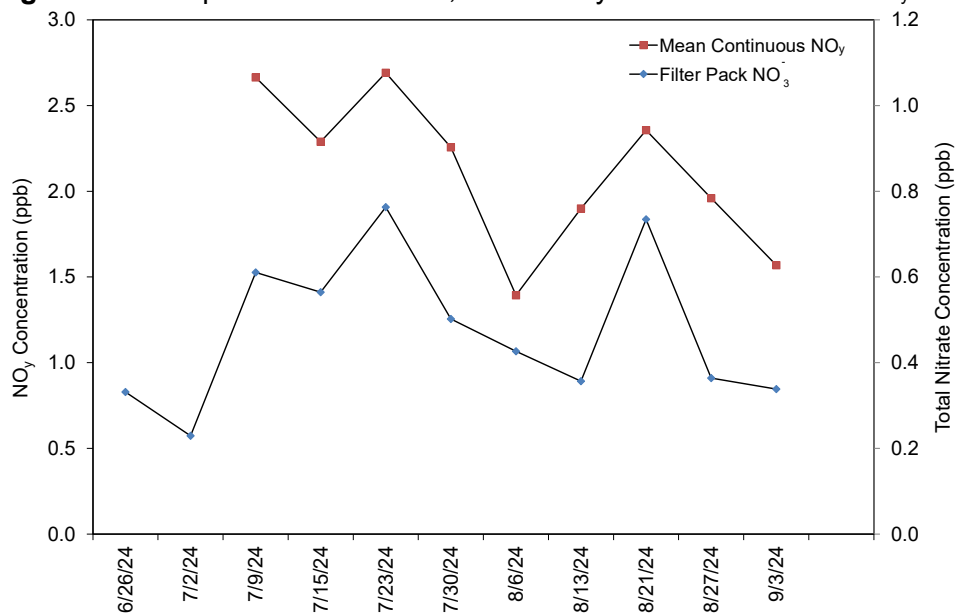
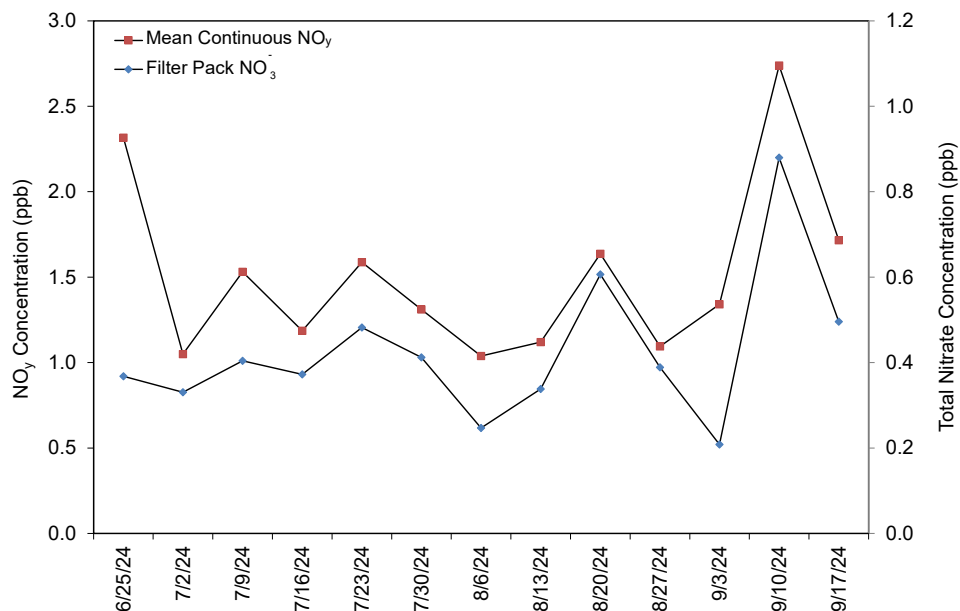
Figure 30. Comparison of GRS420, TN Weekly Mean Continuous NO_y and Total NO_3^- Concentrations**Figure 31.** Comparison of SAN192, NE Weekly Mean Continuous NO_y and Total NO_3^- Concentrations

Figure 32. Comparison of STK138, IL Weekly Mean Continuous NO_y and Total NO₃ Concentrations

Completeness for Continuous Trace-level Gas measurements

Table 10 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 third quarter 2024. The average for fourth quarter 2023 through third quarter 2024 for each of the sites is included for reference.

Table 10. Percent Data Completeness for Continuous Trace-level Gas Measurements (1 of 2)

Site ID	Parameter	Q3 2024	Q4 2023– Q3 2024	Comments
BVL130, IL	CO	93	90	Calibration drift in September.
	NO	93	93	
	NOY	84	90	
	NOYDIF	84	90	
	SO2_GA	92	91	
DUK008, NC	HNO3	92	83	
	NH3	92	83	
	NO	92	83	
	NO2_TRUE	92	83	
	NOX_TRUE	92	83	
	NOY	92	83	
	NOY_MINUS	92	83	
	NOYDIF	92	83	
	TNX	92	83	

Table 10. Percent Data Completeness for Continuous trace-level Gas Measurements (2 of 2)

Site ID	Parameter	Q3 2024	Q4 2023– Q3 2024	Comments
GRS420, TN	CO	82	89	Data were invalidated in August due to precision checks that were outside acceptance criteria from 8/14 – 8/20 and again from 8/23 – 8/31.
	NO	85	86	Data were invalid from 9/18 through the end of September due to calibration drift.
	NOY	85	86	
	NOYDIF	94	91	
	SO2_GA	95	94	
SAN192, NE	NO	84	84	Calibration drift in July.
	NOY	82	82	
	NOYDIF	82	82	
STK138, IL	HNO3	87	87	Calibration drift and long run times for NH3 ZPS checks which affected the other parameters.
	NH3	84	84	
	NO	86	86	
	NO2_TRUE	86	86	
	NOX_TRUE	87	87	
	NOY	87	87	
	NOY_MINUS	87	87	
	NOYDIF	86	86	
	TNX	84	84	

Note: * See Table 11

The parameters listed in Table 10 are both calculated and measured. Table 11 provides information on how the parameters listed in Table 10 are obtained.

Table 11. 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) Third Quarter 2024 Quality Assurance Report. <https://www.epa.gov/castnet/documents-reports>