Clean Air Status and Trends Network (CASTNET)
Quarterly Data Summary for Second Quarter 2020 (April through June)

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

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during second quarter 2020. 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 eight sites and continuous SO_2 concentrations from three sites. Other QC statistics are given in the CASTNET Second Quarter 2020 Quality Assurance Report (Wood, 2020).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O_3 Concentrations through Second Quarter 2020 (ppb)

Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O_3 concentrations measured through second quarter 2020. Two California 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 34 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.

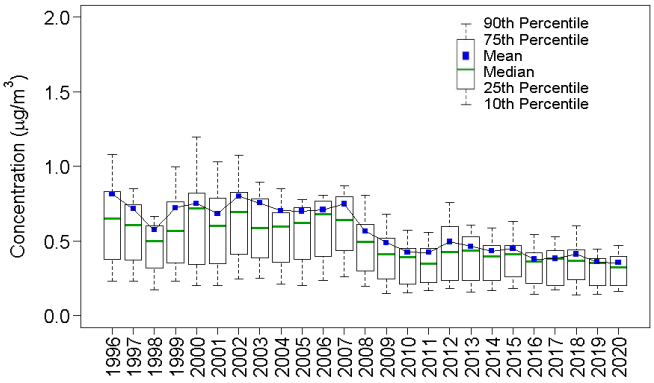
Second Quarter Concentrations

Quarterly mean HNO_3, NO_3^-, NH_4^+, total NO_3^-, SO_2, SO_4^{2-}, K^+, and Na^+ concentrations decreased at eastern sites in 2020, and Cl^-, Ca^{2+}, and Mg^{2+} concentrations increased. Quarterly mean HNO_3, NO_3^-, total NO_3^-, SO_4^{2-}, and Na^+ concentrations decreased at western sites in 2020 while NH_4^+, SO_2, Cl^-, Ca^{2+}, K^+, and Mg^{2+} concentrations increased.

Quarterly O_3 concentrations were analyzed using box plots constructed by averaging all valid hourly O_3 concentrations within second quarter 2020 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 O_3 concentrations at eastern sites. 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

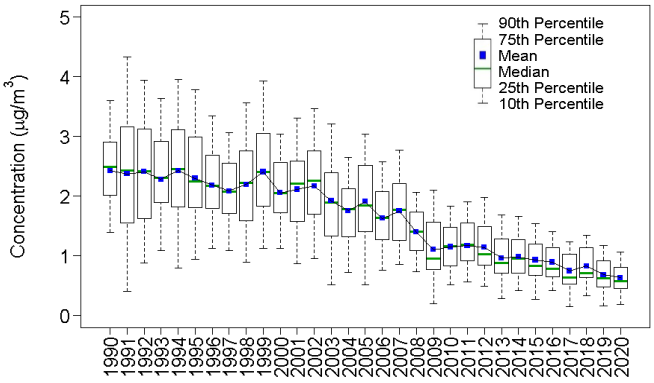
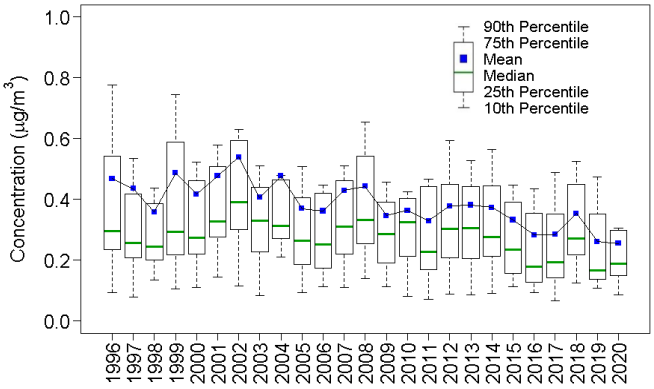


Figure 3. Trends in Second Quarter Mean NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

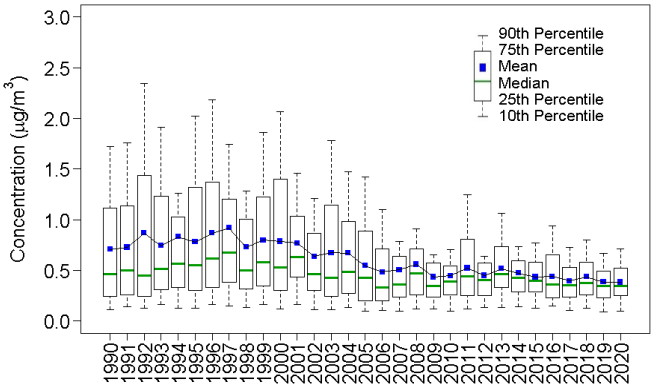
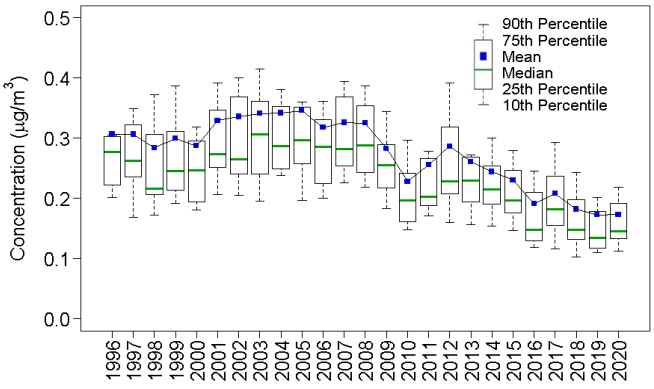


Figure 4. Trends in Second Quarter Mean NH_4^+ Concentrations

Western Reference Sites



Eastern Reference Sites

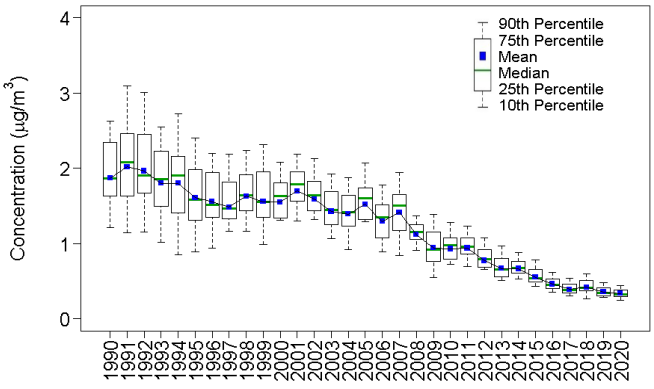
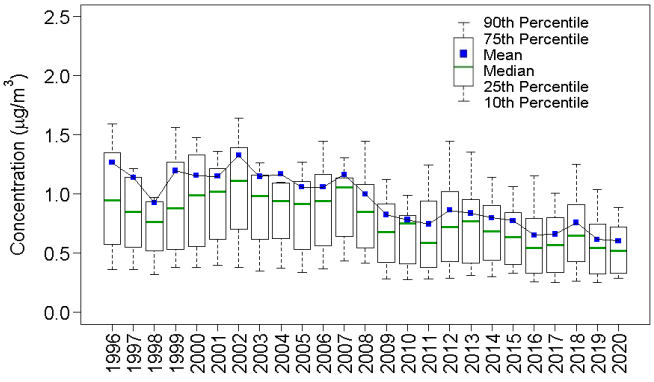


Figure 5. Trends in Second Quarter Mean Total NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

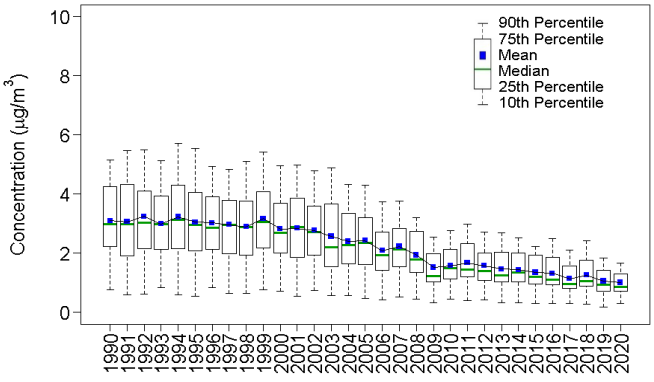
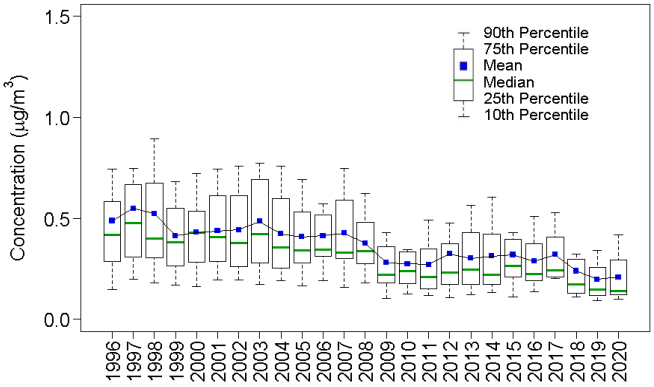


Figure 6. Trends in Second Quarter Mean SO_2 Concentrations

Western Reference Sites



Eastern Reference Sites

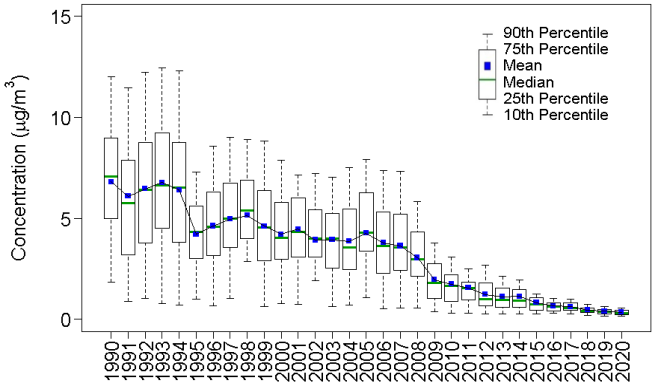
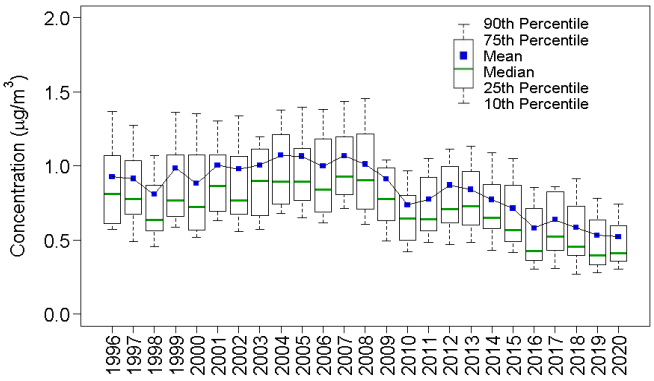


Figure 7. Trends in Second Quarter Mean SO_4^{2-} Concentrations

Western Reference Sites



Eastern Reference Sites

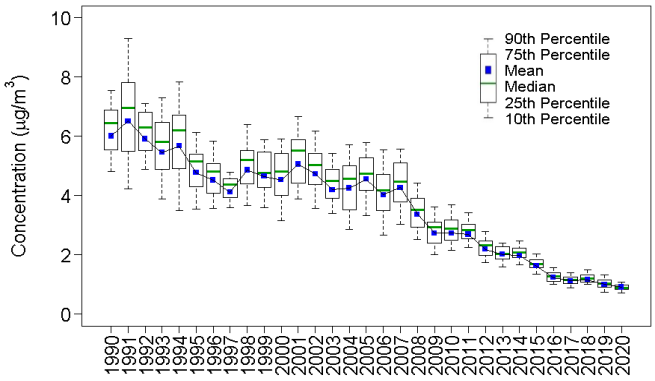
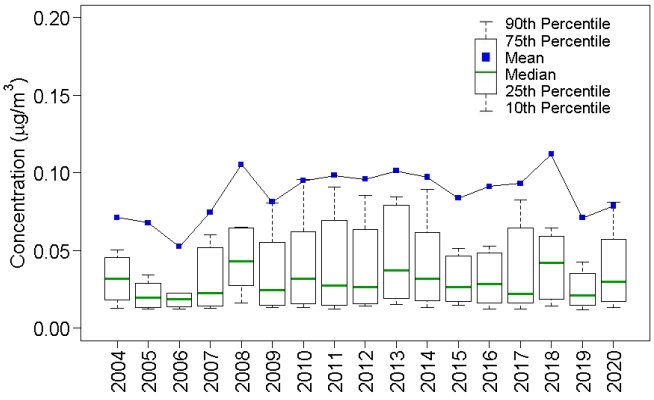


Figure 8. Trends in Second Quarter Mean Cl^- Concentrations

Western Reference Sites



Eastern Reference Sites

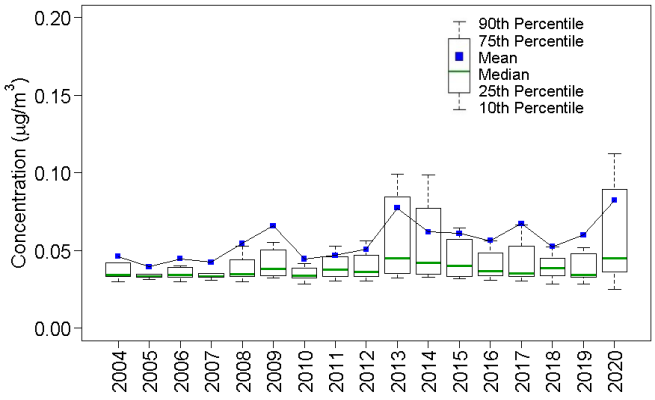
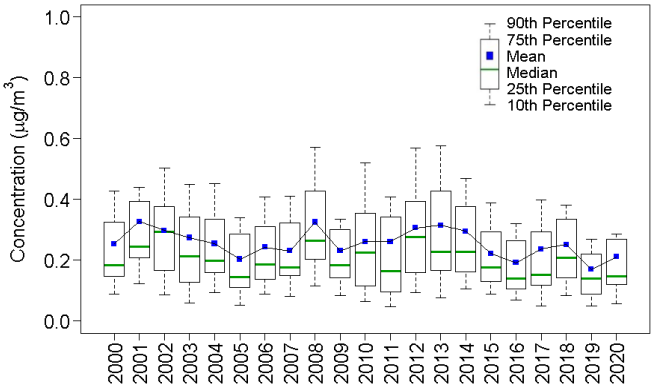


Figure 9. Trends in Second Quarter Mean Ca^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

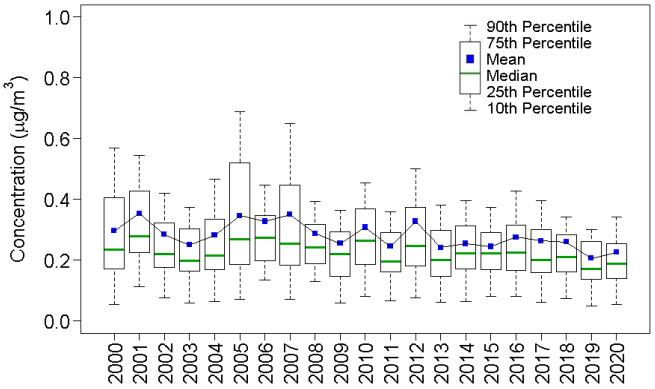
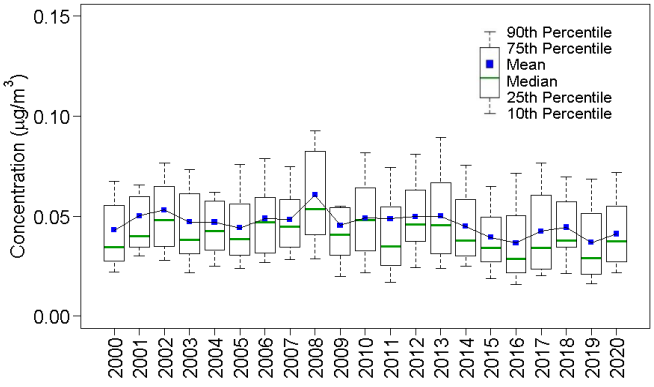


Figure 10. Trends in Second Quarter Mean K^{+} Concentrations

Western Reference Sites



Eastern Reference Sites

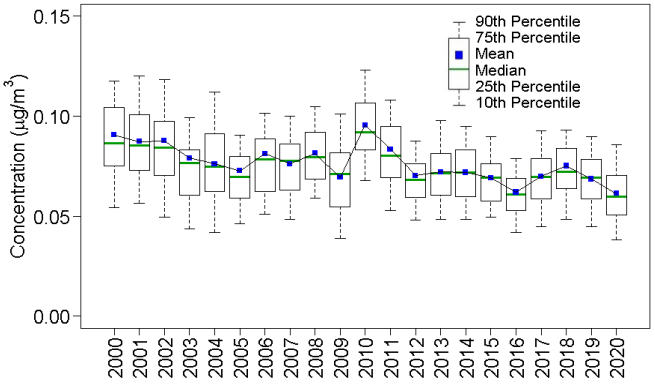
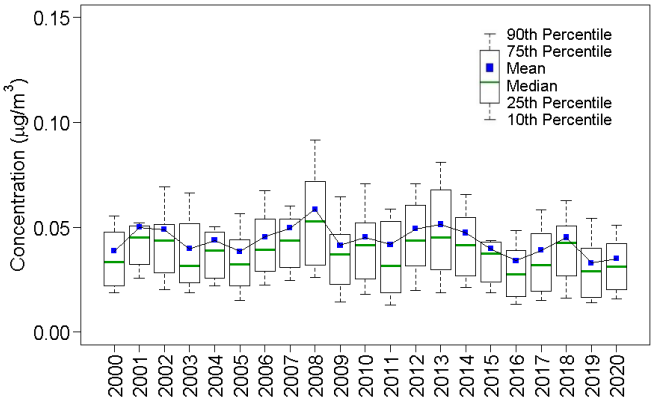


Figure 11. Trends in Second Quarter Mean Mg^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

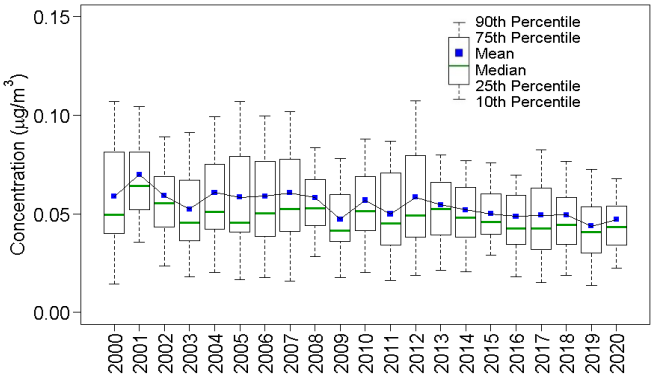
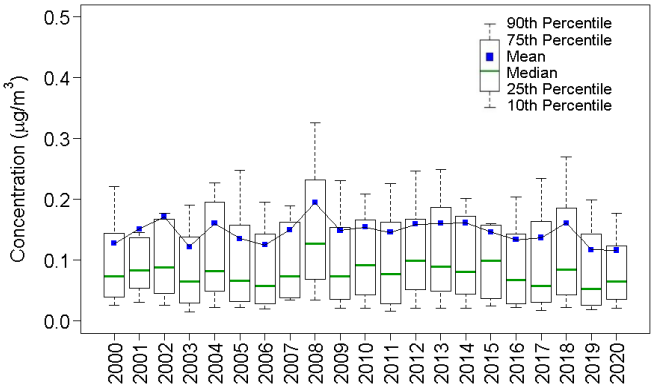


Figure 12. Trends in Second Quarter Mean Na^+ Concentrations

Western Reference Sites



Eastern Reference Sites

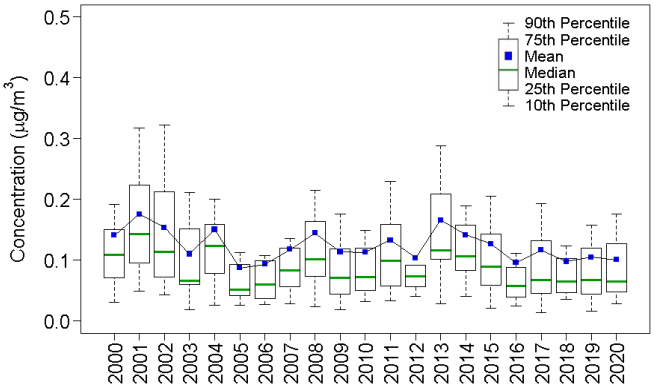
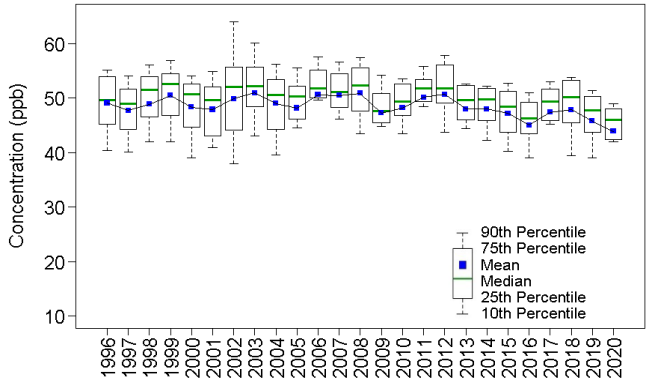
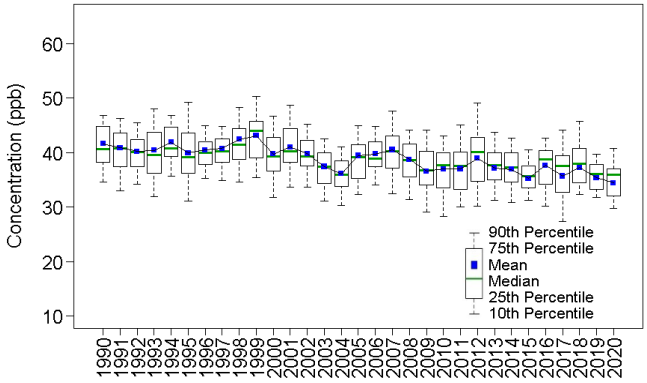


Figure 13. Trends in Second Quarter Mean O_3 Concentrations

Western Reference Sites



Eastern Reference Sites



Changes in 3-year Average Second Quarter Concentrations

Three-year averages of quarterly mean concentrations of total NO_3^-, NH_4^+, SO_2, SO_4^{2-}, and O_3 were reduced over the period 1990–1992 through 2018–2020 for eastern reference sites and 1996–1998 through 2018–2020 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 O_3 Pollutant Concentrations

	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1990–1992	3.1	2.0	6.5	6.1	41
2018–2020	1.1	0.4	0.4	1.0	36
Percent Change	-65	-81	-94	-83	-13

Table 2. Western Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O_3 Pollutant Concentrations

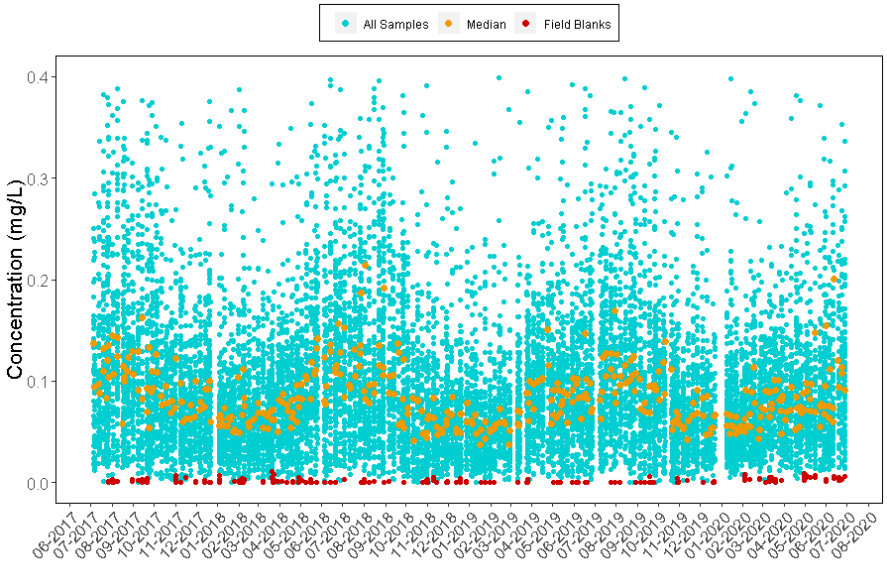
	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1996–1998	1.1	0.3	0.5	0.9	49
2018–2020	0.7	0.2	0.2	0.5	46
Percent Change	-41	-41	-59	-38	-6

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 2017 through second quarter 2020. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

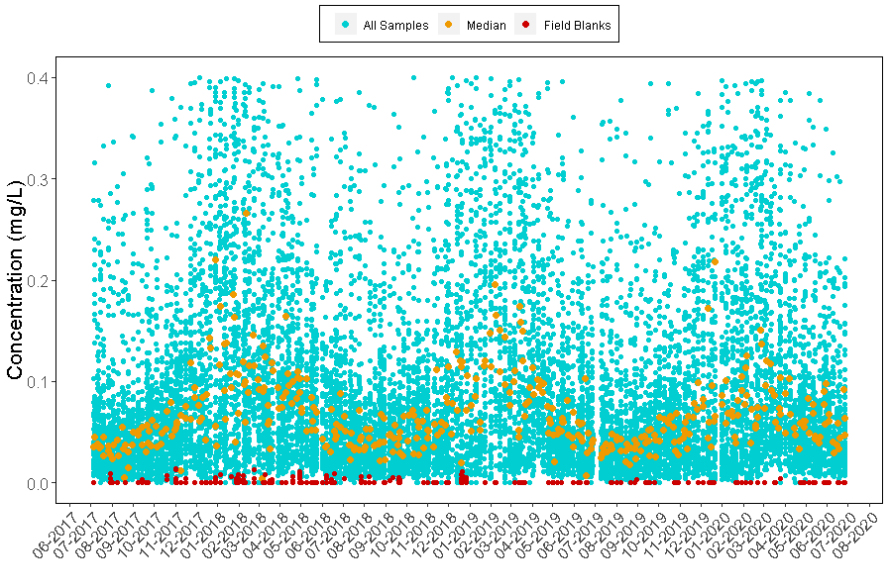
Previous review of filter pack analysis control charts indicated possible potassium contamination (Figure 22). Corrective actions were implemented and subsequent testing indicated these actions have been effective.

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



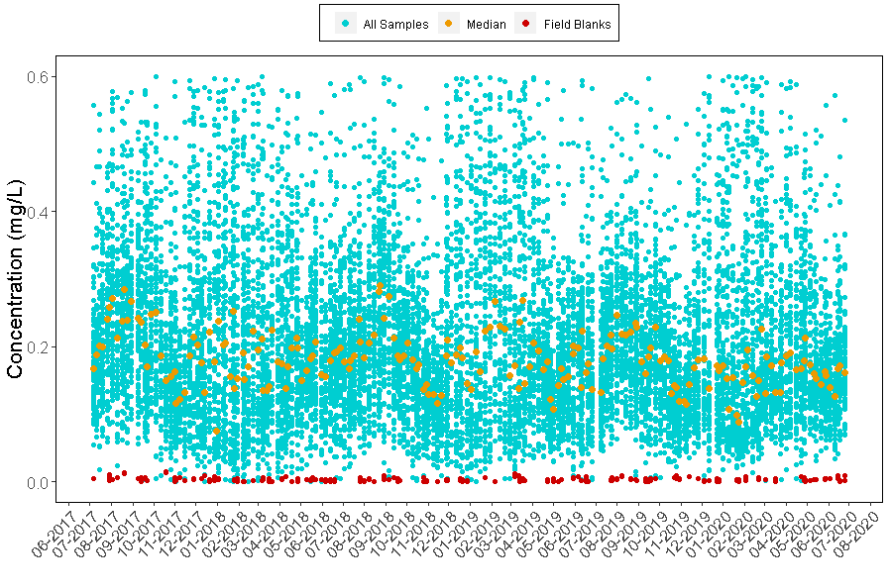
Note: Nominal reporting limit is 0.008 mg/L.

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



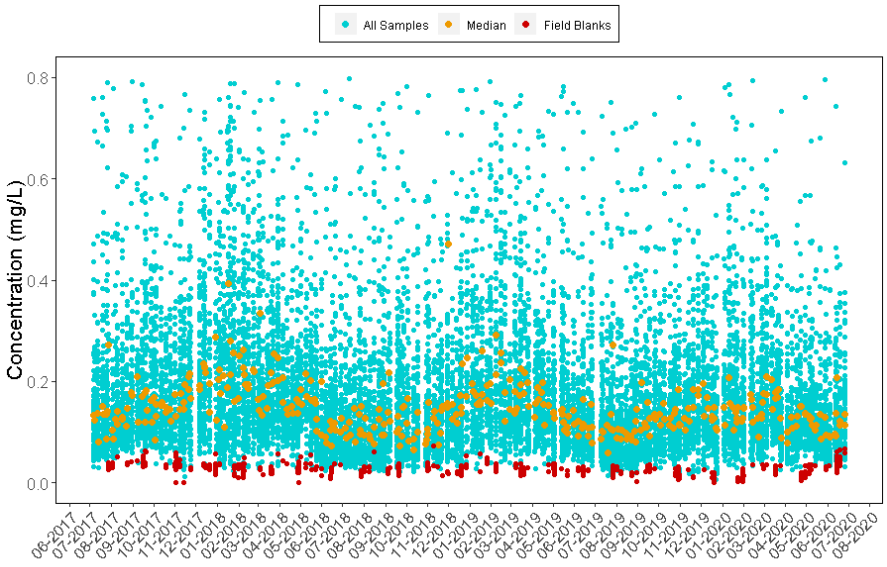
Note: Nominal reporting limit is 0.008 mg/L.

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



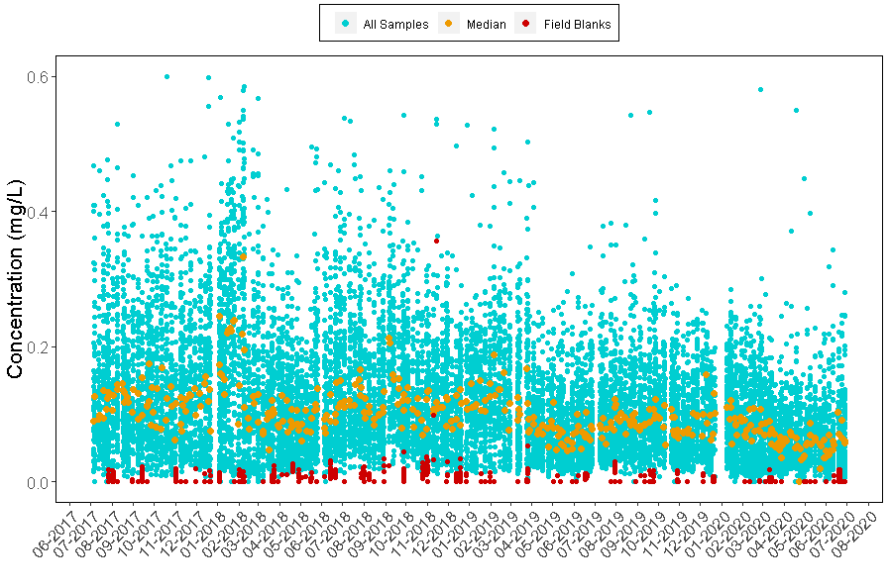
Note: Nominal reporting limit is 0.020 mg/L.

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



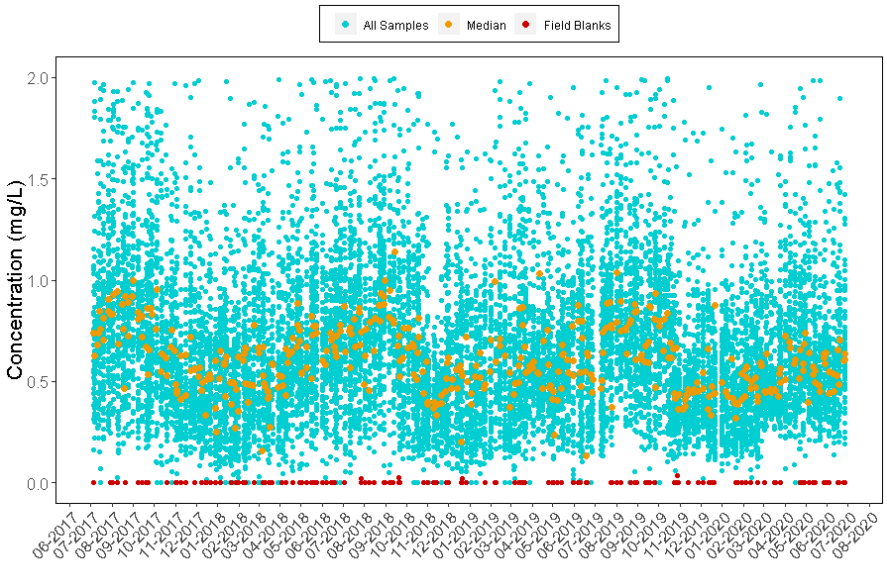
Note: Nominal reporting limit is 0.040 mg/L.

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



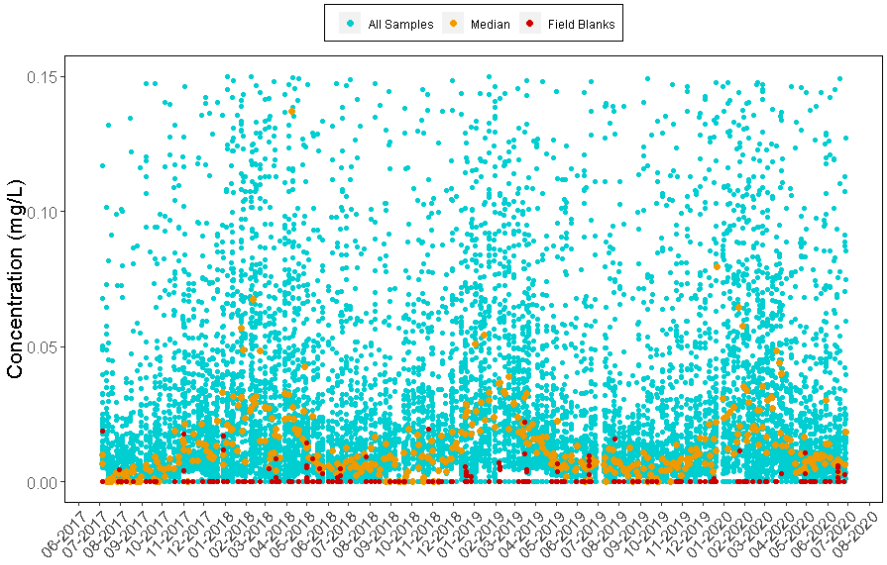
Note: Nominal reporting limit is 0.040 mg/L.

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



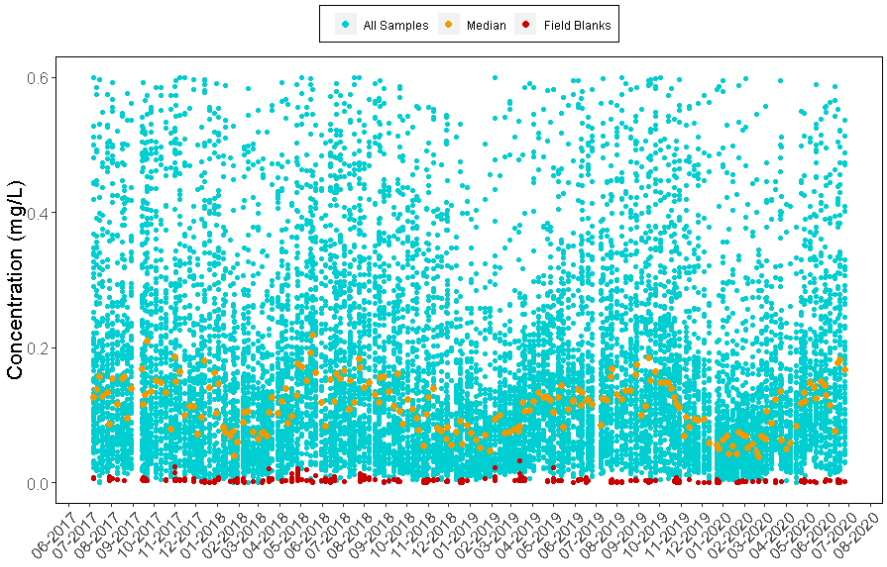
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



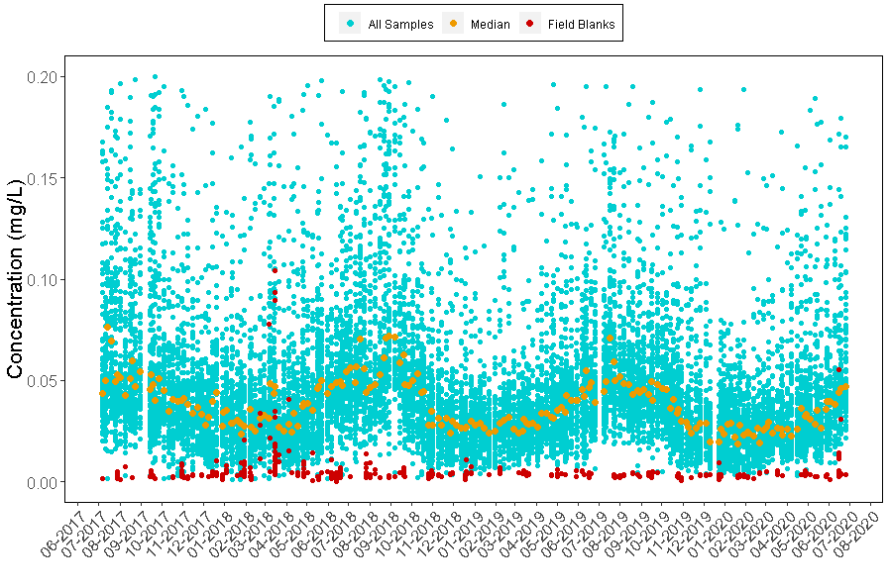
Note: Nominal reporting limit is 0.020 mg/L.

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



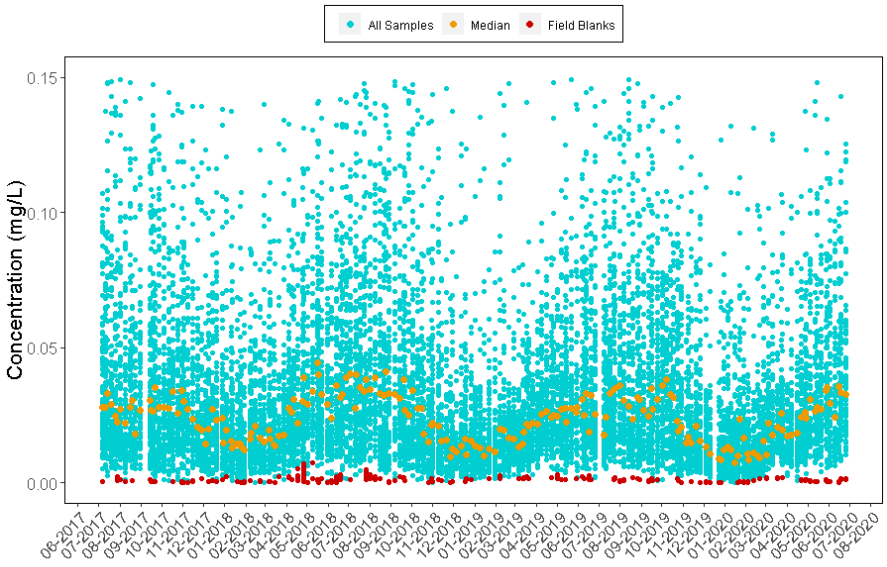
Note: Nominal reporting limit is 0.006 mg/L.

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



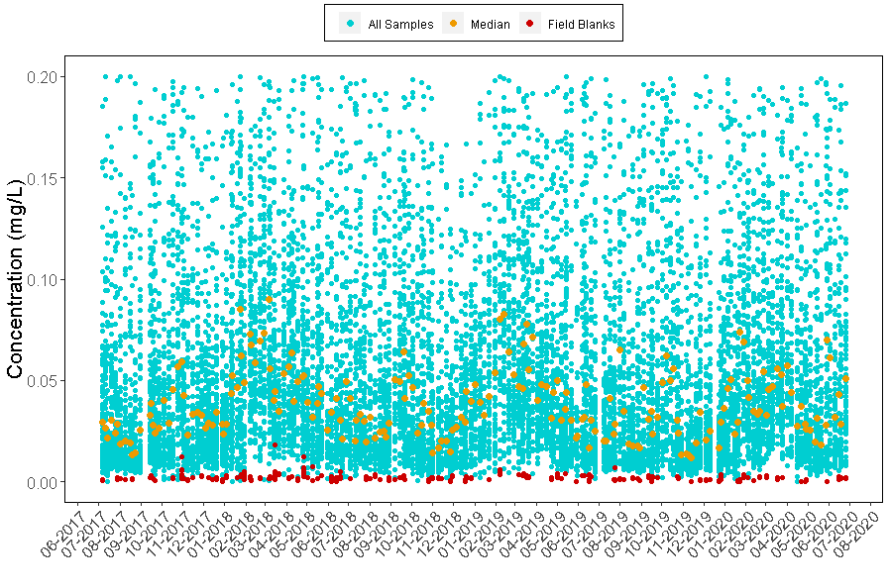
Note: Nominal reporting limit is 0.006 mg/L.

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.

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

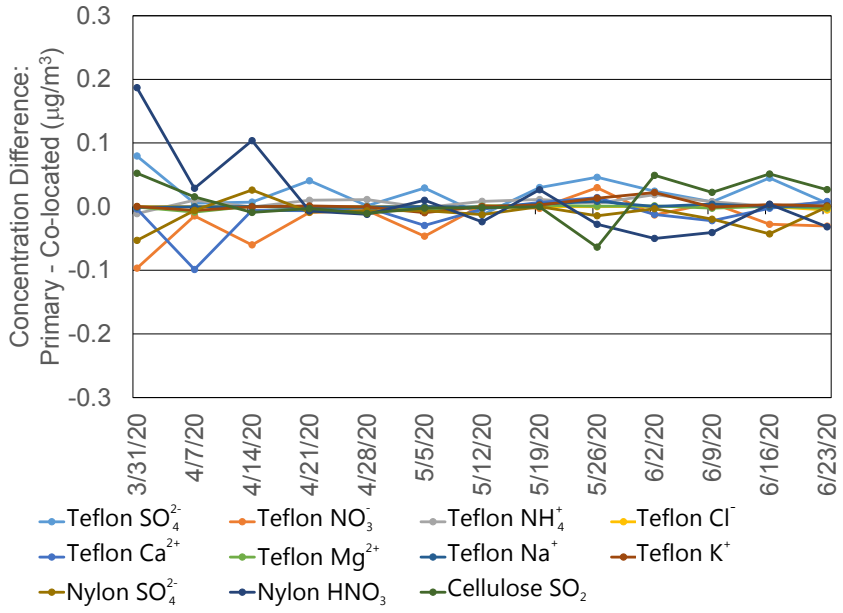
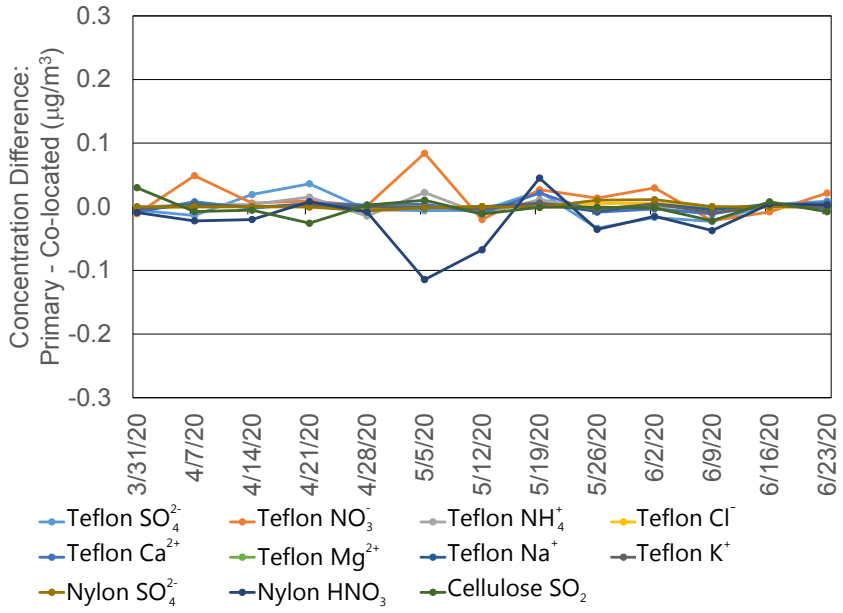


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



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 2020. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Second Quarter 2020

	SO_4^{2-}	NO_3^-	NH_4^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HNO_3	SO_2	Total NO_3^-
MCK131/231, KY											
$\overline{X}$ (µg/m^3)	1.08	0.40	0.43	0.25	0.04	0.06	0.08	0.05	0.87	0.36	1.26
$\overline{Y}$ (µg/m^3)	1.06	0.42	0.42	0.27	0.04	0.06	0.08	0.05	0.86	0.35	1.27
MAD	0.03	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.04	0.02	0.03
MARPD	2.76	6.86	2.06	5.87	5.16	5.09	6.01	1.05	4.36	5.72	2.54
ROM406/206, CO											
$\overline{X}$ (µg/m^3)	0.52	0.27	0.21	0.17	0.03	0.04	0.04	0.02	0.45	0.16	0.71
$\overline{Y}$ (µg/m^3)	0.52	0.25	0.21	0.17	0.03	0.04	0.04	0.02	0.48	0.16	0.72
MAD	0.02	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.01	0.04
MARPD	4.02	11.23	5.66	5.95	9.15	10.90	10.83	10.00	8.42	9.57	5.66

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 2020

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
CHE185, OK	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	The site was down from mid-April through late-May due to storm damage. Eight sample weeks were affected.
BEL116, MD	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	Intermittent power failures from the middle to the end of June affected one sample. Additionally, there was a 2-week sample, and one sample was lost in return mail.
BVL130, IL	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	The last sample installed for first quarter was on the tower for five weeks due to local pandemic restrictions.
CAD150, AR	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	An extended power outage affected three sampling weeks.
CVL151, MS	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	Power outages caused by storm damage affected two sampling weeks in April and an additional sampling week in June.
BBE401, TX	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two filter packs were received with damaged Teflon filters and were invalidated.
GRC474, AZ	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The first two filter packs for the quarter were not installed because the park was closed.
MEV405, CO	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The quarter included a 2-week sample. Additionally, one sample has not yet been received.

Precision of Ozone Concentrations

Time series of co-located hourly O_3 concentration differences for second quarter 2020 are provided in Figures 27 and 28 for MCK131/231 and ROM406/206, respectively. The figures indicate generally no consistent bias between the co-located analyzers at these site locations although excessive system moisture was observed at MCK231 on 4/9 as indicated by subsequent differences in Figure 27.

Figure 27. Time Series of the Differences in Co-located O_3 Concentrations for MCK131/231, KY

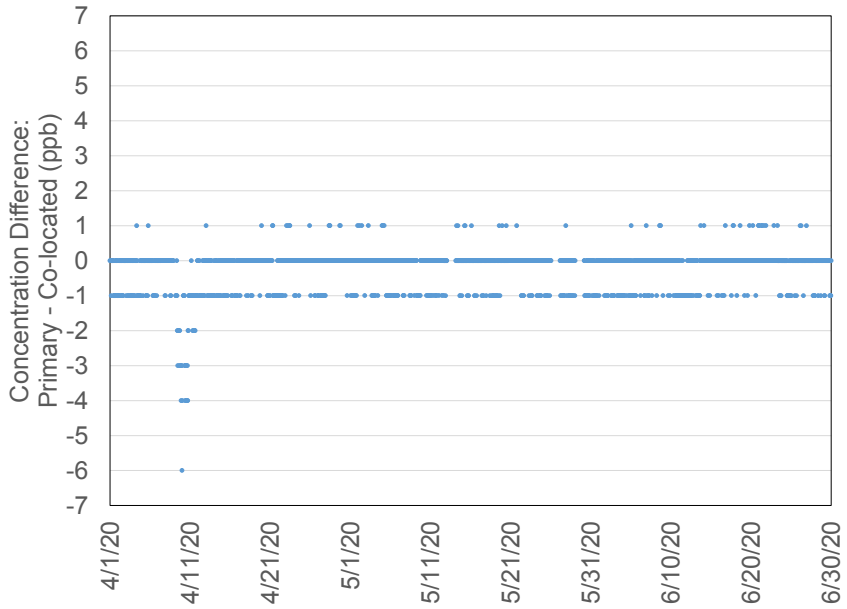


Figure 28. Time Series of the Differences in Co-located O_3 Concentrations for ROM406/206, CO

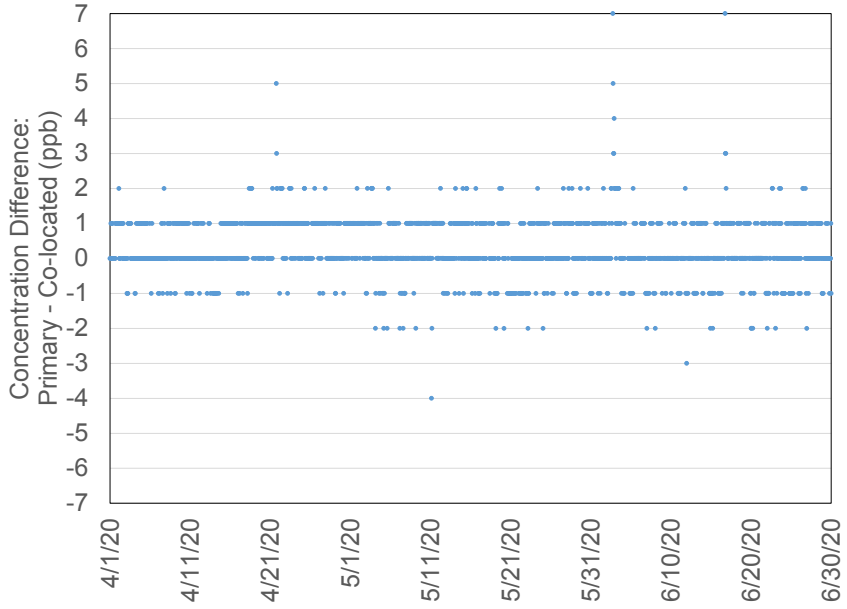


Table 5 gives MARPD data for O_3 data measured at the two co-located sites.

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

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	3	7/1/19	0.8	2085
	4	10/1/19	1.1	2003
	1	1/1/20	1.0	2063
	2	4/1/20	0.8	1986
ROM406/206, CO				
	3	7/1/19	1.4	2030
	4	10/1/19	1.1	1983
	1	1/1/20	0.8	2004
	2	4/1/20	1.3	2028

Completeness for O_3 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 2020

Site ID	Percent Completeness	Comments
CHE185, OK	52.7	The site was down from mid-April through late-May due to storm damage.
CAD150, AR	73.6	Power outages occurred in April and June.
CVL151, MS	80.2	Power outages occurred in April and June.
ESP127, TN	82.4	The site analyzer malfunctioned in late May and was replaced in early June. In addition, there were intermittent periods of high bench temperatures in late June requiring data invalidation.
NPT006, ID	82.4	The shelter air conditioner malfunctioned in mid-June resulting in several periods of high bench temperatures requiring data invalidation.
WSP144, NJ	85.7	There were several QC failures during the quarter requiring invalidation of associated data.
BEL116, MD	86.8	Intermittent power failures occurred from the middle to the end of June.
GTH161, CO	87.9	The analyzer sample pump failed in April. There was a QC failure in May.
VIN140, IN	87.9	There were intermittent periods of high bench temperatures during April requiring data invalidation. In addition, the site analyzer pump malfunctioned in late May and was replaced in early June.
CAN407, UT	89.0	Temperature issues caused the loss of several data points in April and May.

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 2020	Q3 2019–Q2 2020	Comments
CAD150, AR	76.9	93.2	Power outages occurred in April and June.
CVL151, MS	83.8	93.5	Power outages occurred in April and June.
NPT006, ID	83.9	92.3	The shelter air conditioner malfunctioned in mid-June resulting in several periods of high bench temperatures requiring data invalidation.
ESP127, TN	85.8	94.3	The site analyzer malfunctioned in late May and was replaced in early June. In addition, there were intermittent periods of high bench temperatures in late June requiring data invalidation.
WSP144, NJ	86.4	92.0	There were several QC failures during the quarter requiring invalidation of associated data.
GTH161, CO	89.7	96.4	There was a sample analyzer pump failure in April and a QC failure in May.

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 NO_3^- concentrations collected at the eight 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 eight sites with available data are shown in Table 8. Ratios of NO_y to total NO_3^- varied from 2.66 at PNF126 to 6.02 at ROM206.

Table 8. Summary of Total NO_3^- and NO_y Measurements for Second Quarter 2020

Site ID	Elevation	Total NO_3^- (ppb)	NO_y (ppb)	Ratio
DUK008, NC	164	0.35	1.45	4.21
BVL130, IL	213	0.73	3.74	5.17
MAC426, KY	243	0.44	1.44	3.41
HWF187, NY	497	0.14	0.67	5.26
GRS420, TN	793	0.34	1.81	5.54
PNF126, NC	1216	0.28	0.75	2.66
PND165, WY	2386	0.13	0.67	5.21
ROM206, CO	2742	0.22	1.27	6.02

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

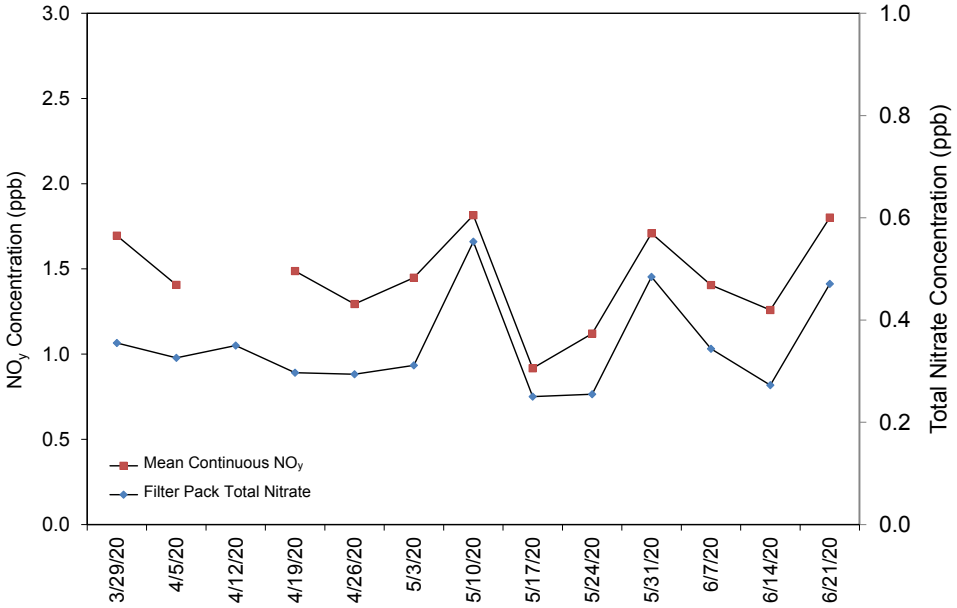


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO_3^- Concentrations

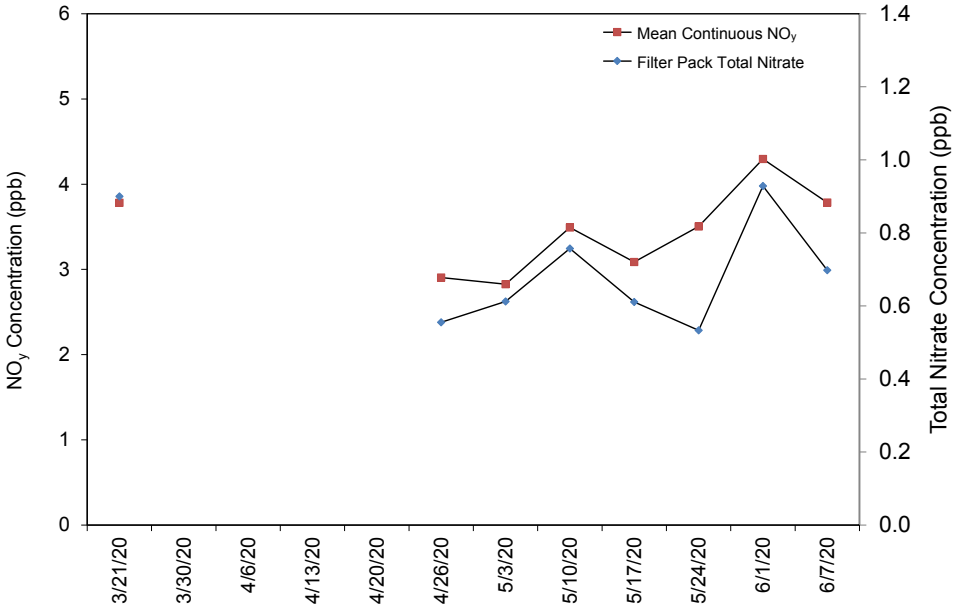


Figure 31. Comparison of MAC426 Weekly Mean NO_y and Total NO_3^- Concentrations

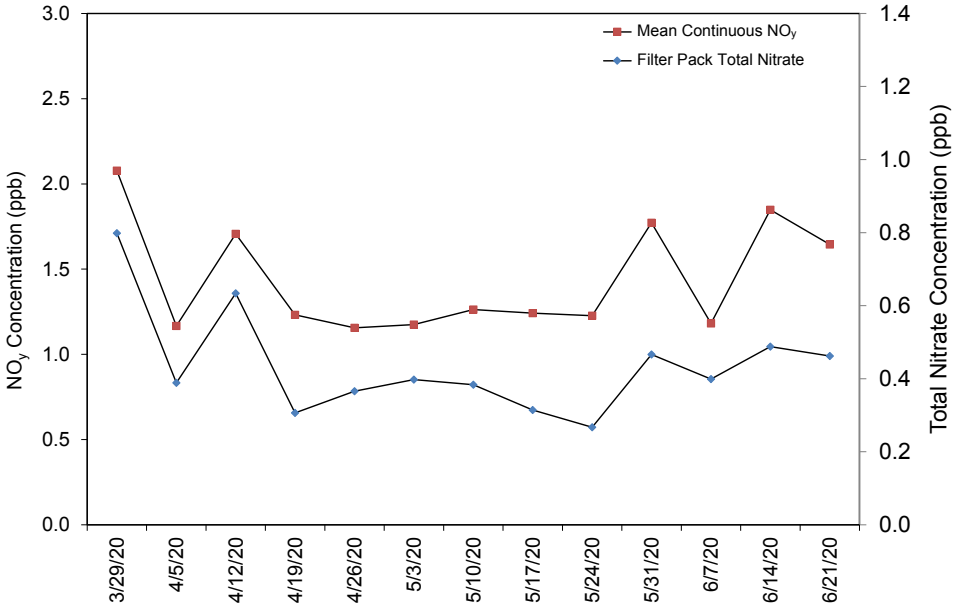


Figure 32. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

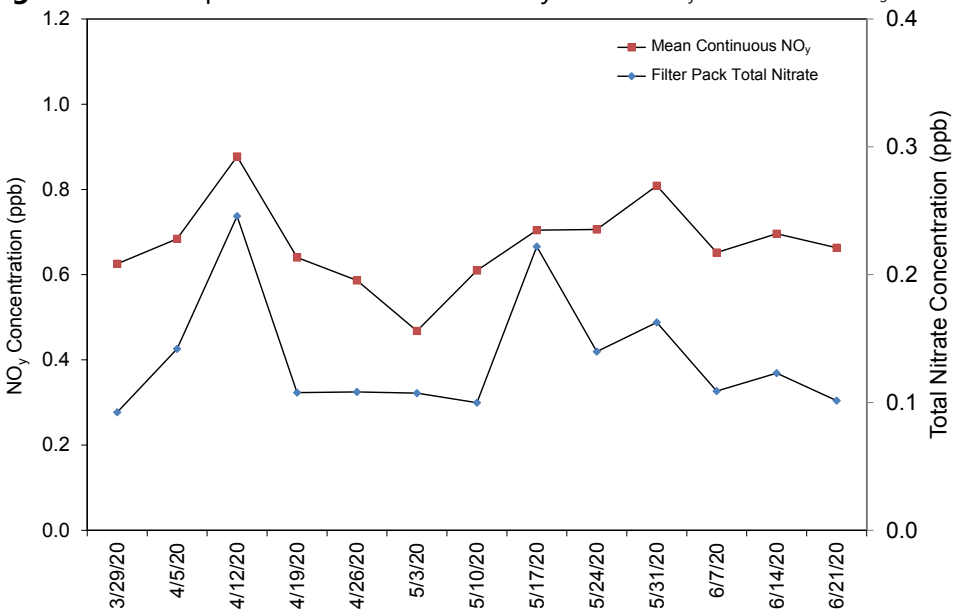


Figure 33. Comparison of GRS420 Weekly Mean NO_y and Total NO_3^- Concentrations

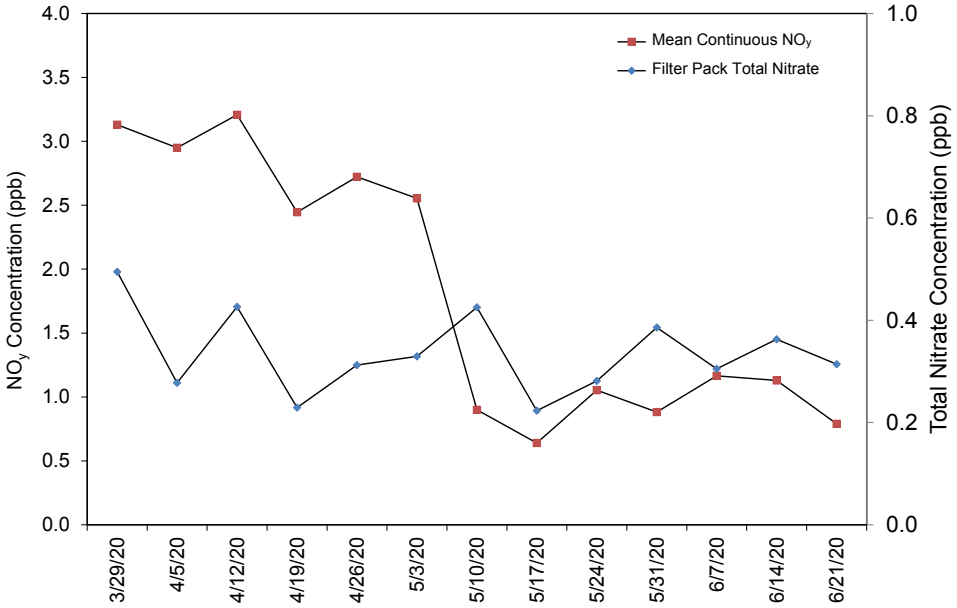


Figure 34. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

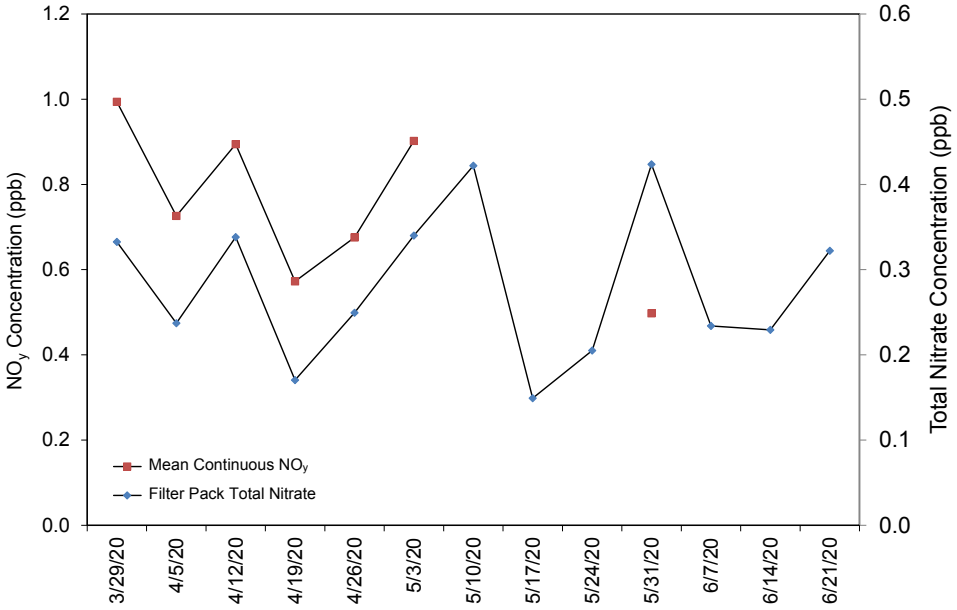


Figure 35. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

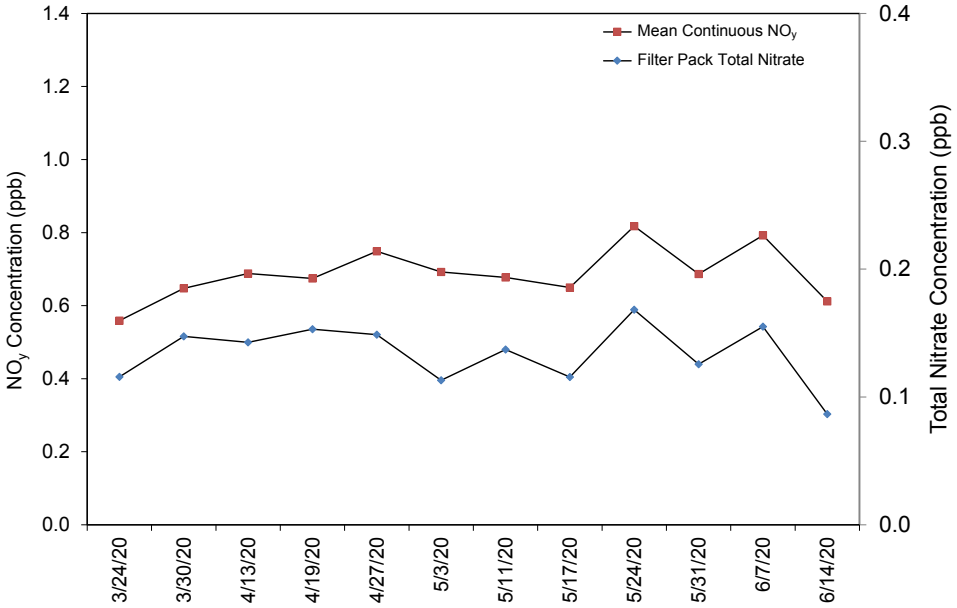
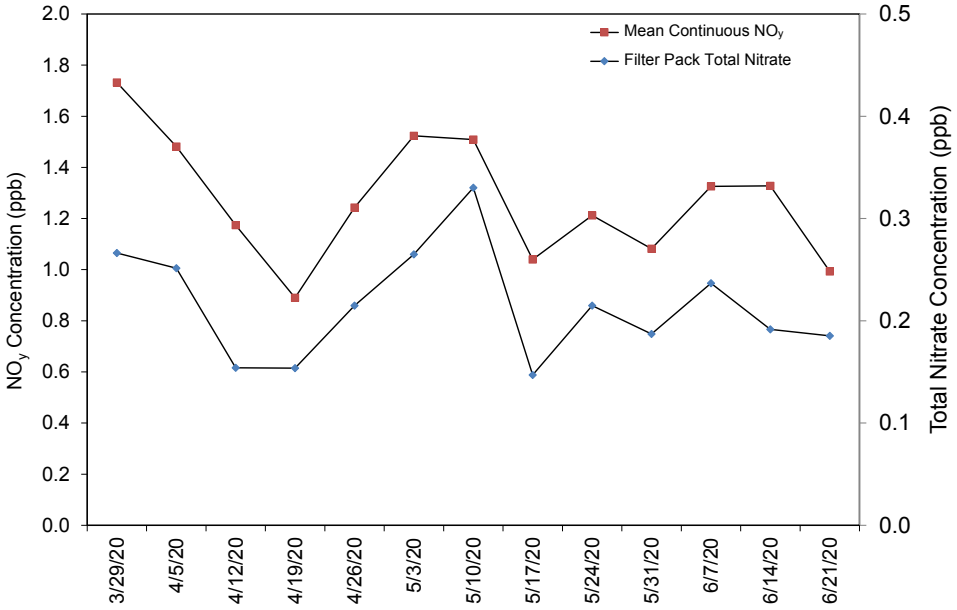


Figure 36. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figures 37 through 39 provide diagrams that compare weekly filter pack SO_2 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 SO_2 Concentrations

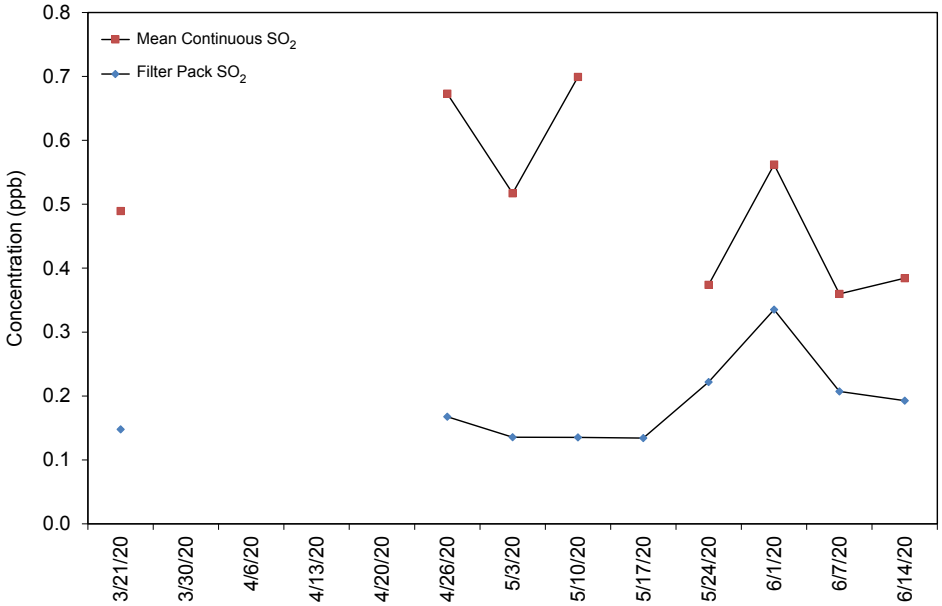


Figure 38. Comparison of MAC426 Weekly Mean SO_2 Concentrations

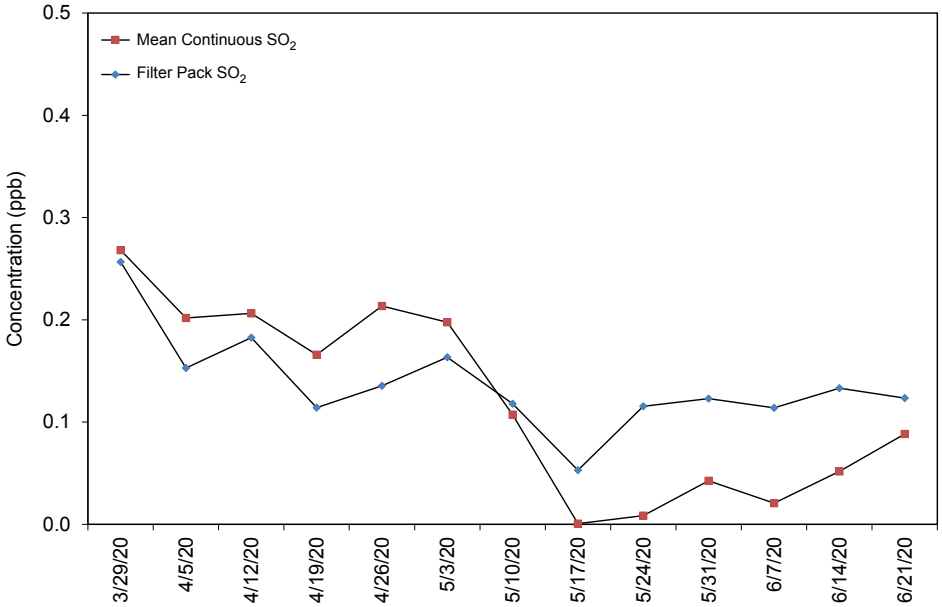
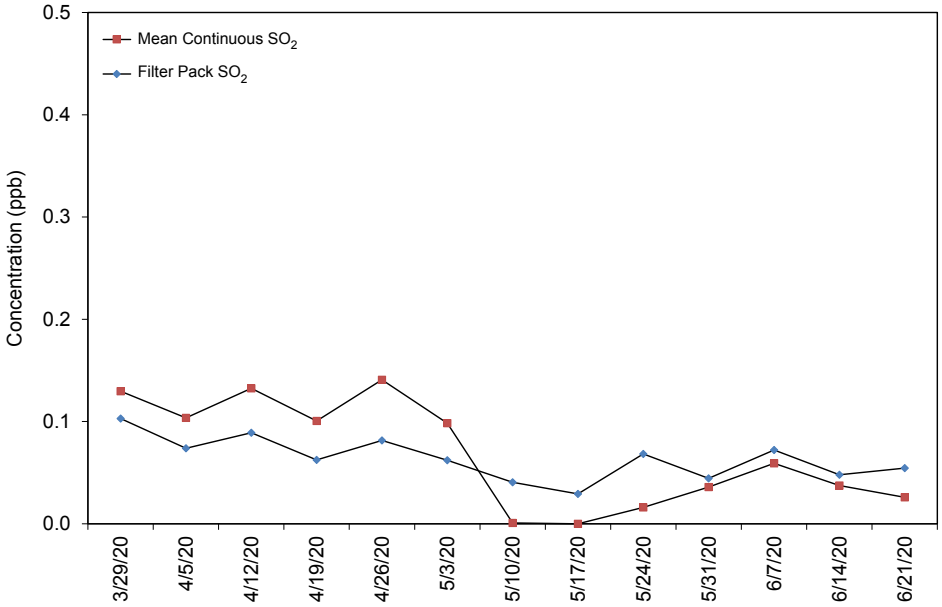


Figure 39. Comparison of GRS420 Weekly Mean SO_2 Concentrations



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 2020. The annual hourly average 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 2020	Q3 2019 – Q2 2020	Comments
BVL130, IL	CO	64	36	The auto reference ran during the zsp QC check on 6/8/2020 and corrupted the zsp check. Ambient data were invalid from 6/6/2020 until 6/18/2020. Additional data were invalidated from 6/23/2020 to 6/28/2020 due to moisture.
	NO	96	94	
	NOY	96	94	
	NOYDIF	96	94	
	SO2_GA	78	86	The sample pump failed in mid-June and was replaced.
CHC432, NM	NO	98	96	
	NOX	98	96	
	NOXDIF	98	96	
DUK008, NC	HNO3	71	56	The system required recalibration in April. In addition, the system was stuck running the qc check from 5/23 to 5/26 and NO-related parameters were invalidated during each NH3 QC run.
	NH3	71	57	
	NO	81	71	
	NO2_TRUE	75	70	
	NOX_TRUE	77	70	
	NOY	71	58	
	NOY_MINUS	81	67	
	NOYDIF	72	58	
	TNX	81	69	
GRS420, TN	CO	93	89	
	NO	93	86	
	NOY	93	86	
	NOYDIF	93	88	
	SO2_GA	93	90	
HWF187, NY	NO	96	83	
	NOY	96	77	
	NOYDIF	96	77	
MAC426, KY	CO	87	89	
	NO	87	92	The gas dilution system malfunctioned in early April. The pump was replaced on 4/17/2020.
	NOY	87	87	
	NOYDIF	87	87	
	SO2_GA	97	95	
PND165, WY	NO	92	90	
	NOY	92	90	
	NOYDIF	92	90	

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

Site ID	Parameter*	Q2 2020	Q1 2019 – Q2 2020	Comments
PNF126, NC	NO	94	93	The site analyzer malfunctioned in mid-June.
	NOY	47	81	
	NOYDIF	47	81	
ROM206, CO	NO	89	93	QC failures occurred in late June.
	NOY	89	93	
	NOYDIF	89	93	

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. 2020. *Clean Air Status and Trends Network (CASTNET) Second Quarter 2020 Quality Assurance Report.* https://java.epa.gov/castnet/documents.do