



# Clean Air Status and Trends Network

## Fourth Quarter 2017 Quality Assurance Report

### Summary of Quarterly Operations (October through December) with 2017 Annual Summary

EPA Contract No. EP-W-16-015

#### Introduction

This quarterly report summarizes results from the Clean Air Status and Trends Network (CASTNET) quality assurance/quality control (QA/QC) program for data collected during fourth quarter 2017. It also provides an annual summary that includes data from the three previous quarters. The various QA/QC criteria and policies are documented in the CASTNET Quality Assurance Project Plan (QAPP; Amec Foster Wheeler, 2016). The QAPP is comprehensive and includes standards and policies for all components of project operation from site selection through final data reporting. It is reviewed annually and updated as warranted.

#### Significant Events for 2017

The assessment needed to maintain International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005 accreditation by the American Association for Laboratory Accreditation (A2LA) was performed April 4–6, 2017. The assessment covered the analytical laboratory and field laboratory. The noted deficiencies were straightforward and involved mainly updates to documentation plus the addition of two new standard operating procedures. Amec Foster Wheeler prepared a plan to address the deficiencies noted in the A2LA assessment and submitted the plan to A2LA, as required, within the 30-day post-assessment period on May 5, 2017. Amec Foster Wheeler completed the steps required by the A2LA to maintain ISO/IEC 17025:2005 accreditation, and the accreditation will continue through May 2019.

The meeting to discuss the annual management review report in support of ISO/IEC 17025:2005 accreditation was held May 19, 2017.

As Amec Foster Wheeler began looking for possible replacements for Pall Corporation's Nylasorb filter, which has been discontinued by Pall, Amec Foster Wheeler developed a preventative action document to detail steps taken during the process of locating a suitable replacement filter. The preventative action document will continue to be updated until a replacement filter is found.

Amec Foster Wheeler continued evaluating possible replacements for the Pall Nylasorb nylon filter. Field testing of the co-located MTL Corp and Nylasorb filter packs took place at the Gainesville test site and at the co-located field sites at MCK131/231, KY and ROM406/206, CO. A statistical comparison of co-located, unwashed MTL Corp nylon filters with Pall Nylasorb nylon filters was provided to EPA in early October. The comparison included results from standard 3-stage CASTNET filter packs that were installed during routine field sampling. Nylasorb filters were packed for the primary sites, and MTL nylon filters were packed for the co-located sites. Preliminary results were below the CASTNET 20 percent precision criterion for MTL lot 701 unwashed filters. Co-located sampling resumed on October 24, 2017, in order to evaluate the performance of the MTL unwashed filters from lot 701 in cold weather.

Unwashed filters from MTL lot 709 did not pass acceptance testing. In response, alternative sources (e.g., AMD Manufacturing) were tested along with filters pre-washed by MTL. These filters did not pass acceptance testing. The decision was made to wash MTL filters in-house until further notice. The laboratory began testing filter washing procedures using custom-made filter washing trays. Filters from MTL and AMD Manufacturing that did not pass acceptance tests were washed by Amec Foster Wheeler. After washing by Amec Foster Wheeler, only the MTL filters met acceptance criteria. Testing of the Amec Foster Wheeler-washed MTL filters with co-located Nylasorb filters began at the Gainesville test site in fourth quarter to verify their performance.

The CASTNET QAPP Revision 9.1 was submitted to EPA for review and comment on November 1, 2017.

A technical systems audit (TSA) of CASTNET facilities supporting ozone monitoring is required once every three years. The routine TSA for the Air Resource Specialists, Inc. (ARS) ozone facility in Colorado and the GRS420 field site in Tennessee were performed by RTI International. ARS is the National Park Service and Bureau of Land Management contractor for CASTNET. The audit report, including the ARS audit response, is available on the EPA CASTNET website, <https://java.epa.gov/castnet/documents.do>.

All ozone 1-point QC checks that did not meet the criterion for a passing check promulgated in the January 2017 revision of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems were deleted from EPA's Air Quality System (AQS). This resulted in deletion of 768 records. Two checks for KNZ184, KS from 2011 were not deleted because the status of the site in AQS indicates that it has been closed since 2013. Ozone 1-point QC checks beginning January 2017 were submitted to AQS using the updated criterion.

Amec Foster Wheeler developed a standard protocol to ensure that newly installed inlet filters at CASTNET ozone sites are properly conditioned.

Corrective action for site operator non-compliance with site procedures was required for the site operator at the HOW191, ME site. The site operator was retrained by Amec Foster Wheeler field staff.

Providing a safe working environment is one of Amec Foster Wheeler's goals. Sites are routinely checked for safe working conditions at each calibration (i.e., twice per year). During 2017, Amec Foster Wheeler performed internal safety audits of selected sites. These safety audits provide a more in-depth review of site safety and include a safety-related evaluation of infrastructure condition and maintenance, use of equipment, site operator activities at the site, and verification that procedures are understood and followed by site personnel. There were no findings during 2017.

### **Quarterly/Annual Summary**

Table 1 lists the quarters of data that were validated to Level 3 during 2017 by site calibration group. Table 2 lists the sites in each calibration group along with the calibration schedule. Table 3 presents the measurement criteria for continuous field measurements. These criteria apply to the instrument challenges performed during site calibrations. Table 4 presents the measurement criteria for laboratory filter pack measurements. These criteria apply to the QC samples listed in the following section of this report. Table 5 presents the critical criteria for ozone monitoring. Table 6 presents the critical criteria for trace-level gas monitoring.

### **Laboratory Intercomparison Results Summary**

Amec Foster Wheeler's CASTNET laboratory regularly participates in the Environment Canada (ECAN) Proficiency Testing (PT) Program for Inorganic Environmental Substances. The results reported by the participating laboratories are evaluated for systematic bias and precision. Systematic bias is assessed using the Youden (1969) non-parametric analysis, while precision is calculated using algorithm A from ISO standard 13528 (ISO, 2005). Laboratory results are considered systematically biased when individual parameters are ranked by the Youden analysis to be consistently and significantly higher or lower than the assigned value without regard to flagged results.

The CASTNET laboratory's ECAN results for study codes 0109 and 0110 for the eight CASTNET parameters are listed in Table 7. A data entry error for one sulfate value in study 0109 resulted in an "action low" flag. All other results for study 0109 were rated as "ideal." A new corrective action, CA-0061, was implemented to include additional review steps prior to submission of data for laboratory PT results. Analyses of all parameters passed for PT study 0110. There was a slight low bias (-2.6 percent) for calcium; however, no corrective action was required. The laboratory's PT plan requires action for individual test results that are greater than three standard deviations from the assigned value, bias 5 percent or higher for a single parameter, three or more biased results of any magnitude in a single study, or a consecutive study result indicating bias of any magnitude for a given parameter. The overall laboratory rating indicates a percent score. For results received during 2017, the overall laboratory performance rating was "good" for study 0109, and "very good," for study 0110. The 5-year historical laboratory rating is listed by ECAN as "very good," which is 0 to 5 percent of the sum of parameters biased and results flagged.

### **Quality Control Analysis Count**

The QC sample statistics presented in this report are for reference standards (RF) and continuing calibration verification spikes (CCV) used to assess accuracy and for replicate sample analyses (RP) used to assess "in-run" precision. In addition, laboratory method blanks (MB) containing reagents without a filter; laboratory blanks (LB) containing reagents and a new, unexposed filter; and field blanks (FB) containing reagents and an unexposed filter that was loaded into a filter pack assembly and shipped to and from the monitoring site while remaining in sealed packaging are also included. Tables 8 through 11 present the number of analyses in each category that were performed during each quarter of 2017.

### **Sample Receipt Statistics**

Ninety-five percent of field samples from EPA-sponsored sites must be received by the CASTNET laboratory in Gainesville, FL no later than 14 days after removal from the sampling tower. Table 12 presents the relevant sample receipt statistics for each of the four quarters of 2017 together with an annual summary for each category.

### **Data Quality Indicator (DQI) Results**

Figures 1 through 3 present the results of RF, CCV, and RP QC sample analyses for fourth quarter 2017. All results were within the criteria listed in Table 4. Table 13 presents the percent recoveries and standard deviations for RF, CCV, and RP QC sample analyses for 2017. Quarterly averages are all within criteria.

Table 14 presents quarterly co-located filter pack precision results for data validated to Level 3 during the year. Results for MCK131/231, KY and ROM406/206, CO were within the criterion for all of the 11 parameters reported.

Figure 4 presents completeness statistics for continuous measurements validated to Level 3 during the year. All parameters met the 90 percent criterion.

Table 15 presents summary statistics of critical criteria measurements at ozone sites collected during fourth quarter 2017. The statistics presented contain data validated at Level 2 and Level 3. All data associated with QC checks that fail to meet the criteria listed in Table 5 were or will be invalidated unless the cause of failure has no effect on ambient data collection, and passing results still meet frequency criteria. During fourth quarter, no values exceeded documented criteria or were otherwise notable.

Table 16 presents summary statistics of critical criteria measurements at trace-level gas monitoring sites collected during fourth quarter 2017. The statistics presented contain data validated at Level 2 and Level 3. All data associated with QC checks that fail to meet the criteria listed in Table 6 were or will be invalidated unless the cause of failure has no effect on ambient data collection, and passing results still meet frequency criteria. During fourth quarter, no values exceeded documented criteria or were otherwise notable.

### **Laboratory Control Sample Analysis**

The laboratory control sample (LCS) is a reagent blank spiked with the target analytes from the established analytical methods and carried through the same extraction process that field samples must undergo. The LCS is not required by the CASTNET QA/QC program. LCS analyses are performed by the laboratory to monitor for potential sample handling artifacts and provide a means to identify possible analyte loss from extraction to extraction. Figure 5 presents LCS analysis results for fourth quarter 2017. All recovery values were between 90 percent and 105 percent.

### **Blank Results**

Figures 6 through 8 present the results of MB, LB, and FB QC sample analyses for fourth quarter 2017. All fourth quarter results were within criteria (two times the reporting limit) listed in Table 4 with the exception of three Teflon FB filter results for calcium. These three results fell between two and four times the reporting limit. All other fourth quarter QC results were within criteria. Table 17 summarizes the record of filter blanks for 2017. All 2017 results were within criteria listed in Table 4 with the exception of 14 Teflon FB results for calcium that occurred during quarters 1, 2, and 4; a single Teflon FB result for potassium; and a single Teflon FB result for sodium, both of which occurred during quarter 2. All other blank QC checks in their respective batches were within criteria. All boxes of filters associated with acceptance test results that were out of established criteria were rejected and excluded from use in field sampling.

### **Suspect/Invalid Filter Pack Samples**

Filter pack samples that were flagged as suspect or invalid during each of the four quarters of 2017 are listed in Table 18. This table also includes associated site identification and a brief description of the reason the sample was flagged. During fourth quarter, 14 filter pack samples were invalidated.

### **Field Problem Count**

Table 19 presents counts of field problems affecting continuous data collection for more than one day for each quarter during 2017. The problem counts are sorted by a 30-, 60-, or 90-day time period to resolution. A category for unresolved problems is also included. Time to resolution indicates the period taken to implement corrective action.

### **Field Calibration Results**

A summary of field calibration failures by parameter for each quarter of 2017 is listed in Table 20. Calibrations were performed at 27 sites during fourth quarter 2017. During 2017, all sites and parameters were within the criteria listed in Table 3 with the exception of the parameters at the five sites that are listed in Table 20.

Table 21 presents field accuracy results for 2017 based on instrument challenges performed using independent reference standards during site calibration visits. Each parameter was within its criterion with at least 90 percent frequency except solar radiation at 88.9 percent frequency. Per CASTNET project protocols, data are flagged but still considered valid if the calibration criterion is not exceeded by more than its magnitude (i.e., if within two times the criterion). All calibration failures reported in 2017 for the indicated parameters were within two times the criterion with the exception of flow rate at OXF122, OH in March 2017, and temperature at PNF126, NC and ESP127, TN in July 2017. Data associated with the failures were invalidated.

## References

- Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler). 2016. *Clean Air Status and Trends Network (CASTNET) Quality Assurance Project Plan (QAPP) Revision 9.0*. Prepared for U.S. Environmental Protection Agency (EPA), Office of Air and Radiation, Clean Air Markets Division, Washington, DC. Contract No. EP-W-16-015. Gainesville, FL. <https://java.epa.gov/castnet/documents.do>.
- American Society for Testing and Materials (ASTM). 2008. ASTM E29-08, “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.” ASTM International, West Conshohocken, PA, DOI:10.1520/E0029-08. [www.astm.org](http://www.astm.org).
- Environment Canada (ECAN) Water Science and Technology Directorate. 2016. *Rain and Soft Waters PT Study 0109 Report*. Proficiency Testing Program, Burlington, Ontario, Canada. Prepared for Amec Foster Wheeler Environment & Infrastructure, Inc., Newberry, FL, USA.
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- International Organization for Standardization (ISO). 2005. *Statistical Methods for the Use in Proficiency Testing by Interlaboratory Comparisons, Annex C, Robust Analysis, Section C.1: Algorithm A*. Standard 13528. ISO 13528:2005(E).
- U.S. Environmental Protection Agency (EPA). 2015. Title 40 *Code of Federal Regulations* Part 58, “Appendix A to Part 58 – Quality Assurance Requirements for Monitors used in Evaluations of National Ambient Air Quality Standards.”
- Youden, W.J. (Ku, H.H., ed). 1969. *Precision Measurement and Calibration*. NBS Special Publication 300-Volume 1. U.S. Government Printing Office, Washington, DC.



**Table 1** Data Validated to Level 3 through Fourth Quarter 2017

Calibration Group*	Months Available	Number of Months	Complete Quarters	Number of Quarters
SE-4/MW-6 <sup>†</sup>	July 2016 – June 2017	12	Quarter 3 2016 – Quarter 2 2017	4
E-1/SE-5	August 2016 – July 2017	12	Quarter 4 2016 – Quarter 2 2017	3
MW-7/W-9	September 2016 – August 2017	12	Quarter 4 2016 – Quarter 2 2017	3
E-2/MW-8	October 2016 – September 2017	12	Quarter 4 2016 – Quarter 3 2017	4
E-3/W-10 <sup>‡</sup>	May 2016 – April 2017	12	Quarter 3 2016 – Quarter 1 2017	3

**Notes:** \* The sites contained in each calibration group are listed in Table 2.

<sup>†</sup> Contains MCK131/231 co-located pair

<sup>‡</sup> Contains ROM206 of the ROM406/ROM206 co-located pair

**Table 2** Field Calibration Schedule for 2017

Calibration Group	Months Calibrated	Sites Calibrated			
Eastern Sites (24 Total)					
E-1 (8 Sites)	February/August	BEL116, MD BWR139, MD	WSP144, NJ CTH110, NY	ARE 128, PA PSU106, PA	PED108, VA VPI120, VA
E-2 (11 Sites)	April/October	ABT147, CT ASH135, ME HOW191, ME	WST109, NH CAT175, NY HWF187, NY <sup>2</sup>	NIC001, NY WFM007, NY WFM105, NY	EGB181, ON UND002, VT
E-3 (5 Sites)	May/November	KEF112, PA MKG113, PA	LRL117, PA PAR107, WV	CDR119, WV	
Southeastern Sites (11 Total)					
SE-4 (6 Sites)	January/July	SND152, AL GAS153, GA	BFT142, NC CND125, NC	COW137, NC SPD111, TN	
SE-5 (5 Sites)	February/August	CAD150, AR IRL141, FL	SUM156, FL CVL151, MS	DUK008, NC <sup>1</sup>	
Midwestern Sites (19 Total)					
MW-6 (6 Sites)	January/July	CDZ171, KY CKT136, KY	MCK131, KY MCK231, KY	PNF126, NC <sup>2</sup> ESP127, TN	
MW-7 (9 Sites)	March/September	ALH157, IL BVL130, IL <sup>3</sup> STK138, IL	VIN140, IN RED004, MN DCP114, OH	OXF122, OH QAK172, OH PRK134, WI	
MW-8 (4 Sites)	April/October	SAL133, IN HOX148, MI	ANA115, MI UVL124, MI		
Western Sites (11 Total)					
W-9 (5 Sites)	March/September	KNZ184, KS KIC003, KS	CHE185, OK SAN189, NE	ALC188, TX	
W-10 (6 Sites)	May/November	GTH161, CO ROM206, CO <sup>1</sup>	NPT006, ID CNT169, WY	PND165, WY <sup>1</sup> PAL190, TX	

**Notes:** <sup>1</sup> Trace-level gas calibrations are performed quarterly in February, May, August, and November.

<sup>2</sup> Trace-level gas calibrations are performed quarterly in January, April, July, and October.

<sup>3</sup> Trace-level gas calibrations are performed quarterly in March, June, September, and December.

**Table 3** Data Quality Indicators for CASTNET Continuous Measurements

Measurement		Criteria <sup>1</sup>	
Parameter <sup>2</sup>	Method	Precision	Accuracy
Filter pack flow	Mass flow controller	± 10%	± 5%
Ozone <sup>3</sup>	UV absorbance	All points within ± 2% of full scale of best fit straight line Linearity error < 5%	
Wind speed	Anemometer	± 0.5 m/s	The greater of ± 0.5 m/s for winds < 5 m/s or ± 5% for winds ≥ 5 m/s
Wind direction	Wind vane	± 5°	± 5°
Sigma theta	Wind vane	Undefined	Undefined
Ambient temperature	Platinum RTD	± 1.0°C	± 0.5°C
Delta temperature	Platinum RTD	± 0.5°C	± 0.5°C
Relative humidity	Thin film capacitor	± 10% (of full scale)	± 10%
Precipitation	Tipping bucket rain gauge	± 10% (of reading)	± 0.05 inch <sup>4</sup>
Solar radiation	Pyranometer	± 10% (of reading taken at local noon)	± 10%
Surface wetness	Conductivity bridge	Undefined	Undefined

**Notes:** °C = degrees Celsius  
m/s = meters per second  
RTD = resistance-temperature device  
UV = ultraviolet

<sup>1</sup> Precision criteria apply to co-located instruments, and accuracy criteria apply to calibration of instruments. Co-located precision criteria do not apply to CASTNET sites that are configured and operated in accordance with Part 58 of Title 40 of the *Code of Federal Regulations* (EPA, 2015)

<sup>2</sup> Meteorological parameters are only measured at six of the EPA-sponsored CASTNET sites: IRL141, FL; BVL130, IL; BEL116, MD; CHE185, OK; PAL190, TX; and PND165, WY. Meteorological measurements at IRL141 are sponsored by the St. Johns River Water Management District, and those at PND165 are sponsored by the Bureau of Land Management-Wyoming State Office as part the Wyoming Air Resources Monitoring System.

<sup>3</sup> Ozone is not measured at 10 EPA-sponsored CASTNET sites: KIC003, KS; KNZ184, KS; RED004, MN; DUK008, NC; EGB181, ON; CAT175, NY; NIC001, NY; WFM007, NY; WFM105, NY; and UND002, VT.

<sup>4</sup> For target value of 0.50 inch



**Table 4** Data Quality Indicators for CASTNET Laboratory Measurements

Analyte	Method	Precision <sup>1</sup> (MARPD)	Accuracy <sup>2</sup> (%)	Nominal Reporting Limits	
				mg/L	µg/Filter
Ammonium (NH <sub>4</sub> <sup>+</sup> )	AC	20	90–110	0.020*	0.5
Sodium (Na <sup>+</sup> )	ICP-OES	20	95–105	0.005	0.125
Potassium (K <sup>+</sup> )	ICP-OES	20	95–105	0.006	0.15
Magnesium (Mg <sup>2+</sup> )	ICP-OES	20	95–105	0.003	0.075
Calcium (Ca <sup>2+</sup> )	ICP-OES	20	95–105	0.006	0.15
Chloride (Cl <sup>-</sup> )	IC	20	95–105	0.020	0.5
Nitrate (NO <sub>3</sub> <sup>-</sup> )	IC	20	95–105	0.008*	0.2
Sulfate (SO <sub>4</sub> <sup>2-</sup> )	IC	20	95–105	0.040	1.0

**Notes:** <sup>1</sup> This column lists precision goals for both network precision calculated from co-located filter samples and laboratory precision based on replicate samples.

<sup>2</sup> This column lists laboratory accuracy goals based on reference standards and continuing calibration verification spikes. The criterion is 90–110 percent for ICP-OES reference standards.

AC = automated colorimetry

IC = ion chromatography

ICP-OES = inductively coupled plasma-optical emission spectrometry

MARPD = mean absolute relative percent difference

mg/L = milligrams per liter

µg/Filter = micrograms per filter

\* = as nitrogen

Values are rounded according to American Society for Testing and Materials (ASTM) E29-08, “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications” (ASTM, 2008).

For more information on analytical methods and associated precision and accuracy criteria, see the CASTNET QAPP, (Amec Foster Wheeler, 2016).

**Table 5** Ozone Critical Criteria\*

Type of Check	Analyzer Response
Zero	Less than ± 3.1 parts per billion (ppb)
Span	Less than ± 7.1 percent between supplied and observed concentrations
Single Point QC	Less than ± 7.1 percent between supplied and observed concentrations

**Notes:** \* Applies to CASTNET sites that are configured and operated in accordance with Part 58 of Title 40 of the *Code of Federal Regulations* (EPA, 2015). The minimum frequency for these checks is once every two weeks.

Values are rounded according to ASTM E29-08, “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications” (ASTM, 2008).

**Table 6** Trace-level Gas Monitoring Critical Criteria\*

Parameter	Analyzer Response	
	Zero Check	Span Check / Single Point QC Check
SO <sub>2</sub>	Less than ± 1.51 ppb	Less than ± 10.1 percent between supplied and observed concentrations
NO <sub>y</sub>	Less than ± 1.51 ppb	
CO	Less than ± 30.1 ppb	

**Notes:** \*Applies to CASTNET sites that are configured and operated in accordance with Part 58 of Title 40 of the *Code of Federal Regulations* (EPA, 2015). The minimum frequency for these checks is once every two weeks.

Values are rounded according to ASTM E29-08, "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications" (ASTM, 2008).

SO<sub>2</sub> = sulfur dioxide

NO<sub>y</sub> = total reactive oxides of nitrogen

CO = carbon monoxide

ppb = parts per billion

**Table 7** CASTNET Laboratory Results for ECAN PT Studies

Test Parameter	Analytical Method	Reference Method	Laboratory Performance Rating*	
			Good: Study 0109 Winter 2016	Very Good: Study 0110 Summer 2017
Ammonia	AC	EPA Method 350.1	Ideal	Ideal
Chloride	IC	EPA Method 300.0	Ideal	Ideal
Nitrate + Nitrite	IC	EPA Method 300.0	Ideal	Ideal
Sulfate	IC	EPA Method 300.0	1 of 10 Samples Flagged†	Ideal
Calcium	ICP-OES	EPA Method 6010	Ideal	-2.6 percent   -0.0035
Magnesium	ICP-OES	EPA Method 6010	Ideal	Ideal
Potassium	ICP-OES	EPA Method 6010	Ideal	Ideal
Sodium	ICP-OES	EPA Method 6010	Ideal	Ideal

Notes: \*Expressed as bias percent slope (percent deviation of test results from assigned values) | y-intercept.

Ideal slope = 1 | y-intercept = 0. Any result not 1 | 0 is reported as biased by ECAN.

†Ideal slope | intercept but sample flagged for result outside of three standard deviations from its assigned value.

Investigation found an entry error in data designated for the submission package. The actual value was within assigned limits. A corrective action was issued to require additional internal peer review of data designated for entry in the submission package.

AC = automated colorimetry

ICP-OES = inductively coupled plasma-optical emission spectrometry

IC = ion chromatography

Source: Environment Canada (2016; 2017)

**Table 8** QC Analysis Count for First Quarter 2017

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO <sub>4</sub> <sup>2-</sup>	60	202	89	16	24	89
	NO <sub>3</sub> <sup>-</sup>	60	202	89	16	24	89
	NH <sub>4</sub> <sup>+</sup>	34	183	87	16	24	89
	Cl <sup>-</sup>	60	202	89	16	24	89
	Ca <sup>2+</sup>	35	184	88	16	24	89
	Mg <sup>2+</sup>	35	184	88	16	24	89
	Na <sup>+</sup>	35	184	88	16	24	89
	K <sup>+</sup>	35	184	88	16	24	89
Nylon	SO <sub>4</sub> <sup>2-</sup>	56	205	87	18	24	89
	NO <sub>3</sub> <sup>-</sup>	56	205	87	18	24	89
Cellulose	SO <sub>4</sub> <sup>2-</sup>	58	200	80	17	24	89

**Table 9** QC Analysis Count for Second Quarter 2017

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO <sub>4</sub> <sup>2-</sup>	62	192	83	16	24	87
	NO <sub>3</sub> <sup>-</sup>	62	192	83	16	24	87
	NH <sub>4</sub> <sup>+</sup>	32	176	81	16	24	87
	Cl <sup>-</sup>	62	192	83	16	24	87
	Ca <sup>2+</sup>	32	176	81	16	24	87
	Mg <sup>2+</sup>	32	176	81	16	24	87
	Na <sup>+</sup>	32	176	81	16	24	87
	K <sup>+</sup>	32	176	81	16	24	87
Nylon	SO <sub>4</sub> <sup>2-</sup>	48	195	80	16	24	87
	NO <sub>3</sub> <sup>-</sup>	48	195	80	16	24	87
Cellulose	SO <sub>4</sub> <sup>2-</sup>	47	176	74	15	24	86

**Table 10** QC Analysis Count for Third Quarter 2017

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO <sub>4</sub> <sup>2-</sup>	52	205	87	18	24	91
	NO <sub>3</sub> <sup>-</sup>	52	205	87	18	24	91
	NH <sub>4</sub> <sup>+</sup>	34	182	85	17	24	91
	Cl <sup>-</sup>	52	205	87	18	24	91
	Ca <sup>2+</sup>	34	183	85	17	24	91
	Mg <sup>2+</sup>	34	183	85	17	24	91
	Na <sup>+</sup>	34	183	85	17	24	91
	K <sup>+</sup>	34	183	85	17	24	91
Nylon	SO <sub>4</sub> <sup>2-</sup>	48	208	80	16	24	89
	NO <sub>3</sub> <sup>-</sup>	48	208	80	16	24	89
Cellulose	SO <sub>4</sub> <sup>2-</sup>	48	176	80	16	24	89

**Table 11** QC Analysis Count for Fourth Quarter 2017

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO <sub>4</sub> <sup>2-</sup>	49	181	78	16	26	74
	NO <sub>3</sub> <sup>-</sup>	49	181	78	16	26	74
	NH <sub>4</sub> <sup>+</sup>	32	165	78	16	26	74
	Cl <sup>-</sup>	49	181	78	16	26	74
	Ca <sup>2+</sup>	32	165	78	16	26	74
	Mg <sup>2+</sup>	32	165	78	16	26	74
	Na <sup>+</sup>	32	165	78	16	26	74
	K <sup>+</sup>	32	165	78	16	26	74
Nylon	SO <sub>4</sub> <sup>2-</sup>	42	175	69	14	24	54
	NO <sub>3</sub> <sup>-</sup>	42	175	69	14	24	54
Cellulose	SO <sub>4</sub> <sup>2-</sup>	49	168	72	17	24	74

**Table 12** Filter Pack Receipt Summary for 2017

Description	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Annual Summary
Count of samples received more than 14 days after removal from tower:	12	14	18	26	70
Count of all samples received:	814	751	815	774	3154
Fraction of samples received within 14 days:	0.985	0.981	0.978	0.966	0.978
Average interval in days:	4.737	4.61	5.171	6.740	5.315*
First receipt date:	01/04/2017	04/04/2017	07/03/2017	10/02/2017	01/04/2017
Last receipt date:	03/31/2017	06/29/2017	09/29/2017	12/29/2017	12/29/2017

Note: \*annual average

**Table 13** Filter Pack QC Summary for 2017

Filter Type	Parameter	Reference Sample <sup>1</sup> Recovery (%R)			Continuing Calibration Verification Samples (%R)			In-Run Replicate <sup>2</sup> (RPD)		
		Mean	Std. Dev.	Count <sup>3</sup>	Mean	Std. Dev.	Count <sup>3</sup>	Mean	Std. Dev.	Count <sup>3</sup>
Teflon	SO <sub>4</sub> <sup>2-</sup>	98.00	2.37	226	101.00	1.39	792	1.21	1.20	342
	NO <sub>3</sub> <sup>-</sup>	99.09	1.45	226	98.45	1.30	792	2.43	2.38	342
	NH <sub>4</sub> <sup>+</sup>	99.49	1.80	134	99.90	1.54	717	0.55	0.56	336
	Ca <sup>2+</sup>	103.06	2.30	135	100.23	1.19	719	1.14	1.67	337
	Mg <sup>2+</sup>	97.97	1.80	135	99.93	1.02	719	1.09	1.38	337
	Na <sup>+</sup>	97.33	1.58	135	99.87	1.08	719	0.92	0.89	337
	K <sup>+</sup>	98.22	1.66	135	99.86	0.95	719	1.29	1.42	337
	Cl <sup>-</sup>	99.99	1.59	226	103.00	1.24	792	1.79	1.94	342
Nylon	SO <sub>4</sub> <sup>2-</sup>	103.03	1.64	197	100.83	1.65	796	5.09	4.15	321
	NO <sub>3</sub> <sup>-</sup>	100.14	1.40	197	98.56	1.93	796	2.67	2.67	321
Cellulose	SO <sub>4</sub> <sup>2-</sup>	97.74	2.53	207	101.06	1.54	737	2.00	2.49	314

Notes: % R = percent recovery

RPD = relative percent difference

<sup>1</sup> Results of reference sample analyses provide accuracy estimates

<sup>2</sup> Results of replicate analyses provide precision estimates

<sup>3</sup> Number of QC Samples

**Table 14** Precision Results for Third Quarter 2016 through Second Quarter 2017

Quarter	SO <sub>4</sub> <sup>2-</sup>	NO <sub>3</sub> <sup>-</sup>	NH <sub>4</sub> <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	Cl <sup>-</sup>	HNO <sub>3</sub>	SO <sub>2</sub>	Total NO <sub>3</sub> <sup>-</sup>
<b>MCK131/231, KY</b>											
2016 Q3	1.15	4.29	1.93	4.05	5.57	1.85	8.67	0.85	2.95	8.98	2.69
2016 Q4	2.79	5.63	1.96	7.79	7.05	5.52	4.19	0.84	2.55	4.20	3.67
2017 Q1	1.83	5.65	2.45	9.91	8.64	2.86	5.44	6.47	2.58	3.93	3.91
2017 Q2	1.48	6.64	1.65	4.10	4.82	3.91	9.91	0.93	3.72	3.10	3.43
Average	1.81	5.55	2.00	6.46	6.52	3.53	7.05	2.27	2.95	5.05	3.43
<b>ROM406/206, CO</b>											
2016 Q3	4.10	5.90	6.28	5.64	6.55	6.65	5.87	4.11	7.33	18.64	6.07
2016 Q4	4.12	18.61	10.98	12.17	14.05	11.42	16.15	13.83	8.03	9.71	10.15
2017 Q1	5.73	15.04	7.62	19.17	10.12	12.62	9.00	2.62	8.03	10.80	6.79
2017 Q2	3.32	15.87	3.75	7.37	7.78	9.07	13.24	5.14	5.20	4.67	6.39
Average	4.32	13.85	7.16	11.09	9.63	9.94	11.07	6.42	7.15	10.96	7.35

Note: 0 of 88 site-quarter-parameters were outside criterion

**Table 15** Ozone QC Summary for Fourth Quarter 2017 (1 of 2)

Site ID	% Span Pass <sup>1</sup>	Span  %D  <sup>2</sup>	% Single Point QC Pass <sup>1</sup>	Single Point QC  %D  <sup>2</sup>	% Zero Pass <sup>1</sup>	Zero Average (ppb) <sup>2</sup>
ABT147, CT	100.00	0.51	100.00	0.54	98.95	0.30
ALC188, TX	100.00	0.70	100.00	0.86	100.00	0.24
ALH157, IL	100.00	3.08	100.00	2.25	100.00	0.63
ANA115, MI	94.85	3.75	98.97	3.53	100.00	0.14
ARE128, PA	100.00	0.60	100.00	0.80	100.00	0.29
ASH135, ME	100.00	1.83	100.00	1.95	100.00	0.21
BEL116, MD	100.00	1.44	100.00	1.42	100.00	0.22
BFT142, NC	100.00	0.42	100.00	0.50	100.00	0.14
BVL130, IL	100.00	1.75	100.00	1.43	100.00	0.16
BWR139, MD	100.00	2.71	100.00	1.75	100.00	0.66
CAD150, AR	100.00	0.90	100.00	0.85	100.00	0.45
CDR119, WV	90.82	3.41	90.82	3.51	100.00	0.39
CDZ171, KY	95.00	1.70	94.87	2.16	100.00	0.15
CKT136, KY	100.00	0.46	100.00	0.62	100.00	0.16
CND125, NC	97.94	1.54	97.94	1.22	98.97	0.28
CNT169, WY	100.00	0.54	100.00	0.81	100.00	0.19
COW137, NC	100.00	0.85	100.00	0.89	100.00	0.24
CTH110, NY	97.80	2.64	97.80	1.83	97.80	1.11
CVL151, MS	100.00	3.84	100.00	3.71	100.00	0.29
DCP114, OH	100.00	1.71	100.00	2.22	100.00	0.20
ESP127, TN	100.00	2.10	100.00	1.89	100.00	0.20
GAS153, GA	100.00	1.82	100.00	3.60	100.00	1.09



**Table 15** Ozone QC Summary for Fourth Quarter 2017 (2 of 2)

Site ID	% Span Pass <sup>1</sup>	Span  %D  <sup>2</sup>	% Single Point QC Pass <sup>1</sup>	Single Point QC  %D  <sup>2</sup>	% Zero Pass <sup>1</sup>	Zero Average (ppb) <sup>2</sup>
GTH161, CO	100.00	0.93	100.00	1.10	100.00	0.15
HOX148, MI	100.00	2.52	100.00	1.71	100.00	0.47
HWF187, NY	100.00	1.02	100.00	1.01	100.00	0.12
IRL141, FL	98.85	0.67	100.00	0.85	100.00	0.61
KEF112, PA	100.00	1.26	100.00	1.78	100.00	0.27
LRL117, PA	100.00	0.89	98.95	1.27	100.00	0.22
MCK131, KY	98.95	1.79	100.00	1.64	100.00	0.37
MCK231, KY	100.00	0.61	100.00	0.52	100.00	0.21
MKG113, PA	93.07	5.57	93.00	5.41	96.00	0.77
NPT006, ID	100.00	0.65	100.00	0.71	100.00	0.17
OXF122, OH	100.00	2.04	100.00	1.72	100.00	0.31
PAL190, TX	100.00	1.48	100.00	1.92	100.00	0.54
PAR107, WV	100.00	0.68	98.95	0.88	100.00	0.20
PED108, VA	100.00	0.65	100.00	0.76	100.00	0.15
PND165, WY	98.91	1.80	98.91	2.62	100.00	0.64
PNF126, NC	100.00	2.98	100.00	2.93	100.00	0.30
PRK134, WI	100.00	1.03	100.00	0.96	100.00	0.19
PSU106, PA	100.00	0.81	100.00	0.76	100.00	0.42
QAK172, OH	100.00	4.27	100.00	2.86	100.00	1.30
ROM206, CO	100.00	3.14	100.00	2.88	100.00	0.16
SAL133, IN	100.00	2.63	100.00	2.16	100.00	0.31
SAN189, NE	100.00	2.12	100.00	2.17	100.00	0.74
SND152, AL	100.00	1.70	97.92	1.61	97.92	1.55
SPD111, TN	100.00	0.90	100.00	0.64	100.00	0.29
STK138, IL	98.91	2.12	100.00	1.18	100.00	1.04
SUM156, FL	100.00	2.81	100.00	2.87	100.00	0.21
UVL124, MI	100.00	0.52	100.00	0.72	100.00	0.16
VIN140, IN	100.00	0.91	100.00	0.87	100.00	0.28
VPI120, VA	98.85	1.06	100.00	0.78	98.85	0.39
WSP144, NJ	100.00	0.99	98.95	1.27	100.00	0.52
WST109, NH	100.00	0.39	100.00	0.45	100.00	0.14

**Notes:** <sup>1</sup> Percentage of comparisons that pass the criteria listed in Table 5.

<sup>2</sup> Absolute value of the average percent differences between the on-site transfer standard and the site monitor.

%D= percent difference

ppb= parts per billion

**Table 16** Trace-level Gas QC Summary for Fourth Quarter 2017

Parameter	% Span Pass <sup>1</sup>	Span  %D  <sup>2</sup>	% Single Point QC Pass <sup>1</sup>	Single Point QC  %D  <sup>2</sup>	% Zero Pass <sup>1</sup>	Zero Average (ppb) <sup>2</sup>
BVL130, IL						
SO <sub>2</sub>	100.00	2.07	100.00	1.01	100.00	0.12
NO <sub>y</sub>	100.00	2.09	100.00	1.72	100.00	0.37
CO	100.00	1.56	100.00	3.60	100.00	10.74
DUK008, NC						
NO <sub>y</sub>	100.00	3.32	97.06	5.96	100.00	0.74
HWF187, NY						
NO <sub>y</sub>	100.00	1.80	100.00	1.74	100.00	0.27
PND165, WY						
NO <sub>y</sub>	100.00	2.62	91.30	5.63	100.00	0.11
PNF126, NC						
NO <sub>y</sub>	100.00	1.38	100.00	1.96	100.00	0.36
ROM206, CO						
NO <sub>y</sub>	100.00	0.63	100.00	1.96	100.00	0.24

**Notes:** <sup>1</sup> Percentage of comparisons that pass the criteria listed in Table 6.

<sup>2</sup> Absolute value of the average percent differences between the supplied and observed concentrations.

%D = percent difference

ppb = parts per billion

**Table 17** Summary of Filter Blanks for 2017 (1 of 2)

Parameter Name	Detection Limit Total $\mu\text{g}$	Total Number	Number > Detection Limit	Average Total $\mu\text{g}$	Average Absolute Deviation	Maximum Total $\mu\text{g}$
<b>FIELD BLANKS</b>						
Teflon-NH <sub>4</sub> <sup>+</sup> -N	0.500	342	0	0.500	0.000	0.500
Teflon- NO <sub>3</sub> <sup>-</sup> -N	0.200	342	3	0.201	0.002	0.363
Teflon- SO <sub>4</sub> <sup>2-</sup>	1.000	342	0	1.000	0.000	1.000
Cl <sup>-</sup>	0.500	342	0	0.500	0.000	0.500
Ca <sup>2+</sup>	0.150	342	80	0.172	0.035	0.613
Mg <sup>2+</sup>	0.075	342	0	0.075	0.000	0.075
Na <sup>+</sup>	0.125	342	6	0.127	0.003	0.313
K <sup>+</sup>	0.150	342	6	0.156	0.011	1.662
Nylon- NO <sub>3</sub> <sup>-</sup> -N	0.200	322	0	0.200	0.000	0.200
Nylon - SO <sub>4</sub> <sup>2-</sup>	1.000	322	0	1.000	0.000	1.000
Cellulose - SO <sub>4</sub> <sup>2-</sup>	2.000	342	39	2.094	0.168	3.940
<b>LABORATORY BLANKS</b>						
Teflon-NH <sub>4</sub> <sup>+</sup> -N	0.500	104	0	0.500	0.000	0.500
Teflon- NO <sub>3</sub> <sup>-</sup> -N	0.200	104	0	0.200	0.000	0.200
Teflon- SO <sub>4</sub> <sup>2-</sup>	1.000	104	0	1.000	0.000	1.000
Cl <sup>-</sup>	0.500	104	0	0.500	0.000	0.500
Ca <sup>2+</sup>	0.150	104	2	0.151	0.003	0.228
Mg <sup>2+</sup>	0.075	104	0	0.075	0.000	0.075
Na <sup>+</sup>	0.125	104	0	0.125	0.000	0.125
K <sup>+</sup>	0.150	104	0	0.150	0.000	0.150
Nylon- NO <sub>3</sub> <sup>-</sup> -N	0.200	102	0	0.200	0.000	0.200
Nylon -SO <sub>4</sub> <sup>2-</sup>	1.000	102	0	1.000	0.000	1.000
Cellulose -SO <sub>4</sub> <sup>2-</sup>	2.000	102	8	2.113	0.209	5.330

**Table 17** Summary of Filter Blanks for 2017 (2 of 2)

Parameter Name	Detection Limit Total $\mu\text{g}$	Total Number	Number > Detection Limit	Average Total $\mu\text{g}$	Average Absolute Deviation	Maximum Total $\mu\text{g}$
<b>METHOD BLANKS</b>						
Teflon-NH <sub>4</sub> <sup>+</sup> -N	0.500	66	0	0.500	0.000	0.500
Teflon- NO <sub>3</sub> <sup>-</sup> -N	0.200	67	0	0.200	0.000	0.200
Teflon- SO <sub>4</sub> <sup>2-</sup>	1.000	67	0	1.000	0.000	1.000
Cl <sup>-</sup>	0.500	67	0	0.500	0.000	0.500
Ca <sup>2+</sup>	0.150	66	0	0.150	0.000	0.150
Mg <sup>2+</sup>	0.075	66	0	0.075	0.000	0.075
Na <sup>+</sup>	0.125	66	0	0.125	0.000	0.125
K <sup>+</sup>	0.150	66	0	0.150	0.000	0.150
Nylon- NO <sub>3</sub> <sup>-</sup> -N	0.200	65	0	0.200	0.000	0.200
Nylon -SO <sub>4</sub> <sup>2-</sup>	1.000	65	0	1.000	0.000	1.000
Cellulose -SO <sub>4</sub> <sup>2-</sup>	2.000	67	0	2.000	0.000	2.000
<b>ACCEPTANCE TEST VALUES<sup>1</sup></b>						
Teflon-NH <sub>4</sub> <sup>+</sup> -N	0.500	250	0	0.500	0.000	0.500
Teflon- NO <sub>3</sub> <sup>-</sup> -N	0.200	250	0	0.200	0.000	0.200
Teflon- SO <sub>4</sub> <sup>2-</sup>	1.000	250	0	1.000	0.000	1.000
Cl <sup>-</sup>	0.500	250	0	0.500	0.000	0.500
Ca <sup>2+</sup>	0.150	250	7	0.153	0.006	0.475
Mg <sup>2+</sup>	0.075	250	0	0.075	0.000	0.075
Na <sup>+</sup>	0.125	250	2	0.126	0.002	0.275
K <sup>+</sup>	0.150	250	0	0.150	0.000	0.150
Nylon- NO <sub>3</sub> <sup>-</sup> -N	0.200	230	0	0.200	0.000	0.200
Nylon -SO <sub>4</sub> <sup>2-</sup>	1.000	230	0	1.000	0.000	1.000
Cellulose -SO <sub>4</sub> <sup>2-</sup>	2.000	315	9	2.036	0.070	4.785

**Note:** <sup>1</sup>Only filter batches passing QC requirements are used for sampling and analysis.

**Table 18** Filter Packs Flagged as Suspect or Invalid (1 of 2)

Site ID	Sample	Reason
First Quarter 2017		
ALH157, IL	1703001-02	The data logger malfunctioned during the sampling period.
JOT403, CA	1705003-12	Polled data are only available for the first day of this sampling week. The sample may be recovered if more data are received from Air Resource Specialists.*
KIC003, KS	1701004-03	The flow pump was inoperative.
ROM206, CO	1704001-45	Only potassium was invalidated for a suspect value.
STK138, IL	1703001-49	Insufficient flow volume was caused by a clogged Balston filter.
YEL408, WY	1702003-24	A hole was found in the Teflon filter upon unloading the filter pack.
Second Quarter 2017		
ALH157, IL	1716001-02	The data logger malfunctioned.
BEL116, MD	1720001-06	Power failure
BVL130, IL	1714001-08	A suspect potassium value was invalidated.
CAT175, NY	1721001-11	The data logger malfunctioned
CHE185, OK	1717004-02	Data collection problem – data should be recoverable.*
GLR468, MT	1722003-08	The data logger malfunctioned
HOW191, ME	1716001-25 1717001-25	Flow system leak
KEF112, PA	1714001-29	A suspect potassium value was invalidated.
NEC602, WY	1717005-04	A polling error resulted in negative flow volume. Data should be recoverable.†
NIC001, NY	1719001-35	Power failure
NPT006, ID	1720004-04	Channels were left down after an audit. Data may be recoverable.†
OXF122, OH	1721001-36	Data were flagged as “calibrator onsite” and may be recoverable.*
QAK172, OH	1721001-44	Data were flagged as “calibrator onsite” and may be recoverable.*
SAN189, NE	1716004-06	Filter pack data were invalidated as suspect.
STK138, IL	1717001-49	The filter pack was not properly installed.
UND002, VT	1718001-51	Power failure
UVL124, MI	1714001-52	The data logger malfunctioned.
VIN140, IN	1719001-53	Data were flagged as “calibrator onsite” and may be recoverable.*

**Table 18** Filter Packs Flagged as Suspect or Invalid (2 of 2)

Site ID	Sample	Reason
Third Quarter 2017		
BUF603, WY	1727005-02	Power failure
NEC602, WY	1729005-04 1731005-04	There are missing or invalid data. Polling errors – data may be recoverable. †
UND002, VT	1727001-51 1728001-51 1730001-51	There were intermittent power failures.
VOY413, MN	1731003-22	Insufficient flow volume
WFM007, NY	1729013-01	The filter pack ran during a cloud event.
Fourth Quarter 2017		
CNT169, WY	1741001-16 1746001-16	There were intermittent power failures.
HOW191, ME	1741001-25	Power failure
JOT403, CA	1744003-12	Flow rate data were missing.
KIC003, KS	1742004-03	Power failure
NIC001, NY	1742001-35	Power failure
PNF126, NC	1743001-41	The data logger charger failed.
SAN189, NE	1743004-06	The site operator left the pump turned off.
THR422, ND	1743003-21	The filter pack quick-connect was not fully engaged.
UND002, VT	1742001-51 1743001-51 1746001-51	There were intermittent power failures
VOY413, MN	1743003-22	Power failure
YEL408, WY	1744003-24	Power failure

**Notes:** \*Data were recovered.

†Sample remains invalid.



**Table 19** Field Problems Affecting Data Collection

Days to Resolution	Problem Count
First Quarter 2017	
30	427
60	15
90	3
Unresolved by End of Quarter	19
Second Quarter 2017	
30	603
60	6
90	0
Unresolved by End of Quarter	19
Third Quarter 2017	
30	729
60	11
90	4
Unresolved by End of Quarter	26
Fourth Quarter 2017	
30	494
60	13
90	0
Unresolved by Date of Publication	18

**Note:** \*High 30-day counts were mostly due to high humidity in ozone monitoring sample streams identified via review of 1-minute data.

**Table 20** Field Calibration Failures by Parameter for 2017

Site ID	Parameter(s)
First Quarter 2017	
OXF122, OH	Flow Rate
Second Quarter 2017	
PAL190, TX	Solar Radiation
Third Quarter 2017	
ESP127, TN	Temperature (ambient)
PNF126, NC	Temperature (zero and ambient)
Fourth Quarter 2017	
ASH135, ME	Flow Rate

**Note:** Per CASTNET project protocols, data for all parameters except flow are flagged as “suspect” (S) but still considered valid if the calibration criterion is not exceeded by more than its magnitude (i.e., if within two times the criterion). If flow calibrations fall within two times the criterion, these data are adjusted per approved protocol described in the CASTNET QAPP, (Amec Foster Wheeler, 2016). Please refer to Table 15 for documentation of the QC failures affecting the validity of ozone data.

**Table 21** Accuracy Results for 2017 Field Measurements

Parameter	Percent Within Criterion
Flow Rate	98.4
Wind Speed < 5 m/s	100.0
Wind Speed ≥ 5 m/s	100.0
Wind Direction North	90.0
Wind Direction South	100.0
Temperature (0°C)	99.2
Temperature (ambient)	98.4
Delta Temperature (0°C)	100.0
Delta Temperature (ambient)	100.0
Relative Humidity	100.0
Precipitation	100.0
Solar Radiation	88.9
Wetness (w/in 0.5 volts)	100.0

**Notes:** °C = degrees Celsius  
m/s= meters per second

**Figure 1** Reference Standard Results for Fourth Quarter 2017 (percent recovery)

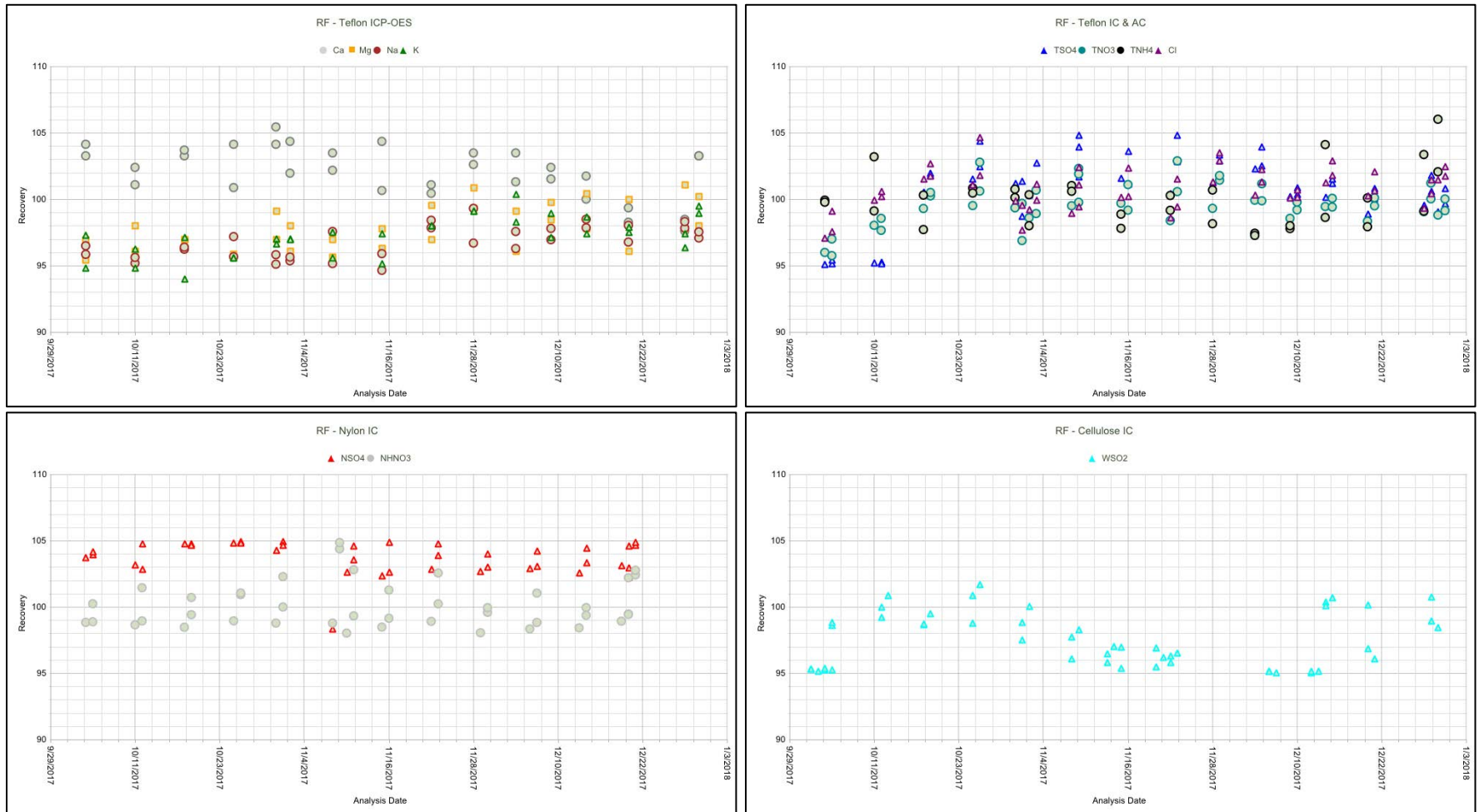
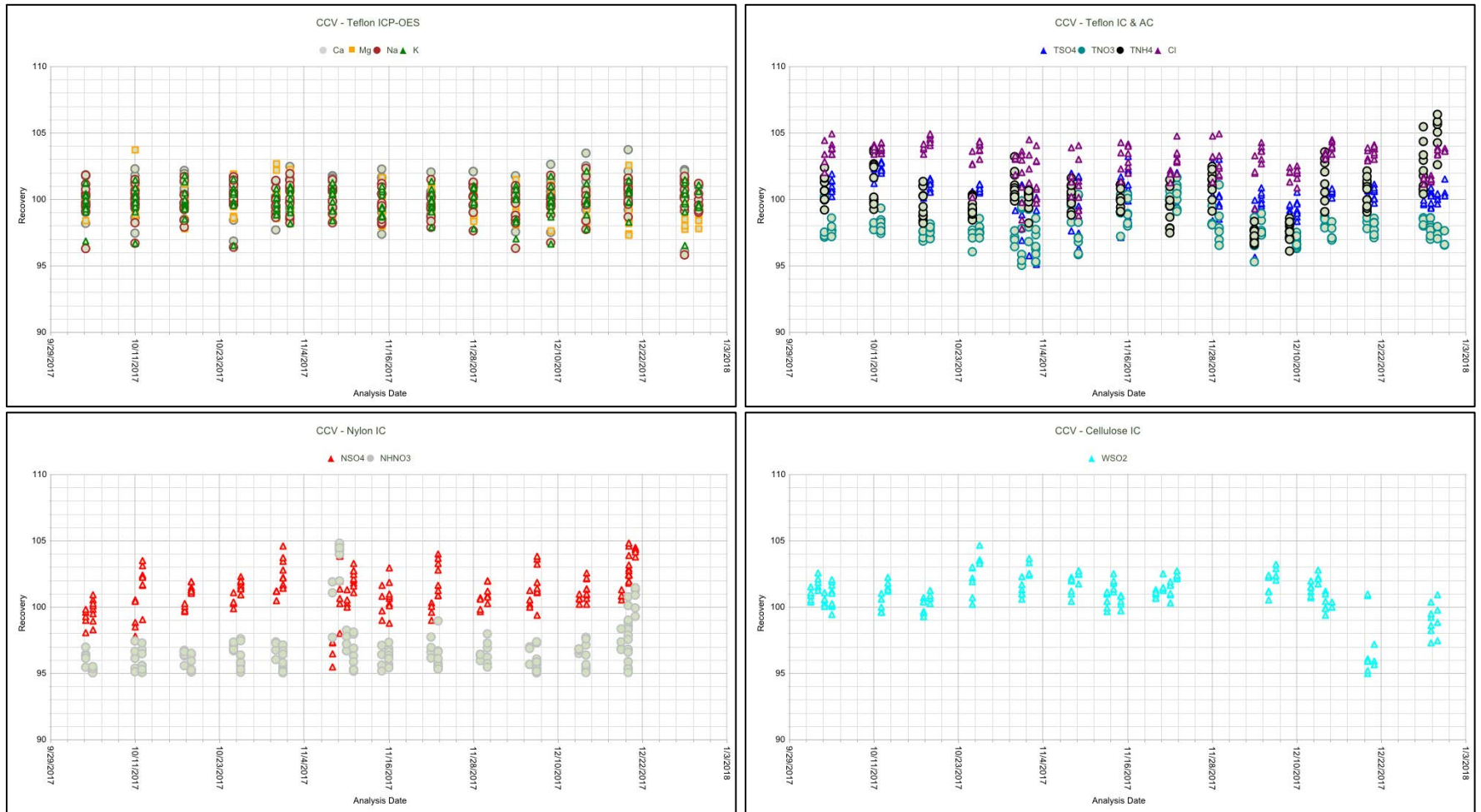
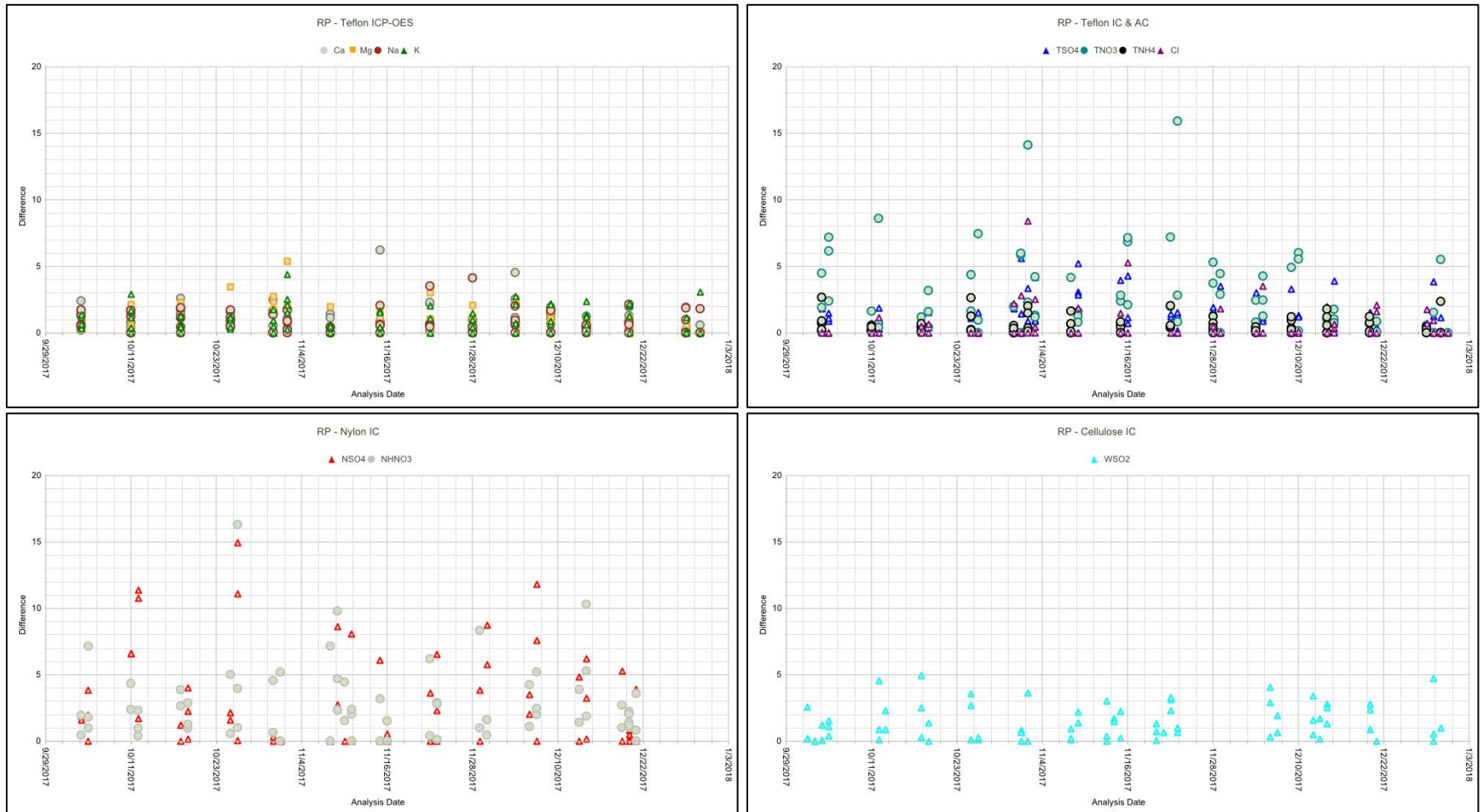


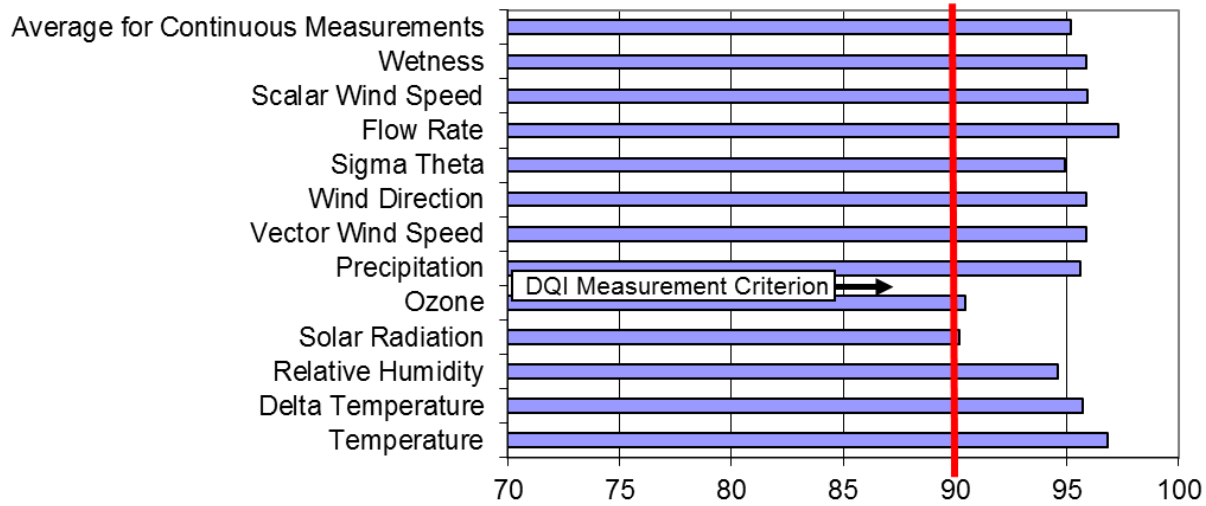
Figure 2 Continuing Calibration Spike Results for Fourth Quarter 2017 (percent recovery)



**Figure 3** Replicate Sample Analysis Results for Fourth Quarter 2017 (percent difference)



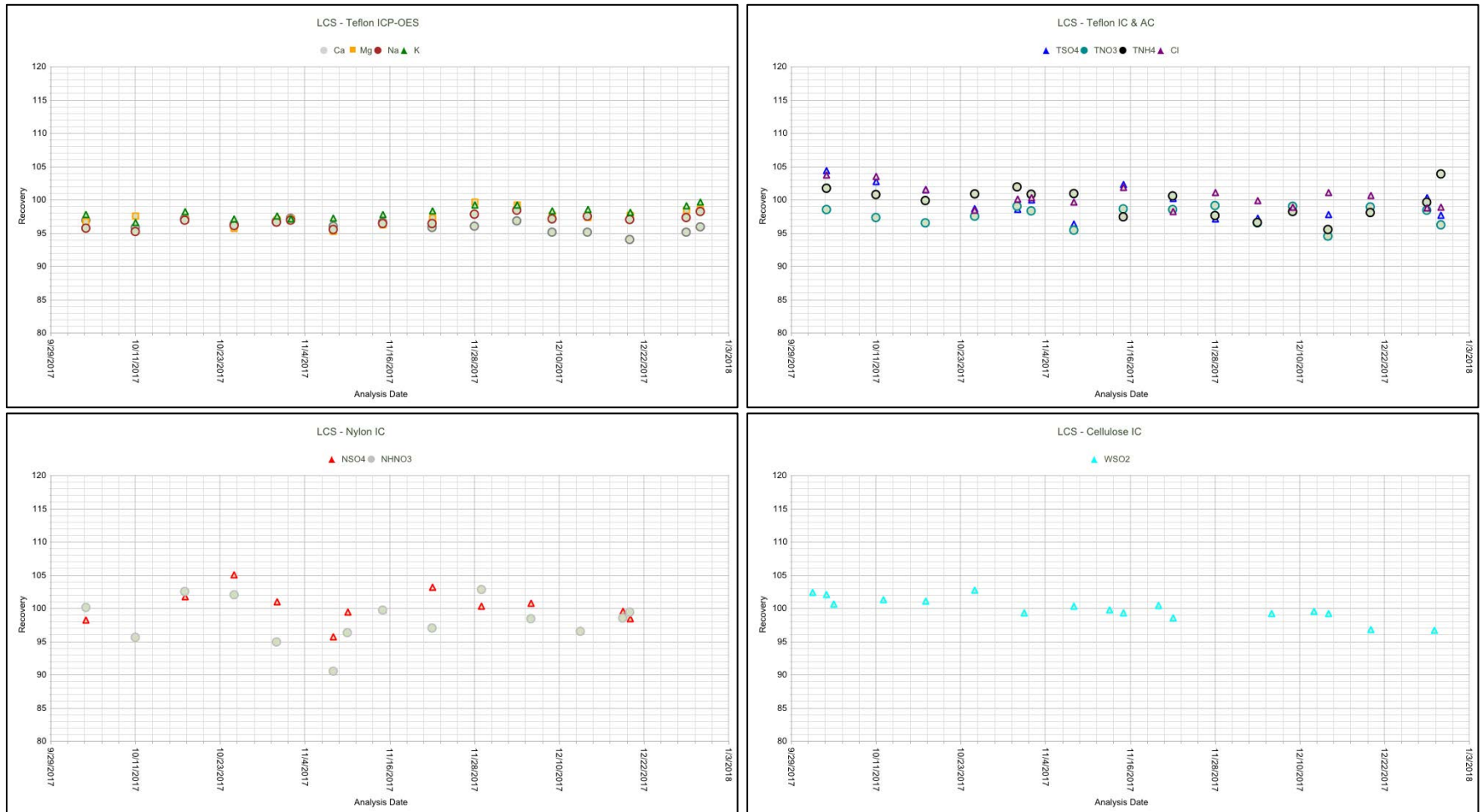
**Figure 4** Percent Completeness of Measurements for Second Quarter 2016 through Third Quarter 2017\*



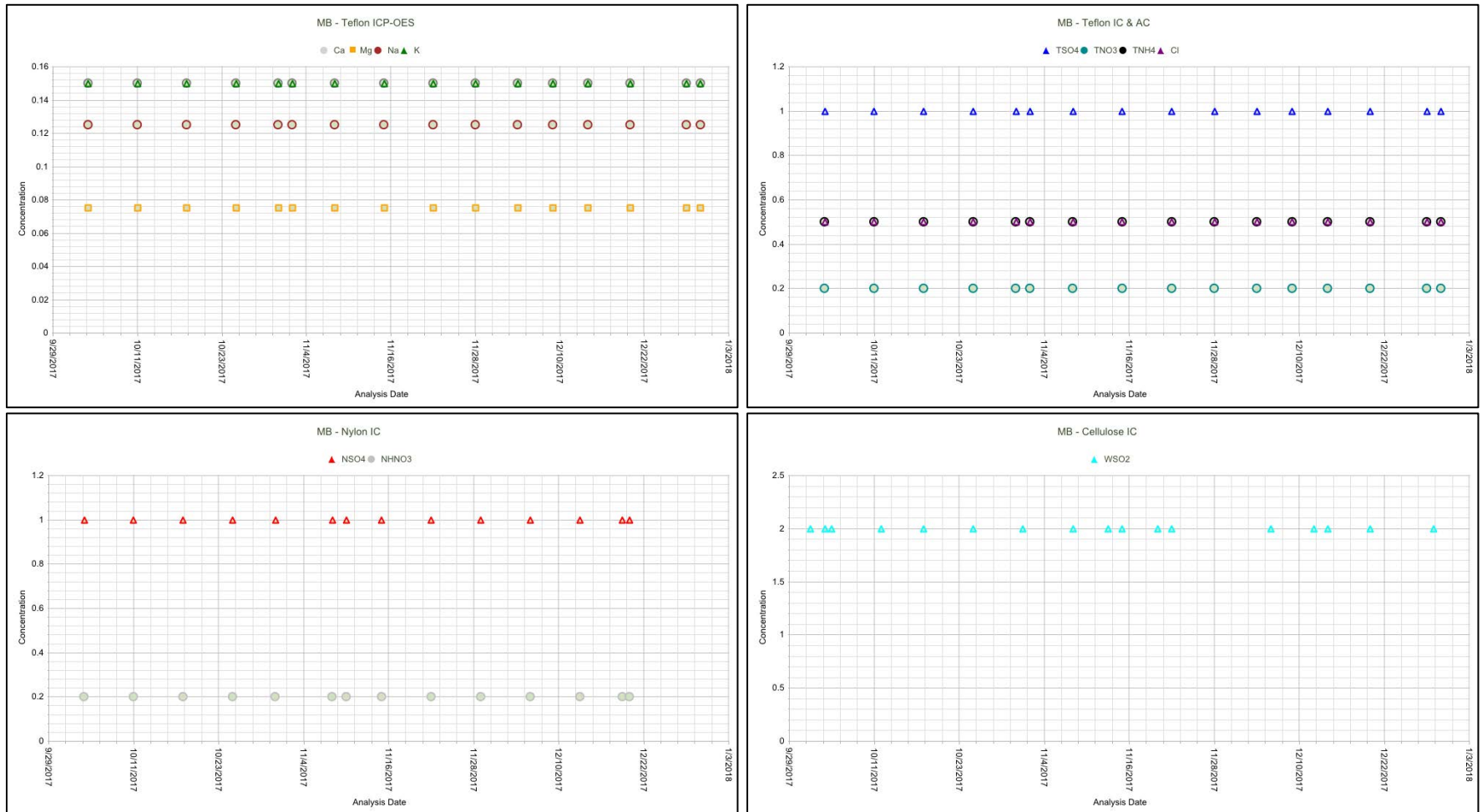
**Note:** \*Presents Level 3 data available during the fourth quarter of 2017



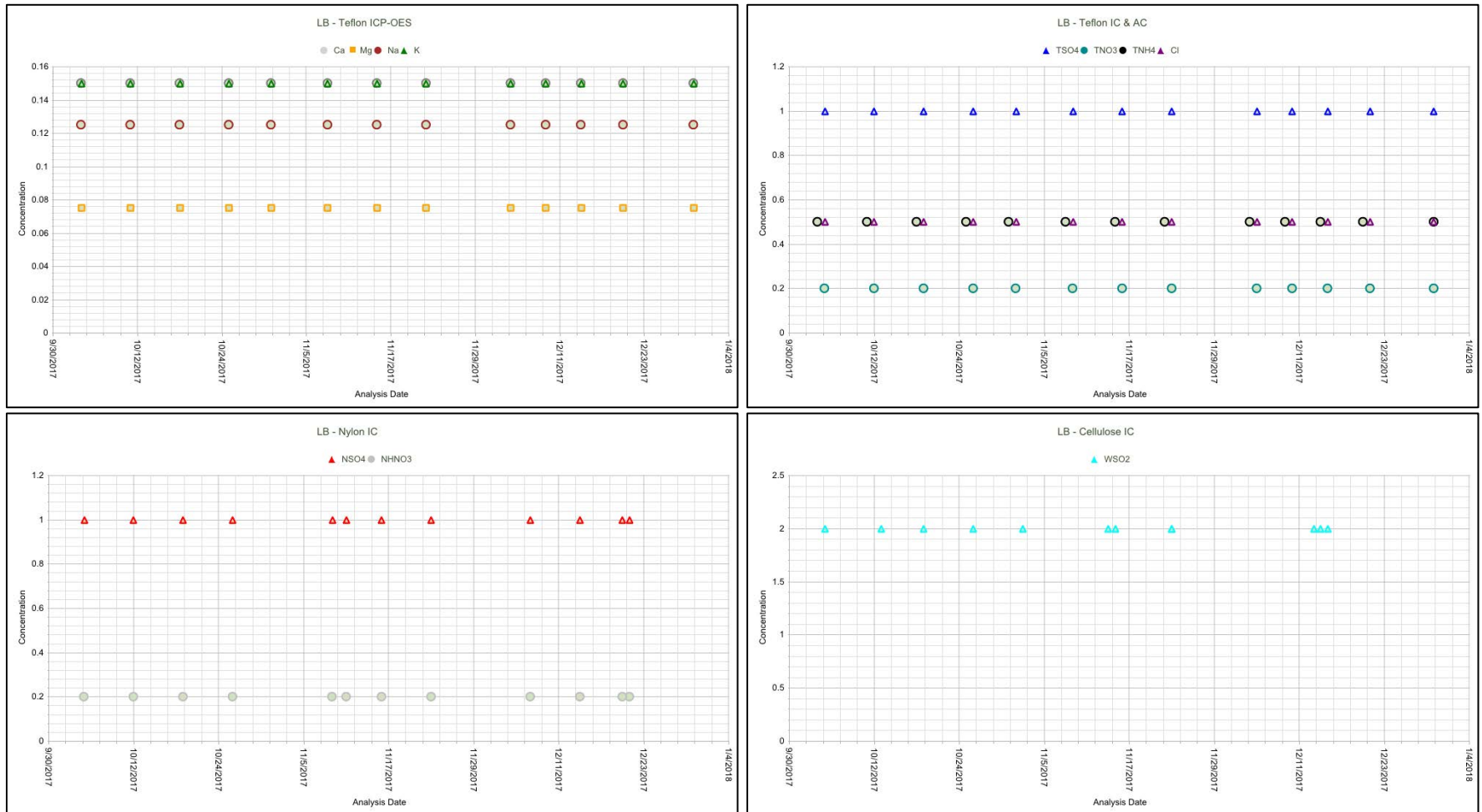
**Figure 5** Laboratory Control Sample Results for Fourth Quarter 2017 (percent recovery)



**Figure 6** Method Blank Analysis Results for Fourth Quarter 2017 (total micrograms)



**Figure 7** Laboratory Blank Analysis Results for Fourth Quarter 2017 (total micrograms)



**Figure 8** Field Blank Analysis Results for Fourth Quarter 2017 (total micrograms)

