RTI/0212053/07ADS

March 24, 2016

Annual Data Summary Report for the Chemical Speciation of $PM_{2.5}$ Filter Samples Project

January 1 through December 31, 2015

Prepared for:
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

EPA Contract No. PR-NC-09-010

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**RTI International is a trade name of Research Triangle Institute.*

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Executive Summary

Introduction

The U.S. Environmental Protection Agency (EPA) established a $PM_{2.5}$ Chemical Speciation Network (CSN) in 1999, and monitoring operations began in February, 2000. The CSN includes the Speciation Trends Network (STN), a core set of 52 speciation trends analysis sites, as well as a variable number of other sites. RTI supported EPA with the chemical speciation analysis of the $PM_{2.5}$ filter samples since the inception of the CSN program until the end of 2015.

As part of this program, RTI supported EPA/OAQPS by shipping ready-to-use filter packs loaded into cartridges and coated denuders to all the field sites and by conducting gravimetric analysis of Teflon filters and chemical analyses of Teflon, Nylon and Quartz-fiber filters used in the samplers after sample collection. Beginning October 1, 2014, gravimetric analysis of Teflon Filters was discontinued for the entire network except for a few sites. Six sites continued gravimetric analysis in 2014. Beginning in 2015, only three sites performed gravimetric analysis. RTI was also responsible for scheduling shipments of filters to the monitoring sites and for data reporting. RTI staff performed an extensive array of quality assurance/quality control (QA/QC) activities to ensure that the data provided to EPA and the States are of the highest quality. Laboratory QA activities and results in terms of accuracy, precision, completeness and sensitivity are summarized in this report, along with any corrective actions taken between January 1 and December 31, 2015.

Data Quality Overview

Analytical data completeness typically exceeded 95%, and laboratory accuracy and precision were within limits as demonstrated by routine QC samples, laboratory audits, and instrument intercomparison. There was no Technical Systems Audit (TSA) of RTI performed by EPA in 2015. The last TSA was conducted by EPA in July 2012. The 2012 TSA complimented all RTI laboratories for good compliance with the Standard Operating Procedures (SOPs), good record-keeping and quality-control practices and for the excellent agreement in results between the RTI analyses and the EPA results. The TSA reported no deficiencies. The TSA of the DRI OC/EC laboratory was performed in October 2013 with the report finalized in March 2014. The TSA found that the lab followed good QC and record keeping procedures.

Laboratory Performance

Section 3.0 of this report provides the details of accuracy, precision, and other measures of laboratory performance. The laboratories consistently met their QC goals of routine analyses, which are detailed in Sections 3.1 (Gravimetry Laboratory), 3.2 (Ion Analysis), 3.3 (Organic and Elemental Carbon (OC/EC) by IMPROVE_A), and 3.4 (X-ray Fluorescence).

Data quality for gravimetric mass results was found to be satisfactory during 2015. Issues included problems with the weighing chamber environmental controls. These issues were dealt with aggressively to minimize downtime, as described in Section 3.1. No filters were weighed during periods of chamber issues.

No data quality issues were reported by the Ion Analyses Lab (Section 3.2) during 2015. The DRI OC/EC lab discovered during the preparation of this report that during 2015 two analyzers were not updated with the correct temperature settings post-calibration and that a total of 521 analyses were impacted. However, the lab notes that the replicate analyses performed on a different analyzer agreed within the QC criteria. (Sections 3.3). New URG 3000N software have now been deployed throughout the entire CSN network to sample quartz filters for OC/EC. DRI analyzes all filters from the 3000N samplers using the IMPROVE_A protocol.

The XRF laboratory operated by RTI generally met the prescribed QC criteria for analysis (Sections 3.4.1). Lot-specific background correction was performed as discussed in the 2013 annual data summary report.

No significant quality issues were reported by the denuder refurbishment laboratory (Section 3.5). Operations in RTI's Sample Handling and Archiving Laboratory (SHAL) proceeded satisfactorily during 2015 (Section 3.6). There was one instance when the incoming packages were delayed by the shipping carrier due to inclement weather.

No significant data quality issues were reported by the data processing and data validation functions during 2015 (Sections 4.0 and 5.0).

Data were reviewed and posted to a secure Web site on a monthly basis for review. Finalized data are posted to the EPA Air Quality System (AQS) database approximately 60 days after initial posting (Section 4.0). A number of data users with total number of communications exceeding 700, contacted SHAL, data processing, and QA personnel with questions about specific data items, or to request explanations about apparent discrepancies. RTI attempts to answer such questions promptly, and works closely with the agencies to determine the most appropriate data flags for particular situations.

Estimation of MDLs and Uncertainties

Method Detection Limits (MDLs) for all laboratory methods are provided in Appendix A. Uncertainties are estimated based on laboratory QC data, augmented by a 5% concentration-proportional term to account for field handling and sample volume uncertainties. Results from collocated samplers (Section 5.3) indicate that this uncertainty model is reasonable for most chemical species.

Quality Issues

There were no Corrective Action Request (CAR) issued during 2015. There were some issues that have not been assigned CARs because there was no specific action that RTI could take, or because they required input and cooperation from others outside RTI. These issues are summarized in Table ES-1.

Table ES-1. Summary of Quality Issues during 2015

CAR Number	Lab	Description	Response	Effect on Data
None	SHAL	Delivery delayed by UPS.	Due to inclement weather in Louisville, KY the incoming shipment of CSN sampled filters scheduled to arrive at RTI on Friday April 3, 2015 was delayed by UPS. No packages were delivered to RTI that Friday. The incoming packages delivered on Monday were assigned the "RDC" flag (Return Shipment Delayed by Shipping Company). A total of 141 sampling events were assigned this flag.	
None	SHAL	Moved SHAL laboratory in November 2015.	The SHAL moved from the 1000 Parliament Court location in Durham, NC to RTI's main campus the morning of Monday November 2, 2015. The new SHAL was located in the same laboratory as the OC/EC analysis laboratory. Packages of sampled filters from the network were stored in RTI's filter archive prior to processing. The refrigerated filter archive replaced the walk-in cold room at the 1000 Parliament Court location. The new SHAL processed CSN packages from Monday November 2, 2015 through December 11, 2015.	
None	SHAL	Late-arriving Coolers	Delivery Order Project Officer (DOPO) and others are notified whenever coolers are received late from the field.	Data are flagged as missing.
None	DRI OC/EC	Incorrect temperature calibration parameters used for two analyzers	RTI has requested DRI to implement corrective actions to prevent such instances from recurring in the future. DRI reports that additional steps have been implemented including: a) requiring the technician to record the previous calibration values (m, b, & r2) in the analyzer and on the hardcopy analyzer logbook prior to start of calibration; b) requiring the technician to restart the analyzer and record the new calibration parameters (m, b, & r2) after completion of temperature calibration; c) verifying if before and after calibrations are the same; and d) a review by the DRI QA manager after the semi-annual calibrations are complete.	Replicates analysis indicate that OC, EC and TC are within acceptable criteria.

1.0 Introduction

1.1 Program Overview

In 1997, the U.S. Environmental Protection Agency (EPA) promulgated the new National Ambient Air Quality Standards (NAAQS) for particulate matter (PM). The regulations (given in 40 CFR Parts 50, 53, and 58) apply to the mass concentrations (µg/m^3 of air) of particles with aerodynamic diameters less than 10 micrometers (the PM_{10} standard) and less than 2.5 micrometers (the $PM_{2.5}$ standard).

In response to the 1997 $PM_{2.5}$ NAAQS, a federal reference method (FRM) network of approximately 900 sites that measures gravimetric mass and a Chemical Speciation Network (CSN) was established to monitor levels of $PM_{2.5}$ in the U.S. The CSN consists of approximately 150 sampling sites as of the date of this report, which includes six collocated sites. The mass measurement data from the FRM network is used for identifying areas that meet or do not meet the NAAQS criteria and supporting designation of an area as attainment or non-attainment. The $PM_{2.5}$ CSN, which is mostly supported by RTI International (RTI), includes the Speciation Trends Network (STN), a core set of 52 speciation trends monitoring sites located primarily in urban areas and a variable number of other sites operated by State, Local and Tribal air monitoring agencies.

This data summary report covers the quality assurance (QA) aspects of the collection and chemical analysis of samples from the CSN sites from December 1, 2014 through December 31, 2015. RTI supported the $PM_{2.5}$ CSN by shipping ready-to-use filter packs loaded into cartridges and coated denuders to the field sites and by conducting gravimetric and chemical analyses of the several types of filters used in the samplers. As a result of the network assessment performed by the EPA, several changes were implemented:

- Beginning October 1, 2014, gravimetric analysis of Teflon Filters was discontinued for the entire network except for a few sites. Six sites continued gravimetric analysis from 10/1/2014 through 12/31/2014. These include WV-Guthrie (54-039-0011), Skyview (12-103-0026), Athens (13-059-0001), Douglas (13-069-0002), Shreveport Airport (22-015-0008), and Bonne Terre (29-186-0005). Beginning in 2015, only Shreveport, Douglas & WV-Guthrie continued doing gravimetric mass.
- Quartz backup filters were collected at 5% frequency in 2014, but were discontinued beginning in 2015.
- Beginning in 2015, the quartz 24 hour blank samples were collected at only 49 sites in the CSN. These 24 hour blanks were collected at a 10% frequency for sites with 1-in-3 day schedule, and at 20% frequency for sites with 1-in-6 day schedule.

The details of the QA activities that are performed for the CSN are described in the RTI QA Project Plan (QAPP) for this project, along with the Standard Operating Procedures (SOPs).

1.2 Project/Task Description

The CSN laboratory contract involves four broad areas:

1. Supplying each site or State with sample collection media (loaded filter packs and coated denuders) and field data documentation forms. RTI shipped the collection media to monitoring agencies on a schedule specified by the Delivery Order Project Officer (DOPO).
2. Receiving the samples from the field sites and analyzing the sample media for gravimetric mass and for an array of chemical constituents, including elements (by energy-dispersive x-ray fluorescence [EDXRF]), and soluble anions and cations (by ion chromatography). Desert Research Institute (DRI), a subcontractor to RTI, is performing analysis of carbonaceous material using the IMPROVE_A thermal-optical analysis method in both the reflectance and transmittance modes. Analysis of semi-volatile organic compounds, optical density and examination of particles by electron or optical microscopy are included in RTI's contract with EPA/OAQPS, but have not been performed to date.
3. Assembling validated sets of data from the analyses, preparing data reports for EPA management and the State Agencies within 45 days of sampling, and entering data into the Air Quality System (AQS) data bank 60 days after initial data reports are first submitted to the DOPO and the State Agencies.
4. Establishing and applying a comprehensive QA/quality control (QC) system. RTI's Quality Management Plan (QMP), QAPP, and associated SOPs provide the documentation for RTI's quality system.

1.3 Major Laboratories and Operational Areas

This report addresses the operation of RTI's Sample Handling and Archiving Laboratory (SHAL) and QA/QC for the four major analytical areas active during the time period of January 1 through December 31, 2015. These analytical areas are: (1) gravimetric determination of particulate mass on Teflon® filters; (2) determination of 33 elements on Teflon® filters using X-ray fluorescence (XRF) spectrometry; (3) determination of nitrate, sulfate, sodium, ammonium, and potassium on nylon filters using ion chromatography; and (4) determination of organic carbon (OC), elemental carbon (EC), total carbon (TC), and individual peaks for OC, EC, and pyrolysis carbon on quartz filters using thermal optical reflectance (TOR) and transmittance (TOT) by the IMPROVE_A protocol. RTI laboratories conduct the gravimetric, ions, and XRF measurements. DRI performs the IMPROVE_A carbon analysis for the quartz filters. Denuder refurbishment, data processing, and QA and data validation are also major elements of this program performed by RTI, and are also included in this report.

2.0 Quality Issues and Corrective Actions

2.1 Data Quality

RTI staff perform an extensive array of QA/QC activities to ensure that the CSN data provided to EPA and the States are of the highest quality and so that they can support the needs of scientific research and regulatory compliance.

Data quality for the CSN has several dimensions, supporting a goal of usefulness to data users. There are several metrics that are considered in assuring and assessing the quality of the CSN data set:

- Accuracy. All analyses standardized to reference values that are traceable to the National Institute of Standards and Technology (NIST.)
- Precision. Measured both as laboratory and whole-system through regular QC replicates and results from samplers collocated at the same site.
- Completeness. Excellent completeness (>95%) is demonstrated overall. Some individual sites may have lower completeness, typically due to site maintenance, instrument downtime due to repairs and/or upgrades or shipping problems.
- Spatial coverage. Selection of sites for CSN is outside of RTI's control. The CSN sites are generally selected to evaluate population-based health effects and tend to be in populated areas. Because of this, the CSN has relatively little coverage of rural sites in the western United States, where IMPROVE sites predominate.
- Comparability. Intercomparison studies recently conducted by EPA have shown good agreement with programs such as the FRM network for mass, and IMPROVE results for mass and for most of the major chemical species.
- Representativeness. While primary site selection and field-sampling operations are out of RTI's control, the RTI laboratories follow appropriate extraction and sample preparation procedures to guard against non-representative sampling of the filters.
- Sensitivity/Detection. The ability to quantify major species, such as gravimetric mass, OC, sulfate, nitrate, ammonium, and iron, is adequate; however, many of the trace elements are routinely below limits of detection. Data users should carefully screen out species that are present in such low levels that their inclusion would only add noise to their analysis. Method Detection Limits (MDLs) are provided in Appendix A of this report.

In addition to the general data quality assessment criteria listed above, there are other, specific issues that affect CSN data usability. The following specific issues and characteristics of the data should be taken into account by data users:

- Lack of blank correction. From the beginning of the CSN program, blank corrections have not been applied (except for normal laboratory calibrations).
  The main concern is the artifact in OC measurement. The IMPROVE network includes

blank correction for OC in its reported data. This is a fundamental difference between the data reported by CSN and IMPROVE.

- Intermittent media contamination issues. Equipment and media contamination issues arise from time to time and may cause the occasional outliers reported by the monitoring agencies, in which the CSN mass differs from the mass reported by a nearby FRM sampler. RTI makes an effort to flag data, retroactively if necessary, to invalidate or mark as suspicious any events reported by the monitoring agencies.
- Estimation of Uncertainty.
  - Comparability between CSN and other networks. RTI worked with XRF experts at the University of California at Davis (UC Davis) and EPA to define an acceptable method for determining XRF uncertainty. This work resulted in a White Paper that was delivered to EPA in 2006.[1] A peer-reviewed publication based on this work was published in the Journal of the Air and Waste Management Association in early 2010.[2]
  - Realism of total uncertainty estimates based on statistics from sites with side-by-side collocation of samplers.[3] Uncertainties calculated from collocation results agree with uncertainties reported to AQS within a factor of 2x for most species. See Section 5.3 and Table 5-5 for uncertainty statistics for 2015.

2.2 Summary of Data Completeness

Appendix B of this report includes the data completeness summary for the Reporting Batches delivered in 2015. Table B-1 provides the completeness for the "core" STN sites. Table B-2 summarizes completeness for the non-STN sites that are supported on the CSN contract with EPA. Data completeness network-wide typically exceeded 95% during 2015. Completeness is defined as the number of valid measurement values divided by the potential number of values. Data records with AQS validity status codes ("suspicious" data) are included in the completeness figure, but data records with an AQS null value code are counted as missing data.

2.3 Corrective Actions

To ensure ongoing quality work, RTI reacts quickly and decisively to any unacceptable changes in data quality. These reactions are usually in the form of corrective actions. Most corrective actions have been in response to very short-term problems, such that very few results were impacted negatively. The following subsections describe any significant corrective actions undertaken in each laboratory area during 2015.

[1] Gutknecht, W. F., J. B. Flanagan, and A. McWilliams, "Harmonization of Interlaboratory X-ray Fluorescence Measurement Uncertainties." RTI/0208858/TO2/04D, August 4, 2006.
[2] Gutknecht, W.F., J.B. Flanagan, A. McWilliams, R.K.M. Jayanty, et al. 2009. Harmonization of uncertainties of X-ray fluorescence data from $PM_{2.5}$ air filter analysis. *Journal of the Air and Waste Management Association*, February, 2010.
[3] Flanagan, J.B., Jayanty, R.K.M., Rickman, E.E., Jr., Peterson, M.R., 2006. PM2.5 Speciation Trends Network: Evaluation of whole-system uncertainties using data from sites with collocated samplers. J. Air & Waste Manage. Assoc. 56, 492-499.

2.3.1 Gravimetric Mass

There were no quality issues that affected data quality during the reporting period. See Section 3.1.1 for a summary of operational and maintenance issues that were addressed during 2015.

2.3.2 Ion Analysis

There were no significant issues that affected data quality in RTI's Ion Chromatography laboratory during the reporting period. See Section 3.2.1 for a summary of operational and maintenance issues that were addressed during 2015.

2.3.3 Elemental Analysis

There were no significant issues that affected data quality in RTI's XRF laboratory during the reporting period. See Section 3.4.1 for a summary of operational and maintenance issues that were addressed during 2015.

2.3.4 Organic Carbon/Elemental Carbon Analysis

All of the reportable CSN carbon analyses by the IMPROVE_A method are being performed by DRI, which is a subcontractor on the CSN contract. DRI reports that an issue was discovered during the preparation of this report. About 521 analyses were performed on two analyzers that had old temperature calibration parameters, although the replicate analyses on another analyzer were within QC criteria. DRI reports that they have talked to the analysts involved, and that the following corrective actions have been implemented at DRI: a) prior to start of temperature calibration, the analyst must record the calibration parameters in the analyzer log book; b) after the completion of the temperature calibration, the technician must restart the analyzer and record the new calibration parameters in the log book; c) compare the before and after parameters and confirm it is different; if not repeat the process; and d) after the completion of the semi-annual calibrations, the results will be reviewed by the DRI QA manager. See Section 3.3.1 for a summary of operational issues.

2.3.5 Sample Handling and Archiving Laboratory (SHAL)

There was one instance where the incoming shipment was delayed due to inclement weather. Those samples were flagged "RDC", a flag newly created in 2015 to track delays by shipping carrier.

2.3.6 Data Processing

There were no quality issues or corrective actions taken during this reporting period. The uncertainties for the carbon values for the samples collected by URG 3000N have not yet been posted into AQS, pending direction from EPA about the method to be used for calculations. Blank-corrections and/or artifact corrections for the IMPROVE_A carbon measurements rely on the same set of calculations, and these have also not been posted, pending direction from EPA.

2.4 Other Quality Issues

No other quality issues were experienced during 2015.

3.0 Laboratory Quality Control Summaries

3.1 Gravimetry Laboratory

The RTI Gravimetric Laboratory's weigh chamber was used to tare and post-sample weigh 189 Teflon filters for the $PM_{2.5}$ speciation program between January 1 and December 31, 2015. During the same time period, the laboratory performed tare and post-sample weighings of 1,118 Teflon filters to support the Tribal Air Monitoring Support (TAMS) through the CSN contract. Determination of $PM_{2.5}$ mass is based on two separate weighings performed several weeks apart. The total also reflects a contingency buffer factored into the number of filters tared each week to ensure an adequate number of tared filters for sampling and extra filters for use in in-house blanks contamination monitoring. Filter weighing totals given in this report are those recorded by the laboratory's database application. Beginning October 1, 2014, gravimetric analysis of Teflon Filters was discontinued for the entire network except for a few sites. Six sites continued gravimetric analysis from 10/1/2014 through 12/31/2014. These include WV-Guthrie (54-039-0011), Skyview (12-103-0026), Athens (13-059-0001), Douglas (13-069-0002), Shreveport Airport (22-015-0008), and Bonne Terre (29-186-0005). Beginning in 2015, only Shreveport, Douglas & WV-Guthrie continued doing gravimetric mass.

3.1.1 Quality Issues and Corrective Actions

No significant filter quality issues were identified in the Gravimetry Laboratory in 2015. The laboratory continued to proactively monitor mass balance data and to perform routine filter inspections during conditioning and weighing. No pervasive problem with extraneous contaminating debris was identified in 2015 in the routine visual inspection in the chamber. Lot stability tests indicated that the two Teflon filter lots used for the program in 2015 did not have issues with debris or outgassing.

The laboratory's environmental chambers experienced no downtime due to system failure in 2015. However, during the course of 2015, the high bay that houses the chambers had minor problems with the building's chilled water supply and steam boiler. The chambers' temperature and humidity controls could not maintain the chamber set points when the building conditions became unstable. RTI's Facilities and Maintenance HVAC team quickly responded to fix these issues. RTI's Facilities and Maintenance coordinated with the Gravimetric Laboratory before performing any additional work on the high bay so as to have minimal effect on project work. In all cases, weighing was suspended pending repair and stabilization of the chamber environment. As an example, Figure 3-1 illustrates the environmental history stability of Chamber 2. This level of tracking was implemented in 2014 with an improved Vaisala HMT333 data logger. The figure shows 1-min temperature and relative humidity (RH) readings for the entire year. As seen, both temperature and RH were within specified limits except for periods of service, maintenance issues or planned special study as noted on the figure. No CSN filters were impacted during these periods.

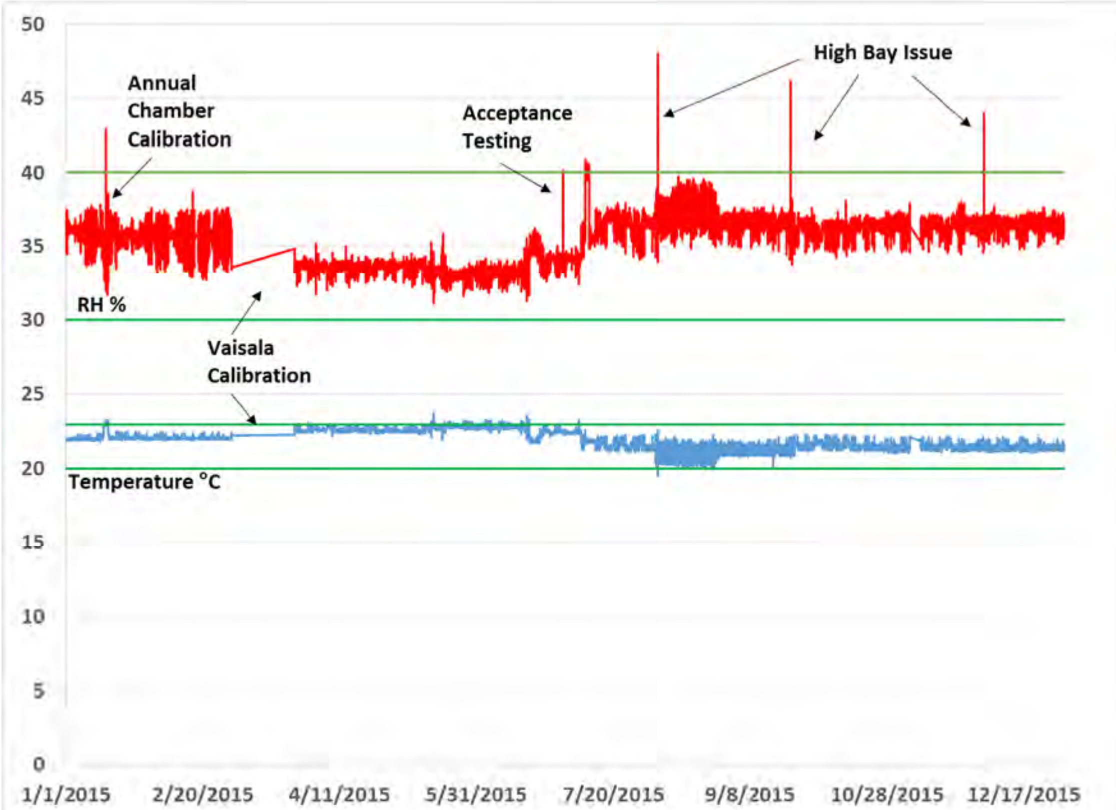


Figure 3-1. Gravimetric Laboratory Chamber 2 Environmental History during 2015

The gravimetric laboratory continues to monitor any instance of static electricity effects in the laboratory. The electrostatic devices employed by the Gravimetric Laboratory include grounding wrist straps, continuous wrist strap monitors, and anti-static laboratory coats.

An MTL AH-225 Precision Weighing System was used for all filter weighing in 2015 for the CSN. The robotic weighing system (RWS) provides greater precision and lower detection limits than are possible with manual weighing. The robotic autohandler is equipped with a highly sensitive Mettler Toledo microanalytical balance which has seven 1” Polonium strips attached to the inside of the balance chamber as well as an MTL-designed Faraday pan. The RWS is linked to a network computer for electronic data transmission to database or spreadsheet without hand entry of weighing data.

Working mass standards were removed from use during the year when due for re-verification by Henry Troemner LLC or Heusser Neweigh. Troemner and Heusser Neweigh are independent commercial mass metrology laboratories offering weight calibration services. Both weight calibration laboratories and processes are ISO/IEC 17025 compliant. The laboratory maintains several sets of working mass standards and substituted verified standards when standards were removed from service. The laboratory’s staggered (summer and winter) re-verification schedule ensures that verified weights are available when a working set is removed from routine use in the chambers. Verifications have already been scheduled for 2016.

3.1.2 Description of QC Checks Applied

Internal QC checks applied in the Gravimetric Laboratory are described in **Table 3-1**, along with results achieved during this reporting period. In addition to routine QC checks, the RWS provides the capability of performing a balance repeatability test prior to each weigh session. A Balance Repeatability test is performed by using an internal single weight that is weighed multiple times in a row. The Mettler XP6 balance that is installed in the RWS uses an internal calibration weight that is applied to verify the balance performance prior to performing a weigh session. As seen in Figure 3-2, the balance repeatability in 2015 was on average 0.55 µg with a standard deviation of 0.14 µg, with individual session tests ranging typically from 0.2 to 1.2 µg. Fourteen instances of 285 tests resulted in a repeatability above 0.8 µg, the suggested RWS upper limit. However, all but one of the data points were within the criteria specified in the QA Handbook, Volume II[4], which states that the accepted balance repeatability for ambient air filter weighing is 1.0 µg. The test was repeated after balance calibration for this date, and the repeatability test was then under the suggested RWS upper limit.

3.1.3 Summary of QC Results

QC tracking of Laboratory Blanks, Duplicates, and Standard Weights are completed for all filters weighed on the RWS. All results were included in this annual review and are presented here to provide a full representation of the laboratory performance. Internal QC values generated by the laboratory usually met the criteria shown in **Tables 3-1 and 3-2**; however, a small number of outliers were noted. Twenty five of the outlier laboratory blank weighings for five individual laboratory blank filters fell outside the warning limit. These weighings occurred over the course of the entire year; therefore, it is not believed to be a systematic issue of debris on Teflon. Although the balance test weights used in the laboratory are working standards and may fall out of tolerance due to wear (scratches or nicks during handling) or environmental contamination, the weights were quite stable in 2015. The laboratory's primary standards are maintained by RTI's Quality Systems personnel and are used to audit the microbalances and verify the working mass standards annually.

[4] Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program. Section PM2.5 Filter Based Local Conditions Validation Template. May 2013. http://www.epa.gov/ttnamti1/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf

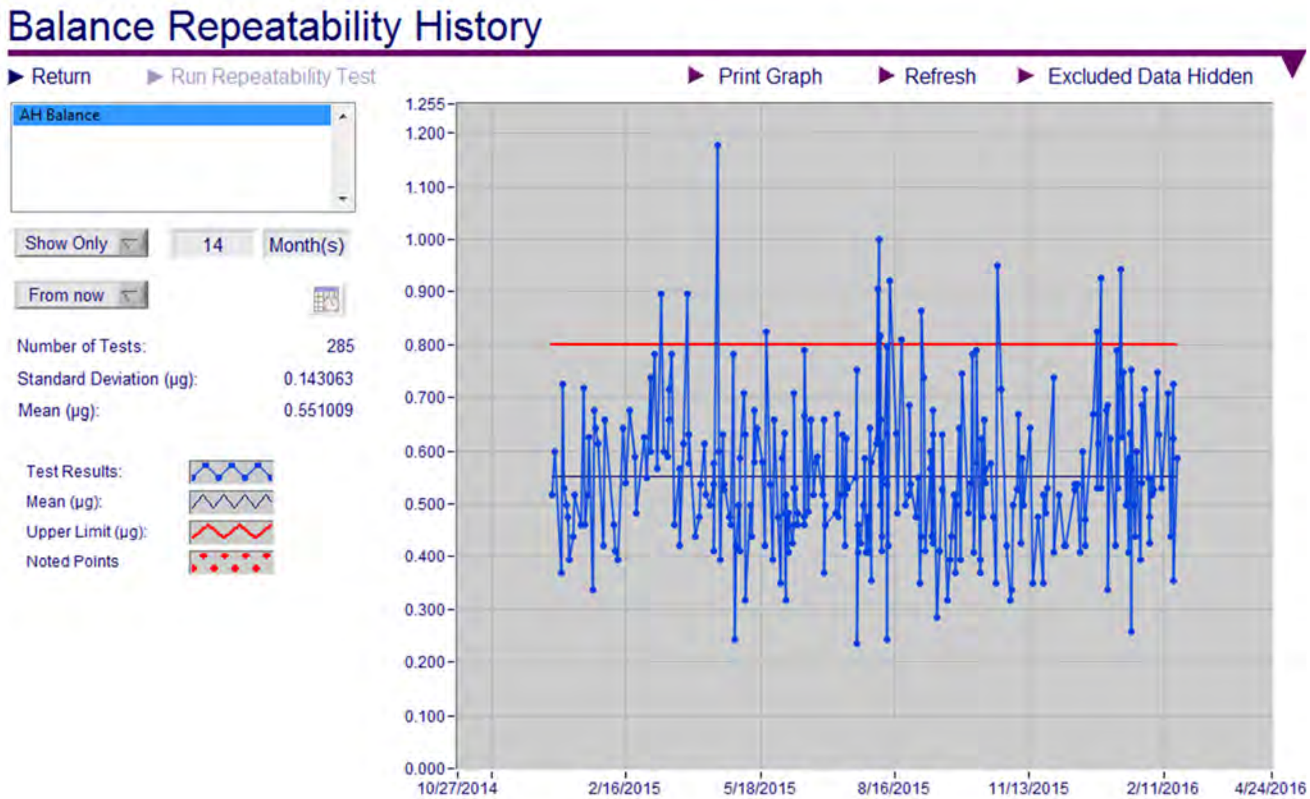


Figure 3-2. Gravimetric Laboratory RWS Balance Repeatability History during 2015 (Note: the y-axis units are in µg)

Table 3-1. Summary of QC Checks Applied and Results Achieved in the Gravimetric Laboratory

QC Check	Requirements	QC Checks Applied in RTI Laboratory	Average Value Determined by Lab	Comments
Working standard reference weights (mass reference standards)	Verified value ± 3 µg [Standard reference weights initially calibrated at purchase by Troemner. Verified by Troemner in 2015. Verified by the laboratory in conjunction with 2015 internal balance audit performed by RTI Quality Systems Program.	100-mg S/N 07012014100B 07/05/2014 Calibration: 99.961 mg ± 0.0025 Laboratory Tolerance Interval: 99.958 – 99.964 mg 06/26/2015 Calibration 99.961 mg ± 0.0025 Laboratory Tolerance Interval: 99.958 – 99.964 mg 100-mg S/N 07122013100J 12/05/2014 Calibration: : 99.9944 mg ± 0.0025 Laboratory Tolerance Interval: 99.991 – 99.997 mg	Mean = 99.961 mg Std Dev = 0.0010 for 302 weighings Mean = 99.961 mg Std Dev = 0.0010 for 142 weighings Mean = 99.994 mg Std Dev = 0.0013 for 317 weighings	Laboratory average falls within tolerance interval. One individual weighing fell 3 µg below lower limit. Laboratory average falls within tolerance interval. No weighing exceeded tolerance interval. Laboratory average falls within tolerance interval. One individual weighing fell 9 µg below lower limit. One individual weighings fell 3 µg above upper limit.

QC Check	Requirements	QC Checks Applied in RTI Laboratory	Average Value Determined by Lab	Comments
		12/05/2014 Calibration: Verified Mean Value of 12/05/2014 Calibration: 99.9904 mg Laboratory Tolerance Interval: 99.987 – 99.993 mg	Mean = 99.990 mg Std Dev = 0.0015 for 967 weighings	Laboratory average falls within tolerance interval. One individual weighing fell 14 µg below lower limit. One individual weighing fell 5 µg below lower limit. One individual weighing fell 4 µg below lower limit. Four individual weighings fell 3 µg below lower limit. Three individual weighings fell 2 µg below lower limit. Eight individual weighings fell 1 µg below lower limit. One individual weighing fell 7 µg above upper limit. Two individual weighings fell 3 µg above upper limit. One individual weighing fell 2 µg above upper limit. Seven individual weighings fell 1 µg above upper limit. Weight was removed from service on 11/26/2015.
		200-mg S/N 11252014200A 12/02/2014 Calibration: 199.9946 mg ± 0.0025 Laboratory Tolerance Interval: 199.992 – 199.998 mg : Verified Mean Value of 12/02/2014 Calibration: 199.994 mg Laboratory Tolerance Interval: 199.991 – 199.997 mg 200-mg S/N 11252014200B Verified Value of 12/02/2014 Calibration: 200.041 mg Laboratory Tolerance Interval: 200.038 – 200.044 mg	Mean = 199.993 mg Std Dev = 0.0008 for 186 weighings Mean = 199.994 mg Std Dev = 0.0015 for 865 weighings Mean = 200.040 mg Std Dev = 0.0015 for 401 weighings	Laboratory average falls within tolerance interval. No weighing exceeded tolerance interval. Laboratory average falls within tolerance interval. One individual weighing fell 4 µg above upper limit. Four individual weighings fell 3 µg above upper limit. Four individual weighing fell 2 µg above upper limit. Five individual weighings fell 1 µg above upper limit. Weight was removed from service on 11/26/2015. Laboratory average falls within tolerance interval. Four individual weighings fell 3 µg below lower limit. Eleven individual weighings fell 2 µg

QC Check	Requirements	QC Checks Applied in RTI Laboratory	Average Value Determined by Lab	Comments
				below lower limit. Four individual weighing fell 1 µg below lower limit. One individual weighing fell 3 µg above upper limit. Weight was removed from service on 6/10/2015.
		6/26/2015 Calibration: 200.0377 mg ± 0.0025 Laboratory Tolerance Interval: 200.035 – 200.041 mg	Mean = 200.038 mg Std Dev = 0.0009 for 141 weighings	Laboratory average falls within tolerance interval. No weighing exceeded tolerance interval.
		200-mg S/N 07012014200C 07/05/2014 Calibration: : 200.011 mg ± 0.0025 Laboratory Tolerance Interval: 200.008 – 200.014 mg	Mean = 200.010 mg Std Dev = 0.0010 for 302 weighings	Laboratory average falls within tolerance interval. No weighing exceeded tolerance interval.
Balance calibrations	Auto (internal) calibration daily	Daily	N/A	
	External calibration annually or as needed	All balances inspected and externally calibrated by Mettler Toledo on August 10, 2015, using NIST-traceable weight	N/A	Next inspection and external calibration scheduled for August 2016
Balance audits	Annually	Audits of all balances performed by RTI Quality Systems Program personnel on November 19, 2015, using Class S-1 NIST-traceable weights	N/A	Audit included environmental evaluation, level test, scale-clarity test, zero-adjustment test, off-center (corner load) test, precision test, and accuracy test; all balances performed satisfactorily.
RH/T monitoring devices calibrations	Annually	Chamber temperature and humidity sensors, temperature and humidity controllers, and process alarm control board (mother board) calibrated by Bahnson Environmental Specialties on January 14, 2015	N/A	Chamber sensors, controllers, and process boards are calibrated on-site annually by Environmental Specialties
		Chamber data loggers calibrated by Veriteq Data Logger Test and Calibration Services on June 3, 2015.	N/A	Next calibration due July 2016

QC Check	Requirements	QC Checks Applied in RTI Laboratory	Average Value Determined by Lab	Comments
Laboratory (Filter) blanks	Initial weight ± 15 µg	1,267 total replicate weighings of 164 individual laboratory blanks	Average difference between final and initial weight = 1.1 µg Std Dev = 5.2 Min wt change = -19 µg Max wt change = 26 µg	25 total replicate weighings of 5 individual laboratory blank filters (2.0% of the replicate weighings; 3.0% of the individual laboratory blanks) exceeded the 15 µg criterion.
Replicates	Initial weight ± 15 µg	5,706 individual filters were weighed as pre-sampling (tared) replicates 1,998 individual filters were weighed as post-sampling replicates	Average difference = -0.39 µg Average difference = -1.26 µg	2 replicate weighings (0.04% of the weighings) exceeded the 15 µg criterion on the first pass. Outliers would be reweighed in order to confirm a mass value with two weights within 10 µg of each other. 1 replicate weighings (0.05% of the weighings) exceeded the 15 µg criterion. Filter was reweighed to confirm value with two weights within 10 µg of each other.

Table 3-2 details the results of the lot stability tests performed to ensure filters are conditioned at least as long as the stability test indicate. All lot stability tests are performed on 12 filters, with 2 filters randomly selected from each of 6 randomly selected boxes. The filters are weighed until a 24-hour weight change < ± 5 µg is demonstrated or for 5 consecutive days.

Table 3-2. Summary of Lot Stability QC Results for the Gravimetric Laboratory

Lot	Received	24 Hours (mg)	48 Hours (mg)	72 Hours (mg)	96 Hours (mg)	120 Hours (mg)	Comment
203963	10/31/14	136.288	136.289	136.288	136.291	136.287	Weight changes fall within required range
		131.424	131.421	131.419	131.424	131.419	
		135.628	135.626	135.625	135.629	135.627	
		135.397	135.391	135.391	135.399	135.392	
		133.187	133.187	133.187	133.187	133.188	
		132.754	132.754	132.748	132.748	132.746	
		132.581	132.587	132.580	132.586	132.584	
		135.000	135.001	134.999	134.999	134.999	
		131.607	131.604	131.609	131.611	131.608	

		135.105	135.105	135.107	135.107	135.110	
		132.056	132.047	132.047	132.047	132.047	
		135.538	135.536	135.535	135.536	135.538	
7007283	5/19/15	137.296	137.296	137.295	137.293	137.296	Weight changes fall within required range
		136.414	136.414	136.415	136.413	136.413	
		134.190	134.192	134.187	134.185	134.186	
		138.488	138.483	138.481	138.480	138.482	
		139.550	139.548	139.546	139.546	139.546	
		136.228	136.228	136.228	136.229	136.228	
		138.604	138.605	138.605	138.605	138.604	
		139.200	139.195	139.194	139.197	139.194	
		138.680	138.683	138.682	138.682	138.681	
		139.480	139.477	139.478	139.479	139.479	
		135.049	135.047	135.047	135.047	135.045	
		135.686	135.684	135.686	135.688	135.686	

3.1.4 Determination of Uncertainties and Method Detection Limits

The Gravimetric Laboratory's MDL calculations are based on replicate weighings of a large number of filters from filter lot acceptance batches. Because determination of gravimetric mass requires two separate weighings, each of which contributes to the total uncertainty, a multiplicative factor of 1.414 is included to account for the fact that each filter must be weighed twice to generate the final net mass. MDLs reported to AQS are shown in Appendix A.

3.1.5 Audits, Performance Evaluations, Training, and Accreditations

Table 3-3 contains information regarding audits, performance evaluations (PEs), training, and accreditations for the Gravimetric Laboratory.

Table 3-3. Description of Audits, PEs, Training, and Accreditations

Type of Evaluation	Date	Administered By	Significant Findings/Comments
Internal Audit	January 30, 2015	RTI FRM Project QA Officer	The auditor noted that the gravimetric chambers were clean and that the log books and records were up to date.
Accreditation	Updated Scope of Accreditation Certificate issued July 1, 2015	National Environmental Laboratory Accreditation Program (NELAP)	RTI maintains accreditation in the National Environmental Laboratory Accreditation Program (NELAP) through the Louisiana Department of Environmental Quality (LDEQ) Louisiana Environmental Laboratory Accreditation Program (LELAP).
External Audit	March 5, 2015	National Environmental Laboratory	The Louisiana Department of Environmental Quality (LDEQ) Environmental Laboratory Accreditation Program (LELAP) sent contract auditors to conduct an onsite assessment of

Type of Evaluation	Date	Administered By	Significant Findings/Comments
		Accreditation Program (NELAP)	RTI's laboratory. The Corrective Action Plan from the assessment indicated only two minor findings for the Gravimetric Laboratory related to reviewing and updating the QAPP to include notifying the primary accreditation body in writing if the technical manager is out of the office for more than thirty-five (35) consecutive calendar days. The laboratory met the requirements for successful participation in proficiency test studies as outlined in LAC 33:I.4711 and in the 2009 TNI Standard.

3.2 Ions Analysis Laboratory

The Ion Analysis Laboratory used eight ion chromatograph systems to analyze approximately 24,971 filter samples for cations (sodium, potassium, and ammonium) and anions (nitrate and sulfate), excluding duplicates and replicates. The analyses were performed for the CSN program during the period January 1, 2015 through January 11, 2016. During this period, more than 1,977 QC samples were analyzed for anions and more than 1,673 QC samples were analyzed for cations.

3.2.1 Quality Issues and Corrective Actions

There were no quality issues or corrective actions during the reporting period.

3.2.2 Description of QC Checks Applied

Ion chromatographic analyses were performed by personnel from RTI's Ion Analysis Laboratory. Eight Dionex ion chromatographic systems were used for performance of the CSN measurements and are summarized in **Table 3-4**. Distribution of samples among these nine instruments was determined by laboratory workload and instrument availability.

Table 3-4. Description of Ion Chromatographic Systems Used for Analysis of $PM_{2.5}$ Filter Samples

System No.	Dionex IC Model	Ions Measured
A5	DX-600	SO_4^{2-}, NO_3^-
A6	ICS-2000	SO_4^{2-}, NO_3^-
A8	ICS-3000	SO_4^{2-}, NO_3^-
A9	ICS-3000	SO_4^{2-}, NO_3^-
C3	ICS-2000	Na^+, NH_4^+, K^+
C4	DX-600	Na^+, NH_4^+, K^+
C6	ICS-3000	Na^+, NH_4^+, K^+
C7	ICS-3000	Na^+, NH_4^+, K^+

QC checks for ion analyses are summarized in **Table 3-5**. For ion analyses, a daily multipoint calibration (7 points for cations; 8 points for anions) is performed over the range of 0.05 to 25.0 ppm for each ion (Na^+, NH_4^+, and K^+ for cation analyses; NO_3^- and SO_4^{2-} for anion analyses) followed by QC samples, including (1) an RTI-prepared QC sample containing concentrations of each ion in the mid- to high-range of the calibration standard concentrations; (2) an RTI-prepared QC sample containing concentrations of each ion at the lower end of the calibration standard concentrations; both of these solutions prepared from a commercially available NIST-traceable standard containing known concentrations of each ion. This standard is different from the commercial standards that are used to prepare calibration standards.

The regression parameters (a,b,c, and correlation coefficient, r) for the standard curve for each ion are compared with those obtained in the past. Typically, a correlation coefficient of 0.999 or better is obtained for each curve. If the correlation coefficient is < 0.999, the analyst carefully examines the individual chromatograms for the calibration standards and re-runs any standard that is judged to be out of line with respect to the other standards or to values (peak area and/or height) obtained in the past for the same standard. Possible causes for an invalid standard run include instrumental problems, such as incomplete sampling by the autosampler. If necessary, a complete recalibration is performed. When all individual calibrations have been judged acceptable, the results for the QC samples are carefully examined. If the observed value for any ion being measured differs by more than 10% from the known value, the problem is identified and corrected. Any field samples are then analyzed.

During an analysis run, a replicate sample, a QC sample, and a spiked sample are analyzed at the rate of at least one for every 20 field samples. Precision objectives for replicate analyses are ±5% for concentrations that equal or exceed 100 times the MDL, ±10% for concentrations at 10 times the MDL, and ±100% for concentrations at the MDL. MDLs for each instrument and analyte are listed in **Table 3-6**. The observed value for any ion being measured must be within 10% of the known value for the QC samples (**Table 3-7**), and ion recoveries for the spiked samples must be within 90 to 110% of the target value. If these acceptance criteria are not met for any QC or spiked sample, the problem is identified and corrected. All field samples analyzed since the last acceptable check sample are then re-analyzed.

Table 3-5. Ion Analysis of $PM_{2.5}$ Quality Control Checks

QC Check	Frequency	Requirements
Calibration Regression Parameters	Daily	r ≥0.999
• Initial QC Checks: • RTI prepared QC sample at mid- to high-range concentration • RTI prepared QC sample at lower-end concentration	Daily, immediately after calibration Daily, immediately after calibration	Measured concentrations within 10% of known values Measured concentrations within 10% of known values

Table 3-5. Ion Analysis of $PM_{2.5}$ Quality Control Checks (Cont.)

QC Check	Frequency	Requirements
• Periodic QC Checks:		
• Replicate sample †	Every 20 samples	RPD** = 5% at 100x MDL* RPD = 10% at 10x MDL* RPD = 100% at MDL*
• QC sample	Every 20 samples	Measured concentrations within 10% of known values
• Matrix spiked sample extract	Every 20 samples	Recoveries within 90 to 100% of target values
• Duplicates ‡	At least one per day	No limit set. This data gathered for comparability studies.
• Reagent Blanks	One reagent blank per reagent used (DI H_2O and/or eluent sample set extracted)	No limit set. This data gathered for comparability studies.

* MDL = Minimum Detectable Limit
** RPD = Relative Percent Difference
† Replicates indicate a specific sample is run twice on the same instrument.
‡ Duplicates indicate a specific sample is run on two different instruments.

Table 3-6. Minimum Detection Limit* for Each Instrument and Analyte

Instrument	Nitrate	Sulfate	Sodium	Ammonium	Potassium
A5	0.070	0.100	NA	NA	NA
A6	0.211	0.036	NA	NA	NA
A8	0.109	0.159	NA	NA	NA
A9	0.044	0.046	NA	NA	NA
C3	NA	NA	0.109	0.244	0.228
C4	NA	NA	0.290	0.160	0.134
C6	NA	NA	0.063	0.029	0.066
C7	NA	NA	0.105	0.007	0.019

* In µg/filter
NA – Not applicable

Table 3-7. Definitions and Specifications for QC Samples

Ion	Sample ID	Description/Specification
Anions	QC-CPI_LOW	0.6 ppm nitrate, 1.2 ppm sulfate
	QC-CPI_MED-HI	3.0 ppm nitrate, 6.0 ppm sulfate
	RTI-QC-HIGH	6.0 ppm nitrate, 12.0 ppm sulfate
	RTI-QC-MED	1.5 ppm nitrate, 3.0 ppm sulfate
Cations	GFS 0.4 PPM	0.4 ppm each sodium, ammonium, and potassium
	GFS 4.0 PPM	4.0 ppm each sodium, ammonium, and potassium
	RTI 2.0 PPM	2.0 ppm each sodium, ammonium, and potassium
	RTI 5.0 PPM	5.0 ppm each sodium, ammonium, and potassium

3.2.3 Summary of QC Results

QC checks performed included the following:

- Percent recovery for QC samples
- Relative percent difference (RPD) for replicates
- Spike recovery
- Reagent blank (elution solution and DI water).

Table 3-8 shows recoveries for all five analytes (nitrate, sulfate, sodium, ammonium, and potassium) with low, medium, and high QC for all of the instruments used for analysis.

Average recoveries for the QC samples ranged from 97.9 to 101.9% for the year. These recoveries are well within our acceptance range of 90 to 110%.

Table 3-9 shows percent recovery for all analyte spikes for the year. Average recoveries for the spikes ranged from 98.1 to 100.0%.

Table 3-10 presents filter blank (NQC BLANK) and reagent blank statistics for all analytes over the 12-month period. Ion loadings on cleaned nylon filters have to be less than 1 µg/filter to be accepted. Please note that beginning in May 2015, the ion analysis laboratory started using Pall pre-cleaned nylon filters. About 1% of the pre-cleaned filters from each filter batch is tested for acceptance.

3.2.4 Assessment of Between-instrument Comparability

Anion duplicates were analyzed on all anion instruments and cation duplicates were analyzed on all cation instruments. **Table 3-11** compares QC samples run on separate instruments on the same day. Each day, the anion instruments ran at least four QC samples. Similarly, the cation instruments ran at least four QC samples on each instrument each day. This Table shows that the difference between two instruments analyzing the same QC sample are typically within ±5% of the nominal concentration. The calculated average difference and standard deviation indicate a high level of between-instrument comparability.

Table 3-8. Average Percent Recovery for QC Samples

Analyte	Sample ID	Count	Conc. µg/mL	Avg % Rec *	SD	Min Conc. µg/mL	Max Conc. µg/mL
Nitrate	QC-CPI_LOW	539	0.6	97.9%	1.4%	0.566	0.631
	QC-CPI_MED-HI	538	3.0	100.4%	1.8%	2.798	3.199
	QC-HIGH	272	6.0	101.4%	1.5%	5.624	6.462
	QC-MED	628	1.5	99.5%	1.4%	1.420	1.589
Sulfate	QC-CPI_LOW	539	1.2	97.9%	1.4%	1.117	1.263
	QC-CPI_MED-HI	538	6.0	99.9%	1.6%	5.600	6.407
	QC-HIGH	272	12.0	100.3%	1.3%	11.628	12.783
	QC-MED	628	3.0	99.4%	1.0%	2.906	3.180
Sodium	GFS 0.4 PPM	559	0.4	99.3%	2.2%	0.366	0.437
	GFS 4.0 PPM	541	4.0	100.3%	1.2%	3.798	4.212
	RTI 2.0 PPM	297	2.0	100.0%	1.2%	1.892	2.056
	RTI 5.0 PPM	276	5.0	100.5%	1.0%	4.825	5.160
Ammonium	GFS 0.4 PPM	559	0.4	101.9%	2.0%	0.371	0.440
	GFS 4.0 PPM	541	4.0	100.0%	1.8%	3.699	4.363
	RTI 2.0 PPM	297	2.0	99.7%	1.3%	1.855	2.073
	RTI 5.0 PPM	276	5.0	100.3%	1.4%	4.652	5.239
Potassium	GFS 0.4 PPM	559	0.4	99.9%	2.9%	0.357	0.438
	GFS 4.0 PPM	541	4.0	99.2%	1.6%	3.678	4.319
	RTI 2.0 PPM	297	2.0	99.5%	1.2%	1.871	2.043
	RTI 5.0 PPM	276	5.0	99.4%	1.2%	4.773	5.193

* Acceptance criteria for average percent recovery is ± 10%.

Table 3-9. Average Percent Recovery for Spikes

Analyte	Avg Recovery *	StDev	Count	Min	Max
Nitrate	99.7%	1.6%	516	91.4%	105.4%
Sulfate	100.0%	1.6%	516	89.3%	106.0%
Sodium	99.1%	1.4%	516	92.7%	103.1%
Ammonium	98.7%	1.7%	516	91.5%	104.0%
Potassium	98.1%	2.2%	516	89.1%	103.5%

* Acceptance criteria for average percent recovery is ± 10%

Table 3-10. Filter Blank (NQC) and Reagent Blank Values (ppm) for all Analytes

Analyte	Type	Count	Avg (ppm)	StDev (ppm)	Min (ppm)	Max (ppm)
Nitrate	Reagent	540	0.001	0.003	0.000	0.022
	NQC	180	0.005	0.008	0.000	0.040
Sulfate	Reagent	540	0.000	0.003	0.000	0.034
	NQC	180	0.001	0.004	0.000	0.036
Sodium	Reagent	540	0.002	0.004	0.000	0.034
	NQC	196	0.002	0.003	0.000	0.017
Ammonium	Reagent	540	0.000	0.001	0.000	0.019
	NQC	196	0.000	0.001	0.000	0.005
Potassium	Reagent	540	0.001	0.003	0.000	0.023
	NQC	196	0.002	0.004	0.000	0.016

* NQC is a blank filter extract analyzed to test the acceptability of the cleaned nylon filter batches. One nylon filter is tested from each bottle used for filter cleaning. If the ion loading for any ion is >1 µg/filter or 0.040 ppm, the filters from that bottle are rejected.

** Reagent is a 25-ml aliquot of deionized water that has been pipetted into an extraction tube and carried through the same extraction procedure as the filters.

3.2.5 Determination of Uncertainties and MDLs

Detection limits are determined by analyzing the lowest calibration standard 7 times and the detection limit, in µg/mL (or ppm), is calculated as 3 times the standard deviation of the 7 measurements. This detection limit is multiplied by 25mL, which is the extraction volume for each filter, to determine the detection limits in µg/filter. These calculations are performed for each instrument so that the detection limits are reported by instrument. Since most samples are not analyzed in replicate, analytical uncertainties must be estimated based on historical data and scientific judgment. A simple formula of the form $U = a \cdot C + b$ is used, where U is the uncertainty and C is the concentration. The coefficients “a” and “b” vary by instrument and by analyte. The “b” coefficient is essentially MDL/3. The value for “a” is assumed to be 0.05 (5%). MDLs for the CSN Program are summarized in Appendix A and represent the maximum MDL by species shown in **Table 3-6**.

3.2.6 Audits, Performance Evaluations, Training, and Accreditations

No routine audits or performance evaluations were performed during 2015.

Table 3-11. Between-instrument Comparability: IC Systems A6 vs. A9 and C3 vs. C7

Analyte	QC Type	Conc., ppm	Count	Average * Difference (ppm)	Standard Deviation of Diff. (ppm)	Minimum Diff. ppm)	Maximum Diff. (ppm)
Nitrate	QC-CPI_LOW	1.2	192	-0.001	0.009	-0.021	0.028
	QC-CPI_MED-HI	6.0	198	0.007	0.028	-0.099	0.103
	QC-HIGH	12.0	50	0.060	0.053	-0.036	0.312
	QA-MED	3.0	265	-0.003	0.017	-0.059	0.053
Sulfate	QC-CPI_LOW	1.2	192	-0.003	0.013	-0.043	0.041
	QC-CPI_MED-HI	6.0	198	0.042	0.060	-0.206	0.279
	QC-HIGH	12.0	50	0.083	0.169	-0.443	0.702
	QC-MED	3.0	265	0.006	0.024	-0.103	0.073
Sodium	GFS 0.4 PPM	0.4	201	-0.040	0.358	-3.604	0.021
	GFS 4.0 PPM	4.0	185	0.012	0.040	-0.135	0.172
	RTI 2.0 PPM	2.0	53	-0.005	0.019	-0.083	0.029
	RTI 5.0 PPM	5.0	49	0.040	0.040	-0.071	0.149
Ammonium	GFS 0.4 PPM	0.4	201	-0.036	0.354	-3.558	0.034
	GFS 4.0 PPM	4.0	185	-0.003	0.061	-0.236	0.265
	RTI 2.0 PPM	2.0	53	-0.014	0.054	-0.373	0.025
	RTI 5.0 PPM	5.0	49	0.018	0.066	-0.193	0.232
Potassium	GFS 0.4 PPM	0.4	201	-0.037	0.353	-3.548	0.057
	GFS 4.0 PPM	4.0	185	-0.010	0.056	-0.228	0.234
	RTI 2.0 PPM	2.0	53	-0.011	0.022	-0.115	0.022
	RTI 5.0 PPM	5.0	49	0.010	0.065	-0.131	0.217

* Differences are calculated as Concentration of A6 – Concentration of A9 for Anions and Concentration of C3 – Concentration of C7 for Cations.

3.3 DRI Carbon Analysis Laboratory

The DRI Carbon Analysis Laboratory, as a subcontractor to RTI for EPA's Chemical Speciation Network (CSN), received and analyzed 12,949 quartz-fiber filters in batches 212 through 235 during the period January 1, 2015 through January 4, 2016. (Batch numbers refer to sets of quartz filters sent from RTI to DRI twice per month.) Of the 12,949 filters, 12,947 were actually part of the CSN sets and are reported here. DRI performed 15,993 analyses on these quartz-fiber filter samples in the batches using the IMPROVE_A method (Chow et al. 2007) and reported the results of those analyses to RTI. Nine DRI Model 2001 Thermal/Optical Carbon Analyzers (designated as units # 6 – 13, 16, and 20) were used for the CSN IMPROVE_A analyses.

3.3.1 Quality Issues and Corrective Actions

During the preparation of this report, DRI discovered that for two instruments, the temperature calibration parameters were not updated following the calibration process. A total of 521 analyses were affected, of which 56 analyses were replicate analyses and 38 voids. Analyses of replicates indicated that the values were within QC criteria. DRI reports that they have talked to the analysts involved, and have added following corrective actions: a) prior to start of temperature calibration, the analyst must record the calibration parameters in the analyzer log book; b) after the completion of the temperature calibration, the technician must restart the analyzer and record the new calibration parameters in the log book; c) compare the before and after parameters and confirm it is different; if not repeat the process; and d) after the completion of the semi-annual calibrations, the results will be reviewed by the DRI QA manager.

3.3.2 Description of QC Checks Applied

Samples received at the DRI Carbon Laboratory follow the chain-of-custody procedure specified in DRI SOP #2-111.4. Samples are analyzed following DRI SOP # 2-216r3, revised October 22, 2012. Quality control (QC) measures for the DRI carbon analysis are included in the SOP and summarized in **Table 3-12.** It specifies the frequency and standards required for the specified checks, along with the acceptance criteria and corrective actions.

Table 3-13 contains a list of quality-related data flags assigned to carbon analysis data and the number of filter analysis results assigned each flag by the DRI Carbon Laboratory during the reporting period. Out of 15,993 analyses, there were 1,684 runs flagged as invalid. In addition, 1,203 runs (including replicates and duplicates) were assigned blank or backup flags (i.e., backup filters, SHAL blanks, and 24-hour field blanks) based on information that RTI provided to DRI on January 31, 2016. Blanks are not identified in the data files that RTI sends to DRI at the time the filters are to be analyzed. A complete list of sample IDs for blank filters was provided to DRI in January 2016, after all the 2015 data had been processed and validated.

There were 1,362 runs with valid replicate (or duplicate) flags. In many cases, there was more than one flag for a sample run. The flag category “v” will generally result in additional runs. Only flags assigned in DRI Carbon Laboratory data reports to RTI are included in the table. RTI interprets the DRI Carbon Laboratory validation flags and assigns AQS null value codes or validity status codes when reporting the data to AQS.

Table 3-12. DRI Carbon Analysis Quality Control Measures

Requirement	Calibration Standard and Range	Calibration Frequency[b]	Acceptance Criteria	Corrective Action
Laboratory Blank Check	NA[a]	Beginning of analysis day.	<0.2 µg C/cm^2.	Check instrument and filter lots.
Leak Check	NA	Beginning of analysis day.	Oven pressure drops less than 0.52 mm Hg/s.	Locate leaks and fix.
Laser Performance Check	NA	Beginning of analysis day.	Transmittance >700 mV; Reflectance >1500 mV	Check laser and filter holder position.
Calibration Peak Area Check	NIST 5% CH_4/He gas standard; 20 µg C (Carle valve injection loop, 1000 µl).	Every analysis.	Counts >20,000 and 95-105% of average calibration peak area of the day.	Void analysis result and repeat analysis with second filter punch.
Auto-Calibration Check	NIST 5% CH_4/He gas standard; 20 µg C (Carle valve injection loop, 1000 µl).	Beginning of analysis day.	95-105% recovery and calibration peak area 90-110% of weekly average.	Troubleshoot and correct system before analyzing samples.
Manual Injection Calibration	NIST 5% CH_4/He or NIST 5% CO_2/He gas standards; 20 µg C (Certified gas-tight syringe, 1000 µl).	End of analysis day.	95-105% recovery and calibration peak area 90-110% of weekly average.	Troubleshoot and correct system before analyzing samples.
Sucrose Calibration Check	10µL of 1800 ppm C sucrose standard; 18 µg C.	Thrice per week (began March, 2009).	95-105% recovery and calibration peak area 90-110% of weekly average.	Troubleshoot and correct system before analyzing samples.
System Blank Check	NA	Once per week	<0.2 µg C/cm^2.	Check instrument and filter lots.
Multiple Point Calibrations	1800 ppm C Potassium hydrogen phthalate (KHP) and sucrose; NIST 5% CH_4/He, and NIST 5% CO_2/He gas standards; 9-36 µg C for KHP and sucrose; 2-30 µg C for CH_4 and CO_2.	Every six months or after major instrument repair.	All slopes ±5% of average.	Troubleshoot instrument and repeat calibration until results are within stated tolerances.
Sample Replicates (on the same or a different analyzer)	NA	Every 10 analyses.	±10% when OC and TC ≥10 µg C/cm^2 ±20% when EC ≥ 10µg C/cm^2 or <±1 µg/cm^2 when OC and TC <10 µg C/cm^2 <±2 µg/cm^2 when EC <10µg C/cm^2	Investigate instrument and sample anomalies and rerun replicate when difference is > ±10%.
Temperature Calibrations	Tempilaq® G (Tempil, Inc., South Plainfield, NJ, USA); Three replicates each of 121, 184, 253, 510, 704, and 816 °C.	Every six months, or whenever the thermocouple is replaced.	Linear relationship between thermocouple and Tempilaq® G values with R^2 >0.99.	Troubleshoot instrument and repeat calibration until results are within stated tolerances.
Oxygen Level in Helium Atmosphere (using GC/MS)[c]	Certified gas-tight syringe; 0-100 ppmv.	Every six months, or whenever leak is detected.	Less than the certified amount of He cylinder.	Replace the He cylinder and/or O_2 scrubber.
Interlaboratory comparisons	NA	Once per year.	NA	Review and verify procedures.
External systems audits	NA	Once every two to three years.	NA	Take action to correct any deficiencies noted in audit report.

[a] NA: Not Applicable.

[b] Calibration performed by carbon analyst, except for interlaboratory comparisons and external systems audits, which are conducted by the U.S. Environmental Protection Agency (EPA) National Air and Radiation Environmental Laboratory (NAREL).

[c] Gas chromatography/mass spectrometer (Model 5975, Agilent Technology, Palo Alto, CA, USA).

Table 3-13. DRI Carbon Laboratory-Assigned Data Flags

Validation Flag Category	Validation Flag Subcategory	Description	No. of Sample Runs
n		Foreign substance on sample	*1*
s		Suspect analysis result	*2*
v		Void (invalid) analysis result	*1684*
	v2	Replicate analysis failed acceptable limit	*82*
	v3	Potential contamination	*25*
	v5	Analytical instrument error	*1525*
	v6	Analyst error	*46*
	v7	Software malfunction	*6*
		Total (n, s, v)	**1687**
r		Replicate analysis	
	r1	First replicate analysis on same analyzer (duplicate)	*82*
	r5	Replicate on different analyzer	*1280*
		Total (r)	**1362**
		No n, s, v, or r flag	**12944**
		Total no. of original sample runs (incl. blank and replicate flags)	**15993**

3.3.3 Summary of QC Results

3.3.3.1 Blanks

Table 3-14 contains the number of instrument system blanks run during the reporting period and the average, standard deviation, maximum, minimum, and median measured blank values for the nine carbon aerosol analyzers used during the period. **Table 3-15** gives the laboratory blank statistics for each of the nine carbon analyzers used during the reporting period.

Laboratory blanks are run at the beginning of each analysis day for each operating analyzer. They may be rerun until the analyzer gives readings lower than 0.2 µg C/cm^2 of TC. However, they are also run to check instrument performance after repairs and adjustments. In addition, laboratory system blanks are assigned to the instrument and not to the project. The data in **Tables 3-14** and **3-15** include all laboratory and system blank data that were analyzed using the IMPROVE_A method for this and other projects. Blanks that did not meet the 0.2 µg C/cm^2 criteria were repeated until the system was clean. DRI uses the term "system blank" for a run that is made without a filter punch in the analyzer and "laboratory blank" for a run with a "clean" punch in the analyzer. DRI's SOP distinguishes laboratory blanks from system blanks.

Tables 3-16 through **3-18** give the analysis results by analyzer for the 24-hour field blanks, backup filters, and SHAL blanks, respectively. These blank filters were identified based upon the list of blank filters IDs provided to DRI by RTI on January 31, 2016. There were no trip blanks during 2015. SHAL blanks are pre-fired filters that have never been sent to the field, and are packaged and labeled by RTI to look like the other filters in a shipment. SHAL blanks are intended to diagnose the amount of carbon picked up during the filter storage, shipping, and handling processes at and between RTI and DRI. There is minimal instrument to instrument variation among the 24-hour field blanks or backup filters. Differences between means for each instrument were typically less than one standard deviation. Some differences between means may be due to the influence of high outliers, some of which may be sampled filters that were incorrectly identified as blanks. For SHAL and 24-hour field blanks, the number of filters with TC > 2.0 $\mu g/cm^2$ (excluding replicates) was 0 and 62, respectively. For all types of blanks, it was found that nearly all the TC was in OC, with negligible quantities of EC.

Table 3-19 summarizes the results for each type of blank combined over all analyzers. Average TC concentration was 0.35 ± 0.21 $\mu g/cm^2$ for the 116 SHAL blanks, 1.2 ± 1.1 $\mu g/cm^2$ for the 743 field blanks (after removing 5 filters with an RTI invalid code of 1), and 3.6 ± 1.9 $\mu g/cm^2$ for the 156 backup filters (after removing 3 filters with an RTI invalid code of 1).

3.3.3.2 Calibrations

Table 3-20 provides summary statistics for full multi-point calibrations by analyzer for the period during which the project samples were analyzed. The multipoint calibrations are performed semi-annually or whenever major repairs or changes are made to the instruments. Separate calibrations are performed using four different sources of carbon: methane (CH_4), carbon dioxide (CO_2), sucrose ($C_{12}H_{22}O_{11}$), and potassium hydrogen phthalate (KHP). The average of the regression slopes through zero is obtained and used for converting counts to µg C. The slope represents the response of the entire analyzer to generic carbon compounds and includes the efficiencies of the oxidation and methanator zones and sensitivity of the FID. The slope and correlation are for a least squares fit to all points in calibration curves using the four sources of carbon while the scatter is the standard deviation (root mean square of the variance) of the actual points from the fitted curve. Note that Analyzer 7 was only used for routine operation from August 24, 2015 on and Analyzer 13 was removed from routine operation June 5, 2015.

Table 3-14. DRI Carbon Laboratory System Blank Statistics for Each Analyzer

Analyzer			IMPROVE_A Parameter (units are µg C/cm^2)													
No.	No.*	Statistic*	O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
6	40	Mean	0.000	0.001	0.007	0.000	0.000	0.000	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.008
		StdDev	0.001	0.002	0.010	0.000	0.000	0.000	0.011	0.011	0.000	0.000	0.001	0.001	0.001	0.011
		Max	0.006	0.013	0.032	0.002	0.000	0.000	0.034	0.034	0.000	0.000	0.003	0.003	0.003	0.034
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.002
7	6	Mean	0.000	0.000	0.011	0.000	0.000	0.000	0.011	0.011	0.000	0.000	0.000	0.000	0.000	0.011
		StdDev	0.000	0.000	0.012	0.000	0.000	0.000	0.012	0.012	0.001	0.000	0.000	0.001	0.001	0.012
		Max	0.000	0.000	0.027	0.000	0.000	0.000	0.027	0.027	0.003	0.000	0.000	0.003	0.003	0.027
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.008	0.000	0.000	0.000	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.009
8	18	Mean	0.000	0.001	0.003	0.000	0.000	0.000	0.005	0.004	0.000	0.000	0.000	0.000	0.000	0.005
		StdDev	0.000	0.005	0.007	0.000	0.001	0.000	0.010	0.010	0.000	0.000	0.001	0.000	0.001	0.010
		Max	0.000	0.022	0.030	0.000	0.004	0.000	0.031	0.031	0.000	0.000	0.004	0.000	0.004	0.031
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	38	Mean	0.000	0.000	0.007	0.000	0.000	0.000	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.007
		StdDev	0.001	0.000	0.011	0.000	0.000	0.000	0.011	0.011	0.000	0.000	0.001	0.001	0.001	0.011
		Max	0.006	0.000	0.040	0.002	0.000	0.000	0.042	0.042	0.000	0.000	0.006	0.006	0.006	0.042
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	16	Mean	0.000	0.000	0.012	0.000	0.000	0.000	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.012
		StdDev	0.000	0.000	0.012	0.000	0.000	0.000	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.012
		Max	0.000	0.000	0.038	0.002	0.000	0.000	0.038	0.038	0.000	0.000	0.000	0.000	0.000	0.038
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.011	0.000	0.000	0.000	0.011	0.011	0.000	0.000	0.000	0.000	0.000	0.011
11	41	Mean	0.000	0.004	0.013	0.000	0.000	0.000	0.017	0.017	0.000	0.000	0.001	0.001	0.001	0.018
		StdDev	0.000	0.013	0.015	0.001	0.000	0.000	0.025	0.025	0.000	0.000	0.004	0.004	0.004	0.025
		Max	0.000	0.058	0.044	0.004	0.002	0.000	0.102	0.102	0.000	0.000	0.025	0.025	0.025	0.102
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.007	0.000	0.000	0.000	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.007
12	14	Mean	0.002	0.005	0.029	0.004	0.000	0.000	0.040	0.040	0.002	0.000	0.000	0.003	0.003	0.042
		StdDev	0.007	0.017	0.070	0.011	0.000	0.000	0.088	0.088	0.009	0.000	0.001	0.010	0.010	0.097
		Max	0.028	0.062	0.267	0.037	0.002	0.002	0.304	0.304	0.035	0.000	0.003	0.038	0.038	0.342
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.006	0.000	0.000	0.000	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.007
13	3	Mean	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.006	0.000	0.007	0.007	0.009
		StdDev	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.002	0.004	0.011	0.000	0.012	0.012	0.014
		Max	0.000	0.001	0.000	0.000	0.004	0.004	0.004	0.004	0.007	0.018	0.000	0.021	0.021	0.025
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001
20	7	Mean	0.000	0.000	0.003	0.000	0.001	0.000	0.004	0.003	0.001	0.000	0.000	0.000	0.001	0.004
		StdDev	0.000	0.000	0.008	0.000	0.002	0.000	0.010	0.008	0.002	0.000	0.000	0.000	0.002	0.010
		Max	0.000	0.000	0.022	0.000	0.005	0.000	0.028	0.022	0.005	0.000	0.000	0.000	0.005	0.028
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
All	183	Mean	0.000	0.002	0.010	0.000	0.000	0.000	0.012	0.012	0.000	0.000	0.000	0.001	0.001	0.013
		StdDev	0.002	0.008	0.023	0.003	0.001	0.000	0.029	0.029	0.003	0.001	0.002	0.004	0.004	0.031
		Max	0.028	0.062	0.267	0.037	0.005	0.004	0.304	0.304	0.035	0.018	0.025	0.038	0.038	0.342
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

* Excludes replicates

Table 3-15. DRI Carbon Laboratory Lab Blank Statistics for Each Analyzer

Analyzer No.	No.*	Statistic*	IMPROVE_A Parameter (units are µg C/cm^2)													
			O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
6	326	Mean	0.005	0.016	0.030	0.003	0.001	0.003	0.055	0.056	0.001	0.002	0.003	0.004	0.002	0.059
		StdDev	0.039	0.041	0.075	0.014	0.009	0.017	0.139	0.140	0.005	0.009	0.015	0.020	0.013	0.146
		Max	0.640	0.329	0.936	0.157	0.120	0.229	1.303	1.303	0.063	0.091	0.154	0.259	0.137	1.394
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.002	0.000	0.000	0.000	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.005
7	137	Mean	0.022	0.028	0.049	0.008	0.000	0.001	0.108	0.109	0.000	0.001	0.001	0.001	0.001	0.109
		StdDev	0.090	0.076	0.124	0.027	0.002	0.004	0.275	0.277	0.001	0.004	0.004	0.006	0.005	0.279
		Max	0.543	0.366	0.795	0.175	0.022	0.031	1.332	1.352	0.012	0.027	0.049	0.049	0.049	1.354
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.002
8	180	Mean	0.004	0.010	0.025	0.005	0.001	0.008	0.046	0.053	0.001	0.003	0.009	0.013	0.007	0.059
		StdDev	0.027	0.033	0.057	0.021	0.007	0.039	0.131	0.140	0.009	0.019	0.038	0.058	0.040	0.151
		Max	0.244	0.223	0.331	0.139	0.080	0.388	0.875	0.892	0.064	0.154	0.279	0.462	0.462	0.955
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
9	306	Mean	0.011	0.015	0.021	0.003	0.000	0.002	0.050	0.052	0.000	0.002	0.002	0.005	0.003	0.055
		StdDev	0.069	0.055	0.070	0.014	0.000	0.009	0.179	0.185	0.001	0.011	0.022	0.030	0.028	0.188
		Max	0.781	0.413	0.977	0.108	0.007	0.067	1.400	1.427	0.009	0.106	0.292	0.407	0.407	1.445
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
10	304	Mean	0.005	0.013	0.024	0.005	0.000	0.004	0.047	0.051	0.001	0.003	0.003	0.007	0.002	0.054
		StdDev	0.035	0.046	0.064	0.023	0.001	0.030	0.150	0.159	0.008	0.016	0.018	0.037	0.014	0.164
		Max	0.411	0.359	0.583	0.221	0.010	0.371	1.120	1.158	0.091	0.171	0.189	0.421	0.140	1.165
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
11	331	Mean	0.007	0.014	0.027	0.006	0.003	0.005	0.058	0.060	0.001	0.004	0.004	0.006	0.004	0.064
		StdDev	0.047	0.047	0.062	0.025	0.034	0.029	0.166	0.170	0.010	0.018	0.029	0.035	0.030	0.177
		Max	0.485	0.402	0.428	0.251	0.517	0.301	1.386	1.445	0.138	0.172	0.299	0.430	0.360	1.445
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.038	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	346	Mean	0.006	0.016	0.030	0.008	0.002	0.005	0.061	0.064	0.002	0.004	0.003	0.006	0.004	0.068
		StdDev	0.029	0.050	0.083	0.025	0.019	0.025	0.168	0.171	0.012	0.017	0.017	0.031	0.023	0.182
		Max	0.280	0.350	0.997	0.159	0.289	0.289	1.413	1.426	0.102	0.205	0.225	0.429	0.288	1.430
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.000	0.000	0.000	0.000	0.000	0.005
13	96	Mean	0.000	0.004	0.013	0.002	0.000	0.001	0.019	0.020	0.001	0.000	0.000	0.001	0.000	0.020
		StdDev	0.001	0.016	0.031	0.007	0.001	0.003	0.051	0.052	0.002	0.002	0.001	0.003	0.001	0.052
		Max	0.008	0.115	0.152	0.062	0.004	0.019	0.328	0.347	0.012	0.019	0.007	0.019	0.007	0.347
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
20	240	Mean	0.037	0.070	0.054	0.009	0.002	0.003	0.172	0.174	0.001	0.002	0.003	0.004	0.003	0.176
		StdDev	0.089	0.106	0.090	0.025	0.021	0.023	0.288	0.290	0.011	0.011	0.025	0.029	0.026	0.293
		Max	0.450	0.455	0.750	0.163	0.315	0.342	1.388	1.462	0.158	0.140	0.316	0.383	0.345	1.462
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.003	0.014	0.000	0.000	0.000	0.022	0.022	0.000	0.000	0.000	0.000	0.000	0.022
All	2266	Mean	0.010	0.021	0.030	0.006	0.001	0.004	0.068	0.070	0.001	0.003	0.003	0.006	0.003	0.074
		StdDev	0.054	0.060	0.076	0.022	0.017	0.024	0.186	0.190	0.008	0.014	0.022	0.032	0.024	0.195
		Max	0.781	0.455	0.997	0.251	0.517	0.388	1.413	1.462	0.158	0.205	0.316	0.462	0.462	1.462
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.038	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.003

* Excludes replicates

Table 3-16. DRI Carbon Analysis Statistics for 24-Hour Field Blanks

Analyzer No.	No.*	Statistic*	O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
			IMPROVE_A Parameter (units are µg C/cm²)													
6	97	Mean	0.121	0.308	0.644	0.051	0.009	0.008	1.133	1.132	0.011	0.001	0.000	0.003	0.005	1.137
		StdDev	0.097	0.173	0.655	0.095	0.049	0.041	0.907	0.901	0.052	0.005	0.001	0.010	0.017	0.911
		Max	0.401	1.190	6.109	0.792	0.394	0.364	8.485	8.454	0.426	0.038	0.009	0.073	0.119	8.516
		Min	0.000	0.086	0.159	0.000	0.000	0.000	0.315	0.315	0.000	0.000	0.000	0.000	0.000	0.315
		Median	0.116	0.269	0.515	0.028	0.000	0.000	0.979	0.979	0.000	0.000	0.000	0.000	0.000	0.979
7	18	Mean	0.109	0.253	0.506	0.018	0.000	0.002	0.886	0.888	0.001	0.001	0.000	0.002	0.000	0.888
		StdDev	0.107	0.085	0.206	0.047	0.000	0.006	0.282	0.286	0.004	0.005	0.000	0.006	0.000	0.286
		Max	0.337	0.429	1.064	0.196	0.000	0.023	1.671	1.694	0.017	0.023	0.001	0.023	0.001	1.694
		Min	0.000	0.138	0.198	0.000	0.000	0.000	0.578	0.578	0.000	0.000	0.000	0.000	0.000	0.578
		Median	0.096	0.253	0.450	0.000	0.000	0.000	0.894	0.902	0.000	0.000	0.000	0.000	0.000	0.902
8	58	Mean	0.158	0.247	0.570	0.051	0.026	0.050	1.052	1.076	0.059	0.009	0.001	0.043	0.019	1.096
		StdDev	0.099	0.232	0.276	0.166	0.183	0.282	0.840	0.936	0.361	0.041	0.005	0.219	0.120	1.046
		Max	0.524	1.846	1.676	1.257	1.394	2.143	6.697	7.446	2.753	0.303	0.037	1.662	0.914	8.359
		Min	0.000	0.060	0.204	0.000	0.000	0.000	0.426	0.448	0.000	0.000	0.000	0.000	0.000	0.448
		Median	0.140	0.198	0.477	0.008	0.000	0.000	0.859	0.860	0.000	0.000	0.000	0.000	0.000	0.866
9	142	Mean	0.101	0.308	0.660	0.062	0.044	0.057	1.176	1.189	0.074	0.007	0.000	0.037	0.024	1.213
		StdDev	0.157	0.289	0.532	0.222	0.260	0.336	1.282	1.350	0.485	0.040	0.000	0.263	0.196	1.508
		Max	1.205	2.674	3.734	2.240	2.719	3.433	12.150	12.863	5.372	0.348	0.002	3.001	2.288	15.150
		Min	0.000	0.000	0.143	0.000	0.000	0.000	0.143	0.143	0.000	0.000	0.000	0.000	0.000	0.143
		Median	0.068	0.234	0.511	0.000	0.000	0.000	0.858	0.858	0.000	0.000	0.000	0.000	0.000	0.858
10	139	Mean	0.140	0.291	0.553	0.043	0.004	0.016	1.031	1.043	0.017	0.004	0.000	0.016	0.004	1.048
		StdDev	0.138	0.174	0.342	0.093	0.050	0.083	0.629	0.664	0.083	0.019	0.002	0.058	0.020	0.674
		Max	1.247	1.220	2.467	0.659	0.592	0.837	4.505	4.750	0.844	0.176	0.016	0.428	0.183	4.933
		Min	0.000	0.042	0.110	0.000	0.000	0.000	0.152	0.152	0.000	0.000	0.000	0.000	0.000	0.152
		Median	0.128	0.266	0.446	0.003	0.000	0.000	0.856	0.856	0.000	0.000	0.000	0.000	0.000	0.856
11	129	Mean	0.114	0.337	0.748	0.094	0.026	0.029	1.230	1.253	0.057	0.010	0.000	0.041	0.038	1.361
		StdDev	0.138	0.247	0.551	0.243	0.144	0.170	0.875	0.951	0.335	0.050	0.004	0.290	0.244	1.279
		Max	1.149	2.094	4.590	2.344	1.561	1.770	6.687	7.124	2.994	0.518	0.047	3.014	2.531	12.187
		Min	0.000	0.000	0.143	0.000	0.000	0.000	0.310	0.310	0.000	0.000	0.000	0.000	0.000	0.143
		Median	0.089	0.286	0.607	0.028	0.000	0.000	1.064	1.066	0.000	0.000	0.000	0.000	0.000	1.091
12	96	Mean	0.139	0.312	0.693	0.074	0.012	0.035	1.230	1.253	0.061	0.015	0.001	0.064	0.041	1.294
		StdDev	0.111	0.218	0.444	0.151	0.108	0.179	0.875	0.951	0.323	0.074	0.005	0.303	0.228	1.147
		Max	0.723	1.794	2.753	0.986	1.060	1.497	6.687	7.124	2.773	0.686	0.043	2.399	1.961	9.085
		Min	0.000	0.061	0.176	0.000	0.000	0.000	0.310	0.310	0.000	0.000	0.000	0.000	0.000	0.310
		Median	0.120	0.277	0.573	0.024	0.000	0.000	1.064	1.066	0.000	0.000	0.000	0.000	0.000	1.066
13	16	Mean	0.215	0.231	0.613	0.057	0.010	0.037	1.126	1.153	0.030	0.010	0.000	0.030	0.003	1.156
		StdDev	0.108	0.105	0.484	0.131	0.041	0.085	0.707	0.765	0.063	0.028	0.000	0.079	0.012	0.765
		Max	0.550	0.500	2.137	0.514	0.162	0.317	2.989	3.307	0.208	0.109	0.000	0.317	0.046	3.307
		Min	0.112	0.064	0.242	0.000	0.000	0.000	0.418	0.418	0.000	0.000	0.000	0.000	0.000	0.418
		Median	0.196	0.218	0.515	0.000	0.000	0.000	0.945	0.956	0.000	0.000	0.000	0.000	0.000	0.956
20	48	Mean	0.144	0.295	0.531	0.036	0.003	0.007	1.009	1.013	0.003	0.010	0.000	0.010	0.006	1.019
		StdDev	0.175	0.128	0.298	0.060	0.015	0.040	0.505	0.500	0.015	0.041	0.002	0.043	0.023	0.513
		Max	1.181	0.683	1.603	0.245	0.096	0.275	2.559	2.536	0.096	0.267	0.015	0.275	0.115	2.606
		Min	0.000	0.057	0.187	0.000	0.000	0.000	0.308	0.308	0.000	0.000	0.000	0.000	0.000	0.308
		Median	0.120	0.271	0.446	0.002	0.000	0.000	0.922	0.926	0.000	0.000	0.000	0.000	0.000	0.926
All	743	Mean	0.128	0.302	0.637	0.060	0.019	0.030	1.147	1.158	0.042	0.007	0.000	0.031	0.020	1.177
		StdDev	0.134	0.220	0.481	0.169	0.147	0.197	0.933	0.978	0.300	0.042	0.003	0.210	0.160	1.098
		Max	1.247	2.674	6.109	2.344	2.719	3.433	12.150	12.863	5.372	0.686	0.047	3.014	2.531	15.150
		Min	0.000	0.000	0.110	0.000	0.000	0.000	0.143	0.143	0.000	0.000	0.000	0.000	0.000	0.143
		Median	0.116	0.260	0.517	0.007	0.000	0.000	0.930	0.930	0.000	0.000	0.000	0.000	0.000	0.930

* Excludes replicates and filters with RTI Invalid Code = 1

Table 3-17. DRI Carbon Analysis Statistics for Backup Filters

Analyzer			IMPROVE_A Parameter (units are µg C/cm^2)													
No.	No.*	Statistic*	O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
6	8	Mean	0.744	0.904	1.101	0.365	0.226	0.353	3.339	3.466	0.287	0.081	0.000	0.142	0.015	3.481
		StdDev	0.140	0.348	0.634	0.241	0.386	0.475	1.337	1.468	0.384	0.100	0.000	0.156	0.035	1.491
		Max	0.950	1.490	2.614	0.654	0.912	1.201	5.621	5.956	0.897	0.304	0.000	0.433	0.099	6.055
		Min	0.567	0.575	0.595	0.094	0.000	0.000	1.954	1.960	0.000	0.000	0.000	0.000	0.000	1.960
		Median	0.729	0.807	0.926	0.292	0.027	0.104	2.942	3.003	0.069	0.049	0.000	0.077	0.000	3.013
7	0	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		StdDev	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Max	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Min	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	32	Mean	0.672	0.830	1.082	0.328	0.237	0.294	3.149	3.206	0.260	0.068	0.001	0.092	0.035	3.241
		StdDev	0.425	0.466	0.464	0.306	0.459	0.496	1.784	1.827	0.390	0.121	0.006	0.174	0.162	1.895
		Max	2.233	1.875	2.641	1.265	1.604	1.722	7.399	7.399	1.281	0.441	0.037	0.902	0.902	8.300
		Min	0.006	0.174	0.390	0.000	0.000	0.000	0.570	0.570	0.000	0.000	0.000	0.000	0.000	0.570
		Median	0.646	0.685	0.953	0.227	0.000	0.042	2.537	2.584	0.066	0.000	0.000	0.017	0.000	2.584
9	50	Mean	0.350	1.088	1.240	0.388	0.303	0.303	3.367	3.368	0.266	0.070	0.000	0.034	0.034	3.402
		StdDev	0.220	0.571	0.682	0.287	0.477	0.473	1.893	1.885	0.392	0.111	0.000	0.090	0.086	1.910
		Max	1.140	2.328	3.752	1.171	1.855	1.864	8.410	8.249	1.610	0.405	0.000	0.615	0.586	8.418
		Min	0.007	0.000	0.089	0.000	0.000	0.000	0.141	0.141	0.000	0.000	0.000	0.000	0.000	0.141
		Median	0.346	1.098	1.135	0.331	0.062	0.085	3.172	3.172	0.080	0.003	0.000	0.007	0.009	3.172
10	36	Mean	0.965	1.003	1.076	0.323	0.186	0.345	3.554	3.713	0.276	0.070	0.000	0.160	0.001	3.714
		StdDev	0.480	0.478	0.528	0.213	0.406	0.518	1.534	1.657	0.415	0.111	0.000	0.152	0.006	1.656
		Max	2.713	2.451	2.796	0.787	1.431	1.864	6.517	6.758	1.517	0.395	0.001	0.497	0.038	6.758
		Min	0.046	0.155	0.296	0.000	0.000	0.000	0.497	0.500	0.000	0.000	0.000	0.000	0.000	0.500
		Median	0.929	0.937	0.976	0.262	0.000	0.129	3.321	3.380	0.099	0.020	0.000	0.123	0.000	3.380
11	10	Mean	0.524	0.946	1.759	0.454	0.526	0.465	4.209	4.147	0.388	0.139	0.006	0.007	0.068	4.216
		StdDev	0.417	0.674	1.650	0.359	0.538	0.520	2.532	2.419	0.433	0.186	0.018	0.019	0.177	2.536
		Max	1.432	1.886	6.270	1.065	1.320	1.320	8.895	8.337	1.175	0.569	0.058	0.059	0.569	8.906
		Min	0.000	0.135	0.468	0.000	0.000	0.000	0.604	0.604	0.000	0.000	0.000	0.000	0.000	0.604
		Median	0.414	1.085	1.284	0.455	0.440	0.260	4.621	4.603	0.254	0.074	0.000	0.000	0.005	4.651
12	15	Mean	0.625	0.941	1.513	0.446	0.283	0.455	3.808	3.980	0.481	0.072	0.001	0.270	0.098	4.077
		StdDev	0.325	0.412	0.699	0.429	0.517	0.717	1.856	2.028	0.891	0.075	0.002	0.456	0.290	2.249
		Max	1.332	1.651	3.325	1.623	1.685	2.266	8.267	8.848	3.196	0.204	0.005	1.719	1.138	9.986
		Min	0.244	0.442	0.741	0.017	0.000	0.000	1.752	1.752	0.000	0.000	0.000	0.000	0.000	1.752
		Median	0.568	0.951	1.281	0.299	0.000	0.110	3.701	3.807	0.081	0.068	0.000	0.088	0.005	3.859
13	5	Mean	0.890	1.171	1.232	0.614	0.634	0.829	4.541	4.737	0.716	0.129	0.000	0.211	0.016	4.753
		StdDev	0.073	0.341	0.354	0.392	0.585	0.649	1.515	1.610	0.589	0.103	0.000	0.141	0.024	1.628
		Max	1.014	1.621	1.622	1.100	1.170	1.341	6.426	6.699	1.270	0.268	0.000	0.368	0.053	6.727
		Min	0.827	0.737	0.798	0.179	0.000	0.010	2.748	2.758	0.010	0.000	0.000	0.010	0.000	2.758
		Median	0.881	1.149	1.280	0.501	0.933	1.249	4.463	4.600	1.039	0.099	0.000	0.240	0.000	4.600
All	156	Mean	0.633	0.985	1.222	0.376	0.282	0.355	3.498	3.572	0.311	0.077	0.001	0.107	0.033	3.605
		StdDev	0.424	0.508	0.716	0.299	0.467	0.524	1.798	1.848	0.475	0.115	0.006	0.201	0.134	1.903
		Max	2.713	2.451	6.270	1.623	1.855	2.266	8.895	8.848	3.196	0.569	0.058	1.719	1.138	9.986
		Min	0.000	0.000	0.089	0.000	0.000	0.000	0.141	0.141	0.000	0.000	0.000	0.000	0.000	0.141
		Median	0.567	0.953	1.033	0.293	0.000	0.102	3.211	3.240	0.084	0.013	0.000	0.034	0.000	3.271

* Excludes replicates and filters with RTI Invalid Code = 1

Table 3-18. DRI Carbon Analysis Statistics for SHAL Blanks

Analyzer			IMPROVE_A Parameter (units are µg C/cm^2)													
No.	No.*	Statistic*	O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
6	19	Mean	0.066	0.067	0.156	0.001	0.000	0.000	0.289	0.289	0.000	0.000	0.000	0.000	0.000	0.289
		StdDev	0.045	0.046	0.104	0.004	0.000	0.000	0.150	0.150	0.000	0.000	0.000	0.000	0.000	0.150
		Max	0.177	0.171	0.501	0.019	0.000	0.000	0.727	0.727	0.000	0.000	0.000	0.000	0.000	0.727
		Min	0.000	0.000	0.050	0.000	0.000	0.000	0.098	0.098	0.000	0.000	0.000	0.000	0.000	0.098
		Median	0.057	0.056	0.140	0.000	0.000	0.000	0.295	0.295	0.000	0.000	0.000	0.000	0.000	0.295
7	10	Mean	0.113	0.051	0.233	0.000	0.006	0.006	0.404	0.404	0.006	0.000	0.000	0.000	0.000	0.404
		StdDev	0.112	0.059	0.183	0.000	0.019	0.019	0.261	0.261	0.019	0.000	0.000	0.000	0.000	0.261
		Max	0.303	0.150	0.566	0.000	0.061	0.061	0.865	0.865	0.061	0.000	0.000	0.000	0.000	0.865
		Min	0.000	0.000	0.056	0.000	0.000	0.000	0.056	0.056	0.000	0.000	0.000	0.000	0.000	0.056
		Median	0.102	0.030	0.159	0.000	0.000	0.000	0.340	0.340	0.000	0.000	0.000	0.000	0.000	0.340
8	7	Mean	0.085	0.019	0.078	0.000	0.000	0.000	0.182	0.182	0.000	0.000	0.000	0.000	0.000	0.182
		StdDev	0.070	0.023	0.062	0.000	0.000	0.000	0.120	0.120	0.000	0.000	0.000	0.000	0.000	0.120
		Max	0.231	0.049	0.176	0.000	0.000	0.000	0.414	0.414	0.000	0.000	0.000	0.000	0.000	0.414
		Min	0.022	0.000	0.000	0.000	0.000	0.000	0.047	0.047	0.000	0.000	0.000	0.000	0.000	0.047
		Median	0.066	0.007	0.046	0.000	0.000	0.000	0.156	0.156	0.000	0.000	0.000	0.000	0.000	0.156
9	20	Mean	0.094	0.050	0.159	0.000	0.000	0.001	0.303	0.304	0.000	0.001	0.001	0.002	0.001	0.305
		StdDev	0.051	0.048	0.083	0.000	0.000	0.002	0.112	0.112	0.001	0.002	0.002	0.003	0.003	0.112
		Max	0.208	0.167	0.342	0.002	0.000	0.010	0.532	0.532	0.004	0.010	0.008	0.012	0.012	0.533
		Min	0.000	0.000	0.045	0.000	0.000	0.000	0.152	0.152	0.000	0.000	0.000	0.000	0.000	0.152
		Median	0.094	0.051	0.136	0.000	0.000	0.000	0.303	0.303	0.000	0.000	0.000	0.000	0.000	0.303
10	14	Mean	0.115	0.084	0.207	0.006	0.004	0.003	0.416	0.414	0.009	0.000	0.000	0.006	0.007	0.421
		StdDev	0.053	0.078	0.179	0.019	0.015	0.006	0.269	0.264	0.018	0.001	0.000	0.012	0.017	0.272
		Max	0.211	0.253	0.610	0.069	0.056	0.022	0.915	0.915	0.056	0.004	0.000	0.040	0.056	0.919
		Min	0.055	0.000	0.039	0.000	0.000	0.000	0.110	0.110	0.000	0.000	0.000	0.000	0.000	0.110
		Median	0.089	0.084	0.133	0.000	0.000	0.000	0.357	0.361	0.000	0.000	0.000	0.000	0.000	0.374
11	13	Mean	0.081	0.075	0.150	0.000	0.000	0.000	0.306	0.306	0.000	0.000	0.000	0.000	0.000	0.306
		StdDev	0.049	0.045	0.088	0.000	0.000	0.000	0.138	0.138	0.001	0.000	0.000	0.001	0.001	0.138
		Max	0.163	0.157	0.324	0.000	0.000	0.000	0.495	0.495	0.004	0.000	0.000	0.004	0.004	0.499
		Min	0.000	0.000	0.026	0.000	0.000	0.000	0.069	0.069	0.000	0.000	0.000	0.000	0.000	0.069
		Median	0.090	0.068	0.135	0.000	0.000	0.000	0.340	0.340	0.000	0.000	0.000	0.000	0.000	0.340
12	23	Mean	0.138	0.070	0.205	0.014	0.004	0.008	0.429	0.433	0.003	0.004	0.001	0.004	0.000	0.434
		StdDev	0.076	0.052	0.117	0.044	0.011	0.016	0.229	0.235	0.007	0.013	0.007	0.012	0.001	0.235
		Max	0.301	0.182	0.473	0.162	0.051	0.056	1.024	1.029	0.024	0.059	0.033	0.052	0.003	1.032
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.094	0.094	0.000	0.000	0.000	0.000	0.000	0.094
		Median	0.117	0.060	0.193	0.000	0.000	0.000	0.376	0.376	0.000	0.000	0.000	0.000	0.000	0.376
13	5	Mean	0.058	0.030	0.348	0.014	0.000	0.001	0.450	0.451	0.000	0.000	0.001	0.001	0.000	0.451
		StdDev	0.041	0.030	0.266	0.028	0.000	0.001	0.301	0.302	0.000	0.000	0.002	0.002	0.001	0.303
		Max	0.106	0.075	0.674	0.064	0.000	0.003	0.788	0.791	0.000	0.000	0.005	0.005	0.002	0.793
		Min	0.000	0.000	0.051	0.000	0.000	0.000	0.121	0.121	0.000	0.000	0.000	0.000	0.000	0.121
		Median	0.073	0.033	0.269	0.000	0.000	0.000	0.306	0.306	0.000	0.000	0.000	0.000	0.000	0.306
20	5	Mean	0.067	0.084	0.197	0.000	0.000	0.000	0.349	0.349	0.000	0.000	0.000	0.000	0.000	0.349
		StdDev	0.010	0.071	0.147	0.000	0.000	0.000	0.155	0.155	0.000	0.000	0.000	0.000	0.000	0.155
		Max	0.080	0.190	0.435	0.000	0.000	0.000	0.522	0.522	0.000	0.000	0.000	0.000	0.000	0.522
		Min	0.051	0.004	0.092	0.000	0.000	0.000	0.176	0.176	0.000	0.000	0.000	0.000	0.000	0.176
		Median	0.067	0.090	0.116	0.000	0.000	0.000	0.288	0.288	0.000	0.000	0.000	0.000	0.000	0.288
All	116	Mean	0.098	0.062	0.183	0.004	0.002	0.003	0.350	0.350	0.002	0.001	0.000	0.002	0.001	0.351
		StdDev	0.067	0.054	0.136	0.022	0.009	0.010	0.203	0.204	0.009	0.006	0.003	0.007	0.006	0.206
		Max	0.303	0.253	0.674	0.162	0.061	0.061	1.024	1.029	0.061	0.059	0.033	0.052	0.056	1.032
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.047	0.000	0.000	0.000	0.000	0.000	0.047
		Median	0.085	0.055	0.143	0.000	0.000	0.000	0.320	0.320	0.000	0.000	0.000	0.000	0.000	0.322

* Excludes replicates

Table 3-19. DRI Carbon Analysis Annual Statistics for CSN Blank Categories

Type of Blank	No.*	Statistic*	IMPROVE_A Parameter (units are µg C/cm^2)													
			O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
SHAL	116	Mean	0.098	0.062	0.183	0.004	0.002	0.003	0.350	0.350	0.002	0.001	0.000	0.002	0.001	0.351
		StdDev	0.067	0.054	0.136	0.022	0.009	0.010	0.203	0.204	0.009	0.006	0.003	0.007	0.006	0.206
		Max	0.303	0.253	0.674	0.162	0.061	0.061	1.024	1.029	0.061	0.059	0.033	0.052	0.056	1.032
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.047	0.000	0.000	0.000	0.000	0.000	0.047
		Median	0.085	0.055	0.143	0.000	0.000	0.000	0.320	0.320	0.000	0.000	0.000	0.000	0.000	0.322
		MDL	0.200	0.162	0.408	0.065	0.028	0.029	0.609	0.612	0.028	0.018	0.010	0.021	0.018	0.617
24-Hour Field	743	Mean	0.128	0.302	0.637	0.060	0.019	0.030	1.147	1.158	0.042	0.007	0.000	0.031	0.020	1.177
		StdDev	0.134	0.220	0.481	0.169	0.147	0.197	0.933	0.978	0.300	0.042	0.003	0.210	0.160	1.098
		Max	1.247	2.674	6.109	2.344	2.719	3.433	12.150	12.863	5.372	0.686	0.047	3.014	2.531	15.150
		Min	0.000	0.000	0.110	0.000	0.000	0.000	0.143	0.143	0.000	0.000	0.000	0.000	0.000	0.143
		Median	0.116	0.260	0.517	0.007	0.000	0.000	0.930	0.930	0.000	0.000	0.000	0.000	0.000	0.930
		LQL	0.402	0.659	1.443	0.506	0.440	0.590	2.798	2.934	0.899	0.126	0.009	0.631	0.481	3.293
Backup	156	Mean	0.633	0.985	1.222	0.376	0.282	0.355	3.498	3.572	0.311	0.077	0.001	0.107	0.033	3.605
		StdDev	0.424	0.508	0.716	0.299	0.467	0.524	1.798	1.848	0.475	0.115	0.006	0.201	0.134	1.903
		Max	2.713	2.451	6.270	1.623	1.855	2.266	8.895	8.848	3.196	0.569	0.058	1.719	1.138	9.986
		Min	0.000	0.000	0.089	0.000	0.000	0.000	0.141	0.141	0.000	0.000	0.000	0.000	0.000	0.141
		Median	0.567	0.953	1.033	0.293	0.000	0.102	3.211	3.240	0.084	0.013	0.000	0.034	0.000	3.271
		LQL	1.271	1.525	2.149	0.898	1.402	1.572	5.395	5.543	1.426	0.346	0.017	0.602	0.401	5.710

* Excludes replicates and filters with RTI Invalid Code = 1

Table 3-21 provides summary statistics for the multi-point temperature calibrations of each carbon analyzer. The temperature calibrations are performed every six months or after a major instrument repair. Criteria for an acceptable calibration are given in **Table 3-12**. In reviewing the temperature calibration data for this report, it was discovered that in two instances, the temperature calibration of Analyzer #7 on July 17, 2015 and Analyzer #11 on November 17, 2015, the correct parameters for the new temperature calibration curve were not uploaded to the instrument. For Analyzer #7, 331 analyses were affected, including 29 voids and 31 replicates, before new, correct parameters were entered. A comparison of the correct temperature calibration parameters indicated that the temperatures with the incorrect calibration parameters underestimated the correct temperature by about 1 °C at 140 °C and 5 °C at 840 °C. The review of the data also indicated 66 instances in which Analyzer #7 was either the first or second analyzer for a replicate pair. Of these 66 replicates, all passed the replicate analysis criteria given in **Table 3-24** for OC and EC. For Analyzer #11, 190 analyses were affected, including 9 voids and 25 replicates. A comparison using the correct parameters indicated that the temperatures with the incorrect calibration parameters underestimated the correct temperature by about 4 °C at 140 °C and 22 °C at 840 °C. The review of the data also indicated 31 instances in which Analyzer #11 was either the first or second analyzer for a replicate pair. Of these 31 replicates, all passed the replicate analysis criteria given in **Table 3-24** for OC and EC.

Table 3-22 provides a summary of the oxygen leak tests that are performed every six months or after major instrument repairs. The results are considered acceptable if the O_2 concentration is < 100 ppm. The O_2 contents were well below 100 ppm, in the range of 5-54 ppm. Note that in 2015, a more comprehensive four-point test procedure was used, producing higher and more realistic estimates of the uncertainty in the oxygen levels. The scheduled February 2016 tests were not completed in time for this report.

Table 3-20. DRI Multi-Point Calibration Statistics

Analyzer No.	Date	Slope	Correlation	Comment
6	09/22/14	21.05	0.9931	
	01/27/15	22.08	0.9960	
	04/01/15	22.37	0.9972	
	05/27/15	22.61	0.9966	
	10/23/15	22.41	0.9983	
	02/11/16	20.03	0.9761	
7	07/23/14	20.88	0.9880	Removed from service Oct '14
	08/10/15	20.92	0.9971	Returned to service Nov '15
	10/15/15	20.86	0.9964	
8	08/27/14	21.91	0.9969	
	03/12/15	21.70	0.9927	
	07/06/15	21.16	0.9922	
	08/28/15	22.04	0.9901	
	09/23/15	22.32	0.9965	
	10/07/15	22.48	0.9962	
9	12/31/14	20.73	0.9975	
	04/02/15	20.88	0.9961	
	06/17/15	20.92	0.9978	
	08/14/15	21.06	0.9978	
10	12/14/14	21.45	0.9815	Removed from service Dec '14
	10/30/15	22.07	0.9978	Returned to service Nov '15
11	12/23/14	27.25	0.9906	
	02/07/15	26.86	0.9977	
	03/15/15	25.93	0.9971	
	06/17/15	26.01	0.9894	
	08/19/15	21.46	0.9946	
	11/18/15	21.14	0.9944	
	02/08/16	21.78	0.9898	
12	12/01/14	24.00	0.9968	
	01/26/15	22.44	0.9987	
	03/04/15	21.92	0.9977	
	05/07/15	21.36	0.9941	
	08/14/15	22.29	0.9962	
13	12/01/14	24.00	0.9968	
	05/26/15	22.99	0.9977	Removed from service Jun '15
20	07/22/14	20.86	0.9840	
	01/29/15	21.10	0.9985	
	05/10/15	19.94	0.9945	
	11/11/15	20.77	0.9970	

Figure 3-3 shows the daily autocalibration response during the reporting period for each analyzer. Using the Carle valve, the methane standard is injected once in a He-only atmosphere, once in a He/O_2 atmosphere, and finally the normal calibration peak at the end. The three peaks should have similar peak areas if the catalysts are in good condition and the calibration factor holds. Thermogram peaks are compared and the calibration peak area is examined. Significant changes in calibration peak area counts are monitored and instruments are checked for performance against daily calibrations. Typical ranges fall between 20,000 and 32,000 counts. Sudden changes or atypical counts result in instrument maintenance. Details of instrument maintenance performed during the reporting period as a result of the autocalibration check are included in **Table 3-23**. In addition, metadata concerning QC measures and instrument maintenance are reported to RTI quarterly.

Table 3-21. DRI Multi-Point Temperature Calibration Statistics

			Analyzer No.								
Cal No.	**Param.**	**Units**	**6**	**7***	**8**	**9**	**10**	**11**	**12**	**13****	**20*****
1	Slope		1.0191	1.0193	1.0415	1.0078	1.0131	1.0120	1.0246	1.0244	1.0301
	Intercept	° C	9.5004	13.6290	-0.2807	14.9100	4.4679	8.3083	6.3087	3.7206	3.4665
	r^2		0.9973	0.9993	0.9969	0.9993	0.9997	0.9987	0.9995	0.9997	0.9978
	Date		Sep-14	Jul-14	Aug-14	Dec-14	Dec-14	Dec-14	Aug-14	Nov-14	Nov-14
2	Slope		1.0269	*1.0211*	1.0190	1.0133	1.0257	1.0211	1.0252	1.0202	1.0104
	Intercept	° C	-2.3949	*-1.2008*	7.7793	0.4643	9.2034	-1.2008	5.7896	8.3191	-0.4515
	r^2		0.9993	*0.9996*	0.9990	0.9989	0.9987	0.9996	0.9998	0.9992	0.9987
	Date		Mar-15	*Jul-15*	Feb-15	Apr-15	Apr-15	Jun-15	Feb-15	May-15	May-15
3	Slope		1.0227	1.0108	1.0236	1.0046	1.0444	*1.0211*	0.9885		1.0334
	Intercept	° C	6.8274	-4.9853	-7.1754	-1.3248	4.5738	*-1.2008*	9.3238		2.9435
	r^2		0.9996	0.9995	0.9997	0.9989	0.9994	*0.9996*	0.9998		0.9996
	Date		May-15	Oct-15	Aug-15	Aug-15	Oct-15	*Nov-15*	Aug-15		Nov-15
4	Slope		1.0261		1.0110			1.0544			
	Intercept	° C	10.8300		-3.6038			-7.6363			
	r^2		0.9996		0.9990			0.9978			
	Date		Oct-15		Sep-15			Feb-16			

* Analyzer #7 taken out of regular service 10/21/14 - 8/23/15.

** Analyzer #13 taken out of regular service 6/5/15.

*** Analyzer #20 taken out of regular service 8/31/14 - 8/10/15.

Italics indicate two instances (Analyzer #7 on 7/17/15 and Analyzer # 11 on 11/17/15) in which incorrect temperature calibration parameters were used. See text for details.

Table 3-22. DRI Oxygen Test Statistics

Analyzer No.	O_2 Statistics		August 2014 140 (°C)	August 2014 580 (°C)	February 2015 140 (°C)	February 2015 580 (°C)	August 2015 140 (°C)	August 2015 580 (°C)
6	Mean O_2	(ppm)	23.7	24.5	31.3	31.6	53.9	45.9
	Std Dev	(ppm)	0.7	0.6	4.1	3.9	12.3	8.0
7	Mean O_2	(ppm)	10.3	10.7	Not in Service		14.8	13.6
	Std Dev	(ppm)	0.8	0.5	Oct '14- Jan '15		5.7	5.7
8	Mean O_2	(ppm)	9.3	9.1	9.9	9.9	17.2	17.7
	Std Dev	(ppm)	0.5	0.6	4.0	3.6	7.9	8.0
9	Mean O_2	(ppm)	13.1	13.0	10.9	10.2	19.5	16.0
	Std Dev	(ppm)	0.6	0.5	3.6	4.1	6.4	8.1
10	Mean O_2	(ppm)	18.0	18.4	14.2	12.5	19.9	15.3
	Std Dev	(ppm)	1.0	1.0	3.3	4.0	5.8	8.0
11	Mean O_2	(ppm)	11.0	10.3	5.4	5.5	18.3	16.5
	Std Dev	(ppm)	0.6	0.6	3.8	4.0	5.7	7.4
12	Mean O_2	(ppm)	15.0	16.0	18.9	18.2	19.0	16.5
	Std Dev	(ppm)	0.5	0.7	3.6	3.9	6.0	6.8
13	Mean O_2	(ppm)	28.0	23.5	29.9	24.4	Not in Service	
	Std Dev	(ppm)	1.0	0.5	3.4	3.7	after Jun '15	
20	Mean O_2	(ppm)	9.7	9.2	16.5	16.1	19.6	10.6
	Std Dev	(ppm)	0.7	0.4	3.9	3.9	9.8	7.1

Note that the acceptance criteria is < 100 ppm O_2

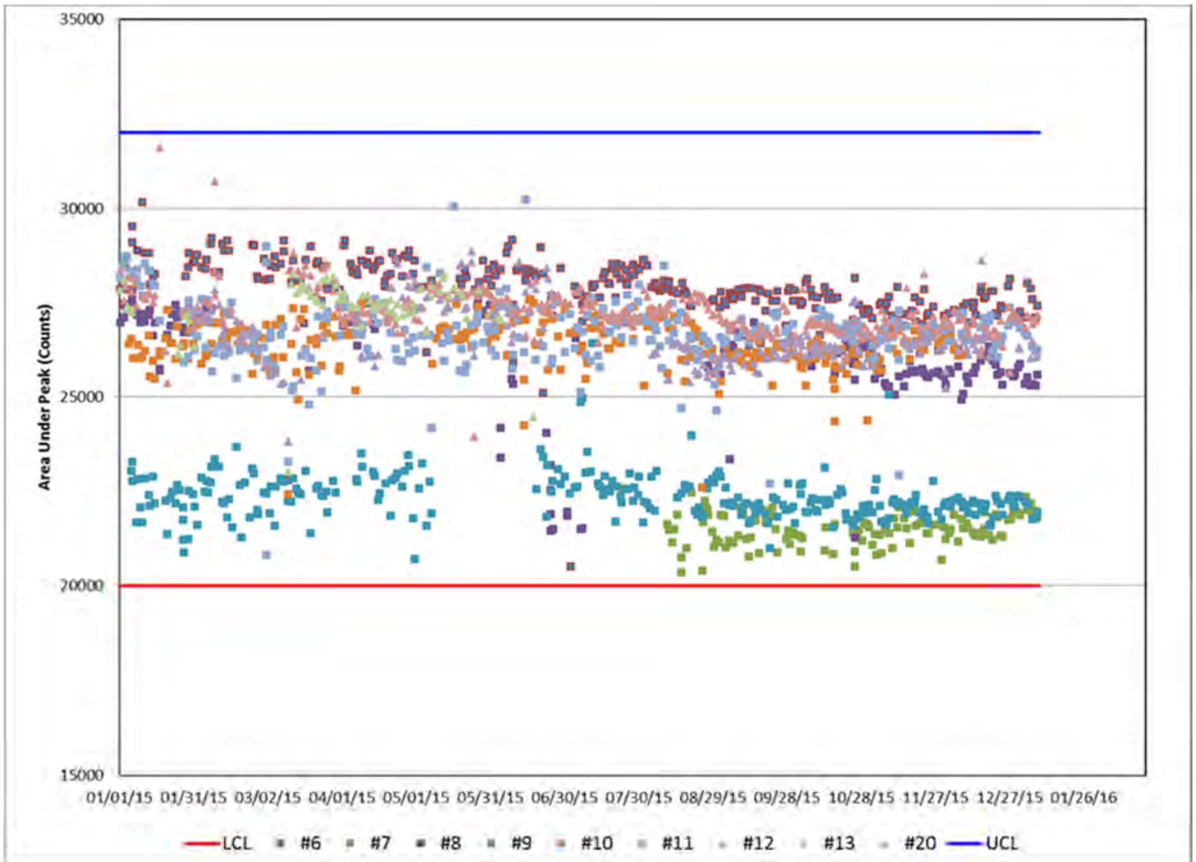


Figure 3-3. DRI Carbon Analyzer Daily AutoCalibration (cmdAutoCalibCheck) Response for Batches 212 thru 235 (01/01/15 – 01/07/16)

3.3.3.3 Replicate and Duplicate Analyses

Replicate analysis results are from two or more punches from the same sample run on different analyzers. Duplicate analysis results are from two punches from the same sample run on the same analyzer. **Table 3-24** gives the criteria and summary statistics for replicate and duplicate IMPROVE_A carbon analyses run on all analyzers for the CSN filter samples during the reporting period. A replicate or duplicate analysis was selected randomly from every group of 10 samples. A total of 1,362 replicate or duplicate analyses were analyzed during the reporting period. Of the 1,362 replicates or duplicates, 15 contained f, g, h, i, or n analysis flags for filter damaged or ripped, filter deposit damaged, filter holder assembly problem, inhomogeneous sample deposit, or foreign substance on sample, respectively. These were not included in the replicate and duplicate statistical summary. Of the 1,347 remaining, 79 were duplicate analyses and 1,268 were replicate analyses.

Table 3-23. Summary of Instrument Maintenance Performed as a Result of Autocalibration Peak Response

Analyzer No.	Date	Resolution
6	06/23/15 07/02/15	Cal peak low – repaired Carle valve screw and adjusted it Cal peak low – adjusted Carle valve
7	---	
8	01/05/15	Cal peak low – replaced ferrule to repair leak
9	01/02/15 05/26/15 06/18/15	Cal peak low – balanced flows Cal peak low – adjusted flows Cal peak low – changed FID and electrometer; adjusted Carle valve
10	06/05/15	Cal peak high – insulated electrometer
11	---	
12	---	
13	---	
20	---	

3.3.4 Assessment of Duplicate and Replicate Analyses

Duplicate and replicate analysis results for TC, OC, and EC agree well, with higher relative percent differences (RPD) at loading levels below 10.0 µg C/cm^2. Replicate analyses results are more variable than duplicate analyses, but remain within acceptable limits. The small size (25 mm) of the filter used in the IMPROVE_A carbon analysis method does not permit more than three punches (each ~0.5 cm^2) to be taken from the filter. Samples not meeting replicate criteria (i.e., for TC, OC, or EC < 10 µg C/cm^2, TC, OC < ± 1.0 µg C/cm^2 and EC < ± 2.0 µg C/cm^2; and for TC, OC or EC ≥ 10 µg C/cm^2, TC or OC < 10% RPD and EC < 20% RPD) are re-analyzed or examined for inhomogeneities.

Table 3-24. DRI Replicate Analysis Criteria and Statistics

			Replicates				Duplicates				
Range	Criteria	Statistic	No.	TC	OC	EC	No.	TC	OC	EC	Units
All		Count	1268				79				
TC, OC, & EC < 10 µg C/cm²	TC, OC < ±1.0 µg C/cm²	Count		128	237	1110		13	18	76	
	EC < ±2.0 µg C/cm²	No. Fail		0	1	5		0	0	1	
		%Fail		0.0	0.4	0.5		0.0	0.0	1.3	%
		Mean		0.285	0.330	0.401		0.234	0.291	0.289	µg C/cm²
		StdDev		0.228	0.252	0.391		0.184	0.231	0.389	µg C/cm²
		Max		0.872	1.026	2.557		0.812	0.823	2.551	µg C/cm²
		Min		0.002	0.001	0.000		0.085	0.024	0.000	µg C/cm²
		Median		0.230	0.279	0.281		0.216	0.222	0.192	µg C/cm²
TC, OC, & EC ≥ 10 µg C/cm²	TC, OC %RPD < 10%	Count		1140	1031	158		66	61	3	
	EC %RPD < 20%	No. Fail		0	0	0		0	0	0	
		%Fail		0.0	0.0	0.0		0.0	0.0	0.0	%
		Mean		1.73	2.16	4.07		1.54	1.50	3.22	%RPD
		StdDev		1.19	1.49	3.16		1.08	1.24	2.06	%RPD
		Max		5.22	6.84	15.80		4.85	5.28	4.53	%RPD
		Min		0.00	0.00	0.03		0.01	0.04	0.85	%RPD
		Median		1.57	1.93	3.51		1.35	1.15	4.27	%RPD

The SOP states that the criteria for EC < 10 µg C/cm² is ± 2.0 µg C/cm² to achieve consistency with EC criteria of an RPD < 20% for EC ≥ 10 µg C/cm². Instrument performance is also verified to eliminate instrument issues as a source of replicate or duplicate variation. Higher percent differences in OC and TC may be due to inhomogeneous sample deposits and organic artifacts. Higher percent differences in EC may be due to the low EC loadings on the samples.

3.3.5 Determination of MDLs and LQLs

Table 3-25 gives estimated minimum detection limits (MDLs) for IMPROVE_A parameters for batches 212 through 235 (~2015). The MDLs in **Table 3-25** are determined as three times the standard deviation of DRI system and lab blanks and RTI SHAL blanks, although only the DRI lab blanks are also used to determine Carbon Laboratory MDLs. The DRI system and lab blanks are used to assess instrument performance as used in multiple projects. In addition, the MDLs reported here for system and lab blanks tend to be less than the MDLs reported in the current SOP and RTI data reports. DRI routinely uses a more conservative set of MDLs than those in the SOP to be more conservative in its assessments of data quality.

Table 3-25 also gives estimated lower quantifiable limits (LQLs) for the IMPROVE_A parameters. These LQLs are determined as three times the standard deviation of the 24-hour field blanks and backup filters based on blank identification information provided to DRI after the analyses were completed.

Table 3-25. Estimated MDLs and LQLs for IMPROVE_A Parameters for Batches 212-235

Type of Blank	No.*	Statistic*	IMPROVE_A Parameter (units are µg C/cm^2)													
			O1TC	O2TC	O3TC	O4TC	OPTRC	OPTTC	OCTRC	OCTTC	E1TC	E2TC	E3TC	ECTRC	ECTTC	TCTC
System	183	Mean	0.000	0.002	0.010	0.000	0.000	0.000	0.012	0.012	0.000	0.000	0.000	0.001	0.001	0.013
		StdDev	0.002	0.008	0.023	0.003	0.001	0.000	0.029	0.029	0.003	0.001	0.002	0.004	0.004	0.031
		Max	0.028	0.062	0.267	0.037	0.005	0.004	0.304	0.304	0.035	0.018	0.025	0.038	0.038	0.342
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
		MDL	0.006	0.024	0.068	0.010	0.002	0.001	0.088	0.088	0.008	0.004	0.006	0.011	0.011	0.094
Lab	2266	Mean	0.010	0.021	0.030	0.006	0.001	0.004	0.068	0.070	0.001	0.003	0.003	0.006	0.003	0.074
		StdDev	0.054	0.060	0.076	0.022	0.017	0.024	0.186	0.190	0.008	0.014	0.022	0.032	0.024	0.195
		Max	0.781	0.455	0.997	0.251	0.517	0.388	1.413	1.462	0.158	0.205	0.316	0.462	0.462	1.462
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.038	0.000
		Median	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.003
		MDL	0.163	0.180	0.228	0.065	0.051	0.072	0.559	0.571	0.024	0.042	0.066	0.097	0.072	0.586
SHAL	116	Mean	0.098	0.062	0.183	0.004	0.002	0.003	0.350	0.182	0.002	0.001	0.000	0.002	0.001	0.351
		StdDev	0.067	0.054	0.136	0.022	0.009	0.010	0.203	0.295	0.009	0.006	0.003	0.007	0.006	0.206
		Max	0.303	0.253	0.674	0.162	0.061	0.061	1.024	0.370	0.061	0.059	0.033	0.052	0.056	1.032
		Min	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.188	0.000	0.000	0.000	0.000	0.000	0.047
		Median	0.085	0.055	0.143	0.000	0.000	0.000	0.320	0.122	0.000	0.000	0.000	0.000	0.000	0.322
		MDL	0.200	0.162	0.408	0.065	0.028	0.029	0.609	0.121	0.028	0.018	0.010	0.021	0.018	0.617
24-Hour Field	743	Mean	0.128	0.302	0.637	0.060	0.019	0.030	1.147	1.158	0.042	0.007	0.000	0.031	0.020	1.177
		StdDev	0.134	0.220	0.481	0.169	0.147	0.197	0.933	0.978	0.300	0.042	0.003	0.210	0.160	1.098
		Max	1.247	2.674	6.109	2.344	2.719	3.433	12.150	12.863	5.372	0.686	0.047	3.014	2.531	15.150
		Min	0.000	0.000	0.110	0.000	0.000	0.000	0.143	0.143	0.000	0.000	0.000	0.000	0.000	0.143
		Median	0.116	0.260	0.517	0.007	0.000	0.000	0.930	0.930	0.000	0.000	0.000	0.000	0.000	0.930
		LQL	0.402	0.659	1.443	0.506	0.440	0.590	2.798	2.934	0.899	0.126	0.009	0.631	0.481	3.293
Backup	156	Mean	0.633	0.985	1.222	0.376	0.282	0.355	3.498	3.572	0.311	0.077	0.001	0.107	0.033	3.605
		StdDev	0.424	0.508	0.716	0.299	0.467	0.524	1.798	1.848	0.475	0.115	0.006	0.201	0.134	1.903
		Max	2.713	2.451	6.270	1.623	1.855	2.266	8.895	8.848	3.196	0.569	0.058	1.719	1.138	9.986
		Min	0.000	0.000	0.089	0.000	0.000	0.000	0.141	0.141	0.000	0.000	0.000	0.000	0.000	0.141
		Median	0.567	0.953	1.033	0.293	0.000	0.102	3.211	3.240	0.084	0.013	0.000	0.034	0.000	3.271
		LQL	1.271	1.525	2.149	0.898	1.402	1.572	5.395	5.543	1.426	0.346	0.017	0.602	0.401	5.710

* Excludes replicates and filters with RTI Invalid Code =1

3.3.6 Audits, PEs, Training, and Accreditations

3.3.6.1 System Audits

EPA's National Air and Radiation Laboratory (NAREL) through 2013, has historically conducted periodic technical system audits (TSAs), performance evaluations (PEs), and inter-comparisons of $PM_{2.5}$ chemical speciation laboratories, including DRI. TSAs were conducted approximately once every three years and inter-comparisons/PEs approximately yearly. These audits, PEs, and inter-comparisons cover the analysis of mass by gravimetry, elements by x-ray fluorescence (XRF), ions by ion chromatography (IC), and carbon analysis by thermo-optical methods, including the (now phased out) STN thermo-optical transmittance (TOT) and thermo-optical reflectance methods of IMPROVE (also phased out) and IMPROVE_A. DRI has participated in these programs since 2005. The last TSA of DRI's Environmental Analysis Facility (EAF), including its Carbon Laboratory, was conducted on October 29, 2013, with a report issued March 6, 2014. The report found that "Good laboratory practices, good QC practices, and good record keeping are performed in the carbon analysis laboratory." NAREL TSA reports may be found at EPA's Ambient Monitoring Technical Information center (AMTIC) website at:

http://www.epa.gov/ttnamti1/pmspec.html

3.3.6.2 Performance Evaluations

Inter-laboratory comparisons and PEs, including DRI's Carbon Laboratory, have been conducted annually from 2005 through 2014. The latest report available is the 2013-2014 comparison report issued May 30, 2014. The most recent and previous year's reports are available at EPA's Ambient Monitoring Technical Information center (AMTIC) website at:

http://www.epa.gov/ttnamti1/pmspec.html

3.3.6.3 Accreditations

There are no accreditation programs specifically for thermal/optical carbon analysis, but since 2008, DRI has been accredited annually by the Texas Commission on Environmental Quality (TCEQ) through the National Environmental Laboratory Accreditation Program (NELAP) for the gravitational analysis of TSP, PM_{10}, and $PM_{2.5}$.

3.3.7 References

Chow, J.C.; Watson, J.G.; Chen, L.W.; Chang, M.C..; Robinson, N.F..; Dana Trimble; Steven Kohl. (2007). The IMPROVE_A Temperature Protocol for Thermal/Optical Carbon Analysis: Maintaining Consistency with a Long-Term Database. *J. Air Waste Manage. Assoc.*, **57**:1014-1023.

Chow, J.C.; Watson, J.G.; Robles, J.; Wang, X.L.; Chen, L.-W.A.; Trimble, D.L.; Kohl, S.D.; Tropp, R.J.; Fung, K.K. (2011). Quality assurance and quality control for thermal/optical analysis of aerosol samples for organic and elemental carbon. *Anal. Bioanal. Chem.*, **401**(10):3141-3152. DOI 10.1007/s00216-011-5103-3.

3.4 X-ray Fluorescence Laboratory

Three EDXRF instruments were used to analyze more than 12,250 filters for 33 elements during the period of January 1 through December 31, 2015.

3.4.1 RTI International XRF Laboratory

3.4.1.1 Quality Issues and Instrument Maintenance and Repairs

No repairs and maintenance were performed for XRF 1 and XRF 2. The following repair and maintenance was performed for XRF 4:

- 11/10/15 – Preventive maintenance performed, checked voltages, resolution, and stability

3.4.1.2 Description of QC Checks Applied

QC activities for the analysis of elements by EDXRF for the RTI XRF Laboratory, their frequency of application and control limits, comments, and corrective actions are shown in **Table 3-26**.

Table 3-26. QC Procedures Performed in RTI XRF Elemental Analysis Laboratory

QC Check	QC Frequency	Control Limits	Comments/ Corrective Action
Calibration	as needed	—	—
Calibration verification[1]	monthly	90–110% average recovery	check calibration
Instrument precision[2]	analyzed with each tray of samples (10 tray autosampler)	within 5% CV	check calibration and reanalysis of tray
Energy calibration	daily	—	—
Sample replicate precision (Relative Percent Difference [RPD])	5%	+/- 50 RPD	Reanalysis

1 Using NIST SRM
2 Micromatter QC

3.4.1.3 Summary of QC Results

Precision was monitored by the reproducibility of the measurements of the multi-element Micromatter QC sample at a certified concentration of 5-10 µg/cm^2. Please note that this concentration refers to the loading of element or compound used in the standard and not necessarily each individual element. The QC sample has six selected elements and is analyzed with each tray of samples. Comparison of the element's replicate values gives the measure of reproducibility or precision. The data used to monitor precision are presented in **Tables 3-27 through 3-29**. The percent coefficient of variation (%CV) for the average of all data for each of the six elements ranged between 0.22 and 0.53% for XRF 1, between 0.29 and 0.73% for XRF 2, and between 0.22 and 0.56% for XRF 4, indicating excellent precision.

Table 3-27. Summary of RTI XRF 1 Laboratory QC Precision Data, µg/cm^2, 1/1/2015 through 12/31/2015

Element	n	Min	Max	Average	Std Dev	%CV	Slope (%/year)
Si	517	4.94	5.06	5.00	0.0266	0.53	-0.150
Ti	517	6.75	6.84	6.80	0.0198	0.29	-0.094
Fe	517	6.89	7.00	6.95	0.0205	0.29	0.018
Cd	517	5.49	5.62	5.55	0.0263	0.47	0.210
Se	517	3.92	4.03	3.99	0.0159	0.40	-0.184
Pb	517	9.06	9.22	9.12	0.0200	0.22	-0.037

Table 3-28. Summary of RTI XRF 2 Laboratory QC Precision Data, μg/cm², 1/1/2015 through 12/31/2015

Element	N	Min	Max	Average	Std Dev	%CV	Slope (%/year)
Si	548	5.15	5.30	5.24	0.0278	0.53	0.578
Ti	548	8.58	8.73	8.64	0.0251	0.29	0.230
Fe	548	7.14	7.25	7.20	0.0216	0.30	0.263
Cd	548	4.35	4.47	4.41	0.0273	0.62	0.243
Se	548	2.94	3.07	3.00	0.0220	0.73	0.191
Pb	548	7.76	7.97	7.89	0.0351	0.45	-0.049

Table 3-29. Summary of RTI XRF 4 Laboratory QC Precision Data, μg/cm², 1/1/2015 through 12/31/2015

Element	n	Min	Max	Average	Std Dev	%CV	Slope (%/year)
Si	419	4.55	4.69	4.64	0.0258	0.56	0.139
Ti	419	5.94	6.05	5.99	0.0245	0.41	-0.112
Fe	419	6.59	6.69	6.64	0.0224	0.34	0.192
Cd	419	5.54	5.70	5.59	0.0222	0.40	0.086
Se	419	3.75	3.86	3.80	0.0194	0.51	-0.435
Pb	419	8.97	9.09	9.02	0.0196	0.22	-0.050

n = number of observations
Min = minimum value observed
Max = maximum value observed
Std Dev = standard deviation
%CV = percent coefficient variation ((Std Dev/Average)*100)

Recovery or system accuracy was determined by the analysis of four different NIST Standard Reference Material (SRM) filters (SRM 2783) each month. Recovery is calculated by comparisons of measured and expected values. **Tables 3-30 through 3-32** show recovery for 8 elements of the 33 elements normally measured. The slope refers to the regression slope through the data points (n=48) for the whole year. The average recovery values for all the elements ranged between 90 and 110% for XRF 1; between 90 and 113% for XRF 2; and between 90 to 113% for XRF 4. Note that every month, 33 elements of the Micromatter calibration standards are analyzed as unknowns to verify calibration.

Table 3-30. Percent Recovery Determined from Analysis of NIST SRM 2783 for RTI XRF 1, 1/1/2015 through 12/31/2015 (n=48)

Element	Min	Max	Average	Std Dev	%CV	Slope (%/year)
Al	92	102	98	0.0505	2.22	-6.161
K	90	96	92	0.0075	1.53	-0.240
Ca	91	102	97	0.0286	2.24	-3.101
Mn	90	104	97	0.0012	3.85	-0.036
Fe	90	98	94	0.0403	1.50	-5.157
Cu	90	101	93	0.0010	2.64	0.048
Zn	94	110	102	0.0091	4.99	-0.302
Pb	90	107	98	0.0015	4.88	-0.067

Table 3-31. Percent Recovery Determined from Analysis of NIST SRM 2783 for RTI XRF 2, 1/1/2015 through 12/31/2015 (n=48)

Element	Min	Max	Average	Std Dev	%CV	Slope (%/year)
Al	93	107	99	0.0768	3.36	-1.502
K	90	95	91	0.0069	1.43	-0.851
Ca	90	99	94	0.0278	2.24	-0.911
Mn	91	107	97	0.0016	4.98	-0.067
Fe	90	98	92	0.0542	2.06	-6.188
Cu	90	104	94	0.0013	3.52	-0.157
Zn	93	113	104	0.0096	5.15	-0.363
Pb	90	109	95	0.0012	3.81	-0.027

Table 3-32. Percent Recovery Determined from Analysis of NIST SRM 2783 for RTI XRF 4, 1/1/2015 through 12/31/2015 (n=48)

Element	Min	Max	Average	Std Dev	%CV	Slope (%/year)
Al	90	97	95	0.0427	1.95	-5.750
K	90	92	91	0.0047	0.99	0.257
Ca	90	104	97	0.0356	2.79	-5.433
Mn	90	108	100	0.0016	4.89	-0.144
Fe	90	96	94	0.0375	1.40	-3.897
Cu	90	103	95	0.0014	3.57	0.031
Zn	95	109	103	0.0086	4.64	-0.419
Pb	90	113	101	0.0019	5.91	-0.077

Replicates were analyzed at a frequency of at least 5% of the number of filters analyzed in the RTI XRF Laboratory. Six elements were selected for comparison through regression analysis. **Table 3-33** shows the correlation coefficients and average RPDs for the replicate analysis. The correlation coefficients for XRF 1 range from 0.9987 to 0.9999, the correlation coefficients for XRF 2 range from 0.9990 to 0.9999, and the correlation coefficients for XRF 4 range from 0.9994 to 0.9999 indicating acceptable replication with all four instruments. Also, for the six elements, the average RPD was within ±2% on XRF 1 and XRF 4, within ±3% for XRF 2.

Table 3-33. Summary of Replicate Results for XRF 1, XRF 2, and XRF 4

Element	n	Correlation Coefficient	Average RPD
XRF 1			
Si	336	0.9987	-0.53
S	336	0.9987	-0.36
K	336	0.9999	-0.42
Ca	336	0.9995	-1.29
Fe	336	0.9999	0.19
Zn	336	0.9995	1.83
XRF 2			
Si	330	0.9997	2.81
S	330	0.9998	0.11
K	330	0.9999	0.23
Ca	330	0.9999	-0.68
Fe	330	0.9999	-0.10
Zn	330	0.9990	0.51
XRF 4			
Si	262	0.9995	0.43
S	262	0.9998	0.15
K	262	0.9999	-0.24
Ca	262	0.9998	-1.09
Fe	262	0.9999	-0.06
Zn	262	0.9994	-0.87

3.4.1.4 Determination of Uncertainties and MDLs

MDLs are determined periodically by obtaining data from the analysis of 10 laboratory blanks. The MDLs are calculated as three times the average counting uncertainty for each element. This is equivalent to a “3-sigma” MDL; data users should be careful to know what multiple has been used in establishing the MDL when comparing values reported by different environmental laboratories, since some laboratories may report 1-sigma, 2-sigma, or 2.5-sigma detection limits. The network-wide maximum of the calculated MDLs based on XRF uncertainty from XRF 1, XRF 2, and XRF 4 are presented in Appendix A.

Instrument counting uncertainties for each analytical result are automatically calculated by the Thermo WinTrace software, except when the concentration value is zero. The instrument software does not calculate uncertainty values when the peak counts, and hence the concentrations are zero (i.e., peak area ≤ background area). In such cases where the measured result is zero, an uncertainty calculation is performed during the import process into the RTI XRF database, using the following formula[5] (Watson, 2003):

Counting uncertainty = slope * A * sqrt (3 * sqrt (B * t) + B * t) / t

Where

A = scaling factor
B = background counts (cps) is incorporated during the importing of the data into the RTI XRF database
t = livetime
Slope = element-specific instrument calibration slope

The instrument-reported (or calculated, when counts are zero) uncertainties are then combined with the attenuation uncertainty, calibration uncertainty and field-sampling and handling uncertainty to arrive at a total uncertainty. This is performed to harmonize the uncertainties between instruments and laboratories using consistent uncertainty estimation methods as reported in Gutknecht et al. (2006; 2010)[6,7]. For $PM_{2.5}$, the attenuation uncertainty is estimated using the homogeneous layer model for all elements. The calibration uncertainty is assumed to be 5%, and is consistent with the estimated uncertainty of the calibration standards. The field sampling and handling uncertainty accounts for the uncertainties in the flowrate, filter deposit area, and losses and/or contamination during shipping and handling steps. Based on analysis of prior data, the field sampling and handling uncertainty is assumed to be 5%. The total harmonized uncertainty is then calculated as:

Total Harmonized XRF Uncertainty

$$U_i = \sqrt{\delta^2_{i,\text{attenuation}} + \delta^2_{i,\text{calibration}} + \delta^2_{i,\text{field-sampling \& handling}} + \delta^2_{i,\text{instrument peak counts}}}$$

Where

U_i = total harmonized XRF Uncertainty for element i
δ_i = uncertainty for each component for element i

[5] Watson, Wayne, ThermoFisher Scientific (Previously Thermo NORAN), Personal Communication to Ms. Andrea McWilliams, June 20, 2003

[6] Gutknecht, W. F., J. B. Flanagan, and A. McWilliams, "Harmonization of Interlaboratory X-ray Fluorescence Measurement Uncertainties." RTI/0208858/TO2/04D, August 4, 2006. Available online at http://epa.gov/ttn/amtic/files/ambient/pm25/spec/xrfdet.pdf

[7] Gutknecht, W.F., J.B. Flanagan, A. McWilliams, R.K.M. Jayanty, et al. 2010. Harmonization of Uncertainties of X-Ray Fluorescence Data from $PM_{2.5}$ Air Filter Analysis. *Journal of the Air and Waste Management Association*, 60, pp. 184-194.

3.4.1.5 Audits, PEs, Training, and Accreditations

In 2015, the EPA did not conduct any audits or conduct an inter-laboratory study for the CSN program.

3.5 Denuder Refurbishment Laboratory

The purpose of the laboratory is to clean and refurbish the coatings on acid-gas-removing denuders used in samplers within the CSN operated by EPA and various state, local, and tribal agencies, which utilize the RTI/EPA contract. The laboratory also prepares denuders for capture of either acidic or basic gases from the atmosphere and subsequent extraction and analysis to quantify the concentrations of these gases. The laboratory follows these SOPs, which are kept on file in the laboratory:

- Standard Operating Procedures for Coating [MetOne] Aluminum Honeycomb Denuders with Magnesium Oxide
- Standard Operating Procedure for Coating and Extracting Annular Denuders with Sodium Carbonate [IMPROVE]
- Standard Operating Procedure for Coating and Extracting Denuders for Capture of Ammonia and Its Measurement [specific for use with glass honeycomb denuder] [MetOne]
- Standard Operating Procedure for Coating and Extracting Compact Parallel-Plate Denuders for Capture of Ammonia [specific for use with the parallel plate denuder for the MetOne SASS sampler]

3.5.1 Quality Issues and Corrective Actions

Mr. Jim O'Rourke coordinates the Denuder Refurbishment Laboratory. He reviews the denuder refurbishment SOPs to ensure procedures are clearly stated and all processes are up to date. Personnel have been cross-trained to be able to process denuders. At present, there are two persons trained to refurbish and coat denuders. RTI is also capable of coating denuders in a glove cabinet so that exposure of denuders to ambient air is minimized and the denuders can later be extracted to quantify the mass of acidic (e.g., HNO_3) or basic (e.g., NH_3) gases collected.

For the 2015 calendar year, there were no quality issues reported.

3.5.2 Operational Discussion

3.5.2.1 Numbers of Denuder Serviced

Table 3-34 lists the denuders refurbished and the number of refurbishments completed in 2015.

Table 3-34. Denuder Refurbishments, January 1, 2015 through November 25, 2015

Denuder Type	Total Refurbished
Aluminum Honeycomb	376

3.5.2.2 Scheduling of Replacements

MetOne speciation sampler aluminum honeycomb denuders are coated with magnesium oxide. Because the MetOne denuders are part of the sampling module and six sets of modules are in circulation to each site, these denuders are refurbished at 18-month intervals. RTI is able to remove MgO from denuders using a dilute hydrochloric acid solution. As needed, RTI orders uncoated aluminum honeycomb denuder substrates from MetOne, cleans them with solvent and deionized water, and then coats them with magnesium oxide. The change-out occurs whenever the MetOne denuder assembly has been in use for 18 months.

3.5.3 Description of QC Checks Applied and Results

QC checks for coating weight are no longer done. Work in earlier years of the project(s) showed that coating weights on the same types of MgO-coated denuders were usually within 10% of one another and that the amount (number of moles) of MgO applied far exceeded the expected mass (number of moles) of acidic gases that would be drawn through the denuder during the cumulative sampling period. Now the newly-coated denuder surfaces are examined by holding the denuder up to a light and sighting along the interior to determine the coating is thoroughly applied and the annuli are not blocked.

3.6 Sample Handling and Archiving Laboratory

3.6.1 Quality Issues and Corrective Actions

There was one quality issue in the SHAL during 2015.

Due to inclement weather in Louisville, KY the incoming shipment of CSN sampled filters scheduled to arrive at RTI on Friday April 3, 2015 was delayed by UPS. No packages were delivered to RTI that Friday. The incoming packages delivered on Monday were assigned the “RDC” flag (Return Shipment Delayed by Shipping Company). A total of 141 sampling events were assigned this flag.

While not a quality issue, the SHAL moved from the 1000 Parliament Court location in Durham, NC to RTI’s main campus the morning of Monday November 2, 2015. The new SHAL was located in the same laboratory as the OC/EC analysis laboratory. Packages of sampled filters from the network were stored in RTI’s filter archive prior to processing. The refrigerated filter archive replaced the walk-in cold room at the 1000 Parliament Court location. The new SHAL processed CSN packages from Monday November 2, 2015 through December 11, 2015.

3.6.2 Description of QC Checks Applied

The SHAL uses a customized database program written specifically for RTI's SHAL operation. This database has been refined over 15 years to incorporate many built-in QC checks. For example, RTI has assigned an inventory number to all filter modules in the network. The database will only accept allowable inventory numbers for filter modules. This avoids errors in data input for any filter module used for a sampling event. Another example is the unique number of the Teflon filters used by RTI. RTI purchases Teflon filters with a check sum digit in the numbering sequence. The database will only accept those filter numbers with the correct check sum. This prevents inadvertent entry of incorrect filter identification numbers.

- Bar-code readers are used to input identification numbers from modules, containers, and data forms to eliminate data transcription errors.
- A SHAL technician other than the one who prepared an outgoing shipment checks the package of outgoing filters. A checklist is used by the technician to verify that the package contents are correct before it is shipped from RTI. This check is performed on all outgoing shipments from the SHAL.
- Blank filters are taken from the SHAL refrigerator and sent unopened to the analytical laboratories for analysis. The results of the analysis of these QC filters are used to improve the overall quality of the program.
- The field site operators are provided contact information for the SHAL laboratory so they may communicate directly with personnel at RTI if any problems are discovered upon receipt of the filter modules. RTI personnel will attempt to resolve issues promptly. For example, a Field Data Form may be faxed or emailed from RTI to the site operator if necessary.

3.6.3 Summary of QC Results and Field Site Completeness

During calendar year 2015, the SHAL shipped out and received back more than 28,000 packages of filters. By employing the QC checks described in Section 3.6.2, the majority of the coolers shipped and received at RTI contained the correct filter modules and the required paperwork for completing the sampling event at the field site. This is a critical component of the network operation and support. The high number of correctly packaged shipments sent from RTI helped the field-sampling locations meet their completion goals. (See Appendix B). Data completeness at the sites was typically 90 to 100%, although there was a wide variation for some months at some sites. Most often, lower data completeness was due to factors beyond the control of RTI, such as inclement weather preventing state/local operators accessing the site for filter retrievals/changes, operational problems or activities at the sites such as malfunctioning samplers, sampler upgrades, lost power etc., and so forth.

3.6.4 Summary of Scheduling Problems

RTI prepares shipping schedules for the CSN and distributes these to all field sampling locations through the EPA DOPO's. The schedules indicate when each cooler will be sent from RTI, the scheduled sampling date for the filters, and the return ship date from the site back to

RTI. The schedules are designed to allow RTI to send the sampling site clean filters, allowing time for field site operators to set up and retrieve filters from the samplers. A 48 hour window for sample retrieval by the site operator is built into the schedule. **Table 3-35** lists those sites with less than 95% of their filters run on the intended sampling date during 2015. If a site ran the sampler on a different date than originally scheduled, the actual date on which the sample was collected is reported to the AQS. No flags are applied just for this change in sampling date. Flags are only applied to those sampling events that are recommended by the site operator on the form due to specific observations (e.g. wildfires, etc.), or those that arise during QA review due to data inconsistencies (e.g., outliers for sulfur/sulfate ratio, mass balance, etc.).

Table 3-35. Sites with Less than 95% of Filters Run on Intended Sampling Date

AQS Site Code	POC	Location	Events(1)	On Date	Percent
370570002	5	Lexington (NC)	16	12	75.0
060658001	6	Riverside-Rubidoux (Collocated)	116	91	78.4
420692006	5	Scranton	16	14	87.5
150030010	5	Kapolei	228	202	88.6
460990008	5	Sioux Falls School Site	230	208	90.4
391530023	5	5 Points	118	109	92.4
471570075	6	Shelby Farms – Seq	230	215	93.5
560210100	5	Cheyenne NCore – Seq	230	217	94.3
401091037	5	OCUSA Campus	116	110	94.8

(1)For sites with both SASS and URG 3000 N, each sampler was counted separately.

3.6.5 Support Activities for Site Operators and Data Users

SHAL staff provided support to site operators and data users throughout 2015. A summary of email and phone communications with site operators and data users is presented in **Table 3-36**. In consultation with EPA, a list of frequently asked questions has been prepared (currently under review) that can be posted on the AMTIC website that site operators and data users can refer to for clarification on common issues/questions.

Table 3-36. Summary of SHAL Communications with Site Operators and Data Users

Description	Number of Communications
Site will send cooler late	61
Site needs schedule	65
RTI did not receive cooler	32
Change of operator/site information	45
Sampler problems/questions	88
Field Blank/Trip Blank ran as routine sample	12
Request change of ship date from RTI	8
Site is stopping	11
Miscellaneous QA Issues	235
Data questions/reporting	100
Site did not receive cooler	37
Other	83
Total	777

3.6.6 Audits, PEs, Training, and Accreditations

- All new SHAL technicians must undergo a formal training process before they handle any filters. This process includes a Safety and Occupational Health Orientation, a review of the SOP and instruction by senior staff in filter handling. A record of this training is kept on file.
- SHAL staff periodically review the SOP and a record of this review is added to their training file.
- All SHAL staff are trained in the handling of the 25mm quartz filters used in the URG 3000N sampler and the proper installation and removal of the quartz filter using the URG 3000N cassette.
- Throughout the year, senior SHAL staff will periodically observe the SHAL technicians processing filter modules. A checklist has been prepared listing each step in the module processing task. The checklist is used during the observation of the technician. The SHAL supervisor keeps the completed checklists. Technicians are briefed following the review of any findings. A summary of the reviews for calendar year 2015 is shown in **Table 3-37**.

3.6.7 Site Changes 2015

A chronological listing of CSN field site changes during 2015 is listed below in **Table 3-38.** During 2015, a number of sites stopped sampling permanently as shown in Table 3-38. This may be part of the reason for reduced data completeness seen in Appendix B.

Table 3-37. Review of SHAL Technician Processing Filter Modules

Module Type	Number Observed	Findings	Findings Reviewed with Technician
MET ONE	80	4	4
URG 3000N	80	4	4

Table 3-38. CSN Field Site Changes During 2015

Date	AQS Site ID	Site Name	State	Description
1/1/15	340070002	Camden-NJ	NJ	Changed from 1-day-in-3 to 1-day-in-6 sampling collection frequency.
1/1/15	340273001	Chester	NJ	Changed from 1-day-in-3 to 1-day-in-6 sampling collection frequency.
1/1/15	210670012	Lexington Health Dept.	KY	Site is stopping permanently. Last event = 12/31/14.
1/1/15	210190017	Ashland Health Department	KY	Site is stopping permanently. Last event = 12/31/14.
1/1/15	210430500	Grayson	KY	Site is stopping permanently. Last event = 12/31/14.
1/1/15	120111002	Univ. of Florida Ag School	FL	Site is stopping permanently. Last event = 12/31/14. Samplers being moved to Broward County nCore site. First event at new location 1/3/15.
1/3/15	120110034	Broward County nCore	FL	New site started sampling 1/3/15.
1/3/15	020900034	Alaska Ncore	AK	Site is starting speciation sampling. First event is 1/3/15.
1/12/15	060290014	Bakersfield	CA	Samplers restarting. Site had been down since 9/10/13.
1/12/15	060290014	Bakersfield Collocated Sampler	CA	Samplers restarting. Site had been down since 9/10/13.
1/12/15	191530030	Public Health Building	IA	Site is stopping permanently. Last event = 1/12/15.
1/18/15	370570002	(NC) - Lexington	NC	Site is stopping permanently. Last event = 1/18/15.
1/24/15	130590001	Athens - Met One	GA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	291860005	Bonne Terre - Met One	MO	Site is stopping permanently. Last event = 1/24/15.
1/24/15	370210034	Buncombe County Board of Education	NC	Site is stopping permanently. Last event = 1/24/15.

1/24/15	420490003	Erie	PA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	450450015	Greenville ESC	SC	Site is stopping permanently. Last event = 1/24/15.
1/24/15	420430401	Harrisburg	PA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	390990014	Head Start	OH	Site is stopping permanently. Last event = 1/24/15.
1/24/15	261130001	Houghton Lake	MI	Site is stopping permanently. Last event = 1/24/15.
1/24/15	010890014	Huntsville Old Airport	AL	Site is stopping permanently. Last event = 1/24/15.
1/24/15	470990002	Lawrence County	TN	Site is stopping permanently. Last event = 1/24/15.
1/24/15	290470005	Liberty - Met One	MO	Site is stopping permanently. Last event = 1/24/15.
1/24/15	191130040	Linn County Health	IA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	470370023	Lockeland School - Met One	TN	Site is stopping permanently. Last event = 1/24/15.
1/24/15	390490081	Maple Canyon	OH	Site is stopping permanently. Last event = 1/24/15.
1/24/15	271095008	MN - Rochester	MN	Site is stopping permanently. Last event = 1/24/15.
1/24/15	011011002	MOMS	AL	Site is stopping permanently. Last event = 1/24/15.
1/24/15	390870012	ODOT Garage	OH	Site is stopping permanently. Last event = 1/24/15.
1/24/15	261470005	Port Huron	MI	Site is stopping permanently. Last event = 1/24/15.
1/24/15	420110011	Reading Airport	PA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	371590021	Rockwell	NC	Site is stopping permanently. Last event = 1/24/15.
1/24/15	420692006	Scranton	PA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	530330030	Seattle 10th Ave	WA	Site is stopping permanently. Last event = 1/24/15.
1/24/15	121030026	Skyview	FL	Site is stopping permanently. Last event = 1/24/15.

1/24/15	261150006	Sterling State Park	MI	Site is stopping permanently. Last event = 1/24/15.
1/24/15	390950026	Toledo Airport	OH	Site is stopping permanently. Last event = 1/24/15.
1/24/15	470654002	UTC	TN	Site is stopping permanently. Last event = 1/24/15.
1/24/15	551330027	Waukesha, Cleveland Ave	WI	Site is stopping permanently. Last event = 1/24/15.
4/1/15		Network Wide		Increased the number of icepacks in speciation packages from 6 to 8 for the warmer months.
2/11/15	290990019	Arnold West	MO	Collection frequency of speciation samples reduced from 1-in-3 days to 1-in-6 days beginning 2/11/15.
2/11/15	360010005	Albany Co HD	NY	Collection frequency of speciation samples reduced from 1-in-3 days to 1-in-6 days beginning 2/11/15.
2/11/15	010732003	Wylam	AL	Collection frequency of speciation samples reduced from 1-in-3 days to 1-in-6 days beginning 2/11/15.
3/7/15	530611007	Marysville 7th Ave	WA	Site is stopping permanently. Last event = 3/7/15.
3/13/15	530330030	Seattle 10th Ave	WA	Site began speciation sampling on 3/13/15.
4/3/15		Network Wide		UPS could not deliver incoming speciation packages to RTI on Friday April 3, 2015 due to severe weather in Louisville, KY during the night. All packages arriving at RTI on Monday April 6, 2015 were assigned the qualifying flag "RDC" for "Return Shipment Delayed by Shipping Company" .
5/3/15	090090027	Criscuolo Park	CT	Sampling frequency changed from Alternate 1/3 to regular 1/3 day sampling.
5/24/15	080010006	Commerce City	CO	Site is down temporarily. Last sample date=5/24/15.
5/24/15	420030008	Lawrenceville	PA	Site is down temporarily. Last sample date=5/24/15.
5/30/15		Network Wide		Nylon filters used in the CSN changed to Nylasorb Nylon Membrane Filters, 1.0 micron pore size, 47mm diameter from Pall Life Sciences. These filters do not require pre-washing. Blanks levels are verified as part of QA/QC.

7/11/15	Tribal	Pala 2	CA	Site is stopping permanently. Last event = 7/11/15.
8/4/15	Tribal	Pala 1	CA	Site is stopping permanently. Last event = 8/4/15.
8/28/15	090090027	Criscuolo Park	CT	Started Sequential Sampling. First event 8/28/15.
9/12/15	420030008	Lawrenceville	PA	Site resumed sampling on 9/12/15. Had been down since 5/24/15

4.0 Data Processing

4.1 Quality Issues and Corrective Actions

No significant quality issues arose during the period of this report that affected reportable data.

4.2 Operational Summary

Routine data-processing activities have remained largely unchanged since the beginning of the program. These include the following:

- Accepting data entered from field forms
- Accepting data from the laboratories
- Backing up and maintaining the database
- Generating data monthly for validation and review
- Posting review data monthly to the Web site for external review
- Incorporating data change requested by the States
- Uploading finalized data to AQS
- Responding to user inquiries and data requests, including support to EPA and RTI personnel.

4.3 Operational Changes and Improvements

No significant changes were made during the period of this report.

4.4 Monthly Data Postings to Web Site

Each month, RTI posts data for samples received on or before the 15th of the previous month. **Table 4-1** shows monthly totals for postings, and **Table 4-2** shows totals for events. Sample dates may overlap between different batches due to different shipping schedules for the 1-in-3 and 1-in-6 sampling schedules. In addition, the latest date may include samples received late (i.e., after the previous report's cutoff date).

Table 4-1. Events Posted to Web Site

Report		Sampling Date				Blanks		Backup Filters (3)
Report	Date	Earliest	Latest	Total (1)	Routine	Field	24 Hour(2)	Routine
181	2/13/2015	12/1/2014	1/13/2015	1,746	1,407		165	174
182	3/13/2015	12/13/2014	2/8/2015	1,244	1,092		152	
183	4/15/2015	1/24/2015	3/10/2015	1,186	1,058	76	52	
184	5/15/2015	3/7/2015	4/9/2015	1,072	1,020		52	
185	6/15/2015	3/31/2015	5/12/2015	1,448	1,256	140	52	
186	7/15/2015	5/6/2015	6/9/2015	975	923		52	
187	8/14/2015	5/30/2015	7/11/2015	1,207	1,155		52	
188	9/15/2015	7/2/2015	8/11/2015	1,141	1,089		52	
189	10/15/2015	8/4/2015	9/12/2015	1,166	1,040	74	52	
190	11/13/2015	8/22/2015	10/9/2015	1,095	1,043		52	
191	12/15/2015	10/3/2015	11/14/2015	1,145	1,093		52	
192	1/15/2016	10/30/2015	11/20/2015	409	383		26	
			Total	13,834	12,559	290	811	174

1) Counts for Total Events include routine events, field blanks, 24-hour blanks and backup filters.

2) 24 Hour blanks are only used with the URG 3000N samplers. Only results for OC/EC analysis by the IMPROVE_A method are reported for these samples.

3) Backup filters are only used for URG 3000N samplers. Only results for OC/EC analysis by the IMPROVE_A method are reported. Note that EPA discontinued collection of backup quartz filters beginning in 2015.

Table 4-2. Records Posted to Web Site

Report		Sampling Date				Blanks		Backup
Batch	**Date**	**Earliest**	**Latest**	**Total (1)**	**Routine**	**Field**	**24 Hour (2)**	**Filters (3)**
181	2/13/2015	12/1/2014	1/13/2015	151,492	145,096		3,960	2,436
182	3/13/2015	12/13/2014	2/8/2015	116,153	112,505		3,648	
183	4/15/2015	1/24/2015	3/10/2015	116,094	108,993	5,853	1,248	
184	5/15/2015	3/7/2015	4/9/2015	106,327	105,079		1,248	
185	6/15/2015	3/31/2015	5/12/2015	141,346	129,315	10,783	1,248	
186	7/15/2015	5/6/2015	6/9/2015	96,332	95,084		1,248	
187	8/14/2015	5/30/2015	7/11/2015	120,237	118,989		1,248	
188	9/15/2015	7/2/2015	8/11/2015	113,434	112,186		1,248	
189	10/15/2015	8/4/2015	9/12/2015	114,061	107,114	5,699	1,248	
190	11/13/2015	8/22/2015	10/9/2015	108,696	107,448		1,248	
191	12/15/2015	10/3/2015	11/14/2015	113,850	112,602		1,248	
192	1/15/2016	10/30/2015	11/20/2015	40,080	39,456		624	
			Total	1,338,102	1,293,867	22,335	19,464	2,436

1) Counts for Total Events include routine events, field blanks, 24-hour blanks, and backup filters.

2) 24 Hour blanks are only used with the URG 3000N samplers. Only results for OC/EC analysis by the IMPROVE_A method are reported for these samples.

3) Backup filters are only used for URG 3000N samplers. Only results for OC/EC analysis by the IMPROVE_A method are reported.

Postings to AQS

After data have been posted to the external Web site, the state/local monitoring agencies have 45 days to review data and send corrections to RTI. RTI then is required to post data to AQS within 15 days. RTI met all processing deadlines for this reporting year. **Table 4-3** contains totals of events posted to AQS. **Table 4-4** contains totals of records posted to AQS. Note that blanks involve fewer records per event, as temperature and barometric pressure for field blanks are not posted to AQS. Please note that the tables do not include the last batch (Batch 192) posted to AQS, as the postings were performed after the timing of this report.

4.5 Data User Support Activities

RTI had continuing data-user support throughout the year. Most responses may be categorized into four categories; data change requests, requests for old data, support requests for the Speciation Data Validation and Analysis Tool (SDVAT), and requests from data users.

4.5.1 Data Change Requests

Sites are asked to review their data and submit any changes to RTI within 45 days. RTI then processes these changes before posting the data to AQS. Sites report changes via e-mail. Many sites do not report unless they have changes, whereas others send a report back indicating there are no changes to be made. **Table 4-5** shows a count of the number of change requests per batch. Note that many requests represent multiple sites (often an entire state).

Table 4-3. Events Posted to AQS

Report Batch	Routine(1)	Blanks		Backup Filters (2)
		24 Hour(2)	Field	
181	1,420	165		174
182	1,094	152		
183	1,064	52	76	
184	1,026	52		
185	1,261	52	140	
186	928	52		
187	1,161	52		
188	1,095	52		
189	1,047	52	74	
190	1,050	52		
191	1,100	52		
192	390	26		
total	12,636	811	290	174

(1) A sampling event is defined as a sample taken at a single AQS site ID and Parameter Occurrence Code (POC) on a single day. This would represent two physical samplers at sites that use URG 3000N samplers for carbon sampling
(2) URG 3000N samplers only

Table 4-4. Records Posted to AQS

Report Batch	Routine	Blanks		Backup Filters (1)
		24 Hour (1)	Field	
181	80,300	2,145		2,262
182	62,273	1,976		
183	60,325	676	3,345	
184	58,159	676		
185	71,446	676	6,163	
186	52,626	676		
187	65,859	676		
188	62,092	676		
189	59,287	676	3,257	
190	59,470	676		
191	62,324	676		
192	22,244	338		
total	716,405	10,543	12,765	2,262

(1) URG 3000N only

Table 4-5. Change Requests per Report Batch(1)

	Report Batch											
	181	182	183	184	185	186	187	188	189	190	191	192
Change Requests[1]	2	1	3	1	4	1	3	6	3	2	3	2

1) Number of site data contact changes. Multiple data changes by one site contact are counted as one request

5.0 Quality Assurance and Data Validation

5.1 QA Activities

5.1.1 QAPP Updates

RTI's QAPP was revised in January 27, 2014 to reflect personnel changes.

5.1.2 SOP Updates

RTI's SOPs were updated in preparation for the procurement of the CSN contract in July 2008. All SOPs were finalized in 2009, after contract award. One SOP was added during 2012: EIS-401 on ICP/MS analysis for metals. DRI updated the *DRI Model 2001 Thermal/Optical Carbon Analysis (TOR/TOT) of Aerosol Filter Samples – Method IMPROVE_A* SOP in 2012. The current versions of all SOPs are listed in Section 7 of this report.

5.1.3 Internal Surveillance Activities

The QA Manager follows up regularly with the laboratories on data issues as part of the monthly data review process, and sometimes requests raw data for verification. Outstanding quality issues were discussed at monthly project meetings, and any new changes required were implemented. Each laboratory performs its own internal surveillance and QC. For example, SHAL technicians crosscheck each other's outgoing packages (coolers) before they are shipped to the sites. In the chemical laboratories, the supervisor checks and approves data before it is released.

5.1.4 Data User Support Activities

The Project Manager, QA Manager, SHAL Supervisors, Data Processing Supervisor and other project personnel responded to a number of questions and requests for data during 2015. These originated from both network participants (state agency personnel and EPA), as well as data users who were not affiliated with the CSN program. See Sections 3.0 and 4.0 for additional information.

5.2 Data Validation and Review

5.2.1 Review of Monthly Data Reports to the CSN Web Site

Each month, RTI reviews data completed during the previous month. These reviews include the following activities:

- Verification of data attribution to the correct site, POC, and date
- Automated range checks (e.g., barometric pressure, temperature)
- Investigation and corrective actions when discrepancies are found

- Level 1 checks (e.g., reconstructed mass balance, anion/cation balance, and sulfur/sulfate balance)

The monitoring agencies are responsible for Level 2 and above data validation and to recommend data flagging and/or invalidation. To aid the monitoring agencies, beginning in 2013, after discussions with EPA, RTI began to invalidate certain events when sufficient evidence was available and notified the respective monitoring agencies of the events invalidated with a brief justification. No action was needed by the agency unless they disagreed with the invalidation.

Tables 5-1 through **5-3** summarize the data flags attached to the data posted to the Web site for review by the state and local agencies. These flags are assigned during the data review process, although some flags are assigned by field operators or by the laboratories. Examining trends in flag percentages is a useful tool in diagnosing potential problems; however, during 2015 the flag percentages were low and stable. Please note that during 2015, a new flag, RDC, was added to track return shipment delays due to shipment carrier. Delayed receipt of sampled filters also may impact the temperature at which the samples are received. Consequently, batch 184 which was impacted by RDC flag also showed a higher fraction of samples with temperature of receipt above 4°C. Other variations in the percentages of flags such as DST, temperature of receipt above 4°C, is explained by seasonal factors.

Table 5-1 lists the percentages of records that are flagged with Validity Status Codes defined in AIRS/AQS. Data records containing a validity status code should be used with caution because the reported concentration value may have been flagged as an outlier, or some unusual circumstance was reported by the field operator or by the laboratory. **Table 5-2** lists the percentages of records containing Null Value Codes defined in AIRS/AQS. These data records have been invalidated due to more serious problems. Concentration values will not be included in AQS when a Null Value Code has been assigned to the record. **Table 5-3** lists percentages of internal RTI informational flags. These flags are not defined in AIRS/AQS, but give more insight to the monitoring agencies during data review about the reasons why AIRS/AQS flags were set. The complete definitions of all flags are given in the report (.rtf) files that are posted on the external RTI QA Web Site for review by the state/local monitoring agencies.

Shipping containers received from the field sites are checked for internal temperature when they are opened for module disassembly. The temperature goal is 4°C, but some fraction of the packages is always higher than this goal.

Table 5-1. Summary of Validity Status Codes by Delivery Batch Number (percent of data records reported)

Flag	Description	181	182	183	184	185	186	187	188	189	190	191	192
1	Critical Criteria Not Met	0.11%	0.04%										
2	Operational criteria not met							0.06%					
3	Possible field contamination												
5	Outlier - cause unknown	0.95%	0.49%	0.41%	0.89%	0.72%	0.41%	1.14%	0.91%	0.98%	1.11%	1.27%	1.34%
IA	African Dust							0.08%					
IE	Demolition	0.06%				0.07%							
IF	Fire - Canadian							0.33%					
IH	Fireworks	0.06%						0.29%					
II	High Pollen Count				0.46%	0.07%							
IJ	High Winds		0.15%	0.34%	0.13%	0.11%				0.04%	0.09%		0.24%
IK	Infrequent Large Gatherings												
IL	Other	0.19%	0.28%		0.21%	0.05%	0.10%		0.18%	0.41%	0.09%	0.15%	0.54%
IM	Prescribed Fire					0.07%							
IP	Structural Fire												
IR	Unique Traffic Disruption							0.08%					
IT	Wildfire-U. S.					0.07%		0.67%	0.26%	1.66%	0.06%		
W	Flow Rate Average Out of Spec.	0.03%		0.13%	0.02%			0.02%	0.04%	0.13%			
X	Filter Temperature Difference Out of Spec.	0.48%	0.24%	0.51%	0.37%	0.68%	0.72%	0.51%	0.75%	0.33%	0.37%	0.13%	0.18%
Y	Elapsed Sample Time Out of Spec.					0.02%	0.08%						

Table 5-2. Summary of Null Value Codes by Delivery Batch Number (percent of data records reported)

Flag	Description	181	182	183	184	185	186	187	188	189	190	191	192
AB	Technician Unavailable		0.23%	0.25%	0.39%	0.09%	0.04%	0.12%	0.37%	0.14%	0.32%	0.41%	0.19%
AC	Construction/Repairs in Area	0.54%	0.17%									0.11%	0.24%
AD	Shelter Storm Damage	0.02%	0.04%										
AF	Scheduled but not Collected	3.92%	2.17%	1.82%	1.51%	1.38%	1.24%	1.86%	1.18%	1.87%	1.24%	2.84%	1.23%
AG	Sample Time out of Limits	0.50%	0.69%	0.66%	0.64%	0.49%	0.54%	0.54%	0.52%	0.45%	0.55%	0.56%	0.29%
AH	Sample Flow Rate out of Limits	0.46%	0.57%	0.84%	0.49%	0.37%	0.57%	0.32%	0.45%	0.59%	0.37%	0.66%	1.28%
AI	Insufficient Data (Can't Calculate)	0.02%		0.06%	0.02%		0.18%		0.04%	0.13%		0.02%	0.76%
AJ	Filter Damage	0.06%	0.03%	0.25%	0.07%	0.09%	0.07%	0.04%	0.02%	0.04%	0.09%	0.10%	0.25%
AK	Filter Leak	0.02%	0.02%	0.02%								0.02%	
AL	Voided by Operator	0.18%	0.19%	0.31%	0.28%	0.39%	0.10%	0.14%	0.04%	0.02%	0.16%	0.31%	
AM	Miscellaneous Void	0.08%	0.15%	0.04%	0.16%	0.03%	0.34%	0.02%	0.11%	0.15%	0.04%	0.06%	0.23%
AN	Machine Malfunction	0.73%	0.51%	0.79%	1.20%	0.74%	1.14%	0.96%	1.12%	0.47%	1.46%	0.66%	0.29%
AO	Bad Weather										0.09%		
AP	VANDALISM					0.07%							
AQ	Collection Error	0.10%	0.02%	0.14%	0.02%	0.15%	0.07%	0.15%	0.20%	0.11%	0.16%	0.11%	
AR	Lab Error	0.19%	0.12%	0.41%	0.13%	0.16%	0.21%	0.40%	0.30%	0.45%	0.33%	0.23%	0.22%
AS	Poor Quality Assurance Results								0.02%				
AU	Monitoring Waived	0.01%		0.02%			0.03%						
AV	Power Failure	0.40%	0.34%	0.14%		0.53%	0.47%	0.32%	0.32%	0.51%	0.18%	0.90%	0.52%
AW	Wildlife Damage									0.02%			
BA	Maintenance/Routine Repairs	0.03%	0.11%	0.15%	0.09%	0.02%	0.05%			0.09%			
BB	Unable to Reach Site	0.05%		0.09%			0.10%	0.10%					
BE	Building/Site Repairs		0.07%	0.04%					0.04%		0.24%	0.07%	0.19%
BI	Lost or Damaged in Transit					0.14%	0.10%						

Table 5-3. RTI-assigned Flags (not reported to AQS) by Delivery Batch Number (percent of data records reported)

Flag	Description	181	182	183	184	185	186	187	188	189	190	191	192
DFM	Filter missing	0.05%	0.06%	0.12%		0.07%	0.10%	0.15%	0.06%	0.06%	0.02 %	0.04%	
DST	Shipping temperature out of specifications	17.3%	8.10%	14.7%	30.5%	15.6%	19.7%	26.8%	25.2%	26.7%	17.5 %	18.0%	8.4%
FC3	Channel 3 used instead of designated channel	1.3%	1.8%	1.7%	1.8%	1.7%	1.4%	1.5%	1.9%	1.7%	1.9%	2.3%	1.5%
FC4	Channel 4 used instead of designated channel	0.55%	0.77%	0.70%	0.73%	0.72%	0.60%	0.59%	0.77%	0.67%	0.76 %	0.92%	0.59%
FC5	Channel 5 used instead of designated channel	0.64%	0.95%	0.80%	0.92%	0.95%	0.98%	1.03%	1.11%	0.97%	0.72 %	1.06%	0.88%
FC6	Channel 6 used instead of designated channel	0.27%	0.40%	0.34%	0.39%	0.41%	0.42%	0.44%	0.47%	0.41%	0.29 %	0.45%	0.37%
FC7	Channel 7 used instead of designated channel	0.31%	0.32%	0.13%	0.29%	0.29%	0.16%	0.17%	0.23%	0.23%	0.10 %	0.14%	0.13%
FCE	Corrected - operator data entry error	3.72%	3.53%	1.89%	2.59%	2.16%	1.94%	3.88%	2.78%	2.45%	0.83 %	0.52%	0.40%
FES	Field environmental data taken from other flow channel	0.03%	0.06%	0.17%	0.02%	0.03%	0.05%	0.04%	0.02%	0.06%	0.04 %	0.08%	0.32%
FHT	Pickup Holding Time Exceeded	25.9%	28.7%	17.2%	25.4%	22.9%	27.3%	18.9%	27.%	23.0%	23.5 %	22.9%	29.9%
FSL	Sample lost						0.21%						
LFA	Filter inspection flags* - filter wet		0.00%	0.02%		0.02%	0.02%	0.00%			0.00 %	0.02%	0.19%
LFL	Filter inspection flags* -Loose Material							0.04%					
LFT	Filter inspection flags* - Tear		0.04%		0.02%	0.07%	0.05%	0.04%		0.04%			
QAC	Anion/Cation total charge ratio out of limits	0.26%	0.23%	0.18%	0.27%	0.31%	0.37%	0.39%	0.31%	0.54%	0.59 %	0.50%	0.48%
QL1	Outlier based on Level 1 check (e.g., Sulfur/Sulfate Ratio outside limits)	0.07%	0.09%	0.07%	0.07%	0.06%	0.05%	0.08%	0.16%	0.09%	0.08 %	0.08%	0.13%
QMB	Total mass balance outside limits	0.62%	0.17%	0.17%	0.57%	0.35%		0.68%	0.45%	0.36%	0.46 %	0.71%	0.75%
RDC	Return shipment delayed by shipping company				11.52 %	0.07%							
RTS	Refrigeration lost prior to analysis									0.48%			

Figure 5-1 shows the average temperature, the 10th, 50th and 90th percentiles, and the interquartile range plotted monthly through the end of 2015. Significant events with the potential to affect package temperature are indicated on the chart, including the change from the original "picnic cooler" type shipping container to a lighter-weight custom designed package, and the change from FedEx to UPS as the carrier. Although some fraction of the containers is always above 4°C goal, particularly during summer, temperature percentiles have generally trended lower in recent years, indicating that shipping conditions are under good control. Any package that is received above 4°C generates a "DST" flag, which is included in the monthly report going to the monitoring agencies for their information. No flag corresponding to DST has been defined in AQS. The larger fraction of filters with more than 4°C in March 2015 corresponds to the filters that were impacted by delayed return shipment as a result of inclement weather. To reduce shipping costs, EPA reduced the number of icepacks per shipment from eight to six for shipments from October through March (fall and winter shipments) for all but three CSN sites. These three sites, San Jose - Jackson St (CA), Children's Park (AZ), and Kapolei (HI), were selected by EPA based on their historical return shipment temperatures and shipping time considerations. As shown in Figure 5-1, the temperature distribution during these months is in general quite similar to the temperature distribution in previous years.

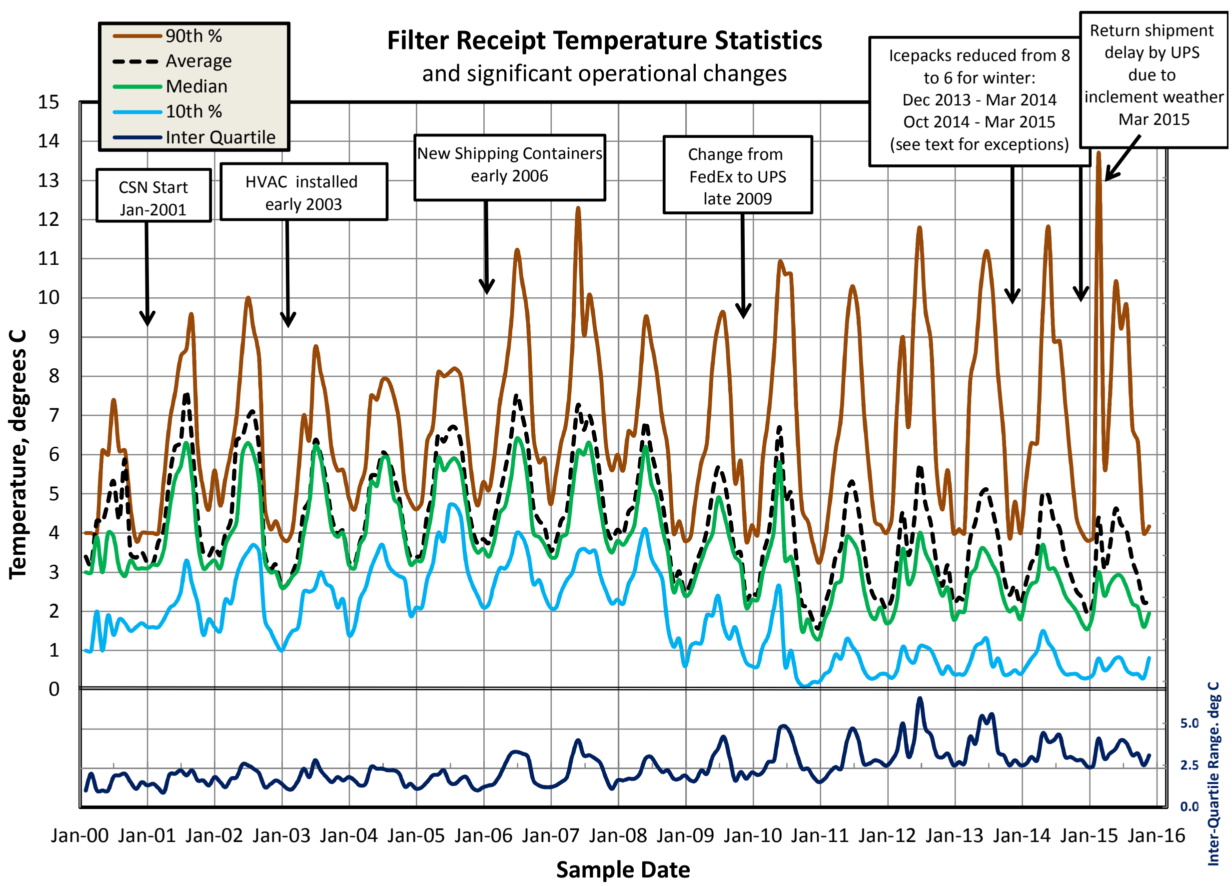


Figure 5-1. Filter Receipt Temperature Statistics.

5.2.2 Review of Monthly Data Packages to AQS

Approximately 60 days after initial posting on the RTI Web site, the data are uploaded to the AQS database. Prior to uploading, the data processing staff prepares a QC summary report, which is reviewed by the QA Manager. This summary and review includes the following main areas:

- Verification that changes requested by the state agencies have been implemented. This includes checking data flags that are different between original reporting (Web site posting) and final AQS reporting.

- Verification that record counts match exactly the number of records previously reported on the CSN Web site, with allowance for all records that were added and deleted during processing. Record counts may change as the result of such things as elimination of duplicate records, or re-reporting of previously reported that has been changed or corrected.

- Scanning for unusual values such as start times other than midnight.
- Scanning for formatting errors such as the following:
  - duplicate records
  - flags and other data in incorrect columns
  - previously delivered data (unless they are Modify records)
  - MDLs and uncertainties that do not agree between the original report and the AQS data file.

5.3 Analysis of Collocated Data

The CSN program operated six sites with collocated samplers during 2015, shown in **Table 5-4**. All six sites included collocated MetOne samplers for Teflon and nylon filters, plus the URG 3000N samplers for quartz on both the primary and collocated sampler. The primary samplers at these sites run on a 1-in-3 schedule, but the collocated (secondary) samplers typically only run on a 1-in-6 day schedule, which governs how much collocation data are available for analysis. The data from the sites with collocated samplers affords an opportunity to calculate

Table 5-4. Collocated Sites in the CSN During 2015.

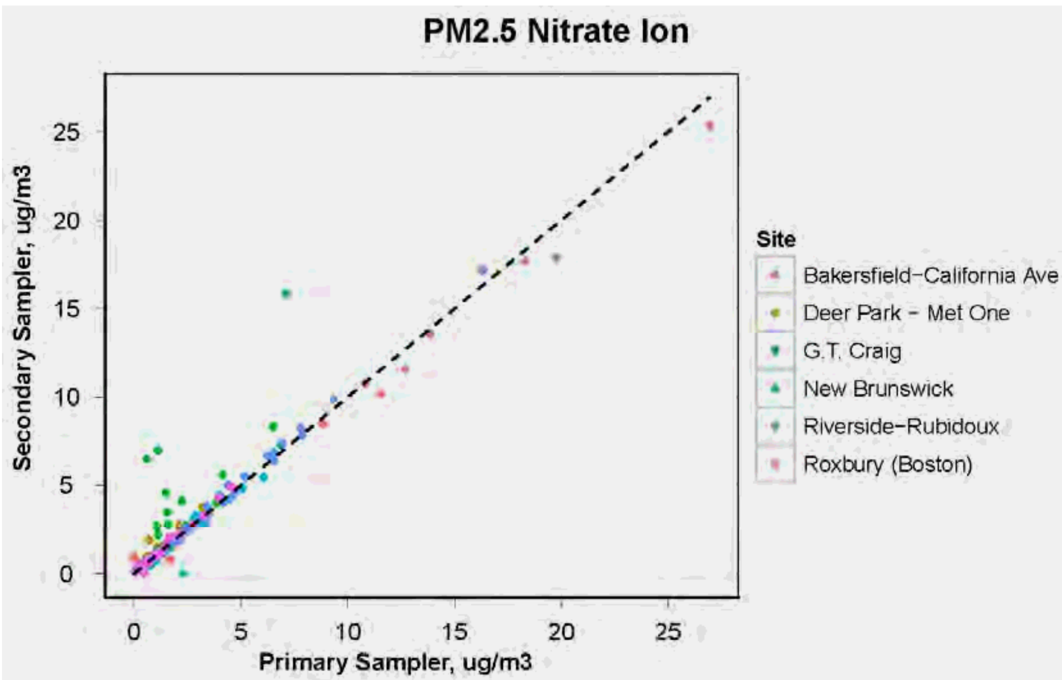
Location Name	State	AQS Code	Sampler Type
Bakersfield-California Ave*	California	060290014	MetOne SASS + URG 3000N
Deer Park	Texas	482011039	MetOne SASS + URG 3000N
G.T. Craig	Ohio	390350060	MetOne SASS + URG 3000N*
New Brunswick	New Jersey	340230006	MetOne SASS + URG 3000N
Riverside-Rubidoux	California	060658001	MetOne SASS + URG 3000N
Roxbury (Boston)	Massachusetts	250250042	MetOne SASS + URG 3000N

** The collocated URG 3000N sampler at the Bakersfield-California Ave site was out of service for nearly all of 2015 and is therefore not included in Figure 5-2 statistics for carbon species.*

total precision and compare the values with the uncertainty values that are currently being reported to AQS. Absolute accuracy cannot be assessed from this dataset because neither of the collocated samplers can be assumed to be more accurate than the other. Collocation data from the URG 3000N samplers may also be useful in evaluating the magnitude and uncertainty of the artifact in Organic Carbon measurement.

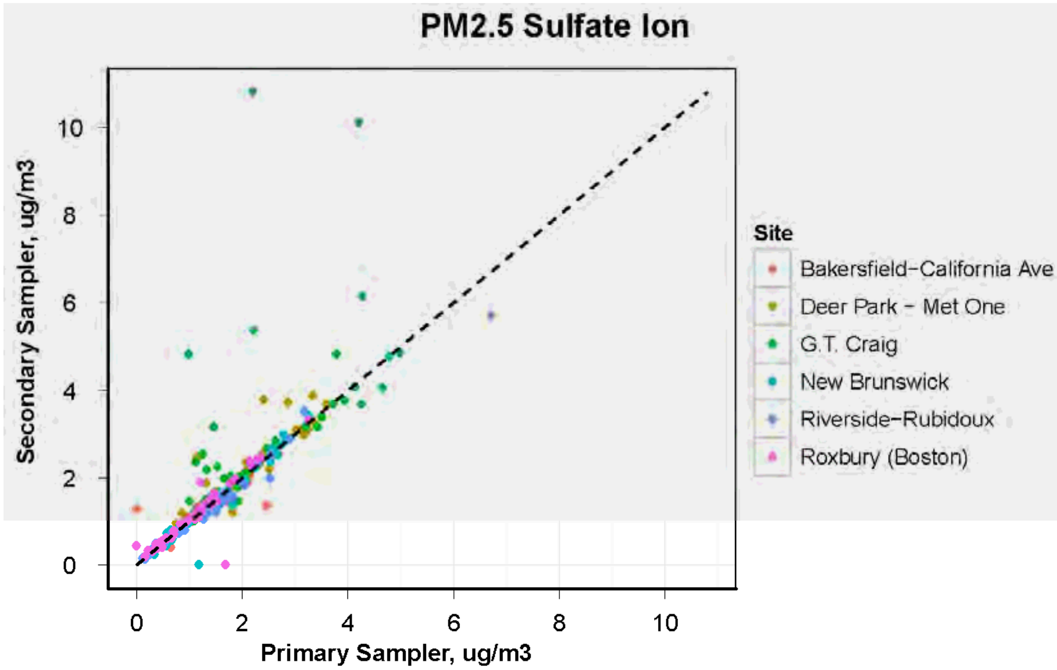
The figures that follow (**Figure 5-2**) show examples of the comparisons for $PM_{2.5}$ nitrate, sulfate, sulfur and OC/EC (IMPROVE_A TOR and TOT methods). Beginning in October 2014, mass measurements were discontinued for the entire network with a few exceptions. Therefore, there is no collocated data for mass. Also included in the figure are linear least-squares regression parameters (slope, intercept, R^2) by site for each of these species.

Figure 5-2 Collocation Data for Selected Species During 2015.



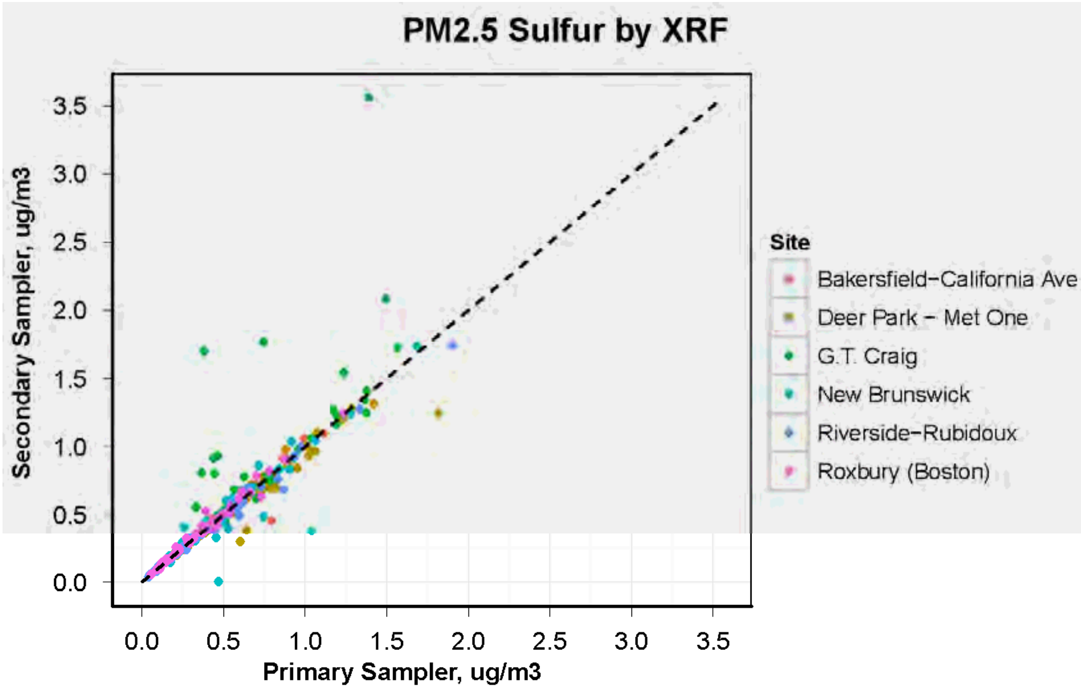
Site	Intercept	Slope	R2
Bakersfield-California Ave	0.068	0.94	1.00
Deer Park - Met One	-0.094	1.20	0.91
G.T. Craig	0.080	1.50	0.69
New Brunswick	0.022	0.92	0.93
Riverside-Rubidoux	0.079	0.98	0.99
Roxbury (Boston)	-0.023	1.10	0.99

Figure 5-2 (continued).



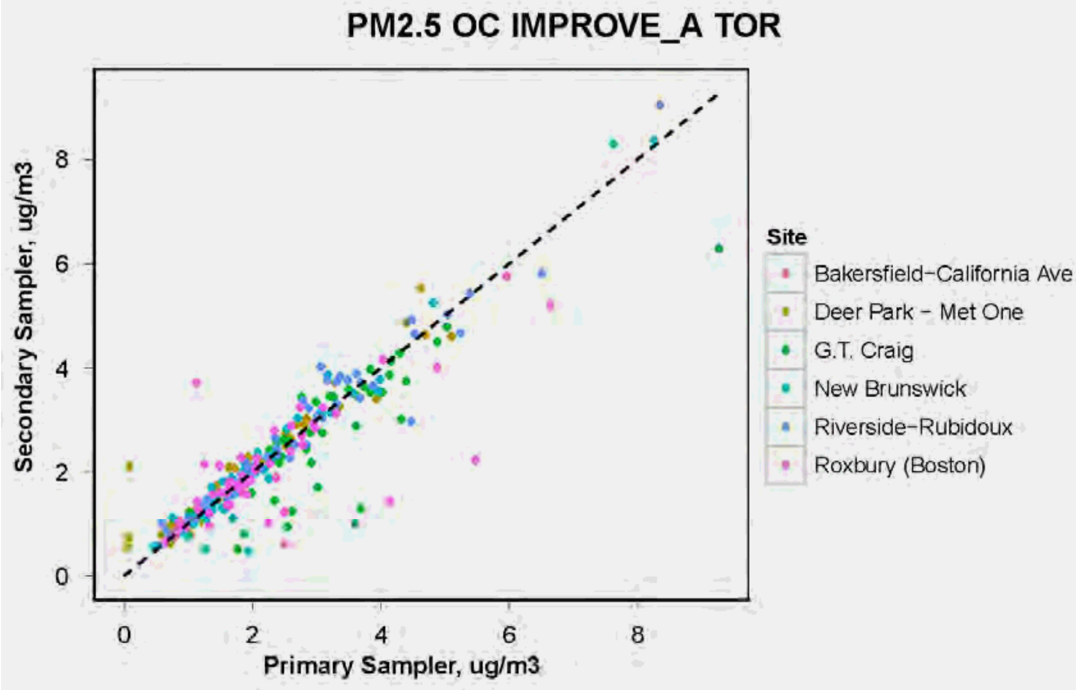
Site	Intercept	Slope	R2
Bakersfield−California Ave	0.270	0.78	0.78
Deer Park − Met One	0.150	0.98	0.86
G.T. Craig	0.510	1.10	0.38
New Brunswick	−0.032	1.00	0.96
Riverside−Rubidoux	0.076	0.89	0.98
Roxbury (Boston)	0.071	0.97	0.85

Figure 5-2 (continued).



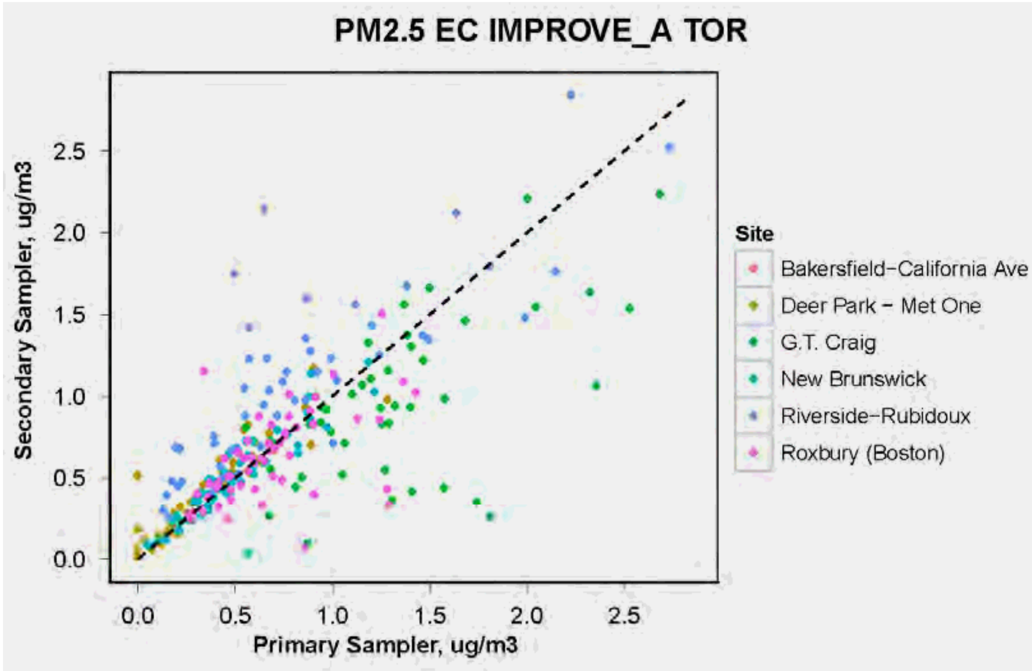
Site	Intercept	Slope	R2
Bakersfield−California Ave	0.0180	0.95	0.93
Deer Park − Met One	0.0570	0.85	0.91
G.T. Craig	0.0530	1.20	0.56
New Brunswick	0.0150	0.92	0.85
Riverside−Rubidoux	0.0140	0.93	0.99
Roxbury (Boston)	0.0064	1.00	0.98

Figure 5-2 (continued).



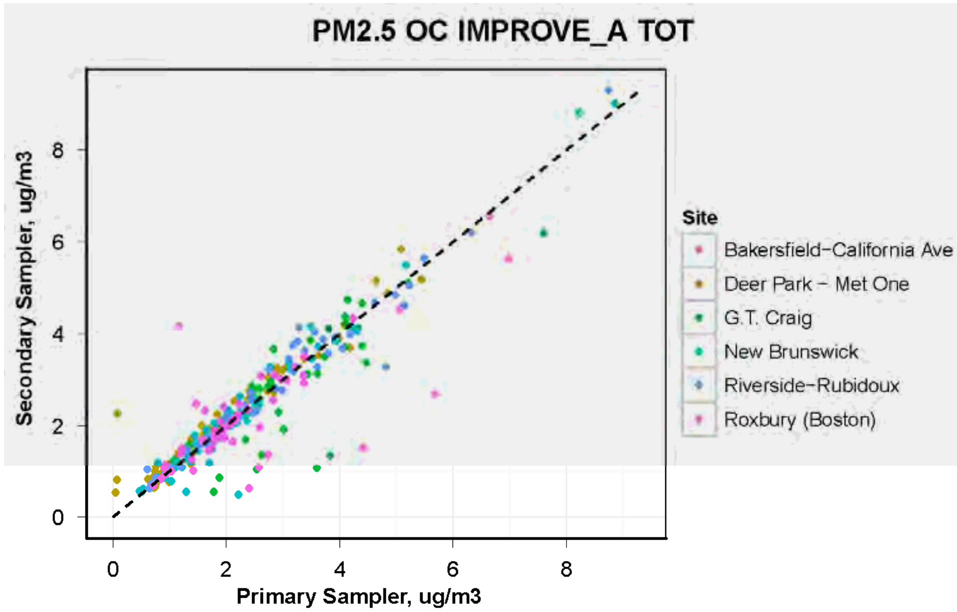
Site	Intercept	Slope	R2
Deer Park − Met One	0.23	0.94	0.92
G.T. Craig	0.40	0.73	0.68
New Brunswick	−0.10	1.00	0.96
Riverside−Rubidoux	0.13	0.97	0.95
Roxbury (Boston)	0.64	0.64	0.59

Figure 5-2 (continued).



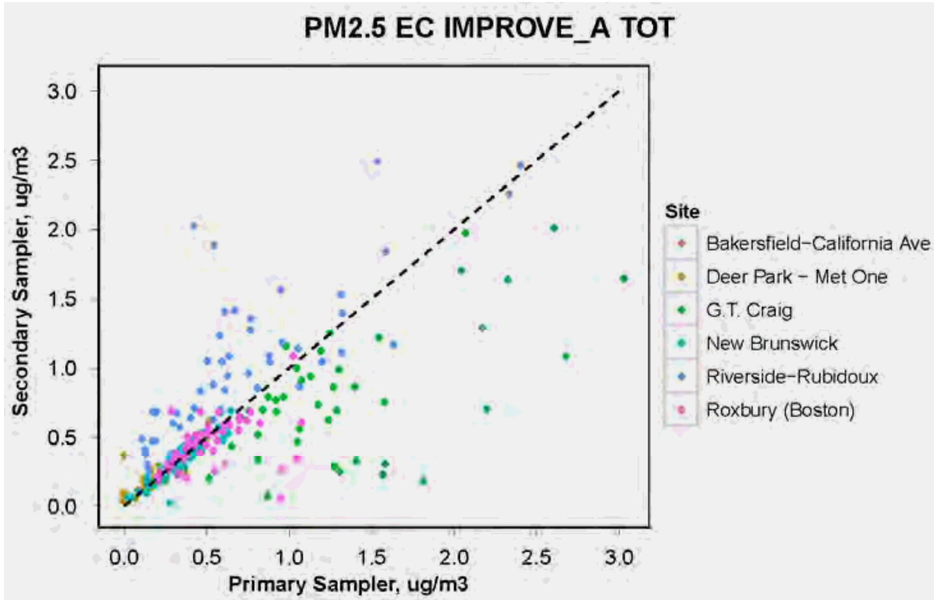
Site	Intercept	Slope	R2
Deer Park − Met One	0.080	0.92	0.81
G.T. Craig	0.180	0.59	0.41
New Brunswick	0.041	0.93	0.83
Riverside−Rubidoux	0.450	0.79	0.67
Roxbury (Boston)	0.260	0.52	0.31

Figure 5-2 (continued).



Site	Intercept	Slope	R2
Deer Park – Met One	0.250	0.95	0.93
G.T. Craig	0.150	0.86	0.69
New Brunswick	−0.089	1.00	0.96
Riverside–Rubidoux	0.093	0.98	0.96
Roxbury (Boston)	0.590	0.69	0.62

Figure 5-2 (continued).



Site	Intercept	Slope	R2
Deer Park − Met One	0.049	0.84	0.77
G.T. Craig	0.160	0.48	0.43
New Brunswick	0.020	0.92	0.83
Riverside−Rubidoux	0.430	0.82	0.62
Roxbury (Boston)	0.270	0.35	0.19

These figures demonstrate good or excellent agreement for the major analytes; however, precision for the species sampled by the MetOne sampler at the G.T. Craig site are visibly poorer than those at the other five sites likely due to sampler issues. Likewise, carbon data (in particular, elemental carbon data) at the G.T. Craig and Roxbury (Boston) sites showed larger variability than the other sites, also likely due to sampler issues.

Table 5-5 provides an analysis of the collocated sampling data, and compares the precisions calculated from the collocation data vs. the uncertainties reported to AQS. Data from collocated samplers provide an estimate of the whole-system measurement precision. Comparison of the collocated precision to the reported uncertainties (also an estimate of the precision) is a way of reconciling these uncertainty/precision estimates. If both of the values compare reasonably, the uncertainty estimate is reflective of the whole-system measurement precision. If the differences are large, then it may indicate that either the uncertainties do not capture the real-world whole-system variability and/or issues with the collocated data set (or outliers). For the most part, reported uncertainties are in the same ballpark range as the collocated precision.

The first column indicates the name of the chemical analyte. Only species having 10 or more paired values meeting the selection criteria (see below) are included in the table. Note that the standard deviations under Sampler 1 and Sampler 2 are primarily determined by variability of the ambient concentrations, and that the relative contribution of experimental errors is small.

Table 5-5. Precision of Collocated Samplers, 2015

Analyte	Sampler 1		Sampler 2		Avg Rel Diff (ARD)(2)	Avg Rel AQS Unc (AvAQS)(3)	Ratio(4) AvAQS/ARD	Counts(5)
	Avg. Conc	St Dev(1)	Avg. Conc	St Dev(1)				
PARTICULATE MATTER (GRAVIMETRY)								
Particulate matter 2.5µm	Mass measurements discontinued by EPA at these sites.							
ANIONS AND CATIONS BY IC								
Ammonium	0.79	1.07	0.85	1.21	13%	8%	64%	288
Sodium	0.17	0.20	0.19	0.22	24%	11%	45%	294
Potassium	0.10	0.32	0.10	0.27	22%	14%	63%	281
Nitrate	1.82	3.02	1.93	3.07	10%	8%	77%	297
Sulfate	1.52	0.98	1.64	1.26	7%	7%	98%	296
TRACE ELEMENTS BY XRF								
Aluminum	0.130	0.189	0.113	0.172	28%	21%	76%	164
Barium	0.033	0.039	0.031	0.035	28%	26%	94%	38
Bromine	0.005	0.003	0.006	0.003	20%	26%	129%	204
Calcium	0.075	0.083	0.074	0.081	25%	11%	**45%**	272
Chromium	0.007	0.006	0.005	0.006	48%	27%	55%	28
Cobalt	0.003	0.001	0.003	0.001	15%	34%	**224%**	10
Copper	0.011	0.014	0.011	0.012	22%	16%	75%	198
Chlorine	0.105	0.159	0.106	0.185	31%	13%	**43%**	239
Cesium	0.019	0.008	0.022	0.006	25%	34%	134%	10
Iron	0.152	0.173	0.154	0.184	19%	7%	**38%**	295

Analyte	Sampler 1		Sampler 2		Avg Rel Diff (ARD)(2)	Avg Rel AQS Unc (AvAQS)(3)	Ratio(4) AvAQS/ARD	Counts(5)
	Avg. Conc	St Dev(1)	Avg. Conc	St Dev(1)				
Lead	0.012	0.010	0.013	0.013	19%	31%	163%	21
Manganese	0.007	0.006	0.007	0.007	18%	22%	123%	101
Nickel	0.003	0.002	0.003	0.001	38%	25%	65%	44
Magnesium	0.046	0.047	0.047	0.044	30%	20%	65%	120
Selenium	0.003	0.001	0.004	0.001	26%	34%	133%	11
Titanium	0.017	0.017	0.016	0.016	24%	25%	104%	68
Silicon	0.190	0.330	0.180	0.302	20%	13%	64%	279
Zinc	0.017	0.030	0.018	0.033	19%	15%	79%	250
Sulfur	0.529	0.336	0.542	0.389	6%	7%	114%	295
Potassium	0.089	0.233	0.089	0.221	12%	9%	77%	295
Sodium	0.184	0.170	0.183	0.162	23%	18%	81%	199
ORGANIC AND ELEMENTAL CARBON BY IMPROVE_A METHOD (Sampled by URG 3000N)								
OC IMPROVE TOR	2.337	1.430	2.264	1.364	11%	N/A	N/A	268
OC IMPROVE TOT	2.462	1.470	2.417	1.447	11%	N/A	N/A	268
EC IMPROVE TOR	0.719	0.500	0.706	0.460	20%	N/A	N/A	265
EC IMPROVE TOT	0.591	0.511	0.550	0.435	21%	N/A	N/A	266
O1 IMPROVE	0.221	0.193	0.229	0.237	37%	N/A	N/A	203
O2 IMPROVE	0.575	0.345	0.559	0.322	14%	N/A	N/A	268
O3 IMPROVE	0.823	0.523	0.797	0.496	18%	N/A	N/A	267
O4 IMPROVE	0.492	0.288	0.462	0.268	16%	N/A	N/A	266
OP IMPROVE TOR	0.322	0.323	0.313	0.325	27%	N/A	N/A	198
OP IMPROVE TOT	0.433	0.366	0.446	0.393	21%	N/A	N/A	231
E1 IMPROVE	0.897	0.589	0.886	0.586	12%	N/A	N/A	266
E2 IMPROVE	0.075	0.084	0.063	0.052	33%	N/A	N/A	260
TC IMPROVE	3.048	1.812	2.965	1.722	12%	N/A	N/A	268

1 The standard deviations are a function of the natural variability of the environmental levels and are not indicative of the analytical precision.
2 ARD: Calculated as the average of the absolute value of the relative difference between the two samplers' values, divided by the square root of 2. See text for description.
3 AvAQS: Average value of the relative uncertainties as reported to AQS. See text for description.
4 AvAQS/ARD is the ratio of reported uncertainties divided by the uncertainty determined by average relative difference of the collocated samples. Values greater than 200% or less than 50% are shown in bold.
5 Counts are the number of individual observations included in the statistics. Only observations where both concentration values were above twice the uncertainty are included in the statistics.

The precision values determined from the collocation data are shown in the column titled "Avg Rel. Diff" (ARD). This is simply the average of the unsigned differences between the two samplers, and is calculated using the following formula:

$$ARD = \frac{1}{n\sqrt{2}} \sum \frac{|C_1 - C_2|}{(C_1 + C_2)/2}$$

Where

- C_1 and C_2 are the concentrations from the primary and collocated samplers, respectively
- The factor of $1/\sqrt{2}$ is used to convert the difference to a single-sampler basis
- The summation is over all valid concentration values where the concentration (C_1 or C_2) is greater than twice the uncertainty reported to AQS.

The precision values estimated based on uncertainties reported to AQS during 2014 are summarized under the column titled "Avg Rel AQS Unc." (AvAQS). This is the average of all the relative uncertainties reported to AQS over the collocation data set, and is calculated as follows:

$$AvAQS = \frac{1}{n} \sum_i \sum_j \frac{U_{ij}}{C_{ij}}$$

Where

- U_{ij} and C_{ij} refer to the uncertainty and concentration for the i^{th} exposure with the j^{th} sampler (j=1 or 2).
- n refers to the total number of measurements (i.e., 2 * i)
- The criteria for inclusion in the average (index i) is the same as in the previous equation.

The next column provides the ratio of AvAQS to ARD defined above. This is essentially the average under- or over-estimate of the uncertainty for each chemical species reported during 2014. The final column shows the number of sampling events included in the averages subject to the criteria defined above. Ratios greater than 200% or less than 50% indicate situations in which the uncertainties reported to AQS were different from the uncertainty estimated from collocation data by a factor of 2 or more. Calcium (45%), Cobalt (224%), Chlorine (43%) and Iron (38%) disagreed by more than a factor of 2. Compared to 2014, Barium showed better agreement in 2015.

5.4 Analysis of Trip and Field Blanks

CSN Field Blanks for the MET ONE SASS samplers were collected at a frequency of 3% during 2015. No Trip Blank samples are currently being collected for the MET ONE SASS samplers. As a result of the network assessment performed by the EPA, few changes were implemented to the blanks: Quartz backup filters were collected at 5% frequency in 2014, but was discontinued beginning in 2015. Likewise, beginning in 2015, the quartz 24 hour blank samples were collected at only 49 sites in the CSN. These 24 hour blanks were collected at a 10% frequency for sites with 1-in-3 day schedule, and at 20% frequency for sites with 1-in-6 day schedule. Data from these blanks allow evaluation of contamination, which may come from a number of different sources. In addition, the Field Blank data can sometimes signal problems in the analytical laboratories or with filters received from the manufacturers, as was the case during 2013 when chromium contamination was discovered. **Table 5-6** shows the distributions (percentiles) for field blanks and 24-hour blanks during 2015.

For XRF analysis, the average and median Field Blanks were well below the average MDLs for all elements. The manufacturer-originated chromium background contamination issue in Teflon Filters that was described previously did not appear to affect the mean field blank chromium loading in 2014.

5.5 Analysis of Backup Filters for the URG 3000N

URG 3000N samplers used for sampling for carbon on quartz filters were installed 2007 through 2009, replacing sampling by the MetOne. Two new types of blank filters are defined for use with the URG 3000N: “backup filters,” and “24-hour blanks.”

The results for the 24-hour blanks, which are only run for quartz filters with the URG 3000N sampler, are included in **Table 5-6**. These blanks are somewhat analogous to Field Blanks because they are exposed in the field without airflow. However, 24-hour blanks are exposed for a much longer period of time than are the Field Blanks used for nylon and Teflon filters. See the CSN Field QAPP and the relevant SOPs for more information about how each type of blank is handled. The 24-hour blank results most likely include some portion of the well-known adsorption artifact, plus contamination picked up during shipping, handling, and analysis.

Table 5-6. Concentration Percentiles for Field and 24-hour Blanks (Reporting Batches 181 through 192).

Analyte	Mean (µg/m^{3})	Percentiles of Concentration (µg/m^{3})						
		5	10	25	Median	75	90	95
Cations and anions by ion chromatography (Field Blanks)								
Ammonium	0.0028	0	0	0	0	0	0	0
Potassium	0.0105	0	0	0	0	0.019	0.027	0.034
Sodium	0.0238	0	0.0093	0.014	0.019	0.030	0.046	0.058
Nitrate	0.0209	0	0	0	0.012	0.033	0.055	0.069
Sulfate	0.0280	0	0	0	0	0.023	0.068	0.11
Mass by gravimetry								
Particulate matter 2.5µm	1.02	0.42	0.52	0.83	0.83	1.0	1.7	1.9
Organic and elemental carbon by IMPROVE A Method (24-hour Blanks)								
OC IMPROVE TOR	0.12	0.0521	0.0602	0.0755	0.0992	0.133	0.197	0.263
OC IMPROVE TOT	0.12	0.0521	0.0604	0.0755	0.0992	0.134	0.197	0.258
EC IMPROVE TOR	0.0033	0	0	0	0	0	0.0024	0.0075
EC IMPROVE TOT	0.0021	0	0	0	0	0	0.0006	0.0052
O1 IMPROVE	0.0137	0	0	0.0032	0.0123	0.0199	0.0266	0.0317
O2 IMPROVE	0.0322	0.0122	0.0149	0.0205	0.0277	0.0366	0.0496	0.0625
O3 IMPROVE	0.0679	0.0277	0.0323	0.0414	0.0551	0.0753	0.114	0.143
O4 IMPROVE	0.0065	0	0	0	0.0008	0.0067	0.0164	0.0226
OP IMPROVE TOR	0.0020	0	0	0	0	0	0	0.0041

Analyte	Mean (µg/m³)	Percentiles of Concentration (µg/m³)						
		5	10	25	Median	75	90	95
OP IMPROVE TOT	0.0032	0	0	0	0	0	0.0024	0.0094
E1 IMPROVE	0.0045	0	0	0	0	0	0.0028	0.0098
E2 IMPROVE	0.0008	0	0	0	0	0	0.0004	0.0035
E3 IMPROVE	0	0	0	0	0	0	0	0
TC IMPROVE	0.126	0.0521	0.0604	0.0755	0.0992	0.134	0.200	0.263
Trace elements by XRF (Field Blanks)								
Aluminum	0.0016	0	0	0	0.0	0.0016	0.0027	0.0061
Antimony	0.0013	0	0	0	0.0	0	0.0035	0.0071
Arsenic	0.0001	0	0	0	0.0	0	0.0006	0.0010
Barium	0.0001	0	0	0	0.0	0	0	0
Bromine	0.0004	0	0	0	0.0002	0.0007	0.0011	0.0013
Cadmium	0.0014	0	0	0	0	0	0.0059	0.0094
Calcium	0.0008	0	0	0	0	0	0.0011	0.0018
Cerium	0.0003	0	0	0	0	0	0.0013	0.0020
Cesium	0.0001	0	0	0	0	0	0.0000	0.0001
Chlorine	0.0004	0	0	0	0	0	0.0011	0.0018
Chromium	0.0006	0	0	0	0	0	0.0009	0.0023
Cobalt	0.0002	0	0	0	0	0.0003	0.0006	0.0008
Copper	0.0002	0	0	0	0	0	0.0004	0.0007
Indium	0.0020	0	0	0	0	0.0021	0.0071	0.0106
Iron	0.0041	0	0	0	0.0006	0.0023	0.0077	0.0243
Lead	0.0001	0	0	0	0	0	0.0004	0.0008
Magnesium	0.0005	0	0	0	0	0	0.0020	0.0037
Manganese	0.0001	0	0	0	0	0	0.0002	0.0004
Nickel	0.0005	0	0	0	0	0.0003	0.0006	0.0016
Phosphorus	0.0000	0	0	0	0	0	0	0
Potassium	0.0006	0	0	0	0	0.0004	0.0015	0.0019
Rubidium	0.0003	0	0	0	0	0.0005	0.0010	0.0014
Selenium	0.0002	0	0	0	0	0.0003	0.0007	0.0009
Silicon	0.0018	0	0	0	0	0.0019	0.0040	0.0065
Silver	0.0008	0	0	0	0	0	0.0024	0.0059
Sodium	0.0005	0	0	0	0	0	0.0015	0.0040
Strontium	0.0002	0	0	0	0	0	0.0008	0.0013
Sulfur	0.0034	0	0	0	0	0	0.0015	0.0019
Tin	0.0006	0	0	0	0	0	0.0017	0.0039
Titanium	0.0004	0	0	0	0	0.0005	0.0015	0.0017
Vanadium	0.0003	0	0	0	0	0.0004	0.0011	0.0014
Zinc	0.0001	0	0	0	0	0	0.0005	0.0008
Zirconium	0.0004	0	0	0	0	0	0.0004	0.0034

"Backup Filters" are quartz filters placed immediately after the routine (front) filter. **Table 5-7** shows the percentile points of the backup filters acquired during the last few events in 2014 that are reported as part of this data summary report. As noted before, no backup filters were collected during 2015. Results from the backup filters might be one approach to assess the organic carbon artifact. However, a draft recommendation made by the EPA and the IMPROVE Steering Committee is to use monthly median 24-hr blanks[8], although it is yet to be finalized.

Table 5-7. Concentration Percentiles for URG 3000N Backup Filters

Analyte	Mean	Percentiles of Concentration (as ug/m^3)						
		5	10	20	50 (median)	70	90	95
OC IMPROVE TOR	0.37	0.12	0.16	0.22	0.34	0.50	0.64	0.69
OC IMPROVE TOT	0.38	0.12	0.16	0.23	0.35	0.51	0.64	0.72
EC IMPROVE TOR	0.011	0	0	0	0.0037	0.01	0.03	0.05
EC IMPROVE TOT	0.0036	0	0	0	0	0.0014	0.006	0.011
O1 IMPROVE	0.068	0.008	0.019	0.035	0.061	0.092	0.12	0.14
O2 IMPROVE	0.11	0.03	0.04	0.06	0.10	0.15	0.18	0.19
O3 IMPROVE	0.13	0.05	0.06	0.09	0.11	0.16	0.21	0.26
O4 IMPROVE	0.040	0.0	0.01	0.02	0.03	0.058	0.081	0.10
OP IMPROVE TOR	0.030	0.0	0	0	0.0	0.043	0.11	0.14
OP IMPROVE TOT	0.038	0.0	0	0	0.01	0.052	0.13	0.16
E1 IMPROVE	0.033	0.0	0	0	0.01	0.049	0.11	0.13
E2 IMPROVE	0.008	0.0	0	0	0.00	0.012	0.026	0.037
E3 IMPROVE	0	0	0	0	0	0	0	0
TC IMPROVE	0.38	0.12	0.16	0.23	0.35	0.52	0.64	0.72

[8] "Recommendations to Users of CSN and IMPROVE Speciation Data Regarding Sampling Artifact Correction for $PM_{2.5}$ Organic Carbon", Memorandum from Neil Frank, US EPA, to PM NAAQS Review Docket EPA-HQ-OAR-2007-0492, June 14, 2012.

6.0 External Audits

6.1 Performance Evaluation (PE) Audit Results

Annual interlaboratory intercomparison studies have been conducted since 2007 as part of EPA's QA oversight for the CSN and the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. The PE samples for these annual studies are prepared at the National Air and Radiation Environmental Laboratory (NAREL) located in Montgomery, AL. The filters used as PE samples are prepared by multiple collocation of samplers at the NAREL facility. Since the samples (except for metallic weights included in the gravimetry evaluation) are of unknown mass or concentration, agreement among the participating laboratories is the primary metric of performance.

The multi-lab PE study requires each participating laboratory to analyze a set of blind PE samples. Each lab received detailed instructions for analyzing the samples and reporting the results to NAREL. PE samples are provided for the following $PM_{2.5}$ speciation analyses:

- Gravimetric Mass Analysis
  - Teflon® filters
  - Metallic transfer weights
- Ion Chromatography (IC) Analysis – Nylon filters
- Carbon by Thermal Optical Analysis (TOA) – quartz filters
  - IMPROVE_A Method (by TOR/TOT)
  - CSN Method (by TOT) (previously referred to as the STN method)
- Elemental analysis by X-Ray Fluorescence (XRF) – Teflon® filters
  - 25 mm filters
  - 47 mm filters

6.1.1 Interlaboratory Performance Evaluation Study, 2014

The last interlaboratory performance evaluation was conducted in 2014. No evaluation was conducted by EPA in 2015. Participants in the 2014 interlaboratory study, in addition to RTI, included:

- California Air Resources Board (CARB)
- Desert Research Institute (DRI)

- Oregon Division of Environmental Quality (ODEQ)
- South Coast Air Quality Management District (AQMD)
- University of California, Davis (UCD)
- EPA NAREL

Unknowns were distributed to RTI and the other labs in February 2014 for gravimetry, XRF, ion chromatography, and OC/EC. RTI submitted its results to NAREL on March 14, 2014.

6.1.2 Interlaboratory Performance Results

A final report summarizing the findings from the interlaboratory performance evaluation is available online at:

http://www.epa.gov/ttnamti1/files/ambient/pm25/qa/multilabspeciationpt92013.pdf

RTI's performance on gravimetric mass, IC, OC/EC and XRF has been uniformly within the range of the other laboratories and in good agreement with the designated reference labs.

6.2 Technical Systems Audit (TSA)

EPA did not perform a TSA during 2015. The last TSA was performed in 2012 by EPA NAREL. The findings from that audit were summarized in a Technical Memorandum dated November 14, 2012, which is available online at

http://www.epa.gov/ttnamti1/files/ambient/pm25/spec/tsa2012final.pdf

The report included evaluation of RTI’s analytical results for the unknown samples that had been provided by the auditors. No deficiencies were noted.

7.0 List of References

7.1 List of CSN Documents

Type	Title	Date Revised	Author	Document No.
SOP	Standard Operating Procedure for Sample Handling and Archiving Laboratory (SHAL)	2/18/2009	O'Rourke	
SOP	Standard Operating Procedure for Shipping Filters to and from an Off-Site Laboratory	2/18/2009	O'Rourke	
SOP	Standard Operating Procedure for Long-Term Archiving of PM Filters and Extracts	8/24/2009	C. Haas	
SOP	Standard Operating Procedure for Procurement and Acceptance Testing of Teflon, Nylon, and Quartz Filters	9/19/2011	E. Hardison	
SOP	Standard Operating Procedure for Cleaning Nylon Filters Used for the Collection of $PM_{2.5}$ Material	8/25/2009	E. Hardison	
SOP	Standard Operating Procedure for Particulate Matter (PM) Gravimetric Analysis	7/8/2008	Greene	
SOP	Standard Operating Procedure for the X-Ray Fluorescence Analysis of Particulate Matter Deposits on Teflon Filters	8/19/2009	McWilliams	
SOP	Standard Operating Procedure for $PM_{2.5}$ Anion Analysis	8/26/2009	E. Hardison	
SOP	Standard Operating Procedure for $PM_{2.5}$ Cation Analysis	8/26/2009	E. Hardison	
SOP	DRI Model 2001 Thermal/Optical Carbon Analysis (TOR/TOT) of Aerosol Filter Samples – Method IMPROVE_A	10/22/2012	DRI	
SOP	Standard Operating Procedure for the Determination of Carbon Fractions in Particulate Matter Using the IMPROVE_A Heating Protocol on a DRI Model 2001 Analyzer	2/13/2009	Peterson	
SOP	Standard Operating Procedures for Temperature Calibration of the Sample Thermocouple in a Sunset Laboratory or a DRI Model 2001 Carbon Aerosol Analyzer	2/16/2009	Peterson	
SOP	Standard Operating Procedure for the Determination of Organic, Elemental, and Total Carbon in Particulate Matter Using a Thermal/Optical-Transmittance Carbon Analyzer	2/13/2009	Peterson	

Type	Title	Date Revised	Author	Document No.
SOP	Standard Operating Procedure for the Determination of Carbon Fractions in Particulate Matter Using the IMPROVE_A Heating Protocol on a Sunset Laboratory Dual-Mode Analyzer	2/17/2009	Peterson	
SOP	DRI Standard Operating Procedure: Analysis of Semi-Volatile Organic Compound by GC/MS	9/24/2008	DRI	
SOP	Standard Operating Procedure for Sample Preparation and Analysis of PM_{10} and $PM_{2.5}$ Samples by Scanning Electron Microscopy	7/8/2009	Crankshaw	
SOP	Standard Operating Procedure for Coating and Extracting Annular Denuders with Sodium Carbonate	2/17/2009	Eaton	
SOP	Standard Operating Procedures for Coating Aluminum Honeycomb Denuders With Magnesium Oxide	2/17/2009	Eaton	
SOP	Standard Operating Procedure for Coating Annular Denuders with XAD-4 Resin	5/9/2008	Eaton	
SOP	Procedures for Coating R&P Speciation Sampler Chemcomb™ Denuders with Sodium Carbonate	5/21/2008	Eaton	
SOP	Standard Operating Procedure for Coating and Extracting Denuders for Capture of Ammonia and Its Measurement	2/17/2009	Eaton	
SOP	Standard Operating Procedure for Coating and Extracting Compact Parallel-Plate Denuders for Determining Ammonia Determination	3/12/2010	Eaton	
SOP	Standard Operating Procedure for Database Operations	5/8/2008	Rickman	
SOP	Standard Operating Procedure for Assigning Data Validation Flags for the Chemical Speciation Network	5/15/2008	Wall	
SOP	Standard Operating Procedure—Speciation Data Processing Disaster Recovery Plan	5/21/2008	Rickman	
SOP	Standard Operating Procedure for the X-Series ICP-MS for the Analysis of Particulate Deposits on Teflon Filters	1/23/2012	Weber	
SOP	DRI Standard Operating Procedure: Procedure for Light Transmission Analysis	7/14/2008	DRI	
SOP	Standard Operating Procedure for Document Control and Storage for the $PM_{2.5}$ Chemical Speciation Program	2/18/2009	D. Haas	
SOP	Standard Operating Procedure for Corrective Action for the $PM_{2.5}$ Chemical Speciation Program	5/21/2008	Flanagan/Haas	

Type	Title	Date Revised	Author	Document No.
SOP	Standard Operating Procedure for Training for Staff Working on the $PM_{2.5}$ Chemical Speciation Program	5/8/2008	Haas	
QAPP	QAPP for PM2.5 of Chemical Speciation Samples	1/27/2014	RTI	RTI/0212053/01QA
Report	Tests of Acceptance of X-Ray Fluorescence Instrument #4 Operated by RTI International	11/4/2009	McWilliams/Flanagan	0212053.001.T06/01D
Report	2009 Annual Data Summary Report	3/1/2010	RTI and Subs	RTI/0212053/01ADS
Report	2010 Annual Data Summary Report	2/28/2011	RTI and Subs	RTI/0212053/02ADS
Report	2011 Annual Data Summary Report	2/28/2012	RTI and Subs	RTI/0212053/03ADS
Report	2012 Annual Data Summary Report	7/1/2013	RTI and Subs	RTI/0212053/04ADS
Report	2013 Annual Data Summary Report	12/9/2014	RTI and Subs	RTI/0212053/05ADS
Report	2014 Annual Data Summary Report	8/25/2015	RTI and Subs	RTI/0212053/06ADS
Report	2015 Annual Data Summary Report	2/29/2016	RTI and Subs	RTI/0212053/07ADS

Appendix A

Method Detection Limits

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Appendix A
Method Detection Limits (Network-wide Maximum)

Analysis	Analyte	Mass (µg)	Concentration (µg/m^3) by sampler type	
			SASS	URG 3000N
Gravimetry	Particulate matter 2.5µm	5.5	0.57	
Anions and Cations	Ammonium	0.24	0.03	
	Potassium	0.23	0.03	
	Sodium	0.29	0.03	
	Nitrate	0.21	0.02	
	Sulfate	0.16	0.02	
Organic and elemental carbon*	E1 IMPROVE	0.12		0.0040
	E2 IMPROVE	0.13		0.0041
	E3 IMPROVE	0.34		0.0111
	EC IMPROVE TOR	0.42		0.0136
	EC IMPROVE TOT	0.35		0.0113
	O1 IMPROVE	0.20		0.0064
	O2 IMPROVE	0.46		0.0149
	O3 IMPROVE	0.85		0.0275
	O4 IMPROVE	0.25		0.0080
	OC IMPROVE TOR	1.47		0.0477
	OC IMPROVE TOT	1.53		0.0496
	OP IMPROVE TOR	0.14		0.0046
	OP IMPROVE TOT	0.27		0.0089
	TC IMPROVE	1.65		0.0536
Trace Elements	Aluminum	0.242	0.0278	
	Antimony	0.500	0.0574	
	Arsenic	0.025	0.0029	
	Barium	0.105	0.0121	
	Bromine	0.022	0.0025	
	Cadmium	0.215	0.0247	
	Calcium	0.073	0.0084	
	Cerium	0.094	0.0107	
	Cesium	0.110	0.0126	
	Chlorine	0.078	0.0088	
	Chromium	0.025	0.0028	
	Cobalt	0.014	0.0016	
	Copper	0.024	0.0028	
	Indium	0.317	0.0364	
	Iron	0.020	0.0023	
	Lead	0.044	0.0050	
	Magnesium	0.175	0.0198	
	Manganese	0.018	0.0021	

Analysis	Analyte	Mass (µg)	Concentration (µg/m^3) by sampler type	
			SASS	URG 3000N
	Nickel	0.016	0.0019	
	Phosphorus	0.155	0.0178	
	Potassium	0.106	0.0119	
	Rubidium	0.025	0.0029	
	Selenium	0.025	0.0029	
	Silicon	0.178	0.0201	
	Silver	0.363	0.0416	
	Sodium	0.526	0.0594	
	Strontium	0.034	0.0039	
	Sulfur	0.095	0.0109	
	Tin	0.353	0.0405	
	Titanium	0.051	0.0059	
	Vanadium	0.037	0.0042	
	Zinc	0.025	0.0028	
	Zirconium	0.220	0.0252	

* MDLs and uncertainties for OC/EC are currently not reported to AQS pending EPA direction on uncertainty calculations. Values shown in this table are MDLs reported by DRI for the samples analyzed during 2015.

Appendix B
Data Completeness Summary

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Table B-1. Percentage of Routine Exposure Records – STN Sites
Monthly Percent Data Completeness by Site

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Allen Park	MI	261630001	5	SASS with URG 3000N	100	100	100	90	91	99	100	100	100	100	100
Allen Park	MI	261630001	5	URG 3000N	100	100	100	100	100	100	100	100	91	100	100
Bakersfield-California Ave	CA	060290014	5	SASS with URG 3000N	0	50	69	67	82	71	86	80	70	75	86
Bakersfield-California Ave	CA	060290014	5	URG 3000N	0	0	33	78	82	71	86	80	70	75	75
Bakersfield-California Ave (Collocated)	CA	060290014	6	SASS with URG 3000N		99	100	80	100	75	83	75	80	83	80
Bakersfield-California Ave (Collocated)	CA	060290014	6	URG 3000N		0	0	20	17	0	17	0	20	0	0
Beacon Hill - Seq	WA	530330080	6	SASS with URG 3000N	90	99	90	100	100	100	100	100	100	100	100
Beacon Hill - Seq	WA	530330080	6	URG 3000N	90	100	83	100	100	100	100	100	100	100	100
Blair Street	MO	295100085	6	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Blair Street	MO	295100085	6	URG 3000N	100	100	100	100	91	100	100	70	91	100	100
Burlington	VT	500070012	5	SASS with URG 3000N	100	100	100	100	90	86	100	100	100	100	100
Burlington	VT	500070012	5	URG 3000N	100	100	100	100	100	86	78	88	80	100	100
Capitol - Seq	LA	220330009	5	SASS with URG 3000N	100	100	81	57	92	100	100	92	100	99	100
Capitol - Seq	LA	220330009	5	URG 3000N	100	100	83	80	86	100	100	83	100	100	100
Chamizal - Seq	TX	481410044	5	SASS with URG 3000N	88	99	100	100	100	100	90	99	81	22	100
Chamizal - Seq	TX	481410044	5	URG 3000N	50	100	100	100	100	100	100	100	83	100	100
Chicopee - Seq	MA	250130008	5	SASS with URG 3000N	100	100	100	100	100	100	90	100	100	100	92
Chicopee - Seq	MA	250130008	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Com Ed - Seq	IL	170310076	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	99	100	100
Com Ed - Seq	IL	170310076	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Criscuolo Park	CT	090090027	5	SASS with URG 3000N	93	84	86	100	100	80	45	27	99		
Criscuolo Park	CT	090090027	5	URG 3000N	100	100	88	100	100	78	73	80	100		
Criscuolo Park - Seq	CT	090090027	5	SASS with URG 3000N									100	100	50

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Criscuolo Park - Seq	CT	090090027	5	URG 3000N									100	80	50
Deer Park - Met One	TX	482011039	6	SASS with URG 3000N	100	100	100	100	100	92	100	100	100	100	100
Deer Park - Met One	TX	482011039	6	URG 3000N	100	89	100	100	100	100	100	100	100	100	100
Deer Park Collocated - Met One	TX	482011039	7	SASS with URG 3000N	100	100	100	80	71	97	100	100	100	100	100
Deer Park Collocated - Met One	TX	482011039	7	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Elizabeth Lab	NJ	340390004	5	SASS with URG 3000N	100	100	88	100	100	100	100	100	100	100	100
Elizabeth Lab	NJ	340390004	5	URG 3000N	100	100	100	100	100	86	100	100	100	100	100
Essex - Seq	MD	240053001	5	SASS with URG 3000N	100	100	91	100	100	100	100	100	100	100	78
Essex - Seq	MD	240053001	5	URG 3000N	50	100	100	60	71	100	100	100	100	100	80
Fargo NW	ND	380171004	5	SASS with URG 3000N	100	100	100	100	99	100	100	89	100	100	100
Fargo NW	ND	380171004	5	URG 3000N	100	100	100	80	100	100	91	90	100	100	100
G.T. Craig	OH	390350060	5	SASS with URG 3000N	100	63	81	75	100	89	92	100	100	100	100
G.T. Craig	OH	390350060	5	URG 3000N	100	75	88	88	100	100	100	100	100	100	88
G.T. Craig - Collocated	OH	390350060	6	SASS with URG 3000N	86	100	33	100	100	75	100	100	100	100	85
G.T. Craig - Collocated	OH	390350060	6	URG 3000N	100	100	100	100	83	100	100	100	100	100	80
Garinger High School - Seq	NC	371190041	5	SASS with URG 3000N	100	100	100	100	82	89	100	100	80	99	100
Garinger High School - Seq	NC	371190041	5	URG 3000N	100	100	100	100	100	100	100	100	83	100	100
Hawthorne	UT	490353006	5	SASS with URG 3000N	83	100	100	90	91	100	100	100	100	99	89
Hawthorne	UT	490353006	5	URG 3000N	91	89	100	80	82	100	100	90	91	100	89
Henrico Co.	VA	510870014	5	SASS with URG 3000N	80	88	77	100	100	100	92	100	100	91	100
Henrico Co.	VA	510870014	5	URG 3000N	22	50	38	75	100	100	100	100	100	100	100
Hinton - Seq	TX	481130069	5	SASS with URG 3000N	80	100	99	100	100	100	100	99	100	100	93
Hinton - Seq	TX	481130069	5	URG 3000N	80	100	100	100	100	80	67	83	67	100	83
Indpls. Washington Park	IN	180970078	5	SASS with URG 3000N	100										
Indpls. Washington Park	IN	180970078	5	URG 3000N	100										
Indpls. Washington Park - Seq	IN	180970078	5	SASS with URG 3000N	100	100	83	100	99	100	100	100	99	99	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Indpls. Washington Park - Seq	IN	180970078	5	URG 3000N	100	100	83	100	100	100	100	100	100	100	100
Jackson NCORE	MS	280490020	5	SASS with URG 3000N	80	100	89	100	100	100	100	100	100	100	100
Jackson NCORE	MS	280490020	5	URG 3000N	89	100	100	88	100	100	89	100	100	100	75
JFK Center	KS	202090021	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
JFK Center	KS	202090021	5	URG 3000N	89	100	100	100	100	86	100	100	100	100	100
La Casa	CO	080310026	5	SASS with URG 3000N	73	89	88	100	91	71	100	99	100	100	78
La Casa	CO	080310026	5	URG 3000N	30	100	63	100	73	43	100	75	90	71	89
Lawrenceville	PA	420030008	6	SASS with URG 3000N	91	100	100	100	80	0			0	88	88
Lawrenceville	PA	420030008	6	URG 3000N	100	100	100	100	80	0			0	88	88
McMillan Reservoir - Met One	DC	110010043	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	91	100	100
McMillan Reservoir - Met One	DC	110010043	5	URG 3000N	100	89	100	100	100	100	100	90	100	100	100
MLK	DE	100032004	5	SASS with URG 3000N	100	100	100	78	100	100	99	100	100	78	40
MLK	DE	100032004	5	URG 3000N	100	100	100	78	100	100	100	100	100	78	40
New Brunswick	NJ	340230006	5	SASS with URG 3000N	100	100	91	100	100	100	100	100	100	100	100
New Brunswick	NJ	340230006	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	88
New Brunswick (Collocated)	NJ	340230006	6	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	83
New Brunswick (Collocated)	NJ	340230006	6	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
North Birmingham - Seq	AL	010730023	5	SASS with URG 3000N	80	100	90	100	100	80	93	100	89	90	100
North Birmingham - Seq	AL	010730023	5	URG 3000N	90	83	83	100	100	100	100	100	100	100	100
Peoria Site 1127 - Seq	OK	401431127	5	SASS with URG 3000N	90	100	100	100	100	100	90	99	100	100	89
Peoria Site 1127 - Seq	OK	401431127	5	URG 3000N	100	100	100	100	100	80	83	83	83	100	80
Philips - Seq	MN	270530963	5	SASS with URG 3000N	80	100	100	100	100	100	100	100	99	100	100
Philips - Seq	MN	270530963	5	URG 3000N	90	100	100	100	86	100	100	100	100	100	100
Phoenix Supersite - Seq	AZ	040139997	7	SASS	100										
Phoenix Supersite - Seq	AZ	040139997	7	SASS with URG 3000N	88	100	100	100	100	100	98	100	99	100	100
Phoenix Supersite - Seq	AZ	040139997	7	URG 3000N	90	100	100	100	86	100	100	100	100	100	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
Portland - SE Lafayette	OR	410510080	6	SASS with URG 3000N	100	100	100	100	91	88	92	100	100	99	100
Portland - SE Lafayette	OR	410510080	6	URG 3000N	100	89	100	100	91	100	92	100	100	89	100
Reno - Seq	NV	320310016	5	SASS with URG 3000N	100	100	100	100	99	100	90	100	100	100	100
Reno - Seq	NV	320310016	5	URG 3000N	100	100	100	100	100	60	100	100	100	100	100
Riverside-Rubidoux - Seq	CA	060658001	5	SASS with URG 3000N	80	100	90	100	92	100	91	99	100	90	91
Riverside-Rubidoux - Seq	CA	060658001	5	URG 3000N	90	100	100	100	86	100	100	100	83	100	83
Riverside-Rubidoux (Collocated)	CA	060658001	6	SASS with URG 3000N	100	100	80	100	100	100	100	100	100	83	83
Riverside-Rubidoux (Collocated)	CA	060658001	6	URG 3000N	100	100	100	100	100	100	100	100	50	100	83
Roxbury (Boston) - collocated	MA	250250042	6	SASS with URG 3000N	100	100	100	100	100	100	100	85	99	100	100
Roxbury (Boston) - collocated	MA	250250042	6	URG 3000N	100	100	100	100	83	100	100	100	100	100	100
Roxbury (Boston) - Seq	MA	250250042	5	SASS with URG 3000N	100	100	100	100	100	100	91	91	100	100	100
Roxbury (Boston) - Seq	MA	250250042	5	URG 3000N	100	100	100	100	86	100	100	100	100	100	100
Sacramento Del Paso Manor - Seq	CA	060670006	5	SASS with URG 3000N	100	91	83	100	100	100	100	100	100	100	100
Sacramento Del Paso Manor - Seq	CA	060670006	5	URG 3000N	100	83	100	100	100	100	100	100	100	100	100
San Jose - Jackson Street	CA	060850005	5	SASS with URG 3000N	100	100	89	100	100	100	100	100	100	100	100
San Jose - Jackson Street	CA	060850005	5	URG 3000N	100	100	100	100	100	100	89	100	100	100	100
SER-DNR Headquarters	WI	550790026	5	SASS with URG 3000N	100	100	100	90	91	100	91	100	82	99	91
SER-DNR Headquarters	WI	550790026	5	URG 3000N	95	100	90	80	91	100	73	100	91	100	100
Shelby Farms - Seq	TN	471570075	6	SASS with URG 3000N	100	100	100	100	100	100	80	100	99	78	83
Shelby Farms - Seq	TN	471570075	6	URG 3000N	100	100	100	100	100	100	83	100	100	100	100
South DeKalb - Met One	GA	130890002	5	SASS with URG 3000N	90	100	100	100	100	100	100	99	99	100	100
South DeKalb - Met One	GA	130890002	5	URG 3000N	94	100	88	100	100	100	100	100	90	100	100
St. Lukes Meridian (IMS) - Seq	ID	160010010	5	SASS with URG 3000N	93	99	100	100	100	100	100	91	100	100	99

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
St. Lukes Meridian (IMS) - Seq	ID	160010010	5	URG 3000N	100	100	100	100	100	100	100	100	100	80	100
Sydney	FL	120573002	5	SASS with URG 3000N	99	100	80	100	100	100	100	100	99	99	70
Sydney	FL	120573002	5	URG 3000N	100	100	90	100	100	100	100	100	100	100	90
Univ. of Florida Ag School - Seq	FL	120111002	5	SASS with URG 3000N	75										
Univ. of Florida Ag School - Seq	FL	120111002	5	URG 3000N	38										
Woolworth St	NE	310550019	5	SASS with URG 3000N	86	95	84	95	95	95	95	95	95	95	95
Woolworth St	NE	310550019	5	URG 3000N	100	100	88	100	90	100	100	100	100	100	100
WV Guthrie Ag Center - Seq	WV	540390011	5	SASS with URG 3000N	22	53	100	90	100	100	100	91	100	100	91
WV Guthrie Ag Center - Seq	WV	540390011	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	83

Table B-2. Percentage of Routine Exposure Records – Non-STN Sites
Monthly Percent Data Completeness by Site

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
5 Points	OH	391530023	5	SASS with URG 3000N	88	100	69	100	88	100	100	100	75	100	60
5 Points	OH	391530023	5	URG 3000N	100	100	100	100	100	100	100	100	75	100	60
AL - Phenix City	AL	011130001	5	SASS with URG 3000N	100	100	100	100	83	100	100	80	100	100	100
AL - Phenix City	AL	011130001	5	URG 3000N	50	100	100	100	100	100	100	80	100	100	100
Alaska NCore	AK	020900034	5	SASS with URG 3000N	98	90	89	90	100	100	100	100	71	100	99
Alaska NCore	AK	020900034	5	URG 3000N	75	56	89	82	90	100	91	100	100	89	100
Albany Co HD	NY	360010005	5	SASS with URG 3000N	100	100	85	100	100	100	100	99	98	100	100
Albany Co HD	NY	360010005	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Arendtsville	PA	420010001	5	SASS with URG 3000N	83	100	100	100	100	100	100	100	100	100	100
Arendtsville	PA	420010001	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Arnold West - Met One	MO	290990019	6	SASS with URG 3000N	100	88	100	100	100	100	86	100	100	100	100
Arnold West - Met One	MO	290990019	6	URG 3000N	100	88	100	100	100	100	100	100	100	100	100
Ashland Health Department	KY	210190017	5	SASS with URG 3000N	100										
Ashland Health Department	KY	210190017	5	URG 3000N	100										
Athens - Met One	GA	130590001	5	SASS with URG 3000N	0	0									
Athens - Met One	GA	130590001	5	URG 3000N	0	0									
Augusta - Met One	GA	132450091	5	SASS with URG 3000N	100	72	59	80	80	100	100	93	100	100	83
Augusta - Met One	GA	132450091	5	URG 3000N	100	75	60	80	100	80	67	100	100	100	83
Blaine Anoka County Airport - Seq	MN	270031002	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	99	100	100
Blaine Anoka County Airport - Seq	MN	270031002	5	URG 3000N	100	83	100	100	86	100	100	100	100	100	100
Bonne Terre - Met One	MO	291860005	5	SASS with URG 3000N	100	67									
Bonne Terre - Met One	MO	291860005	5	URG 3000N	89	83									
Bountiful	UT	490110004	5	SASS with URG 3000N	2	100	100	100	100	75	100	80	100	100	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Bountiful	UT	490110004	5	URG 3000N	100	100	100	100	100	75	100	100	100	100	80
Broward County nCore	FL	120110034	5	SASS with URG 3000N	100	91	100	100	94	100	99	100	90	100	100
Broward County nCore	FL	120110034	5	URG 3000N	100	83	100	100	100	80	100	100	67	100	100
Buffalo - Met One	NY	360290005	6	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Buffalo - Met One	NY	360290005	6	URG 3000N	100	100	100	100	100	75	100	100	75	100	100
Buncombe County Board of Education	NC	370210034	5	SASS with URG 3000N	83	100									
Buncombe County Board of Education	NC	370210034	5	URG 3000N	100	100									
Butte-Greeley School	MT	300930005	5	SASS with URG 3000N	100	99	63	60	81	100	83	80	100	100	60
Butte-Greeley School	MT	300930005	5	URG 3000N	90	0	80	100	100	100	83	80	100	100	80
Camden-NJ	NJ	340070002	5	SASS with URG 3000N	89	100	100	100	100	100	100	100	98	88	100
Camden-NJ	NJ	340070002	5	URG 3000N	94	100	100	100	100	75	83	100	100	100	100
Cannons Lane	KY	211110067	6	SASS with URG 3000N	92	100	90	100	100	100	100	100	100	100	98
Cannons Lane	KY	211110067	6	URG 3000N	73	89	90	100	100	100	100	100	100	100	100
Canton Fire Station	OH	391510017	5	SASS with URG 3000N	100	100	83	100	100	100	100	100	99	99	83
Canton Fire Station	OH	391510017	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Chester (PA)	PA	420450002	5	SASS with URG 3000N	100	100	99	100	100	100	100	81	98	100	80
Chester (PA)	PA	420450002	5	URG 3000N	100	80	100	80	80	100	100	100	100	100	80
Chesterfield	SC	450250001	5	SASS with URG 3000N	88	100	83	100	100	100	36	83	100	100	100
Chesterfield	SC	450250001	5	URG 3000N	100	75	80	60	100	100	83	100	25	33	40
Cheyenne NCore - Seq	WY	560210100	5	SASS with URG 3000N	90	100	83	67	80	100	100	100	62	60	67
Cheyenne NCore - Seq	WY	560210100	5	URG 3000N	90	100	14	60	83	100	100	100	60	50	67
Children's Park - Seq	AZ	040191028	5	SASS with URG 3000N	100	100	100	89	100	100	99	100	99	100	100
Children's Park - Seq	AZ	040191028	5	URG 3000N	100	100	100	80	86	100	100	100	100	100	100
Columbus - Met One	GA	132150011	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	98	100	100
Columbus - Met One	GA	132150011	5	URG 3000N	90	100	100	100	100	100	100	100	100	100	100
Commerce City	CO	080010006	5	SASS with URG 3000N	100	100	100	100	80	75					

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
Commerce City	CO	080010006	5	URG 3000N	90	75	100	83	80	75					
Dearborn	MI	261630033	5	SASS with URG 3000N	100	100	100	100	100	75	100	100	100	100	100
Dearborn	MI	261630033	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Del Norte - Seq	NM	350010023	5	SASS with URG 3000N	90	100	100	100	100	100	100	100	100	100	100
Del Norte - Seq	NM	350010023	5	URG 3000N	50	100	100	100	86	100	100	100	100	80	100
Division St. - Seq	NY	360610134	5	SASS with URG 3000N	100	100	90	100	100	100	100	91	100	100	100
Division St. - Seq	NY	360610134	5	URG 3000N	100	100	50	40	29	100	100	100	100	100	83
Douglas - Met One	GA	130690002	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Douglas - Met One	GA	130690002	5	URG 3000N	100	100	100	40	100	75	100	100	100	100	100
East Providence - Seq	RI	440071010	5	SASS with URG 3000N	100	100	100	100	91	88	100	90	100	100	99
East Providence - Seq	RI	440071010	5	URG 3000N	90	100	83	100	86	60	100	100	100	100	83
El Cajon - Floyd Smith Drive	CA	060731018	5	SASS with URG 3000N	99	88	100	100	100	100	89	100	100	75	50
El Cajon - Floyd Smith Drive	CA	060731018	5	URG 3000N	100	88	100	100	80	100	89	100	100	75	50
Elkhart Prairie Street	IN	180390008	5	SASS with URG 3000N	100										
Elkhart Prairie Street	IN	180390008	5	URG 3000N	100										
Erie	PA	420490003	5	SASS with URG 3000N	57	100									
Erie	PA	420490003	5	URG 3000N	75	100									
Evansville Buena Vista Rd	IN	181630021	5	SASS with URG 3000N	100	100	65	83	100	100	100	100	100	100	100
Evansville Buena Vista Rd	IN	181630021	5	URG 3000N	100	100	100	100	83	100	100	100	100	83	100
Fairbanks State Bldg	AK	020900010	6	SASS with URG 3000N	100										
Fairbanks State Bldg	AK	020900010	6	URG 3000N	93										
Florence	PA	421255001	5	SASS with URG 3000N	83	100	100	83	80	100	67	100	75	83	80
Florence	PA	421255001	5	URG 3000N	40	75	100	100	100	100	100	100	100	100	100
Freemansburg	PA	420950025	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Freemansburg	PA	420950025	5	URG 3000N	100	100	80	100	100	100	83	100	100	100	100
Fresno - Garland	CA	060190011	5	SASS with URG 3000N	91	90	100	90	92	97	84	100	100	89	81
Fresno - Garland	CA	060190011	5	URG 3000N	86	100	100	91	91	100	91	100	100	78	90

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Gary litri	IN	180890022	5	SASS with URG 3000N	99	100	100	100	86	100	100	100	100	100	100
Gary litri	IN	180890022	5	URG 3000N	100	100	100	80	100	100	100	80	100	100	100
Grand Rapids - Seq	MI	260810020	5	SASS with URG 3000N	100	100	93	89	100	100	100	100	100	100	100
Grand Rapids - Seq	MI	260810020	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	83
Granite City	IL	171190024	5	SASS with URG 3000N	79	96	77	96	92	97	97	94	97	96	95
Granite City	IL	171190024	5	URG 3000N	90	100	60	80	83	100	100	100	100	80	100
Grayson	KY	210430500	5	SASS with URG 3000N	75										
Grayson	KY	210430500	5	URG 3000N	83										
Green Bay East High School	WI	550090005	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Green Bay East High School	WI	550090005	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Greensburg	PA	421290008	5	SASS with URG 3000N	100	100	100	100	80	80	100	80	75	100	96
Greensburg	PA	421290008	5	URG 3000N	100	100	100	100	80	80	100	80	75	100	80
Greenville ESC	SC	450450015	5	SASS with URG 3000N	75	0									
Greenville ESC	SC	450450015	5	URG 3000N	25	0									
Harrisburg	PA	420430401	5	SASS with URG 3000N	83	50									
Harrisburg	PA	420430401	5	URG 3000N	100	50									
Hattie Avenue	NC	370670022	5	SASS with URG 3000N	100	98	75	100	83	75	100	100	100	86	100
Hattie Avenue	NC	370670022	5	URG 3000N	100	100	75	50	83	75	100	100	100	100	100
Head Start	OH	390990014	5	SASS with URG 3000N	86	100									
Head Start	OH	390990014	5	URG 3000N	90	100									
Horicon Palmatory	WI	550270001	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	91	100	91
Horicon Palmatory	WI	550270001	5	URG 3000N	100	100	100	100	100	100	100	100	91	100	100
Houghton Lake	MI	261130001	5	SASS with URG 3000N	100	100									
Houghton Lake	MI	261130001	5	URG 3000N	100	100									
HU-Beltsville Met One - Seq	MD	240330030	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
HU-Beltsville Met One - Seq	MD	240330030	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Huntsville Old Airport	AL	010890014	5	SASS with URG 3000N	100	100									

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Huntsville Old Airport	AL	010890014	5	URG 3000N	100	100									
IS 52 - Seq	NY	360050110	5	SASS with URG 3000N	100	100	100	100	100	100	100	99	99	100	100
IS 52 - Seq	NY	360050110	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Jasper Post Office	IN	180372001	5	SASS with URG 3000N	100	100	100	100	100	100	83	100	100	100	100
Jasper Post Office	IN	180372001	5	URG 3000N	100	100	100	100	100	100	100	80	100	100	100
Jefferson Elementary - Seq	IA	191630015	5	SASS with URG 3000N	89	100	100	100	100	100	80	100	100	100	100
Jefferson Elementary - Seq	IA	191630015	5	URG 3000N	100	67	67	100	100	100	100	100	100	100	100
Jeffersonville Walnut St	IN	180190006	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Jeffersonville Walnut St	IN	180190006	5	URG 3000N	100	100	100	100	83	100	100	100	100	100	100
Jerome Mack Middle School	NV	320030540	5	SASS with URG 3000N	100	100	100	88	100	100	99	100	100	88	100
Jerome Mack Middle School	NV	320030540	5	URG 3000N	100	100	100	88	100	100	100	100	100	88	100
Johnstown	PA	420210011	5	SASS with URG 3000N	100	100	98	100	100	100	100	63	100	100	100
Johnstown	PA	420210011	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Kapolei	HI	150030010	5	SASS with URG 3000N	83	100	70	99	65	62	83	88	83	80	80
Kapolei	HI	150030010	5	URG 3000N	86	89	50	100	64	63	83	88	75	80	80
Karnack - Met One	TX	482030002	5	SASS with URG 3000N	100	100	100	100	83	100	100	100	100	100	100
Karnack - Met One	TX	482030002	5	URG 3000N	100	100	100	100	83	100	100	100	75	100	100
Lancaster	PA	420710007	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Lancaster	PA	420710007	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Lawrence County	TN	470990002	5	SASS with URG 3000N	100	100									
Lawrence County	TN	470990002	5	URG 3000N	100	100									
Lexington (NC)	NC	370570002	5	SASS with URG 3000N	86	0									
Lexington (NC)	NC	370570002	5	URG 3000N	92	0									
Lexington Health Department	KY	210670012	5	SASS with URG 3000N	100										
Lexington Health Department	KY	210670012	5	URG 3000N	100										
Liberty (PA)	PA	420030064	6	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Liberty (PA)	PA	420030064	6	URG 3000N	100	100	100	100	100	100	100	100	100	100	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	182	183	184	185	186	187	188	189	190	191
Liberty - Met One	MO	290470005	5	SASS with URG 3000N	100	100									
Liberty - Met One	MO	290470005	5	URG 3000N	100	100									
Lindon	UT	490494001	5	SASS with URG 3000N	80	100	100	60	100	100	100	100	100	83	100
Lindon	UT	490494001	5	URG 3000N	88	100	100	60	100	100	100	100	100	100	100
Linn County Health	IA	191130040	5	SASS with URG 3000N	100	100									
Linn County Health	IA	191130040	5	URG 3000N	100	100									
Lockeland School - Met One	TN	470370023	5	SASS with URG 3000N	100	50									
Lockeland School - Met One	TN	470370023	5	URG 3000N	100	100									
Lorain	OH	390933002	5	SASS with URG 3000N	100	100	100	100	83	100	100	100	100	100	100
Lorain	OH	390933002	5	URG 3000N	100	100	100	100	100	100	100	50	80	100	100
Macon - Met One	GA	130210007	5	SASS with URG 3000N	100	100	100	100	83	100	100	100	100	100	100
Macon - Met One	GA	130210007	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Maple Canyon	OH	390490081	6	SASS with URG 3000N	100	100									
Maple Canyon	OH	390490081	6	URG 3000N	100	100									
Marcus Hook	PA	420450109	5	SASS with URG 3000N	83	100	100	100	100	100	83	80	100	100	100
Marcus Hook	PA	420450109	5	URG 3000N	88	100	80	100	83	100	67	40	100	83	80
Marysville - 7th Ave	WA	530611007	5	SASS with URG 3000N	100	100	100								
Marysville - 7th Ave	WA	530611007	5	URG 3000N	90	100	100								
Mechanicsburg	IN	180650003	5	SASS with URG 3000N	100	100	85	100	100	100	100	80	100	83	100
Mechanicsburg	IN	180650003	5	URG 3000N	100	100	100	60	100	100	83	80	75	100	100
Millbrook - Seq	NC	371830014	5	SASS with URG 3000N	100	100	100	100	94	100	95	95	86	96	96
Millbrook - Seq	NC	371830014	5	URG 3000N	100	100	100	100	100	100	100	100	83	100	100
MN - Rochester	MN	271095008	5	SASS with URG 3000N	100	100									
MN - Rochester	MN	271095008	5	URG 3000N	100	100									
MOMS	AL	011011002	5	SASS with URG 3000N	100	100									
MOMS	AL	011011002	5	URG 3000N	100	100									
Moundsville Armory	WV	540511002	5	SASS with URG 3000N	100	100	100	100	100	100	83	80	100	100	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
Moundsville Armory	WV	540511002	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	83
Naperville	IL	170434002	5	SASS with URG 3000N	95	95	95	76	95	95	95	95	95	95	95
Naperville	IL	170434002	5	URG 3000N	100	75	80	80	100	100	100	100	100	100	100
National Trail High School - Seq	OH	391351001	5	SASS with URG 3000N	70	100	100	78	92	100	100	100	100	100	85
National Trail High School - Seq	OH	391351001	5	URG 3000N	90	100	100	80	86	100	100	100	100	100	86
New Garden	PA	420290100	5	SASS with URG 3000N	100	100	100	100	100	100	88	100	98	83	100
New Garden	PA	420290100	5	URG 3000N	100	100	80	100	83	100	100	100	75	83	100
Newark	NJ	340130003	5	SASS with URG 3000N	100	100	88	100	90	100	99	100	100	100	75
Newark	NJ	340130003	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	75
NJ-Chester	NJ	340273001	5	SASS with URG 3000N	99	100	100	100	100	100	100	99	98	100	100
NJ-Chester	NJ	340273001	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
NLR Parr	AR	051190007	5	SASS with URG 3000N	92	100	89	80	100	89	100	100	100	99	100
NLR Parr	AR	051190007	5	URG 3000N	95	100	90	80	100	100	100	100	100	100	100
North Los Angeles - Seq	CA	060371103	5	SASS with URG 3000N	80	99	100	100	100	100	100	100	100	89	92
North Los Angeles - Seq	CA	060371103	5	URG 3000N	90	100	100	100	100	100	100	100	100	100	100
Northbrook - Seq	IL	170314201	5	SASS with URG 3000N	76	95	95	95	86	95	95	78	95	95	80
Northbrook - Seq	IL	170314201	5	URG 3000N	90	100	100	100	100	83	83	83	100	100	100
Northeast Wastewater Treatment Plant	PA	421010048	5	SASS with URG 3000N	100	97	99	100	100	100	82	99	63	87	89
Northeast Wastewater Treatment Plant	PA	421010048	5	URG 3000N	100	100	100	100	100	100	82	100	64	67	80
OCUSA Campus	OK	401091037	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	78	100	100
OCUSA Campus	OK	401091037	5	URG 3000N	100	100	100	100	100	100	100	80	100	100	100
ODOT Garage	OH	390870012	5	SASS with URG 3000N	100	97									
ODOT Garage	OH	390870012	5	URG 3000N	100	100									
Parklane	SC	450790007	5	SASS with URG 3000N	97	96	93	95	87	95	87	95	88	74	95
Parklane	SC	450790007	5	URG 3000N	95	100	80	100	91	100	91	90	100	67	100
PerkinstownCASNET	WI	551198001	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
PerkinstownCASNET	WI	551198001	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Pinnacle State Park - Seq	NY	361010003	5	SASS with URG 3000N	100	91	100	89	100	100	100	92	96	100	93
Pinnacle State Park - Seq	NY	361010003	5	URG 3000N	100	83	83	80	86	50	100	100	100	100	100
Platteville	CO	081230008	5	SASS with URG 3000N	100	100	100	100	60	100	100	100	75	100	100
Platteville	CO	081230008	5	URG 3000N	100	100	100	100	80	100	100	100	100	100	100
Port Huron	MI	261470005	5	SASS with URG 3000N	100	100									
Port Huron	MI	261470005	5	URG 3000N	100	100									
Public Health Building - Met One	IA	191530030	5	SASS with URG 3000N	67										
Public Health Building - Met One	IA	191530030	5	URG 3000N	80										
Queens College - Seq	NY	360810124	6	SASS with URG 3000N	100	93	100	100	100	100	100	100	100	99	100
Queens College - Seq	NY	360810124	6	URG 3000N	90	100	100	100	100	100	67	83	100	80	100
Reading Airport	PA	420110011	5	SASS with URG 3000N	100	100									
Reading Airport	PA	420110011	5	URG 3000N	100	100									
Ritner	PA	421010055	5	SASS with URG 3000N	98	100	100	100	98	100	85	98	100	83	100
Ritner	PA	421010055	5	URG 3000N	90	100	100	100	100	100	83	100	100	83	100
Rochester Primary - Seq	NY	360551007	5	SASS with URG 3000N	100	89	82	100	100	56	100	91	100	86	73
Rochester Primary - Seq	NY	360551007	5	URG 3000N	100	80	100	100	100	100	100	83	100	75	67
Rockwell	NC	371590021	5	SASS with URG 3000N	71	0									
Rockwell	NC	371590021	5	URG 3000N	83	0									
Rome Elementary	GA	131150003	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Rome Elementary	GA	131150003	5	URG 3000N	100	100	100	100	83	100	100	100	100	67	100
Rossville - Met One	GA	132950002	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Rossville - Met One	GA	132950002	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Scranton	PA	420692006	5	SASS with URG 3000N	100	100									
Scranton	PA	420692006	5	URG 3000N	40	100									
Seattle 10th Ave	WA	530330030	5	SASS with URG 3000N	100	100		80	100	100	86	80	100	99	100

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
Seattle 10th Ave	WA	530330030	5	URG 3000N	100	100		80	100	100	100	80	100	100	100
Shreveport Airport - Met One	LA	220150008	5	SASS with URG 3000N	50	100	50	100	86	100	88	67	83	100	100
Shreveport Airport - Met One	LA	220150008	5	URG 3000N	70	100	50	60	86	100	88	67	83	80	100
Sieben Flats - Seq	MT	300490004	5	SASS with URG 3000N	100	100	100	100	100	78	100	100	99	100	100
Sieben Flats - Seq	MT	300490004	5	URG 3000N	90	83	67	100	86	60	100	83	100	100	100
Sinclair Community College	OH	391130038	5	SASS with URG 3000N	100	100	100	100	79	95	100	100	100	99	80
Sinclair Community College	OH	391130038	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Sioux Falls School Site	SD	460990008	5	SASS with URG 3000N	92	86	98	80	100	100	91	89	80	90	78
Sioux Falls School Site	SD	460990008	5	URG 3000N	95	75	100	80	100	100	91	90	90	90	78
Skyview	FL	121030026	5	SASS with URG 3000N	100	100									
Skyview	FL	121030026	5	URG 3000N	90	50									
Spring Hill Elementary School	TN	470931020	5	SASS with URG 3000N	83	100	100	100	100	100	100	100	97	100	100
Spring Hill Elementary School	TN	470931020	5	URG 3000N	100	100	100	100	100	100	100	100	100	80	100
Springfield Pumping Station - Met One	IL	170310057	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	75	100	100
Springfield Pumping Station - Met One	IL	170310057	5	URG 3000N	80	50	100	60	100	100	100	100	75	100	100
St Theo	OH	390350038	6	SASS with URG 3000N	100	100	80	100	83	98	98	80	98	100	99
St Theo	OH	390350038	6	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Sterling State Park	MI	261150006	5	SASS with URG 3000N	100	100									
Sterling State Park	MI	261150006	5	URG 3000N	100	100									
Steubenville	OH	390810017	5	SASS with URG 3000N	80	100	80	100	100	75	83	100	75	100	100
Steubenville	OH	390810017	5	URG 3000N	100	100	100	80	83	100	100	100	100	100	100
SW HS	MI	261630015	5	SASS with URG 3000N	86	78	100	100	100	75	100	83	100	100	60
SW HS	MI	261630015	5	URG 3000N	80	75	100	100	83	75	100	100	100	100	60
Tacoma - Met One	WA	530530029	5	SASS with URG 3000N	100	100	100	83	100	100	98	80	100	100	83
Tacoma - Met One	WA	530530029	5	URG 3000N	100	100	100	83	100	100	100	80	100	100	100
Taft	OH	390610040	5	SASS with URG 3000N	100	100	100	100	100	100	92	100	93	100	87

Site	State	AQS Code	POC	Sampler Type	Report Batch										
					181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**
Taft	OH	390610040	5	URG 3000N	100	100	100	100	100	67	45	100	100	67	90
Tallahassee Community College	FL	120730012	5	SASS with URG 3000N	100	100	100	85	100	100	100	100	100	100	100
Tallahassee Community College	FL	120730012	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Tecumseh	MI	260910007	5	SASS with URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Tecumseh	MI	260910007	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	100
Toledo Airport	OH	390950026	5	SASS with URG 3000N	100	100									
Toledo Airport	OH	390950026	5	URG 3000N	100	100									
UTC	TN	470654002	5	SASS with URG 3000N	98	100									
UTC	TN	470654002	5	URG 3000N	100	100									
Waukesha, Cleveland Ave. Site	WI	551330027	5	SASS with URG 3000N	99	100									
Waukesha, Cleveland Ave. Site	WI	551330027	5	URG 3000N	100	100									
Whiteface - Met One	NY	360310003	5	SASS with URG 3000N	86	81	100	100	100	100	100	100	100	100	100
Whiteface - Met One	NY	360310003	5	URG 3000N	100	100	80	100	100	100	100	100	100	100	100
Wichita Dept. of Env. Health - Met One	KS	201730010	5	SASS with URG 3000N	100	100	100	100	100	100	100	80	100	100	100
Wichita Dept. of Env. Health - Met One	KS	201730010	5	URG 3000N	100	100	100	100	100	100	100	100	100	100	80
Wylam	AL	010732003	5	SASS with URG 3000N	73	64	100	100	100	100	100	100	100	98	100
Wylam	AL	010732003	5	URG 3000N	90	33	60	100	100	100	100	80	75	100	100
Yakima Mental Health	WA	530770009	5	SASS with URG 3000N	100	100	100	100	100	75	83	100	100	100	100
Yakima Mental Health	WA	530770009	5	URG 3000N	100	100	100	100	83	100	83	100	100	100	100