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Environmental Technology Verification Program
Advanced Monitoring Systems Center

Quality Assurance Project Plan for Verification of Black Carbon Monitors

QUALITY ASSURANCE PROJECT PLAN

for

Verification of
Black Carbon Monitors

Version: 1.0

April 12, 2013

Prepared by

Battelle
505 King Avenue
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SECTION A
PROJECT MANAGEMENT

A1 VENDOR APPROVAL PAGE

ETV Advanced Monitoring Systems Center

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Black Carbon Monitors

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April 12, 2013

APPROVAL:

Name _____

Company _____

Date _____

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ACRONYMS

ADQ	Audit of data quality
AMS	Advanced Monitoring Systems
BC	Black carbon
DQI	Data quality indicator
DQO	Data quality objective
DRI	Desert Research Institute
EC	Elemental carbon
EPA	U.S. Environmental Protection Agency
ETV	Environmental Technology Verification
IMPROVE	Interagency Monitoring of PROtected Visual Environments
LAC	Light absorbing carbon
LRB	Laboratory record book
OC	Organic carbon
QA	Quality assurance
QAO	Quality assurance officer
QAPP	Quality assurance project plan
QMP	Quality management plan
RAAS	Reference Ambient Air Sampler
RMO	Records management office
RPD	Relative percent difference
SI	International standards
SOP	Standard operating procedure
TOR	Thermal optical reflectance
TSA	Technical systems audit
VTC	Verification test coordinator

A3 DISTRIBUTION LIST

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A4 VERIFICATION TEST ORGANIZATION

The verification test described in this document will be conducted under the auspices of the U.S. Environmental Protection Agency (EPA) through the Environmental Technology Verification (ETV) Program. It will be performed by Battelle, which is managing the ETV Advanced Monitoring Systems (AMS) Center through a cooperative agreement with EPA. The scope of the AMS Center covers verification of monitoring technologies for contaminants and natural species in air, water, and soil.

This verification test will be coordinated and directed by Battelle in cooperation with EPA. This test will include a 30-day period of field testing that will be conducted at the Battelle Columbus Operations Special Support Site (BCS3) located at 2555 International St., in Columbus, OH. The field testing is planned to involve the evaluation of multiple commercial monitors for black carbon (BC) in airborne particulate matter. The vendors of the BC monitors will install, maintain, and if necessary repair their systems during the verification test. Reference method sampling for BC will be performed by Battelle and analysis of the collected reference samples will be performed by Desert Research Institute (DRI) under a purchase order from Battelle.

Quality assurance (QA) oversight will be provided by the Battelle AMS Center Quality Manager, and the EPA at its discretion. This test is Quality Category III which requires a QA review of 10% of the test data (see section C1). The organization chart in Figure 1 identifies the responsibilities of the organizations and individuals associated with the verification test. Roles and responsibilities are defined further below.

A4.1 Battelle

Dr. Kenneth Cowen is the AMS Center Verification Test Coordinator (VTC) for this test. In this role, Dr. Cowen will have overall responsibility for ensuring that the technical, schedule, and cost goals established for the verification test are met. Specifically, he will:

- Prepare and oversee review and approval of the QAPP.

- Establish a budget for the testing and manage staff to ensure the budget is not exceeded.

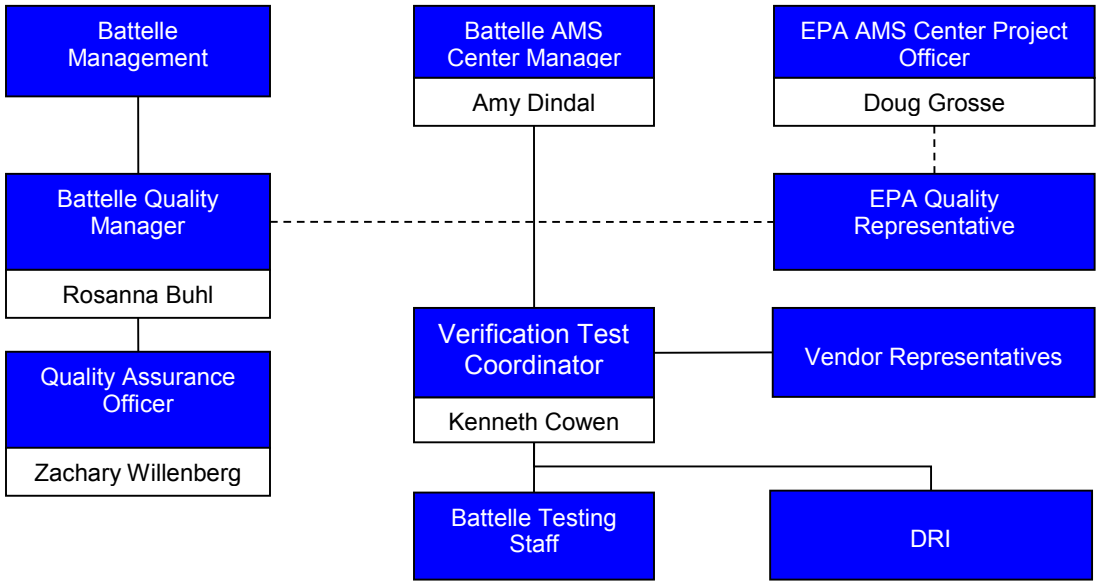

Figure 1. Organization chart for the black carbon monitor verification.

- Revise the draft QAPP in response to reviewers' comments.
- Assemble a team of qualified technical staff to conduct the verification test.
- Direct the team (Battelle, EPA, vendor(s)) in performing the verification test in accordance with this QA project plan (QAPP).
- Hold a kick-off meeting approximately one (1) week prior to the start of the testing to review the critical logistical, technical, and administrative aspects of the testing. Responsibility for each aspect of the testing will be reviewed to ensure each participant understands his/her role.
- Ensure that all quality procedures specified in the QAPP and in the AMS Center Quality Management Plan[1] (QMP) are followed.
- Prepare the draft and final QAPP, verification report(s), and verification statement(s).
- Revise the draft QAPP, verification report(s), and verification statement(s) in response to reviewers' comments.

- Coordinate distribution of the final QAPP, verification report(s), and statement(s).
- Respond to QAPP deviations and any issues raised in assessment reports, audits, or from test staff observations, and institute corrective action as necessary.
- Serve as the primary point of contact for vendor representatives and collaborators.

Ms. Amy Dindal is Battelle's manager for the AMS Center. Ms. Dindal will:

- Review the draft and approve the final QAPP.
- Attend the project kick-off meeting.
- Review the draft and final verification report(s) and verification statement(s).
- Ensure that necessary Battelle resources, including staff and facilities, are committed to the verification test.
- Ensure that confidentiality of sensitive vendor information is maintained.
- Support Dr. Cowen in responding to any issues raised in assessment reports and audits
- Maintain communication with EPA's AMS Center Project Officer.
- Facilitate a stop work order if Battelle or EPA QA staff discover adverse findings that will compromise data quality or test results.

Battelle Field Testing Staff will oversee the testing of the BC monitors during the verification test. Battelle staff will visit the testing site at the BCS3 facility daily during the verification test to conduct the reference sampling, verify proper operation of the BC monitors being tested, and communicate with the BC monitor vendors as needed. The responsibilities of the field testing staff will be to:

- Assist in planning for training and testing as necessary;
- Attend the project kick-off meeting
- Conduct testing and collect data and samples according to this QAPP.

- Collect reference samples and ship samples to the DRI laboratory for analysis.
- Report results of the reference sampling and analysis.
- Record qualitative observations about the maintenance and operation of the BC monitors during testing.
- Assure that the data from the BC monitors are compiled, recorded, and transmitted to the VTC on at least a weekly basis.
- Perform analysis of the collected data to carry out the statistical evaluations in Section B1.1.
- Support Dr. Cowen in responding to any issues raised in assessment reports and audits related to statistics and data reduction as needed;
- Immediately report deviations from this QAPP to the VTC
- Provide input on test procedures, technology operation and maintenance, and field conditions for the draft verification reports.

Ms. Rosanna Buhl is Battelle's Quality Manager for the AMS Center. Ms. Buhl will:

- Review, or designate the review of the draft and final QAPP.
- Assign a Quality Assurance Officer (QAO) for this verification test.
- Delegate to other Battelle quality staff any QAO responsibilities assigned below as needed to meet project schedules.
- Review any audit checklists prepared by the QAO for completeness and detail.
- Review draft and final audit reports prior to release to the VTC and/or EPA for clarity and appropriate assessment of findings.
- Review audit responses for appropriateness.
- Review and approve QAPPs and deviations.
- Review draft and final verification report(s) and verification statement(s).
- Maintain real-time communication with the QAO on QA activities, audit results, and concerns.

- Work with the QAO, VTC, and Battelle's AMS Center Manager to resolve data quality concerns and disputes.
- Recommend a stop work order if audits indicate that data quality or safety is being compromised.

Mr. Zachary Willenberg is Battelle's QAO for this test. Mr. Willenberg will:

- Attend the verification test kick-off meeting and lead the discussion of the QA elements of the kick-off meeting checklist.
- Prior to the start of verification testing, verify the presence of applicable training records, including any vendor training on test equipment.
- Conduct a technical systems audit at least once near the beginning of the verification test.
- Conduct audits to verify data quality.
- Prepare and distribute an audit report for each audit.
- Verify that audit responses for each audit finding and observation are appropriate and that corrective action has been implemented effectively.
- Communicate to the VTC and/or technical staff the need for immediate corrective action if an audit identifies QAPP deviations or practices that threaten data quality.
- Provide a summary of the QA/QC activities and results for the verification reports.
- Review the draft and final verification report(s) and verification statement(s).
- Maintain real-time communication with the Battelle Quality Manager on QA activities, audit results, and concerns, including potential schedule and budget problems.
- Communicate data quality concerns to the VTC and/or Battelle's AMS Center Quality Manager; recommend the need for a stop work order if audits indicate that data quality or safety is being compromised.

A4.2 Vendors

The responsibilities of the BC monitor vendors are as follows:

- Review and provide comments on the draft QAPP.
- Approve the final QAPP prior to test initiation.
- Provide duplicate units of their BC monitor for evaluation during the verification test.
- Provide all other equipment/supplies/reagents/consumables needed to operate their monitors for the duration of the verification test.
- Supply a representative to install, operate, and maintain their monitors during the verification test.
- Review the data from their duplicate monitors provided by the Battelle field testing staff.
- Provide training to site operator(s) and others associated with supervising and/or maintaining BC monitor operation including during the verification testing period.
- Provide written instructions for routine operation of their monitor, including a daily checklist of diagnostic and/or maintenance activities.
- Review and provide comments on the draft verification report and verification statement for their BC monitor.

A4.3 EPA

EPA's responsibilities are based on the requirements stated in the "Environmental Technology Verification Program Quality Management Plan" (EPA QMP)[2]. The roles of specific EPA testing staff are as follows:

Mr. Doug Grosse is EPA's Project Officer (PO) for the AMS Center. Mr. Grosse will:

- Review and approve the draft and final QAPP.
- Oversee the EPA review process for the QAPP and verification report.

- Be available during the testing to review and authorize any QAPP deviations by phone and provide the name of a delegate to the Battelle AMS Center Manager should he not be available during the testing period.
- Review and approve the draft and final verification report.
- Coordinate the submission of the verification report for final EPA approval.
- Post the QAPP and verification report on the ETV web site.

The EPA's AMS Center quality representative may:

- Review the draft and final QAPP.
- Perform at his/her option one external TSA during the testing.
- Prepare and distribute an assessment report summarizing results of the external audit.
- Perform audits of data quality.
- Notify the EPA AMS Center PO of the need for a stop or modify work order if the audit of data quality indicates that data quality is being compromised.
- Review the draft and final verification report.

A4.4 Desert Research Institute (DRI)

DRI is responsible for preparing and analyzing the reference filter samples used for comparison with the BC monitoring systems being tested. DRI will be responsible for shipment of the reference sampling media to the field and for analysis of the exposed filters received from the field.

Mr. Anthony Chen is the DRI Technical Lead for this verification test. In this role, Mr. Chen is responsible for ensuring that the reference filter preparation, shipment, and analysis activities meet the scheduled milestones agreed upon by DRI and Battelle. Mr. Chen will:

- Review the draft QAPP.
- Be the primary DRI contact for Battelle's VTC.

- Ensure that designated DRI staff are available for the verification test.
- Coordinate distribution of the QAPP to DRI staff.
- Coordinate the filter preparation, shipment, and analysis activities.
- Review and approve all data and records related to sampling and analysis activities.
- Deliver reference filter analysis results to Battelle's VTC within the agreed-upon turnaround time.

A4.4 Verification Test Stakeholders

This QAPP and the verification report and verification statement based on testing described in this document will be reviewed by experts in the fields related to BC monitoring. The stakeholders for this verification test are Joann Rice from EPA's Office of Air Quality Planning and Standards, and Andrea Polidori from the South Coast Air Quality Management District.

A5 BACKGROUND

The ETV Program's AMS Center conducts third-party performance testing of commercially available technologies that detect or monitor natural species or contaminants in air, water, and soil. Stakeholder committees of buyers and users of such technologies recommend technology categories, and technologies within those categories, as priorities for testing. Among the technology categories recommended for testing are "black carbon" monitors. Because of the nature of "black carbon", this technology category includes monitors for both BC and elemental carbon (EC). Although BC and EC are operationally defined based on different properties, for convenience the term "black carbon" will be used in this QAPP to refer to both BC and EC.

Black carbon is a term that is commonly used to describe strongly light absorbing carbon (LAC), which is thought to play a significant role in global climate change through direct absorption of light, interaction with clouds, and by reducing the reflectivity of snow and ice. BC is formed from the incomplete combustion of fossil fuels, biofuels, and biomass and can be emitted from

both anthropogenic and natural sources. It is a primary component of soot and has been linked to adverse health effects and visibility reduction. Consequently, there is a great deal of interest in monitoring BC in the atmosphere. However, differences in measurement techniques result in measurements that are operationally defined and characterize the particulate matter based on either its light absorbing properties (leading to determination of BC) or its refractory properties (leading to determination of EC), as illustrated in Figure 2. In this figure, the use of the subscript *a* denotes that the measurements are technique specific and result in estimations of BC or EC that are "apparent" based on the technique being used. The methods used to determine EC are termed thermal-optical in Figure 2 because they involve conversion of particulate carbon to gaseous form under varying temperatures and controlled atmospheres while the particulate sample is monitored by either transmission or reflection of light.

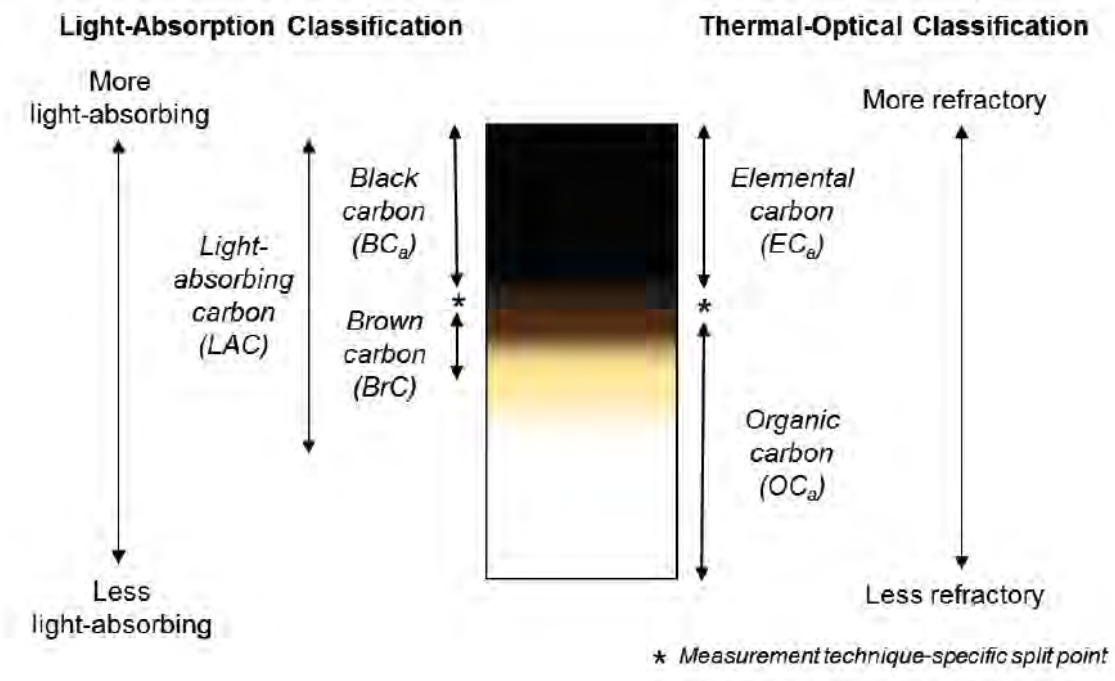

Figure 2. Illustration of measurements of carbonaceous particulate matter. (Source: U.S. EPA)[3]

A6 VERIFICATION TEST DESCRIPTION AND SCHEDULE

The purpose of this verification test is to generate performance data on BC monitoring technologies so organizations and users interested in installing and operating these systems can understand the technology performance under a specified set of conditions. The test will be conducted over a testing period of approximately 30 days and will involve the continuous operation of BC monitors at an ambient air monitoring station installed at the BCS3 facility in Columbus, OH. The results from the BC monitors will be evaluated relative to those of a common "reference" method to assess comparability to that reference method. The reference method selected for this comparison is the method used in the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network. However, it should be noted that this determination of comparability relies on comparisons to a thermal optical method which may result in biases in favor of similar thermal optical methods and against light absorption methods. The unit-to-unit precision of the BC monitors will be determined from comparisons of paired data from duplicate monitors. Operational performance parameters such as data completeness, maintenance requirements, ease of use, consumables, and costs will be determined from observations by the Battelle field testing staff. This test is not intended to simulate long-term performance of these technologies at a monitoring site.

A6.1 Technology Description

The most common techniques used for the measurement of BC include light absorption and thermal-optical methods. Near real-time monitors that provide high time resolution measurements have been developed based on both types of methodology, and a single monitor may perform both types of measurements. These monitors are the subject of this verification test, and each monitor tested will be evaluated for each type of measurement that it makes. Details of the specific instruments being tested will be described in the corresponding verification reports that will be prepared for this verification test. Brief, generic descriptions of these methods are provided below.

In general, light absorption techniques rely on the measurement of light absorption at one or more specific wavelengths as that light passes through particle samples either collected on filters or suspended in a volume of air. Since BC is highly light-absorbing the amount of light absorption can be related to the amount of BC present through a wavelength dependent absorption coefficient. Continuous BC monitors based on light absorption may use a filter tape on which ambient particulate matter is collected as a sample spot. Advancement of the tape places a collected sample spot in position for analysis, while particulate matter collection continues on a previously unexposed spot on the tape. In this verification test, the Magee Scientific/Aerosol Co. Aethalometer™ Model AE33-7, which is representative of light absorption techniques, will be tested.

Thermal-optical techniques rely on the measurement of evolved gases that are released from collected samples as the samples are heated under specific temperature profiles and in controlled atmospheres. These techniques typically characterize both the organic carbon (OC) and EC fractions of the collected particulate matter and include optical measurements to correct for artifacts associated with charring of organic materials. Continuous monitors based on thermal-optical methods function by automating the sequence of controlled temperatures and controlled atmospheres needed to distinguish EC and OC fractions. In this verification test, the Sunset Laboratory Model 4 OC-EC Field Analyzer, which is representative of thermal-optical methods, will be tested.

A6.2 Verification Test Description and Schedule

This verification test will involve the evaluation of BC monitors under realistic operating conditions at an existing ambient air monitoring station. The BC monitors will be operated continuously sampling ambient air for approximately 30 days, during which time a series of reference method samples will also be collected. Specifically, each day during the test period duplicate integrated filter reference samples will be collected over successive 12-hour periods. Thus, over the 30-day field period, a total of 120 reference filter samples will be collected (i.e.,

duplicate samples during each of the 60 12-hour sampling periods). The resulting samples will be analyzed for BC by DRI using the IMPROVE thermal/optical reflectance (TOR) method[4], which monitors the filter sample by means of optical reflectance. Results from the BC monitors will be compared to the reference results to assess the comparability of the BC monitor results to the reference results.

Table 1 shows the planned schedule of testing and data analysis/reporting activities to be conducted in this verification. The verification field test is planned to begin in April 2013 with installation of the BC monitors, and will be completed in May 2013, with the removal of the BC monitors from the field site. The period of operation of the BC monitors at the testing site will be approximately 30 days, with routine operation expected to begin on April 5 and continue through May 3, 2013. During testing, duplicate filter reference samples will be collected twice each day, with each sampling period covering approximately 12 hours (e.g., 7 am to 7 pm and 7 pm to 7 am).

Table 1. Planned Verification Test Schedule

Date(s)	Testing Activities	Data Analysis and Reporting
March 25- 29	Equipment installation/shakedown	--
April 5-May 3	Routine operation Reference sampling Analysis of reference samples Performance of TSA	Prepare report template Review and summarize field testing staff observations Compile data from BC monitors Begin draft report(s)
May 6-7	Remove monitoring systems from test site	--
May 1-31	Complete analysis of reference samples Perform ADQ #1 (10% of all data)	Continue preparation of draft report(s)
June 28		Perform data analysis
July 31	--	Complete data analysis Complete draft report(s)
August 31	Perform ADQ #2	Complete review of draft report(s)
September 30	--	Revise draft report(s) Submit final report(s) for EPA approval

Subsequent to the verification test, a verification report will be drafted for each BC monitor tested. This report will be reviewed by the vendor and by peer reviewers, and submitted to EPA for final signature. In performing the verification test, Battelle will follow the technical and QA procedures specified in this QAPP and will comply with the data quality requirements in the AMS Center QMP.[1]

A6.3 Test Facility

The test will be conducted at the BCS3 facility located at 2555 International St., in Columbus, OH. Figure 3 shows an aerial photograph of the test site (red marker "A") and the surrounding area. The test site is located near a rail yard and in the vicinity of multiple industrial and

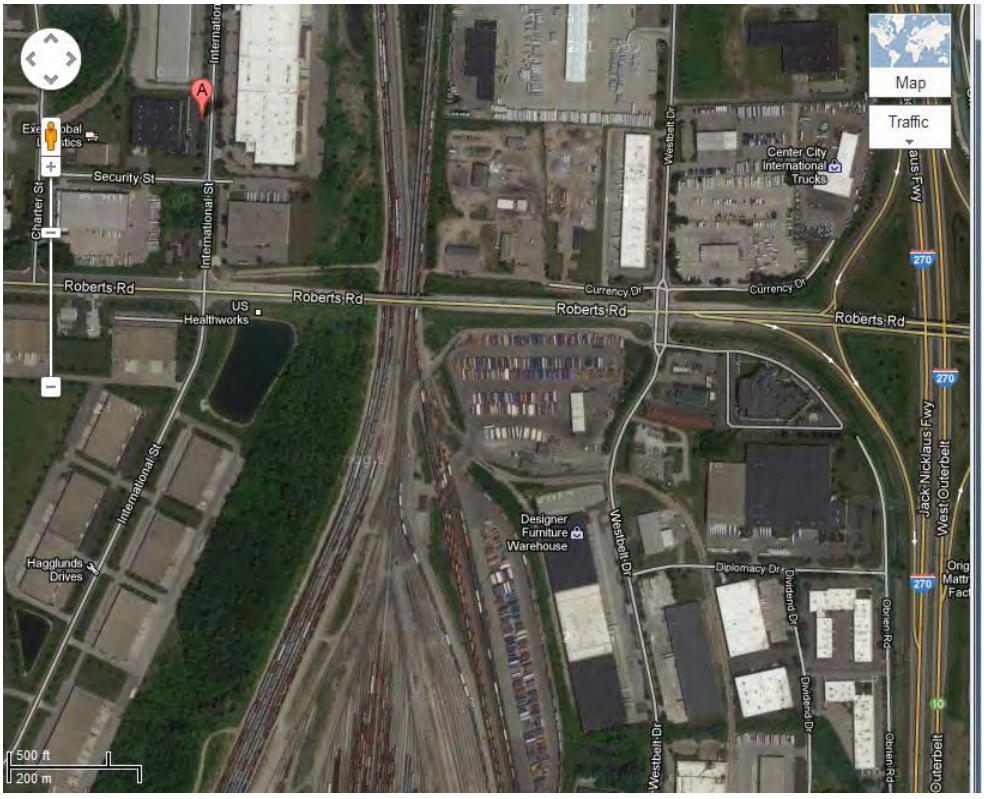

Figure 3. Aerial photograph of test site and surrounding area.

shipping facilities which result in frequent truck traffic past the site. The site also receives regionally transported air pollution due to its location on the western side of the Columbus metropolitan area. An environmentally controlled mobile laboratory will be installed at the site to serve as a shelter for the BC monitors and as work space for the testing staff. Reference samples will be collected using an Andersen Reference Ambient Air Sampler (RAAS) speciation sampler located on a platform adjacent to the mobile laboratory.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The objective of this verification test is to evaluate the performance of the BC monitors under realistic operating conditions. This evaluation will in part assess the capabilities of the monitors for determining the ambient concentrations of BC through comparisons to collocated reference samples collected during the verification test period. Additionally, this evaluation will assess instrument precision based on comparisons of results from duplicate BC monitors, and will assess data completeness based on the fraction of the data collected relative to the maximum amount of data that could be collected during the testing period. The test will rely upon operator observations to assess other operational performance characteristics of the monitoring systems being tested such as ease of use, maintenance and repair needs, and consumables use.

The data quality objectives (DQOs) for this verification test were established to assess the performance of the BC monitors relative to the IMPROVE_A_TOR reference method. In order to provide a suitable benchmark for comparison, the reference samples must be of suitable quality to allow for an accurate assessment of the BC monitors being evaluated. Thus, the DQOs for this verification test include objectives for reference method accuracy and precision, as well as data completeness for the reference method sample collection and analysis. The DQOs are quantitatively defined in Table 2 in terms of specific data quality indicators (DQIs) and their acceptance criteria. The quality of the reference method measurements will be assured by

adherence to these DQI criteria and the requirements of the reference methods including the calibration and QA/QC requirements of those methods, which are discussed in detail in Sections B2 to B7 of this QAPP. Calibration standards and QC samples must meet International Standards (SI) traceability, when available. The quality of the reference method measurements will be monitored by inclusion of blank samples and performance evaluation (PE) samples as appropriate. Section C1.1 presents a description of the PE audit samples/ measurements to be performed and the acceptance criteria for those measurements.

Table 2. DQIs and Criteria for Critical Measurements for Reference Methods.

Measurement	DQI	Method	Criteria
Reference method flow rate	Accuracy	Comparison to SI traceable flow transfer standard	±5%
		Comparison to SI traceable temperature sensor	±2 ºC
		Comparison to SI traceable pressure sensor	±5 mmHg
IMPROVE_A_TOR analysis method	Accuracy	Analysis of standard reference material	±10% of actual concentration
	Precision	Analysis of duplicate samples	RPD[a] ≤ 15%
	Laboratory Blank Check	Analysis of clean filter punch	≤0.2 µg TC[b]/cm^2

[a] RPD - Relative Percent Difference
[b] TC – total carbon.

Additionally, the verification test relies in part on observations of the Battelle field testing staff for assessment of the performance of the monitoring systems being tested. The requirements for these observations are described in the discussion of documentation requirements and data review, verification, and validation requirements for this verification test.

The Battelle QAO signee will perform a TSA at least once during this verification test to augment these QA/QC requirements. This TSA will be performed within the first week of the verification test. The EPA quality representative also may conduct an independent TSA, at her discretion.

A8 SPECIAL TRAINING/CERTIFICATION

Documentation of training related to technology testing, field testing, data analysis, and reporting is maintained for all Battelle technical staff in training files at their respective locations. The Battelle QAO may verify the presence of appropriate training records prior to the start of testing. Battelle technical staff supporting this verification have a minimum of a bachelor's degree in science/engineering. The VTC has a Ph.D. in Physical Chemistry and has approximately 14 years of experience performing ETV verifications.

A9 DOCUMENTATION AND RECORDS

The records for this verification test will include the QAPP, chain-of-custody forms, laboratory record books (LRB), data collection forms, electronic files (both raw data and spreadsheets), and the final verification report(s). All of these records will be maintained at the test facility or in the VTC's office during the test and may be transferred to permanent storage at Battelle's Records Management Office (RMO) at the conclusion of the verification test. All Battelle LRBs are stored indefinitely by Battelle's RMO. EPA will be notified before disposal of any files. The documentation and results of the reference method measurements made by DRI will be submitted to Battelle within 10 days after completion of all sample analyses, review of the data, and calculation of analyte concentrations in the ambient air. Section B10 further details the data recording practices and responsibilities.

SECTION B

MEASUREMENT AND DATA ACQUISITION

B1 EXPERIMENTAL DESIGN

This test will specifically address verification of BC monitors by evaluating the comparability and precision of the monitors, as well as data completeness, reliability, and maintenance needs of each monitor. Comparability will be determined for the monitors by comparison of their results to BC concentration measurements from the filter-based reference samples. Unit-to-unit precision will be assessed through comparison of paired results from the duplicate monitors. Data completeness will be assessed as the percentage of maximum data return that is achieved by the monitoring systems over the test period. Reliability and maintenance needs will be evaluated by means of observations by field testing staff, and records of needed maintenance, vendor activities, and consumables used.

B1.1 Test Procedures

During testing, duplicate BC monitors will be installed inside an environmentally controlled shelter at the BCS3 test site. The monitors will be installed by the vendors, and are intended to operate continuously over the 30-day testing period. Routine maintenance of the BC monitors will be performed by Battelle testing staff according to vendor instructions. Any repair or replacement of the monitors will be performed by the vendor and will be documented by Battelle. Data from the BC monitors will be retrieved by the Battelle testing staff and provided to the respective vendors at least weekly. Battelle testing staff will conduct daily checks of the monitors to confirm proper operation. The results of those checks will be documented on checklists for each analyzer and any observed problems will be communicated promptly to the respective vendor. Maintenance activities performed on the monitors will be documented by Battelle and noted in any data analysis activities.

Integrated filter samples will be collected over 12-hour sampling periods throughout the testing period, i.e., from 7:00 a.m. to 7:00 p.m. and from 7:00 p.m. to 7:00 a.m. daily. The filters used for this test will consist of pre-fired 47 mm Pallflex quartz fiber filters. For sampling the filter samples will be installed in a RAAS speciation sampler mounted on a platform placed at approximately the same height as the roof of the trailer housing the BC monitors being tested. Duplicate filter samples will be collected by simultaneous sampling in parallel channels of the RAAS sampler at a flow rate of 16.7 L/min, after passage of the sample air through the sampler's $PM_{2.5}$ inlet. The filter samples will be retrieved after each sampling period and stored under refrigeration until being shipped to the analytical laboratory for analysis by the IMPROVE_A_TOR method. The collected samples will be shipped to the DRI laboratory for analysis within 7 days of collection. Results from the reference method analysis will be divided by the total volume of air sampled during the respective sampling periods and expressed as average BC concentrations during the sampling periods.

B1.1.1 Comparability

The BC monitors undergoing testing will be evaluated for comparability in two ways. Firstly, comparability will be determined from a linear least squares regression analysis of the measured BC concentrations from the continuous monitor against the corresponding BC results from the reference method. For comparison to the reference results, average concentrations from each of the monitors being tested will be determined separately for each of the 12-hour sampling periods, by averaging the monitor's individual results over the corresponding sampling period. The monitors being tested will be operated such that the measurement times can be synchronized with the reference measurements to the extent possible. These averages will then be plotted separately for each monitor being tested against the mean of the corresponding duplicate reference method measurements. The slope and intercept of these plots will be determined from a linear regression analysis and reported independently for each of the monitors.

Additionally, comparability will be determined in terms of the relative percent difference (RPD) between the mean value of the reference measurements and the results from each BC monitor being tested. The RPD will be calculated using Equation 1:

$$RPD = \frac{1}{n}\sum_{i=1}^{n}\frac{C_i - \overline{C(ref)_i}}{C(ref)_i}\cdot 100 \quad (1)$$

where C_i is the average BC concentration measured by the BC monitor during the i^{th} reference sampling period, and $\overline{C(ref)_i}$ is the mean of the duplicate reference method BC concentrations for the i^{th} reference sampling period.

Both measures of comparability will be determined relative to the results from both reference methods.

B1.1.2 Correlation

The degree of correlation of each BC monitor's results to the reference results will be determined based on the coefficient of determination (r^2) value of the linear regression performed to assess accuracy (Section B1.1.1). Correlation will be determined separately for each unit of each BC monitor undergoing testing, and relative to the results from the reference method.

B1.1.3 Precision

Precision (P) will be determined based on a comparison of paired measurements from the duplicate BC monitors being tested. For this assessment of precision, the P between the paired measurements from the duplicate BC monitors will be calculated using Equation 2:

$$P = \frac{1}{n}\sum_{i=1}^{n}\frac{\left|C(1)_i - C(2)_i\right|}{[C(1)_i + C(2)_i]/2} \quad (2)$$

where $C(1)_i$ and $C(2)_i$ are the BC concentrations measured by the first and second of the two duplicate monitoring systems. Precision will be calculated for each set of duplicate BC monitors

for each reference sampling period, and the overall mean precision will also be reported. For this calculation, measurement data below twice the vendor's stated instrumental detection limit will be excluded from the analysis.

B1.1.4 Data Completeness

Data completeness will be assessed in two ways, based on the overall data return achieved by each BC monitor during the testing period. First, for each of the BC monitors data completeness will be calculated as the total hours of apparently valid data reported by the monitor divided by the maximum total possible hours of monitoring data in the entire field period. Also, for each BC monitor data completeness will be calculated as the percentage of 12-hour reference method sampling periods in which the monitor provided at least 9 hours of valid data (75%). The causes of any substantial incompleteness of data return will be established from operator observations or vendor records, and noted in the discussion of data completeness results.

B1.1.5 Operational Factors

Operational factors such as maintenance needs, data output, consumables used, ease of use, repair requirements, etc., will be evaluated based on observations recorded by Battelle testing staff. Battelle staff will be at the monitoring site whenever the vendor is present and will record all activities performed on the monitoring systems and will complete a daily checklist for each analyzer to ensure proper operation. A laboratory record book will be maintained at the test site, and will be used to enter daily observations on these factors. Examples of information to be recorded in the record books include the daily status of diagnostic indicators for the monitoring systems; use or replacement of any consumables; the effort or cost associated with maintenance or repair; vendor effort (e.g., time on site) for repair or maintenance; the duration and causes of any down time or data acquisition failure; and Battelle testing staff observations about ease of use of the monitoring systems. These observations will be summarized in describing monitoring system performance in the verification report. Explanatory information may be requested from the vendor and included from the report as needed.

B1.3 Reporting

The statistical comparisons described above will be conducted separately for each of the BC monitors being tested. Additionally, information on the operational parameters will be compiled and reported. A verification report that presents the test procedures, test data, and results of the statistical evaluation of those data will be prepared for each BC monitor tested.

Operational aspects of the monitoring systems will be recorded by Battelle testing staff at the time of observation during the field test, and summarized in the verification report. For example, descriptions of the data acquisition procedures, use of vendor-supplied proprietary software, consumables used, repairs and maintenance needed, and the nature of any problems will be presented in the report. The verification report will briefly describe the ETV program, the AMS Center, and the procedures used in verification testing, and the results of the verification test will be stated quantitatively. Each draft verification report will be subjected to review by the vendor, EPA, and other peer reviewers. The review comments will be addressed in a subsequent revision of the report, and the peer review comments and responses will be tabulated to document the peer review process. The reporting and review process will be conducted according to the requirements of the ETV/AMS Center QMP.[2]

B2 SAMPLING METHOD REQUIREMENTS

Filter sampling will be performed by Battelle testing staff as described in Section B1.1 to provide reference method measurements. The reference samples will be collected from a platform near the roof of the same mobile laboratory at the monitoring site that houses the BC monitors being tested. The standard sampling inlet used by the RAAS sampler will be used to prevent liquid water from being drawn into the sample stream. A 2.5 μm cyclone inlet inside the sampler will be used to limit the size of particles in the sample stream to less than an aerodynamic diameter of 2.5 μm.

Audits of filter sampling procedures will be carried out by Battelle testing staff as part of the TSA procedure (Section C1.2) and the PE audit procedure (Section C1.1).

B3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Sample handling procedures are designed to minimize handling of the reference filter cassettes and limit the number of transfers of the filters. Upon receipt, DRI will inspect the filters and pre-fire them according to DRI Standard Operating Procedure (SOP) #2-106.The filters will then be loaded into separate, pre-labeled Petri dishes in DRI's laboratory facilities, sealed, and shipped to Battelle for sampling. When not in use, the filters will remain in their sealed Petri dishes and stored in an environmentally controlled environment (e.g., in the mobile laboratory), to prevent contamination. The filters will be loaded into sampling cassettes inside the mobile laboratory by Battelle testing staff using clean, lint-free gloves and will be loaded into and unloaded from the reference sampler by Battelle testing staff. The filters will be installed in the sampler and sampled continuously for 12 hours after which the exposed cassettes will be retrieved from the sampler and clean, unexposed cassettes will be installed. Upon retrieval, the exposed filters will be removed from the sampling cassettes, resealed in their respective Petri dishes and stored refrigerated until shipment back to DRI for analysis. The exposed samples will be shipped to DRI within 7 days of collection.

Sample custody will be documented throughout sample preparation, sample collection, sample recovery, and sample analysis, using standard chain-of-custody forms provided by DRI. Each chain-of-custody form will be signed by the person relinquishing samples once that person has verified that the chain-of-custody form is accurate. Upon receipt at the laboratory, chain-of-custody forms will be signed by the person receiving the samples once that person has verified that all samples identified on the chain-of-custody forms are present in the shipping container. Any discrepancies will be noted on the form and the sample receiver will immediately contact the VTC to report missing or compromised samples. Copies of all chain-of-custody forms will be delivered to the VTC upon request, and maintained with the test records.

B4 ANALYTICAL METHOD REQUIREMENTS

Analysis of the reference method samples will be performed by the IMPROVE_A_TOR method as described in the DRI SOP #2-216r3, dated October 22, 2012,[4] This method is "based on the preferential oxidation of organic and elemental carbon (OC and EC) compounds at different temperatures." In general, this method calls for a small punch from a quartz fiber filter to be heated under prescribed temperature profiles in different oxidative atmospheres and for the liberated carbonaceous species to be monitored with a flame ionization detector (FID) after conversion first to CO_2 and subsequently to CH_4.

B5 QUALITY CONTROL REQUIREMENTS

As described in Section A7, reference method sampling will be carried out using a RAAS speciation sampler. Analysis of the reference samples will be performed by DRI using the IMPROVE_A_TOR method. A variety of quality control activities will be performed to ensure the data quality of the reference method. Specific quality control activities include calibration and verification of the reference sampling equipment, calibration and verification of the analytical instrumentation, and analysis of duplicate samples and field blanks. The following sections describe the quality control (QC) activities and acceptance criteria for the reference method sampling and analysis. After initial installation of the BC analyzers being tested, no additional QC activities are planned for those analyzers other than those performed automatically by the analyzers as part of their routine operation.

B5.1 Reference Sample Collection

Quality control activities for the filter sampling include calibration of the sampler flow rate and of the sampler temperature and pressure sensors. After the initial calibration, checks of the sampler flow rate and the temperature/pressure sensors will performed after every third sampling day. After each flow rate check, each sampling train will be checked for leaks to ensure proper

operation. Additionally, a field blank sample will be collected at least every fifth sampling day. The field blanks will be collected by installing a clean, unexposed filter into a filter cassette and installing the loaded cassette into one of the reference sample channels without drawing any air through the filter. The cassette will then be recovered and the filter will be removed and handled like a normal sample.

B5.2 Reference Sample Analysis

The analysis of the reference samples will be conducted by DRI according to the IMPROVE_A_TOR method using a DRI Model 2001 carbon analyzer. In this method, a portion of the filter sample is heated under various gaseous atmospheres (pure He and 98% He/2% O_2) to preset temperature conditions between 140 and 840 ºC and the evolved gas is analyzed for the presence of carbonaceous species. During analysis, the reflectance of the filter is monitored to correct for artifacts introduced during the analysis procedure.

Table 3 summarizes the quality control requirements of the method. If the sampling or analytical performance strays outside the required tolerances, the relevant QC checks will be conducted again or the relevant QC samples will be prepared again and reanalyzed. If performance problems persist, the reference instrument will be recalibrated, and/or affected samples will be reanalyzed. Reference sample results not meeting the requirements will be excluded from comparison to the continuous monitor results.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

The equipment used for the reference method sampling and analysis will be tested, inspected, and maintained so as to meet the data quality objectives of this verification test. System preventive maintenance will be performed prior to the start of the verification test and for each sampling period as needed. Each analyzer will be checked daily to ensure proper operation, and

vendors will be notified when repairs may be required. Laboratory equipment maintenance is conducted according to the laboratory SOP.[4]

Table 3. QC Requirements for the Analytical Method

Measured Parameter	QC Check	Required Performance
Range	Multipoint calibration (daily when analysis is performed)	Concentrations must bracket range of all sample concentrations
Accuracy	Multipoint calibration (Every 6 months or after major instrument repair)	All slopes ±5% of average
Detection limit	System blank check (daily when analysis is performed)	≤0.2 µg TC/cm^2
Accuracy	Leak check (daily when analysis is performed)	Oven pressure drops less than 0.52 mm Hg/s
Accuracy	Laser performance check (daily when analysis is performed)	Transmittance >700 mV; reflectance >1,500 mV
Accuracy	Calibration peak area check (Every analysis)	Counts >20,000 and 95–105% of average calibration peak area of the day
Accuracy	Auto-calibration check (daily when analysis is performed)	95–105% recovery and calibration peak area 90–110% of weekly average
Accuracy	Manual injection calibration (daily when analysis is performed)	95–105% recovery and calibration peak area 90–110% of weekly average
Accuracy	Sucrose calibration check (thrice per week)	95–105% recovery and calibration peak area 90–110% of weekly average
Precision	Analysis of duplicate samples (every 10th sample)	±10% when OC and TC ≥10 µg C/cm^2; ±20% when EC ≥10 µg C/cm^2, or <±1 µg C/cm^2 when OC and TC <10 µg C/cm^2; <±2 µg C/cm^2 when EC <10 µg C/cm^2

B7 INSTRUMENT CALIBRATION AND FREQUENCY

B7.1 Reference Method Sampling Calibration

The calibration for the reference method sampling trains includes a single point flow rate calibration at the nominal flow rate using an SI-traceable flow transfer standard. This calibration will be performed at the beginning of the verification test with flow checks performed no less frequently than once every three days throughout the verification test. Flows will be adjusted if

measured flows are found to differ from the nominal flow rate by more than 5% (i.e. acceptable flow range of 15.9 – 17.5 L/min).

Verification of the calibration of the temperature and pressure sensors in the reference sampler will be performed by conducting single point calibration checks of the sensors at the beginning of the verification test using SI-traceable standards. Agreement between the readings from the reference sampler and the calibration devices must be within ± 2 ºC for the temperature sensor and ± 5 mmHg for the pressure sensor, or the sensors will be recalibrated.

B7.2 Analytical Instrumentation Calibration

Prior to sample analysis, a calibration of the DRI analysis equipment will be conducted according to the method SOP.[4] Also, calibration checks will be conducted as described in Section B.5.2.

B7.3 Continuous BC Monitors

Upon installation at the field site the BC monitors being tested will be calibrated by the respective vendors according to their recommended procedures. These activities will be documented by Battelle. The Model 4 OC-EC analyzer performs an automatic calibration check using a certified methane standard with every sample analysis. The Model AE33-7 Aethalometer automatically monitors internal operational parameters and provides an indication if recalibration is needed. Recalibration is not likely to be needed within the 30-day period of the field test, but if needed will be performed by the vendor.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Upon receipt of any supplies or consumables used for the reference method, the DRI staff will visually inspect the materials and ensure that the materials received are those that were ordered and that there are no visual signs of damage that could compromise the suitability of the materials. If damaged or inappropriate goods are received they will be returned or disposed of

and arrangements will be made to receive replacement materials. Certificates of analysis (COA) or other documentation of analytical purity will be checked for all gases, reagents, and standards to ensure suitability for this verification test. Unsuitable materials will be returned or disposed of and arrangements for the receipt of replacement materials will be made.

B9 NON-DIRECT MEASUREMENTS

No non-direct measurements will be used during this verification test.

B10 DATA MANAGEMENT

Various types of data will be acquired and recorded electronically or manually by Battelle and the instrument vendors during this verification test. All manually recorded data will be recorded in permanent ink. Corrections to written records will be made by drawing a single line through the entry to be corrected and providing a simple explanation for the correction, along with a date and the initials of the person making the correction. Table 4 summarizes the types of data to be recorded. All maintenance activities, repairs, calibrations, and operator observations relevant to the operation of the monitoring systems being tested will be documented by Battelle or vendor staff in the laboratory record book (LRB).

Results from the reference method will be compiled by DRI staff in electronic format, and submitted to Battelle in the form of an analytical report at the conclusion of reference sample analyses.

Records received by or generated by any Battelle or vendor staff during the verification test will be reviewed by a Battelle staff member within one week of receipt or generation and before the records are used to calculate, evaluate, or report verification results. If a Battelle staff member generated the record, this review will be performed by a Battelle technical staff member involved

in the verification test, but not the staff member who originally received or generated the record. The review will be documented by the person performing the review by adding his/her initials

Table 4. Summary of Data Recording Process

Data to Be Recorded	Where Recorded	How Often Recorded	By Whom	Disposition of Data
Dates, times, and details of test events	ETV LRBs, field sampling records	Start/end of test event	Battelle	Used to organize/check test results; manually incorporated in data spreadsheets as necessary
BC monitor calibration information, maintenance, down time, etc.	ETV LRBs, or electronically	When performed	Vendor or Battelle	Incorporated in verification report as necessary
BC monitor readings	Recorded electronically by each monitor and then downloaded to computer daily	Recorded continuously by each monitor	Vendor for transfer to Battelle	Converted to spreadsheet for statistical analysis and comparisons
Reference method procedures, calibrations, QA, etc.	ETV LRBs, or data recording forms	Throughout sampling and analysis processes	Battelle	Retained as documentation of reference method performance
Reference method analysis results	Electronically from analytical method	Every sample analysis	DRI	Converted to spreadsheets for calculation of ambient air concentrations, and statistical analysis and comparisons

and date to the hard copy of the record being reviewed. In addition, any calculations performed by Battelle will be spot-checked by Battelle technical staff to ensure that calculations are performed correctly. Calculations to be checked include any statistical calculations described in this QAPP.

Among the QA activities conducted by Battelle QA staff will be an audit of data quality. This audit will consist of a review by the Battelle QAO of at least 10% of the test data. During the

course of any such audit, the Battelle QAO will inform the technical staff of any findings and any immediate corrective action that should be taken. If serious data quality problems exist, the Battelle QAO will inform the AMS Center Manager who is authorized to stop work. Once the assessment report has been prepared, the VTC will ensure that a response is provided for each adverse finding or potential problem, and will implement any necessary follow-up corrective action. The Battelle QAO will ensure that follow-up corrective action has been taken.

SECTION C

ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

One of the major objectives of the QAPP is to establish mechanisms necessary to anticipate and resolve potential problems before data quality is compromised. Internal QC measures described in this QAPP will yield day-to-day information on data quality. The responsibility for interpreting the results of these checks and resolving any potential problems resides with the VTC. Technical staff has the responsibility to identify problems that could affect data quality or usability. Any problems that are identified will be reported to the VTC, who will work with the Battelle QAO to resolve any issues. Action will be taken to identify and appropriately address the issue and minimize losses and correct data, where possible. Battelle will be responsible for ensuring that the audits described in the following subsections are conducted as part of this testing. See Table 5 for the proposed schedule of audits.

Any departures from the approved QAPP must be reported within 24 hours and documented in a formal deviation submitted to the Battelle AMS Center Manager, QM, and EPA PO. If approval by EPA or his designee is not received within 24 hours of notification testing will be halted until a suitable resolution has been achieved.

C1.1 Performance Evaluation Audit

A PE audit will be conducted either prior to the beginning of the testing or within the first week of testing to assess the quality of the critical measurements associated with the reference sampling and analysis methods. Table 5 shows the critical measurements to be audited, with the audit procedures and acceptance criteria for the audit comparisons. If the PE audit results do not meet the acceptance criteria shown, they will be repeated. If the outlying results persist, a change in reference method instrument and a repeat of the PE audit may be considered, and data

will be flagged until the PE audit results are acceptable. This audit will be performed once during the verification test, and will be the responsibility of the VTC or designee.

Table 5. Methods and Acceptance Criteria for PE Audit Measurements

Critical Measurement	PE Audit Method	Acceptance Criteria
Reference method sampling flow rate	Flow rate check with independent SI-traceable flow rate standard	± 5% of nominal flow rate
Reference sampler temperature sensor	Check with independent SI-traceable temperature sensor	± 2 ºC
Reference sampler pressure sensor	Check with independent SI-traceable pressure sensor	± 5 mm Hg

The PE audit of the filter sampling flow rate will be conducted using an independent SI-traceable flow transfer standard. With an unused filter installed, the flow rate through the sampling train will be measured and compared to the nominal flow rate. This filter will not be used as one of the reference samples. The target criterion for this audit is agreement between the measured and nominal flow rate within ±5%. If this criterion is not met, the cause of the problem will be investigated and corrected if possible. Components of the sampling train will be replaced as necessary until the flow rate criterion is met.

C1.2 Technical Systems Audits

The Battelle QAO will perform a TSA within the first week of testing. The purpose of this audit is to ensure that the verification test is being performed in accordance with the AMS Center QMP,[1] this QAPP, published reference methods, and any SOPs used by the analytical laboratory. In this audit, the Battelle QAO may review the reference methods used, compare actual test procedures to those specified or referenced in this plan, and review data acquisition and handling procedures. The Battelle QAO will prepare a project-specific checklist based on the QAPP requirements to guide the TSA, which will include a review of the test location and general testing conditions; observe the testing activities; and review laboratory record books. In the TSA, the Battelle QAO will tour the test site; observe the reference method sampling and sample recovery; inspect documentation of reference sample chain of custody; and review laboratory

record books. He will also check data acquisition procedures, and may confer with the vendor and Battelle testing staff. A TSA report will be prepared as a memo to the VTC within 10 business days after completion of the audit; the completed checklist will be attached. The Battelle AMS Center Manager, QM, and EPA PO will be copied on the memo. The VTC will respond to the audit within 10 business days. The Battelle QAO or designate will verify that all audit Findings and Observations have been addressed and that corrective actions are appropriately implemented. A copy of the complete TSA report with corrective actions will be provided to the EPA PO within 10 business days after receipt of the audit response. At EPA's discretion, EPA QA staff may also conduct an independent on-site TSA during the verification test. The TSA findings will be communicated to technical staff at the time of the audit and documented in a TSA report..

C1.3 Data Quality Audit

The Battelle QAO will audit at least 10% of the sample results acquired in the verification test and 100% of the calibration and QC data per the QAPP requirements. A checklist based on the QAPP will guide the audit. An initial ADQ will be conducted on the first batch of test data within 10 business days of when data were posted on the project SharePoint site to identify errors early in the data reduction process. The first batch is defined as the testing and variable data generated over the first week of testing. The remaining data will be audited at the completion of the 30 day field test after all data has been posted on the project SharePoint site and once all statistical analyses for that set of tests are complete. During this ADQ, the Battelle QAO will trace the data from initial acquisition, through reduction and statistical comparisons, to final presentation in the verification reports. It will also confirm reconciliation of the initial ADQ.

All formulae applied to the data will be verified, and 10% of the calculations will be checked. Data for each set of tests will be reviewed for calculation and transcription errors and data traceability. An audit report will be prepared as a memo to the VTC within 10 business days after completion of each data audit; the completed checklist will be attached. The Battelle AMS

Center Manager, QM, and EPA PO will be copied on the memo. The TC will respond to the audit within 10 business days. The Battelle QAO will verify that all audit Findings and Observations have been addressed and that corrective actions are appropriately implemented. A copy of the complete ADQ report with corrective actions will be provided to the EPA PO within 10 business days after receipt of the audit response. EPA QA staff may also conduct an independent ADQ.

C1.4 QA/QC Reporting

Each assessment and audit will be documented in accordance with Section 10.5 of the AMS Center QMP.[1] The results of the TSA will be submitted to EPA. Assessment reports will include the following:

- Identification of Findings and Observations
- Recommendations for resolving problems
- Response to adverse findings or potential problems
- Confirmation that solutions have been implemented and are effective
- Citation of any noteworthy practices that may be of use to others.

C2 REPORTS TO MANAGEMENT

The Battelle QAO, during the course of any assessment or audit, will identify to the technical staff performing experimental activities any immediate corrective action that should be taken. If serious quality problems exist, the Battelle Quality Manager will notify the AMS Center Manager, who is authorized to stop work. Once the assessment report has been prepared, the VTC will ensure that a response is provided for each adverse finding or potential problem and will implement any necessary follow-up corrective action. The Battelle Quality Manager will ensure that follow-up corrective action has been taken. The QAPP and final report are reviewed by EPA AMS Center quality assurance staff and the EPA AMS Center program management staff. Upon final review and approval, both documents will then be posted on the ETV website

(www.epa.gov/etv). A summary of the required assessments and audits, including a listing of responsibilities and reporting timeframes, is included in Table 6.

Table 6. Summary of Assessment Reports[a]

Assessment	Prepared By	Report Submission Timeframe	Submitted To
TSA	Battelle	TSA response is due to QAO within 10 business days TSA responses will be verified by the QAO and provided to EPA within 20 business days	EPA ETV AMS Center
ADQ 1 (first batch)	Battelle	ADQ will be completed within 10 business days after receipt of first data set	EPA ETV AMS Center
ADQ 2 (reduced data and verification report)	Battelle	ADQ will be completed within 10 business days after completion of the verification report review	EPA ETV AMS Center

a. Any QA checklists prepared to guide audits will be provided with the audit report.

SECTION D

DATA VALIDATION AND USABILITY

D1 DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

The key data review and data verification requirements for this test are stated in Section A7 of this QAPP. In general, the data review requirements specify that data generated during this test will be reviewed by a Battelle technical staff member within one week of generation of the data. The reviewer will be familiar with the technical aspects of the verification test but will not be the person who generated the data. This process will serve both as the data review and the data verification, and will ensure that the data have been recorded, transmitted and processed properly. Furthermore, this process will ensure that the monitoring systems data and reference method data were collected under appropriate testing conditions and that the reference sample data meet the specifications of analytical methods. Time series plots will be generated to assess potential anomalies in the data.

The data validation requirements for this test involve an assessment of the quality of the data relative to the DQIs and audit acceptance criteria specified for this test. The DQIs listed in Section A7 will be used to validate the quality of the data. The QA audits described within Section C of this document, including the PE audit and the audit of data quality, are also designed to validate the quality of the data.

D2 VERIFICATION AND VALIDATION METHODS

Data verification is conducted as part of the data review as described in Section A7 of this QAPP. A visual inspection of handwritten data will be conducted to ensure that all entries were

properly recorded or transcribed, and that any erroneous entries were properly noted (i.e., single line through the entry, with an error code and the initials of the recorder and date of entry). Electronic data from the BC monitors and analytical equipment used during the test will be inspected to ensure proper transfer from the datalogging system. All calculations used to transform the data will be reviewed to ensure the accuracy and the appropriateness of the calculations. Calculations performed manually will be reviewed and repeated using a handheld calculator or commercial software (e.g., Excel). Calculations performed using standard commercial office software (e.g., Excel) will be reviewed by inspection of the equations used for the calculations and verification of selected calculations by handheld calculator. Calculations performed using specialized commercial software (i.e., for analytical instrumentation) will be reviewed by inspection and, when feasible, verified by handheld calculator, or standard commercial office software. The Battelle staff member doing the verification will document the activities.

To ensure that the data generated from this test meet the goals of the test, a number of data validation procedures will be performed. Sections B and C of this QAPP provide a description of the validation safeguards employed for this verification test. Data validation efforts include the completion of QC activities, and the performance of ADQ and PE audits as described in Section C. The data from this test will be evaluated relative to the measurement DQIs described in Section A7, and the PE audit acceptance criteria given in Section C1.1 of this QAPP. Data failing to meet these criteria will be flagged in the data set and not used for evaluation of the monitoring systems, unless these deviations are accompanied by descriptions of their potential impacts on the data quality.

An audit of data quality will be conducted by the Battelle QAO to ensure that data review, verification, and validation procedures were completed, and to assure the overall quality of the data.

D3 RECONCILIATION WITH USER REQUIREMENTS

The purpose of this verification test is to evaluate the performance of continuous monitors for BC in ambient air. In part, this evaluation will include comparisons of results from the monitoring systems to the results from reference method samples generated from the IMPROVE_A_TOR method for sample collection and analysis. To meet the requirements of the user community, the reference data collected during this verification test will meet the QA requirements of the reference method. Additional performance data regarding operational characteristics of the BC monitors will be collected by verification test personnel. To meet the requirements of the user community, these data will include thorough documentation of the performance of the monitoring systems during the verification test. The data review, verification, and validation procedures described above will ensure that data meeting these requirements is accurately presented in the verification reports generated from this test, and will ensure that data not meeting these requirements will be appropriately flagged and discussed in the verification reports.

This QAPP and the resulting ETV verification report(s) will be subjected to review by the vendor, EPA, and expert peer reviewers. The reviews of this QAPP will assure that this verification test and the resulting report(s) meet the needs of potential users of these monitoring systems.

SECTION E

REFERENCES

1. Battelle, Quality Management Plan for the ETV Advanced Monitoring Systems Center, Version 8.0, U.S. EPA Environmental Technology Verification Program, prepared by Battelle, Columbus, Ohio, April 2011.

2. U.S. EPA, Environmental Technology Verification Program Quality Management Plan, EPA Report No: EPA 600/R-08/009, U.S. Environmental Protection Agency, Cincinnati, Ohio, January 2008.

3. Report to Congress on Black Carbon, EPA-450/R-12-001, U.S. Environmental Protection Agency, March 2012, available at http://www.epa.gov/blackcarbon/.

4. Desert Research Institute, DRI Model 2001 Thermal/Optical Carbon Analysis (TOR/TOT) of Aerosol Filter Samples - Method IMPROVE_A, DRI SOP#2-216r3, prepared by DRI, Reno, NV, October 22, 2012.