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NORTH CAROLINA
Environmental Quality

Duplin County Air Monitoring Study (DCAMS)
Quality Assurance Guidance Document (QAGD)

North Carolina Department of Environmental Quality | Division of Air Quality
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DISCLAIMER

This Quality Assurance Guidance Document, or QAGD, covers the monitoring study borne out of the settlement agreement with the North Carolina Environmental Justice Network, or NCEJN, the Rural Empowerment Association for Community Help, or REACH, and the Waterkeeper Alliance, Inc., or Waterkeeper, and the North Carolina Department of Environmental Quality, or DEQ, Division of Air Quality, or DAQ. Throughout this document where it states "complainants", these groups are included by this reference.

Quality Assurance Guidance Document Acronym Glossary

ADQ – Audit of Data Quality
ADR – Alternative dispute resolution
ARM – Air Resource Manager
BAM – Beta attenuation monitor
CFR – Code of Federal Regulations
Chief – Ambient Monitoring Section Chief
COC – Chain of custody
CV – Coefficient of Variation
DAQ – North Carolina Division of Air Quality
DCAMS – Duplin County Air Monitoring Study
DEQ – North Carolina Department of Environmental Quality
DIT – Department of Information Technology
DQA – Data quality assessment
DQI – Data quality indicators
DQO – Data quality objectives
ECB – Electronics and Calibration Branch
EPA – United States Environmental Protection Agency
ECRCO – External Civil Rights Compliance Office
FEM – Federal equivalent method
FRM – Federal reference method
H_2S – Hydrogen sulfide
IBEAM – Internet-Based Enterprise Application Management
IR – Infrared
LDL – Lower detection limit
LMS – North Carolina Learning Management System
LPM – Liters per minute
m – meters
m^3/hour – Cubic meters per hour
mg/m^3 – milligrams per cubic meter
$\mu g/m^3$ – micrograms per cubic meter
MQO – Measurement quality objective
MSR – Management systems review
NAAQS – National ambient air quality standards
NCEJN - North Carolina Environmental Justice Network
NIST - National Institute of Science and Technology
$PM_{2.5}$ – Particles with an average aerodynamic diameter of 2.5 microns or less, also known as fine particles
QA – Quality assurance
QAGD – Quality assurance guidance document
QAM – Quality Assurance Manager
QA/QC – Quality assurance/quality control
QC – Quality control
RCO – Raleigh Central Office

REACH – Rural Empowerment Association for Community Help
RSD – Relative standard deviation
SCC – Sharp cut cyclone
SD – Standard deviation
SOP – Standard operating procedure
VOC – Volatile organic compounds
WIRO – Wilmington Regional Office

1.0 Approval Sheet

Title: Quality Assurance Guidance Document for the Duplin County Air Monitoring Study

The attached *Quality Assurance Guidance Document for the Duplin County Air Monitoring Study* is hereby recommended for approval and commits the State of *North Carolina*, Department of Environmental Quality Division of Air Quality to follow the elements described within.

1) Signature: _________________________________ Date ____________
   DEQ, Air Quality Division Director

2) Signature: _________________________________ Date ____________
   DAQ Quality Assurance Manager

3) Signature: _________________________________ Date ____________
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3.0 Distribution

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4.0 Project/Task Organization

The division director organized the Division of Air Quality, or DAQ, Ambient Monitoring Section into three main branches: The Projects and Procedures Branch, the Laboratory Analysis Branch and the Electronics and Calibration Branch. The chief of the Ambient Monitoring Section, or chief, has responsibility for managing these branches per stated policy. The chief delegates the responsibility and authority to develop, organize, and maintain and implement quality programs to the supervisors of each branch, in accordance with the quality management plan. These supervisors have direct responsibility for assuring data quality.

Figure 1 shows the organizational structure for the implementation of the Duplin County Air Monitoring Study, or DCAMS. The following information lists the specific responsibilities of the division director and each significant position within the DAQ Ambient Monitoring Section and the regional offices.

The Ambient Monitoring Section is responsible for coordinating all aspects (quality assurance, or QA, data collection and data processing) of the DCAMS.

Air Quality Division Director: The DAQ director, or division director, supervises the chief and Wilmington regional office supervisor. The director is responsible for ensuring adequate human and financial resources are available to support the DCAMS. The director has ultimate responsibility and final authority on all aspects of the DCAMS. The director also serves as a liaison with other divisions in the Department of Environmental Quality, or DEQ, with the North Carolina General Assembly, the North Carolina Department of Information Technology, or DIT, and with other regional air-monitoring agency organizations.

Project Administrator/QA Manager: The project administrator/QA manager, or QAM, has overall supervision of this project. The project manager, QA supervisor, ECB supervisor and database manager report to the project administrator. The project administrator’s duties include, but are not limited to the following:

- Maintaining oversight of QA activities;
- Approving standard operation procedures (SOPs) and QA project plans (QAGDs);
- Developing, administering and maintaining the quality management plan;
- Assuring that QAGDs are established and effectively implemented for the project;
- Supervising the Ambient Monitoring Section staff; and
- Serving as the liaison with the United States Environmental Protection Agency, or EPA, Region 4;

If the project administrator is unavailable to perform these duties, the project manager is responsible.

Project Manager: The project manager is responsible for the establishment of the network sites as well as training all staff in site operation and sample handling. The project manager is also responsible for ensuring successful outcomes and managing all aspects of the study. The field site operator reports to the project manager as well as to the supervisor of the ECB. The project manager reports directly to the project administrator. The project manager duties include, but are not limited, to the following:

- Serving as a liaison with the complainants;

- Maintaining overall responsibility for the monitoring network design and review;
- Maintaining oversight of all QA activities;
- Verifying implementation of all DACMS QAGDs and procedures;
- Serving as the tie-breaker in the event of an impasse on how to handle corrective actions or make a judgment call on data validity
- Preparing periodic reports and the final project report;
- Responding to requests for DCAMS data;
- Ensuring training availability and utilization; and
- Approving and implementing procedures.

Quality Assurance Supervisor: The QA supervisor is responsible for coordinating and assessing the effectiveness of the quality system for the project. The QA supervisor reports directly to the project administrator/QAM. The QA supervisor's duties include the following:

- Supporting and assisting the QAM in providing oversight of all QA activities;
- Communicating with the QAM to bring to his attention QA matters that need attention;
- Directing the activities of QA staff;
- Verifying implementation of all DCAMS QAGDs and procedures;
- Ensuring training availability and utilization; and
- Approving and implementing procedures.

Quality Assurance Coordinator: The QA coordinator performs data verifications, validations and data quality assessments. The QA coordinator reports directly to the QA supervisor. The QA coordinator duties include the following:

- Uploading environmental data to DAQ's ENVISTA Air Resource Manager, or ARM, database;
- Organizing and managing all documentation on the collection and verification of data;
- Assessing the effectiveness of the network system;
- Ensuring timely and appropriate SOP and QAGD updates;
- Verifying and validating the data;
- Verifying that all required QA/QC activities are performed and that measurement quality standards are met;
- Maintaining QA records, flagging suspect data, and assessing and reporting on data quality;
- Identifying data quality problems and initiating actions that result in solutions; and
- Providing training and certification to appropriate personnel.

Quality Assurance Auditor: The QA auditor performs data quality assessments. The QA auditor reports directly to the QA supervisor. The QA auditor duties include the following:

- Assessing the effectiveness of the network system;
- Verifying that all required QA/QC activities are performed and that measurement quality standards are met by conducting annual system audits;
- Assessing and reporting on data quality;
- Identifying data quality problems and initiating actions that result in solutions; and
- Providing training and certification to appropriate personnel.

Backup Site Operator and Quality Assurance Coordinator: The backup site operator and QA coordinator reports directly to the QA supervisor as well as to the project manager. He may perform all of the duties performed by the electronic technicians, field site operator, and QA coordinators.

Statistician: The statistician calculates the statistics for data quality assessments. The statistician reports directly to the QA supervisor. The statistician duties include the following:

- Interpreting data;
- Preparing statistical analysis and summaries of the data, including graphs, for QA and reporting;
- Planning and conducting data quality assessments, or DQAs, based on interpretation of data; and
- Participating in systems audits.

Electronics and Calibration Branch Supervisor: The Electronics and Calibration Branch, or ECB, supervisor supervises the electronic technicians. The ECB supervisor reports directly to the project administrator. The ECB supervisor has the responsibility and authority to:

- Supervise the ECB staff;
- Approve QAGDs and SOPs;
- Schedule performance audits and standard certifications;
- Maintain documentation and records of performance audits and standard certifications;
- Identify data quality problems and initiate actions that result in solutions; and
- Provide training and certification to field personnel and maintain training records.

Electronics Technicians: The electronic technicians purchase, evaluate, install and maintain all the monitoring equipment and meteorological sensors. The electronic technicians report directly to the ECB supervisor. The electronic technicians are responsible for:

- Installing all field equipment and monitoring sites;
- Maintaining an inventory of spare parts and spare equipment to prevent unnecessary downtime;
- Performing and documenting all major maintenance and repairs of field equipment as described by the SOPs 2.12.1, 2.53.1, 2.55 and 2.56;
- Calibrating and certifying all transfer standards and periodically checking calibration of primary standards to ensure quality calibrations;
- Verifying the calibration of all meteorological sensors and conducting performance audits on meteorological sensors and other gaseous sensors;
- Maintaining documentation and records of calibration verifications, performance audits and standard certifications;
- Identifying data quality problems and initiating actions that result in solutions; and
- Providing training and certification to field operators.

Field Site Operator: The field site operator is responsible for collecting and deploying samples and retrieving meteorological data, when necessary, at the monitoring sites. The field site operator reports directly to the project manager. The field site operator's duties include:

- Ensuring that monitoring programs implement the QA elements of SOPs and QAGDs;
- Assisting in the acquisition of resources, calibration and maintenance of equipment, and maintenance of inventories;
- Participating in training and certification activities;
- Performing all required QC activities to ensure MQOs are met;
- Performing corrective actions to address any activities that do not meet acceptance criteria as prescribed in the QAGD and SOPs;
- Documenting deviations from established procedures and methods;
- Reporting nonconforming conditions and corrective actions to the QA coordinators and the project manager;
- Performing level 1 data verification activities and flagging suspect data; and
- Recommending changes, when needed, in the QA program.

Wilmington Regional Office Supervisor: The Wilmington Regional Office, or WIRO, supervisor supervises the WIRO staff. The WIRO supervisor reports directly to the division director and has direct access to the project administrator and project manager. The WIRO supervisor has the responsibility and authority to:

- Supervise and delineate duties for the WIRO staff;
- Assist with identifying monitoring sites and obtaining approval from property owners;
- Assure division policies are maintained at the regional office level;
- Recommend changes when needed in the QA program;
- Identify data quality problems and initiate actions that result in solutions; and
- Provide training and certification to regional office personnel and maintain training records.

Wilmington Regional Office Monitoring Staff: The WIRO monitoring staff assists with identifying monitoring sites, contacting property owners, obtaining use agreements with property owners and serving as a backup field operator when needed. The WIRO monitoring staff report directly to the WIRO supervisor and have direct access to the project manager. The WIRO monitoring staff responsibilities include:

- Identifying monitoring sites and obtaining approval from property owners;
- Serving as a backup field operator when needed;
- Recommending changes when needed in the QA program; and
- Identifying data quality problems and initiating actions that result in solutions.

Database Manager: The database manager assists in the development of SOPs for data management and is responsible for data management of both the analytical and meteorological data. The data manager assists in the preparation of periodic reports. The data manager reports to the project administrator. The data manager's duties include, but are not limited, to the following:

- Assisting with the uploading of environmental data to DAQ's ENVISTA ARM database;
- Maintaining and updating the ENVISTA ARM database when sites and monitors are established or shut down. Ensuring data are backed up on a routine basis;

- Maintaining a backup database and server; and
- Archiving data.

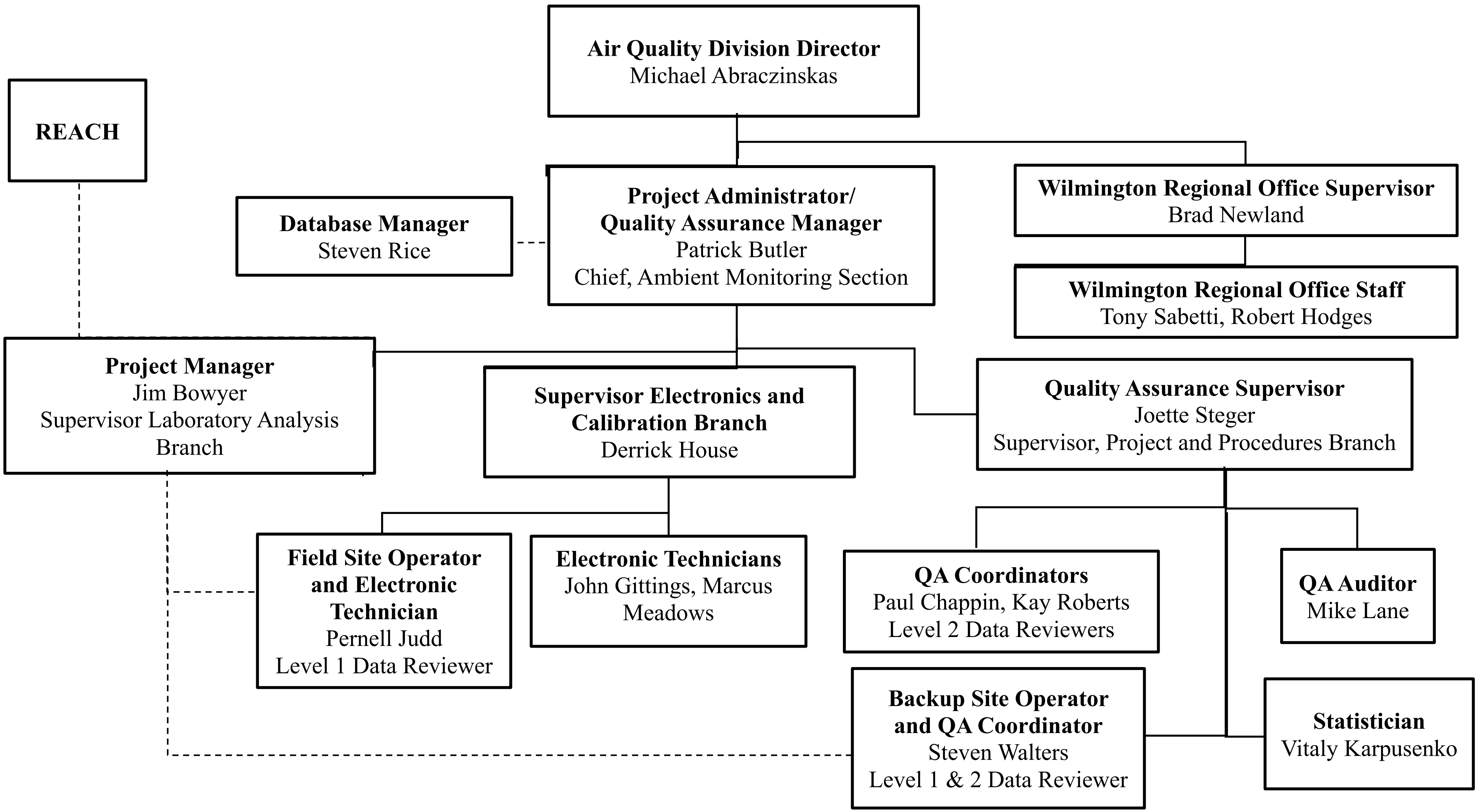

Figure 1. Organizational Structure for the Duplin County Air Monitoring Study

5.0 Problem Definition and Background

In 1996, the North Carolina legislature required that the state develop a general permit program to prevent the discharge of waste from animal operations, including swine operations with 250 or more swine. DEQ began issuing general permits for controlling swine waste management systems on January 1, 1997.

The following year the North Carolina legislature enacted a moratorium on new and expanded lagoon and spray field waste management systems at swine facilities (see G.S. 143-215-101). DEQ has since issued revised general permits, first on June 4, 2004, and again on Feb. 20, 2009. In 2013, DENR published draft state permits to control animal waste, including AWG100000, the *Swine Waste Management System General Permit*.

On December 6, 2013, complainants consisting of the North Carolina Environmental Justice Network, or NCEJN, and the Waterkeeper Alliance, Inc., or Waterkeeper, along with others submitted comments to DEQ requesting the modification of the proposed general permit for the purpose of complying with Title VI. The comments requested that DEQ "assess the racial and ethnic impact of the permitting program" before finalizing the general permit and "adopt measures that protect communities from pollution from swine facilities."

The DEQ finalized the renewal of Permit NO. AWG1000000, or the General Permit, on March 7, 2014. On September 3, 2014, complainants, consisting of the NCEJN, Rural Empowerment Association for Community Help, or REACH and the Waterkeeper, submitted a complaint to EPA's Office of Civil Rights, now called the External Civil Rights Compliance Office, or ECRCO. The complaint alleged DEQ issued a general permit for industrial swine facilities in North Carolina in violation of Title VI and EPA implementing regulations, 40 C.F.R. Part 7. EPA accepted the complaint for investigation on Feb. 20, 2015. The EPA found that the allegation met EPA's jurisdictional requirements.

On March 6, 2015 the complainants NCEJN, REACH and Waterkeeper along with DEQ agreed to engage in Alternative Dispute Resolution (ADR) and EPA placed its investigation on hold pending the outcome of ADR. The Parties commenced ADR but failed to reach resolution, and EPA reinstated its investigation on May 5, 2016.

On July 11, 2016, the complainants (NCEJN, REACH and Waterkeeper) filed a second complaint with EPA alleging that DEQ directly, and through the actions of third parties, engaged in and failed to protect the complainants from intimidation, which is prohibited by Title VI and EPA regulations 40 C.F.R. § 7.100.

On August 2, 2016, EPA accepted for investigation the complainants' second complaint. EPA found that the complaint met EPA's jurisdictional requirements.

On January 12, 2017, EPA sent to DEQ a Letter of Concern providing preliminary information on ECRCO's investigation and making a series of recommendations.

EPA suspended its investigation on March 8, 2017 in light of the fact that the complainants and DEQ agreed to engage in ADR. EPA informed the complainants and DEQ that, pursuant to procedures set forth in its Complaint Resolution Manual, EPA would resume its investigation if the Parties did not reach resolution through ADR. On June 30, 2017, complainants and DEQ entered into mediation.

EPA regulations require that for all agency projects involving the generation, acquisition and use of environmental data, the agency create a plan and appropriate documentation and have an approved QAGD. The QAGD is the critical planning document for any environmental data collection operation because it documents how the agency will implement QA and QC activities during the project's life cycle.

The DCAMS is a short-term project projected to last for approximately 12 months. The purpose of this QAGD is to prescribe requirements, procedures and guidelines for the DCAMS, specifically for data collection and review for the fulfillment of the DCAMS. This QAGD serves as a reference document for implementing the QA program and provides detailed operational procedures for measurement processes used by DEQ's DAQ. The QAGD should be particularly beneficial to field operators, QA coordinators, project managers and project administrators responsible for implementing, designing and coordinating the DCAMS. The QAGD is a compilation of QA requirements, procedures and guidelines that are applicable to air pollution and meteorological measurements systems. They are designed to achieve a high percentage of valid data samples (>75 percent) while maintaining integrity and accuracy. This QAGD clearly and thoroughly establishes QA protocols and QC criteria required to successfully implement and maintain the state of NC's DCAMS. The field operator, assisted by regional staff and the electronic technician, will operate and maintain the monitoring stations. The DAQ will ensure its Ambient Monitoring Section implements and adheres to the QA programs for the field and data processing phases of the monitoring program.

After the conclusion of the 12-month study period, DEQ will determine, based on the data collected, whether to extend the study for an additional agreed upon period of time. Should DEQ determine to extend the study, the QA coordinators and QA auditor will annually review, and as needed, revise this QAGD and its associated SOPs. If no revisions are necessary, the QA coordinators and QA auditor will document the review via a memo to the QA supervisor containing the review data and the name of the individual or individuals completing the review. Additionally, after the conclusion of the 12-month study period, the project manager will compile a draft report and provide it to the interested parties for comment. The project manager will post a final version of the report on the DAQ website.

The QA coordinators developed this QAGD to ensure that the DCAMS will comply, to the degree possible, with EPA QA requirements, where such requirements exist.

6.0 Project/Task Description

To ensure that residents have access to reliable information about air quality, DEQ will design and implement a temporary ambient air quality study in partnership with REACH to determine the degree of air contamination and air pollution in and around Duplin County, North Carolina. DEQ and the complainants agree to undertake the air monitoring activities outlined in the Air Quality Monitoring Agreement. The work required to collect, document, and report these data include, but is not limited to:

- Establishing a monitoring network that has accurate and reliable monitors and data recording equipment;
- Developing encompassing documentation for:
    - Data and report format, content, and schedules;
    - Quality objectives and criteria; and
    - SOPs providing activities and schedules for:
        - Equipment operation and preventative maintenance; and
        - Instrument calibrations, zero, span, precision and accuracy evaluations;
- Establishing assessment criteria and schedules; and
- Verifying and validating data.

6.1 Field Activities

Field operators will perform those activities that support continued successful operation of the DCAMS. Personnel will perform field activities that include, but are not limited to, conducting instrument QC checks and calibrations or calibration verifications, periodic preventative maintenance activities and servicing equipment located at the monitoring sites.

6.2 Laboratory Activities

Laboratory personnel will perform those activities that support continued successful operation of the DCAMS. Additionally, where analysis of samples is required, the laboratory personnel shall perform those duties such that data quality provided meets or exceeds EPA QA requirements. Laboratory personnel shall be responsible for preparing consumables for field use. This may include, but not limited to, performing assays on materials before and after exposure to the ambient atmosphere, preparing and analyzing control samples, maintaining consumable inventories, shipping and receiving activities and performing instrument audits.

6.3 Project Assessment Techniques

The EPA defines an assessment as an evaluation process used to measure the performance or effectiveness of a system and its elements. In this document, the DAQ uses “assessment” as an all-inclusive term to denote any of the following: audit, performance evaluation, peer review, inspection or surveillance. Section 20.0- Assessment and Response Action- discusses the details of assessments. Table 2 provides information on the parties implementing assessments and their frequency.

Table 2. Assessment Schedule

Assessment Type	Assessment Agent	Frequency
Technical System Audit	QA Auditor	At start of project Annually At end of project
Network Assessment	Project Manager	Annually
Appendix E Siting Review	Field Operator	Annually

Table 2. Assessment Schedule

Assessment Type	Assessment Agent	Frequency
Data Verification and Validation	QA Coordinators	Monthly
Quality Assurance Guidance Document Review and Updates	QA Coordinators QA Auditor	Review annually Update as needed or every 5 years
Standard Operating Procedures Review and Updates	Field Operator QA Coordinators	Review annually Update as needed or every 5 years
Data Quality Assessment	QA Auditor	Quarterly
Semi-annual Flow Rate Audit	QA Coordinators	Every 6 months

6.4 Project Records

DAQ will establish and maintain procedures for the timely preparation, review, approval, issuance, use, control, revision and maintenance of documents and records. Table 3-Critical Documents and Records- presents the categories and types of records and documents that are applicable to document control for the DCAMS. Section 9.0- Documentation and Records- explains in more detail information on key documents in each category. detail Information on key documents in each category.

Table 3. Critical Documents and Records

Categories	Record/Document Type
Site Information	Network Descriptions
	Site Files
	Site Maps
	Site Pictures
	Appendix E Siting Reviews
	Network Assessments
Environmental Data Operations	Quality Assurance Guidance Documents
	Standard Operating Procedures
	Field Notebooks and Logbooks
	Inspection/Maintenance Records
Raw Data	Any Original Data (routine and quality control, or QC) Including Data Entry Forms
Data Reporting	Monthly Verified and Validated Data
	Quarterly Data/Summary Reports
	Annual Report
Data Management	Data Algorithms
	Data Management Plans/Flowcharts
	Data Management Systems
Quality Assurance	Data Quality Assessments
	Quality Assurance Reports
	Response/Corrective Action Documentation

7.0 Data and Measurement Quality Objectives and Criteria

The DAQ operates under an EPA-approved quality management plan that describes the agency's system for communicating and implementing quality within the agency.

A quality system is a structured and documented set of management activities in which an organization applies sufficient QC practices to ensure the data produced by an operation will be of the type and quality needed and expected by the data user. Quality control defines the procedures DAQ implements to assure that DAQ obtains and maintains acceptability in the generated data set. Quality control procedures, when properly executed, provide data that meet or exceed the minimally acceptable quality criteria established to assist management in making confident decisions. The policy of DAQ is to implement a QA program to assure DAQ collects data of known and acceptable precision, bias, completeness, comparability and representativeness within the DCAMS.

The current objectives of the DCAMS are informational. The DAQ will use the data to determine the ambient air quality within the boundaries of Duplin County. This QAGD describes how the program controls and evaluates data quality so that the DAQ will meet the data quality objectives (DQO) of the project. The highest priority objective is informational and to determine the concentrations of $PM_{2.5}$, NH_3 and H_2S in the ambient air. Based on the information collected, additional monitoring may be needed to ensure human health and the environment are protected. The data may also be used in air quality studies and assessments. To achieve these objectives:

- All data should be traceable to a National Institute of Science and Technology (NIST) primary standard, when such a standard is available.
- All data shall be of a known and documented quality. The DAQ shall establish the level of quality required for each specific monitoring project during the initial planning stages of the project. The level of quality will depend upon the data's intended use. Two major measurements used to define quality are precision and bias.
- All data shall be comparable. This means the DAQ will measure all data in a similar and scientific manner. The use of standard methodologies for sampling, calibration, auditing, etc. referenced in the QAGD should achieve this goal.
- All data shall be representative of the parameters measured with respect to time, location and the conditions from which the data are obtained. The use of approved standard methodologies should ensure that the data generated are representative.
- The QAGD must be dynamic to continue to achieve its stated goals as techniques, systems, concepts and project goals change.

Measurement quality objectives, or MQOs, are the translation of the DQOs into parameters that are directly measurable. The DAQ sets the MQOs so that when DAQ meets them, the data user can assume that the DAQ also met the DQOs. The EPA designed MQOs to evaluate and control various phases (sampling, preparation and analysis) of the measurement process.

The US EPA's Quality Assurance Handbook, Volumes I and II, provides information regarding these objectives and their use. The EPA defines MQOs in terms of the following data quality indicators, or DQIs:

- Precision
- Bias
- Representativeness
- Detection Limits
- Completeness
- Comparability
- Accuracy

Precision - "Precision is a measure of agreement between two replicate measurements of the same property, under prescribed similar conditions. The DAQ will calculate this agreement as the standard deviation (US EPA QA/G-5, Appendix D[1])." This is the random component of error.

Bias - "Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction (US EPA QA/G-5, Appendix D)." Bias is determined by estimating the positive and negative deviation from the true value as a percentage of the true value.

Representativeness - "Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process condition or environmental condition. Representativeness is a qualitative term that should be evaluated to determine whether in situ or other measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied (US EPA QA/G-5, Appendix D)."

Detection Limit – The lowest concentration or amount of the target analyte that can be determined to be different from zero by a single measurement at a stated level of probability. For this study, the DAQ will use the detection limits reported in the instrument vendors' documentation on detection limits.

Completeness - Completeness is a metric quantifying the amount of valid data obtained from a measurement system compared to the amount that were expected to be obtained under correct, normal conditions. For the DCAMS the DAQ will express completeness as a percentage. Data completeness requirements are included in 40 CFR 50, Appendix N Sections 4.1 and 4.2 for $PM_{2.5}$. The EPA does not have published completeness requirements for H_2S and NH_3. Thus, The DAQ will use the completeness requirements for SO_2 in 40 CFR 50 Appendix T Section 3(b) for H_2S and the completeness requirements for NO_2 in 40 CFR 50 Appendix S Sections 3.1 and 3.2 for NH_3.

Comparability - "Comparability is the qualitative term that expresses the confidence that two data sets can contribute to a common analysis and interpolation. Comparability must be carefully evaluated to establish whether two data sets can be considered equivalent

[1] https://www.epa.gov/sites/production/files/2015-06/documents/g5-final.pdf

regarding the measurement of a specific variable or groups of variables (US EPA QA/G-5, Appendix D)."

Accuracy - a combination of precision and bias. This term has been used throughout the CFR. In general, this QAGD will follow the conventions of the NIST and, more recently, of EPA (ref. NIST Report 1297 and EPA G-9) and will not use the term accuracy, but will describe measurement uncertainties as precision, bias, and total uncertainty.

For each of these attributes, the QA coordinators developed acceptance criteria using various parts of 40 CFR, EPA supplied guidance documents and the instrument manuals. **Table** 4 through **Table 10** provide detailed descriptions of these MQOs and how the field operators, QA coordinators and QA auditors will use them to control and assess measurement uncertainty.

Table 4. $PM_{2.5}$ Measurement Quality Objectives
Parameter – $PM_{2.5}$ (Continuous Met One E-BAM, Local Conditions)

1) Criteria ($PM_{2.5}$ CLC)	2) Frequency	3) Acceptable Range	Information /Action
CRITICAL CRITERIA - $PM_{2.5}$ Continuous, E-BAM, Local Conditions			
Field Activities			
Sampling Instrument			
Average Flow Rate	every 24 hours of operation	average within 5 percent of 16.67 liters/minute	1, 2 and 3) Part 50 App L Sec 7.4.3.1
Variability in Flow Rate	every 24 hours of operation	CV* ≤ 2 percent	1, 2 and 3) 40 CFR Part 50, App. L Sec 7.4.3.2
One-point Flow Rate Verification	1/30 days	± 3 percent of transfer standard ± 4 percent of flow rate design value	1, 2 and 3) 40 CFR Part 50, App. L, Sec 9.2.5 and 7.4.3.1 and 40 CFR Part 58, Appendix A Sec 3.2.3 & 3.3.2
BAM Specific Critical Criteria			
Reference Membrane Span Foil Verification (BAM)	1/90 days	+ 5 percent of ABS Value	1,2 and 3) BAM 1022 Operation Manual
OPERATIONAL CRITERIA - $PM_{2.5}$ Continuous, E-BAM, Local Conditions			
Routine Verifications			
Mid-month Flow Rate Verification	1/30 days	± 3 percent of transfer standard	1) 40 CFR Part 50 App L, Sec 7.4.6.1 2) Recommendation 3) BAM SOP Sec 5.3
Design Flow Rate Verification	1/30 days	± 4 percent of design flow rate	1) 40 CFR Part 50 App L, Sec 7.4.6.1 2) Recommendation 3) BAM SOP Sec 5.3
Temp Verification	1/30 days	± 2°C	1) 40 CFR Part 50 App L, Sec 7.4.6.1 2) Recommendation 3) BAM SOP Sec 5.3

Table 4. $PM_{2.5}$ Measurement Quality Objectives
Parameter – $PM_{2.5}$ (Continuous Met One E-BAM, Local Conditions) – Continued

1) Criteria ($PM_{2.5}$ CLC)	2) Frequency	3) Acceptable Range	Information /Action
Pressure Verification	1/30 days	± 10 mm Hg	1) 40 CFR Part 50 App L, Sec 7.4.6.1 2) Recommendation 3) BAM SOP Sec 5.3
Leak Check	every 30 days	< 1.5 LPM BAM	1) 40 CFR Part 50 App L, Sec 7.4.6.1 2) Recommendation 3) BAM SOP Sec 5.3
Annual Multi-Point Calibrations			
Temperature Calibration	Electromechanical maintenance or transport or 1/365 days	± 2ºC	1) 40 CFR Part 50, App. L, Sec 9.3 2 and 3) Method 2.12 sec 6.4
Temperature Calibration	Electromechanical maintenance or transport or 1/365 days	± 2ºC	1) 40 CFR Part 50, App. L, Sec 9.3 2 and 3) Method 2.12 sec 6.4
Pressure Calibration	Electromechanical maintenance or transport or 1/365 days	± 10 mm Hg	1) 40 CFR Part 50, App. L, Sec 9.3 2 and 3) Method 2.12 sec 6.5 BP verified against independent standard verified against a lab primary standard that is certified NIST traceable 1/365 days
Flow Rate Multi-point Calibration	Electromechanical maintenance or transport or 1/365 days	± 2 percent of transfer standard	1) 40 CFR Part 50, App. L, Sec 9.2. 2) 40 CFR Part 50, App. L, Sec 9.1.3, Method 2.12 Table 6-1 3) 40 CFR Part 50, App. L, Sec 9.2.5
Design Flow Rate Adjustment	at multi-point calibration	± 2 percent of design flow rate	1,2 and 3) 40 CFR Part 50, App. L, Sec 9.2.6
Accuracy			
Temperature Audit	1/90 days	± 2°C	1, 2 and 3) Method 2.12 Sec. 10.2.2 & Table 3-1
Pressure Audit	1/90 days	±10 mm Hg	1, 2 and 3) Method 2.12 Sec. 10.2.3 & Table 3-1

Table 4. $PM_{2.5}$ Measurement Quality Objectives Parameter – $PM_{2.5}$ (Continuous Met One E-BAM, Local Conditions) – Continued			
1) Criteria ($PM_{2.5}$ CLC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
Semi Annual Flow Rate Audit	1/90 days	± 4 percent of audit standard ± 5 percent of design flow rate	1 and 2) Part 58, App A, Sec 3.3.3 3) Method 2.12 Sec. 10.2.1 & Table 10-1
Monitor Maintenance			
Virtual Impactor (SCC)	Every 30 days	cleaned	1,2 and 3) Recommendation
Inlet Cleaning	Every 30 days	cleaned	1,2 and 3) Method 2.12 Sec 9.3
Filter Chamber Cleaning	Every 30 days	cleaned	1,2 and 3) Method 2.12 Sec 9.3
Circulating Fan Filter Cleaning	1/30 days	cleaned/changed	1,2 and 3) Method 2.12 Sec 9.3
BAM Specific Operational Criteria			
Cleaning Nozzle and Vane (BAM)	Every 30 days	cleaned	1, 2 and 3) BAM SOP Sec 10.1.3
Replace or Clean Pump Muffler	1/182 days	cleaned or changed	
Smart Heater Test	1/30 days	heater turns when forced off	1, 2 and 3) BAM SOP Sec 10.3.3
Clean/replace internal debris filter	1/365 days		
72-Hour zero filter test	At installation and 1/365 days		1, 2 and 3) BAM SOP Sec 9.6.10
Check of membrane span foil	1/365 days	Avg. < ± 5 percent of ABS	1, 2 and 3) BAM SOP Sec 10.4.3
Beta detector count rate	1/365 days	between 600,00 and 1,000,000	1, 2 and 3) BAM SOP Sec 10.4.4
SYSTEMATIC CRITERIA - $PM_{2.5}$ Continuous, E-BAM, Local Conditions			
Siting	1/365 days	meets siting criteria or waiver documented	1) 40 CFR Part 58 App E, sections 2-5 2) Recommendation 3) 40 CFR Part 58 App E, sections 2-5

Table 4. $PM_{2.5}$ Measurement Quality Objectives Parameter – $PM_{2.5}$ (Continuous Met One E-BAM, Local Conditions) – Continued			
1) Criteria ($PM_{2.5}$ CLC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
Data Completeness	24-hour averages	≥ 75 percent	Part 50, App. N, Sec. 4.1 (b) 4.2 (a)
Reporting Units	all hourly and 24-hour values	$\mu g/m^3$ at ambient temp/pressure ($PM_{2.5}$)	1. 2 and 3) 40 CFR Part 50 App N Sec 3.0 (b)
Rounding convention for data reporting	all 1-hour averages	to one decimal place, with additional digits to the right being truncated	1. 2 and 3) 40 CFR Part 50 App N Sec 3.0 (b)
Annual 3-yr average	all concentrations	nearest 0.1 $\mu g/m^3$ (≥ 0.05 round up)	1,2 and 3) 40 CFR Part 50, App. N Sec 3 and 4 Rounding convention for data reporting is a recommendation
24-hour, 3-year average	all concentrations	nearest 1 $\mu g/m^3$ (≥ 0.5 round up)	1,2 and 3) 40 CFR Part 50, App. N Sec 3 and 4 Rounding convention for data reporting is a recommendation
Detection Limit			
Lower DL	1 hour	Less than 10 $\mu g/m^3$	1,2 and 3) E-BAM Operations Manual
	24 hour	Less than 2 $\mu g/m^3$	1,2 and 3) 40 CFR Part 50, Appendix L Section 3.1
Upper Conc. Limit	1 hour	10,000 $\mu g/m^3$	1,2 and 3) E-BAM Operations Manual
Precision			
Primary Quality Assurance Org.	Annual and 3 year estimates	90 percent CL of CV*** ≤ 10 percent for values > 3 $\mu g/m^3$	1, 2 and 3) 40 CFR Part 58, App A, Sec 4.3.1 and 2.3.1.1.
Field Activities			
Flow Rate Transfer Std.	1/365 days	± 2 percent of NIST Traceable Std.	1) 40 CFR Part 50, App. L Sec 9.1 & 9.2 2) Method 2-12 Section 6.3.3 and Table 3-1 3) 40 CFR Part 50, App. L Sec 9.1 & 9.2
Field Thermometer	1/365 days	± 0.1° C resolution, ± 0.5° C accuracy	1, 2 and 3) Method 2.12 Sec 4.2.2 & Table 3-1

Table 4. $PM_{2.5}$ Measurement Quality Objectives **Parameter – $PM_{2.5}$ (Continuous Met One E-BAM, Local Conditions) – Continued**			
1) Criteria ($PM_{2.5}$ CLC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
Field Barometer	1/365 days	± 1 mm Hg resolution, ± 5 mm Hg accuracy	1, 2 and 3) Method 2.12 Sec 4.2.2 & Table 3-1
Field Manometer	1/365 days	± 0.1 in H_2O resolution, ± 1.0 in H_2O accuracy	1, 2 and 3) Method 2.12 Sec 4.2.2 & Table 3-1
Clock/timer Verification	1/30 days	1 min/month	1and 2) Method 2.12 Table 3-1 3) 40 CFR Part 50, App. L Sec 7.4.12
*****CV= Coefficient of Variation**			

Table 5. NH_3 Measurement Quality Objectives Parameter – NH_3 (Continuous AreaRAE, Local Conditions)			
1) Criteria (NH_3 CLC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
CRITICAL CRITERIA - NH_3 (Continuous AreaRAE, Local Conditions)			
Average Flow Rate	1/7 days	± 20 percent of design flow rate of 0.4 L/min	1) Operation and Maintenance Manual 2 and 3) Recommendation
Calibration Verification	1/7 days	± 10 ppm for cylinder concentration of 50 ppm	1) Operation and Maintenance Manual 2 and 3) Recommendation
Zero Point Verification	1/7 days	0 ± 1 ppm	1) Operation and Maintenance Manual 2 and 3) Recommendation
OPERATIONAL CRITERIA - NH_3 (Continuous AreaRAE, Local Conditions)			
Data Download	1/7 days	Not applicable	1) Operation and Maintenance Manual 2) Recommendation
Clock/timer Verification	1/7 days	10 minute/week	1, 2, and 3) Recommendation
Factory Calibration	Annually	Manufacturer's acceptance criteria	1, 2 and 3) Operation and Maintenance Manual
Inlet filter	1/30 days or when wet	Replace filter	1, 2 and 3) Operation and Maintenance Manual
Gaseous Standards	All gas cylinders	**NIST [a] Traceable** (e.g., EPA Protocol Gas) 50 ppm [b] NH3	1) 40 CFR Part 50 Appendix F Section 1.3.1 2) Not applicable Green book 3) 40 CFR Part 50 Appendix F Section 1.3.1 Gas producer used must participate in EPA Ambient Air Protocol Gas Verification Program 40 CFR Part 58 Appendix A section 2.6.1
SYSTEMATIC CRITERIA - NH_3 (Continuous AreaRAE, Local Conditions)			
Siting	1/365 days	meets siting criteria or waiver documented	1) Operation and Maintenance Manual 2) Recommendation 3) Recommendation
Data Completeness	Project	1) 4 quarters complete in	1, 2, and 3) Recommendation

Table 5. NH_3 Measurement Quality Objectives Parameter – NH_3 (Continuous AreaRAE, Local Conditions)			
1) Criteria (NH_3 CLC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
		each year 2) ≥75 percent sampling days in quarter 3) ≥ 75 percent of hours in a day	
Reporting Units	All data	ppm (NH_3)	1, 2 and 3) Operation and Maintenance Manual
Rounding Convention for Data	All data	to one decimal places	1, 2 and 3) Operation and Maintenance Manual
Sample Probe, Inlet, Sampling Train	All Sites	Treated stainless steel probe with tygon connector to sampler	1, 2, and 3) Recommendation
Field Activities			
Flow Rate Transfer Std.	1/365 days	± 2 percent of NIST Traceable Std.	1) 40 CFR Part 50, App. L Sec 9.1 & 9.2 2) Method 2-12 Section 6.3.3 and Table 3-1 3) 40 CFR Part 50, App. L Sec 9.1 & 9.2

Table 6. H_2S Measurement Quality Objectives Parameter – H_2S (Continuous Jerome Meter, Local Conditions)			
1) Criteria (H_2S CLC)	**2) Frequency**	**3) Acceptable Range**	**Information /Action**
CRITICAL CRITERIA - H_2S (Continuous Jerome Meter, Local Conditions)			
Sampling Instrument			
Sensor Regeneration	Daily	Not applicable	1 and 2) Operation Manual
Flow Rate Verification	1/ 7 days	± 20 percent of design flow rate of 0.15 L/min	1) Operation Manual 2 and 3) Recommendation
One Point QC Check Single Analyzer	1/ 180 days	expected value range (0.2 - 0.3PPM)	1 and 2) Operation Manual 3) Recommendation
Shelter Temperature Range	Daily (hourly values)	0 to 40 º C (hourly average)	1, 2 and 3) Operation Manual
OPERATIONAL CRITERIA - H_2S (Continuous Jerome Meter, Local Conditions)			
Data Download	1/ 7 days	Not applicable	1 and 2) recommendation
Shelter Temperature Device Check	1/6 months	± 2º C of NIST standard	1, 2 and 3) QA Handbook Volume 2 Section 7.2.2
Factory Calibration	1/365 days	± 2 percent of expected value	1 and 2) Operation Manual 3) Recommendation
Fritware in intake	1/7 days	Inspect and replace if dirty	1, 2 and 3) Operation Manual
Internal Filters and Tubing	1/ 180 days or as needed	Replace	1, 2 and 3) Operation Manual
Zero air filter	1/ 365 days	Replace	1, 2 and 3) Operation Manual
Gaseous Standards (Flow Transfer Method using a permeation tube)	All permeation tubes	**NIST [a] Traceable** (e.g., EPA Protocol Gas) 25 ppm [b] of H2S	1) 40 CFR Part 50 Appendix F Section 1.3.1 2) Not applicable Green book 3) 40 CFR Part 50 Appendix F Section 1.3.1 Gas producer used must participate in EPA Ambient Air Protocol Gas Verification Program 40 CFR Part 58 Appendix A section 2.6.1

Table 6. H_2S Measurement Quality Objectives
Parameter – H_2S (Continuous Jerome Meter, Local Conditions) – Continued

1) Criteria (H_2S CLC)	2) Frequency	3) Acceptable Range	Information /Action
SYSTEMATIC CRITERIA - H_2S (Continuous Jerome Meter, Local Conditions)			
Siting	1/365 days	meets siting criteria or waiver documented	1) Operation and Maintenance Manual 2) Recommendation 3) Recommendation
Data Completeness	Project	1) 4 quarters complete in each year 2) ≥75 percent sampling days in quarter 3) ≥ 75 percent of hours in a day	1, 2, and 3) Recommendation
Reporting Units	All data	ppm (H_2S)	1, 2 and 3) Operation Manual
Rounding convention	All data	to three decimal places	1, 2 and 3) Operation Manual
Sample Probe, Inlet, Sampling Train	All Sites	Treated stainless steel probe with Teflon connector to sampler	1, 2, and 3) Recommendation
Field Activities			
Flow Rate Transfer Std.	1/365 days	± 2 percent of NIST Traceable Std.	1) 40 CFR Part 50, App. L Sec 9.1 & 9.2 2) Method 2-12 Section 6.3.3 and Table 3-1 3) 40 CFR Part 50, App. L Sec 9.1 & 9.2

Table 7. Ambient Temperature Measurement Quality Objectives Measurement Quality Objectives Parameter (Local Conditions) Ambient Temperature (AT) (Thermistor)			
1) Requirement (AT)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
CRITICAL CRITERIA-AT			
Accuracy	At purchase Every 182 days	± 0.5°C	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Volume 4, Appendix C
Time Constant	At purchase	≤ 1 minute	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Volume 4, Appendix C
Operating Range	At purchase	-30 – 50	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Resolution	At purchase	0.1	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving 1/182 days	3 pt. Water Bath with NIST traceable thermistor or thermometer. All points within ± 0.5 ºC of standard.	1, 2 & 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements, Ver. 2.0 (Final) Table 0-4 NCore Calibration & Accuracy Criteria
OPERATIONAL CRITERIA-AT			
Calibration and audit standards	Purchase, recertify 1/365 days or per	Thermistor with measurement range -50°C to + 40°C; Accuracy ≤±0.2°C	1, 2 & 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV:

Table 7. Ambient Temperature Measurement Quality Objectives Measurement Quality Objectives Parameter (Local Conditions) Ambient Temperature (AT) (Thermistor)			
1) Requirement (AT)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
	NIST/ASTM certification frequency	NIST traceable certified over -30°C to +30°C; and Resolution ≤±0.1°C	Meteorological Measurements, Ver. 2.0 (Final) Table 0-4 NCore Calibration & Accuracy Criteria
Annual Accuracy Evaluation	Every site 1/365 days	3 pt. Water Bath with NIST traceable thermistor or thermometer. All points within ± 0.5 ºC of standard.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
Minimum Sample Frequency	Every site Every work day	Hourly	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Raw Data Collection Frequency	Every site Every work day	1 minute	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Hourly Recorded Ambient Temperature	1/30 days	Local record low ≤ Temp ≤ local record high; Temp ≤ 5°C from previous hourly record; Temp varies ≥ 0.5°C/12 consecutive hours, or per site specific climatology criteria	1, 2 and 3) EPA -454/R-99-005 Feb 2000, Chapter 8,Table 8-4
Appropriate radiation shield	1/182 days	Free from dirt, no surface damage	1, 2 & 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements, Ver. 2.0 (Final)

Table 7. Ambient Temperature Measurement Quality Objectives Measurement Quality Objectives Parameter (Local Conditions) Ambient Temperature (AT) (Thermistor)			
1) Requirement (AT)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
DAS Clock/timer Verification	1/7 days (or every site visit if site visited less than weekly)	< ± 1 minute NIST EST.	1, 2 and 3) Recommendation
Data Acquisition System (internal battery back-up)	1/182 days	Check Battery Back-up, Replace as needed	1, 2 and 3) Recommendation
SYSTEMATIC CRITERIA-AT			
Sensor/Monitor	At purchase/installation	Meets requirements listed in QA Handbook	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Standard Reporting Units	All data	ºC (final units in AQS)	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Rounding convention for data reported to AQS	All data	1 decimal place	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Completeness	Quarterly Hourly	75 percent of hourly averages for the quarter 75 percent of minute averages for the hour	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological

Table 7. Ambient Temperature Measurement Quality Objectives
Measurement Quality Objectives Parameter (Local Conditions) Ambient Temperature (AT) (Thermistor)

1) Requirement (AT)	2) Frequency	3) Acceptance Criteria	Information /Action
			Measurement Quality Objectives
Siting	1/365 days	Meets siting criteria or waiver documented	1) 40 CFR Part 58 App E, sections 2-6 2) Recommendation 3) 40 CFR Part 58 App E, sections 2-6
Distance from Obstruction	At installation/moving 1/365 days	1.5x the tower diameter from tower support & at least 2x height from ground (i.e., 4 m for a sensor located at 2 m above ground) from trees & buildings	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Distance Above Ground	At installation/moving 1/365 days	1.25 to 2 meters	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Recommended Ground Cover	At installation/moving 1/365 days	Non-irrigated or un-watered short grass, or natural earth at least 9 m in diameter. The surface should not be concrete, asphalt or oil-soaked. Reflection from these surfaces may affect sensor performance.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Technical Systems Audit	1/3 years	Data meets acceptance criteria in validation table	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 10 & Appendix A

Table 8. Wind Speed Measurement Quality Objectives

Measurement Quality Objectives Parameter (Local Conditions) Wind Speed (WS) (Cup, prop or sonic anemometer)

1) Requirement (WS)	2) Frequency	3) Acceptance Criteria	Information /Action
CRITICAL CRITERIA-WS			
Accuracy	At purchase 1/182 days	± 0.2 m/s	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Volume 4, Appendix C
Starting Threshold	At purchase 1/182 days	≤ 0.5 meters per second	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final)
Operating Range	At purchase	0.5 – 50.0 meters per second	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Resolution	At purchase	0.1 meters per second	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Verification/ Calibration	Upon receipt/ adjustment/ repair/ installation/ moving 1/182 days	NIST-traceable Synchronous Motor, CTS method. Zero plus 4 to 5 evenly spaced points between 0.5 and 50 m/s. ±0.25m/s ≤5m/s; 5 percent >2m/s not to exceed 2.5m/s.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
OPERATIONAL CRITERIA-WS			

Table 8. Wind Speed Measurement Quality Objectives

Measurement Quality Objectives Parameter (Local Conditions) Wind Speed (WS) (Cup, prop or sonic anemometer)

1) Requirement (WS)	2) Frequency	3) Acceptance Criteria	Information /Action
Calibration and audit standards	Purchase, recalibrate 1/365 days or at frequency dependent upon use	NIST Traceable Synchronous motor, or Series of NIST Traceable constant speed motors to generate WS in range of 2 m/s thru 50 m/s	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
Annual Accuracy / Performance Evaluation	Every site 1/365 days	NIST-traceable Synchronous Motor. At least 4 to 5 points between 0.5 and 50 m/s. ±0.25 m/s ≤ 5m/s; 5 percent > 2m/s not to exceed 2.5 m/s.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
Minimum Sample Frequency	Every site Every day	Hourly	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Raw Data Collection Frequency	Every site Every day	1 minute	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Hourly Recorded WS	Every workday 1/30 days	0 m/s ≥ WS ≤ 25 m/s0, WS varies ≥ 0.1 m/s/3 consecutive hours, WS varies ≥ 0.5 m/s/12 consecutive hours, or per site specific climatology criteria	1, 2 and 3) EPA -454/R-99-005 Feb 2000, Chapter 8,Table 8-4

Table 8. Wind Speed Measurement Quality Objectives

Measurement Quality Objectives Parameter (Local Conditions) Wind Speed (WS) (Cup, prop or sonic anemometer)

1) Requirement (WS)	2) Frequency	3) Acceptance Criteria	Information /Action
Preventative maintenance	1/182 days	Follow manufacturer's instructions; replace sensor bearings	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.6.2.1
Routine maintenance	1/182 days	Application of cleaning and protective lubricants to mounting hardware	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.6.2.1
Visual Inspection	1/7 days (or every site visit if site visited less than weekly)	Moving freely, no visual damage	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.6.1
DAS Clock/timer Verification	1/7 days (or every site visit if site visited less than weekly)	< ± 1 minute NIST EST	1, 2 and 3) Recommendation
Data Acquisition System (internal battery back-up)	1/182 days	Check Battery Back-up, Replace as needed	1, 2 and 3) Recommendation
SYSTEMATIC CRITERIA-WS			
Sensor/Monitor	At purchase/installation	Meets requirements listed in QA Handbook	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Standard Reporting Units	All data	Meters per second (final units in AQS)	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume

Table 8. Wind Speed Measurement Quality Objectives Measurement Quality Objectives Parameter (Local Conditions) Wind Speed (WS) (Cup, prop or sonic anemometer)			
1) Requirement (WS)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
			IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Rounding convention for data reported to AQS	All data	1 decimal place	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Completeness	Quarterly Hourly	75 percent of hourly averages for the quarter 75 percent of minute averages for the hour	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Siting	1/365 days	Meets siting criteria or waiver documented	1) 40 CFR Part 58 App E, sections 2-6 2) Recommendation 3) 40 CFR Part 58 App E, sections 2-6
Distance from Obstruction	At installation/moving 1/365 days	2x the height of the obstruction	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Distance Above Ground	At installation/moving 1/365 days	10 meters	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors

Table 8. Wind Speed Measurement Quality Objectives

Measurement Quality Objectives Parameter (Local Conditions) Wind Speed (WS) (Cup, prop or sonic anemometer)

1) Requirement (WS)	2) Frequency	3) Acceptance Criteria	Information /Action
Recommended Ground Cover	At installation/moving 1/365 days	Grass or gravel	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Technical Systems Audit	1/3 years	Data meets acceptance criteria in validation table	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 10 & Appendix A

Table 9. Wind Direction Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Wind Direction (WD) (Vane or sonic anemometer)			
1) Requirement (WD)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
CRITICAL CRITERIA-WD			
Data Validity	Every 182 days	Data set bracketed between two valid calibration checks, "as-left" and "as-found", readings should be the same within ±2 degrees	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.5.2.5
Orientation	1/182 days	True north location must be determined accurate to <1 degree, and wind vane "reference position" must be fixed to true north accurate to <2 degrees	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.5.2.1
Starting Threshold	1/182 days	≤ 0.5 meters per second at 10 degrees	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final)
Operating Range	At purchase	0 – 360 (or 540) degrees	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Resolution	At purchase	1.0 degrees	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives

Table 9. Wind Direction Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Wind Direction (WD) (Vane or sonic anemometer)			
1) Requirement (WD)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
Verification/Calibration	Upon receipt/adjustment/repair / installation/moving 1/182 days	Solar Noon, GPS, Magnetic Compass, CTS method. Points every 45 º between 0 and 360 (540) º. ±5 degrees; includes orientation error.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
OPERATIONAL CRITERIA-WD			
Calibration and audit standards	Purchase, recalibrate 1/365 days or at frequency dependent upon use	**Alignment to True North:** Solar Noon method, and or Transit & Compass, map, and site magnetic declination, or GPS accuracy ≤3 meters with lock on minimum 3 satellite signals **Linearity:** Linearity wheel with evenly spaced preset markings, e.g., 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, 360°	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
Annual Accuracy Evaluation	Every site 1/365 days	Solar Noon, GPS or Magnetic Compass. At least 4 to 5 between 0 and 360 (540) degrees. ±5 degrees; includes orientation error.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
Minimum Sample Frequency	Every site Every work day	Hourly	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives

Table 9. Wind Direction Measurement Quality Objectives.
Measurement Quality Objectives Parameter (Local Conditions) Wind Direction (WD) (Vane or sonic anemometer)

1) Requirement (WD)	2) Frequency	3) Acceptance Criteria	Information /Action
Raw Data Collection Frequency	Every site Every work day	1 minute	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Hourly Recorded WD	Every workday 1/30 days	0°≥ WD ≤ 360°, WD varies ≥ 1°/3 consecutive hours, or per site specific climatology criteria	1, 2 and 3) EPA -454/R-99-005 Feb 2000, Chapter 8, Table 8-4
Preventative maintenance	1/182 days	Follow manufacturer's instructions; replace sensor bearings	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.6.2.1
Routine maintenance	1/182 days	Application of cleaning and protective lubricants to mounting hardware	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.6.2.1
Visual Inspection	1/7 days (or every site visit if site visited less than weekly)	Moving freely, no visual damage	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 2.6.1
DAS Clock/timer Verification	1/7 days (or every site visit if site visited less than weekly)	< ± 1 minute NIST EST	1, 2 and 3) Recommendation
Data Acquisition System (internal battery back-up)	1/182 days	Check Battery Back-up, Replace as needed	1, 2 and 3) Recommendation

Table 9. Wind Direction Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Wind Direction (WD) (Vane or sonic anemometer)			
1) Requirement (WD)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
SYSTEMATIC CRITERIA-WD			
Sensor/Monitor	At purchase/installation	Meets requirements listed in QA Handbook	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Standard Reporting Units	All data	Degrees (final units in AQS)	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Rounding convention for data reported to AQS	All data	1 decimal place	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Completeness	Quarterly Hourly	75 percent of hourly averages for the quarter 75 percent of minute averages for the hour	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Siting	1/365 days	Meets siting criteria or waiver documented	1) 40 CFR Part 58 App E, sections 2-6 2) Recommendation 3) 40 CFR Part 58 App E, sections 2-6
Distance from Obstruction	At installation/moving 1/365 days	2x the height of the obstruction	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version

Table 9. Wind Direction Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Wind Direction (WD) (Vane or sonic anemometer)			
1) Requirement (WD)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
			2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Distance Above Ground	At installation/moving 1/365 days	10 meters	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Recommended Ground Cover	At installation/moving 1/365 days	Grass or gravel	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Technical Systems Audit	1/3 years	Data meets acceptance criteria in validation table	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 10 & Appendix A

Table 10. Relative Humidity Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Relative Humidity (RH) (Psychrometer/ Hygrometer)			
1) Requirement (RH)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
CRITICAL CRITERIA-RH			
Accuracy	At purchase Every 182 days	± 0.5°C	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Volume 4, Appendix C
Time Constant	At purchase	≤ 1 minute	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Volume 4, Appendix C
Operating Range	At purchase	0 – 100	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Resolution	At purchase	0.5	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving 1/182 days	NIST traceable psychrometer or standard solution. All points within ± 7 percent RH of standard.	1, 2 & 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements, Ver. 2.0 (Final) Table 0-4 NCore Calibration & Accuracy Criteria
OPERATIONAL CRITERIA-RH			

Table 10. Relative Humidity Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Relative Humidity (RH) (Psychrometer/ Hygrometer)			
1) Requirement (RH)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
Calibration and audit standards	Purchase, recertify 1/365 days or per NIST/ASTM certification frequency	RH meter NIST traceable standard ±2 percent RH; Assman Style Psychrometer with matched pair NIST Traceable /ASTM Thermometers with measurement Resolution 0.1° C each and appropriate temp range	1, 2 & 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements, Ver. 2.0 (Final) Table 0-4 NCore Calibration & Accuracy Criteria
Annual Accuracy Evaluation	Every site 1/365 days	NIST traceable psychrometer or standard solution. All points within ± 7 percent RH of standard.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-4 NCore Calibration and Accuracy Criteria
Minimum Sample Frequency	Every site Every work day	Hourly	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Raw Data Collection Frequency	Every site Every work day	1 minute	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Hourly Recorded Ambient Temperature	1/30 days	0 ≤ RH ≤ 100; RH ≤ 5 percent from previous hourly record; RH varies from morning to evening, or per site specific climatology criteria	1, 2 and 3) EPA -454/R-99-005 Feb 2000, Chapter 8,Table 8-4
Appropriate radiation shield	1/182 days	Free from dirt, no surface damage	1, 2 & 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements, Ver. 2.0 (Final)

Table 10. Relative Humidity Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Relative Humidity (RH) (Psychrometer/ Hygrometer)			
1) Requirement (RH)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
DAS Clock/timer Verification	1/7 days (or every site visit if site visited less than weekly)	< ± 1 minute NIST EST.	1, 2 and 3) Recommendation
Data Acquisition System (internal battery back-up)	1/182 days	Check Battery Back-up, Replace as needed	1, 2 and 3) Recommendation
SYSTEMATIC CRITERIA-RH			
Sensor/Monitor	At purchase/installation	Meets requirements listed in QA Handbook	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Standard Reporting Units	All data	percent	1, 2 and 3)) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Rounding convention for data reported to AQS	All data	1 decimal place	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological Measurement Quality Objectives
Completeness	Quarterly Hourly	75 percent of hourly averages for the quarter 75 percent of minute averages for the hour	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0-3 NCore Meteorological

Table 10. Relative Humidity Measurement Quality Objectives. Measurement Quality Objectives Parameter (Local Conditions) Relative Humidity (RH) (Psychrometer/ Hygrometer)			
1) Requirement (RH)	**2) Frequency**	**3) Acceptance Criteria**	**Information /Action**
			Measurement Quality Objectives
Siting	1/365 days	Meets siting criteria or waiver documented	1) 40 CFR Part 58 App E, sections 2-6 2) Recommendation 3) 40 CFR Part 58 App E, sections 2-6
Distance from Obstruction	At installation/moving 1/365 days	1.5x the tower diameter from tower support & at least 2x height from ground (i.e., 4 m for a sensor located at 2 m above ground) from trees & buildings	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Distance Above Ground	At installation/moving 1/365 days	1.25 to 2 meters	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Recommended Ground Cover	At installation/moving 1/365 days	Non-irrigated or un-watered short grass, or natural earth at least 9 m in diameter. The surface should not be concrete, asphalt or oil-soaked. Reflection from these surfaces may affect sensor performance.	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Table 0.12 Siting and Exposure for Meteorological Sensors
Internal Systems Audit	1/ year	Data meets acceptance criteria in validation table	1, 2 and 3) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final) Section 10 & Appendix A

8.0 Training Requirements

Adequate education and training are integral to any monitoring program that strives for reliable and comparable data. DAQ personnel will meet the educational requirements, accountability standards and training requirements for their positions. DAQ requires all staff to take specific, mandatory governmental training courses, such as safety training, defensive driving and harassment awareness courses, among others. The DAQ maintains records on personnel qualifications and training in several locations, dependent upon the applicability of the information. For example, staff may maintain copies of certificates received from classes or workshops, whereas human resources will keep records of personnel qualifications.

The DAQ aims training at increasing the effectiveness of employees and their organization. As part of a QA program, 40 CFR Part 58, Appendix A requires the development of operational procedures for training. These procedures should include information on:

- Personnel qualifications – general and position specific
- Training requirements – by position
- Training frequency

Training for air monitoring personnel consists of required reading prior to implementing the requirements of this QAGD. Documents team members must read shall include this QAGD and the SOPs and instrument manuals specific to the equipment personnel will be working with or servicing. Employee supervisors shall document required reading on a form indicating the employee has read and understood the QAGD or SOP. Alternatively, the employee will document training in the North Carolina Learning Management System, or LMS. Employees will also document reading of the QAGDs and SOPs in the employee Value in Performance, or VIP, performance management system.

The DAQ supervisors actively encourage all employees to pursue training opportunities whenever possible and as needed because the project manager continually evaluates the DCAMS to ensure it is meeting the project objective. Because of these evaluations, the project manager could add new equipment, procedures or new personnel to the project. DAQ provides vendor based training for its personnel when DAQ obtains new equipment. The employees document this training in the LMS. Additionally, personnel are encouraged to periodically identify, request, and attend pertinent courses and seminars. These courses and seminars may be provided as videotapes, closed circuit transmission, web based real-time interactive formats, and/or live instruction. Organizations that provide these training opportunities include local and regional universities, the Air and Waste Management Association, the Mid Atlantic Regional Air Management Association, and EPA. The DAQ supervisors track this training for their employees in the LMS. Air monitoring personnel currently have sufficient training to perform necessary functions at an acceptable level. The DAQ supervisors also track and document this training in both the LMS and VIP.

Monitoring staff provide new monitoring personnel and local station operators the necessary on-the-job training for their individual monitoring tasks. The employee documents all on-the-job training in the LMS. The project administrator/QAM invites all monitoring staff to the North Carolina DAQ ambient monitoring workshop held each spring. This workshop provides an opportunity to discuss and train on monitoring and the QC and QA processes to ensure the collection of valid data. A senior staff member provides hands-on instruction with the analyzers as on the job training when new employees are hired. The vendor provides training when DAQ purchases new monitors and other equipment. DAQ and EPA staff provides training annually during the monitoring workshop.

DEQ - DAQ Training Links

Air Monitoring:	http://www.epa.gov/ttn/amtic/training.html
Professional Skills:	http://oshr.nc.gov/state-employee-resources/training

9.0 Documentation and Records

The following information describes DAQ's document and records procedures for the DCAMS. Table 11. Documentation and Records Information lists the documents and records pertaining to all data DAQ is required to collect and all other data deemed important by its policies and records management procedures, including documents and records required to support the concentration data reported to the project manager and complainants.

Table 11. Documentation and Records Information

Categories	Record/Document Type	File Locations
Management and Organization	Final Settlement Agreement	DCAMS Project Page on SharePoint
	Quality Management Plan	DEQ Website
	Organizational structure	Ambient Monitoring Administration Page on SharePoint
	Personnel qualifications and training	DEQ HR and DAQ Training page on SharePoint
	Training records and certifications	Learning Management System and Value In Performance
Site Information	Network descriptions Site files Site maps Site pictures	DCAMS Project Page on SharePoint
Environmental Data Operations	Quality Assurance Guidance Document Standard Operating Procedures Field and laboratory notebooks Sample handling/custody records Inspection/Maintenance Records	DCAMS Project Page on SharePoint
Raw Data	Any original data (routine and QC) Including data entry forms	DCAMS Project Page on SharePoint Laboratory Analysis Branch
Data Reporting	Data/summary reports Final Report	DCAMS Project Page on SharePoint
Data management	Data algorithms Data Management Plans/Flowcharts Data management systems	DCAMS Project Page on SharePoint
	Pollutant data Meteorological data	ENVISTA ARM database

Table 11. Documentation and Records Information

Categories	Record/Document Type	File Locations
Quality assurance	Appendix E siting reviews Control charts Data quality assessments Quality assurance reports Technical system audits Response/corrective action reports Site performance audits Quality assurance and technical notes	DCAMS project page on SharePoint

The majority of documentation and records produced by the DCAMS consist of data and information gathered to support the data collection activities. Documentation and records include:

- QAGDs;
- SOPs,
- Logbooks and data collection records in electronic and written format,
- Instrument and equipment calibration information,
- QA documentation in electronic and written format and
- Documentation that supports data review, validation and certification activities.

Section 19.0 Data Management contains detailed information regarding how DAQ will manage data from the DCAMS, including information on data recording, transmittal, storage and retrieval.

9.1 Statewide Policy and Procedure Documentation

DAQ maintains records of program policy and procedure documentation. The DAQ publishes documents in this category with the date and revision information clearly noted, generally in a document header. Documents in this category include:

- QAGDs,
- SOPs, which contain the electronic QA/QC data forms that technicians must document and
- QA and technical notes, which provide air monitoring policy interpretations or best practices.

The QAM and project manager must approve all QAGD changes before the monitoring staff implements those changes. The QAM, project manager, and any affected branch supervisor must approve all SOP revisions before the monitoring staff implement them, including changes to forms. Additionally, SOPs must not conflict with any part of this QAGD or with the settlement agreement.

The DAQ publishes QAGDs and SOPs with the date and revision information clearly noted, generally, in a document header. The project manager or QA coordinators distribute all of these documents electronically to the project team and post the documents to the DCAMS SharePoint project page. When the QA coordinators prepare a document that supersedes an older version, the replacement document clearly states its effective date. The project manager or QA coordinators notify all individuals on the project team that a new version is available and posted on the DCAMS SharePoint project page.

When the QA coordinators replace a QAGD or SOP with a newer version, they move the previous or older version to a subfolder on the SharePoint page that is marked for archived documents. Thus, the DAQ makes older versions of the QAGD and SOPs available in case someone needs to revisit procedures from a specific period in the past.

9.2 Data Collection Records and Logbooks

Table 11. -Documentation and Records Information- lists the documents and records DAQ must retain. The appropriate sections of this QAGD will discuss the details of these various documents and records. The DAQ will collect all raw data required for calculations, the submissions to the complainants, and QA/quality control, or QA/QC, data electronically or on data forms included in the field and analytical methods; see Section 11.0 Sampling Methods Requirements. **All field operators, QA coordinators, QA auditors and other DAQ personnel shall fill out hardcopy information in indelible ink. They shall make corrections by inserting one line through the incorrect entry, initialing and dating this correction and placing the correct entry alongside the incorrect entry, if they can accomplish this legibly, or by providing the information on a new line if the above is not possible.**

9.2.1 Logbooks

Each field operator and electronic technician will be responsible for obtaining, maintaining and documenting the appropriate logbooks or associated QA/QC data forms. The particulate monitor has an electronic logbook (e-log) created for that specific monitor type. After each use, the field operator uniquely numbers these e-logs by giving them a specific file name before saving them to a storage device such as a laptop computer. From the laptop computer, the field operator will transfer the e-log to the DCAMS SharePoint project page. The field operator will use these e-logs to record information about the site and laboratory operations, as well as document routine operations.

Completion of data entry forms, associated with all routine environmental data operations, are required even when the field logbooks contain all appropriate and associated information required for the routine operation being performed.

9.2.2 Electronic Data Collection

Certain instruments can provide an automated means for collecting information that DAQ would otherwise record on data entry forms. Section 19.0 Data Management details information on these systems. To reduce the potential for data entry errors, the DAQ will use automated systems where appropriate and will record the same information the field operator would record on data entry forms. To provide backup, electronic copies of the automated data collection information will be stored for an appropriate period by the Project and Procedures Branch staff on the DCAMS SharePoint project page. Electronic backup copies of automated data collection information will also be stored on the DCAMS SharePoint project page.

9.3 Reference Materials

Because of the technical nature of ambient air monitoring, DAQ requires numerous reference materials to administer the DCAMS effectively. This category includes publications such as instrument operation manuals, troubleshooting guides, EPA guidance documentation, EPA technical memoranda and various other reports. DAQ maintains access to applicable reference materials as long as DAQ has an administrative need for them. DAQ retains these documents at the Raleigh Central Office, or RCO, in the Internet-Based Enterprise Application Management, or IBEAM, general documents module, or on the SharePoint page.

9.4 Data Archiving and Retrieval

The DAQ will retain all the information listed in Table 11.-Documentation and Records Information- for five complete calendar years from the date of collection in accordance with 2 CFR Section 200.333. However, if a party begins any litigation, claim, negotiation, audit or other action involving the records before the expiration of the five-year period, the DAQ will retain the records until completion of the action and resolution of all issues that arise from it, or until the end of the regular five-year period, whichever is later.

10.0 Network Description

10.1 Probe Siting Criteria

General probe siting criteria for analyzers used in the DCAMS shall, where possible, adhere to the requirements listed in 40 CFR Part 58, Appendix E and the instructions outlined below. However, DAQ notes that, due to the informational nature of the DCAMS, and the urgent need to begin immediate data collection, certain siting criteria may be waved in order to facilitate immediate placement of monitors in the field. In consultation with REACH, DAQ will determine the placement of a temporary, fixed, air-monitoring site in or near Kenansville North Carolina, taking into consideration EPA's siting criteria. The site will be within 1-2 miles of a previously operated PM2.5 monitoring site operated in Kenansville. This is to provide continuity of data from the historical data in comparison with the current time-period.

10.1.1 Hydrogen Sulfide and Ammonia Siting Criteria

Due to instrument restrictions, intake probes for the hydrogen sulfide, or H2S, and ammonia, or NH3, must be 1 to 2 meters, or m, above ground. Ideally, probes should be at least 1 m away, both vertically and horizontally, from any supporting structure. DAQ will use its best efforts to locate probes at least 2 m away from any small local obstruction, and at least 10 m from any trees. The DAQ shall measure the distance from the drip-line or outside edge of the crown, not the trunk. In situations where trees or shrubs could be considered an obstruction (this is particularly true of large coniferous trees), the distance between the trees or shrubs and the monitors shall be at least twice the height the tree protrudes above the probe intake. The distance between the probes and any large obstruction (such as buildings) higher than the probe should be more than twice the height that the obstruction extends above the probe. Again, the nature of this study may result in siting compromises in order to facilitate immediate data collection. Whenever possible, DAQ will adhere strictly to the siting criteria laid down in EPA Guidance Documents.

The monitors are expected to have an unrestricted airflow in at least a 270^{o} arc around the monitor. The arc must include the predominant wind directions and any major sources in the area. Title 40 CFR Part 58, Appendix E, provides explanation of these and other siting criteria.

10.1.2 PM2.5 Siting Criteria

When monitoring for $PM_{2.5}$, it is important to select a site or sites where the collected particulate matter mass is representative of the monitored area. Optimum placement of the sampling inlet for $PM_{2.5}$ is at breathing height level. However, the DAQ must also consider practical factors such as prevention of vandalism, security and safety precautions.

Given these considerations, the sampler inlet for micro scale $PM_{2.5}$ monitors must be between 2 and 7 m above the ground. For middle or larger spatial scales, the inlet must be 2 to 15 m above the ground. If the sampler is located on a roof or other structure, there must be a 2 m separation from walls, parapets, penthouses, etc. No furnace or incineration flues should be nearby. Samplers should be located at least 20 m from the drip-line of the nearest trees, but must be 10 m from the drip-line. Where possible, the sampler should be located away from obstacles such as buildings, so that the distance between the obstacle and the sampler is at least two times the height that the obstacle protrudes above the sampler. There should be unrestricted airflow in an arc of at least 270° around the sampler. The predominant wind direction for the season with the greatest pollutant concentration potential must be included in the 270° unrestricted arc. If the sampler is to measure concentrations from a road or point source, the DAQ must site the monitor to avoid obstructions between the road or point source and the sampler even when sampler placement meets other spacing criteria from obstructions.

The DAQ considers many factors in establishing a particle sampling location. These include accessibility under all weather conditions, availability of adequate electricity, and the security of the monitoring personnel and equipment. The DAQ must situate the sampler where the operator can reach it safely despite adverse weather conditions. If the sampler is located on a rooftop, the DAQ will take care that a slippery roof surface does not jeopardize the operator's personal safety. The DAQ also considers the reality that routine operational procedures such as calibration, maintenance and minor repairs require transporting supplies and equipment to and from the monitoring site.

The lack of suitable power source can often result in the loss of many samples because of power interruptions or fluctuations. To ensure that adequate power is available, consult the manufacturer's instruction manual for the sampler's minimum voltage and power requirements. The security of the sampler depends mostly on the location. Rooftop sites with locked access and ground level sites with fences are common. In all cases, the DAQ considers security of the operating personnel as well as the sampler.

10.2 Meteorological Sensors

The EBAM samplers used for this study come equipped with mounting brackets and booms to mount the MET sensors on a mounting arm that is attached to the EBAM and located at same height as the particulate sampling train inlet of the EBAM. The electronic technician shall mount the sensors on the provided mounting brackets and booms that come with the EBAM sampler. The booms shall be strong enough so that they will not sway or vibrate in strong winds. The electronic technician shall mount the wind direction sensors so that a sensor's wind vane is not hindered or influenced by adjacent sensors. Usually, this means mounting the sensors a minimum of 0.6 m apart and insure the wind vane has an unobstructed 360 degree freedom of movement.

10.2.1. Wind Velocity and Wind Direction Sensors

The DAQ uses wind sensors to measure wind speed and wind direction at a height near the sampling probe. For source-oriented monitors, it is appropriate to place the sensor at or slightly above the level of the probe to best measure wind data at probe height without interfering with airflow at the probe or the probe causing obstructions to the wind sensors. Typically, the wind direction sensor is placed at one end of the mounting cross-arm and the wind speed sensor is located on the opposite end of the same mounting cross-arm.

10.2.2. Temperature and Humidity Sensors

Where possible, the electronic technician shall mount temperature and humidity sensors over an open plot of short grass or natural earth (not concrete or asphalt) at least 9 m in diameter. A height of 1.25 to 2 m above the ground surface is the standard height for mounting temperature and humidity sensors, but tower mounting, as is the case in most air pollution/meteorological monitoring applications, is also acceptable. For the DCAMS, the electronic technician will mount the sensors on the same mounting cross-arm that is used to support the wind sensors. The EBAM source oriented particulate sampler comes equipped with mounting arms that are sufficient to mount the RH, AT, WS, and WD sensors so that they are not influenced by each other. Wherever the sensor is mounted, the electronic technician should measure and record the height of the sensor.

Where possible, the sensors shall be no nearer any obstructions than a distance of two times the height differential between the height of the sensor and the height of the obstruction. This applies to both manmade and natural obstructions. The electronic technician shall measure the distance from the edge of the crown or drip-line of the vegetation, not the trunk. The electronic technician shall position the sensors at a minimum of 30 m from large paved areas (streets, parking lots, etc.), steep slopes, ridges, hollows, or bodies of standing water. The electronic technician shall locate temperature probes so that they are not influenced by heat leakage from the shelter containing the electronics and recorders for the meteorological equipment.

10.3. Sampling Frequency

The EPA establishes minimum sampling frequencies, which the DAQ follows accordingly. All of the monitors used in the DCAMS sample continuously, except for the Jerome Meter used for measuring H_2S, which samples for 20 seconds every 15 minutes. The DAQ will collect the minimum number of samples required for appropriate summary statistics. The EPA requires that at least 75 percent of the total possible observations must be present before summary statistics are calculated. The exact requirements appear in **Table 12.** **Table 13** provides the sampling schedule and frequency for all monitors used in the DCAMS and for meteorological data.

Table 12.- Requirements for Calculating Summary Statistics

Pollutant	Completeness Requirement (percent)	Time Frame
H_2S	75	Per hour, quarter, and day
NH_3	75	Per hour, quarter and day
$PM_{2.5}$	75	Per hour, quarter and day
Ambient Temperature	75	Per hour and quarter
Relative Humidity	75	Per hour and quarter
Wind Speed	75	Per hour and quarter
Wind Direction	75	Per hour and quarter

Table 13. Pollutant Sampling Schedule and Frequency

Pollutant	Time Frame	Frequency	Monitor Type

H_2S	Midnight to midnight	20 seconds every 15 minutes for 24 hours a day on 7 days a week	Continuous
NH_3	Midnight to midnight	24/7	Continuous
$PM_{2.5}$	Midnight to midnight	24/7	Continuous
Ambient Temperature	Midnight to midnight	24/7	Continuous
Relative Humidity	Midnight to midnight	24/7	Continuous
Wind Speed	Midnight to midnight	24/7	Continuous
Wind Direction	Midnight to midnight	24/7	Continuous

11.0 Sampling Methods Requirements

11.1 Sample Methodology

This subsection describes the sampling methods used in the DCAMS. Table 14.- DCAMS Monitors- lists the specific methods used. None of these methods are EPA federal reference methods, or FRMs, or federal equivalent methods, or FEMs. No FRM or FEM exists for measuring ammonia or hydrogen sulfide.

Table 14. DCAMS Monitors

Pollutant	Analyzer	EPA Reference/Equivalence
$PM_{2.5}$ local conditions, continuous	Met One E-BAM (with PM_{10} head and SCC)	Not reference method (AQS Method Code 733)
NH_3	AreaRAE	Not reference method (AQS Method Code 093)
H_2S	Jerome Meter	Not reference method (AQS Method Code 017)
Ambient temperature	Model 592 Ambient Temperature Sensor	QA Handbook for Air Pollution Measurement Vol. 4 Appendix C
Relative humidity	Model 593 Relative Humidity Sensor	QA Handbook for Air Pollution Measurement Vol. 4 Appendix C
Wind speed	MetOne 034B Wind Sensor	QA Handbook for Air Pollution Measurement Vol. 4 Section 2.6
Wind direction	MetOne 034B Wind Sensor	QA Handbook for Air Pollution Measurement Vol. $ Section 2.5

11.1.1. Particulate Matter (Continuous Operation, E-BAM)

Met One designed the E-BAM as a simple, compact and self-contained beta gauge for portable applications where rapid deployment and short interval real-time measurements are required.

The Met One Instruments, Inc. model E-BAM automatically measures and records airborne PM_{10} or $PM_{2.5}$ particulate concentration levels using the principle of beta ray attenuation. A small 14C (Carbon 14) element emits a constant source of high-energy electrons known as beta particles. A sensitive scintillation detector detects and counts these beta particles. A vacuum pump draws air, at a rate of 16.7 liters per minute, or LPM, through a size selective inlet, down the inlet tube, and deposits the airborne particulate on a filter tape that is located between the beta source and detector. The accumulation of mass onto the filter tape increasingly attenuates beta ray transmission through the media. The detector continuously monitors beta attenuation through the filter tape throughout the measurement cycle. The degree of beta ray attenuation is used to determine the mass of particulate matter deposited on the filter tape. During sampling, the flow rate is precisely controlled. Having determined both mass and sample volume, the E-BAM calculates and reports the ambient PM concentration, expressed as micrograms per cubic meter, or $\mu g/m^3$, or milligrams per cubic meter, or mg/m^3.

11.1.2. Ammonia - NH_3 (Continuous Operation, AreaRAE)

The AreaRAE is a programmable portable gas monitor designed to provide continuous monitoring of toxic gases, oxygen, and combustible gases. It can measure concentrations of up to five gases: combustible gases, VOCs, oxygen, and two types of toxic gases. The NH3 (Ammonia) sensor was the only sensor used for this study.

Table 15. AreaRAE Gas Limitations

Gas	Detection Range	Resolution	Sensor Type
Combustible Gases	Percent of Lower Explosive Limit (LEL)	1 percent	Catalytic Bead
VOC	0-200 ppm	0.1 ppm	PID
Oxygen	0-30 percent	0.1 percent	Electrochemical cell
CO (Carbon Monoxide)	0-500 ppm	1 ppm	Electrochemical cell
H_2S (Hydrogen Sulfide)	0-100 ppm	1 ppm	Electrochemical cell
SO_2 (Sulfur Dioxide)	0-20 ppm	0.1 ppm	Electrochemical cell
NO (Nitric Oxide)	0-250 ppm	1 ppm	Electrochemical cell
NO_2 (Nitrogen Dioxide)	0-30 ppm	0.1 ppm	Electrochemical cell
HCN (Hydrogen Cyanide)	0-50 ppm	1 ppm	Electrochemical cell
NH_3 (Ammonia)	**0-50 ppm**	**1 ppm**	**Electrochemical cell**
PH_3 (Phosphine)	0-5 ppm	0.1 ppm	Electrochemical cell
Cl_2 (Chlorine)	0-50 ppm	0.1 ppm	Electrochemical cell
ClO_2 (Chlorine Dioxide)	0-1 ppm	0.1 ppm	Electrochemical cell

The AreaRAE uses photoionization detectors (PIDs) and electrochemical cell detectors (ECD) for detecting a variety of gasses. The PIDs use ultraviolet (UV) rays to bombard gas samples and detect a broad range of VOCs such as formaldehyde, methane, and benzene, as well as hydrocarbons. These sensors provide an instant reading indicating whether gas is present and average the instant readings over programmable sample collection durations.

11.1.3. Hydrogen Sulfide - H_2S (Continuous Operation, Jerome Meter)

A thin gold film, in the presence of hydrogen sulfide, undergoes an increase in electrical resistance proportional to the mass of hydrogen sulfide in the sample. The Jerome meter uses this principle, along with pulling ambient air over the gold film sensor for a precise period. The meter determines the amount absorbed and displays the measured concentration of hydrogen sulfide in ppm. During normal sampling, the meter dilutes the ambient air sample in the flow system at a ratio of 100:1. When sampling in Range 0 (where low levels of hydrogen sulfide are expected), the meter draws undiluted air samples across the gold film sensor.

The instrument's microprocessor automatically re-zeroes the digital meter at the start of each sample cycle and freezes the meter reading until the next sample cycle is activated, thus eliminating drift between samples. During the sample mode cycle, bars on the LCD represent the percentage of sensor saturation. Depending on the concentrations, the meter can take 50 to 500 samples before the sensor reaches saturation.

At that point, the operator must initiate a 10-minute heat cycle to remove the accumulated hydrogen sulfide from the sensor. During the sensor regeneration cycle, the meter closes both solenoids to cause air to pass through a scrubber filter and provide clean air for the regeneration process. The flow system's final scrubber filter prevents contamination of the environment. The heat generated during the regeneration may cause some low level thermal drift. To ensure maximum sample accuracy, operators should wait 30 minutes after regeneration before zeroing and using the instrument.

11.1.4. Ambient Temperature Sensor

The ambient temperature sensor is mounted in a radiation shield to prevent interference from solar and terrestrial radiation. The Model 592 Temperature sensor and radiation shield mount directly onto the MetOne Instruments Type 191 cross-arm or other, 1-inch diameter horizontally mounted boom. This sensor is mounted directly on a cross arm connected directly to the EBAM tripod at a height of approximately 2.0 meters above ground level. The sensor connects to the EBAM electronics with a 4-pin connecting cable. Table 16 below describes the ambient temperature sensor specifications.

Table 16. Model 592 Ambient Temperature Sensor Specifications

Temperature Range (Standard)	-30°C to 50°C
Temperature Range (Optional)	-50°C to 50°C
Accuracy (Standard)	± 0.15°C
Accuracy (Optional)	± 0.1°C
Linearity	± 0.15°C
Time Constant	10 seconds in still air
Input Power	12VDC at 4mA typical
Output	0-1 volts for -30°C to 50°C
Output Impendence	100 Ohms maximum
Maximum Line Length	100 feet

11.1.5. Relative Humidity Sensor

The relative humidity sensor is mounted in a separate radiation shield to prevent any interference from solar or terrestrial radiation. This sensor is mounted directly onto the same cross arm as the temperature sensor, but on opposite ends to provide balance to the cross arm approximately 2.0 meters above ground level. This sensor is also connected to the EBAM electronics with a 4-pin connecting cable. The Model 593 Relative Humidity Sensor responds to a full range of humidity from (0-100 percent). Response is linear with small hysteresis and negligible temperature dependence. Table 17 below describes the relative humidity sensor specifications.

Table 17. Model 593 Relative Humidity Sensor Specifications

Sensing Element	Thin-film capacitor
Range	0-100 percent
Temperature Range	-40°C to 79.4°C
Response Time	10 to 20 seconds at 20°C
Accuracy	better than ±3 percent between 20 percent and 85 percent
Hysteresis	For 0 percent to 100 percent to 0 percent excursion less than ±1 percent
Temperature Coefficient Output	±0.07 percent per 1°C
Input power	12V DC ±2V, 12mA

11.1.6. Wind Speed and Direction Sensor

The MetOne Instruments Model 034B Wind Sensor consists of a wind speed sensor and wind direction sensor mounted together as a single assembly. The wind speed sensor uses a three-cup anemometer to produce a series of contact closures in a magnetic reed switch. The frequency of the closures is proportional to wind speed. The wind direction sensor uses a balanced anodized aluminum vane assembly that changes the value of a linear potentiometer as the wind direction changes. The output of the potentiometer is proportional to the wind direction. The wind speed and wind direction sensor assembly mounts directly to the MetOne Instruments Type 191 cross-arm. It is mounted approximately 1meter away from the EBAM sampler inlet and can be mounted on either side of the cross arm. Tables 18 and 19 below describe the wind speed and wind direction sensor specifications.

Table 18. Model 034B Wind Speed Sensor Specifications

Range	0-167 MPH (0-75 m/s)
Starting Threshold	0.9 MPH
Accuracy Less than 22.7 MPH	0.25 MPH
Greater than 22.7 MPH	± 1.1 percent of true
Temperature Range	-30°C to 70°C
Weight	2lb. 9oz with cable
Output Signal	Pulsed contact closure maximum current 5mA

Table 19. Model 034B Wind Direction Sensor Specifications

Mechanical Range	0-360 degrees
Electronic Range	0-356 degrees
Starting Threshold	0.9 MPH
Accuracy	± 4 degrees
Damping Ratio	0.25 Std. (0.4 to 0.6 optional)
Resolution	0.5 Degrees
Temperature Range	-30°C to 70°C
Output Signal	Potentiometer output (0-10K ohms) Max current 10mA Max open circuit voltage 28

11.2 Sample Collection Methodology

Table 20.-List of SOPs Associated with this Quality Assurance Guidance Document- lists specific SOP titles used in the study. Electronic data collection is the sole means of raw data collection. Operators who download the data from the samplers provide the path for data reporting and analysis. The operator will download data at least once every seven days and transfer it to the RCO

Table 20. List of SOPs Associated with this Quality Assurance Guidance Document

Section 2.3.3 Certification and Accuracy Check of Field Barometers and Thermometers, Revision 7, Nov. 1, 2011
Section 2.12.1 Meteorological Monitoring Standard Operating Procedures for the Electronic and Calibration Branch, Revision 1.5, July 1, 2015
Section 2.39 SOP for Preparing SOPs for the DAQ, Revision 0, Nov. 1, 2010
Section 2.41.4 Data Review and Validation for Continuous Gaseous and Non-Speciated Particulate Monitors, Raleigh Central Office Responsibilities, Revision 1.6, Oct. 15, 2014
Section 2.43 SOP for Completing the Annual Network Review for the DAQ, Revision 1, Aug. 7, 2015
Section 2.53.2 Met One E-BAM Standard Procedures for Operators
Section 2.55 Standard Operating Procedures for Jerome 631-X Hydrogen Sulfide Analyzer, Revision 2, June 16, 2006
Section 2.56 Standard Operating Procedures for AreaRAE Gas Analyzer, Revision 1, June 16, 2006

11.3 Monitoring Facilities

The monitoring station design must encompass the operational needs of the equipment, provide an environment that supports sample integrity and allow the operator to safely and easily service and maintain the equipment. The project manager must consider winter weather conditions during site selection to meet the station safety and serviceability requirements.

11.4 Sampling / Measurement System Corrective Action

The field operator and QA coordinators will take corrective action measures in the ambient air-quality monitoring network to ensure DAQ attains applicable DQOs. There is the potential for many types of sampling and measurement system corrective actions. Each approved SOP details some expected problems and corrective actions needed for a well-run monitoring network. If a team member identifies an error, he or she will immediately implement the appropriate corrective action.

11.5 Analyzer Performance Audits

The DAQ audits the samplers per the methodology required by EPA, when such methodology exists. For each parameter and sampler type, the DAQ performs audit procedures following the procedures defined by the approved SOP.

12.0 Sampling Handling and Custody

The DCAMS does not require DAQ to take any samples that would warrant a sample custody procedure. The instrumentation, located at the DCAMS locations, directly analyze all ambient air samples. The site operator manually transfers the data from the instrumentation located at the site to the DCAMS SharePoint site. The field site operator generates the file names for the data. The QA coordinators will transfer the data from the SharePoint site to the ENVISTA ARM database. The data in the ENVISTA ARM database are the official data. The dates of data upload and modification, within the ENVISTA ARM database, constitute the chain of custody. The field site operator documents all file modifications in operator or manual validation logs. Any modifications are also documented using flags embedded in the database.

13.0 Analytical Methods

The DCAMS does not use any laboratory analytical methods to complete the analysis of any PM, NH_3, or H_2S samples. The DAQ standardizes analytical procedures by comparing the detector responses of unknown samples to the responses of known standards. Specifics on the PM, NH_3, or H_2S monitors' analytics can be found in the respective operation manuals. The DAQ will perform any calibration steps outlined in the standard operating procedures (2.53.2, 2.54.2 and 2.55.2) and instrument manuals. Section 11.1 Sample Methodology provides a summary of how the monitors work.

14.0 Quality Control Requirements and Procedures

The DAQ must perform two distinct and important interrelated functions to assure the quality of data from air monitoring measurements. One function is the control of the measurement process through broad QA activities, such as establishing policies and procedures, developing DQOs, assigning roles and responsibilities, conducting oversight and reviews and implementing corrective actions. The other function is the control of the measurement process through the implementation of specific QC procedures, such as audits, calibrations, checks, replicates, routine self-assessments, etc.

Quality control is the overall system of technical activities that measure the attributes and performance of a process, item or service against defined standards to verify they meet the stated requirements established by the end user. Where possible in the DCAMS, the DAQ uses QC activities to ensure DAQ maintains measurement uncertainty, as discussed in Section 7.0 Data and Measurement Quality Objectives and Criteria, within acceptance criteria for the attainment of the DQOs. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 and the specific instruments' operation manuals provide lists of pertinent QC checks.

Quality control is achieved through periodic maintenance; flow rate audits; acceptance test procedures; accuracy, bias, precision checks, control charts and other verification techniques. Data analyzed from monitors in this study will not undergo routine post-processing to correct for drift. Table 4 through Table 10 provides specific QC procedures.

14.1 Calibrations

Calibration is the process used to verify and rectify an instrument's measurements to minimize deviation from a standard. This multiphase process begins with certifying a calibration or transfer standard against an authoritative standard. The field operator compares the instrument's measurements to this calibration/transfer standard. If significant deviations exist between the instrument's measurements and the calibration/transfer standard's measurements, the field operator adjusts the instrument's response to rectify the analytical instrument's measurements. The instrument vendor calibrates the NH_3 and H_2S monitors so the field operator can only verify the calibration. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 and the specific instruments' operation manuals provide calibration requirements for the critical field and laboratory equipment.

For the PM monitors, the operator adjusts the flow rate when performing a calibration. The design, or desired, flowrate of low-volume PM samplers is 16.67 LPM. After the operator has adjusted the flow rate – using procedures specified in 2.53.2 – the operator verifies the flow rate to ensure the calibration is successful. Using a certified flow transfer standard, the operator measures the monitor's actual flow rate and calculates the percent difference between the known flow rate obtained with the transfer standard and the flow rate reported by the sampler. The calibration verification must be within 2 percent for the calibration to pass.

14.2 Precision Checks

Precision is the measure of agreement among individual measurements of the same property, usually under prescribed similar conditions. To meet the DQOs for precision, DAQ will ensure the entire measurement process is within statistical control. The DAQ will employ various tools in evaluating and monitoring precision measurements. Monitoring data integrity with control charts will provide evidence of deviations from the required precision measurement. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 and the specific instruments' operation manuals provide the precision requirements for the applicable instrumentation.

14.3 Accuracy or Bias Checks

The EPA defines accuracy as the degree of agreement between an observed value and an accepted reference value. Accuracy is a combination of random error (precision), and systematic error (bias). By employing percent difference calculations and plotting the results on control charts, the DAQ can observe trends that indicate bias occurring within the measurements. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 and the specific instruments' operation manuals provide accuracy or bias requirements for the various types of instrumentation.

14.4 Flow Rate Audits

For instruments that monitor flow, the QA coordinator will perform a flow rate audit at least every 6 months and preferably every quarter. The QA coordinator performs the audit by measuring the analyzer's normal operating flow rate using a certified flow-rate transfer standard. The flow rate standard used for auditing may not be the same flow rate standard used to calibrate the analyzer. However, both the calibration standard and the audit standard may be referenced to the same primary flow rate or volume standard. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 and the specific instruments' operation manuals provide details for implementing flow audits.

14.5 Corrective Actions

All DAQ personnel take corrective action measures as necessary to ensure DAQ attains the MQOs. Given the number of monitors, the diversity and the complexity of the instruments, a potential exists that issues may arise with sampling and measurement systems. For the DCAMS, the DAQ has anticipated many of the issues in advance and prepared and equipped the staff to address the issues as they arise. Table 21 presents these issues and the recommended corrective actions.

However, the staff will encounter unexpected or unforeseen circumstances that will necessitate implementation of corrective actions on an "as-necessary" basis. The SOPs contain examples of corrective actions that the staff may need to complete under certain circumstances. Site operators should consult SOPs 2.12.1, 2.53.2, 2.55 and 2.56 for technique-specific checks, required frequency of checks, acceptance criteria and additional corrective action guidance.

Table 21. Corrective Actions

Activity	Problem	Likely Actions
QA/QC check	Out of specification; flow rate check or failed flow rate audit exceeds acceptance criteria	Verify or reproduce performance check findings. Use an alternate transfer standard, if available to confirm failures. Perform alternate performance checks to determine cause, for example – leak tests to aid in flow rate issues. Recalibrate monitor, if possible to do in the field using the appropriate SOP. Identify any required procedural changes to prevent reoccurrence. Document actions on audit worksheet, data sheet or e-log as appropriate. Notify project manager and QA coordinator of performance audit failures as soon as practical.
Clock time	Monitor clock or data	Verify NIST time is accurate.

	acquisition system clock not set to NIST	Diagnose likely causes for differences – power disruption, bad battery back-up, bad board or clock. Document cause and any actions on field logs, data sheets, e-logs as appropriate.
Power	Loss or interruptions	Verify power supply integrity. Verify circuit breaker and fuse integrity. Verify battery, if battery backup is used. Document cause and actions taken on field logs, data sheets or e-log as appropriate.
Data review	Data missing from data download	Verify operation of the data acquisition or logging system. Notify the field operator. Perform site visit to resolve monitor issues.

14.6 Documentation

The field site operator will document all events, including routine site visits, calibrations, analyzer maintenance and calibration equipment maintenance, in field data records and logbooks. The electronic technicians will also document field activities associated with equipment used in the DCAMS on 109 forms. The site operator will control the records, which will be located at the field site when in use and on the DCAMS SharePoint site when the QA coordinators are reviewing them or using them for data validation.

15.0 Equipment Testing, Inspection, and Maintenance Requirements

15.1 Purpose/Background

This section discusses the procedures used to verify that field operators and electronic technicians maintain all instruments and equipment in sound operating condition so the instruments and equipment can operate at acceptable performance levels. The field operators and electronic technicians must document, on appropriate forms, and file in SharePoint all instrument inspection and maintenance activities. See Section 9 for document and record details.

15.2 Testing

The DAQ will follow any available EPA guidance for monitors used in the study, when EPA equivalent or reference methods are not available. When equivalent or reference methods are available, the DAQ will follow those procedures as closely as possible.

Prior to field installation, the electronic technician will assemble and operate the monitors. The technicians will perform external and internal leak checks and temperature, pressure and flow rate multi-point verification checks of the EBAM samplers. The wind speed, wind direction, relative humidity, and temperature sensors attached to the EBAMs will be checked during the EBAM installation, then yearly thereafter unless the sampler has been moved. The electronics technician will use certified synchronized motors, wind angle protractor devices, relative humidity and temperature standards for all verification checks. If any of these checks are out of specification, the technician will contact the vendor for initial corrective action. Once installed at the site, the field operators will again run the tests mentioned above. If the sampling instrument meets the acceptance criteria, the field operator will assume the equipment is operating properly.

15.3 Inspection

Several items periodically require field inspection. The operation manuals and SOPs 2.12.1, 2.53.2, 2.55 and 2.56 identify these items and provide the appropriate inspection procedures.

16.0 Instrument Calibration and Frequency

The electronic technicians are responsible for procuring and maintaining dedicated traceable standards for the certification of the ambient air quality monitoring systems. These standards provide a direct link to established national standards (i.e. NIST) and are the foundation for the collection of the highest quality ambient air pollution data possible in accordance with current procedures and existing federal regulations and guidelines.

16.1 Calibration of Local Primary Standards

A primary standard is a standard that is sufficiently accurate such that it is not calibrated by or subordinate to other standards. The electronic technicians use primary standards to calibrate other standards referred to as working standards. The DAQ uses "local primary standards" or standards certified against NIST-traceable standards and kept in the ECB shop for the sole purpose of certifying transfer standards used in the field to calibrate equipment and verify equipment calibrations. The DAQ owns two "local primary standards." The ECB sends each "local primary standard" to the vendor for recertification in alternate years. The electronic technicians compare the "local primary standard" that did not return to the vendor to the one that did return to the vendor to certify it and uses it to certify equipment for the next year.

16.1.1. Local Primary Flow Rate Standard

The electronic technicians will maintain the local primary flow rate standard used to calibrate the field flow-rate transfer standards and will send them to the manufacturer every 365 days to be recertified against a NIST-traceable flow rate standard.

16.1.2. Local Primary, or Level 2, Temperature Standard

The local primary temperature standard the ECB uses to verify the accuracy of the field temperature transfer-standards will be an Omega Digital Thermometer DPT-1 with a bridge sensor. The ECB will recertify it against a NIST primary standard every 365 days.

16.1.3. Local Primary, or Level 2, Pressure Standard

The local primary pressure standard the ECB uses to verify the accuracy of the field barometer transfer-standards will be a Sensor Model # 2500. The electronic technicians will recertify it every 365 days.

16.2 Calibration of Transfer Standards

The electronic technicians repeat this calibration process using each of the standards on transfer standards. This process establishes the traceability of the calibration.

16.2.1 Flow Transfer Standards

The field flow transfer-standards used for flow rate calibration will have their own certifications and will be traceable to the factory primary flow rate standard. The ECB will employ either an automatic dry-piston flow meter or the manufacturer provided streamline flow transfer-standard for field calibrations and flow rate verifications of the flow rates of the network samplers. Both devices have the advantage of providing volumetric flow rate values directly, without requiring conversion for mass flow measurements, temperature, pressure or water vapor content. The manufacturer establishes and verifies, as needed, a calibration relationship for the flow rate standard, such as an equation, curve, or family of curves, as accurate to within 2 percent over the expected range of ambient temperatures and pressures at which the flow rate standard is used. The ECB technicians shall return the flow rate standards to the manufacturer, who will recalibrate and recertify them at least annually.

16.2.2 Temperature Transfer Standards

The field temperature transfer standards used for calibration of temperature sensors will be mineral oil thermometers or Tetra-Cals that have their own certification. They will be re-verified/recertified at least annually against the local primary temperature standard, or auditor's transfer standard, to 1 °C, over the expected range of ambient temperatures at which the temperature standard is used.

16.2.3 Pressure Transfer Standards

The field pressure transfer-standards will be handheld digital barometers or Tetra-Cals that will have their own certification and will be re-verified or recertified at least annually against the local primary pressure standard.

16.3 Calibration of Laboratory/Field Equipment

SOPs 2.12.1, 2.53.2, 2.55 and 2.56 and the specific instruments' operation manuals provide the specific calibration procedures for the field equipment.

16.4 Documentation

See SOPs 2.12.1, 2.53.2, 2.55 and 2.56 for field QC checks that include frequency and acceptance criteria and references for calibration and verification tests of single and sequential sampler flow rates, temperature, pressure and time. The field sampler flow rate, temperature, and pressure sensor verification checks include one-point checks at least monthly and multipoint checks (calibration without adjustment unless needed as determined independently and then performed by the vendor's authorized service representative) at least annually, as documented by tracking on control charts.

All of these events, as well as sampler and calibration equipment maintenance, will be documented in field data records and logbooks and annotated with the flags required in Appendix L of 40 CFR Part 50 and the manufacturers' operating instruction manuals. The technical staff will keep record logbooks for laboratory and field activities associated with the equipment they use. The RCO or field sites will normally control the records when in use, under review or used for data validation.

17.0 Inspection and Acceptance Requirements for Supplies and Consumables

Table 22. Critical Supplies and Consumables describes critical supplies.

Table 22. Critical Supplies and Consumables

Item	Description	Manufacturer	Supplier, if different	Area
E-BAM tape	boxes of 20	Thermo	Instrument and Air Lab	Instrument and office
In-line filters	2 filters	Thermo	Air Lab	Instrument and office
Hi Vac. grease	High grade silicone	Dow Corning	VWR	Instrument and office
Low-lint wipes	4.5x8.5" and 12x12" Cleaning Wipes	Kimberly Clark	VWR	Instrument and office
Low lint swabs	Micro swabs and bud-type swabs	Tex Wipe	VWR	Instrument and office
O-rings for inlets	1 ¼" and 2 3/8"	Thermo	Air Lab	Instrument and office
Cleaning solution & brush	Tapered brush, alcohol solution, rinse water	Thermo	Air Lab	Instrument and office

17.1 Acceptance Criteria

Acceptance criteria must be consistent with overall project technical requirements. Some of the acceptance criteria, such as observation of damage due to shipping, the electronic technicians will perform once the equipment has arrived on site.

17.2 Tracking and Quality Verification of Supplies and Consumables

The electronic technicians implement tracking and quality verification procedures to assure the appropriate items have been received and that adequate documentation is supplied to the DAQ Business Office to ensure appropriate and timely invoice payment.

1. The electronic technicians inspect packages when received for obvious damage during transit. The electronic technicians open and inspect freight packages as soon as possible after delivery.
2. The electronic technicians open packages, inspect the contents and compare the contents to the packing slip and the list of items ordered.
3. The electronic technicians note discrepancies or damages identified on the packing slip. The electronic technicians notify the manufacturer and supply them with necessary documentation to rectify any discrepancies.
4. Supplies are stored in the office, or with the instrument, and dated with regard to receipt date and labeled if necessary.

18.0 Non-Direct Measurements

This section addresses data not obtained by direct measurement from the DCAMS. This includes data from outside sources and historical monitoring data. At this time, DAQ has not formally determined the types of additional data needed to support this study. Databases and types of data and information of potential interest might include:

- Chemical and physical properties data.
- Sampler manufacturers' operational literature.
- Geographic location data.
- Historical monitoring information.
- External monitoring databases.
- National Weather Service data.

Any use of outside data will be quality controlled to the extent possible following QA procedures outlined in this document and in applicable EPA guidance documents.

19.0 Data Management

19.1 Purpose/Background

The data management involves collecting, downloading, transferring, transforming, uploading, verifying, validating, summarizing and reporting the data generated in this study. These data include descriptive and historical information about each site (e.g. log books, worksheets, etc.), all analytical and meteorological data and summaries and reports about the study. Each month, the QA coordinators will present validated, quality-coded analytical data to the QA supervisor and the project manager. The project manager will submit all data to REACH. The data manager will electronically archive all data on the DAQ ENVISTA ARM database.

Figure 2 displays the generalized flow path of the DCAMS data, as well as the QA/QC data collected within the network. Section 4.0 Project/ Task Organization describes staff responsibilities in more detail.

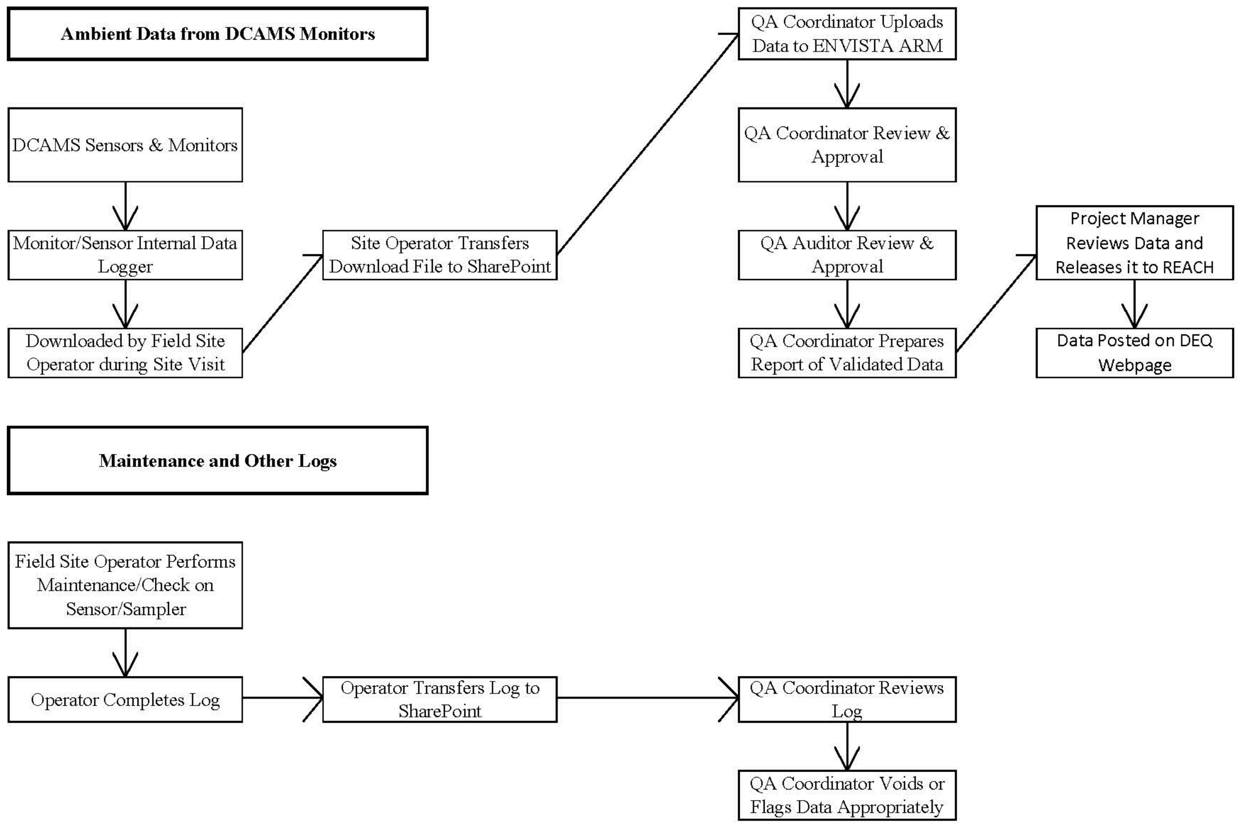

Figure 2. DCAMS Data Flow Path

19.2 Data Collection and Recording

For the DCAMS, DAQ records all data electronically. The site operator manually collects the data and the QA coordinator manually uploads the data to the ENVISTA ARM data storage database. The DAQ uses the ENVISTA ARM database for data verification, validation and reporting. The site operators, QA coordinators, QA auditor and statistician use Microsoft Excel spreadsheets for data manipulations, reporting and in-depth study of the data.

19.3 Data Transmittal and Transformation

Data transmittal is accomplished using manual transfer of the data from the monitor to a portable storage medium. The NH_3 and H_2S monitors can store approximately 1 week of data in their memory, whereas the EBAM can store 1.3 years of data. The monitor data-storage software removes data from the monitor by overwriting data on a first-in, first-out basis. This configuration requires the site operator to extract data from the monitor on a regular basis to prevent any data loss. If the site operator cannot reach the site within seven days of the last visit to download data, then the site operator must visit the site as soon as possible after the seventh day to minimize data loss.

The EBAM and NH_3 monitor record and store a reading every hour. The Jerome meter takes a 20 second sample every 15 minutes, measures the H_2S concentration, and records and stores it.

The site operator downloads the data and the QA coordinator uploads the data to ENVISTA ARM. ENVISTA ARM averages the stored 15-minute H_2S measurements to form averaged hourly values and then averages the hourly values to form 24-hour block averages which are the blocks of measured concentrations that the QA coordinators submit to the project manager. ENVISTA ARM retains all the data, making it readily available for future use.

19.4 Data Verification and Validation

Data verification and validation is an important routine process that involves several steps to ensure the site operators, QA coordinators and QA auditor have carried out the field and data processing operations correctly. The verification and validation process will identify data with errors, biases and physically unrealistic values before DAQ or any data user uses them for further analysis or reaching any type of conclusion. Once the data verifiers and validators have identified these problems, they can correct or invalidate the data. If necessary, the site operators and electronic technicians can take corrective actions.

Each of the network's analytical instruments employed to measure the ambient concentrations of the criteria pollutants undergoes periodic audits, checks or monthly flow rate validations and calibrations. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 (see Table 11.2 for SOP titles) outline these procedures. Audits and checks ascertain the accuracy, precision and repeatability of each instrument in performing its required function.

The instrument-generated data are stored on site in the instruments. When the site operators access the data, they download it to a file, which the QA coordinators use to upload the data into the ENISTA ARM database where the data undergo verification, validation, reduction and analysis. The QA coordinator performs data verification electronically by searching the data for status flags and comparing reported values to acceptable range criteria and reviewing the calibration and maintenance logs provided by the site operators. After they flag data as questionable, they also evaluate the flagged data to identify underlying causes and decide whether the data are valid. If the data are invalid, DAQ does not use them in calculations. If the data are valid, but flagged due to some extenuating circumstance, then DAQ may use the data in calculations, accompanied by a comment documenting the situation.

19.5 Data Reduction and Analysis

Data reduction activities take place throughout the entire data management process. The site operator downloads data from the monitors at the site each week and transfers the download files to the SharePoint site. The QA coordinators upload the data from the SharePoint site to the ENVISTA ARM database. The ENVISTA ARM system can aggregate hourly $PM_{2.5}$ data into the 24-hour averages required to compare against the AQI. These values obtained from reducing these data sets establish whether the monitor recorded values that might affect public health.

The regulations at 40 CFR Part 50 define the quantity of valid data points required within a data set. For most pollutants, the EPA requires a minimum data capture of 75 percent of the interval – hour, day, quarter – for the EPA to consider the interval valid for use. Table 4 through Table 10 summarize these completeness requirements as well as provide specific references to the CFR or guidance documents, if applicable.

The DAQ analyzes data periodically throughout the data collection and validation process. The DAQ also reviews all validated data looking for trends, outliers, etc. to establish the reasonableness of the data sets.

19.6 Data Submission

After the field site operators, QA coordinators and QA auditor complete the validation for a month of data, as described in Sections 19.4 and 19.5, the QA coordinators prepare reports for the project manager. After the project manager reviews the reports, he posts them on the DEQ website and submits them to REACH.

19.7 Data Storage and Retrieval

Once collected, data are stored in a variety of ways and for varying periods. Initially, data are stored in the sampler and/or sensor at the monitoring station. The monitors and sensors keep an unalterable record of instrument measurements for up to seven days, depending on the amount of information stored. The QA coordinators manually upload the data to the ENVISTA ARM database system where the data will be archived.

The DAQ's archiving system makes possible the storage and retrieval of the air quality monitoring data. Backup and recovery procedures exist to ensure the database manager can recover data in the event of a catastrophic failure. When storage space limits the amount of data that DAQ can keep in the database, procedures exist for moving the data into an archive database.

All supporting electronic and written information, such as logbooks, maintenance logs, certifications and diagnostic information worksheets are retained by DAQ for a minimum period of four years, unless any litigation, claim, negotiation, audit or other action involving the records has been started before the expiration of the four-year period. When this type of situation occurs, DAQ will retain the records until completion of the action and resolution of all issues that arise from it, or until the end of the regular four-year period, whichever is later. The data shall be stored on electronic media or in hard copy, whichever format proves most advantageous. After the storage period has passed, the storage media may be disposed of or recycled.

20.0 Assessment and Response Action

An assessment is the process used to measure the performance or effectiveness of the quality system, the DCAMS network and its sites, and various measurement phases of the data operation. To ensure the adequate performance of the quality system, DAQ will perform the following assessments:

- Appendix E siting reviews and network assessments
- Semi-annual flow rate audits
- Data verification and validation
- Data quality audits
- Data quality assessments
- Internal systems audits
- Assessment activities and project planning

20.1 Appendix E Siting Reviews and Assessments

20.1.1 Appendix E Siting Reviews

The field site operator will complete an Appendix E siting review of the DCAMS site and submit a siting review form to the RCO every year. The following criteria are considered:

- Distance and direction of the monitors from the road as well as traffic on the road;
- Distance and direction of the monitors from the dripline of trees as well as height of the trees;
- Distance and direction of the monitors from obstacles, such as buildings and walls, as well as the height of the obstacle; and
- Distance of the monitor inlet from the ground, other monitor inlets, and supporting structures.

The field site operator will consider monitor location, the traffic on the roadway, potential changes to the roadway, population density, changes in nearby land use and other pertinent information during the siting review.

During the siting review, the field site operator will also reconfirm the stated objective for the monitoring site and re-verify the location's spatial scale. If the site location does not support the stated objectives or the designated spatial scale, the field site operator will propose changes to rectify the discrepancy. If practicable, the LAB and WIRO monitoring staff will then take action to relocate the monitors or site, or move the site to a more suitable location, if needed. The field site operator will also identify any files and photographs that need updating during the review.

20.1.2 Network Assessment

The network assessment is a more extensive evaluation of the DCAMS network. The assessment determines at a minimum:

- If the DCAMS program meets the monitoring objectives defined in the Air Quality Monitoring Agreement,
- Whether DAQ should add any additional sites,
- Whether the existing sites are no longer needed and can be terminated, and
- Whether new technologies are appropriate for incorporation into the DCAMS network.

20.2 Semi-annual Flow Rate Audits

A QA coordinator other than the QA coordinator who routinely reviews the $PM_{2.5}$ data completes a flow rate audit on the monitor at least once every 182 days and preferably once every quarter or 91 days. This QA coordinator uses different equipment to conduct the audit than the equipment used to calibrate the monitor and do the monthly or semi-monthly flow checks. The ECB technicians certify the audit equipment and the equipment used to calibrate the monitor using the same primary standard for both. The QA coordinator follows the audit procedures in SOP 2.46.2. If a monitor does not pass the evaluation, the QA coordinator and site operator will take appropriate action to identify why the monitor failed the evaluation and to correct the situation.

20.3 Data Verification and Validation

The site operator, QA coordinators and QA auditor verify and validate the data every month. The site operator verifies the data by completing the maintenance logbook forms and noting any data issues on the form. After the site operator provides the logbook forms and data, the QA coordinators upload the data to ENVISTA ARM and flag data as questionable based on the logbook entries and any monitor provided flags. The QA coordinators also evaluate the flagged data to identify underlying causes and decide whether the data are valid. The QA auditor ensures that the QA coordinators verify and validate data consistently across monitoring programs and have properly documented reasons for all flagged data.

20.4 Audit of Data Quality

An audit of data quality, or ADQ, reveals how the site operators and QA coordinators handled data, what judgments they made and whether they made uncorrected mistakes. An ADQ can often identify the means to correct systematic data reduction errors. The DAQ includes an ADQ as part of the annual systems audit. Sufficient time and effort will be devoted to this activity so that the auditors have a clear understanding and complete documentation of data flow. Pertinent ADQ questions appear on the TSA check sheets, which the auditor shall use in executing an ADQ. The DAQ uses the TSA check sheets to ensure the site operators and QA coordinators maintain data collection and handling integrity. The ADQ will serve as an effective framework for organizing the extensive amount of information gathered during the audit of field monitoring and support functions within the agency. If the auditor finds a problem during the ADQ, the auditor will work with the site operators and QA coordinators to correct the situation and modify the procedures to ensure the problem does not reoccur.

20.5 Data Quality Assessments

A DQA is the statistical analysis of environmental data to determine whether the data meet the assumptions under which the DQOs and data collection design were developed and whether the total error in the data is tolerable. Calculations for DQA activities shall follow the requirements and equations identified in 40 CFR Part 58, Appendix A, Section 4 and reiterated in Section 14 of this QAGD, when the necessary data to do the calculations are available. *Data Quality Assessment - A Reviewer's Guide* (EPA QA/G-9R)[2] describes in detail the DQA process. Terminology associated with measurement uncertainty is found within 40 CFR Part 58, Appendix A. The RCO statistician will calculate estimates of the data quality on a quarterly basis. The DAQ bases the estimates of the data quality on single monitors and aggregates the data from each monitor for an estimate for the network.

20.11 Internal Systems Audits

The internal systems audit is a thorough and systematic qualitative audit, where facilities, equipment, personnel, training, procedures, protocols, and record keeping are examined for conformance with the QAGD and statewide policies governing the collection, analysis, validation, and reporting of ambient air quality data.

The QA auditor may separate systems audit activities into two categories. The categories may be audited independently, or they may be combined. The categories include;

- Field activities – performing routine maintenance of equipment, maintaining certification records, performing associated QA/QC activities, etc.
- Data management activities – collecting, flagging, editing, and uploading data; providing data security, etc.

The QA auditor will interview the key personnel responsible for field operations, QA/QC, data management and reporting.

20.11.1 Post-Audit Activities

The major post-audit activity is the preparation of the systems audit report. The report will include:

- Audit title, identification number, date of report and any other identifying information;
- The QA auditor and audited participants;
- Background information about the project, purpose of the audit, dates of the audit, measurement phase or parameters that were audited and a brief description of the audit process;
- Summary and conclusions of the audit and corrective action required; and
- Attachments or appendices that include all audit evaluations and audit findings.

The QA auditor will prepare a brief written report summarizing the findings. The following areas will be included:

1. Field operations,
2. QA/QC,
3. Data management, and
4. Reporting.

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[2] Available at https://www.epa.gov/sites/production/files/2015-08/documents/g9r-final.pdf.https://www.epa.gov/sites/production/files/2015-08/documents/g9r-final.pdf.

Problems with specific areas will be documented and corrective actions will be implemented.

To prepare the report, the QA auditor will compare observations with collected documents and results of interviews with key personnel. Expected QAGD implementation is compared with observed accomplishments and deficiencies. The audit findings are reviewed in detail and, within 30 calendar days of the completion of the audit, a comprehensive audit report will be generated and distributed to senior staff for comment.

If the affected parties have written comments or questions concerning the audit report, the QA auditor will review and incorporate them as appropriate. Subsequently, a modified report will be prepared and resubmitted in final form within 30 days of receipt of the written comments. The report will include an agreed-upon schedule for corrective action implementation.

20.11.2 Follow-up and Corrective Action Requirements

As part of corrective action and follow-up, an audit finding response form will be generated by the audited unit for each finding in the systems audit report with a corrective action report where appropriate. The audit finding response form is signed by the appropriate supervisor over the area audited and sent to the QA auditor, who reviews and accepts or rejects the corrective action. The audit response form will be completed within 30 days of acceptance of the audit report.

The results of the QA systems audit may result in additional or refresher training for air monitoring staff. Training may be provided in the form of additional communications regarding DAQ's approved practices along with discussions of the elements necessary to satisfy these requirements. It may also be in the form of hands-on technical training.

20.11.3 Audit Schedule

The QA auditor will perform an internal systems audit at the beginning of the project and at the end of the project. If the project lasts for more than one year, the QA auditor will perform an internal systems audit each year that the project continues.

20.12 Assessment Documentation

The DAQ shall execute audits during this project at the frequency and quantity indicated. The site operator shall conduct Appendix E siting reviews every year that the network is operational. The QA auditor will conduct internal system audits at the start of the project and each year the monitors are in operation. DAQ shall perform an ADQ every year that the DCAMS is operational. A QA coordinator, other than the QA coordinator who reviews the data, will conduct semi-annual flow rate audits at least every 182 days and preferably every 91 days. DAQ will retain copies of all documentation of assessments.

21.0 Reports to Management

This section describes the quality-related reports and communications to management necessary to support the DCAMS operations and the associated data acquisition, verification, validation and reporting. Besides the reports discussed in this section, staff meetings occur regularly on either a weekly, biweekly or monthly schedule depending on the part of the organization involved. In addition, the project manager or QA supervisor will hold meetings, as needed, with the affected parties to address any additional issues that may arise.

The EPA's Air Quality Assessment Division within the Office of Air Quality Planning and Standards provides guidance for management report format and content. All reports described below will contain monitoring data for H_2S, NH_3 and $PM_{2.5}$.

21.1 Periodic Reports

Periodically, the project manager will report the results of all monitoring, as well as precision and accuracy tests, DAQ has carried out to REACH. The project manager will submit these reports consistent with the data reporting requirements specified for air quality data as set forth in 40 CFR 58, Appendix A, Section 4.

21.2 Response/Corrective Action Report

Whenever the QA coordinators or other study team members identify a problem, such as a safety defect, an operational problem or a failure to comply with procedures, he or she will initiate a response/corrective action process. This process consists of four steps:

- Identify the problem as soon as possible, ideally within one or two business days;
- Identify why the problem occurred as soon as possible, ideally within five business days;
- Identify a process in which it can be prevented from reoccurring as soon as possible, ideally within five business days; and
- Follow up after putting the process into place as soon as possible, ideally within five to 10 business days.

The field operator will document the four steps above within the electronic site visit logbook from the date of the original problem or infraction.

The DAQ will follow the response/corrective action report procedure whenever the field operator, QA coordinators or QA auditor finds a problem such as a safety defect, an operational problem or a failure to comply with procedures. The DAQ requires a separate report for each problem identified. The response/corrective action report is one of the most important ongoing reports to management because it documents primary QA activities and provides valuable records of QA activities that the project manager can use in preparing other summary reports. The DAQ distributes copies of response/corrective action reports twice: first when the field operator, QA coordinators or QA auditor identifies the problem and schedules corrective action and second when the field operator and others involved complete the corrective action. The QA coordinator or QA auditor will distribute the report to the branch supervisors and QAM. Figure 3 and Figure 4 provide the corrective action report that DAQ uses to document these activities.

Corrective Action Report

Corrective Action Report # (CAR-YYYYMMDD):
Corrective Action Reported by:
Corrective Action Audited by:
Quality Assurance Manager:

Details of Corrective Action Needed

To be completed by the reporter. Explain the corrective action needed along with details of how the issue occurred and what the impact was.	
Date/Time of Incident:	

Corrective Action Taken

Explain what action was taken to resolve the situation if any. If no action was taken, what should be done to prevent the issue from occurring again?			
Signature:		Date:	

Root Cause Analysis

Investigate the root cause and detail what steps led to the incident.			
Signature:		**Date:**	

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Figure 3. Corrective Action Report, Page 1

Acknowledgement of discussions with personnel involved

To be completed by the Quality Assurance Manager or designee. Document discussions with personnel involved in the incident.			
QAM or Designee:		Date:	
Personnel		Date	

Audit

To be completed by the RCO chemist auditor. Explain if the incident has been fixed and if measures are in place to prevent reoccurrence.			
RCO Chemist:		**Date:**	

When form is completed store an electronic copy of the form in IBEAM Documents General Work Module: Document Category = Ambient Work, Document Group = QA Correspondence, Document Type = Correspondence. ID should be the geographical location affected, that is NC if the entire state, NC and regional office abbreviation if it affects one regional office, NC regional office county site if it affects one site, etc. Name /Subject should be the Correction Action Report Number or CAR –YYYYMMDD where YYYYMMDD is the date when the reporter initiated the corrective action. Document Date should be the first day of the incident date. Description should list pollutants or monitors involved.

Figure 4. Corrective Action Report, Page 2

21.3 Final Report

At the end of the study, the project manager will report the results of all monitoring, as well as precision and accuracy tests, DAQ has carried out to REACH. The project manager will submit the final report consistent with the data reporting requirements specified for air quality data as set forth in 40 CFR 58, Appendix A, Section 4.

22.0 Data Validation and Usability

22.1 Sampling Design

Sampling network and monitoring site selection must comply with:

- The Settlement Agreement
- 40 CFR Part 58, Appendix E - Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring, where applicable

Guidance for Choosing a Sampling Design for Environmental Data Collection (EPA QA/G-5S)[3] provides additional guidance.

The ECB technician setting up the site will thoroughly document any deviations from the minimum siting criteria (e.g., shelter location, probe placement) in the site's QC documentation. Examples of deviations include, but are not limited to, insufficient distance from roadways (i.e., marginal terrain criteria) and insufficient distance from influencing objects (e.g., dripline of an adjacent tree or a wall or other obstruction).

22.2 Data Collection Procedures

Section 11.0 Sampling Methods Requirements outlines sample collection procedures. The QA coordinators routinely identify potentially unacceptable data points in the database through electronic application of status flags applied by the monitor during sample collection. Each instrument-specific flag is associated with a unique error. The QA coordinators routinely review these status flags as part of the data validation process. This activity assists in identifying suspect, or potentially bad, data points that could invalidate the resulting averaging periods. The QA coordinators correlate these instrument-applied status flags to one of the data-qualifier codes presented in 11.0 Sampling Methods Requirements .

The field operator must document any deviation from the established sample collection plan in the appropriate logbook and on the field sample data sheet. The QA coordinator may need to investigate and evaluate the data to determine whether the data obtained from one site may qualify as an indicator of data validity or data problems occurring at another site.

22.3 Quality Control

Section 14.0 Quality Control Requirements and Procedures specifies the QC checks that the field operator must perform during sampling. These include the analysis of monthly or semi-monthly flow rate verifications, one point QC checks, and zero point verifications. These checks provide indications of the quality of data produced by specified components of the measurement process. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 specify the procedure, acceptance criteria, corrective action

[3] Available at: https://www.epa.gov/sites/production/files/2015-08/documents/g9r-final.pdf

and changes for each QC check. The QA coordinators, during data validation, should document the corrective actions taken, the affected sampling days or hours, and the potential effect of the actions on the validity of the data. SOP 2.53.2 provides further information about monthly flow rate verifications.

Table 23. Qualifier Code Description and Type

Flag	Flag Description	Flag Qualifier Type	Purpose
IA	African Dust	Informational Only	To provide information on events that influenced the measured values.
IB	Asian Dust	Informational Only	
IC	Chem. Spills & Industrial Accidents	Informational Only	
ID	Cleanup After a Major Disaster	Informational Only	
IE	Demolition	Informational Only	
IF	Fire - Canadian	Informational Only	To provide information on events that influenced the measured values.
IG	Fire - Mexico/Central America	Informational Only	
IH	Fireworks	Informational Only	
II	High Pollen Count	Informational Only	
IJ	High Winds	Informational Only	
IK	Infrequent Large Gatherings	Informational Only	
IL	Other	Informational Only	
IM	Prescribed Fire	Informational Only	
IN	Seismic Activity	Informational Only	
IO	Stratospheric Ozone Intrusion	Informational Only	
IP	Structural Fire	Informational Only	
IQ	Terrorist Act	Informational Only	
IR	Unique Traffic Disruption	Informational Only	
IS	Volcanic Eruptions	Informational Only	
IT	Wildfire-U. S.	Informational Only	
J	Construction	Informational Only	
AA	Sample Pressure out of Limits	Null Data Qualifier	Void the data and submit the code in its place.
AB	Technician Unavailable	Null Data Qualifier	
AC	Construction/Repairs in Area	Null Data Qualifier	
AD	Shelter Storm Damage	Null Data Qualifier	
AE	Shelter Temperature Outside Limits	Null Data Qualifier	
AF	Scheduled but not Collected	Null Data Qualifier	
AG	Sample Time out of Limits	Null Data Qualifier	
AH	Sample Flow Rate out of Limits	Null Data Qualifier	
AI	Insufficient Data (cannot calculate)	Null Data Qualifier	
AJ	Filter Damage	Null Data Qualifier	
AK	Filter Leak	Null Data Qualifier	

Table 23. Qualifier Code Description and Type

Flag	Flag Description	Flag Qualifier Type	Purpose
AL	Voided by Operator	Null Data Qualifier	
AM	Miscellaneous Void	Null Data Qualifier	
AN	Machine Malfunction	Null Data Qualifier	
AO	Bad Weather	Null Data Qualifier	
AP	Vandalism	Null Data Qualifier	
AQ	Collection Error	Null Data Qualifier	
AR	Lab Error	Null Data Qualifier	
AS	Poor Quality Assurance Results	Null Data Qualifier	
AT	Calibration	Null Data Qualifier	
AU	Monitoring Waived	Null Data Qualifier	Void the data and submit the code in its place.
AV	Power Failure	Null Data Qualifier	
AW	Wildlife Damage	Null Data Qualifier	
AX	Precision Check	Null Data Qualifier	
AY	QC Control Points (zero/span)	Null Data Qualifier	
AZ	QC Audit	Null Data Qualifier	
BA	Maintenance/Routine Repairs	Null Data Qualifier	
BB	Unable to Reach Site	Null Data Qualifier	
BC	Multi-point Calibration	Null Data Qualifier	
BD	Auto Calibration	Null Data Qualifier	
BE	Building/Site Repair	Null Data Qualifier	
BH	Interference/co-elution/misidentification	Null Data Qualifier	
BI	Lost or damaged in transit	Null Data Qualifier	
BJ	Operator Error	Null Data Qualifier	
BK	Site computer/data logger down	Null Data Qualifier	
BL	QA Audit	Null Data Qualifier	
BM	Accuracy check	Null Data Qualifier	
BN	Sample Value Exceeds Media Limit	Null Data Qualifier	
BR	Sample Value Below Acceptable Range	Null Data Qualifier	
CS	Calibration Standard	Null Data Qualifier	
DA	Aberrant Data	Null Data Qualifier	
Flag	**Flag Description**	**Flag Qualifier Type**	
DL	Detection Limit Analyses	Null Data Qualifier	
FI	Filter Inspection Flag	Null Data Qualifier	
MB	Method Blank (Analytical)	Null Data Qualifier	

SA	Storm Approaching	Null Data Qualifier	
SC	Sampler Contamination	Null Data Qualifier	
ST	Calibration Verification Standard	Null Data Qualifier	
TC	Component Check & Retention Time Standard	Null Data Qualifier	
TS	Holding Time or Transport Temperature Is Out of Specs.	Null Data Qualifier	
XX	Experimental Data	Null Data Qualifier	
1	Deviation from a CFR/Critical Criteria	Quality Assurance Qualifier	Flag indicating the quality of the data.
2	Operational Deviation	Quality Assurance Qualifier	
3	Field Issue	Quality Assurance Qualifier	
4	Lab Issue	Quality Assurance Qualifier	
5	Outlier	Quality Assurance Qualifier	
6	QAGD Issue	Quality Assurance Qualifier	
7	Below Lowest Calibration Level	Quality Assurance Qualifier	Flag indicating the quality of the data. In some cases, the data may not meet all of the criteria but is still valid.
9	Negative value detected - zero reported	Quality Assurance Qualifier	
CB	Values have been Blank Corrected	Quality Assurance Qualifier	
CL	Surrogate Recoveries Outside Control	Quality Assurance Qualifier	
DI	Sample was diluted for analysis	Quality Assurance Qualifier	
EH	Estimated; Exceeds Upper Range	Quality Assurance Qualifier	
FB	Field Blank Value Above Acceptable	Quality Assurance Qualifier	
FX	Filter Integrity Issue	Quality Assurance Qualifier	
HT	Sample pick-up hold time exceeded	Quality Assurance Qualifier	
LB	Lab blank value above acceptable limit	Quality Assurance Qualifier	
LJ	Identification of Analyte is Acceptable; Reported Value Is an Estimate	Quality Assurance Qualifier	
LK	Analyte Identified; Reported Value May Be Biased High	Quality Assurance Qualifier	
LL	Analyte Identified; Reported Value May Be Biased Low	Quality Assurance Qualifier	
MD	Value less than MDL	Quality Assurance Qualifier	
MS	Value reported is 1/2 MDL substituted.	Quality Assurance Qualifier	
MX	Matrix Effect	Quality Assurance Qualifier	
ND	No Value Detected	Quality Assurance Qualifier	
NS	Influenced by nearby source	Quality Assurance Qualifier	
QX	Does not meet QC criteria	Quality Assurance Qualifier	
SQ	Values Between SQL and MDL	Quality Assurance Qualifier	
SS	Value substituted from secondary	Quality Assurance Qualifier	
SX	Does Not Meet Siting Criteria	Quality Assurance Qualifier	

TB	Trip Blank Value Above Acceptable Limit	Quality Assurance Qualifier	
Flag	**Flag Description**	**Flag Qualifier Type**	
TT	Transport Temperature is Out of Specs.	Quality Assurance Qualifier	
V	Validated Value	Quality Assurance Qualifier	
VB	Value below normal; no reason to invalidate	Quality Assurance Qualifier	
W	Flow Rate Average out of Spec.	Quality Assurance Qualifier	
X	Filter Temperature Difference out of Spec.	Quality Assurance Qualifier	
Y	Elapsed Sample Time out of Spec.	Quality Assurance Qualifier	

22.4 Calibration

Section 14.0 Quality Control Requirements and Procedures addresses the calibration of the monitors, along with the information that the field operator should present to ensure he or she performed the calibrations correctly, and the results are acceptable. When the field operator, QA coordinators or QA auditor identify calibration problems, the QA coordinators shall flag any data produced between the suspect calibration event and any subsequent recalibration to alert data users. SOPs 2.12.1, 2.53.2, 2.55 and 2.56 provide further information about calibrations.

22.5 Data Reduction and Processing

Data reduction aggregates raw data into averages for reporting purposes. The field operator will provide the raw data from the instrument downloads from the monitoring sites to the QA coordinators on a weekly basis. The QA coordinators will upload the data into the ENVISTA ARM data base for data verification, validation, reporting and archiving. Once the data are in ENVISTA ARM, the QA coordinators will verify, correct, flag and void the data. Then the QA auditor will further review the data for correctness, indicating the validity of the data. The QA coordinators monitor and review the data for invalid flags. If the QA coordinators deem the data invalid, they disqualify the data from the data set, and consequently, the data are not used. 40 CFR Part 50 defines criteria for the quantity of valid data points required within a data set. The DAQ will adhere to these criteria when performing the data reduction operations for this study.

Retaining copies of all electronically recorded data sets provides a data audit trail. The site operators and QA coordinators will archive the original download files in SharePoint.

The QA coordinators will review the data monthly to ensure null data codes or any other data qualifiers have been appropriately associated with the data and that the field operator took appropriate corrective actions. The DAQ project manager will make all data accessible to REACH and its partners and available to the public on the DAQ website. The schedule for data sharing will be dependent on the operational parameters of the instruments and staffing required to collect the data. A tentative schedule will be determined before the beginning of monitoring.

The monitoring technician must document any deviation from the established sample collection plan in the appropriate logbook or data sheet. Accurate and complete documentation of any sample collection deviations will assist in any subsequent investigations or evaluations.

23.0 Validation and Verification Methods

Data verification is the process of evaluating the completeness, correctness and conformance of a specific data set against the method, procedural, or contractual requirements, as specified in the SOPs. Data validation is a routine process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e. data verification) to ensure that reported values meet the quality goals of the environmental data operations and that the data can be utilized for its intended use.

The DAQ uses the validation templates provided in Table 4 to Table 10 for a weight of evidence approach. The DAQ handles the criteria as follows:

- Critical criteria are criteria deemed critical to maintaining the integrity of a sample, ambient air concentration value or group of samples. The QA coordinators should invalidate observations that do not meet all criterion on the critical table unless there are compelling reasons and justification for not doing so. Basically, the sample or group of samples that do not meet one or more of these criteria is invalid until proven otherwise.
- Operational criteria are situations were violations of a criterion or a number of criteria may be cause for invalidation of the data. The QA coordinators should consider other quality control information that may or may not indicate the data are acceptable for the parameter they want to control. Therefore, the sample or group of samples, which do not meet one or more of these criteria, is suspect unless: 1.) demonstrated otherwise by other quality control information, and 2.) QA coordinators have adequate documentation of that information. The QA coordinators should investigate, mitigate or justify the reason for not meeting the criteria.
- Systematic criteria include those criteria which are important for the correct interpretation of the data, but do not usually impact the validity of a sample or group of samples. An example criterion is that at least 75 percent of the scheduled samples for each quarter should be successfully collected and validated. The DQOs are also included in this table. If the data do not meet the DQOs, this does not invalidate any of the samples, but it may impact the confidence of any decisions made using the data.
- The designation of QC checks or QC samples as operational or systematic does not imply that the field operators do not need to perform these quality control checks. Not performing an operational or systematic QC check can be a basis for invalidation of all associated data. The DAQ applies the validation templates only to small datasets of single values or a few weeks of information and does not allow a criterion to be in non-conformance simply because it is operational or systematic.

23.1 Validating and Verifying Data

"*Guidance on Environmental Verification and Validation"* (EPA QA/G-8) discusses verification and validation issues at length. The QA coordinators, with assistance from the site operators, will perform all validation and verification activities. The QA coordinators will provide additional support through a final review of all data reconciling any anomalies through discussions with the field site operator. The QA coordinators will also provide other QA/QC support. Following the final review, the QA auditor will provide a final validation of all data.

The QA coordinators should compare the data under evaluation to actual events. However, exceptional field events and activities may occur which negatively affect the integrity of samples. In addition, DAQ expects some QC checks will indicate the data fail to meet the acceptance criteria. The QA coordinators will void or flag data identified as suspect, or does not meet the acceptance criteria, as indicated in Table 23.

The QA coordinators will verify and validate the routine and the associated QC data on a monthly basis. Reviewing a table containing one month of data is the most efficient process for verification/validation activities. If the DAQ can control measurement uncertainty every month, then DAQ will maintain the overall measurement uncertainty during the project within the precision and bias DQIs.

23.2 Verification

After the QA coordinator compiles an entire month of data, he or she will conduct a thorough review of the data to check for completeness and accuracy. The QA coordinator will enter the data into the ENVISTA ARM database and then review the data for routine data outliers and conformance to acceptance criteria. The QA coordinator will void or appropriately flag unacceptable or questionable data. The QA auditor will verify and validate all flagged data again to ensure the QA coordinator entered the values correctly and the data are acceptable for use.

23.3 Validation

Validation of measurement data requires two stages, one at the measurement value level and another at the batch level. The database manager will retain records of all invalid data in the ENVISTA ARM database. The QA coordinators shall include a brief summary explaining why they or the field operator invalidated the sample along with the associated flags. The field operator will provide detailed information in the logbook notes and field data sheets regarding the reason the operator voided or flagged a sample. These documents will remain with the field operators and/or at the monitoring site.

The DAQ uses a weight of evidence approach in validating data. DAQ determines the validity of the data by viewing the 15 minute, when available, and hourly values, any manual checks, e-logs and the information documented therein, correspondence with the field operators and the results of any DAQ audits.

Based upon federal guidance and guidelines as well as field operator judgment, the DAQ developed criteria to use to invalidate a sample or measurement. The field operator will use the null data and qualifier codes listed in Table 23 to invalidate individual samples, or samples from a particular instrument. Upon concurrence of the QA coordinators, QA auditor and QA supervisor, the QA coordinators shall invalidate these samples.

24.0 Reconciliation with Data Quality Objectives

Section 5.0 Problem Definition and Background describes the objectives of the study. Section 7.0 Data and Measurement Quality Objectives and Criteria describes the DQO's for the study

The DAQ QA coordinators will analyze the raw data on at least a monthly basis to ensure all monitors are meeting the required DQO's. If and when the PM data from at least one of the monitors violates the DQI bias and/or precision limits, then the DAQ QA coordinators will investigate to uncover the cause of the violation. For the other monitors and sensors, the QA coordinators will evaluate the zero and span data, where that is available, or the calibration verifications and audits, where that is available, to determine if the monitors are operating correctly and whether they need to do further investigation to uncover any potential problems. If both monitors in the study of a similar type or pollutant violate the DQI, the cause may be at the agency level (operator training) or higher (problems with method designation). If only one monitor or pollutant violates the DQI, the cause is more likely specific to the site (problem with the site). Tools for determining the cause include reviewing data from performance audits, interrogation of the operator or operators, and site visits.

Once the QA coordinators identify a cause, the project manager can implement an appropriate corrective action. Some courses of action include:

- Determining the level of aggregation at which DAQ violated the DQOs: Results from the DQA process tells which monitors are having problems, since the DAQ developed the DQOs at the monitor level. To determine the level at which DAQ will take corrective action, the QA coordinator or QA auditor must determine whether the violations of the DQOs are unique to one site, present at both sites or are caused by a broader problem.
- Extensively reviewing monthly data until DAQ achieves the DQOs: The QAM and QA supervisor will continue to extensively review the QA reports and the QC summaries until the DAQ attains the bias and precision limits for each monitor.

Ultimately specifying tolerable error limits reduces the probability of making an error in a decision due to uncertainty in the data. Decision makers, such as DAQ, need to determine if the data collected within the DCAMS will pose any type of health risk to people living in Duplin County. The DAQ will generate reports to provide a quantitative assessment of the measurement uncertainty within the DCAMS data set. By controlling uncertainty in the data to the extent prescribed by the DQOs, decision makers can use the DCAMS data with confidence

Revision History

This is the original QAGD.

QAGD Annual Review Documentation

Date of Review	Name of Reviewer	Signature of Reviewer	Results of Review

Appendix A Duplin County Air Monitoring Study Standard Operating Procedures

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NORTH CAROLINA
Environmental Quality

Standard Operating Procedure 2.53
Section 2:
Met One E-BAM Standard Procedures for Operators

NORTH CAROLINA
Department of Environmental Quality

North Carolina Department of Environmental Quality | Division of Air Quality
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NORTH CAROLINA
Environmental Quality

Standard Operating Procedure Approval

I certify that I have read and approve of the contents of this revision of SOP 2.53.2 with an effective date of *(Month, Day)*, 2018.

Raleigh Central Office Particulate Matter Lead
Paul J. Chappin, Environmental Chemist

Signature: ____ Date: ______________________

Electronics and Calibration Branch Particulate Matter Lead
Roger Locklear, Electronic Technician

Signature: ____ Date: ______________________

Electronics and Calibration Branch Field Operator
Pernell Judd, Electronic Technician

Signature: ____ Date: ______________________

Projects and Procedure Branch Field Auditor
Steven Walters, Chemist III

Signature: ____ Date: ______________________

Projects and Procedures Branch Supervisor
Joette Steger, Environmental Supervisor

Signature: ____ Date: ______________________

Laboratory Analysis Branch Supervisor and Project Manager
Jim Bowyer, Environmental Supervisor

Signature: ____ Date: ______________________

Ambient Monitoring Section Chief and Quality Assurance Manager
Patrick Butler, Ambient Monitoring Section Chief

DEQ
NORTH CAROLINA
Department of Environmental Quality

Signature: ____ Date: ______________________

U.S. Environmental Protection Agency
Laura Ackerman, Region 4 SESD

Signature: ____ Date: ______________________

ROY COOPER
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Environmental Quality

1.0 SCOPE AND PURPOSE

The U.S. Environmental Protection Agency, or EPA, began regulating fine particles in July 1997. The regulation established the gravimetric based federal reference method, or FRM, in the Code of Federal Regulations, or CFR, at 40 CFR Part 50, Appendix L. This document has been prepared to assist the field operators with the North Carolina Division of Air Quality, or DAQ, to use the MetOne EBAM to monitor the ambient atmosphere for particles with an aerodynamic diameter of 2.5 µm or less, known as fine particles or $PM_{2.5}$. Fine particles are formed in the atmosphere from gases such as sulfur dioxide, reactive oxides of nitrogen, and volatile organic compounds. Sources include power plants, diesel trucks, wood stoves, and industrial processes.

The following document describes the operation and site operator responsibilities for the Met One Instruments E-BAM, or beta attenuation monitor. The E-BAM automatically measures and records the airborne $PM_{2.5}$ concentration using the principle of beta ray attenuation. Although the E-BAM is not an FRM or FEM, the DAQ will compare the hourly concentration recorded by the instrument to the Air Quality Index for 24-hour average concentrations. This comparison will help the DAQ understand how the air in the monitored area compares to established health and welfare standards.

The objective of this standard operating procedure, or SOP, is to familiarize the station operator with the activities used in the collection of air monitoring data. The accuracy of data obtained from any instrument depends upon the instrument's performance and the operator's skill. It is important that the station operator become familiar with both this SOP as well as the manufacturer's operation manual in order to achieve a high level of data quality.

2.0 SAMPLER DESCRIPTION AND SETUP

2.1 Description of Met One E-BAM Monitor

The Met One Instruments Model E-BAM Continuous PM Monitoring System utilizes the principal of beta ray attenuation to accurately measure and report the concentration of airborne particulate matter, or PM, in ambient air at local conditions of temperature and atmospheric pressure. The centerpiece of the measurement system is a small, Carbon 14, or ^{14}C, source that emits a consistent supply of electrons, in the energy of the Beta spectrum to the mass to be measured, and a sensitive detector that counts the incident electrons.

A vacuum pump draws air, at a rate of 16.7 liters per minute, or LPM, through a size selective inlet, down the inlet tube, and deposits the airborne PM on a filter tape located between the beta source and detector. The accumulation of mass onto the filter tape increasingly attenuates beta ray transmission through the media.

Beta attenuation through the filter tape is continuously monitored throughout the measurement cycle. The degree of beta ray attenuation is used to determine the mass of PM deposited on the filter tape. During sampling, the flow rate is precisely controlled.

Having determined both mass and sample volume, the E-BAM calculates and reports the ambient PM concentration, expressed as micrograms per cubic meter, or µg/m^3, or milligrams per cubic meter, or mg/m^3. Figure 5 below demonstrates the E-BAM measurement system. Appendix A contains a diagram that outlines the E-BAM system.

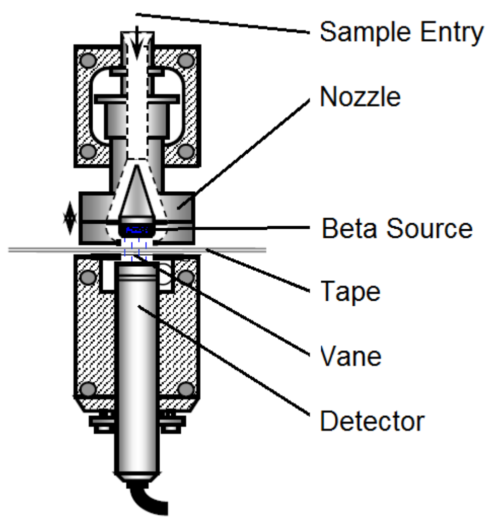

Figure 5. E-BAM Measurement System

WARNING!

The Met One Instruments E-BAM contains a small ^{14}C beta radiation-emitting source. The nominal activity of the source is 60 microcuries, or µCi, ± 15µCi, which is below the "Exempt Concentration Limit" as defined in USC 10 CFR Section 30.71 – Schedule B. Under no circumstances should anyone but factory technicians attempt to remove or access the beta source. The beta source has a half-life of about 5,730 years, and should never need to be replaced unless it becomes damaged or corroded. Neither the ^{14}C source nor the beta ray detector are serviceable in the field. Should these components require repair or replacement, the E-BAM must be returned to the factory for service and recalibration. The E-BAM is manufactured in compliance with the U.S. Nuclear Regulatory Commission safety criteria in 10 CFR 32.27.

Moisture is the primary inference of concern when monitoring PM using the E-BAM. To alleviate the effects of moisture on the E-BAM measurements, all Met One E-BAMs are equipped with a moisture-controlled inlet heater. The inlet heater is used to prevent condensation on the filter paper and is controlled through a feed-back loop using temperature and relative humidity sensors that are located downstream of the filter. The presence of condensation on the filter paper can result in a positive bias in the mass measurements. By heating the air stream in a controlled manner, condensation is avoided and proper mass measurements are calculated. The Met One E-BAM is equipped with a Smart Heater. *NOTE: Moisture entering and running down the inlet tube will not be dried using this heater; therefore, additional care must be taken to avoid moisture intrusion to the inlet tube. The use of the* PM_{10} *sampling inlet typically minimizes intrusion of water into the inlet.*

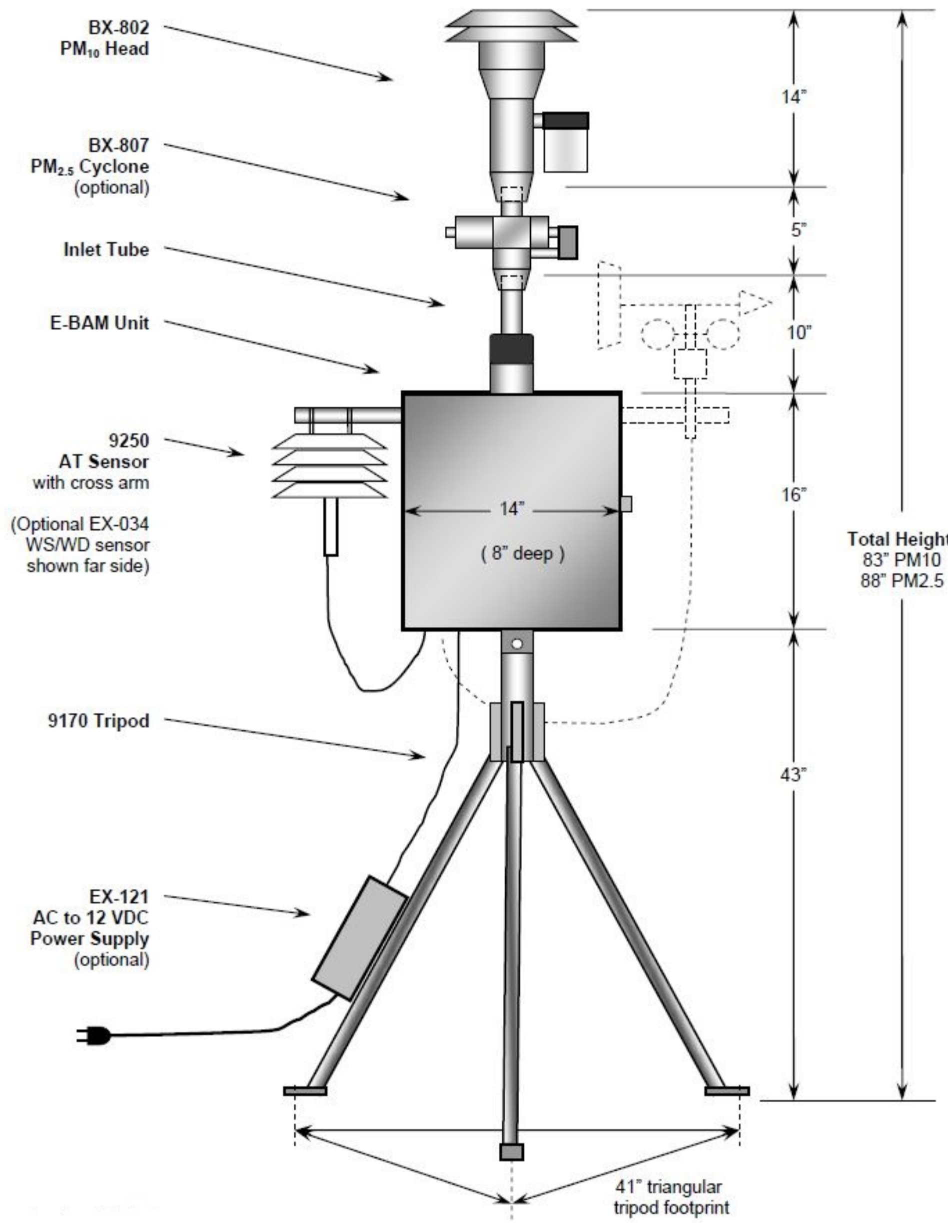

Figure 6. E-BAM Configuration

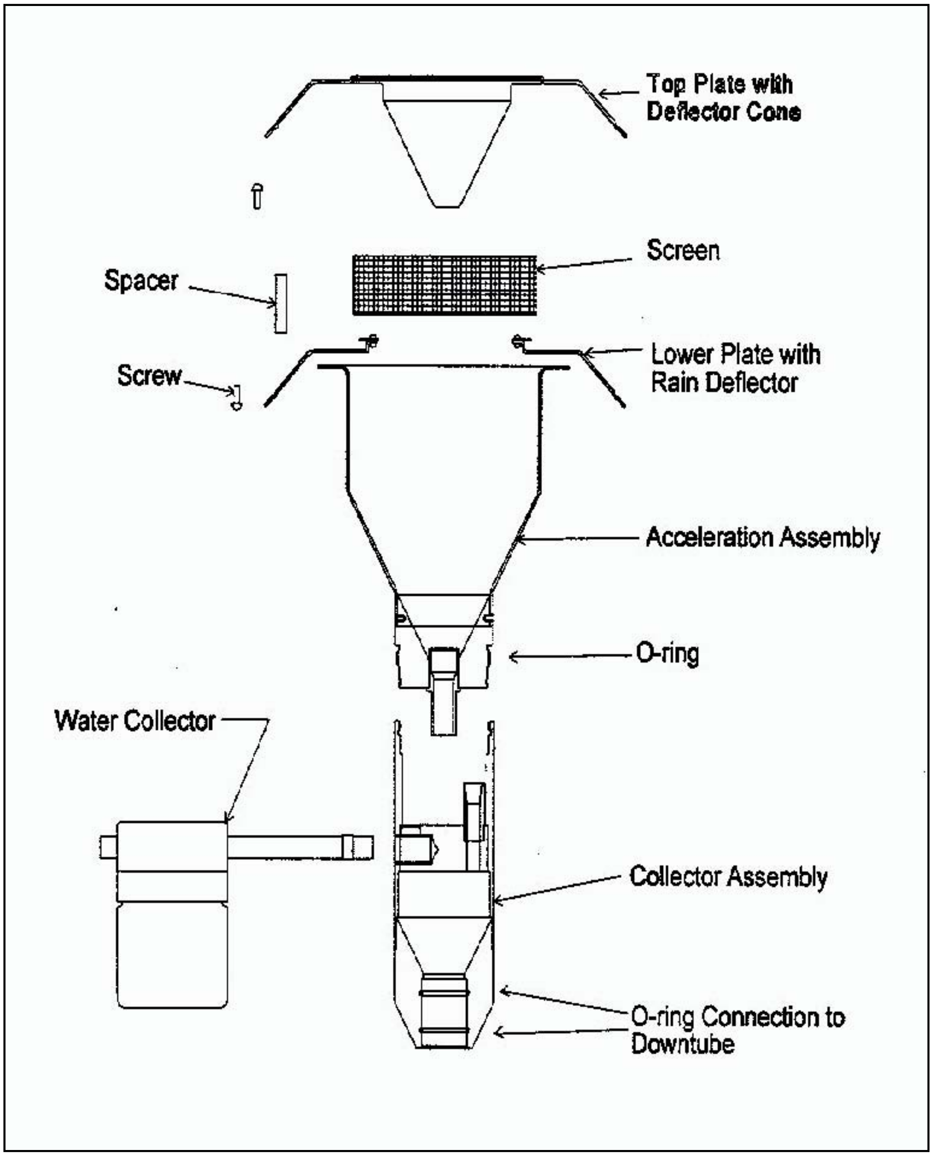

Figure 7. Exploded Cross-Sectional View of PM_{10} Sampler Inlet Head

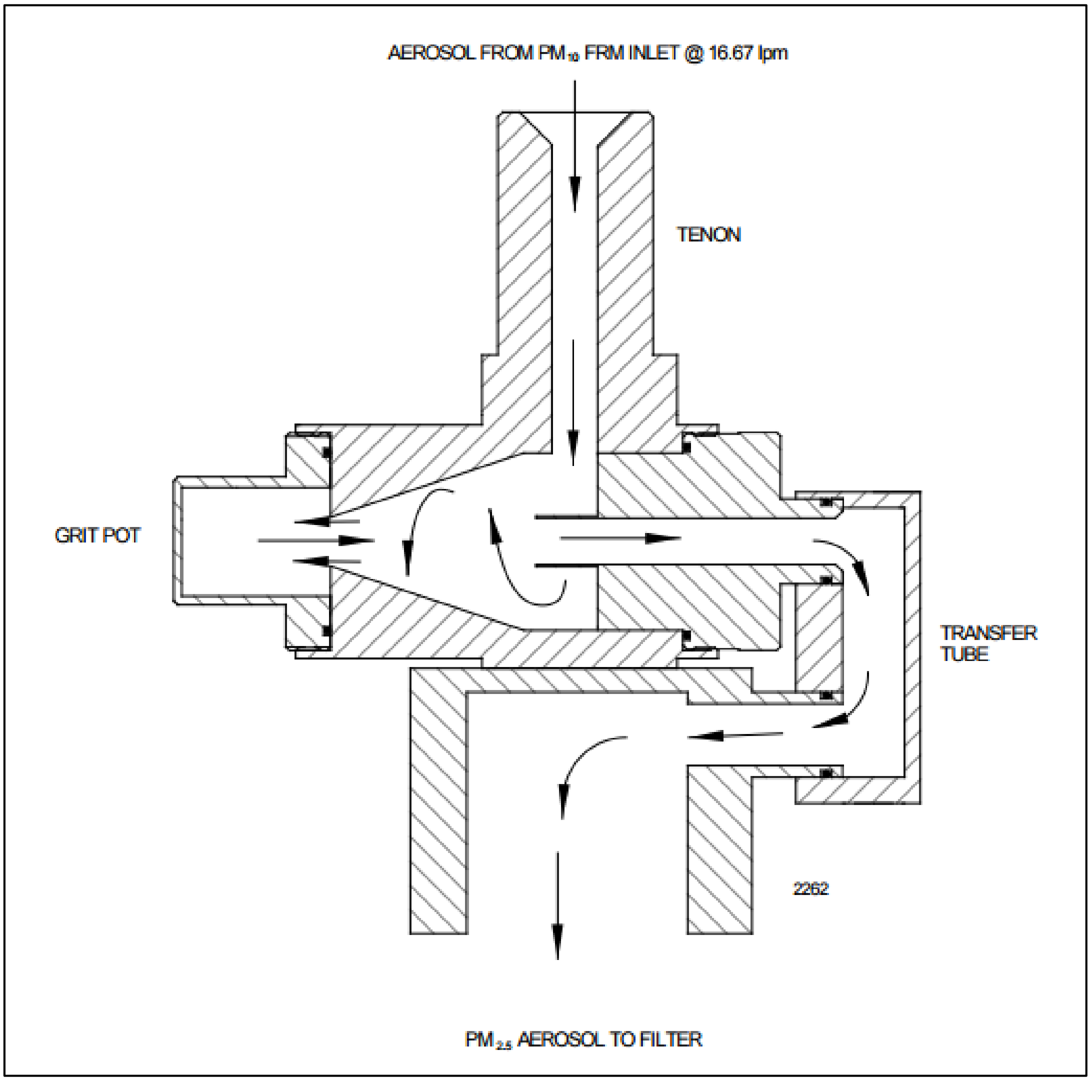

Figure 8. Operation of the SCC

2.2 Initial Setup of the Electronic Logbook

An electronic logbook, or e-log, must be created for each site at the beginning of the calendar year or upon setup. The E-BAM e-log consists of the spreadsheets listed in Table 24. The most current e-log version can be obtained from the IBEAM documents module or by contacting the RCO particulate matter lead. Table 24. The most current e-log version can be obtained from the IBEAM documents module or by contacting the RCO particulate matter lead.

Table 24. Description of E-Log Spreadsheets.

E-Log Spreadsheet	Description
Instructions	Setup of site information (Site Name, AQS ID, SiteID2). Provides a summary of operational evaluations and sampler maintenance for users.
Event Summary	Table for users to track dates of verifications, audits, and maintenance.
Site Visit	Log of every site visit including monitor information, operational parameters, and site activities.
Calibration	Table for documenting sampler calibrations.
Maintenance Log	Table for documenting monthly, quarterly, and annual maintenance activities, as well as tape changes, leak checks, clock verifications, etc.
Verification Audit	Table for documenting all verifications and audits.
Background	Calculates the background coefficient for the E-BAM and determines if the zero background test passes or fails. (Note: there are three background spreadsheets in case multiple tests need to be performed.)
AQS Upload	This spreadsheet is for RCO use. Formulas on this page generate the AQS upload files for all verifications and audits.

Initial setup of the e-log requires selecting the site name from a pull down menu on the "Instructions" tab of the e-log (Figure 4). The AQS ID, pollutant, and E-BAM type field will automatically populate based on the site name.

2.2.1 Electronic Logbook Site Visit Spreadsheet

Every time a field operator visits the E-BAM, the "Site Visit" spreadsheet must be filled out along with any other corresponding spreadsheet (maintenance, calibration, verification, or background). The Site Visit spreadsheet (Figure 5) contains vital data that the operator must collect during each visit, including: monitor information, operational parameters, site activities, and comments.

3.2.2 Monitor Setup

The E-BAM user interface is a vacuum fluorescent display (VFD). The operator accesses all of the features and functions for monitor setup using the touchscreen.

3.4 Power Up and Warm Up Period

The E-BAM is designed to turn on automatically when power is applied. The unit will ask if you are ready to start, then prompt you to verify several setup menus which are described below. Then the unit will perform an automatic self-test routine which takes several minutes. After the self-test, the unit will begin sampling automatically.

Note: If no keypad activity is detected for several minutes after power-up, the E-BAM will automatically begin sampling based on the existing SETUP options and settings, as long as filter tape is installed and no hardware or voltage failures are detected. This makes it possible to fully configure and calibrate the unit in the lab, then simply deploy it to the field and power it up with no further actions required.

Note: The E-BAM must warm up for at least one hour before optimum accuracy of the concentration data can be obtained. This is because the beta detector contains a vacuum tube which must stabilize.
This applies any time the unit is powered up after being off for more than a moment. Setups, tests, and flow calibrations can be performed during this warm up time. The first hour of data should often be discarded or ignored.

2.3 User Interface and Menu System

2.3.1 User Interface

The E-BAM user interface consists of a 4x20 character vacuum fluorescent display (VFD) and a dynamic keypad. The two white keys under the display are called “soft keys”. These are dynamic keys which change in response to a menu option displayed directly above the key on the bottom row of the display. The function of these keys depends on which menu is shown on the display, and are often used for functions such as save, edit and set.

The four red arrow (cursor) keys are used to scroll up, down, left, and right, to navigate in the menu system, and to select items or change fields on the screen. The arrow keys are also often used to change parameters or increment/decrement values in the menu system. The right arrow key can be used to wake up the display if it has turned off to save power.

The MENU/SELECT key is used to enter the main menu or to select an item in a list. The ESC key is used to escape or exit out of a menu.

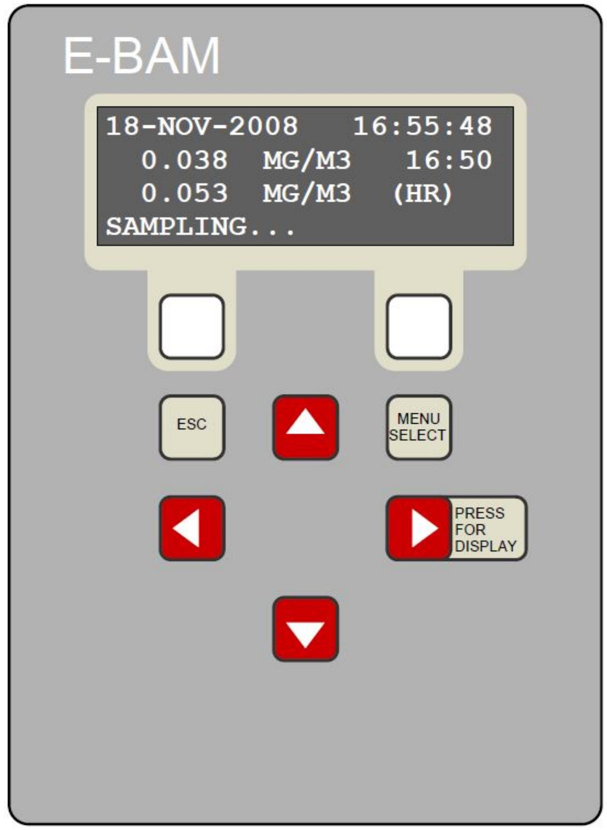

Figure 9. E-BAM User Interface.

2.3.2 Menu System

The E-BAM display shows the Sampling screen when the unit is in normal operation. The active display area shows the current date and time, the latest real-time average concentration, and the last hourly concentration. Also shown is a status message, such as "SAMPLING…". To view the rest of the instantaneous sensor parameters which do not all fit on the display at once, press the down ▼ arrow. The date and time will remain at the top of the display at all times.

To view past data, use the left ◄ arrow key to scroll back to previous data records. There will be one complete data record for every real-time average interval, indicated by the time/date stamp at the top of the screen. For example, if the real-time average is set to 10 minutes, then there will be a complete data record stored every 10 minutes as shown below. Again, you can use the ▼ key to view the rest of the sensor parameters for that record. Press the ESC key at any time to return to the current concentration sampling screen.

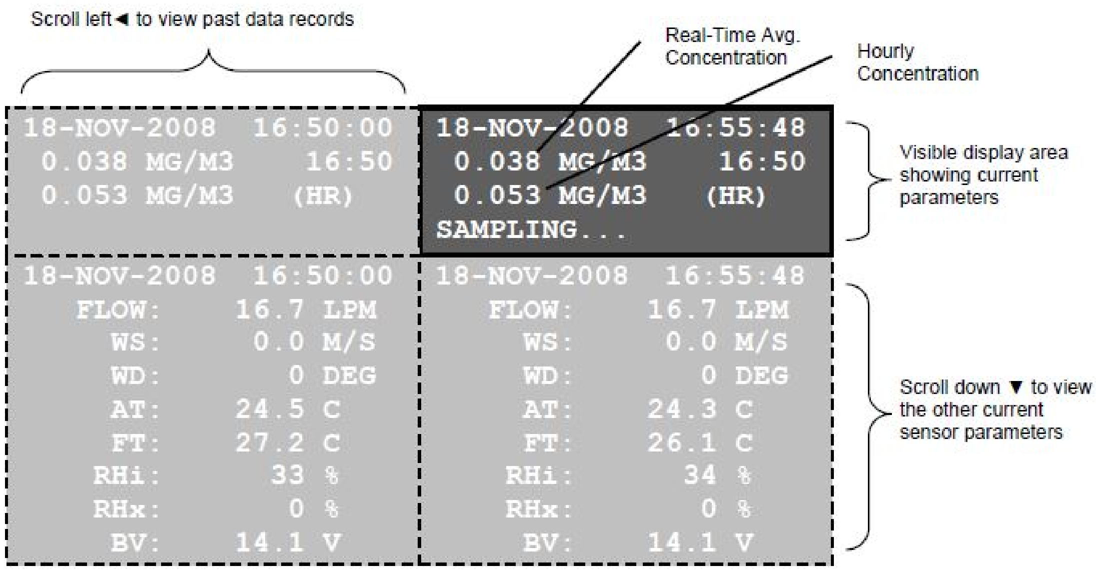

Figure 10. Main Sampling Screen Format.

Table 25 below describes the other parameters visible in the main sampling display as shown above. In addition to the hourly and real-time average concentrations, these are all of the logged parameters in the E-BAM:

Table 25. Parameters in Main Menu.

Parameter	Description
FLOW	Primary air flow rate in actual LPM or standard SLPM.
WS	Wind speed in meters per second (if equipped).
WD	Wind direction in degrees (if equipped).
AT	Ambient temperature in degrees C.
FT	Filter temperature in degrees C.

RHi	Internal filter RH.
RHx	External ambient RH (if equipped).
FLOW	Secondary flow in LPM. Only appears if primary flow is set to SLPM.

The main E-BAM menu system can be entered at almost any time by pressing <MENU/SELECT>. Use the ▲▼ arrow keys to select the desired menu option, then press <MENU/SELECT> to enter the selected sub-menu. The main menu functions are described below.

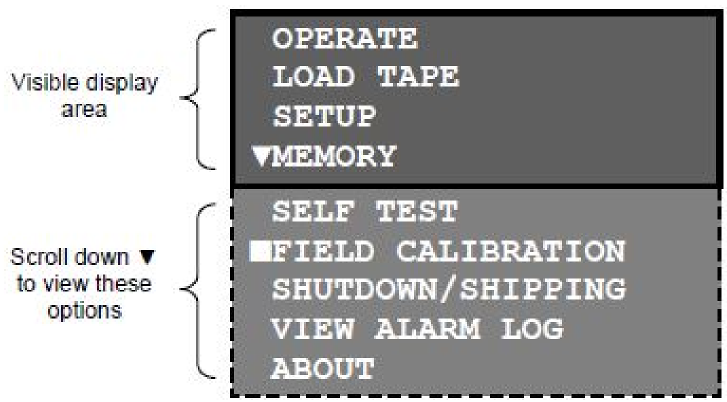

Figure 11. Main E-BAM Menu.

OPERATE: This menu option starts the E-BAM into normal operation mode and starts a new sample cycle. You will see a message which says" WARNING: START OPERATION?" Press <YES> to start a new sample. If the unit is already sampling, this option will simply exit the main menu and display the main sampling screen.

LOAD TAPE: This menu option is used for filter tape installation. If this option is selected, the E-BAM will simply raise the sample nozzle for easy tape loading, then display "PLEASE LOAD TAPE." Load the tape and press the <CONTINUE> key to go back to the main menu.

SETUP: This is the setup menu for the E-BAM.

MEMORY: This menu option displays the amount of memory left in the E-BAM digital data system as shown below. To erase the memory press <CLEAR>. Use the arrow keys to select either the Data Logger or Alarm Log to be cleared, then press <CLEAR> again. The unit will show a caution screen. If you are sure you want to erase the selected log, press <YES>. *CAUTION: Once the data log or the error log is cleared, the erased data can never be recovered.*

SELF TEST: This menu option starts the E-BAM on an automatic self-test cycle, just like the self-test it performs when powered on. Press the ESC key to escape from the self-test and return to the main menu.

FIELD CALIBRATION: This is the field calibration menu for the E-BAM. All of the calibrations and tests in this menu are described in Section 4.0 CALIBRATION.

SHUTDOWN / SHIPPING: This menu option is used to prepare the E-BAM for transport. When you enter this screen, the nozzle will raise, and the display will show "PLEASE INSERT NOZZLE PACKING MATERIAL". Insert the shim under the nozzle with the tab extending through the slot. The E-BAM will automatically lower the nozzle onto the shim, then display: "OK TO TURN OFF E-BAM". The power cord can now be unplugged to power off the E-BAM. *Note: It is OK to power off the E-BAM at almost any time during normal operation. This menu simply allows the opportunity to insert the nozzle shim.*

VIEW ALARM LOG: This menu option allows you to quickly view the error log entries in the E-BAM without having to download the digital data. The screen will display the type or error, as well as the time and date when the error occurred. Scroll through the error records using the ◄► arrow keys. Press <MENU/SELECT> to return to the main menu.

ABOUT: This menu option displays the E-BAM firmware version and revision, as well as the E-BAM serial number. The up/down arrow keys may be pressed to change which firmware version is shown. The E-BAM has two separate firmware files. One is for the master CPU and the other is for the 3610 I/O control board. Press <MENU/SELECT> to return to the main menu. *Note: If the ESC key is pressed while the E-BAM is displaying the ABOUT screen, the unit will prompt the user for a password. This is for entry into an advanced factory test menu. Do not enter this system unless instructed to do so by a Met One technician.*

3.6 Power-Up Settings Verification and Automatic Self-Test

The E-BAM will prompt you to verify several setup parameters whenever it is powered on. These setup screens can also be viewed or edited in the Setup Menu under the main E-BAM menu system. When power is applied to the E-BAM, the unit will show the firmware revision and unit serial number.

1. When power is applied to the E-BAM, the unit will show the firmware revision and unit serial number for just a moment, then display the welcome screen.
2. Press <YES> soft key, and the clock screen will be displayed. The time should be set to Eastern Standard Time and should match a verified NIST time source by ± 1.0 minute. If the time and date are correct press <YES>.
3. If you need to change the time or date, press <NO> and the display will show the time/date set screen. Use the arrow keys to change the values, then press <SET>, or press <CONTINUE> to go on without making changes.
4. After the time is verified, the unit will display the Average Period screen. Press <OK> if the settings are correct.
5. If the settings need to be changed, press the <EDIT> key to enter the edit mode. Select the parameter to be changed with the ◄► keys, and modify the settings with the ▲▼ keys and press <SAVE>. Press <CONTINUE> to exit the edit mode without making changes.
6. The next screen will appear with the location ID number at the top and the tape advance and real time average selections.

7. If the settings need to be changed (1 for tape advance and 10 for real time average), press the <EDIT> key to enter the edit mode. Select the parameter to be changed, and modify the settings with the ▲▼ keys and press <SAVE>. Press <CONTINUE> to exit the edit mode without making changes.

8. After the real-time settings are verified, the E-BAM will go on to display the Machine Type screen. Machine type tells the E-BAM which type of inlet it is equipped with, $PM_{2.5}$ or PM_{10}. *The only difference between the two is whether a $PM_{2.5}$ cyclone is installed or not*. The E-BAM will put the machine type setting onto the data array, so that you can tell if the collected data was $PM_{2.5}$ or PM_{10}. The screen refers the user to a picture located inside the door of the E-BAM for easy identification of the two possible inlet types.

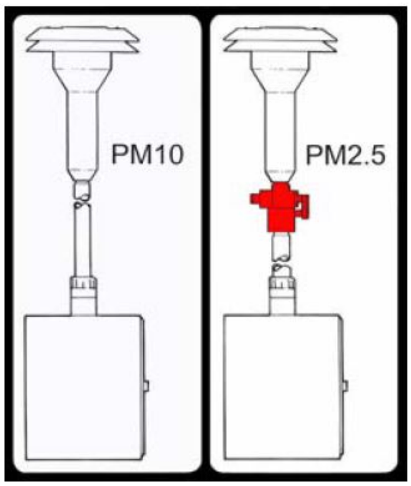

Figure 12. Door Label for Inlet Identification.

9. After the Machine Type is set or verified, the E-BAM will raise the nozzle and check to see if the stainless steel shipping shim is installed under the nozzle. *Note: The shim is attached to the unit with a tether chain, and is also used for the zero portion of the span membrane test.* Remove the shim.

10. After the nozzle shim has been removed, the E-BAM will check if a roll of filter tape is installed. If tape is already installed, the unit will go on to the Power Status screen. If no tape is detected, the unit will prompt you to install a new roll. When the filter tape is installed, press <CONTINUE>.

11. Once on the Power Status screen press <CONTINUE> and the monitor will show the self-test running. The self-test takes several minutes and can only be bypassed by pressing the ESC key.

12. If the self-test finishes without errors, the screen will display that the unit is functioning properly. Press <CONTINUE> to go on to the Start Operation screen.

13. Press <YES> to immediately start the E-BAM sampling on a normal operating cycle. Press <MENU> to forgo operation and enter the main E-BAM menu system instead.

3.7 Filter Tape Installation

A roll of Met One glass fiber filter tape must be loaded into the E-BAM for sampling. A roll of filter tape can last between 45 and 60 days under normal operation. Operators should store spare rolls of filter tape at the site to avoid sampling interruptions. The tape should never be flipped over or reused. This will result in invalid measurements. Use the following steps to load an initial roll of filter tape:

1. If the sample nozzle is in the down position, it will need to be raised. Enter the Load Tape screen in the main E-BAM menu. The unit will raise the nozzle and prompt you to load the tape.

2. If you are replacing a used roll of tape, remove the old roll, then thoroughly clean the nozzle and vane.

3. An empty core tube must be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool-up on. You can use the empty cardboard core tube left over from your last roll to spool-up the new roll. Never fasten the filter tape directly to the aluminum hub.

4. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the nozzle area as shown in Figure 13. Attach the loose end of the filter tape to the empty core tube with tape.

5. Rotate the tape roll to remove excess slack, then install the plastic spool covers tightly. The spool covers clamp the tape rolls to the hubs to prevent them from slipping.

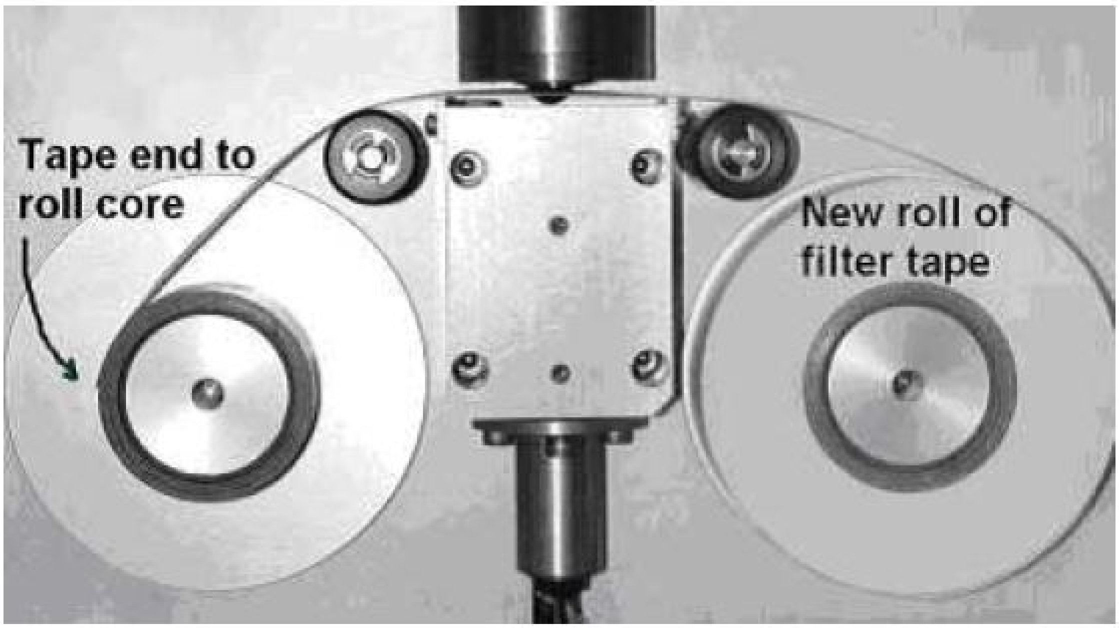

Figure 13. Tape Installation and Direction.

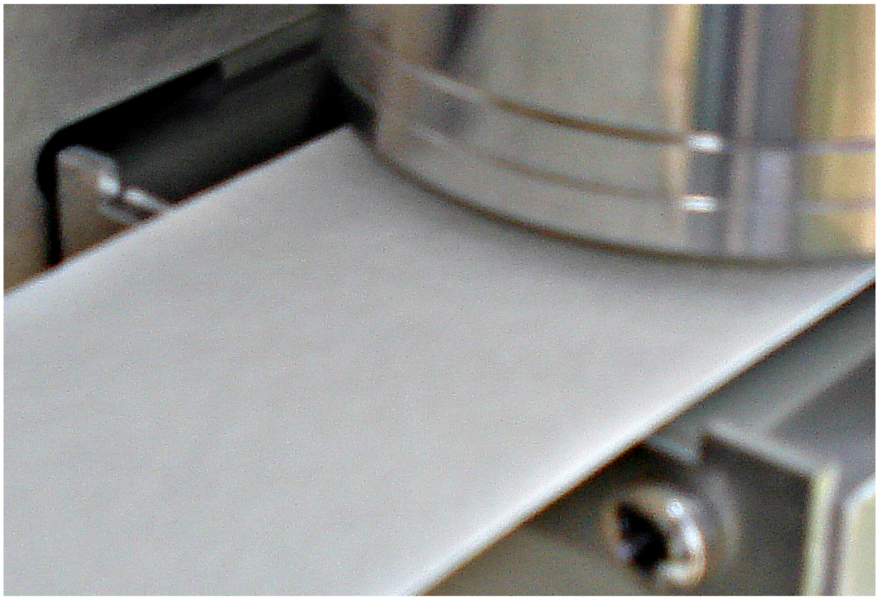

Figure 14. Tape Alignment Guide

4.0 CALIBRATION

A full monitor calibration consists of a beginning "as found" external leak check, the calibration of ambient temperature and pressure sensors, a three-point flow calibration, a one-point flow verification and a final "as left" leak external leak check. It is a good practice to complete all outstanding maintenance activities prior to initiating a full calibration. *Note: A flow verification must be completed prior to a calibration if the sampler was previously operating at the site.* New samplers installed at a site do not need a flow verification prior to a calibration because there is no collected data to envelope. Annual calibrations are required within 365 days of the prior calibration.

2.4 Calibration Requirements

A calibration is required under the following circumstances:

- Upon initial sampler set up.

- Annually (no more than 365 days from the last calibration).
- After a sampler is replaced.
- After a sampler is moved or relocated, no matter the distance.
- After the pump or flow controller is replaced.
- If flow check or a flow audit are not within specifications.
- If the device once used for flow calibration needs to be used as the audit device.
- If the sampler is without power for longer than 48 hours and the flow verification fails.

2.5 Calibration Equipment

All device certifications must be current within 365 days of use. Listed below is the necessary equipment needed for completing a calibration:

- A leak check device or flow audit adapter for performing leak checks (Figure 15).

Figure 15. Leak Check Adapter

- A certified Tetra Cal unit (Figure 16) or Streamline Flow Transfer Standard (FTS).

Figure 16. BGI Tetra Cal with Optional Temperature Probe

- If using a FTS, a digital, water or oil manometer, capable of measuring to a tenth of an inch of water.

- If using a FTS, a 12-18" piece of 1/4" diameter Tygon® tubing to connect the FTS to the manometer.

- A glass thermometer capable of measuring to the nearest half a degree Celsius, that is traceable to a National Institute of Standards and Technology (NIST) standard, or the thermistor probe included with a certified Tetra Cal unit.

- A digital barometer, that is NIST traceable, or the barometer that is part of a certified Tetra Cal unit.
- The most recent revision of the BAM electronic logbook.

Note: If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet. Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.

2.6 Calibration E-Log Setup

1. Open the most recent scrolling e-log for the site. If this is a new site or the first visit of the calendar year, obtain the proper e-log from the IBEAM documents module or contact the RCO PM lead.
2. Select the "Calibration" tab of the e-log.
3. Enter in the information for all of the white boxes under the Visit Information, Thermometer information, Manometer Information, Barometer Information, Tetra Cal or FTS information sections.
4. Do not proceed if any of the devices fail the certification requirement (certified within 365 days of use).

2.7 Calibration: "As Found" Leak Check

There is a 1.0 LPM leak flow allowance due to the factory test conditions. With the inlet shut off, the vacuum in the system is very high; about 21 in Hg (533.4 mm Hg). This is 10 times greater than what the BAM will encounter during normal sampling. If the flow reading during this test is 1.0 LPM or less, there will not be a significant leak during normal operation. A leak check value between 0.75 – 1.0 LPM still passes, but indicates the potential of a leak check failure in the near future. If an "as found" leak value shows a flow between 1.1 – 1.5 LPM, this may result in the flagging or invalidation of data back to the last successful leak check. If an "as found" leak value is measured at greater than 1.5 LPM, data will be flagged or invalidated back to the last successful leak check. Almost all air leaks in the BAM system occur at the nozzle where it contacts the filter tape. Take the following steps to perform an "as found" leak check:

1. Verify that a fresh spot of tape is located beneath the nozzle. If the tape is damaged, it may be difficult to pass the leak check.

2. Remove the PM_{10} head from the inlet tube. Install a leak test valve (or equivalent valve for leak checking FRM samplers) onto the inlet tube. Turn the valve to the off position to prevent any air from entering the inlet tube. If a PM2.5 inlet cyclone is used, it is usually best to install the leak valve above the cyclone in order to test it for leaks as well.

3. Enter the Pump Test screen as described above, and set the mode to <LEAK TEST>. The pump should turn on automatically and ramp up to full speed.

4. The flow rate should drop below 1.0 LPM. If the leak value is greater than 1 LPM, then the nozzle and vane need cleaning, or there may be another leak somewhere in the system.

5. Resolve the leak and perform the check again. A properly functioning E-BAM with a clean nozzle and vane will usually have a leak value of about 0.6 LPM or less using this method, depending on the type of pump used.

6. When finished, exit the Test Pump menu, remove the leak test valve, and re-install the inlet heads.

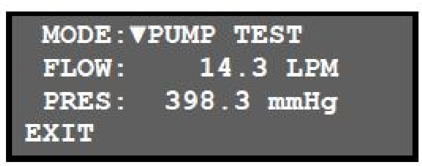

Figure 17. Pump Test Menu.

2.8 Ambient Sensor Calibration

The temperature and pressure must be calibrated prior to the flow because the actual flow is calculated using both ambient temperature and pressure. Field operators do not calibrate or verify any of the inline temperature or pressure sensors inside the E-BAM. *Note: A sensor calibration always requires a flow calibration afterwards.*

2.8.1 Ambient Temperature and Ambient Pressure Sensor Calibration

1. If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet (Figure 18). Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.

Figure 18. Proper Shaded Inlet Location

2. Scroll to the temperature line and press <MENU/SELECT> to enter the ambient temperature sensor calibration menu.

3. The point parameter selects either the high or low calibration point. The high point is the normal ambient calibration point which is used for all field calibrations. The low point is only used for laboratory ice-bath calibrations of the ambient temperature sensor. Select high to perform an ambient temperature sensor calibration.

4. The E-BAM parameter is the instantaneous output from the unit's ambient temperature sensor. This is the parameter that you are calibrating.

5. The ref parameter is the field where you enter the correct temperature as shown on your traceable reference standard temperature audit device. After you have entered the correct temperature using the arrow keys, press the calibrate key to correct the E-BAM sensor reading. The E-BAM and ref parameters should now match. Press the ESC key when finished.

6. If difficulty is encountered during the process, the default key can be pressed to erase all field calibration factors from the temperature sensor and to start over with factory default calibration factors. Then try the calibration again.

Figure 19. Temperature Sensor Calibration Menu.

7. Scroll to the pressure line and press <MENU/SELECT> to enter the ambient pressure sensor calibration menu.

8. The E-BAM parameter is the instantaneous output from the unit's ambient barometric pressure sensor. This is the parameter that you are calibrating. The ref parameter is the field where you enter the correct pressure as shown on your traceable reference standard barometric pressure audit device.

9. After you have entered the correct pressure using the arrow keys, press the calibrate key to correct the E-BAM sensor reading. The E-BAM and ref parameters should now match. Press the ESC key when finished.

10. If difficulty is encountered during the process, the default key can be pressed to erase all field calibration factors from the temperature sensor and to start over with factory default calibration factors. Then try the calibration again.

```
PRESSURE
 E-BAM: 732.8 mmHg
   REF: 737.9 mmHg
CALIBRATE      DEFAULT
```

Figure 20. Pressure Sensor Calibration Menu.

2.9 Flow Calibration

1. Make certain that the E-BAM has warmed up for at least 60 minutes prior to performing flow calibrations.

2. If using a Tetra Cal, place the Tetra Cal flow audit adapter on top of the SCC. Connect the Tetra Cal to the flow adapter with the provided tubing. If a FTS is used, place the FTS on top of the SCC and connect the manometer to the FTS with your Tygon® tubing.

Figure 21. Flow Audit Adapter and FTS with Monometer.

3. Zero the Tetra Cal or manometer.

4. Scroll to the FLOW line and press <MENU/SELECT> key to enter the flow sensor calibration menu as shown in Figure 22. The Setpoint parameter selects which flow to be calibrated.

SETPOINT:▼17.5 LPM	SETPOINT:▼14.0 LPM	SETPOINT:▼16.7 LPM
E-BAM: 17.5 LPM	E-BAM: 14.0 LPM	E-BAM: 16.7 LPM
REF: 17.4 LPM	REF: 14.1 LPM	REF: 16.6 LPM
CALIBRATE DEFAULT	CALIBRATE DEFAULT	EXIT

Figure 22. Sensor Calibration Menu for Flow.

5. The E-BAM uses a two-point flow calibration at 17.5 and 14.0 LPM. The 16.7 LPM point can only be verified, not calibrated. Use the arrow keys to select the 17.5 LPM setpoint first. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 17.5 LPM.

6. Read and record the stated flow rate given by the E-BAM in the "Calibration" page of the e-log.

7. Read and record the actual flow rate given by your certified Tetra Cal, or calculate the flow from your FTS using the given pressure drop in inches of water from the manometer and the formula on the corresponding FTS certification, in the "Calibration" tab of the e-log.

8. The ref parameter is the field where you enter the correct flow as shown on your NIST flow device. After you have entered the correct flow using the arrow keys, press <CALIBRATE> to correct the E-BAM sensor reading.

9. Read and record the new stated flow rate given by the E-BAM (post-calibration) in the "Calibration" page of the e-log.

10. Enter the actual flow value in the field, and press the grey <OK> button to return to the Flow Calibration screen.

11. Set the Setpoint to 14.0 LPM and repeat the calibration process.

12. If difficulty is encountered during the process, press <DEFAULT> to erase all field calibration factors from the flow sensor and to start over with factory default calibration factors. Try the calibration again.

13. Press the ESC key to exit the flow calibration menu when finished.

2.10 Post Calibration Flow Evaluation

The calibration must be verified by performing a single point evaluation using the same certified flow device the monitor was just calibrated with. *Reminder: A post calibration flow evaluation is not interchangeable with a monthly verification. The two processes are not the same.*

1. Zero the Tetra Cal or manometer (the Tetra Cal or FTS should still be in place from your flow calibration).

2. Use the arrow keys to select the 16.7 LPM setpoint. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate.

3. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 LPM. *Do not press the <CALIBRATE> button.*

4. Read and record the stated flow rate (LPM) given by the E-BAM in the "Calibration" tab of the e-log.

5. Read and record the actual flow rate (LPM) given by your certified Tetra Cal, or calculate the flow from your FTS using the given pressure drop in inches of water from the manometer and the formula on the corresponding FTS certification, in the "Calibration" page of the e-log under the "Post-Cal Flow Evaluation" section.

6. Verify that the flow is +/- 2 percent of the NIST flow. **The monitor must be recalibrated if these specifications are not met.**

7. Press the ESC key to exit the flow calibration menu when finished.

8. Remove the Tetra Cal flow audit adapter or FTS from the SCC and replace the PM_{10} inlet.

2.11 Calibration: "As Left" Leak Check

1. Verify that a fresh spot of tape is located beneath the nozzle. If the tape is damaged, it may be difficult to pass the leak check.

2. Remove the PM_{10} head from the inlet tube. Install a leak test valve (or equivalent valve for leak checking FRM samplers) onto the inlet tube. Turn the valve to the off position to prevent any air from entering the inlet tube. If a PM2.5 inlet cyclone is used, it is usually best to install the leak valve above the cyclone in order to test it for leaks as well.

3. Enter the Pump Test screen as described above, and set the mode to Leak Test. The pump should turn on automatically and ramp up to full speed.

4. The flow rate should drop below 1.0 LPM. If the leak value is greater than 1 LPM, then the nozzle and vane need cleaning, or there may be another leak somewhere in the system.

5. Resolve the leak and perform the check again. A properly functioning E-BAM with a clean nozzle and vane will usually have a leak value of about 0.6 LPM or less using this method, depending on the type of pump used.

6. When finished, exit the Test Pump menu, remove the leak test valve, and re-install the inlet heads.

2.12 Performing a Self-Test

After any action taken by the operator that interrupts the sampling cycle of the E-BAM, a self-test must be performed. The self-test checks the movement of tape, nozzle movement and flow.

1. Select the self-test option from the Main menu.
2. The self-test takes several minutes and can only be bypassed by pressing the ESC key.
3. If the self-test finishes without errors, the screen will display that the unit is functioning properly. Press <CONTINUE> to go on to the Start Operation screen.
4. Press <YES> to immediately start the E-BAM sampling on a normal operating cycle. Press <MENU> to forgo operation and enter the main E-BAM menu system instead.

VERIFICATIONS, CHECKS, AND AUDITS

A ***Flow Verification*** must be performed once every thirty days (a.k.a. Monthly Verification). It is a test of the monitor's sensors against certified standards. It is preferred, **but not required**, that the verification be completed with devices that are different from the devices used for the calibration. A flow verification is also required before any action that requires the operator to envelope the data (e.g. moving the monitor, performing maintenance that will break the sampling pathway or shutdown). A flow verification is also required after a power outage lasting more than 48 hours. A monthly flow verification cannot be completed on the same day as a calibration unless it is the final day of the calendar month.

A ***Mid-Month Verification*** is a test of the monitor's sensors against certified standards. The mid-month verification was implemented to avoid invalidating large amounts of data if a monthly flow verification fails. The mid-month verification must follow a verification by 14 to 18 days. The mid-month verification process is the same as the monthly verification procedure. The audit replaces the mid-month verification in the second month of each calendar quarter.

An ***Audit*** must be performed in the second month of each calendar quarter. It is a test of the monitor's sensors against certified standards **that were not used** for the previous calibration, monthly verifications or mid-month verifications. Standards that have been recently recertified (having been used for calibrations/verifications and not used since) are candidates for becoming audit equipment. Audits are also to be performed by personnel other than the normal site operator. If the audit cannot be performed during the second month due to abnormal circumstances (such as the monitor being inoperable or extreme weather events), the mid-month verification must be completed instead. The audit should then be performed in place of the mid-month verification during the third month, before the quarter ends.

All device certifications must be current within 365 days of use. Listed below is the necessary equipment needed for completing a verification or audit:

- A leak check device or flow audit adapter for performing leak checks (Figure 15).
- A certified Tetra Cal unit or Streamline Flow Transfer Standard (FTS).
- If using a FTS, a digital, water or oil manometer, capable of measuring to a tenth of an inch of water.
- If using a FTS, a 12-18" piece of 1/4" diameter Tygon® tubing to connect the FTS to the manometer.
- A glass thermometer capable of measuring to the nearest half a degree Celsius, that is traceable to a National Institute of Standards and Technology (NIST) standard, or the thermistor probe included with a certified Tetra Cal unit.
- A digital barometer, that is NIST traceable, or the barometer that is part of a certified Tetra Cal unit.
- The most recent revision of the BAM electronic logbook.

Note: If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet. Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.

2.13 Tolerances and Corrective Actions for Verifications, Checks, and Audits

If any parameter fails the tolerance listed in Table 26, corrective action is required as indicated. **Do not perform a calibration until after you have verified, checked, or audited all of the parameters.**

2.14 Verification or Audit: E-Log Setup

1. Open the most recent scrolling e-log for the site. If this is a new site or the first visit of the calendar year, obtain the proper e-log from the IBEAM documents module or contact the RCO PM lead.
2. Select the "Verification Audit" tab of the e-log.
3. Enter in the information for all of the white boxes under the Visit Information, Thermometer information, Manometer Information, Barometer Information, Tetra Cal or FTS information sections.
4. Do not proceed if any of the devices fail the certification requirement (certified within 365 days of use).

Table 26. Operation Evaluations

CRITERIA	ACCEPTABLE RANGE	FREQUENCY	CORRECTIVE ACTION
External Leak Check	≤1.0 LPM	1. Before and after any flow verification. 2. During each quarterly audit. 3. Each time the SCC is removed. 4. Each time the tape is changed. 5. Each time the nozzle/vane is cleaned.	1. Clean nozzle and vane. 2. Make sure tape is seated. 3. Check seating and assembly of SCC (o-rings). 4. Perform internal leak check. 5. If unit fails to pass, call ECB
Ambient Temperature Verification or Audit	±2 °C of NIST Thermometer	1. During each monthly and mid-month check. 2. During each quarterly audit.	Perform a flow verification prior to an ambient temperature adjustment. Follow with complete calibration.
Ambient Pressure Verification or Audit	±10 mm Hg of NIST Barometer	1. During each monthly and mid-month check. 2. During each quarterly audit.	Perform a flow verification prior to an ambient pressure adjustment. Follow with complete calibration.
Post Calibration Evaluation	±2 percent	After each monitor calibration	Perform Calibration
Monthly Verification	±3 percent	1. Each calendar month. 2. Power outage > 48 hours	Perform Calibration
Mid-Month Verification	±3 percent	14-18 Days after Flow Rate Verification (in non-audit months)	Perform Calibration
Quarterly Audit	±3 percent ±4 percent of Design Value	Quarterly (preferably the second month)	Perform Calibration
Span Audit	±5 percent of Standard	Quarterly (preferably with the quarterly maintenance).	If unit fails to pass, call ECB and Particulate Lead.

2.15 Verification or Audit: "As Found" Leak Check

There is a 1.0 LPM leak flow allowance due to the factory test conditions. With the inlet shut off, the vacuum in the system is very high; about 21 in Hg (533.4 mm Hg). This is 10 times greater than what the BAM will encounter during normal sampling. If the flow reading during this test is 1.0 LPM or less, there will not be a significant leak during normal operation. A leak check value between 0.75 – 1.0 LPM still passes, but indicates the potential of a leak check failure in the near future. If an "as found" leak value shows a flow between 1.1 – 1.5 LPM, this may result in the flagging or invalidation of data back to the last successful leak check. If an "as found" leak value is measured at greater than 1.5 LPM, data will be flagged or invalidated back to the last successful leak check. Almost all air leaks in the BAM system occur at the nozzle where it contacts the filter tape. Take the following steps to perform an "as found" leak check:

1. Verify that a fresh spot of tape is located beneath the nozzle. If the tape is damaged, it may be difficult to pass the leak check.
2. Remove the PM_{10} head from the inlet tube. Install a leak test valve (or equivalent valve for leak checking FRM samplers) onto the inlet tube. Turn the valve to the off position to prevent any air from entering the inlet tube. If a PM2.5 inlet cyclone is used, it is usually best to install the leak valve above the cyclone in order to test it for leaks as well.
3. Enter the Pump Test screen as described above, and set the mode to Leak Test. The pump should turn on automatically and ramp up to full speed.
4. The flow rate should drop below 1.0 LPM. If the leak value is greater than 1 LPM, then the nozzle and vane need cleaning, or there may be another leak somewhere in the system.
5. Resolve the leak and perform the check again. A properly functioning E-BAM with a clean nozzle and vane will usually have a leak value of about 0.6 LPM or less using this method, depending on the type of pump used.

6. When finished, exit the Test Pump menu, remove the leak test valve, and re-install the inlet heads.

2.16 Verification or Audit: Ambient Temperature and Ambient Pressure

1. If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet (Figure 23). Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.

Figure 23. Proper Shaded Solar Shield Location

2. Scroll to the temperature line and press <MENU/SELECT> to enter the ambient temperature sensor calibration menu.

3. The point parameter selects either the high or low calibration point. Select high to perform an ambient temperature sensor verification or audit.

4. The E-BAM parameter is the instantaneous output from the unit's ambient temperature sensor. This is the parameter that you are verifying. *Note: Do not press <CALIBRATE>.*

5. Read and record the stated temperature given by the E-BAM in the "Verification_Audit" tab of the e-log.

6. Read and record the actual temperature given by your NIST temperature device in the "Verification_Audit" tab of the e-log.

7. Press the ESC key when finished.

Figure 24. Temperature Sensor Calibration Menu.

8. Scroll to the pressure line and press <MENU/SELECT> to enter the ambient pressure sensor calibration menu.

9. The E-BAM parameter is the instantaneous output from the unit's ambient barometric pressure sensor. This is the parameter that you are verifying or auditing. *Note: Do not press <CALIBRATE>.*

10. Read and record the stated pressure given by the E-BAM in the "Verification_Audit" tab of the e-log.

11. Read and record the actual pressure given by your NIST pressure device in the "Verification_Audit" tab of the e-log.

12. Press the ESC key when finished.

2.17 Verification or Audit: Flow

1. If using a Tetra Cal, place the Tetra Cal flow audit adapter on top of the SCC. Connect the Tetra Cal to the flow adapter with the provided tubing. If a FTS is used, place the FTS on top of the SCC and connect the manometer to the FTS with your Tygon® tubing.

2. Zero the Tetra Cal or manometer (the Tetra Cal or FTS should still be in place from your flow calibration).

3. Use the arrow keys to select the 16.7 LPM setpoint. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate.

4. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 LPM. *Do not press the <CALIBRATE> button.*

5. Read and record the stated flow rate given by the E-BAM in the "Verification_Audit" tab of the e-log.

6. Read and record the actual flow rate given by your certified Tetra Cal, or calculate the flow from your FTS using the given pressure drop in inches of water from the manometer and the formula on the corresponding FTS certification, in the "Verification_Audit" page of the e-log.

7. Verify that the flow is **+/-** 3 percent of the NIST flow. **The monitor must be recalibrated if these specifications are not met.**

8. Press the ESC key to exit the flow calibration menu when finished.

9. Remove the Tetra Cal flow audit adapter or FTS from the SCC and replace the PM_{10} inlet.

2.18 Verification or Audit: "As Left" Leak Check

1. Verify that a fresh spot of tape is located beneath the nozzle. If the tape is damaged, it may be difficult to pass the leak check.

2. Remove the PM_{10} head from the inlet tube. Install a leak test valve (or equivalent valve for leak checking FRM samplers) onto the inlet tube. Turn the valve to the off position to prevent any air from entering the inlet tube. If a PM2.5 inlet cyclone is used, it is usually best to install the leak valve above the cyclone in order to test it for leaks as well.

3. Enter the Pump Test screen as described above, and set the mode to Leak Test. The pump should turn on automatically and ramp up to full speed.

4. The flow rate should drop below 1.0 LPM. If the leak value is greater than 1 LPM, then the nozzle and vane need cleaning, or there may be another leak somewhere in the system.

5. Resolve the leak and perform the check again. A properly functioning E-BAM with a clean nozzle and vane will usually have a leak value of about 0.6 LPM or less using this method, depending on the type of pump used.

6. When finished, exit the Test Pump menu, remove the leak test valve, and re-install the inlet heads.

2.19 Verification or Audit: Self-Test

After any action taken by the operator that interrupts the sampling cycle of the E-BAM, a self-test must be performed. The self-test checks the movement of tape, nozzle movement and flow.

1. Select the self-test option from the Main menu.

2. The self-test takes several minutes and can only be bypassed by pressing the ESC key.

3. If the self-test finishes without errors, the screen will display that the unit is functioning properly. Press <CONTINUE> to go on to the Start Operation screen.

4. Press <YES> to immediately start the E-BAM sampling on a normal operating cycle. Press <MENU> to forgo operation and enter the main E-BAM menu system instead.

2.20 Span Membrane Test

Figure 25. Zero and Span Foils.

The Span Membrane Test is used to verify the performance of the E-BAM beta attenuation system. Since it is very important that the upper nozzle, nozzle and vane be clean to ensure valid results, the test must be performed by the primary operator once a quarter following the completion of quarterly maintenance and cleaning. A zero and span foil card (included in the E-BAM accessory kit) will be required to complete this procedure. Take the following steps to complete the process:

1. Scroll to the Membrane Test line and press <MENU/SELECT> to enter the membrane test menu. The E-BAM will ask to start the test as shown below. Press <START> key to begin the test.
2. The unit will advance the filter tape and begin a 4-minute blank zero count. Then the unit will raise the nozzle and prompt you to insert the span membrane.
3. Insert the zero membrane (on top of the filter tape) so that the tab protrudes through the transport plate and triggers the photo sensor. The nozzle will lower and the unit will begin a 4-minute count with the zero membrane in place.
4. After the zero count, the unit will prompt you to remove the zero membrane. The unit will then start a 4-minute blank span count without any membrane in place.

5. The unit will then prompt you to insert the span membrane. Handle the span membrane very carefully to avoid damaging the fragile film. Insert the span membrane into the E-BAM above the filter tape. The unit will perform the final 4-minute span count and display the results.

6. This is a pass/fail test in which the E-BAM will compare the measured mass of the span membrane to the expected mass (ABS) for that exact foil which has been programmed into the E-BAM memory. If the measured and expected values are within 5 percent, the test will pass.

7. If the values are outside of 5 percent, a failure will be generated. If the test fails, the most common causes are a failing or dirty beta detector, or a dirty or damaged span membrane.

8. The measured span value from the test can be viewed. Press the ▼ (down arrow) button on the E-BAM while it is displaying the pass or failure message at the end of the test. The display should show the ZERO and SPAN values the unit just measured. Compare the SPAN value from the display to the expected mass of the membrane (ABS value).

9. Record these values in the e-log.

6.0 MAINTENANCE OF THE E-BAM

All sampler maintenance must be recorded on the "Maintenance Log" tab of the e-log. It is recommended that operators carry the following in items their field maintenance kit:

- Can of compressed air with tube
- Cotton Tipped Applicators
- Phillips Head Screwdriver
- Allen Wrench (5/64")
- Vacuum grease (silicone based)
- 91 percent isopropyl alcohol for cleaning the SCC and PM_{10} head
- Distilled water
- Cotton cloth or Shop Towels

- Kimwipes
- O-rings for the SCC
- Downtube cleaning kit
- BAM tape
- Scotch tape
- Flashlight

Table 27. Summary of Sampler Maintenance

Maintenance Activity	Frequency
• Clean nozzle, vane and rollers • Check E-BAM clock • Check smart heater • Download data, settings, and alarm files	Every 14 – 18 days
• Clean SCC and inspect o-rings • Clean PM_{10} Head • Wipe down interior and exterior of the E-BAM • Empty water collection bottle	Every 30 days
• Verify E-BAM settings • Clean Temperature Probe Solar Shield • Clean Internal Nozzle • Span Mass Audit • Check seals on shelter doors	Every 91 days
• Clean downtube	Every 365 days

6.1 Cleaning the PM_{10} Inlet

The PM_{10} inlet has two primary components: The Acceleration Assembly and the Collector Assembly (Figure 28). These components must be disassembled and cleaned every 30 days.

Figure 26. The PM_{10} Inlet Components

6.1.1 Disassembling the Inlet

1. Remove the PM-10 head by lifting the inlet up and off the sample tube.
2. Using Figure 29 as a guide, unscrew the collector assembly from the accelerator assembly by turning the top portion counterclockwise.

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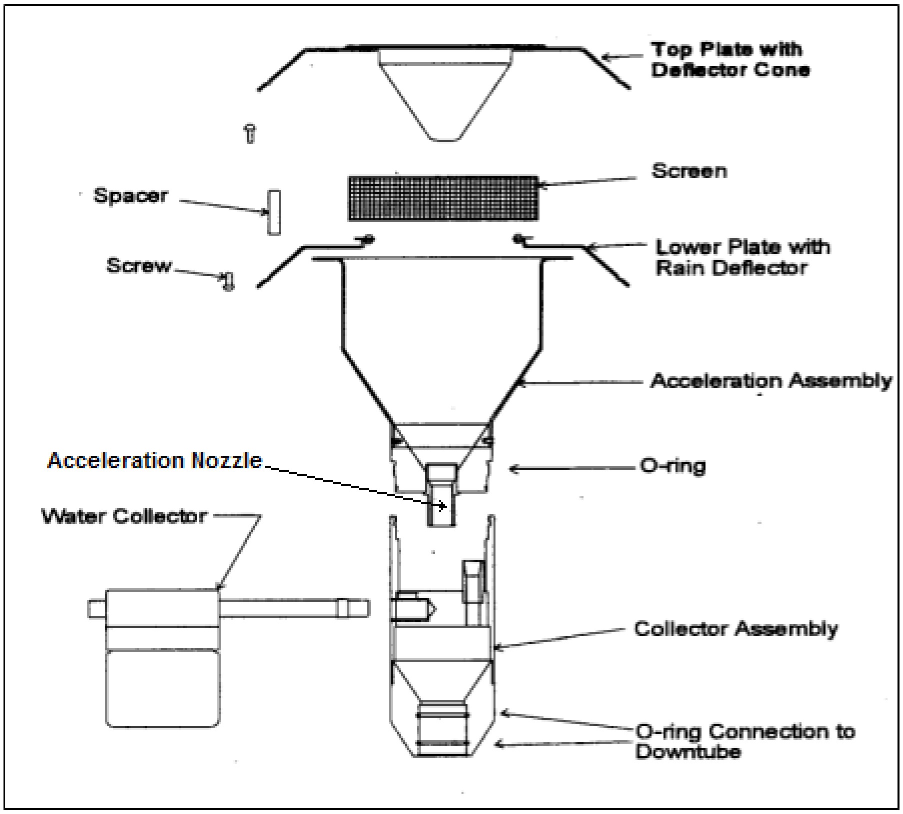


Figure 27. Exploded view PM-10 Inlet Assembly

6.1.2 Cleaning and Maintaining the PM_{10} Accelerator Assembly

1. Remove four Philip head screws from the top and remove the top plate.
2. Clean the top plate with a lint-free cloth and water (or alcohol).
3. Remove the insect screen from the lower plate and clean.
4. Clean the lower plate with a lint free cloth and water (or alcohol) with particular attention to the internal sides of the acceleration chamber.
5. Use water (or alcohol) and a cotton swab to clean the acceleration nozzle.

6. Inspect the large o-ring between the accelerator and collection assembly. Lightly lubricate with the vacuum grease if necessary.

7. Reinstall the insect screen and screw the top plate back onto the bottom plate of the Acceleration Assembly.

6.1.3 Cleaning and Maintaining the PM_{10} Collector Assembly

1. Clean the threads of the Collector Assembly to ensure smooth separation and assembly.

2. Clean the Collector Assembly walls, bottom plate and three vent tubes using a cloth, water (or alcohol) and cotton swab.

3. Clean the hole in the collector plate where the condensate runs to the moisture trap with a cotton swab.

4. Remove the rain jar and clean with a cloth. Inspect the brass nipple. Replace rain jar and lightly coat the threads with grease.

5. Inspect the two inlet tube o-rings for wear and lightly grease if necessary.

6. Reassemble the collector assembly by hand tightening.

7. Place the reassembled PM_{10} head back onto the sampler tube.

6.2Cleaning the SCC

The SCC (Figure 30) is an essential component of the inlet system. It needs to be diligently maintained or it will corrode. The SCC must be cleaned every 30 days. A spare O-ring kit should be kept on hand. Disassemble and clean the SCC following these steps:

1. Remove the PM_{10} head from the sampler tube and SCC.

2. Remove the SCC from its installed position in the instrument.

3. Pull off the side transfer tube. Care should be taken to avoid damaging the two O-ring seals.

4. Unscrew the top cap and the grit chamber.

5. Use alcohol, or if unavailable, water, along with a cotton swab to remove all visible deposits. These deposits are most likely to be found at the bottom of the cone (located beneath the grit chamber) and inside the grit chamber.

6. Inspect all O-rings for shape and integrity. If at all suspect, replace the O-rings.

7. Assemble in reverse order and reinstall on the sampler tube.

Figure 28. Disassembling the SCC for Cleaning

6.3 Inlet Downtube Cleaning

The inlet downtube must be cleaned annually and before a zero background test. Each regional office has been provided with Met One's BX-344 Inlet Cleaning Kit. The kit contains the following downtube cleaning items:

- Lint-free washable microfiber rags for cleaning the inside of the vertical inlet tube. Generic shop rags or cleaning cloths may be used as well.

- A 10' Pull Rope Assembly for pulling the rags or tube brush through the inlet tube. The brass weight allows the rope to feed through the tube.
- A Nylon Tube Brush to remove any debris inside the inlet tube before using the cleaning rags.
- An Allen Wrench, (5/64", not included in the kit) will also be needed.

The procedure for cleaning the inlet downtube is as follows:

1. Stop the sampling cycle if the BAM is in operation.
2. Remove the PM_{10} head and the SCC from the vertical inlet tube.
3. Loosen the waterproof flange around the inlet tube where it enters the enclosure and slowly advance the downtube out of the monitor.
4. Cover the BAM inlet to prevent debris from falling into the hole during the cleaning (a red plastic cap should be provided with each unit for this purpose).

Figure 29. Pull Rope Assembly

5. Feed the weighted end of the pull rope assembly down through the inlet tube until it comes out the bottom. Use the rope to pull the brush through the inlet tube. Repeat as needed.

6. Insert a cleaning rag through the looped end of the pull rope assembly and slip the loop up tight around the rag. ***Note: Do not use paper towels or Kimwipes.***

7. Feed the weighted end of the pull rope assembly down through the inlet tube until it comes out the bottom.

8. Use the rope to pull the rag through the inlet tube. The rag should fit snugly, but it should not be difficult to pull through. The rag may be dampened with water if needed.

9. Visually inspect to determine if the down tube is clean.

10. Reinsert the inlet tube into the inlet tube flange, making sure that the inlet tube is seated correctly in the sampling inlet receiver.

11. Tighten the inlet tube flange and replace the SCC and PM_{10} head.

6.4 Internal Nozzle Cleaning

The inside of the sample nozzle should be cleaned to remove particulate which may have settled on internal surfaces. This cleaning prevents a buildup of debris, which could fall out of the nozzle and on to the tape (causing undesired positive concentration spikes). The following cleaning items will be needed:

- Canned Air (a.k.a. Compressed Air Duster) with Tube
- Allen Wrench, (5/64")
- Kimwipes

Use the following steps to clean the nozzle's internal surfaces:

1. Stop the sampling cycle if the BAM is in operation.

2. Remove the PM_{10} head and the SCC from the vertical inlet tube.

3. Loosen the waterproof flange around the downtube where it enters the enclosure so that it can be moved out of the way.

4. Gently slide the canned air tube down the inlet receiver on top of the E-BAM. Supply multiple short blasts of air, while moving the canned air tube from side to side to blow on all surfaces inside the inlet. You may also swab the visible insides of the nozzle with Kimwipes.

5. Inspect the tape below for debris. If debris is still present, repeat step 4.

6. Clean the collar of the upper inlet, taking care to inspect all O-rings for shape and integrity. If at all suspect, replace the O-rings.

7. Reinsert the inlet tube into the inlet tube flange, making sure that the inlet tube is seated correctly in the sampling inlet receiver.

8. Tighten the inlet tube flange and replace the SCC and PM_{10} head.

6.5 Cleaning the Nozzle, Vane and Rollers

The nozzle and vane (located under the nozzle) must be cleaned regularly to prevent leaks and measurement errors. The cleaning must be done at least once every 14 – 18 days from the last cleaning and each time the filter tape is changed. Some sites may require more frequent cleaning as determined by visual inspection of the filter spots that have previously collected sample. Figure 32 shows the difference between acceptable and inferior sampling areas. The tape on the left is from a properly operated E-BAM with a clean nozzle and vane. The particulate sampling areas have very crisp edges, are perfectly round, and are evenly distributed. The tape to the right is from a unit that has not been properly maintained. A spot of debris has built up on the vane and is punching a hole on the edge of the sample area. **These holes can allow beta particles to get through un-attenuated and negatively affect accuracy even if the nozzle is not leaking.** The spots also show a "halo" effect due to air leaking in around the edge. Debris has built up to the extent that the nozzle no longer seals correctly. These faults are easily corrected and prevented by keeping the nozzle and vane clean.

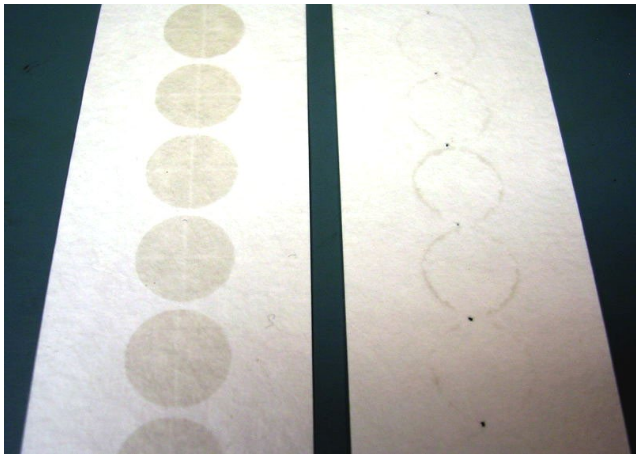
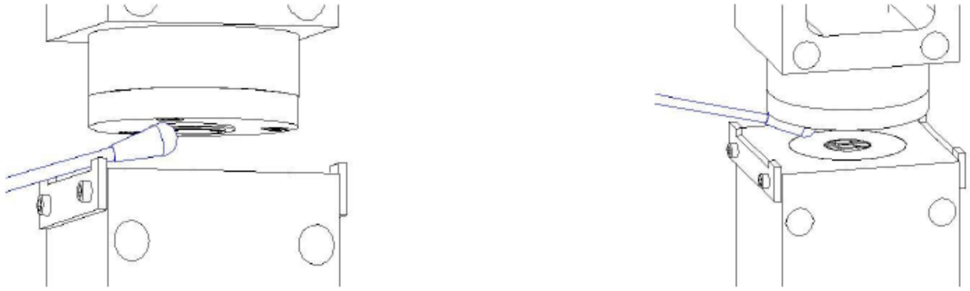


Figure 30. Hourly Filter Samples

Other parts along the filter tape routing within the E-BAM (Figure 33) must also be cleaned regularly to reduce debris accumulation. Over time, a gradual build-up of filter tape debris and particulate may form on the nozzle and vane sealing surfaces. The following cleaning items will be needed:

- Cotton Tipped Swabs
- 91 percent isopropyl alcohol
- Canned Air (a.k.a. Compressed Air Duster) with Tube
- Cleaning Brush



-
- **Figure 31.** Nozzle Cleaning

Use the following steps to clean the nozzle, vane and roller assembly:

1. Down the channels on the data logger.
2. Complete an "As Found" leak check.
3. Navigate to the Test>Leak Test menu and raise the nozzle, if needed.
4. Remove the E-BAM filter tape.
5. Thoroughly clean the nozzle seal and vane with a clean swab soaked in alcohol. Allow the alcohol to dissolve any deposits. Since the beta detector is located beneath the vane, try to prevent debris from falling through the holes.
6. If heavy debris remains on the vane or nozzle, loosen it with the cleaning brush. Do not use any sharp tools.
7. If debris falls through or is found beneath the vane, carefully clean the cavity with a blast of compressed air.
8. Inspect and clean rollers with Kimwipes.
9. Re-install the E-BAM filter tape.
10. Perform an "as left" leak check along with a Self-Test.

11. Return the BAM to the sampling mode.

12. Bring the E-BAM channels back online.

6.6 Pump Test

The E-BAM pump should be periodically tested to ensure it has sufficient vacuum capacity for normal operation.

1. Remove the PM_{10} head and install leak test valve onto the inlet tube. Turn the valve to the OFF position to prevent any air from entering the inlet tube.

2. Scroll to the Pump Test line and press <MENU/SELECT> to enter the leak test and pump test menu. The pump will turn on automatically when this screen is entered.

3. The Mode parameter selects either the Leak Test or Pump Test. The Pump Test mode is used to test the capacity of the pump to determine when it needs to be replaced. The Flow parameter is the instantaneous output from the unit's internal flow sensor. The Pres parameter is the filter pressure reading which indicates the vacuum beneath the filter tape. This is used to measure the vacuum capacity of the pump during the pump test.

4. Set the Mode to Pump Test. The pump should turn on automatically and ramp up to full speed.

5. Very slowly open the leak check valve on the inlet just a small amount, so that the flow reading on the E-BAM display increases to between 14 and 15 LPM, with the pump still at full speed. Allow the flow reading to stabilize.

6. Compare the Pres (vacuum) value from the E-BAM display to the chart below for the particular flow rate. The Pres value should be *less than or equal to* the values in the chart. If the Pres value on the E-BAM display is higher than the poor value in the chart at that particular flow rate, then the E-BAM pump may need to be replaced.

Table 28. Pump Test Vacuum Limits.

Flow Rate	Vacuum Measurement Value Good	Marginal	Poor
14.0	390.5	406.1	429.5
14.1	391.6	407.3	430.8
14.2	393.8	409.6	433.2
14.3	395.0	410.6	434.5
14.4	396.5	412.3	436.1
14.5	398.5	414.5	438.4
14.6	399.5	415.5	439.5
14.7	401.1	417.2	441.3
14.8	403.2	419.3	443.5
14.9	404.5	420.7	445.0
15.0	406.0	422.2	446.6

7. DOWNLOADING DATA FROM THE E-BAM

The E-BAM is supplied with a CD containing a free copy of the Comet™ program, which is a simple Windows-based communications terminal program developed by Met One Instruments. This is the recommended method for all E-BAM data retrieval, since Comet allows the user to easily download the data logs, error logs, and settings (EEPROM) files from the E-BAM without the user having to know any of the underlying communications protocols. The Comet CD also contains a very comprehensive pdf user's manual for the program. Install the program onto the computer that you will be using for data retrieval, and review the manual for complete data examples.

8. QUALITY ASSURANCE AND DATA HANDLING

8.1 Field Operator Quality Assurance

Upon arriving at the site, the field operator is responsible for ensuring that the monitor has collected what appears to be valid data since the previous site visit. This includes reviewing the alarms and collected data. Below is a suggested list of items that operators should be verifying during each site visit:

- Possible changes near the site that could bias the data (fires, construction, etc.)
- Encroachment of wildlife or vegetation
- Vandalism
- Obstructions of the inlet
- Alarms on the screen of the E-BAM
- Abnormalities in the E-BAM downloads
    - Ensuring that there are no gaps in the data

- Investigating repetitive patterns of numbers (especially repeating -5's)
- Checking the ambient temperature data (no abnormal trends, repeating values)

8.2 Quality Assurance Coordinator

The QA coordinator is responsible for reviewing all raw data and logbooks prior to submitting the data to the project manager. The specific QA duties for the QA coordinator are described in the following sections.

8.2.1 E-BAM Download Review

The QA coordinator is responsible for reviewing the E-BAM download data, alarms, and settings to ensure that there are no abnormalities.

- Ensuring that there are no gaps in the data
- Ensuring that repetitive patterns of numbers (especially repeating -5's) have been addressed
- Checking the ambient temperature data (no abnormal trends, repeating values)
- Corresponding alarm flags are investigated and corrective action taken when needed

8.2.2 Electronic Logbook Review

The QA coordinator must review the e-log for each site monthly. E-log reviews are recommended, but not required, to be conducted every 15 days to ensure the operators and the monitors are meeting the necessary requirements.

1. The QA Coordinator must review all e-logs for completeness, verifications, audits, calibrations, and monitor problems. Specifically, the QA Coordinator must verify that:
    - There is a monthly and mid-month verification (or audit) for each calendar month.
    - All devices used were within certification dates.
    - Audit devices were different from the monthly verification devices.

- All leak checks passed.
- All monitor issues and missing data are clearly documented in the comments.
- SCC, monthly, and quarterly maintenance items were completed.
- There is downloaded data (alarms, data, and settings) for all collected data.

2. The QA coordinator and the operator should discuss any discrepancies, errors, concerns, or questions before the final data table is submitted to the project manager.

3. The QA coordinator must bring any problem or suspect problem that affects the validity of the data to the attention of the QAM by e-mail or telephone within 5 business days of discovery.

Appendix A: Frequently Used E-BAM Data Validation Codes

Table 29. Frequently Used E-BAM Data Null Codes (Void Codes)

Null Code	Qualifier Description	Example
AC	Construction/Repairs in Area	Construction Adjacent to site
AD	Shelter Storm Damage	Shelter Storm Damage
AH	Sample Flow Rate out of Limits	Total Flow for E-BAM
AJ	Filter Damage	Tape Break/Hole/Damage for E-BAM
AK	Filter Leak	Filter Leak
AN	Machine Malfunction	Failure of MFC/Pump/Heaters/ Monitor Component
AO	Bad Weather	Water in Down Tube/Monitor
AP	Vandalism	Vandalism
AS	Poor Quality Assurance Results	Failed Flow Check or Failed Leak Check
AV	Power Failure	Power Failure
AW	Wildlife Damage	Animal and/or Insect Damage
AX	Precision Check	Monthly Flow Checks

AZ	Q C Audit	QA coordinator audit for E-BAM
BA	Maintenance/Routine Repairs	Scheduled and Unscheduled Maintenance
BC	Multi-point Calibration	Operator calibration for E-BAM
BE	Building/Site Repair	Monitor Offline for Site/Bldg. Repairs
BJ	Operator Error	Monitor not Sampling following site activity
BK	Site Computer/Data Logger Down	Site Computer/Data Logger Down
DL	Detection Limit Analyses	BAM Background Test
SA	Storm Approaching	Storm Approaching

Table 30. Frequently Used BAM Data Qualifier Codes (Flags)

QA Flags	Qualifier Description	Example
1	Deviation from CFR	Missing monthly flow verification
2	Operational Deviation	Missed cleaning of SCC
6	QAGD Issue	Shelter temperature not within specifications
IH	Fireworks	NC State Fair Fireworks display results in high PM
IM	Prescribed Fire	Planned burn
IP	Structural Fire	Nearby home on fire
IT	Wildfire	Unexpected wildlife fire
J	Construction	Pavement of parking lot; adjacent building construction

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NORTH CAROLINA
Environmental Quality

Standard Operating Procedure

Jerome 631-X Hydrogen Sulfide Analyzer for Operators

North Carolina Department of Environmental Quality | Division of Air Quality
217 West Jones Street, Suite 4000 | 1641 Mail Service Center | Raleigh, North Carolina 27699-1641
919.707.8400

Standard Operating Procedures (SOP) for

Jerome 631-X Hydrogen Sulfide Analyzer

1.0 Purpose:

The purpose of this SOP is to describe the operating procedures for the Jerome Model 631-X Hydrogen Sulfide Analyzer.

2.0 References:

Jerome Model 631-X Hydrogen Sulfide Analyzer Operations Manual

3.0 Equipment Description:

This instrument is a hand held, easy to use hydrogen sulfide vapor detector. It is manufactured by:

Arizona Instrument, LLC
1912 W. 4th Street
Tempe, Arizona 85281 Telephone – (800) 528-7411

4.0 Operation

4.1 Principles of Operation

A thin gold film, when exposed to hydrogen sulfide, undergoes an electrical resistance increase proportional to the mass of hydrogen sulfide in the sample.

When the SAMPLE button is pressed, an internal pump pulls ambient air over the thin gold film sensor for a precise period. The internal microprocessor determines the amount of hydrogen sulfide* absorbed and displays the amount of hydrogen sulfide present in ppm.
(* instrument reads total reduced sulfur compounds present as hydrogen sulfide)

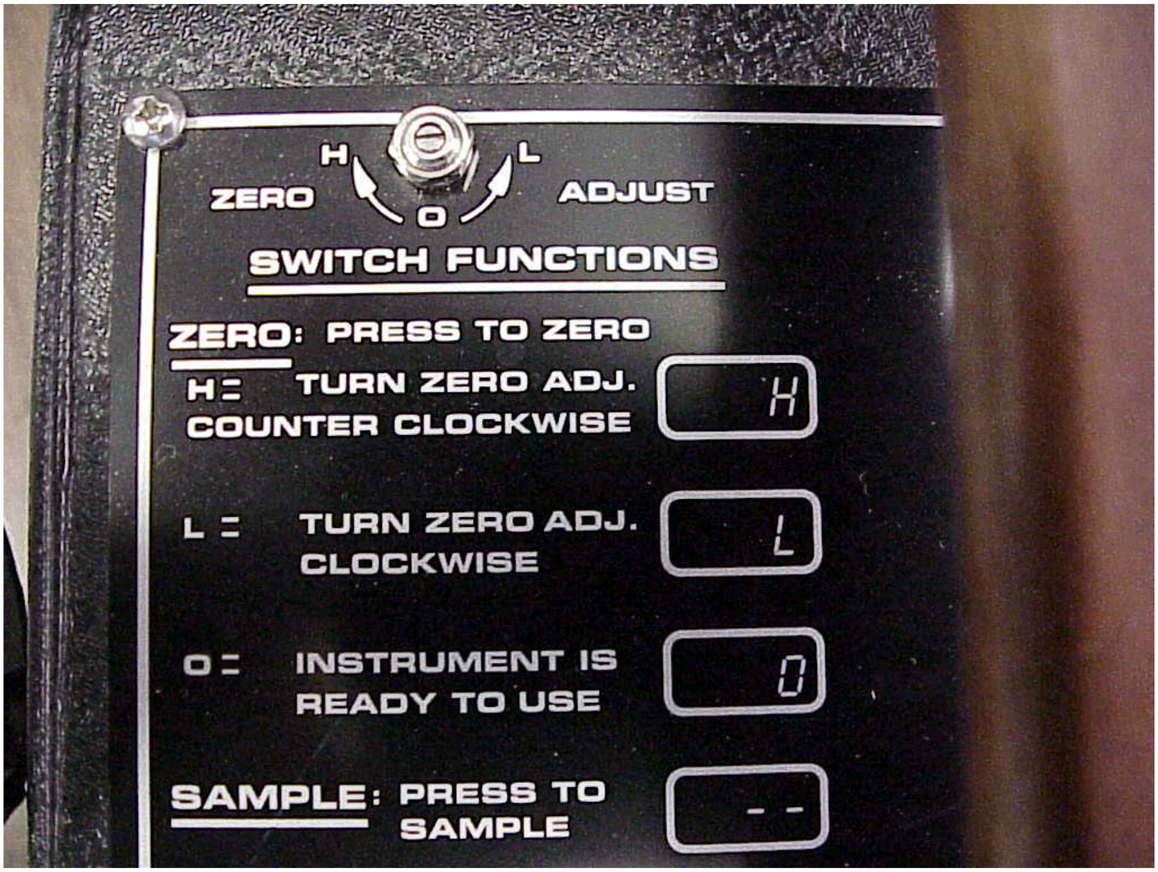
50 to 500 samples may be taken (depending on the H_2S concentration) before the sensor becomes saturated. The degree of sensor saturation is indicated on the display. When saturated, the thin gold sensor must be cleaned using the regeneration cycle. In this, a 10 minute heat cycle drives off hydrogen sulfide absorbed onto the sensor. During

regeneration, clean air is provided by an internal scrubber. The regeneration cycle will not activate on battery power and requires 110 volt or 220 volt AC power to operate.

4.2 Prior to day's usage

a. Press the Power ON button. If the LO BAT remains on, continue to recharge batteries. .
b. Allow 1 minute warm up to stabilize electronics.
c. Use Zero Air Filter to equilibrate instrument to ambient temperature.
   1. Install Zero Air Filter on intake of instrument. (The intake is on the end of the instrument opposite the AC power cord connection.)
   2. Sample repeatedly by pressing the SAMPLE button until readings stabilize. LCD will display bar or bars to indicate current percentage of sensor saturation during sampling. If total saturation occurs, LCD will display .8.8.8 rather than a value.

d. Perform sensor regeneration. Connect the AC power cord. Press the REGEN button. If the display reads P.P.P, power not is reaching the instrument; check the cord and outlet. Regeneration cycle will take 10 minutes. Digital LCD meter will flash .H.H.H during regeneration cycle and will read .0.0.0 when cycle is finished.
   1. DO NOT INTERUPT REGENERATION CYCLE.
   2. Wait a minimum of 30 minutes after end of regeneration cycle to allow sensor to cool.
e. Press and hold the ZERO button.
   1. If LCD reads H, turn ZERO ADJUSTMENT potentiometer counterclockwise until LCD reads 0. The arrow markings on the instrument ZERO ADJUSTMENT potentiometer are misleading; follow these instructions.
   2. If LCD reads L, turn ZERO ADJUSTMENT potentiometer clockwise until LCD reads 0.
   3. Release the ZERO button.
f. Take repeated samples or lock instrument into Survey Mode (see Survey Mode) for one minute.
g. Press the ZERO button again and readjust to 0 if necessary.
h. Repeat sampling with Zero Air Filter until LCD remains on 0.
i. Press power OFF button and disconnect the power cord.



4.3. Sample Mode

a. Press the power ON button.
b. Allow 1 minute for warm-up.
c. Remove Zero Air Filter.
d. Press SAMPLE.
    1. LCD will display bar or bars to indicate current percentage of sensor saturation during sampling. If total saturation occurs, LCD will display .8.8.8 instead of a value.
    2. LCD will display ppm of H_2S measured. Sample reading will continue to be displayed until SAMPLE button is pushed again.
e. DO NOT ATTEMPT to REZERO INSTRUMENT UNTIL REGENERATION IS PERFORMED.

f. Press the power OFF button when not in use. Install Zero Air Filter, unless storing the instrument in its carrying case.

4.4 Survey Mode

In Survey Mode, the instrument samples continuously every 3 to 20 seconds. Sensor will saturate quickly (after 100 samples).

a. Press the power ON button.
b. Allow 1 minute for warm-up.
c. Remove Zero Air Filter.
d. Hold SAMPLE button down until sensor status bars begin flashing. (This may take several seconds.) Press the ZERO button, then release the SAMPLE button. Then release the ZERO button.
e. Press the power OFF button to end survey mode. Install Zero Air Filter, unless storing the instrument in its carrying case.

4.5 Always perform REGENERATION at the end of the day's activities.

4.6When sampling, hold instrument away from body to prevent obstructing the airflow from rear outlet.

4.7 <u>LCD Codes</u>

LCD CODE	EXPLANATION
000	Ready to sample
.000	No hydrogen sulfide reading
.8.8.8	Sensor saturated – regeneration needed
.H.H.H	Sensor regeneration in progress (.H.H.H flashes)
.L.L.L	Re-zero needed
.P.P.P	Power cord required. If power cord is attached and .P.P.P is still displayed LCD, fuse may need replacing.
.LO BAT	Recharge batteries
.E.E.E	Recharge batteries; unit will automatically shut off
.HL	Very high (>50ppm) hydrogen sulfide concentration has been detected.

5.0 Maintenance:

PART/COMPONENT	MAINTENANCE CYCLE	REFER TO PAGE in MANUAL
Charge batteries	At least once a month, after one month's storage, or when LO BAT appears	Page 17
Change .25 inch fritware in intake (Part # 2600 3039)	Weekly or as needed	Page 19
Change internal filters (Part # Z2600 3930, Z2600 3933 and Z2600 3934) and tubing (Part # 2500 3001 and 3002)	After 6 months of use or as needed	Page 20
Replace Zero Air Filter	Annually	
Factory Calibration	Annually	Page 23
Calibration check	Monthly or as needed	Appendix A, Page 36
Replace batteries	Annually or as needed	Page 21

1.0 Changing the Fuse

If the LCD reads .P.P.P when the instrument is connected to AC power, when the REGEN button is pressed, or if the battery will not charge, the fuse may need to be replaced. Refer to Page 22 of the Operations Manual.

2.0 Troubleshooting

Refer to Page 24 of the Operations Manual.

7.0 Storage:

Always store the instrument in the protective carrying case and keep away from moisture and other liquids.

8.0 Specifications:

1. Range	0.003 ppm (3 ppb) to 50 ppm H_2S in four (4) graduated ranges
2. Sensitivity	0.003 ppm H_2S
3. Precision	5 percent relative standard deviation
4. Accuracy	Range 0: $\pm$ 0.003 ppm at 0.050 ppm H_2S
5. Response time–sample mode	
10 to 50 ppm	13 seconds
1.0 to 10.0 ppm	16 seconds
0.10 to 1.00 ppm	25 seconds
0.001 to 0.100 ppm	30 seconds
6. Response time–survey mode	
0 to 50 ppm	3 seconds
1.0 to 9.9 ppm	6 seconds
0.10 to 0.99 ppm	15 seconds
0.001 to 0.099 ppm	20 seconds
7. Flow rate	150 cc/min (0.15 liters/min)
8. Power requirements	110-120 V~, 50/60 Hz, 1A or 220-240 V~, 50/60 Hz,1A
9. Fuse	F1A T250V, 5 mm X 20 mm
10. Internal battery pack	rechargeable nickel cadmium
11. Operating Environment	0°C to 40°C (32°F to 104°F), non-condensing, non-explosive
12. Case construction	aluminum alloy
13. Case dimensions	15 cm X 33 cm X 10 cm (6” w X 13” l X 4” h)
14. Weight	3.18 kilos (7 pounds)

15. Display	liquid crystal

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Standard Operating Procedure 2.56 Section 2: AreaRAE Standard Procedures for Operators

NORTH CAROLINA
Department of Environmental Quality

North Carolina Department of Environmental Quality | Division of Air Quality
217 West Jones Street, Suite 4000 | 1641 Mail Service Center | Raleigh, North Carolina 27699-1641
919.707.8400

Standard Operating Procedure Approval

I certify that I have read and approve of the contents of this revision of SOP 2.56.2 with an effective date of *(Month, Day)*, 2018.

Raleigh Central Office AreaRAE Gas Analyzer Lead
Kay Roberts, Environmental Chemist

Signature: ___________________________________ Date: _______________________

Electronics and Calibration Branch Field Operator
Pernell Judd, Electronic Technician

Signature: ___________________________________ Date: _______________________

Projects and Procedure Branch Field Auditor
Steven Walters, Chemist III

Signature: ___________________________________ Date: _______________________

Projects and Procedures Branch Supervisor
Joette Steger, Environmental Supervisor

Signature: ___________________________________ Date: _______________________

Laboratory Analysis Branch Supervisor and Project Manager
Jim Bowyer, Environmental Supervisor

Signature: ___________________________________ Date: _______________________

Ambient Monitoring Section Chief and Quality Assurance Manager
Patrick Butler, Ambient Monitoring Section Chief

Signature: ___________________________________ Date: _______________________

U.S. Environmental Protection Agency
Laura Ackerman, Region 4 SESD

Signature: ___________________________________ Date: _______________________

Standard Operating Procedures for
AreaRAE Gas Analyzer

1.0 Purpose

This SOP is intended to assist with the calibration, programming, and proper operation of the AreaRAE Portable Gas Monitor.

2.0 References

Greater detail on the properties and usage of this instrument can be found in the Operation and Maintenance Manual published by RAE Systems, Inc.

3.0 Equipment Description

The AreaRAE is a programmable portable gas monitor designed to provide continuous monitoring of toxic gases, oxygen, and combustible gases. It can measure concentrations of up to 5 gases: Combustible gases, VOCs, oxygen, and two types of toxic gases.

Gas	Detection Range	Resolution	Sensor Type
Combustible Gases	Percent of Lower Explosive Limit (LEL)	1 percent	Catalytic Bead
VOC	0-200 ppm	0.1 ppm	PID
Oxygen	0-30 percent	0.1 percent	Electrochemical cell
CO (Carbon Monoxide)	0-500 ppm	1 ppm	Electrochemical cell
H_2S (Hydrogen Sulfide)	0-100 ppm	1 ppm	Electrochemical cell
SO_2 (Sulfur Dioxide)	0-20 ppm	0.1 ppm	Electrochemical cell
NO (Nitric Oxide)	0-250 ppm	1 ppm	Electrochemical cell
NO_2 (Nitrogen Dioxide)	0-30 ppm	0.1 ppm	Electrochemical cell
HCN (Hydrogen Cyanide)	0-50 ppm	1 ppm	Electrochemical cell
NH_3 (Ammonia)	0-50 ppm	1 ppm	Electrochemical cell
PH_3 (Phosphine)	0-5 ppm	0.1 ppm	Electrochemical cell
Cl_2 (Chlorine)	0-50 ppm	0.1 ppm	Electrochemical cell
ClO_2 (Chlorine Dioxide)	0-1 ppm	0.1 ppm	Electrochemical cell

Note: RAE Instrument PIDs are incapable of measuring certain low molecular weight VOCs, including those in natural gas. If the presence of natural gas is suspected, a FID can be used to detect it.

The AreaRAE has a rechargeable lithium ion battery pack which will, 7.4V/4.5 Ah, and can also use a 6 C-cell alkaline battery pack. When fully charged, the lithium ion battery will provide power for up to 36 hours of continuous operation.

The LCD readout shows instantaneous values of all gases monitored, and also has the capability of showing TWA, STEL, peak and minimum values, battery voltage, and elapsed time.

A 100 dB buzzer and flashing red light provide the alarm to indicate exceeded preset limits of TWA, STEL, Low and High alarm levels, as well as battery or sensor failure.

Two point calibrations can be performed using zero air and a standard reference span gas.

An internal sampling pump provides sample flow to the sensors, and can be set on low (300 cc/min) or high (400 cc/min) settings. A 0.2-micron filter is attached to the inlet to the analyzer to filter out water droplets and particulate. Sections of Teflon tubing can be connected to the inlet for remote sampling if desired.

Datalogging capabilities are programmable, with stored readings from 1 per second to 1 per hour possible. Up to 20,000 readings can be stored. Data can be uploaded to PC using serial cable and ProRAE software.

All RAE instruments have an intrinsic safety classification of Class 1, Division I, Group A, B, C, and D.

4.0 Procedures

4.1 General Operation

The AreaRAE has four function keys:

- the **MODE** key turns the instrument on and off, and is used to change the display and navigate the menus.
- the **Y/+** key is used to answer yes, increase numbers in program menus, and to test or acknowledge the alarm.
- the **N/-** key is used to answer no, decrease numbers in configuration, and to toggle on/off the LCD backlight.
- the **RADIO** key initiates or stops radio frequency transmission to the host controller. When transmitting, the red LED above the **RADIO** key will be on.

Turn the AreaRAE on by holding down the **MODE** key. When first turned on, the AreaRAE will emit a single beep and go through an initial sequence in which the status of the sensors is displayed before beginning sampling. If the auto-zero function is enabled in the configuration, the monitor will perform a fresh air calibration.

Once running, the display will flash between the instantaneous sensor readings and the sensor names. Pressing the **MODE** key allows the user to scroll through the different display screens.

To enable transmission of data to the host controller, press the **RADIO** key on the AreaRAE faceplate.

To turn off the AreaRAE, hold down the **MODE** key for 5 seconds. It will beep 5 times before turning off.

4.1.1 User Modes

The AreaRAE has three different user modes of operation:

(a) Text Mode - Allows the display to show the instantaneous gas concentration readings and current battery voltage only. It is possible to get into the calibration menu with the use of a password (the default password of 0000 should be valid), but the configuration parameters cannot be changed. As this operation mode is the simplest of the three, it is probably the best choice for normal operations.

(b) Display Mode – This operation mode is able to display all the information in the Text Mode, as well as the following information:

-Peak Reading: The highest reading of each gas concentration since the monitor was turned on.
- Minimum Reading: The lowest reading of each gas concentration since the monitor was turned on.
- STEL Reading: The last 15-minute average reading of the VOC and toxic gas concentrations.
- TWA Reading: The accumulated reading of the VOC and toxic gas concentrations divided by 8 hours since the monitor was turned on.
- Run Time: Shows the accumulated "On" time in hours and minutes since the monitor was turned on. This display screen also shows the date, clock time, and temperature in degrees C.
- Datalog Menu: If manual datalog mode is selected in the configuration, this allows the user to start and stop the datalog at will.
-LEL and VOC gas names: Shows the gases used to calibrate the LEL and VOC sensors.
- Print Reading: Allows user to print out the gas concentration readings if the monitor is connected to a serial printer.

These readings are accessed by pressing the **MODE** key to scroll through the display screens. In Display Mode, it is not possible to do calibrations or change configuration parameters. This operation Mode would be useful if one needs to observe the additional information (*e.g.*, STEL and TWA concentrations) and avoids the possibility of the user accidentally changing the configuration.

(c) Programming Mode – This operating mode combines the display options of the Display Mode of operation with the ability to modify the configuration and perform calibrations. This option provides the most flexibility in terms of display of information and ability to modify configuration parameters. No password is required to change parameters in Programming Mode.

4.1.2 Programming the AreaRAE Configuration

The AreaRAE configuration parameters can be changed by accessing them from the Text or Programming Modes, or by connecting the unit to a PC with a serial cable and using ProRAE software to set them.

To enter the configuration and calibration menus on the AreaRAE monitor in Text and Programming Mode, hold down the **MODE** key and the **N/-** keys simultaneously for 3-4 seconds. At this point, the display screen will enter the Programming Menu (in Text Mode, the password will need to be entered). The Programming Menu is navigated by pressing the **Y/+** key to access a given option, and the **N/-** key to scroll past it. The **MODE** key enters any change made to the configuration or exits the current menu. Programming options include monitor calibration, setting alarm limits, and setting datalog parameters. The Programming Menu is described in greater detail in the AreaRAE Operation and Maintenance Manual. For ease of use, it is recommended to use a PC to set up the configuration parameters.

AreaRAE has a PC Standby Communication Mode, which allows the monitor to communicate with a PC using ProRAE software. When using the **MODE** key to scroll through the display screens, the last screen before it returns to the instantaneous readings gives the user the option to connect the AreaRAE monitor to a PC for data transfer. This screen asks "**Communicate with PC?**". Press **Y/+** and the LCD displays **"Monitor will pause, OK?**". Press **Y/+** again, and the monitor goes into standby communication mode (display reads "**Ready…**"). It is then possible to connect the monitor with the serial cable to a PC to download data and modify the configuration parameters. While in standby communication mode, all readings and datalogging are stopped. Datalogging must be manually restarted when exiting the standby Mode, unless it is in automatic datalogging mode.

To establish a link between the AreaRAE and the PC, it may be necessary to change the default COM setting by clicking on **Communication -> Setup Port**. Once a link is established, the AreaRAE configuration can be uploaded by going **to Communication -> Receive Configuration.** The configuration can then be modified and sent back to the AreaRAE by going to **Communication -> Send Configuration**.

Logged data from the AreaRAE is also retrieved in this way, by going to **Communication -> Receive Data**. The data file can then be saved to disk and exported to an Excel file, if desired.

4.1.3 Datalog Options

The AreaRAE is capable of 4 types of datalogging, which are chosen with the ProRAE configuration setup:

(a) Automatic Start/Stop: Datalogging begins when the instrument is turned on and stops when it is turned off.
(b) Manual Start/Stop: Datalogging begins when started using the AreaRAE operation menu. Data collection can be scheduled to stop after a certain time period, or manually stopped.
(c) Periodic Start/Stop: This option is used for sampling over a certain time period in the course of a day. Daily start and stop times are designated by the user.
(d) Scheduled Start/Stop: Start and stop times and dates for the datalogging period are designated by the user.

The datalog interval, the rate in seconds at which samples are logged while the datalog is running, can be set using either the ProRAE software or the Program Menu of the AreaRAE. If data will need to be logged for an extended period of time (*i.e.*, more than a few days), it might be necessary to change the datalog interval to a longer time to insure data will be collected over the entire period.

The Program Menu can be used to clear all data from the memory of the AreaRAE.

4.2 Calibration

Calibrations of the AreaRAE sensors should be performed at regular intervals. This can be done through the Calibration Sub-Menu of the AreaRAE, which allows zero and span calibrations of all sensors.

For routine ambient monitoring, it useful to re-zero the sensors with a Fresh Air Calibration. If the ambient air is suspected to have contaminants, certified zero air should be used. If the auto-zero function is enabled in the configuration (using ProRAE Suite), then the monitor will go perform a fresh air calibration when first turned on. If the readings seem to drift away from ambient levels before placing the AreaRAE in the field at monitoring site, it may be necessary to perform another fresh air calibration. In the Text and Programming operation modes, this is done by the following steps:

1. Enter the Program Menu by holding down the **MODE** and **N/-** keys.
2. Display shows "**Calibrate Monitor?**" Press **Y/+**. This enters the calibration submenu.

3. "**Fresh Air Calibration?**" Press **<u>Y/+</u>** if ambient air is free of contaminants, otherwise use certified zero air or charcoal filter.
4. Press the **<u>MODE</u>** key to continue with span gas calibrations. Hold down the **<u>MODE</u>** key for 2-3 seconds to resume sampling.

A successful Fresh Air Calibration will result in ambient readings of 20.9 percent oxygen, and zero readings for all other analytes.

The stability of the AreaRAE sensors makes it possible to use manufacturer calibrations for long periods rather than performing regular in-house calibrations. Manufacturer calibrations are certified for one year, but may be good for a longer period depending on the amount of use and exposure the instrument gets. To insure good readings are being obtained, the sensors should be challenged regularly with a sample of certified calibration gas.

In the event that an in-house calibration is desired, calibration with span gases requires certified standard gases to be used, preferably by filling a tedlar bag with the gas and feeding it to the analyzer. Span gas concentrations can be entered into the AreaRAE program configuration with a PC or laptop using ProRAE Suite software, or they can be manually entered through the Program Menu.

4.3 Troubleshooting

There are a variety of problems that may occur with the operation of the AreaRAE analyzer. Most of them involve problems with the battery or sensors. If the display shows a "**Bat**" message in operation, it means the battery is discharged and needs to be either replaced or recharged.

Incorrect readings can be the result of sensor drift, faulty calibration, or aging or damaged sensors. Make sure that the sensors are regularly serviced and replaced to keep within their warranted lifetimes. Consult the operation and maintenance manual for cleaning and replacing sensors, or send in to the manufacturer.

5.0 Verifications and Checks

5.1 Procedure for verifying the flow rate

To verify the average flow rate for the AreaRAE monitor follow these steps:

- Press the (N/- and MODE) keys simultaneously for approximately 3 seconds
- "Enter password displays" release the N/- key first, holding the MODE key
- "Data logging paused" will be displayed, release the MODE key
- Once the MODE key is released "calibrate monitor" will be displayed. At this point the monitor pump is still working and a flow check can be performed.
- Insert the large venturi (0.1 -1.2 L/min) flow range into the BGI tetraCal, allow the flow standard to run through its start up.

- Attach the flow standard to the sampler inlet, be sure to take the flow reading with the inlet filter in place.
- The sampler design flow is 0.400L/min. Note the Qa flow in L/min from the BGI tetraCal. Write this value on the AreaRae log form.
- If the flow is outside acceptable limits, remove the inlet filter from the sampler and re-attach the flow standard. Measure this flow and note it in the comments section of the log form noting the inlet filter was removed. If the flow is acceptable. Install a new inlet filter on the sampler and recheck the flow again. It's possible the original inlet filter was clogged with moisture and particulates. It's also possible the new filter is too restrictive for the pump to overcome, and the flow will be lower than the design flow. Keep trying new filters until an acceptable flow is achieved.
- Press the MODE key once to turn on the datalogger. At this point the sampler is ready to start sampling and logging data at the desired intervals.

5.2 Procedure for verifying the calibration

- The sampler should be collecting data at this time and the pump should be running.
- Disconnect the Tygon tubing from the sampler inlet filter, and note the probe disconnect time on the sampler log form.
- Turn the NH3 cylinder valve on. NH3 gas should be flowing out of the cylinder.
- Attach the cylinder to the sampler inlet with the sampler inlet filter in place, the sampler readings should begin to rise on the sampler display.
- Depending on the challenge gas concentration, the sampler will begin to beep and flash as the lower and upper alarm limits are reached (perfectly normal).
- Allow the display readings to stabilize, approximately 2-3 minutes.
- Once a stable reading is achieved, note this concentration on the log form.
- Disconnect the cylinder and close the cylinder valve.
- The sampler readings may spike once the cylinder is removed, it's normal due to the residual pressure and gas trapped inside the sampler's internal plumbing. The display values should lower over the next several minutes, but may not reach all the way to zero.
- Now perform the zero check to help flush out the residual NH_3 and re-establish the zero point of the instrument.

6.0 Maintenance

6.1 Battery Charging

Battery power can be checked by pressing the **MODE** key to scroll through the display screens. Voltage should not be below 4.1 volts. *Note: If the instrument is left idle for several days at a time, it will probably be necessary to recharge the battery before use.*

A new battery will last as long as 36 hours (without the alarm or backlighting options). As the battery ages or is subject to cooler temperatures, the battery capacity may be reduced significantly.

The AreaRAE is also equipped with a spare battery pack that uses 4 AA size alkaline batteries. A fully charged set of alkaline batteries will provide 12-14 hours of field operation, and is intended for use in emergency situations when there is not enough time to charge the lithium ion battery. To install the adapter, unscrew the four screws from the back of the AreaRAE to remove the lithium ion battery pack of the monitor. Replace with the alkaline pack and battery adapter into the battery connector. The AreaRAE will detect the alkaline battery adapter, and will not attempt to charge them if plugged in with the AC adapter.

6.2 Sensors

The toxic, combustible, and oxygen sensors all have an expected operating life. Under normal operating conditions, most sensors will lose their original sensitivity after the expected operating life, and will need to be replaced if calibration is repeatedly unsuccessful or if the instrument reading is other than normal following instrument turn-on. The warranty expiry date for each sensor is shown during the power-on sequence when the AreaRAE is first turned on. See the operation and maintenance manual for detailed instructions on sensor replacement.

If new sensors are added, the instrument should be run through an auto zero/span cycle in a clean air environment and calibrated with certified span gases.

6.3 PID Sensor Cleaning / Replacement

During the course of normal operations, a film of gas may build up inside the PID sensor module and the UV lamp, which may then require cleaning with GC-grade methanol. It is recommended to clean the PID sensor module and lamp only when the PID is malfunctioning. See the operation and maintenance manual for instructions on cleaning the PID sensor and UV lamp.

7.0 Safety

The small size of the instrument makes it non-hazardous during use. However, *because this instrument is commonly used to alarm the user of hazardous conditions, all measures should be taken to constantly assure proper maintenance and calibration.*

8.0 General Notes and Comments

The operation and maintenance manual for the AreaRAE contains more detailed advice on the operation and maintenance of this instrument. In addition, the RAE website (www.raesystems.com) has a number of technical reports in pdf format for using the

AreaRAE website for various purposes. A partial list of these reports is listed in Appendices D and E of the operation and maintenance manual.

9.0 Storage

An instrument carrying case is provided to transport, ship and store the AreaRAE analyzer and accessories.

10.0 Attachments

The accessories for the AreaRAE include:

- 0.2-micron water trap filters
- Carbon filters for monitors equipped with a CO sensor
- Handle and shoulder strap
- 15 feet of Teflon tubing for remote sampling
- AC adapter (battery charger)
- Alkaline battery holder for backup power source in the field.
- Serial cable for interface with PC.
- Tool kit (screwdrivers, tweezers, hex wrench)
- RF transmitting antenna

11.0 DOWNLOADING DATA FROM THE AREARAE

To download data from the AreaRAE monitor follow these steps:

- Using a laptop with pro rae suites installed, open the program.
- Select “communicate”.
- Select “receive data” from the dropdown menu.
- ProRaE suites will prompt the user to connect the instrument to the serial port of the computer (the computer must have an RS232 connection or a conversion into USB if available) and the COM port on the sampler, and set instrument to the communication ready mode.
- Connect the sampler to the pc using the data connection cable
- Press the MODE key twice on the sampler
- “communicate with PC?” will be displayed.
- Press the Y/+ key on the sampler.
- “monitor will pause. Ok?” will be displayed.
- Press Y/+ again.
- “Ready…turn radio off!!” will be displayed.
- Click ok on the laptop, and the data should start transferring from the sampler to the laptop. This process may take up to 5 minutes depending on the size of the data file being transferred.
- A text file should appear on the laptop in the proRae suite program.

- Highlight the correct event # paying attention to the date and time of the data download on the left hand side of the laptop screen. That should be the file containing the most recent week of data.
- Review the text file to insure the dates and times are for the correct week of data you are retrieving.
- With the proper event # highlighted and text file visible, select "option" then "export text" from the dropdown menu.
- Save As menu will appear, name the file accordingly (Site Name YYYYMMDD thru YYYYMMDD) and make sure the file is saved in the proper folder (Duplin County NH3 Data).
- This process will save the data from the instrument onto the laptop as a text file that can be used for further processing, validation and storage.
- Disconnect the communication cable from the sampler.
- Press the MODE key once and sampler pump will turn on and start collecting data.
- Press the N/- and MODE key simultaneously.
- Press the N/- key twice until "change datalog?" is displayed.
- Press Y/+ once "clear all data" should be displayed.
- Press Y/+ once "are you sure?" will be displayed.
- Press Y/+ again to clear the data logger on the instrument so that the next week of data can be collected without overwriting previous data.
- "Data cleared" will briefly display and then "change datalog period?" will be displayed.
- Press the MODE key twice to resume datalogging and sampling.

12.0 QUALITY ASSURANCE AND DATA HANDLING

12.1 Field Operator Quality Assurance

Upon arriving at the site, the field operator is responsible for ensuring that the monitor has collected what appears to be valid data since the previous site visit. This includes reviewing the alarms and collected data. Below is a suggested list of items that operators should be verifying during each site visit:

- Possible changes near the site that could bias the data (fires, construction, etc.)
- Encroachment of wildlife or vegetation
- Vandalism
- Obstructions of the inlet
- Alarms on the screen of the AreaRAE Gas Analyzer
- Abnormalities in the downloads
    - Ensuring that there are no gaps in the data
    - Investigating repetitive patterns of numbers

12.2 Quality Assurance Coordinator

The QA coordinator is responsible for reviewing all raw data and logbooks prior to submitting the data to the project manager. The specific QA duties for the QA coordinator are described in the following sections.

12.3 AreaRAE Download Review

The QA coordinator is responsible for reviewing the AreaRAE download data, alarms, and settings to ensure that there are no abnormalities.

- Ensuring that there are no gaps in the data
- Ensuring that repetitive patterns of numbers have been addressed
- Corresponding alarm flags are investigated and corrective action taken when needed

12.4 Electronic Logbook Review

The QA coordinator must review the e-logs for each site on a monthly basis. E-log reviews are recommended, but not required, to be conducted every 15 days to ensure the operators and the monitors are meeting the necessary requirements.

- The QA Coordinator must review all e-logs for completeness, verifications, audits, calibrations and monitor problems. Specifically, the QA Coordinator must verify that:
    - The average flow rate is measured each week and it is 0.400 ± 0.008 LPM.
    - All devices and standards used were within certification dates.
    - Weekly calibration checks were performed and NH_3 measurements were within 7.5 percent of the expected value.
    - All leak checks passed.
    - All monitor issues and missing data are clearly documented in the comments.
    - All maintenance items were completed.
    - There is downloaded data (alarms, data, and settings) for all collected data.
- The QA coordinator and the operator should discuss any discrepancies, errors, concerns, or questions before the final data table is submitted to the project manager.
- The QA coordinator must bring any problem or suspect problem that affects the validity of the data to the attention of the QAM by e-mail or telephone within 5 business days of discovery.