STATE OF VERMONT
AIR QUALITY & CLIMATE DIVISION
QUALITY ASSURANCE PROJECT PLAN

FOR
CRITERIA GAS & PARTICULATE MATTER
AIR POLLUTANT MONITORING

12/15/2019

Section 1. Title and Approval Page

As signed and accepted by the people below, the following Quality Assurance Project Plan (QAPP) commits the Vermont Department of Environmental Conservation, Air Quality & Climate Division to the operations described within.

Document Title: State of Vermont Quality Assurance Project Plan for Criteria Gas & Particulate Matter Air Pollutant Monitoring

Organization: The State of Vermont, Department of Environmental Conservation, Air Quality & Climate Division

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2.4. Acronyms

AMTIC	Ambient Monitoring Technical Information Center
ANSI	American National Standards Institute
APTI	Air Pollution Training Institute
AQCD	(Vermont) Air Quality & Climate Division
AQI	Air Quality Index
AQS	Air Quality System
ASTM	American Society for Testing and Materials
CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	Carbon Monoxide
COC	Chain of Custody
CSN	Chemical Speciation Network
DAS	Data Acquisition System
DQA	Data Quality Assessment
DQO	Data Quality Objective
ENSC	Exchange Network Services Center
EPA	Environmental Protection Agency
ESC	Environmental Systems Corporation
FDMS	Filter Dynamic Measurement System
FEM	Federal Equivalent Method
FOC	Field Operations Center
FRM	Federal Reference Method
IMPROVE	Interagency Monitoring of Protected Visual Environments
LDL	Lower Detection Limit.
MDL	Minimum Detection Limit
MQO	Measurement Quality Objective
NAAQS	National Ambient Air Quality Standards
NAMS	National Air Monitoring Station
NATTS	National Air Toxics Trends Stations
NCORE	National Core (Monitoring Station)
NIST	National Institute of Standards and Technology
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
NOy	Total Reactive Oxides of Nitrogen
NOy-NO	Subtractive difference of NOy and NO
NPAP	National Performance Audit Program
OAQPS	Office of Air Quality Planning and Standards
PE	Performance Evaluation
PM_{10}	Particulate Matter ≤ 10 μm Diameter
$PM_{10-2.5}$	Particulate Matter Between 2.5 And 10 μm Diameter (“Coarse” Particulate)

$PM_{2.5}$	Particulate Matter ≤ 2.5 µm Diameter
POC	Pollutant Parameter Occurrence Code
PTFE	Polytetrafluoroethylene
QA Redbook	Most recent revision of EPA's Quality Assurance Handbook for Air Pollution Measurement Systems; (This multi-volume guidance document was once provided in red binders).
QA/QC	Quality Assurance/Quality Control
QAGD	Quality Assurance Guidance Document
QAPP	Quality Assurance Project Plan
RPD	Relative Percent Difference; RPD = (value1 – value2) / Average (value1 + value2) *100
RSD	Relative Standard Deviation; RSD = (Standard Deviation / Average) * 100%
SDEV	Standard Deviation
SIP	State Implementation Plans
SLAMS	State and Local Monitoring Stations
SOP	Standard Operating Procedure
SPM	Special Purpose Monitoring Station
STN	Speciation Trends Network
STP	Standard Temperature and Pressure (25 °C and 760 mmHg)
TSA	Technical System Audit
TSP	Total Suspended Particulate
TTP	Through the Probe
URG	URG-3000 Speciation Carbon Sampler
VOC	Volatile Organic Compound
VSCC	Very Sharp Cut Cyclone

Section 3. Distribution List

All individuals listed in Table 3.1 will receive a copy of this Quality Assurance Project Plan.

All Monitoring section staff must read and understand the QAPP. The current revision is also available in digital format on the State of Vermont, DEC network drive (Y:\AP_Monitoring\Operations\Quality Assurance Project Plans\2019 Criteria & PM QAPP).

Table 3.1 Vermont QAPP Contact List

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Section 4. Project Organization

The U.S. Environmental Protection Agency (EPA) requires all organizations conducting environmental programs that are fully or partially funded by EPA to establish and implement a structured quality system that ensures the production of quality information products. Through Clean Air Act (CAA) Grant obligations and Federal Requirements, the Vermont Air Quality & Climate Division (AQCD) reports air quality monitoring results to the EPA's Air Quality System (AQS) database and therefore has put into place a quality system comprising various components as described in this Quality Assurance Project Plan (QAPP). The EPA requirements governing the ambient air monitoring activities identified in this QAPP are contained in *40 CFR Part 50, 53* and *58* as well as other guidance documents identified in the References Section.

4.1. Roles and Responsibilities

4.1.1. Office of Air Quality Planning and Standards (OAQPS)

The EPA OAQPS is authorized by the CAA to protect and enhance the quality of the nation's air resources. The standards for air pollutants are established by OAQPS to protect public health and welfare. Compliance with these standards is managed by OAQPS with cooperation from the EPA regional offices, state and local agencies. OAQPS maintains a national database for air quality measurements, and emission inventories and controls. OAQPS also tracks air quality trends, approves instrumental methods, provides quality assurance (QA) guidance, operates the National Performance Audit Program (NPAP) and ensures that national regional laboratories are available to support chemical speciation and QA programs.

4.1.2. EPA New England Office

EPA Regional Offices will address environmental issues related to the states within their jurisdiction and to administer and oversee regulatory and congressionally mandated programs. The major quality assurance responsibilities of EPA's Region I Office, with regard to the Ambient Air Quality Program, are the coordination of quality assurance matters at the Regional level with the state and local agencies. This is accomplished by the designation of EPA Regional Project Officers who are responsible for the technical aspects of the program including:

- Reviewing Quality Assurance Project Plans and Network Plans annually
- Conducting Technical Systems Audits (TSA) every 3 years
- Conducting Performance Audits (NPAP)
- Supporting the FRM Performance Evaluation Program (PEP)
- NIST traceable ozone certification with SRP
- Acting as a liaison by making available the technical and quality assurance information developed by EPA Headquarters and the Region to the state and local agencies, and making EPA Headquarters aware of the unmet quality assurance needs of the state and local agencies.

4.1.3. State of Vermont Personnel

The Vermont AQCD is the Primary Quality Assurance Organization (PQAO) in the state. The major responsibility of the AQCD Monitoring section is to operate a permanent multi-site

monitoring network consistent with this document to provide data of known quality (meets Data Quality Objectives) to the national EPA database. The Air Quality & Climate Division personnel organization chart is shown in Figure 4.1, and the major responsibilities are described below.

- Division Director

Overall responsibility for the functioning of the division, including budgeting authority and is responsible for certifying the criteria pollutant data in AQS.

- Monitoring Section Supervisor

Oversees all monitoring activities, supervises and trains monitoring section personnel, and ensures monitoring operations adhere to the requirements in this QAPP and the associated SOPs. Performs the annual network review, grant work plans and prepares monitoring network reports required by the EPA to assure monitoring operations are consistent with EPA requirements.

- Environmental Analysts (Monitoring Staff)

Responsible for day-to-day monitoring network operations, including all sample chain of custody, preparation, setup and recovery, 1-point QC checks (precision audits), 1-point flow rate verification (flow audits), calibration, troubleshooting, maintenance and upkeep of monitoring equipment and monitoring site infrastructure. Also responsible for routine data review and level 1-2 data validation, as applicable.

- Quality Assurance Coordinator

Responsible for providing an independent assessment of monitoring operations relative to EPA guidelines by conducting annual Performance Evaluations, Semi-Annual Flow Rate Audits, and systems audits of sites, personnel and operations. Responsible for SOP development and review deemed necessary based on these audits. Responsible for final data review, validation and submittal to AQS, as well as managing data and site information in AQS. Responsible for ensuring correct configurations and settings in the data acquisition system.

4.2. AQCD Support Organizations

4.2.1. Wood LLC

Wood LLC Provides gravimetric support for AQCD PM filter-based program and for EPA's CSN. For the former, Wood LLC is responsible for all tasks relating to filter preparation, tare and final weighing, and all quality control and assurance related to gravimetric operations as identified in their latest QAPP and SOP. *QAPP EPA Category I Filter Handling, Acceptance Testing and Gravimetric Analysis for Chemical Speciation Network, Special Studies and State, Local and Tribal Site PM2.5 Federal Reference Method Filter Samples, Contract EP-D-15-001, Revision 1.0, May 2018* and *SOP GLM3180-009 Determination of Particulate Matter (PM) Gravimetric Mass for the Chemical Speciation Network Revision 2, May 2018.*

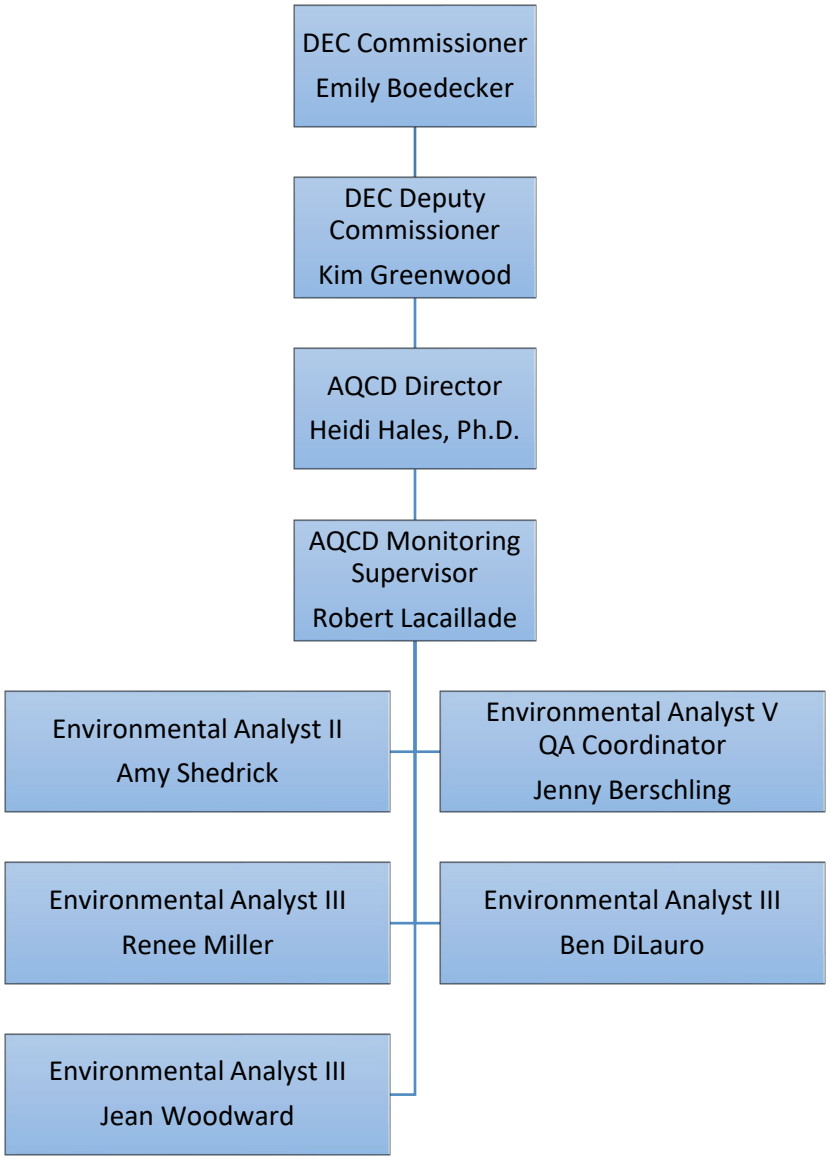
The CSN is an EPA PM2.5 speciation network within the SLAMS/NAMS, as described in 40 CFR Part 58. The Burlington Zampieri site is in the CSN and includes the operation of a SuperSASS and a URG sampler. The shipping, handling and select gravimetric support for these filter samples is performed by the current EPA contractor, Wood LLC.

4.2.2. UCDavis – provides lab analysis support for the IMPROVE and EPA CSN

4.2.3. IMPROVE is a $PM_{2.5}$ visibility/speciation monitoring program cooperatively operated by the National Park Service, Forest Service, Bureau of Land Management, Fish and Wildlife Service, Environmental Protection Agency, and state agencies, whose primary purposes are the protection of visibility in Class I areas and characterization of regional haze. The Underhill site is in the IMPROVE network and the program support is provided and managed by UC Davis.

The CSN is an EPA $PM_{2.5}$ speciation network within the SLAMS/NAMS, as described in *40 CFR Part 58*. The Burlington Zampieri site is in the CSN and includes the operation of a SuperSASS and a URG sampler. The shipping, handling and select gravimetric support for these filter samples is performed by the current EPA contractor, Wood LLC.

Figure 4.1 Vermont AQCD Organizational Chart



Section 5. Problem Definition/Background

In 1970, Congress passed the Clean Air Act (CAA) to control and assess the increased emission of six principal ambient air pollutants also called criteria pollutants. The EPA criteria pollutants are particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and lead. The CAA and its amendments provide the framework for all pertinent state and local organizations to protect air quality by establishing the NAAQS (see Table 5.1), which are health-based standards for these pollutants. It also provided EPA authority to require ambient monitoring of these criteria pollutants by state and local organizations through the Air Quality Monitoring Program.

Air monitoring in Vermont began as local monitoring program and was initially focused on total suspended particulate (TSP). During the 1970s, monitoring methods improved to allow higher quality particulate sampling, and continuous analyzers for the criteria gaseous pollutants. Over time, as EPA has updated requirements and reevaluated standards, the network has evolved as part of the SLAMS national program. The AQCD's monitoring network was expanded numerous times including the addition of PM_{10} monitoring in 1985, air toxics monitoring in 1985, and $PM_{2.5}$ monitoring in 1999. The Chemical Speciation Network (CSN) program was added in 2000, the National Air Toxics Trends Stations (NATTS) program was added in 2004, and NCore was added in 2010.

Ambient air quality monitoring and data reporting regulations were originally developed by EPA and identified in *40 CFR Part 58*. This includes specific requirements for monitoring and reporting ambient air quality data. The monitoring criteria pertain to the following (*40 CFR Part 58, Appendix D*):

- Siting requirements for instruments or instrument probes
- Sampler/monitor operation
- Sampling methodology
- Operating schedules
- Quality assurance procedures
- Data handling

The *40 CFR Part 50* identifies National primary and secondary Ambient Air Quality Standards for criteria pollutants (NAAQS, See Table 5.1). Sampling methods, monitors and samplers must be Federal Reference (FRM) or Federal Equivalent (FEM), and must comply with the applicable parts of *40 CFR Part 58*. Monitoring must meet the needs of the AQCD and EPA within the limits and decisions made by the AQCD Director.

Ambient air monitoring data historically have been and will continue to be the basis for any decisions regarding the attainment or non-attainment of the NAAQS in Vermont. In addition, other monitoring programs are operated to define population exposure to air contaminants known or suspected to cause adverse health effects and/or to cause damage to property or sensitive ecosystems. AQCD monitoring programs covered by this QAPP are summarized below (for a full description, see *Annual Network Monitoring Plan* in Appendix B).

- Criteria Gases: These pollutants are defined by the CAA and EPA as ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Monitoring compliant with *40 CFR Part*

58 for these pollutants using FRM/FEM instruments is performed at four permanent sites in the network (Bennington, Burlington, Rutland, and Underhill).

- $PM_{2.5}$: This program measures ambient concentrations of particulate matter equal to or smaller than 2.5 microns in diameter. This was required in response to a new EPA NAAQS originally promulgated in 1997, and most recently revised in 2012. Continuous $PM_{2.5}$ FEM monitors are operated at four permanent sites (Bennington, Burlington, Rutland, and Underhill). 24-hour filter samples are collected at three permanent sites (Burlington, Rutland, Underhill) using EPA low-volume FRM samplers on tare weighed 47 mm Teflon filters on a 1-in-3 or 1-in-6 day EPA schedule.
- PM_{10}: This program measures ambient concentrations of particulate matter equal to or smaller than 10 microns in diameter. This was required in response to a new EPA NAAQS promulgated in 1985. 24-hour filter samples are collected at three permanent sites (Burlington, Rutland, and Underhill) using EPA FRM samplers on tare weighed 47 mm Teflon filters on a 1-in-3, 1-in-6, or 1-in-12 day EPA schedule.
- $PM_{10\text{-}2.5}$: Also referred to as 'PM Coarse' or 'PMc,' this is particulate matter that is smaller than 10 microns but greater than 2.5 microns in diameter. Vermont AQCD uses paired gravimetric FRM samplers to calculate the mathematical difference in PM_{10} and $PM_{2.5}$ samples collected on the same day. $PM_{10\text{-}2.5}$ is required for NCore.
- NCore: The Underhill site is part of this national EPA network of approximately 75 sites in the country which measure trace level NO/NOy (Total Reactive Nitrogen), trace level SO_2 and trace level CO, as well as O_3, $PM_{2.5}$, PM_{10}, $PM_{10\text{-}2.5}$ and Meteorology (covered in a separate QAPP). NCore sites are typically located at sites with NATTS and IMPROVE speciation, which is the case here (these are covered in separate QAPPs). Monitoring is accomplished using continuous trace level FEM analyzers, filter-based FRM particulate samplers and continuous FEM particulate monitors.
- $PM_{2.5}$ Black Carbon: Vermont operates an Aethalometer at the Rutland site that measures ambient concentrations of black carbon (BC), which is the most strongly light-absorbing component of particulate matter. It is formed by the incomplete combustion of fossil fuels, biofuels, and biomass. Monitoring is accomplished with an Aethalometer which collects aerosol particles continuously. Air is drawn through a spot on a filter tape and analyzed by measuring the transmission of light through the sampled portion of the filter tape versus an unloaded (reference) portion of filter tape. This analysis is done at seven optical wavelengths spanning the range from the near-infrared to the near-ultraviolet. The measurement at 880 nm is the defining standard used for reporting black carbon concentration. There is no standard specifically for BC.

Table 5.1 National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table)

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		Primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (NO_2)		Primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 µg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 µg/m^3 as a calendar quarter average) also remain in effect.

(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require NAAQS.

Section 6. Project Description and Schedule

6.1. Monitoring Network Description

6.1.1. The AQCD currently operates a permanent network of five sites which are participants in five EPA monitoring programs or networks (SLAMS, NCore, NATTS, IMPROVE, CSN). Each year the AQCD submits an Air Monitoring Network Plan to EPA which summarizes the monitoring network and describes each monitoring station as it is currently configured including parameters, siting, monitoring objectives and includes any proposed changes over the next year. A copy of the current plan is included in Appendix B.

6.1.2. All sites are designed to meet *EPA 40 CFR Part 58, Appendices A, C, D, E*, and Measurement Quality Objectives identified in Table 7.1 to obtain high quality data which meets DQOs for each program.

6.1.3. The map of Vermont in Figure 6.1 indicates the approximate location of each site, the parameters measured, and the applicable EPA network. Table 6.1 lists the pollutants monitored, site designation, monitoring objective, scale of representation, operating schedule and frequency for each site. The details of the monitoring network are described the Annual Network Monitoring Plan in Appendix B.

6.1.4. Continuous monitoring is performed for CO, SO_2, NO_2, NO, NOx, NOy, NOy-NO, O_3, $PM_{2.5}$, PM_{10} and BC. "Continuous" refers to the ongoing determination of hourly average concentrations based on the generation of 1-minute sub-averages. Specific analyzers used are listed in Table 6.2 and the EPA FRM/FEM compliance is indicated.

6.1.5. Ozone monitoring is conducted year-round in Bennington, Underhill and Rutland, although the EPA designated monitoring season for Vermont is identified as April 1 to September 30. Design values are calculated only within the designated monitoring season.

6.1.6. Filter-based sampling for $PM_{2.5}$, PM_{10} and $PM_{10-2.5}$ is conducted using EPA FRM samplers and tare weighed 47 mm Teflon filters on a 1-in-3, 1-in-6 or 1-in-12 day EPA schedule. Samples are collected over 24-hours beginning at midnight of the sampling day. Filters are tare- and post-weighed by Wood LLC. Filters are sampled less than 30 days after the tare weighing, recovered within 7 days, 9 hours of the sample end time, stored at $\leq 4°C$, and post-weighed less than 30 days after sampling.

Figure 6.1 2019 Vermont Ambient Air Monitoring Network Map

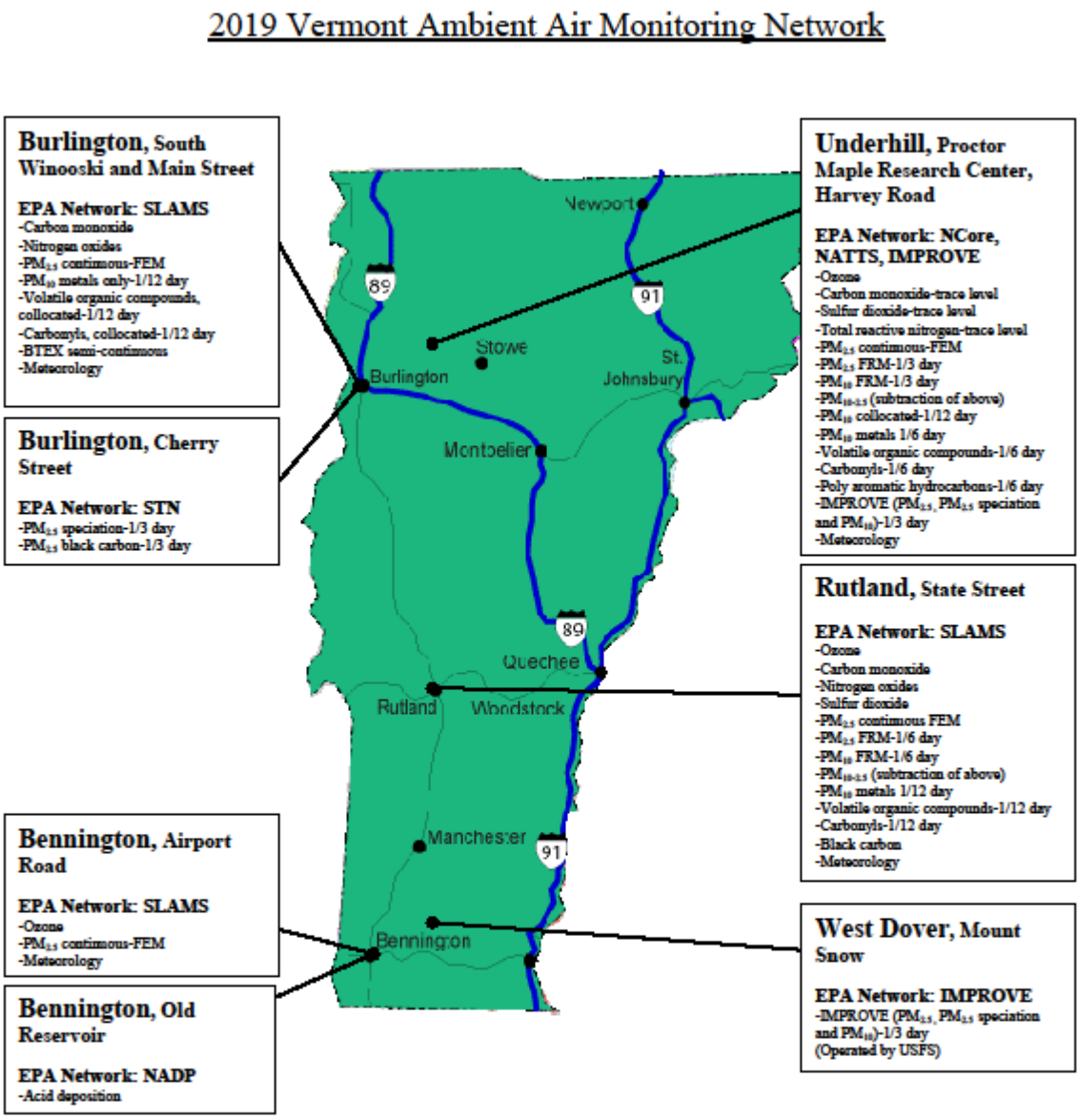


Table 6.1 Vermont Monitoring Network Site Summary

Location	AQS Site Identifier	Location	Network	Parameters Monitored	Scale of Representation	Monitoring Objective
Bennington	50-003-0004	Airport Road, Bennington VT	SLAMS	O_3, $PM_{2.5}$	Regional	Background Transport Population
Burlington, Main Street	50-007-0014	150 South Winooski, Burlington, VT	SLAMS	CO, BTEX, NO, NO_2, NOx, VOC, Carbonyl, $PM_{2.5}$, PM_{10}, PM_{10} Metals	Neighborhood/ Middle	Population
Burlington, Zampieri	50-007-0012	108 Cherry St, Burlington, VT	STN	$PM_{2.5}$ speciation, carbon	Neighborhood	Population
Rutland	50-021-0002	96 State Street, Rutland, VT	SLAMS	CO, NO, NO_2, NOx, SO_2, O_3, $PM_{2.5}$, PM_{10}, $PM_{10-2.5}$, PM_{10} Metals, VOC, Carbonyl, BC-$PM_{2.5}$	Neighborhood	Population
Underhill	50-007-0007	PMRC, Underhill, VT	SLAMS NCore NATTS IMPROVE CASTNET* NADP*	CO, NO, NOy-NO, NOy, SO_2, O_3, $PM_{2.5}$, PM_{10}, $PM_{10-2.5}$, PM_{10} Metals, IMPROVE, VOC, Carbonyl, PAHs	Regional	Background Population

* operated by Forest Ecosystem Monitoring Cooperative (FEMC)

Table 6.2 Methodology & Monitoring Equipment

Method	Manufacturer/Model	EPA Reference Number
$PM_{2.5}$		
Manual Gravimetric Low-Volume Sampler with VSCC	Thermo Environmental Inc. 2000i Thermo Environmental Inc. 2025i	EQPM-0202-143 EQPM-0202-145
Continuous-Broadband Spectroscopy Using Light Scattering with Polychromatic LED	Teledyne Advanced Pollution Instrumentation, Inc. T640	EQPM-0516-236
PM_{10}		
Manual Gravimetric Low-Volume Sampler	Thermo Environmental Inc. 2000i Thermo Environmental Inc. 2025i	RFPS-1298-126 RFPS-1298-127
Continuous-Broadband Spectroscopy Using Light Scattering with Polychromatic LED	Teledyne Advanced Pollution Instrumentation, Inc. T640	NA (Method Code 236)
$PM_{10-2.5}$		
Paired Gravimetric Difference PM_{10} - $PM_{2.5}$	Thermo Environmental Inc. 2025i/2000i	RFPS-0509-176
Black Carbon $PM_{2.5}$		
Optical Absorption	Magee Scientific Aethalometer Model AE33	NA (Method Code 894)

Method	Manufacturer/Model	EPA Reference Number
Sulfur Dioxide		
Pulsed Fluorescent Technique	Teledyne Advanced Pollution Instrumentation, Inc. T100	EQSA-0495-100
	Teledyne Advanced Pollution Instrumentation, Inc. T100U	EQSA-0495-100
Ozone		
Ultra-Violet Absorption Technique	Teledyne Advanced Pollution Instrumentation, Inc. T400/400E	EQOA-0992-087
Carbon Monoxide		
Non-Dispersive Infrared Technique	Teledyne Advanced Pollution Instrumentation, Inc. T300	RFCA-1093-093
	Teledyne Advanced Pollution Instrumentation, Inc. T300U	RFCA-1093-093
Nitrogen Dioxide		
Chemiluminescence Technique	Teledyne Advanced Pollution Instrumentation, Inc. T200	RFNA-1194-099
Total Oxides of Nitrogen (NOY)		
Chemiluminescence Technique	Teledyne Advanced Pollution Instrumentation, Inc. T200U (NOy)	NA (Method Code 699)

6.2. Network Operations Review

All monitoring staff are responsible for on-going assessment of operations and data quality relative to the specific monitoring objectives.

6.2.1. Continuous data are collected to a central database using Agilaire AirVision software. Site data loggers are polled for data using automated routines every 5-minutes for 1-minute data, and hourly for hour averages. Automatic data processing also occurs within this program using various reports and data flagging operations. Minute average data is used for close inspection of suspect data periods. Hourly data are properly coded for upload to AQS. Where available, the continuous $PM_{2.5}$ data are compared to the filter based FRM values using 24-hour averages of 1-hour data.

- The MDLs identified in AQS are for designated instrument methods and are determined by the EPA for criteria pollutants instruments. Both LDLs and MDLs are identified in Table 6.3. All data is submitted to AQS where only data that is less than the absolute minimum defined in AQS is rejected by the import procedure.

6.2.2. Particulate sample concentration for manual filter-based samplers is calculated from the flow and operational data downloaded from the samplers and the net mass (the difference in final and initial filter weights) received from Wood LLC. The concentration in $\mu g/m^3$ is calculated as the net mass divided by the total sampled volume.

- Calculated concentrations for 24-hour filter-based $PM_{2.5}$ and PM_{10}, will be reported to AQS unless the calculated concentration is below the lower limit in AQS, in which case, the sample is invalidated.

Table 6.3 Minimum Detection & Range Limits

Pollutant	MDL	Operating Range*
CO	0.5 ppm	10 ppm
NO/NOx	0.01 ppm	360 ppb
NO_2	0.001 ppm	
O_3	0.005 ppm	150 ppb
SO_2	0.002 ppm	120 ppb
CO Trace Level	0.02 ppm	2.2 ppm
NO/NOy Trace Level	0.05 ppb	120 ppb
NOy-NO Trace Level	0.05 ppb	
SO_2 Trace Level	0.2 ppb	36 ppb
$PM_{2.5}$ Continuous	NA	NA
PM_{10}	4 $\mu g/m^3$	NA

*: values based on 3-year average of ambient concentrations

6.3. Record Keeping and Reporting

6.3.1. All instrument maintenance and quality assurance/performance audits are documented in the Monitoring database using web-based data entry forms.

- Information pertaining to monitoring site conditions are recorded in “unit history” records, including notable weather events, construction, vandalism, and activities within the vicinity of the monitoring trailers.
- Instrument maintenance and troubleshooting is recorded in “unit history” records.
- One-Point QC checks for gas analyzers are recorded in “precision” records.
- Monthly Flow Verifications for particulate samplers are recorded in “flow audit” records.
- Calibration information is stored as a gas calibration or flow calibration record as appropriate.

6.3.2. All validated data, monitor specifications and site descriptions pertaining to all ambient air monitoring sites in the network will be stored in AQS.

6.4. AQS Data submittal

6.4.1. Criteria pollutant data will be submitted within 90 days after the end of the quarter it was collected in.

6.4.2. Non-criteria ambient air pollutant and meteorological data is also uploaded to AQS as close as possible to 90 days after the quarter.

6.4.3. The current AQS database contains data from 1993 to present. Monitoring site information can also be obtained from AQS. On special request, EPA can retrieve and provide data prior to 1993.

Section 7. Data Quality Objectives and Measurement Performance Criteria

EPA OAQPS will be responsible for defining the Data Quality Objectives (DQO) for criteria pollutants as they apply to the end-users or decision makers.

DQOs are statements that define the suitable type of data to collect, specify acceptable levels of potential error by setting control limits for precision and bias, and limits for data completeness of a data set. These measures of performance are used to define quality of data collected to support the intended monitoring objective.

7.1. EPA Data Quality Assessments (DQA)

The EPA has established the following requirements for assuring data of high quality: Quality Assurance Performance Evaluation for each gas analyzer performed annually and the PM monitor flow checks biannually, One-Point Performance checks on analyzers every two weeks, and PM monitor flow checks monthly.

EPA has outlined methods for determining if DQO established by the state program have been achieved: Review program DQO, Review network design, Conduct data review, Conduct statistical tests on data set(s), Verify statistical test results, Define conclusion of data.

7.2. EPA New England Region 1 Objectives

Objectives for the New England Region (CT, MA, ME, NH, RI, VT) are to determine the transport of air pollutants into and out of New England states, determine background levels of air pollutants, determine high concentration areas, determine representative concentrations of pollutants in high population areas, and determine impact that significant sources of pollutants have on ambient levels in order to protect human health and the natural environment.

7.3. State of Vermont DQO and Measurement Quality Objectives (MQO)

The Vermont AQCD DQOs are to determine representative concentrations in population and background areas, provide data to the public and EPA in a timely manner, to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS), issue appropriate health advisory alerts, determine pollution trends, provide data for research, and determine spatial and temporal representations of pollutant concentrations in Vermont.

To meet these DQOs, Vermont operates air monitoring equipment within a set of established MQOs designed to control measurement uncertainty below the levels required for the DQOs. A summary of the data quality assessments (DQAs) and the applicable acceptance criteria used to assess the MQO indicators (precision, bias, representativeness, detection limit, completeness and comparability) are specified in Table 7.1.

- Precision – a measure of mutual agreement among individual measurements of the same property usually under prescribed similar conditions. This is the random component of error. Precision is estimated by various statistical techniques using some derivation of the standard deviation.
- Bias – the systematic or persistent distortion of a measurement process which causes error in one direction. Bias will be determined by estimating the positive and negative deviation from the true value as a percentage of the true value.

- Representativeness – a measure of the degree which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.
- Detectability – The determination of the low range critical value of a characteristic that a method specific procedure can reliably discern.
- Completeness – a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. Data completeness requirements are included in the reference methods (*40 CFR Part 50*).
- Comparability – a measure of confidence with which one data set can be compared to another.

Table 7.1 Vermont MQOs

Pollutant	Precision*	Accuracy/Bias*	Representa-tiveness	Comparability	Completeness	Detectability (MDL)
CO, SO_2	Bi weekly 1-pt check ≤ ±10%	Annual PE Audit ≤ ± 15%	Table 6.1	FRM (Table 6.2)	≥ 75%	Table 6.3
NO_2/NO/ NOx/NOy	Bi weekly 1-pt check ≤ ±15%	Annual PE Audit ≤ ± 15%	Table 6.1	FRM (Table 6.2)	≥75%	Table 6.3
O_3	Bi weekly 1-pt check ≤ ± 7%	Annual PE Audit ≤ ± 15%	Table 6.1	FRM (Table 6.2)	≥ 75%	Table 6.3
$PM_{2.5}$/PM_{10} filter	Collocated sampling, 1/6 days ≤ 10% CV (for samples >3 µg/m^3)	Semi-annual flow Audit ±4% of std. PEP Audit ≤10% (for samples >3 µg/m^3)	Table 6.1	FRM (Table 6.2)	≥ 75%	Table 6.3
$PM_{2.5}$ Continuous	Collocated with FRM at one site per method, 1/6 days ≤10% CV (for samples >3 µg/m^3)	Semi-annual flow Audit ±4% of std. PEP Audit ≤10% (for samples >3 µg/m3)	Table 6.1	FEM (Table 6.2)	≥ 75%	Table 6.3
$PM_{2.5}$ BC	NA	Annually	Table 6.1	NA	≥ 75%	NA

* see Table 20.2 for Precision audit input levels

Section 8. Special Training Requirements

Personnel assigned to complete activities identified in this QAPP and the related SOPs will meet the educational, experience, responsibility, and training requirements identified by the Division Director or Supervisor. Training can come from a variety of individuals and sources including the Supervisor, senior staff, EPA training courses, equipment manufacturer training and college course work.

Training will be provided with the goal of creating highly skilled staff. Individualized training opportunities will be provided for each new employee. Training will initially focus on providing an overall understanding of operations, regulations, monitoring methods and equipment theory. The training will involve the intensive involvement of the Supervisor and senior staff. All staff members must read and understand this QAPP and related SOPs as well as the *EPA QA Handbook Volume II* and other applicable EPA Guidance documents as well as information related monitoring method and equipment theory.

New staff will be expected to visit the EPA AMTIC website to review pertinent documents and observe training videos (i.e. NCore) and to take APTI self-instruction courses *SI-434 Introduction to Air Monitoring* and *SI 471 General Quality Assurance Considerations for Ambient Air Monitoring* within the first six months of employment.

Successful completion of a training program by new staff will be judged by the Supervisor, senior staff trainers and the staff member. The new staff member will maintain a document which lists specific instrument and site-specific tasks which require demonstrated proficiency observed by the Supervisor or senior staff member. This information will be transferred to an electronic version and will become the official training record which the Supervisor will maintain on the ANR 'Y' drive and in the employee's personnel file. Records will indicate successful completion of training and comments of observations will be documented. This record will be updated with subsequent ongoing EPA or Vendor Training.

Staff members are encouraged to pursue certification through the NESCAUM Clean Air Academy. Work time will be provided for participation in this program. Below are links to other pertinent training opportunities:

- Air Pollution Training Institute (apti-learn.net)
- AMTIC (epa.gov/amtic)
- EPA Air Quality Planning & Standards (epa.gov/airquality)
- EPA Environmental Education Offices (epa.gov/education)
- Office of Air and Radiation (epa.gov/oar)
- NESCAUM (nescaum.org/topics/training-clean-air-academy)
- Agilaire (agilairecorp.com/video-training-resources/)
- Vendor training (i.e. API)
- Knowledgewave (training for Microsoft office products)

Section 9. Documentation and Records

9.1. Data Acquisition

9.1.1. Continuous measurement data will be acquired, averaged, stored, evaluated and reported to AQS using Agilaire data loggers (8832, 8872) at each site and AirVision software reporting system. Data will be downloaded from sites hourly, at a minimum. All continuous data review, local storage and reporting will be performed using the Agilaire AirVision system (*SOP 5601 AirVision*) in combination with other software (i.e. Excel) as appropriate.

9.1.2. Concentration calculation and reporting for filter based particulate data is performed in the Monitoring database (*SOP 6030 Particulate Data Validation*).

9.1.3. Filter sample collection events are recorded on paper data sheets that document setup, pick up, sample days, and any observations of these events. The sample specific information is entered to the Monitoring Access database.

9.2. Electronic Logbook

9.2.1. A web-based data entry site will be used to document each routine task (i.e. audit/calibration). The following information will be recorded: site location, date, operator name, analyzer/sampler unit ID, standard unit ID, all settings and observations made, input and response levels, percent error and any maintenance performed. The information is stored in the dedicated AirMonitoring SQL database. The database is used to evaluate monitor performance and assist in data validation.

9.2.2. Logbook type data pertaining to field related activities are entered to the Monitoring database using password protected web forms that are available via any internet browser. Whenever possible, records are entered while on site, upon completion of the task. This generally includes QC tasks (flow and gas audits), calibrations and analyzer maintenance.

9.3. Record Retention

9.3.1. Consistent with the statute of limitations specified in *40 CFR Part 31.42*, all paper records will be retained for at least three years from the end of the year they are generated. $PM_{2.5}$ samples and datasheets will be kept for at least 10 years, although we recognize a potential value in these samples and our policy is not to throw them out. Electronic records are considered "significant" consistent with *VT DEC Records Management Procedure GRS1000.1063* and thus will be retained without a time limit.

9.3.2. All electronic and hardcopy revisions of QAPP and SOPs will be retained at least 3 years after they are revised or superseded.

9.3.3. The AirVision database is backed up daily by the DEC IT division. Archived data is stored on Y drive, which is also backed up daily.

9.4. Data Reports

9.4.1. The EPA AQS database is the official final repository of all validated data. Any request for data (public or Agency) will be satisfied with reports directly queried from AQS.

9.4.2. Near term data that is reported automatically every hour will be identified as "un-validated and subject to change" (for example on AirNow and Vermont AQCD website).

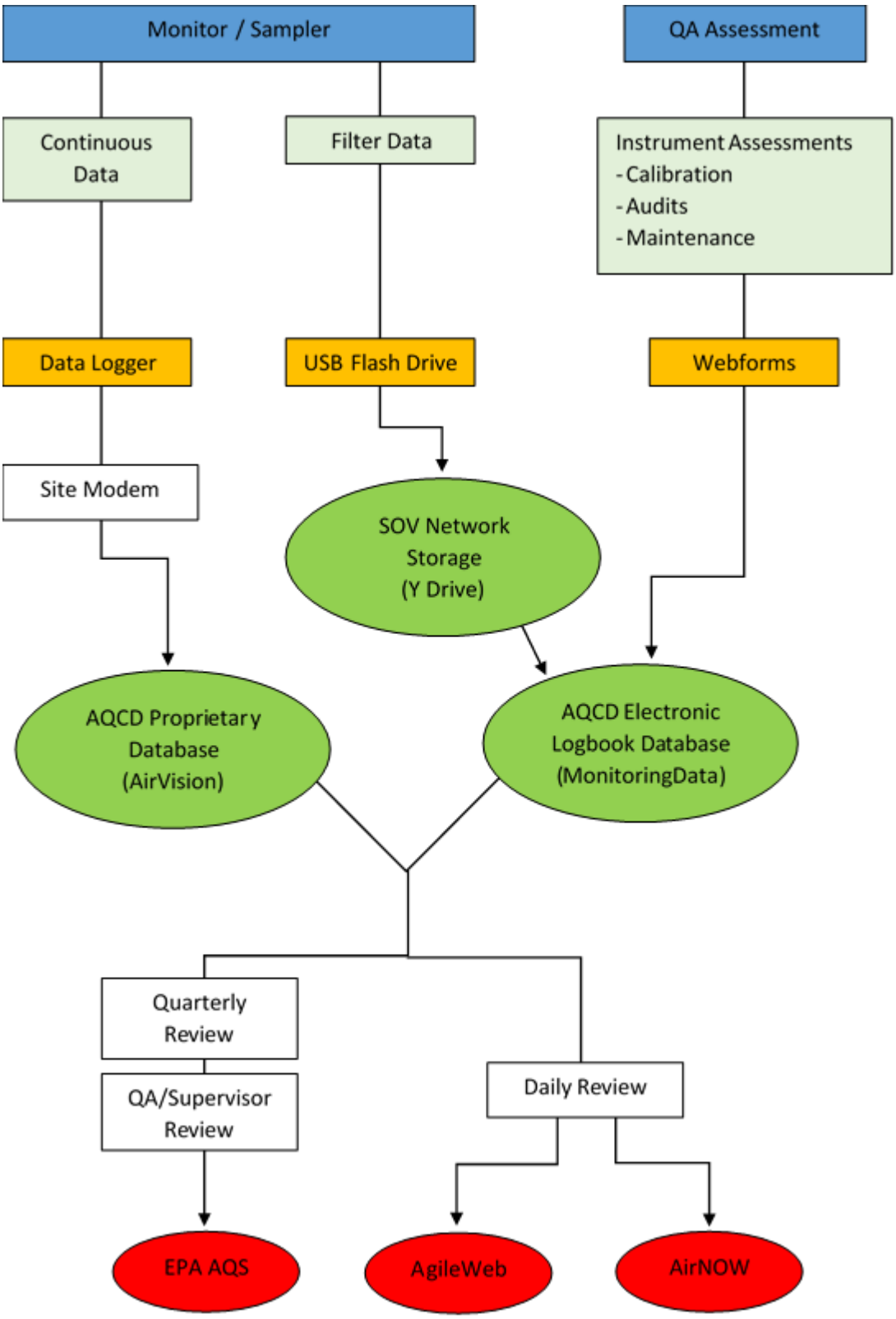
9.4.3. The data reports submitted to EPA are listed in Table 9.1. Summaries of these reports will also be provided to the AQCD at Staff Meetings.

9.4.4. Any data is available on request.

Table 9.1 EPA Report Submittal Schedule

Name of Report	Annual Reporting Date(s)
Quarterly upload of measurement and precision and accuracy data into AQS	within 90 days of the end of the quarter
Annual network review	July 1
Annual data certification	May 1
Annual QAPP review/revision	November 1
Annual PM2.5 Grant Performance Report	January 31

Figure 9.1 Data Flow Diagram



Section 10. Network Process Design

Consistent with *40 CFR Part 58.10*, the Supervisor annually reviews the appropriateness of the monitoring network and determines any necessary changes that should take place by the first of the next year (to allow for complete annual datasets). These proposed changes and the current network design are identified in the Vermont Annual Air Monitoring Network Plan (see Appendix B), which must be put on the AQCD website for a 30-day public review and comment period prior to submittal to EPA by July 1 for review and approval.

10.1. Monitoring Site Selection

10.1.1. The overall data quality objectives of the monitoring network are to determine representative concentrations in areas of high population density and background/transport concentrations for NAAQS compliance, and to identify pollution trends and transport effects. These objectives meet obligations for participation in the SLAMS, NCore, STN and IMPROVE networks.

10.1.2. Permanent monitoring sites are installed consistent with the requirements in *40 CFR Part 58 Appendices D, E*.

10.2. Pollutant Selection

10.2.1. Based on the monitoring objectives and monitoring network participation identified above, the target pollutants for the VT AQCD network covered by this QAPP are CO, SO2, NO2, NO, NOx, NOy, NOy-NO, O3, PM2.5, PM10, PM10-2.5 and BC.

10.2.2. Sampling Equipment

10.2.3. To comply with EPA *40 CFR Part 58* all continuous criteria pollutant gas analyzers and $PM_{2.5}$/PM_{10} samplers (sequential and continuous) operated in the network will be designated as a FRM/FEM.

10.2.4. Pollutants measured and reported that are not criteria pollutants use methods recognized by EPA but are not strictly reviewed in the annual certification process.

10.2.5. Refer to Table 6.2 for details on all equipment currently operated in the network.

10.3. Sampling Frequency

10.3.1. The operating schedule and sample collection frequency is described in Section 6 and is based on requirements in *40 CFR Part 58*. Sampling frequency is subject to the approval of EPA New England.

Section 11. Monitoring/Sample Method Requirements

All monitors are sited as per *40 CFR Part 58, Appendix E*. Monitoring for criteria pollutants is accomplished using EPA reference or equivalent methods. Table 6.2 includes a list of instruments operated by Vermont AQCD and their respective EPA FRM or FEM designation numbers. Analytical method summaries are provided in Section 13. All monitors are installed and operated consistent with *40 CFR Parts 53 & 58*, *EPA QA Handbook, Volume II*, *EPA QA Guidance document 2.12,* and manufacturer's operation manuals.

11.1. Continuous gas analyzers

11.1.1. Analyzers are rack mounted in temperature controlled shelters manufactured by EKTO Manufacturing Corp. They are connected by ¼" FEP Teflon (or equivalent) to a common borosilicate glass manifold. At each site, an inlet tube (glass or Teflon) is positioned approximately a meter above the shelter roof and is connected with leak free fittings to the glass manifold inside the shelter. A blower fan is connected to the manifold exhaust drawing ~50 CFM of ambient air through the manifold. A magnehelic gauge is connected to the last manifold port to verify pressure differential at that point, confirming positive flow through the system.

11.1.2. Each monitoring shelter includes an automated dilution calibrator (a mass flow controlled gas blender/UV photometer) and zero air system used together to audit and calibrate the gas instruments.

11.1.3. Each monitoring shelter includes a data logger. Each station data logger is automatically polled each hour by the central server at National Life in Montpelier, VT (running AirVision software) for 1-minute, 5-minute and 1-hour average results. This data is automatically stored in a dedicated SQL database.

11.1.4. The gas monitors operate continuously providing "instantaneous" output which is used to generate 1-minute base averages which are then used for discrete 5-minute and 1-hour average values.

11.2. $PM_{2.5}$, PM_{10} and $PM_{10-2.5}$ FRM samplers

11.2.1. PM FRM samplers are mounted on the roof of each monitoring shelter.

11.2.2. Teflon filters provided by EPA are sent to Wood LLC gravimetric lab for each calendar year. The lab inspects filters according to the EPA criteria (*40 CFR Part 58* and *EPA Guidance 2.12*) and their SOP (see Appendix C *SOP GLM3180-009 Determination of Particulate Matter (PM) Gravimetric Mass for the Chemical Speciation Network Revision 2, May 2018.*). Filters that don't meet the criteria are rejected for sampling. Good filters are tare weighed and shipped to the AQCD to be used for sample collection.

11.2.3. Tare weighed filters are loaded in magazines used for FRM samplers. (*SOP 3009 Filter Handling*).

11.2.4. The sequential filter samplers are configured to collect 24-hour samples from midnight to midnight on an EPA published 1-in-3 day or 1-in-6 day schedule (*SOP 3095 PM Filter Sampling Field Procedures*).

11.2.5. Filter samples must be recovered within 7 days, 9 hours of the sample date.

11.2.6. Sampled filters returned from the field sites are removed from the sampler magazines, stored in protective slides, processed and express shipped to Wood LLC in coolers with blue ice packs to maintain < 4°C for delivery through final weighing.

11.2.7. Sample filters stored < 4°C must be weighed within 30 days of sample collection.

11.2.8. Wood LLC lab results with tare and final weights, and filter equilibration information, including weighing room temperature/RH% and calibration weight/blank filter checks, are delivered to AQCD in electronic format (i.e. MS Excel spreadsheet).

11.3. Continuous $PM_{2.5}$ FEM monitors

11.3.1. Monitors are located inside monitoring shelters with the sample inlet positioned ≥ 1 meter above the shelter roof using a sealed pass-through port.

11.3.2. These monitors operate continuously providing "instantaneous" output which is used to generate 1-minute base averages which are then used for discrete 5-minute and 1-hour average values.

11.3.3. These are designated as "primary" monitors for EPA AQS reporting and for NAAQS compliance.

11.3.4. EPA requires Vermont to collocate one continuous FEM sampler with the FRM on 1-in-6 day sampling frequency. This is accomplished at the Rutland site.

11.3.5. The T640 sampler also collects non-FEM PM_{10} continuous data. This data is submitted to AQS for informational use only, not for NAAQS compliance.

11.4. Black Carbon $PM_{2.5}$

11.4.1. A black carbon monitor is located inside the designated monitoring shelter with the sample inlet positioned approximately 1 meter above the shelter roof using 5/8" static-dissipative polymer tubing, with a $PM_{2.5}$ size selective inlet.

11.4.2. This monitor is designed to provide instantaneous continuous black carbon concentration results which are used to generate 1-minute base averages which are then used for discrete 5-minute and 1-hour average values for seven different wavelength channels.

11.5. Shelter Environment

11.5.1. Monitoring sites are checked for acceptable shelter temperature, sampling configuration, cleanliness, and general condition on every site visit.

11.5.2. Any compromises in the quality and security of the shelter trailers are addressed as soon as possible, these may include physical barriers, roof leaks, graffiti, etc.

Section 12. Sample Handling and Custody Requirements

12.1. Filter based $PM_{2.5}$, PM_{10} and $PM_{10-2.5}$

12.1.1. Teflon 47 mm filters for each calendar year are obtained through EPA.

12.1.2. Filter sample handling includes shipping, receiving, inspecting ("pin-holing"), weighing, loading, unloading, setup and pickup for $PM_{2.5}$ and PM_{10} sample collection. A chain of custody is maintained though these stages.

12.1.3. The filters are inspected ("pin-holed"), tare and final weighed by Wood LLC following their SOP.

12.1.4. Tare-weighed filters are shipped to the AQCD's FOC where they are loaded into a protective cassette which is then placed in a designated sampler magazine or filter tray depending on the sampling schedule. (*SOP 3009 Shipping and Receiving CT Filters*).

12.1.5. The staff retrieve the prepared samples at the FOC and transport them to each site for setup prior to the scheduled sample day. After the sample day, filters are recovered and returned to the FOC (*SOP 3095 PM Filter Sampling Field Procedures*). The field data sheet is filled out on sample set up and retrieval. It serves as a chain of custody that contains the date and staff's initials for setup and recovery, the actual sample day and status codes on the sampling (if any).

12.1.6. The electronic filter and operational records are downloaded from the sampler and sent to the office via email or brought on USB drive where the files are uploaded to the MS Access "Monitoring" database for review.

12.1.7. As soon as possible after samples are returned to the FOC, the samples are unloaded and each filter is placed in a protective slide and processed for express shipment to Wood LLC in coolers with ice packs (< 4 °C) for post weighing within 30 days of sampling per the reference method.

12.1.8. A chain of custody report is generated for each filter shipment to the lab. The COC contains the Filter ID, Sample Date, Sample Type, and Ship Date.

12.1.9. Archive storage of filters per *40 CFR Part 58.16 (f)* is a minimum period of 5 years after collection, which shall include cold storage of filters after post-sampling laboratory analyses for at least 12 months following field sampling. The EPA recommends that particulate matter filters be archived for longer periods for making NAAQS related decisions or for supporting health related air pollution studies, especially for key sites.

12.2. Details of Wood LLC's weighing operation are found in their SOP, located in Appendix C.

Section 13. Analytical Methods Requirements

13.1. Gas Analyzers

13.1.1. Intake manifolds are made of borosilicate glass or Teflon tubing (with Teflon lined rain cap), meet all residence time requirements of the EPA methods/QA Handbook and are ≥ 1 m above the shelter roof. Instrument sample lines are ¼" FEP Teflon or equivalent.

$$Residence\ Time\ (s) = \frac{Volume\ of\ Flowpath}{Flowrate} = \frac{3.14 * Radius(m)^2 * Length(m)}{Flowrate(ccm)} * \frac{60s}{min} * \frac{1000cm^3}{m^3}$$

13.1.2. Each gas analyzer has a 2 or 5 micron Teflon particulate filter attached to the sample manifold inlet line which is exchanged every 2 weeks.

13.1.3. Instruments have analog (0-1 VDC), serial (GSI), or Modbus (RJ45) outputs configured to interface to the 8832 or 8872 Agilaire data logger.

13.1.4. Operating ranges and MDLs are listed in Table 6.3. Calibration gas input levels are specified in Table 16.1.

13.1.5. Ozone analytical method requirements are detailed in the Reference Method, *40 CFR Part 50, Appendix D*. The AQCD operates Teledyne API Model 400 ozone analyzers. The API ozone analyzer utilizes the UV photometry principle which uses ozone's ability to absorb UV light. Ambient air is passed through a reference and sample measurement cell where UV absorbance is compared between the ambient air containing ozone to reference air where ozone has been removed. The difference is proportional to the concentration of ozone in the ambient air.

13.1.6. Carbon Monoxide analytical method requirements are detailed in the Reference Method, *40 CFR Part 50, Appendix C*. The AQCD operates Teledyne API T300 and T300U CO analyzers. Both analyzer models utilize the non-dispersive infrared (NDIR) principle which uses the CO molecule's ability to absorb IR light to determine concentration. A beam of broad-band IR light is passed through a spinning filter wheel which contains high concentration CO+N_2 on one side and only pure N_2 on the other side. The IR light is then directed through a multi-pass measurement cell filled with sample gas. The attenuated light passing through the CO reference side is compared to the N_2 reference side (CO zero reference) and the difference is proportional to the concentration of CO in the ambient air.

13.1.7. Nitrogen Dioxide and Total Reactive Oxides of Nitrogen analytical method requirements are detailed in the Reference Method, *40 CFR Part 50, Appendix E.* The AQCD operates Teledyne API Model T200 NO_2 and T200U NOy analyzers. Both models utilize the chemiluminescence principle which uses the light emitted from the reaction of NO and O_3 to determine NO and NOx (or NOy) concentrations. The analyzer design incorporates a heated converter which causes a reaction where any NO_2 in the ambient air sample is converted to NO. The alternate measurement cycles of NO (unconverted) and NOx (NO_2 converted + NO) enable the instrument to report NO_2 by the difference (NOx – NO). Similarly, the converter in the NOy analyzer converts all reactive oxides of nitrogen to NO, thus the difference (NOy – NO) can be reported.

13.1.8. Sulfur Dioxide analytical method requirements are detailed in the Reference Method, *40 CFR Part 50, Appendix A*. The Vermont AQCD operates Teledyne API T100 and T100U analyzers. Both analyzers utilize the pulsed fluorescence principle which measures the fluorescence (UV @ 330nm) that is emitted when SO_2 is excited by exposure to UV light between 190-230 nm wavelength.

13.2. Continuous $PM_{2.5}$

13.2.1. The sample inlets are made of ¾" aluminum tubing, with the inlet at ≥ 1 m above the shelter roof, through a weather sealed pass-through, and to the instrument installed inside the shelter.

13.2.2. The TAPI T640 uses Modbus protocols configured to interface to the 8832 or 8872 Agilaire data logger.

13.2.3. Continuous $PM_{2.5}$ FEM requirements are detailed in the Reference Method, *40 CFR Part 50, Appendix L* and *40 CFR Part 53, Subparts A, C, and E.* The T640 instrument is an automated microprocessor controlled sampler using ambient temperature and pressure compensated flow to control and maintain the design flowrate of 5 L/min. The Model T640 is a direct measuring optical aerosol spectrometer that converts optical measurements to mass measurements by determining sampled particle size via scattered light at the single particle level according to Lorenz-Mie Theory. The sampling head draws in whole air ambient sample, which passes through the Aerosol Sample Conditioner (ASC) and then to the optical particle sensor where scattered polychromatic light intensity is measured to determine particle size diameter. The polychromatic LED, combined with a 90° scattered light detection achieves a precise and unambiguous calibration curve in the Mie range, resulting in a large size resolution. Each particle generates a scattered light impulse that is detected at an 85° to 95° angle where amplitude and signal length are measured. The amplitude (height) of the scattered light impulse is directly related to the particle size diameter.

13.3. FRM Particulate Filters

13.3.1. The Vermont AQCD operates TEI 2025i sequential samplers where 1-in-3 day samples are collected, and the 2000i where samples are collected at 6- or 12-day frequency.

13.3.2. The FRM $PM_{2.5}$ and PM_{10} method requirements are detailed in the Reference Method, *40 CFR Part 50, Appendix L* and *Appendix J.* The reference method is a low-volume gravimetric determination using a tare-weighed 47 mm Teflon filter. The samplers use an automated microprocessor and flow controller with a standard PM_{10} size selective inlet to control the design flowrate of 16.67 L/min total flow. Samplers collecting $PM_{2.5}$ have a very sharp cut cyclone (VSSC) which allows $PM_{2.5}$ results to be measured and reported in $\mu g/m^3$. The microprocessor controls the sample collection period and records other sample related information such as flow rate, ambient temperature, filter temperature, ambient pressure, sampling time, and run-time flags that are used to validate the results.

13.3.3. Sample record files containing run-time and sample day information are downloaded onto USB flash drives that are inserted directly to the sampler. The files are then stored on the ANR 'Y' drive.

13.3.4. Details on the analytical methods associated with the gravimetric portion of the program can be found in Wood LLC's SOP. In summary, Teflon filters will be equilibrated for a minimum of 24 hours before tare weighing and post-sample weighing in a rack in the weighing room. The weighing room is positively pressurized with HEPA filtered air, and the temperature and relative humidity are controlled to 20-23°C and 40-45%, respectively. Filters are handled and weighed using an MTL AH225-6 automated filter weighing and data processing system which includes a Mettler XP6 Ultra-Micro Balance. The micro-balance has a resolution to 1 microgram (0.000001 gram) and its performance is checked periodically during a weighing batch process (every 10 filters) by verification of certified span weights (350 mg and 420 mg) and repeated weighing of a sample filter in the batch (re-weigh every 10 filters or 10%). The instrument automatically resets the zero before every sample filter or QC check. Pre- and post-filter weights are stored on the dedicated system computer and sent to the AQCD in excel format. The balance is serviced and calibrated annually by Mettler.

13.3.5. Lab result data is typically provided in Excel files that are emailed to AQCD staff and stored on the state network drive.

13.4. $PM_{10-2.5}$

13.4.1. $PM_{10-2.5}$ concentration results are calculated from the difference in concentration ($\mu g/m^3$) of PM_{10} and $PM_{2.5}$ FRM filters at a given site using the formula $PM_{10-2.5} = PM_{10} - PM_{2.5}$.

13.5. BC $PM_{2.5}$

13.5.1. The aethalometer sample inlet is positioned approximately 1 meter above the shelter roof using 5/8" static-dissipative polymer tubing, with a $PM_{2.5}$ size selective inlet. The tubing passes through the side wall of the shelter and into the back of the instrument.

13.5.2. The Magee AE33 uses Modbus protocols configured to interface to the 8832 or 8872 Agilaire data logger.

13.5.3. The Magee Aethalometer model AE33 collects aerosol particles continuously by drawing the ambient air stream through a spot on the filter tape. It analyzes the aerosol by measuring the transmission of light through the sampled filter tape versus the transmission through an unloaded portion of the filter tape acting as a reference area. This analysis is done at seven optical wavelengths spanning the range from the near-infrared to the near-ultraviolet. The Aethalometer calculates the instantaneous concentration of optically-absorbing aerosols from the rate of change of the attenuation of light transmitted through the particle-laden filter. In the new Model AE33 Aethalometer, two measurements are obtained simultaneously from two sample spots with different rates of accumulation of the sample. Both spots derive their samples from the same input air stream. The two results are combined mathematically to eliminate nonlinearities and provide the compensated particle light absorption and BC mass concentration.

Section 14. Quality Control Requirements

Quality control requirements for all pollutants covered by this QAPP are listed in tables located in Appendix D of this document. QA/QC criteria is excerpted from QA Handbook Volume II, Appendix D, Revision No. 1, 03/17 with the exceptions of the TAPI T640 $PM_{2.5}$ monitor and Aethalometer AE33. The TAPI T640 method is not yet included in the EPA validation template, so criteria currently identified for this method was formulated from a combination of the TAPI operator's manual, performance-based QA Handbook criteria for other FEM continuous methods and the 2018 Draft of the EPA Standard Operating Procedure Teledyne Model 640x Real-Time Continuous PM Monitor. The AE33 does not measure criteria pollutant, so it is not included in the guidance. NOY is treated the same as NO_2 with respect to quality control.

Section 15. Equipment Testing, Inspection and Maintenance Requirements

15.1. Monitoring Shelters

15.1.1. Inspection of the operating condition of all monitoring instruments, manifold/sample lines as well as the overall site condition is performed by all staff with each field visit, following *SOP 0101 General Monitoring Site Condition Check*.

15.1.2. Each monitoring shelter is equipped to perform automatic daily zero/span checks using 24VDC stainless steel solenoid which are connected to the station dilution calibrator/ZAS and the instrument's sample line inlet. Power to the solenoids is controlled by the datalogger.

15.1.3. EKTO Shelters include heat/AC systems which are designed to control temperature to 20-30 °C ± 2 °C.

15.1.4. General maintenance of trailers/enclosures includes, but is not limited to:

- Keep trailers clean and orderly, including floor, desk, instrument racks, tools, cables and tubing.
- Water leaks are identified and remedied as soon as possible. EKTO trailers are built with 'weep-holes' at the base of all four corners. Ensure these are free from obstruction to ensure proper drainage from roof. Use silicone or rubberized roofing compound to seal potential leak sources.

15.2. Monitoring Equipment Acceptance Testing

15.2.1. All monitors used in the AQCD network are designated as federal reference methods (FRM) or federal equivalent methods (FEM) which indicates that their designs have been certified by EPA. Therefore, FRM/FEM designated equipment are assumed to be of sufficient quality to meet the AQCD monitoring network DQOs. The EPA performs FRM/FEM testing through the procedures described in *40 CFR Parts 50 and 53*.

15.2.2. On receipt at AQCD, and prior to field deployment, acceptance testing will be performed at the FOC on all new equipment at the direction of the Supervisor and QA Coordinator.

15.2.3. At a minimum, critical design parameters will be verified. If additional criteria will be assessed, they must be included in the purchase request/order.

15.2.4. Testing will include basic operational functionality (display, software, menus, function keys, pump function, flow, temperature/pressure) and leak checks.

15.2.5. Verification of the manufacturer's published performance specifications for noise, zero and span drift, precision, calibration linearity, and response time will be assessed in the first 10-20 days of deployment to site, ideally collocated with a similar instrument (typically the one slated for replacement).

15.2.6. Equipment that does not perform within test specifications must be repaired by the manufacturer or replaced.

15.2.7. Acceptance testing will be performed by available staff. The QA Coordinator will review acceptance testing results.

15.3. FRM Particulate Filter Inspection

15.3.1. Inspection of calendar year (CY) 47 mm Teflon filters and weighing room conditions is performed by Wood LLC following their SOP. Filters are rejected that do not meet the criteria.

15.3.2. Upon receipt from Wood LLC, the tare-weighed Teflon filters will be inspected by monitoring staff at the FOC prior to loading in the protective cassettes.

15.4. Preventive maintenance

15.4.1. Preventive maintenance activities of gravimetric-related equipment will be performed by Wood LLC gravimetric lab following their SOP.

15.4.2. Preventive maintenance activities associated the AQCD monitoring equipment, such as changing inlet filter or sample lines, cleaning box fan filters or firmware updates is scheduled on a regular frequency and will be based on the Manufacturer's recommendations.

15.4.3. Preventative maintenance activities will be recorded in the Monitoring database as a unit history note with appropriate Task ID.

15.4.4. Preventative maintenance such as roof sealing, grounds (weed trimming), electrical, pneumatic system maintenance is identified in the General Monitoring SOP and is scheduled by the staff as needed.

15.4.5. A spare parts inventory will be maintained at the discretion of the Supervisor. In general, only consumables such as o-rings, v-seals, filters, scrubbers and pumps will be stocked. Other parts will be obtained as necessary.

15.4.6. Based on available resources, backup equipment will be maintained at the FOC and will be used for equipment acceptance testing, and as necessary, to replace malfunctioning or out of control equipment.

Section 16. Instrument Calibration and Frequency

16.1. Gravimetric Operations

16.1.1. Calibrations of the Wood LLC micro-balance will be performed annually.

16.1.2. Calibration checks using a nominal 300 and 500 mg NIST traceable certified weight are performed at the start of each weighing batch and after every 10 sample filters are weighed.

16.1.3. Weighing room Temperature and Relative Humidity Monitoring systems are verified annually during HVAC service.

16.2. Particulate Matter

16.2.1. TEI 2000i/2025i FRM sampler flowrate, temperature and pressure calibrations are verified monthly and adjusted as necessary or annually at a minimum following *SOP 3091 PM Filter Sampler Calibration*.

16.2.2. TAPI T640 FEM sampler flowrate, temperature and pressure calibrations are verified monthly and adjusted if necessary following *SOP 3081 API T640 Continuous PM2.5 Calibration*. The optical detector output is verified monthly with SpanDust and calibrated if necessary (see SOP for details).

16.3. Continuous Gas Analyzers

16.3.1. Gas analyzers are calibrated upon initial installation, following physical relocation, after any repairs or service, following an interruption in operation of more than a few days, upon any indication of analyzer malfunction, if midnight and/or one-point check results exceed the established criteria or every six months at a minimum.

16.3.2. Multipoint calibrations are performed by monitoring staff following *SOP 2001 O3 Calibration* or *SOP 2201 CG Calibration*. Calibration inputs are summarized in

16.3.3. Table 16.1.

16.3.4. Ozone analyzer calibrations are performed using the station ZAS and transfer standard photometer which has been calibrated to a primary O_3 standard at the FOC which is certified annually by EPA Region 1 against their NIST-traceable Standard Reference Photometer (SRP #9).

16.3.5. Continuous CO, NOx, and SO_2 analyzer calibrations are performed using a multi-blend EPA Protocol Gas standard and the station dilution calibrator and ZAS. The calibration span level is dependent on the past three years of routine data. The linearity is verified with 3 points between zero and the calibration span point.

Table 16.1 Calibration and Linearity Points

	Ozone (ppb)	CO (ppm)	SO_2 (ppb)	NO/NOx/ NOy (ppb)	NO_2 (ppb O_3 GPT)
SLAMS	120	10.0	100	300	150
	90	3.0	75	150	120
	60	1.0	40	100	50
	30	0.5	15	30	20
NCORE	120	2.0	30	100	50
	90	1.0	15	60	30
	60	0.5	10	30	15
	32	0.2	5	6	4

16.4. Calibration Standards

16.4.1. Standards used for calibration will either be certified to local primary standards or sent out for certification. Standards requiring periodic calibration and the associated calibration method are listed in Table 16.2.

16.4.2. Standards sent out for calibration must be acceptance tested on return by comparison to another transfer standard. Acceptance testing will be done at the direction of the Supervisor and QA Coordinator.

16.5. Calibration Data

16.5.1. Instrument calibration data will be stored in the Monitoring database by "Unit ID" (a unique unit name, i.e. S1 is sulfur dioxide monitor number 1). Data is entered using the web-based data entry forms.

16.5.2. Calibration datasheets/certification sheets provided by vendors/others will be scanned and stored in the appropriate network folder (Y:\AP_Monitoring\Operations\Documentation), and the paper copy filed in the office by Unit ID.

Table 16.2 Traceable Primary/Secondary Standards Certification Schedule

Unit	Calibration Method
Chinook Streamline Pro Flow Standard With Temperature And Atmospheric Pressure	NIST traceable calibration by the manufacturer
AliCat	NIST traceable calibration by the manufacturer
Compressed Gas Standards (EPA Protocol 1 Standards)	Recertification will be by the supplier per EPA traceability protocol, EPA-600/R-12/531
CME Laminar Flow Element	NIST traceable calibration by CME
Merriam Laminar Flow Rate Elements (Primary)	NIST traceable calibration by CME
Mass Flow Controlled Blender Calibration	AQCD; performed using CME laminar flow rate element system ≤ ±2.0% Accuracy
Ozone Local Primary UV Photometer Referencing	EPA New England; referenced to NIST traceable, regional UV photometer single point difference ≤ ±3%
Ozone Transfer Standard UV Photometer Referencing	AQCD; certified to the local primary standard UV photometer RSD of six slopes ≤ 3.7% Std. Dev. of 6 intercepts ≤ 1.5

Section 17. Inspection/Acceptance Requirements for Supplies and Consumables

17.1. All equipment purchases associated with this QAPP, including supplies and consumables, will be made following Agency guidelines and standard purchase request forms. All purchase requests are authorized by the Supervisor who will ensure to the extent possible the specifications consistent with this QAPP and all applicable EPA requirements or guidance are included.

17.2. All new instruments are acceptance tested as indicated in Section 15.

17.3. All supplies and consumables will be inspected on receipt for defects and consistency with the purchase request. Defective materials will be returned to the vendor.

17.4. All 47mm Teflon filters for the AQCD filter-based particulate samplers will be inspected by Wood LLC.

17.5. New compressed gas standards will be compared to an existing compressed gas standard by comparing a nominal blended concentration within the calibration range, using the same blender and flow rates. The compressed gas standard concentrations must compare to within 4%. Cylinders that fail this test are returned to the vendor (*SOP 5000 Cylinder and Regulator Handling Procedure*).

17.5.1. During cylinder testing, the NO_2 impurity will also be estimated. If the estimated NO_2 impurity concentration is not less than or equal to 1% of the compressed gas standard NO concentration, the compressed gas standard will be returned to the vendor.

Section 18. Data Acquisition Requirements for Non-Direct Measurements

18.1. Chemical and physical properties data and conversion constants that may be necessary in the processing of raw data into reporting units and is not determined from the monitoring regulations or EPA guidance documents will be obtained from nationally recognized sources as follows:

18.1.1. National Institute of Standards and Technology (NIST)

18.1.2. ISO, IUPAC, ANSI, and other widely-recognized national and international standards organizations

18.1.3. CRC Press Handbook of Chemistry and Physics

18.2. Geographic locations and elevations will be determined by GPS measurements.

Section 19. Data Management

19.1. Continuous Data

19.1.1. Continuous data is acquired from each monitor using Agilaire 8832 or 8872 data loggers operating at each site. The data logger calculates a 1-minute base average from instantaneous values, which it uses to calculate 5-minute and 1-hour averages.

19.1.2. Data from the site data logger is polled at least once per hour by the AirVision Server Software located at National Life via Ethernet communications and stored on the AirVision SQL database.

19.1.3. Each weekday, section staff review the AirVision Daily Data Reports, Calibration Reports, information regarding site maintenance activities, and one-minute data (as needed) to determine if operations are in control and consist with this QAPP.

19.1.4. The Daily Summary Report lists the previous day's 1-hour measurement data grouped by site to review and identify site-wide trends or potential failures.

19.1.5. The Parameter Reports (Criteria and MET) summarize the previous day's data grouped by parameter to facilitate network-wide comparisons of same parameters.

19.1.6. The Calibration Report contain data from the automated daily zero and span checks for continuous gas instruments.

19.1.7. The findings of the daily review are summarized and delivered via email to all members of the monitoring section with the primary objective being to identify failures or abnormalities in the monitoring network, and to determine if changes to the schedule are deemed necessary.

19.1.8. Staff also will report abnormally high concentrations to the Supervisor, who will notify the AQCD Director and other interested data users.

19.2. Particulate Matter Filter FRM Data

19.2.1. Each PM filter sample has a dedicated field sheet (COC) where information pertaining to sample setup and takedown data is recorded. Monitoring staff are responsible for entering this information in the Monitoring database.

19.2.2. One staff member is responsible for reviewing each field sheet completed in the field.

19.2.3. A subset of the field sheets is reviewed by the QA Coordinator.

19.2.4. The field sheets are stored in file folders at the Monitoring section office.

19.2.5. The information associated with each filter sample collection event is downloaded from the samplers in field using USB thumb drive or iPort for the 2000i or 2025i samplers.

19.2.6. The data is verified and the filter record is uploaded to the Monitoring database following *SOP 3100 PM Filter Record Management.* The filter record contains information about the sampling period, including filter number, sampling start and end times, total sampling time, temperature min/max/average, barometric pressure min/max/average, and any flags associated with the 24-hour sampling period.

19.2.7. Maintenance, flow checks, audit or calibration of each sampler has a dedicated field sheet where results of the procedure are documented and subsequently entered into the Monitoring Database.

19.2.8. $PM_{2.5}$ and PM_{10} filter weight (tare and final), batch QC (calibration weight check and filter reweighs) and weighing room equilibration data is provided by Wood LLC, in MS Excel files.

19.2.9. The weighing results are recorded by filter number with tare date, time and weight, and final date, time and weight:

Filter ID	Filter Type	Init Date	Init Weight (mg)	Final Date	Final Weight (mg)
T5604663	FF	2016-06-06 06:14:22	355.591	2016-07-05 09:42:58	355.9615

19.2.10. Equilibration data is recorded approximately every minute. This data is used to calculate the temperature and RH standard deviation for the 24-hour filter equilibration period.

Reading Date	Temp (deg C)	RH (%)	Dew Point
6/19/2016 0:00:25	21.09	38.25	6.33
6/19/2016 0:01:26	21.09	37.56	6.07
6/19/2016 0:02:27	21.08	36.92	5.81

19.2.11. The files are stored on the DEC network drive Y:\AP_Monitoring\Data\Lab Temp & RH, and data is uploaded to the Monitoring database using custom forms and queries.

19.2.12. $PM_{2.5}$ and PM_{10} filter concentrations in $\mu g/m^3$ are calculated within the Monitoring database using custom forms and queries using the net mass (final – tare weighing) reported from Wood LLC, and the sampled volume from the filter record. $PM_{2.5}$ is reported at local temperature and pressure, PM_{10} is reported in both local and standard conditions.

19.3. Field Work Records

19.3.1. Field records and data handling associated with regular field work (maintenance, check, audit, calibration, etc.) are the responsibility of the staff performing the activity.

19.3.2. Field information is recorded directly to the Monitoring database using web-based data input forms, preferably at the time work is done, while still on site.

19.3.3. Associated data in AirVision is assigned the proper Null Codes and flags for regular instrument maintenance and audit operations in AirVision.

19.3.4. Above tasks are reviewed at least weekly in Level 1 data review.

19.3.5. A subset of records is reviewed by the QA Coordinator quarterly.

19.3.6. Paper datasheets, so long as they exist, are filed in the Monitoring office in folders by year, site and date. Future plans for data records are electronic only.

19.4. Data Review and Submittal

19.4.1. Weekly, level 1 data review is performed using the AirVision system to review zero and span charts to determine performance trends and validity of the ambient results collected.

19.4.2. Quarterly, level 2 review is performed using the AirVision and Monitoring database systems to review One-Point Quality Control Check results and summarize the quarterly data for report to the QA Coordinator and Supervisor for verification.

19.4.3. As lab results are received, level 2 review is performed for particulate filter data to review PM sample concentrations, filter QA/QC data and data capture.

19.4.4. Quarterly, at 30 days past the quarter, the level 2 reviewer, QA Coordinator and Supervisor review the previous quarter's data. Once it is agreed that the data conforms to the QAPP, is complete and of known quality, the QA Coordinator will create the necessary pipe-delimited text files and submit data to AQS via the ENSC website.

19.4.5. Continuous data report is created using a standard AirVision report.

19.4.6. QA/QC data report uses custom forms and queries in the Monitoring database.

19.4.7. Filter data concentration results are calculated using custom forms and queries in the Monitoring database that combine sample data with lab results.

19.5. Data Integrity

19.5.1. The AirVision data acquisition and reporting system is designed to protect the integrity of data and prevent its loss. The raw data is un-editable. Edits to data are made to a copy of the data and the raw data file can be restored at any time.

19.5.2. Data in the SQL Monitoring database is backed-up daily by the VT DEC IT group.

19.5.3. Additional data validation information is summarized in quarterly reports that are stored on the state file network, filed by year and quarter.

19.5.4. AQS is the final and permanent repository for all AQCD data. Electronic database records are considered "significant" consistent with *VT DEC Records Management Procedure GRS1000.1063* and thus will be retained without time limit. Paper field data sheets are retained at NL for 5 years from the end of the calendar year in which the work was performed.

Section 20. Assessment and Response Actions

Table 20.1 Project Assessments

Assessment Type	Assessment Agency	Frequency
Technical Systems Audit	EPA Regional Office	1 every 3 years
Systems Audits	QA Coordinator	Approx. 1/year/staff
Network Review and Plan Report	EPA Regional Office Air Division	every year App E annually
Annual Performance Evaluation for Continuous Gas Analyzers	QA Coordinator	every year at a minimum
Semi-Annual Flow Rate Audit for Particulate Samplers	QA Coordinator	2 per year, 5-7 months apart
Data Quality Assessment/Certification	Air Division	every year
1-Point QC Check (continuous gas)	Air Division	every 2 weeks at a minimum
Flow check (PM2.5 and PM10)	Air Division	every month, at least 14 days apart

A response/corrective action will be performed whenever a problem is observed such as warning flag, malfunction or whenever any performance assessment indicates the MQOs or control limits have been exceeded.

The assessment and response actions for the PM filter weighing operations will be performed by Wood LLC following their SOP (Appendix C).

20.1. Continuous gas analyzers

20.1.1. Gas monitors undergo an automatic zero and span check every day at midnight. The monitoring staff will report zero/span data outside of control limits to the Supervisor.

20.1.2. One-Point Quality Control Checks will be performed every week, and at least once every 2 weeks. The analyzer is challenged with a known concentration of EPA Protocol gas between the prescribed range of 0.005 and 0.08 ppm for SO_2, NO_2, and O_3, and between the prescribed range of 0.5 and 5 ppm for CO monitors. Input concentrations are generated using an onsite dynamic dilution calibrator and EPA protocol gas cylinder (*40 CFR Part 58 App A Sec 3.1.1*). These checks are performed alternately each week by staff on site and automatically.

20.1.3. Annual Performance Evaluations will be conducted on each primary monitor at least once per year using an independent set of audit equipment (ZAS and dilution calibrator). The evaluation is made by challenging the monitor with independent EPA Protocol audit gas standards of known concentration from at least three audit levels (*40 CFR Part 58 App A Sec 3.1.2*). The QA Coordinator performs this assessment.

20.1.4. One point must be within two to three times the MDL of the instrument.

20.1.5. The second point will be less than or equal to the 99th percentile of the data at the site or the network of sites in the PQAO or the next highest audit concentration level.

20.1.6. The third point may be around the primary NAAQS or the highest 3-year concentration at the site or the network of sites.

Table 20.2 Audit Levels

	Parameter	Units	Operating Range	Calibration Level	Midnight Span	1-Point QC Check Input	PE Input Levels
SLAMS	NO/NOx	ppb	360	300	150	30	4, 30, 130
	NO2	ppb	NA	150	120	20	8, 30, 100
	CO	ppm	12	10	5	1	1.5, 5, 9
	SO2	ppb	120	100	75	15	1.2, 4, 30
	O3	ppb	150	120	90	60	15, 30, 70
NCORE	NOY/NO	ppb	120	100	30	6	4, 30, 80
	NOy – NO	ppb	NA	80	18	4	8, 30, 100
	CO	ppm	2.2	2	1	0.5	0.06, 0.60, 9
	SO2	ppb	36	30	10	5	0.6, 4, 30
	O3	ppb	150	120	90	32	15, 30, 70

20.1.7. Station dilution calibration systems and ozone photometers will be calibrated/verified every 6 months following *SOP 5020 MFC Referencing* and *SOP 5030 Photometer Referencing*. Zero Air Systems undergo maintenance including scrubber exchange annually. The monitoring staff perform these tasks.

20.1.8. Certification of Ozone Primary Standard will be performed at EPA New England Lab *(40 CFR Part 58 App A Sec 2.6.2*).

20.1.9. EPA protocol gas cylinders are certified by the vendor to within ± 2% uncertainty of the certified concentration. The concentration is verified on installation by comparison to the current standard following *SOP 5000 Cylinder and Regulator Handling Procedure*.

20.1.10. EPA will perform annual audits according to the National Performance Audit Program (NPAP). Results that exceed the allowable criteria will elicit a "Request for Corrective Action" letter from EPA identifying the criteria which was exceeded and recommending the cause be identified and comments and recommendations for corrective action (*40 CFR Part 58 App A Sec 3.1.3*). The NPAP will be performed by EPA Region 1 Staff.

20.2. Particulate monitors

20.2.1. A One-Point Flow Rate Verification will be performed at least once every month (minimally separated by 14 days) on each monitor used to measure $PM_{2.5}$ and PM_{10} (*40 CFR Part 58 App A Sec 3.2.1 and 3.3.1*). The audit includes verification at the

operational flow rate, as well as temperature and pressure checks. Instrument outputs are verified against certified transfer standards. Monitoring staff perform this assessment.

20.2.2. A One-Point Flow Rate Verification will be performed at least semi-annually for the BC monitor. The audit includes verification at the operational flow rate, as well as temperature and pressure checks. Instrument outputs are verified against certified transfer standards. Monitoring staff perform this assessment.

20.2.3. Semi-Annual Flow Rate Audit for $PM_{2.5}$ and PM_{10} samplers will be performed twice a year at the operational flow rate. The two audits are spaced between 5 and 7 months apart. An independent certified transfer standard is used. (*40 CFR Part 58 App A Sec 3.2.2 and 3.3.3*). The QA Coordinator performs this assessment.

20.2.4. $PM_{2.5}$ Performance Evaluation Program (PEP) assessments are performed annually for each primary $PM_{2.5}$ monitor (*40 CFR Part 58, Appendix A, 3.2.4*). PEP audits are performed by setting up a collocated $PM_{2.5}$ sampler and collecting a 24-hour sample. EPA or their contractor performs this assessment.

20.3. Systems Audits and Network Review

20.3.1. The QA Coordinator will perform a Systems Audit of monitoring operations and personnel performing these operations to ensure compliance with federal requirements and guidance and this QAPP and its related SOPs.

20.3.2. EPA New England will perform a Technical Systems Audit (TSA) on Vermont's monitoring network and all personnel relative to its operation to ensure compliance with federal requirements and guidance and this QAPP and its related SOPs.

20.3.3. In combination with annual network review, every 5th year the Supervisor will perform a 5-year network assessment consistent with *40 CFR Part 58*.

Section 21. Reports to Management

21.1. Reports to management are listed in Table 21.1.

21.2. These reports are available to other staff and the public upon request.

21.3. Other reports will be provided upon request.

Table 21.1 Reports to Management

Report	Frequency	Preparer	Recipient(s)
AirVision email alarm reports for periods of high concentrations	As Warranted	AirVision configured routine	AQCD Director, Forecasters, Monitoring staff
AQS Quick Look Reports	Quarterly	QA or Environmental Analyst	Supervisor
AQS Precision and Accuracy Report	Quarterly	QA or Environmental Analyst	Supervisor
Quarterly Data Validation Report	Quarterly	Environmental Analyst	Supervisor and QA Coordinator
Quarterly Data Summary Report	Quarterly	QA Coordinator	Supervisor
Accuracy Audit Report	Quarterly	QA Coordinator	Supervisor
Annual Network Review	Annual	Supervisor	AQCD staff
AQS Data Certification (AMP 600)	Annual	QA Coordinator	Supervisor, AQCD Director
Annual Air Quality Report	Annual	Environmental Analyst	AQCD Staff
National Performance Audit Program Audit Reports	As Received	EPA Region 1	Supervisor and AQCD Director
System Audit Reports	As Generated	QA Coordinator	Supervisor

Section 22. Data Review, Validation and Verification Requirements

22.1. Continuous Gas and PM Data

22.1.1. Daily, data acquisition from the AirVision system is checked for completeness and automatically generated flags. The midnight zero and span check results and a summary report of the 1-hour averages (with flags) containing the previous day's hour average data are automatically sent by email to Monitoring staff via the Agilaire AirVision system (Figure 22.1 and Figure 22.2).

22.1.2. Gaps in data polling are apparent in the Daily Summary Report. Polling failures are addressed as soon as possible. The dataloggers store critical parameters for 14 days and data can be manually polled directly from the datalogger to the AirVision database. If the data loss is longer than 14 days, the site computer stores a redundant database for all parameters onsite and data can be imported from that system. Where possible, data can be downloaded directly from the analyzer and inserted into the AirVision database.

22.1.3. Data quality may be generally assessed from the daily report. Data that is abnormally high or low based on the validation criteria established in the AirVision channel configuration is automatically flagged. That data will be reviewed as soon as possible, and results reported to the QA Coordinator and Supervisor. It will be determined whether the data is representative of ambient data, or if the instrument has malfunctioned.

22.1.4. Data collected during unusual events such as nearby construction, road or roofing work or holiday gatherings or a natural exceptional event (such as a forest fire) which causes a noticeable and/or significant increase in the measured values, will be flagged accordingly.

22.1.5. Data flagged with M indicates that someone manually assigned the maintenance flag for auditing or other maintenance or testing procedures. Hourly data flagged with '<' indicates that less than 75% of the hour's minute averages are valid data. These data are addressed as soon as possible in level 1 validation and assigned null codes based on the maintenance that was performed. Specific information on maintenance performed is provided by the staff member who performed the activity.

22.1.6. Data will be evaluated relative to confirmed QA/QC results that indicate performance is inside or outside established validation limits. This includes midnight zero/span, one-point QC checks, and annual PE audit results (Figure 22.3).

22.1.7. If a One-Point QC check is outside of control limits, data will be invalidated back to the last good audit, unless supporting evidence concludes otherwise.

- If the QC check is valid and routine data is invalidated, the QC check is reported to AQS with a comment indicating the resultant period of data invalidated.
- If data is deemed valid despite the failing QC check (for example, the gas delivery failed) the routine data will be assigned a 1V qualifier code, the hours of the QC check given an appropriate null code, and the QC check is reported to AQS with the null code '1C' and a comment indicating why data is valid.

22.1.8. If an accuracy audit or NPAP audit is outside of control limits, but the subsequent zero/span indicates the system is in control, data will not be invalidated.

22.1.9. Data edits, coding and flagging within AirVision are performed by trained Monitoring staff and the QA Coordinator.

Figure 22.1 Example AirVision Calibration Report

Calibration Report

20-Jul-2016

Site	Parameter	Sequence	Phase	Start Time	End Time	Value		Expected Value	Error	Drift Warning Limit
BENINGTN	OZONE	O3ZROSPN	ZERO	20-Jul-2016 00:00:01	00:15:02	-0.1		0	-.1	2
			SPAN	20-Jul-2016 00:00:01	00:30:01	94.5		92.9	1.78%	4%
BRLNGTN3	CO	ZEROSPAN	ZERO	20-Jul-2016 00:00:01	00:14:59	-0.03		0	-.03	.2
			SPAN1	20-Jul-2016 00:00:01	00:32:59	4.86		5	2.85%	5%
	NO		ZERO	20-Jul-2016 00:00:01	00:14:59	-0.1		0	-.15	2
			SPAN	20-Jul-2016 00:00:01	00:50:59	144.2		150	3.85%	5%
	NO2		ZERO	20-Jul-2016 00:00:01	00:14:59	1		0	1.1	2
			GPT	20-Jul-2016 00:00:01	01:06:01	113.1	*	120	5.67%	5%
	NOX		ZERO	20-Jul-2016 00:00:01	00:14:59	0.9		0	.95	2
			SPAN	20-Jul-2016 00:00:01	00:50:59	145		150	3.28%	5%
RUTLAND	CO		ZERO	20-Jul-2016 00:00:00	00:13:01	-0.11		0	-.11	.2
			SPAN1	20-Jul-2016 00:00:00	00:31:01	4.84		4.7	2.94%	5%
	NO		ZERO	20-Jul-2016 00:00:00	00:13:01	0		0	0.00	2
			SPAN	20-Jul-2016 00:00:00	00:49:01	244.8		246	.47%	5%
	NO2		ZERO	20-Jul-2016 00:00:00	00:13:01	0		0	.03	2
			GPT	20-Jul-2016 00:00:00	01:04:01	77.6	*	83	6.5%	5%
	NOX		ZERO	20-Jul-2016 00:00:00	00:13:01	0		0	.02	2
			SPAN	20-Jul-2016 00:00:00	00:49:01	244		246	.81%	5%
	SO2		ZERO	20-Jul-2016 00:00:00	00:13:01	0.2		0	.27	2
			SPAN1	20-Jul-2016 00:00:00	00:31:01	47	*	49.5	5.08%	5%

Figure 22.2 Example AirVision Daily Summary Report with Flags

Daily Summary Report

Site: RUTLAND

7/21/2016

Interval: 001h

	AMBTEMP	BARPRESS	BC	CO	NO	NO2	NOX	OZONE	PM2.5
Hour	DEGC	MMHG	NG/M3	PPM	PPB	PPB	PPB	PPB	UG/M3
00:00	14.8	749	373.9	C	C	C	C	7.3	4
01:00	14.4	749	627.9	.01 C	6.0 C	7.3 C	13.3 C	5.1	2
02:00	13.8	748	467.4	.00 I	10.0	7.6	17.6	4.3	4
03:00	13.0	749	622.8	.00 I	1.7	4.8	6.5	2.7	3
04:00	12.7	749	492.9	.01 I	3.9	4.7	8.6	2.4	6
05:00	13.7	749	726.3	.07	11.9	6.5	18.4	2.8	10
06:00	16.5	749	836.4	.06	25.1	10.7	36.2	6.5	13
07:00	19.8	749	619.8	.23	6.0	6.8	12.8	14.9	8
08:00	22.8	749	585.8	.13 M	3.3 M	6.1 M	8.8 M	28.1	4
09:00	24.2	749	402.5	<	<	<	<	36.6	4
10:00	26.1	748	464.7	<	<	<	<	<	6
11:00	27.4	748	374.4	.01 I	1.6	2.7	4.4	<	5
12:00	28.1	747	401.4	.00 I	-.4 I	1.7	1.2	40.4	7
13:00	29.0	747	329.2	.00 I	.0 I	1.6	1.7	43.1	8
14:00	29.8	746	460.5	.00 I	.0 I	2.3	2.4	45.8	6
15:00	29.4	746	427.1	.03 I	.5	3.0	3.5	45.5	5
16:00	29.3	745	517.5	.06	.5	3.7	4.2	47.3	4
17:00	28.6	745	397.6	.01 I	.0 I	3.0	3.1	50.3	5
18:00	27.4	745	357.7	.03 I	-.4 I	3.5	3.0	50.2	12
19:00	26.1	745	430.4	.07	.3 I	12.2	10.0	41.4	11
20:00	24.2	744	523.1	.07	1.0	10.5	11.6	34.6	8
21:00	22.1	744	582.3	.09	2.8	10.4	15.1	30.1	8
22:00	21.3	744	626.8	.11	.0 I	13.1	12.1	26.1	7
23:00	20.5	743	846.4	.08	2.1	14.4	14.7	22.4	11
Avg	22.2	746	520.6	.05	3.6	6.5	9.9	26.7	6
Max	29.8	749	846.4	.23	25.1	14.4	36.2	50.3	13
Hr. of Max	14	09	23	07	06	23	06	17	06
Min	12.7	743	329.2	.00	-.4	1.6	1.2	2.4	2
Count	24	24	24	21	21	21	21	22	24
Total									

Figure 22.3 Validation Criteria for Continuous Gases

Parameter	Precision Level	Precision (1-Point QC Check)	Midnight Zero	Midnight Span	PE level 1-2	PE level 3+
Ozone	10-100 ppb	± 7%	± 3 ppb (24 hours) ±5 ppb (14 days)	± 7%	± 1.5 ppb	± 15%
CO	1-10 ppm	± 10%	± 0.4 ppm (24 hours) ± 0.6 (14 days)	± 10%	± 0.03 ppm	± 15%
SO2	10-100 ppb	± 10%	± 3 ppb (24 hours) ±5 ppb (14 days)	± 10%	± 1.5 ppb	± 15%
NOY NO NO2 NOX NOYdiff	10-100 ppb	± 15%	± 3 ppb (24 hours) ±5 ppb (14 days)	± 15%	± 1.5 ppb	± 15%

22.1.10. Any data reported prior to validation, such as for real-time reporting on the web (such as AirNow), must be qualified as being "not quality assured and subject to change."

22.2. $PM_{2.5}$ and PM_{10} FRM Filter Data

22.2.1. Filter records are retrieved from the manual samplers once or twice a week. The records are uploaded to the Monitoring database, and reviewed at that time for proper operating conditions (i.e. sampling flow rate, total valid sampling time, start time and date.) Samples that fail the basic criteria or did not run for other reasons are assigned null codes.

Figure 22.4 Validation Criteria for Filter-Based Particulate Samples

Operating Parameter	Criteria
Flow Rate	16.67 LPM ± 4%
Variability in Flow Rate	CV ≤ 2%
Total Sampling Time	24 hours ± 1 hour
Start Time	Midnight ± 15 minutes

22.2.2. Filter weighing results are received via email from Wood LLC and are reviewed at that time. The tare and final weights are imported to the Monitoring database

22.2.3. When filter records and weighing results are both available, the sample concentration in µg/m^3 (Local Conditions) is calculated:

$$PM\left(\frac{\mu g}{m^3}\right) = \frac{Final\ Weight\ (\mu g) - Tare\ Weight\ (\mu g)}{Sampled\ Volume\ (m^3)}$$

Standard conditions are calculated for PM_{10} using the 24-hour average of ambient temperature and barometric pressure as recorded by the sampler and retrieved with the filter record.

$$PM\ STP = PM\ x \left(\frac{T + 273.15}{298.15}\right) x \left(\frac{760}{P}\right)$$

Where T = local ambient 24-hour average of temperature in °C

P= local ambient 24-hour average of barometric pressure in mmHg

PM = Particulate Mass

STP = Standard Temperature and Pressure

These calculations are programmed into the Monitoring database. The set of queries that contains this equation produces a tabular result that can be easily reviewed. Null codes that have already been assigned are present in this result as well:

Actual Start	Burlington 2	Burlington 2	Burlington M	Rutland	Underhill PI	Underhill PI	Underhill PI	Rutland PM
6/2/2016	7.7	7	6.5	5.5	5.2	12.1	11.9	17.2
6/5/2016	5.6	5.6	5.3	5.3	3.3	6.4	6	9.4
6/8/2016	1.4	1.3	17.8	1.7	1.7	4.4	4.6	7
6/11/2016	6.2	6	5	7	2.9	5.2	5.1	12.2
6/14/2016	2.8	2.6	3.7	2.7	2.1	5.1	5.1	8.2
6/17/2016	5.2	5.5	6.1	5.2	3.7	7.8	7.5	15.4
6/20/2016	13	12	13.6	13.7	AN	AV	19.3	23.5
6/23/2016	5.4	4.8	4.6	4.3	3.6	6.4	6.2	11.1
6/26/2016	11.6	11.6	10.9	AL	9.4	13.3	13.6	AL
6/29/2016	6	4.6	6.7	5.5	5.9	7.9	AN	11.8

22.2.4. Flow rate verifications are performed monthly by monitoring staff, and semi-annually by the QA Coordinator.

22.2.5. The flow rate must be within ±4% of the flow standard reading.

22.2.6. The sampler clock time must be within 15 minutes of local standard time.

22.2.7. The temperature probes (ambient, filter, box) must be within ±2°C.

22.2.8. The barometric pressure must be within ± 10 mmHg.

22.2.9. Data edits, coding and flagging of filter records are performed by trained Monitoring staff and the QA Coordinator.

Section 23. Verification and Validation Methods

Vermont air monitoring data will be assessed with a three-tiered review approach, with each review referring to the critical and operational criteria identified in Appendix D.

23.1. Level 1 validation (Daily/Ongoing Review)

23.1.1. Daily review of ambient data and daily zero and span responses is reviewed by all staff.

23.1.2. Review and data validation in AirVision for activities related to field work is performed by the staff who performed the relevant work.

23.1.3. Ongoing weekly and monthly review of trends in zero, span, and 1-point QC data is performed by all staff.

23.2. Level 2 validation (Quarterly Review)

23.2.1. Level 2 validation is detailed in *SOP 6020 Continuous Criteria Pollutant Validation* and *SOP 6030 PM Validation*, and performed by monitoring staff assigned particular subsets of data (i.e. continuous gases, particulate data, etc.)

23.2.2. Quarterly review of QA assessments and ambient data in more detail with a particular focus on trends by site and by network for the quarter.

23.2.3. Level 2 validation is completed with a report to include details of validation decisions made for each site and pollutant.

23.3. Level 3 validation (Final Quarterly Review)

23.3.1. Level 3 validation is detailed in *SOP 6021 Continuous Criteria Pollutant Final Validation and Reporting* and *SOP 6031 PM Final Validation and Reporting* and is performed by the QA Coordinator.

23.3.2. Level 3 review includes reading the quarterly report generated during the level 2 review, as well as more extensive review of QA assessments and a subsets of data to include periods in question which may be due to maintenance, high concentrations, local conditions, etc. Level 3 review is completed with a quarterly report summarizing the data results in statistical and graphical forms as appropriate.

23.3.3. The final quarterly report and the underlying data is reviewed by the QA Coordinator and Supervisor together to verify and agree that the data set is complete, and that data was collected and validated according the critical, operation and systematic criteria.

23.3.4. After this final review is completed, the files to upload ambient and QA data to AQS are created in the proper format, and the upload is completed.

Section 24. Reconciliation with User Requirements

Criteria gas and PM data is reconciled with DQO/MQOs identified in Table 7.1 through quarterly level 1-3 validation review procedures performed by the monitoring staff and QA Coordinator, which include the generation of AirVision QA/QC reports and related excel graphs for each pollutant with examples provided below. In addition, further reconciliation of calendar year data using formulas provided in Table 24.1 is performed as part of the annual data certification process required by *40 CFR Part 58.15*. The AQCD must certify the previous year's criteria and PM data submitted to AQS by May 1. This process involves generating AQS Quicklook reports for applicable data parameters: AMP 251 Raw QA Summary, AMP 600 Certification Report and AMP 450 NC Quicklookreport which include summaries of the data with associated MQO values.

Monthly data report generated in AirVision:

Current Date: 5/6/2016 11:06 AM

Monthly Report

Site Name: BRLNGTN3 007 : 0014 October 2015 Avg Interval: 1 hour

Parameter: CO 42101 Units: PPM 007 Method: 093

Hours

Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Summary		
																									Max	Avg	RDS
01	AY	.00	-.01	-.02	-.01	.00	.02	.03	.02	.03	.02	.02	.01	.03	.04	.05	.04	.05	.04	.04	.08	.04	.03	.03	.08	.03	23
02	AY	.02	.00	.00	-.01	.01	.04	.03	.02	.04	.02	.05	.03	.03	.02	.03	.02	.05	.06	.03	.07	.03	.02	.02	.07	.03	23
03	AY	.20	.01	-.02	-.01	-.01	.02	.00	-.02	-.02	-.02	AV	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	.20	.01	10
04	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN			0
05	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	.37	.31	BA	.30	.28	.27	.28	.28	.25	.28	.35	.29	.22	.37	.29	12
06	AY	.17	.16	.16	.17	.22	.30	.37	.27	.18	.17	.17	.15	.13	.13	.14	.16	.19	.18	.19	.22	.21	.19	.20	.37	.19	23
07	AY	.16	.13	.13	.12	.15	.19	.21	.21	.20	.14	.12	.14	.18	.18	.19	.21	.21	.24	.18	.19	.22	.10	.06	.24	.17	23
08	AY	.07	.07	.07	.08	.18	.14	.13	.09	AX	AX	AX	.06	.09	.08	.12	.12	.14	.24	.23	.23	.20	.13	.11	.24	.13	20
09	AY	.08	.07	.07	.07	.11	.20	.18	.17	.19	.23	.23	.27	.27	.31	.32	.18	.20	.19	.17	.15	.10	.09	.08	.32	.17	23
10	AY	.10	.08	.09	.02	.00	.03	.04	.05	.05	.03	.09	.04	.08	.09	.15	.13	.21	.17	.16	.17	.12	.12	.11	.21	.09	23
11	AY	.09	.07	.05	.05	.06	.07	.07	.08	.10	.11	.12	.12	.12	.18	.17	.16	.17	.28	.18	.14	.16	.16	.13	.28	.12	23
12	AY	.11	.11	.10	.12	.13	.23	.16	.13	.13	.16	.14	.15	.15	.16	.20	.18	.19	.13	.18	.14	.12	.12	.13	.23	.15	23
13	AY	.13	.15	.17	.17	.18	.21	.21	.19	.17	.16	.18	.19	.21	.24	.24	.26	.23	.21	.17	.16	.13	.14	.12	.26	.18	23
14	AY	.10	.11	.11	.12	.13	.16	.17	.14	.10	.11	.10	.09	.10	.13	.11	.12	.12	.10	.12	.10	.10	.13	.15	.17	.12	23

Validation reports generated in the Monitoring database:

QA Validation Report: 10/1/2015 - 12/31/2015

Burlington Main St

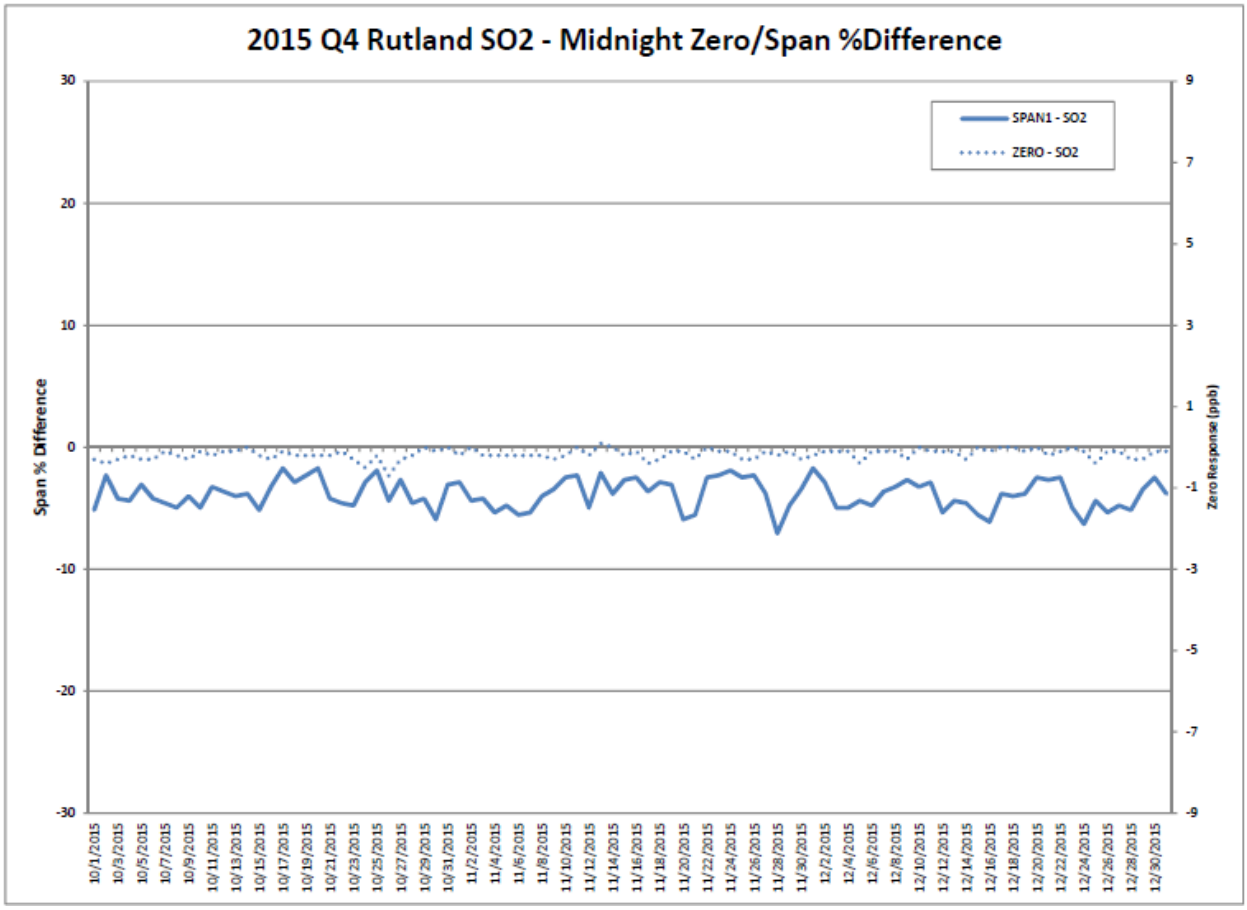
Carbon Monoxide

10/3/2015	C13	DNG 10/3/15 11 - 10/5/15 10; Short power failure caused instrument lock up.	jennyb

PM2.5 Continuous

10/29/2015	FPCON3	Unstable response (20.4 to -4.8 ug/m3). Reference channel swings low then high. All other diagnostic parameters look normal. DNG.	jennyb
12/14/2015	FPCON3	Unstable response (-7.4 ug/m3). Reference channel high then low. All other diagnostic parameters look normal. DNG.	jennyb

Zero Span Charts (created in Excel with data exported from AirVision)



Precision Report generated in Monitoring database:

Current Location	*Unit ID*	*Date*	*Input*	*Response*	*Percent Error*	*Zero Response*	*Report T*
Rutland	**Sulfur Dioxide**						
	S13	10/1/2015	29.7	27.8	-6.40	0	Yes
	S13	10/16/2015	29.7	30.2	1.68	0	Yes
	S13	10/26/2015	29.6	29.8	0.68	-0.1	Yes
	S13	11/12/2015	30	30	0.00	-0.1	Yes
	S13	11/25/2015	29.7	30.2	1.68	0.2	Yes
	S13	12/10/2015	29.69	30.2	1.72	0	Yes
	S13	12/24/2015	29.59	29.4	-0.64	0.2	Yes
			Summary for 'Unit ID' = S13 (Sulfur Dioxide) (7 detail records)				
				Avg	***-0.18***	***0.03***	
				Min	***-6.40***	***-0.10***	
				Max	***1.72***	***0.20***	

Table 24.1 Excerpt from 40 CFR Part 58 Appendix A Sec. 4

Criterion	Equation
Accuracy of Single Sampler Flow - Single Check d_i (flowrate)	$d_i = \frac{meas - audit}{audit} \times 100$
Bias of Single Sampler – Annual Basis	$D = \frac{1}{n_i} \bullet \sum_{i=1}^{n_j} d_i$
Relative Percent Difference for a Collocated Pair (X_i, Y_i)	$d_i = \frac{X_i - Y_i}{(X_i + Y_i)/2} \times 100$
CV (Coefficient of Variation) of a single point flowrate check	$\lvert AB \rvert = AB + t_{0.95n-1} \bullet \frac{AS}{\sqrt{n}}$
AB is the mean of absolute value of d_i	$AB = \frac{1}{n} \bullet \sum_{i=1}^{n} \lvert d_i \rvert$
Completeness	$\frac{n_{valid}}{n_{potential}} \times 100\%$

Section 25. References

Aethalometer Model AE33 User Manual, Version 1.55. Magee Scientific, Ljubljana, Slovenia, July 2017.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 35: State and Local Assistance. 40 CFR Part 35, July 26, 2016.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 50: National Primary and Secondary Ambient Air Quality Standards. 40 CFR Part 50, July 26, 2016.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 53: Ambient Air Monitoring Reference and Equivalent Methods. 40 CFR Part 53, July 26, 2016.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 58: Ambient Air Quality Surveillance. 40 CFR Part 58, July 26, 2016.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 136: Guidelines Establishing Test Procedures for The Analysis of Pollutants. 40 CFR Part 136, July 26, 2016.

EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. United States Environmental Protection Agency, Office of Environmental Information, EPA/240/B-01/003, March 2001.

List of Designated EPA Reference and Equivalent Methods. United States Environmental Protection Agency, Technology Transfer Network, Ambient Monitoring Technology Information Center. http://www.epa.gov/ttn/amtic/criteria.html.

National Ambient Air Quality Standards (NAAQS). United States Environmental Protection Agency, Air and Radiation. https://www.epa.gov/criteria-air-pollutants/naaqs-table.

QA Handbook for Air Pollution Measurement Systems: "Volume I: A Field Guide to Environmental Quality Assurance." United States Environmental Protection Agency, EPA-600/R-94/038a, April 1994.

QA Handbook for Air Pollution Measurement Systems: "Volume II: Ambient Air Quality Monitoring Program." United States Environmental Protection Agency, EPA-454/B-13-003, January 2017.

QA Handbook for Air Pollution Measurement Systems: "Volume IV: Meteorological Measurements Version 2.0." United States Environmental Protection Agency, EPA-454/B-08-002, March 2008.

QA Handbook, Volume II, Appendix D, Measurement Quality Opjectives and Validation Templates. United States Environmental Protection Agency, March 2017.

Report to Congress on Black Carbon. https://www3.epa.gov/airquality/blackcarbon/. EPA March 2012.

Standard Operating Procedure Teledyne Model 640x Real-Time Continuous PM Monitor. United States Environmental Protection Agency, Final – 2nd Draft December September 14, 2018.8, 2019

QAPP EPA Category I Filter Handling, Acceptance Testing and Gravimetric Analysis for Chemical Speciation Network, Special Studies and State, Local and Tribal Site PM2.5 Federal Reference Method Filter Samples. Wood LLC, Contract EP-D-15-001, Revision 1.0, May 2018

Appendix A. Standard Operating Procedures

Appendix B. Annual Network Plan

Appendix C. Wood SOP

Appendix D. Quality control requirements

T640 Draft Validation Template

1) Criteria (PM2.5 Continuous)	2) Frequency	3) Acceptable Range	Information /Action
CRITICAL CRITERIA - PM2.5 CONTINUOUS (LC)			
Sampling Instrument			
Sampler/Monitor Designation	NA	Meets requirements listed in FRM/FEM/ARM designation Confirm method designation on front panel or just inside instrument.	1) 40 CFR Part 58 App. C Sec. 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
Firmware of Monitor	At setup	1. Firmware version 1.0.2.126 or later 2. Firmware settings must be set for flowrate to operate and report at "local conditions" (i.e., not STP).	40 CFR Part 50 App. N Sec. 1 (c)
Data Reporting Period	Report every hour	1. The calculation of an hour of data is dependent on the design of the method. 2. A 24-hour period is calculated in AQS if 18 or more valid hours are reported for a day	Hourly data are always reported as the start of the hour on local standard time 40 CFR Part 50 App. N Sec 3 (c)
Average Flow Rate*	every 24 hours of operation; alternatively, each hour can be checked	average within 5% of 5 lpm	1, 2 and 3) 40 CFR Part 50 App. L Sec 7.4.3.1
Variability in Flow Rate*	every 24 hours of operation	CV ≤ 2%	1, 2 and 3) 40 CFR Part 50 App. L Sec 7.4.3.2
One-point Flow Rate Verification*	every 30 days each separated by 14 days	± 4.1% of transfer standard ± 5.1% of flow rate design value	1, 2 and 3) 40 CFR Part 50 App. L Sec 9.2.5 and 40 CFR Part 58 App. A Sec 3.2.1
OPERATIONAL CRITERIA			
Multi-point Verifications/Calibrations			
Leak Check with HEPA filter	Every 30 days and before each flow rate verification/calibration	0.0-0.3 µg/m^3	User Manual 5.2.8 EPA 2nd Draft SOP, 12/8/2017

One-point Temperature Verification	Every 30 days	± 2.1 °C	1) 40 CFR Part 50 App. L Sec 9.3 2) Method 2.12 Sec. 7.4.5 and Table 6-1 3) Recommendation
Pressure Verification	Every 30 days	± 10.1 mmHg	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/year
PMT verification/Adjustment	Every 30 days	11.3 ± 0.5	User Manual 4.1.4
Check pump PWM	Every 30 days	PWM < 80%	User Manual 5.2.4
Clean air inlet	Every 30 days	cleaned	User Manual 5.2.1
Flow Rate Adjustment	After failing flow rate verification or quarterly	5.0 < ± 2.1%	1,2 and 3) 40 CFR Part 50 App. L Sec. 9.2.6 User Manual 5.2.5
Replace DFU filters	Annually or when Pump PWM value > 80%	replaced	User Manual 5.2.3
Check pump performance	Every 18 months	Pump PWM between 35% and 80	User Manual 5.2.4
Clean Optical Chamber and RH/T sensor	Every 6 months or as needed	Cleaned	User Manual 5.2.6
Downtube Cleaning	every 90 days	cleaned	1,2 and 3) Method 2.12 Sec. 8.4
Sample Relative Humidity		ASC controlled to 35°C	User Manual Table 1-1
Clock/timer Verification	Every 30 days	± 5 minutes	
ACCURACY			
Semi-Annual Flow Rate Audit	Twice a calendar year and 5-7 months apart	< ± 4.1% of audit standard < ± 5.1% of design flow rate	1 and 2) 40 CFR Part 58 App. A Sec. 3.2.2 3) Method 2.12 Sec. 11.2.1
Temperature Audit	every 180 days and at time of flow rate audit	< ± 2.1 °C	1, 2 and 3) Method 2.12 Sec. 11.2.2

Pressure Audit	every 180 days and at time of flow rate audit	< ± 10.1 mmHg	1, 2 and 3) Method 2.12 Sec. 11.2.3
PRECISION			
Collocated Samples	every 12 days for 15% of sites by method designation	CV < 10.1% of samples ≥ 3 µg/m3	1) and 2) 40 CFR Part 58 App. A Sec. 3.2.3 3 Recommendation based on DQO in 40 CFR Part 58 App. A Sec. 2.3.1.1
Single analyzer (collocated monitors)	every 90 days	Coefficient of variation (CV) < 10.1% for values ≥ 3.0 µg/m^3	1,2 and 3) Recommendation in order to provide early (quarterly) evaluation of achievement of DQOs.
Primary Quality Assurance Org.	Annual and 3-year estimates	90% CL of CV < 10.1 % for values ≥ 3.0 µg/m^3	1,2 and 3) 40 CFR Part 58 App. A Sec. 4.2.1 and 2.3.1.1
BIAS			
Performance Evaluation Program (PEP)	5 audits for PQAOs with < 5 sites	< ± 10.1% for value > 3 µg/m^3	1,2 and 3) 40 CFR Part 58 App. A Secs. 2.3.1.1, 3.2.4, and 4.2.1
VERIFICATION/CALIBRATION STANDARDS RECERTIFICATIONS			
Flow Rate Transfer Std.	every 365 days and once a calendar year	± 2.1% of NIST Traceable Standard	1) 40 CFR Part 50 App. L Sec. 9.1 and 9.2 2) Method 2.12 Sec. 4.2.2 and 6.3 3) 40 CFR Part 50 App. L Sec. 9.2.2
Field Thermometer	every 365 days and once a calendar year	± 0.1 °C resolution, ± 0.5 °C accuracy	1, 2 and 3) Method 2.12 Sec. 4.2.2 and 6.4
Field Barometer	every 365 days and once a calendar year	± 1 mmHg resolution, ± 5 mmHg accuracy	1, 2 and 3) Method 2.12 Sec. 4.2.2 and 6.5

* CFR references are specifically for 16.67 total flow rate design value.

Magee AE33 Aethalometer Draft Validation Template

1) Criteria	2) Frequency	3) Acceptable Range	Information /Action
CRITICAL CRITERIA – Black Carbon PM2.5 (LC)			
Sampling Instrument			
Sampler/Monitor Designation	NA	Confirm method designation on front panel or just inside instrument.	
Firmware of Monitor	At setup	1. current firmware 2. Firmware settings must be set for flowrate to operate and report at “local conditions” (i.e., not STP).	
Data Reporting Period	Report every hour	The calculation of an hour of data is dependent on the design of the method.	Hourly data are always reported as the start of the hour on local standard time
One-point Flow Rate Verification*	every 90 days	± 4.1% of transfer standard	
OPERATIONAL CRITERIA			
Multi-point Verifications/Calibrations			
Inspect sample line tubing and size selective inlet	1/month		Manual
Verify time and date	1/month		Manual
Inspect/clean optical chamber	1/6 months		Manual
Flow Check	1/6 months		Manual
Leakage Test	1/6 months		Manual
Clean Air Test	1/6 months		Manual
Stability Test	1/6 months		Manual
ND Filter Test	1/year		Manual
Lubricate optical chamber sliders	1/year		Manual
Install new filter tape roll	As needed		Manual

Change by-pass cartridge filter	1/year		Manual
ACCURACY			
Semi-Annual Flow Rate Audit	Annually	< ± 4.1% of audit standard	
VERIFICATION/CALIBRATION STANDARDS RECERTIFICATIONS			
Flow Rate Transfer Std.	every 365 days and once a calendar year	± 2.1% of NIST Traceable Standard	1) 40 CFR Part 50 App. L Sec. 9.1 and 9.2 2) Method 2.12 Sec. 4.2.2 and 6.3 3) 40 CFR Part 50 App. L Sec. 9.2.2
Field Thermometer	every 365 days and once a calendar year	± 0.1 °C resolution, ± 0.5 °C accuracy	1, 2 and 3) Method 2.12 Sec. 4.2.2 and 6.4
Field Barometer	every 365 days and once a calendar year	± 1 mmHg resolution, ± 5 mmHg accuracy	1, 2 and 3) Method 2.12 Sec. 4.2.2 and 6.5

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