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

FOR
METEOROLOGICAL MONITORING

Revision 1.3

11/1/2023

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 Meteorological Monitoring

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

Preparer: David Ruby, Environmental Analyst, Air Monitoring Section, Air Quality & Climate Division, Davis 4, One National Life Drive, Montpelier, VT 05620-3802

Signing for the State of Vermont:

Signature: Heidi Hales Digitally signed by Heidi Hales Date: 2023.12.04 14:44:01 -05'00'

Heidi Hales, Director, Air Quality & Climate Division

Signature: David Ruby Digitally signed by David Ruby Date: 2023.11.01 11:08:07 -04'00'

David Ruby, Air Monitoring Supervisor, Air Quality & Climate Division

Signature: Timothy Pricer Digitally signed by Timothy Pricer Date: 2023.10.26 15:28:17 -04'00'

Timothy Pricer, Quality Assurance Coordinator, Air Quality & Climate Division

Signing for the Environmental Protection Agency:

Signature:

Michelle Coombs, Air Monitoring State Coordinator, EPA New England

Signature:

Kwabena Kyei-Aboagye, Grants Coordinator, EPA New England

Section 2. Contents

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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
COC	Chain of Custody
CSN	Chemical Speciation Network
CTS	Collocated Transfer Standard
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
SIPS	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)
T_a	Temperature, Ambient or Actual
TSP	Total Suspended Particulate
TTP	Through the Probe
URG	URG-3000 Speciation Carbon Sampler
VSCC	Very Sharp Cut Cyclone

Section 3. Distribution List

All individuals listed in Table 3.1 will receive an electronic copy of this Quality Assurance Project Plan as well as future revisions. The current revision is available in digital format on the State of Vermont, DEC network drive (Y:\AP_Monitoring\Operations\Quality Assurance Project Plans).

All Monitoring section staff must read and understand this QAPP.

Table 3.1 Vermont MET QAPP Contact List

Name	Position	Phone Number	Email Address
Vermont AQCD			
Heidi Hales	Division Director	802-343-7221	Heidi.Hales@vermont.gov
David Ruby	Section Supervisor	802-261-5982	David.Ruby@vermont.gov
Timothy Pricer	Environmental Analyst V	802-461-8439	Timothy.Pricer@vermont.gov
Amy Shedrick	Environmental Analyst II	802-279-5632	Amy.Shedrick@vermont.gov
Jean Woodward	Environmental Analyst III	802-377-5949	Jean.Woodward@vermont.gov
Samuel Williams	Environmental Analyst III	802-461-6266	Samuel.Williams@vermont.gov
Hannah Zambri	Environmental Analyst III	802-261-5569	Hannah.Zambri@vermont.gov
EPA-Region 1-NE			
Leiran Biton	Field Services 1 Branch Chief	617-918-1267	Biton.Leiran@epa.gov
Alysha Murphy	Team Leader	617-918-8381	Murphy.Alysha@epa.gov
Michelle Coombs	Air Monitoring State Coordinator	617-918-8665	Coombs.Michelle@epa.gov

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 meteorological parameter results in support of concurrent 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 and guidelines governing the ambient meteorological monitoring activities identified in this QAPP are specified in *40 CFR Part 58* and the *EPA Quality Assurance Handbook, Vol IV* 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. Vermont Air Quality & Climate Division

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 meteorological monitoring network, in support of the ambient air monitoring network, consistent with this document to provide meteorological 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 maintaining an active line of communication with the Air Monitoring Section Supervisor to ensure the current QA system is maintained and quality data is reported to 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.

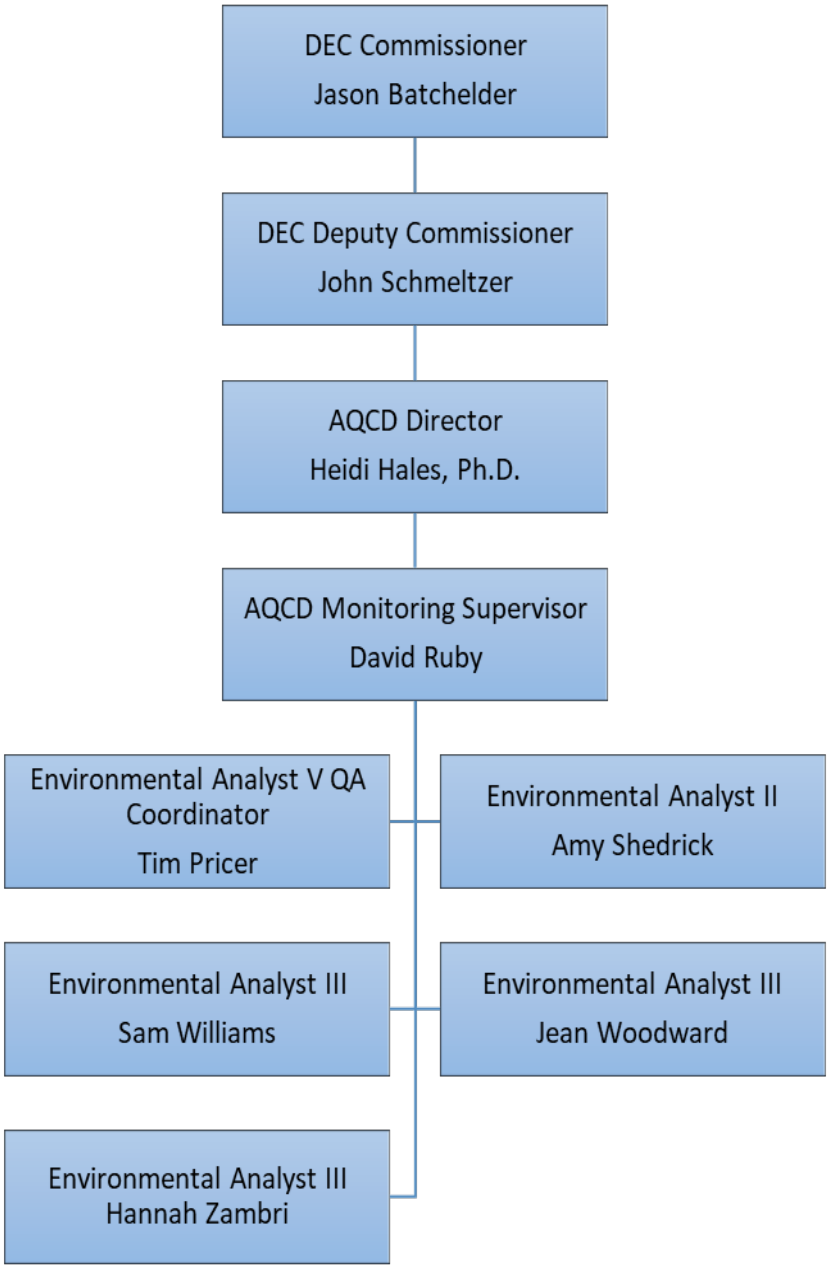
- Environmental Analysts

Responsible for day-to-day meteorological monitoring network operations, including sensor acceptance testing and installation of new or recalibrated sensors, performing routine sensor inspection and biannual verifications/audits at network sites, troubleshooting, maintenance as necessary and upkeep of meteorological monitoring equipment and site infrastructure. As assigned, responsible for annual performance evaluations using a collocated transfer standard system (CTS) for all sensors (except precipitation). Also responsible for routine data review and level 1-2 data validation, as assigned.

- Quality Assurance Coordinator

Responsible for oversight of an independent assessment of meteorological monitoring operations relative to EPA guidelines by overseeing/reviewing the annual performance evaluations and performing systems audits of sites, personnel and operations. Responsible for assisting with development, review and approval of QAPP and SOPs and 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.

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, 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.

Meteorological parameter monitoring is required at NCore and NATTS stations as specified in the Code of Federal Regulations (CFR) Chapter 40 Section 58, Appendix D.3.b and NATTS TAD Revision 3, respectively. Vermont AQCD measures meteorological parameters listed in Table 6.2 at the EPA NCore/NATTS site and at the other network sites (SLAMS) to support the ambient air monitoring pollutant concentration data measured concurrently at these sites.

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 and define population exposure to air contaminants known or suspected to cause adverse health effects and/or to cause damage to property or sensitive ecosystems.

Section 6. Project Description and Schedule

6.1. Monitoring Network Description

6.1.1. Meteorological data are collected by onsite data loggers and transmitted to a central database at the Vermont AQCD's headquarters in Montpelier, VT. These data are uploaded to AirNow and used to assist in forecasting projected air quality index levels and for air pollution modeling purposes and to assess point and regional emission source impacts through pollution and wind roses.

6.1.2. The AQCD currently operates a permanent meteorological network of four sites which are participants in four EPA monitoring programs or networks (SLAMS, NCore, NATTS, IMPROVE). 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 available on the AQCD's website: https://dec.vermont.gov/air-quality/monitoring.

6.1.3. 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 meteorological data which meets DQOs for each program.

6.1.4. The map of Vermont in Figure 6.1 indicates the approximate location of each site, the pollutant and parameters measured, and the applicable EPA network. Table 6.1 lists the permanent air monitoring sites where meteorological parameters are monitored, including site location, parameters monitored, EPA AQS code and network, monitoring objective and scale of representation.

6.1.5. Continuous meteorological monitoring at all indicated sites is performed for wind speed, wind direction, Temperature, barometric pressure, relative humidity, precipitation and solar radiation. "Continuous" refers to the ongoing determination of hourly average values based on 1-minute sub-averages. Specific sensors used are listed in Table 6.2.

Figure 6.1 Vermont Ambient Air Monitoring Network Map

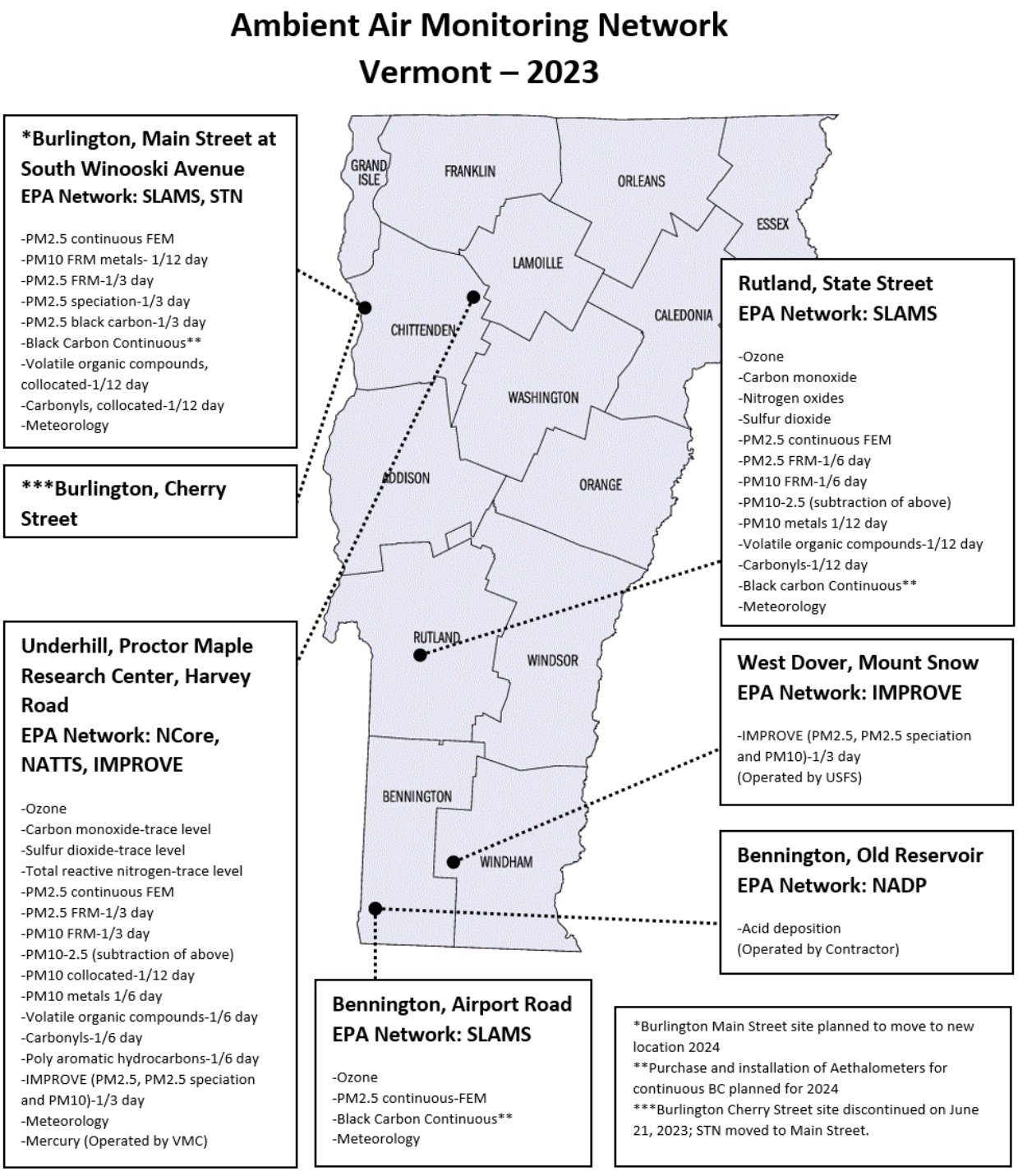


Table 6.1 Vermont Air Monitoring Network Sites with Meteorological Monitoring

Location	EPA 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	VOC, Carbonyl, $PM_{2.5}$, PM_{10}, PM_{10} Metals	Neighborhood/ middle	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	58 Harvey Road, Underhill, VT	SLAMS NCore NATTS IMPROVE CASTNET** NADP*	CO, NO, NO_2, 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); ** suspended 2022

Table 6.2 Meteorological Monitoring Parameters and Equipment

Parameter	Measurement method	Manufacturer/ Model	Range; Accuracy; Resolution (with Units)	
Temperature	Thermistor	Met One Model 083E (with 075B solar shield)	Range Accuracy	-50°C - +50°C ±0.1°C throughout range
Relative Humidity	Thin Film capacitor	Met One Model 083E (with 075B solar shield)	Range Accuracy Resolution	0-100% relative humidity ±2% from 0-100% ±0.1%
Barometric Pressure	Pressure sensor	Met One Model 090D	Range Accuracy Resolution	660-812 mmHg (26”-32”Hg) ±1 mmHg or ±0.125% FS Infinite
Solar Radiation	Pyranometer (silicon photodiode)	Met One Model 096	Range Accuracy	0-3000 W/m^2 solar radiation flux density <±5%
Precipitation (Rain/Snow)	Heated tipping bucket	Met One Model 375	Accuracy Resolution	±0.5% at 0.5”/hr; ± 1.0% at 1” to 3”/hr 0.01 in per tip

Parameter	Measurement method	Manufacturer/ Model	Range; Accuracy; Resolution (with Units)	
Wind Speed	Sonic Anemometer	Met One Model 50.5	Range Accuracy Resolution	0-50 m/sec ±0.15 m/sec ≤ 5 m/sec or ±2% ≥5 m/sec 0.1 m/sec
Wind Direction			Range Accuracy Resolution	0-360° ±3° 1°
Temperature	Precision thermistor	Met One AIO2	Range Accuracy Resolution	-40 to +60 °C ±0.2°C from 0 to 60°C, ±0.5°C from -40 to 0°C 0.1°C
WS	folded-path, low-power sonic anemometer	Met One AIO2	Range Accuracy Resolution	0 to 60 m/s ±0.5m/s or 5% of reading (whichever is greater) 0.1 m/s
WD		Met One AIO2	Range Accuracy Resolution	0 to 360 degrees ±5° (including Compass) 1.0°
Alignment Compass	internal flux-gate compass	Met One AIO2	Accuracy Resolution	±2° 1°
RH	fast-response capacitive	Met One AIO2	Range Accuracy Resolution	0 to 100% ±3% 25°C 1.0%
Barometric	Pressure Sensor	Met One AIO2	Range Accuracy Resolution	600 to 1100 hPa ±0.5 hPa 25°C 0.1 hPa

6.2. Network Operations

All monitoring staff are responsible for sensor testing, installation (sensor/tower/tripod), on-going inspection and assessment of performance, operations and data quality relative to the specific monitoring objectives.

6.2.1. Data Acquisition/Management

- Continuous meteorological measurements are collected in a central database using Agilaire AirVision software. Site data loggers are polled for data using automated routines every hour for 1-hour, 5-minute and 1-minute averages. Automatic data processing also occurs within this program using various reports and data flagging operations. One and five minute average data are used for close inspection of suspect data periods. Hourly data are properly coded for upload to AQS. Where necessary and available, the data are compared to external meteorological measurements such as NWS or NOAA.

6.2.2. Acceptance Testing, Installation, Calibration

- All meteorological sensors operated at the network sites are received from the manufacturer calibrated and certified traceable to NIST. All new and recertified sensors are inspected upon delivery and verified prior to installation. Once installed on the tower or tripod following EPA QA Handbook Vol IV, manufacturer's

recommendations, functional or audit checks (as applicable) are performed to verify performance. Ambient data representativeness and comparability to site/network norms is confirmed before channels are put in service. Due to the design of most system sensors, physical calibration adjustments are not required and would be performed by manufacturer when necessary. Nevertheless, the RH/Temp/BP sensors for sites and CTS may be recalibrated as necessary, on a case by case basis using NIST traceable standards.

6.2.3. Operational Checks/Performance Audits

- Sensor operation is indirectly assessed during daily data reviews, weekly site visits/inspections for damage or obstructions and directly assessed from biannual functional checks of WS/WD/Precipitation sensors and dynamic audits of the RH, Temperature and BP sensors with NIST traceable standards.

6.2.4. CTS Verification

- Annually, each permanent monitoring site meteorological system undergoes a one to two-week collocated comparison to an independent, standalone, NIST Traceable Met One AutoMet meteorological system installed at each site.

6.2.5. Record Keeping and Reporting

- All sensor maintenance, performance verification and quality assurance 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.
- Sensor maintenance, troubleshooting, calibration, certification and biannual checks are recorded in "unit history" records.
- Annual CTS audit results for the collocated period are downloaded from the AutoMet datalogger and AirVision and are then analyzed and summarized using MS Excel or other data programs as appropriate.
- All validated data monitor specifications and site descriptions pertaining to all ambient air monitoring sites in the network will be stored in AQS.
- Meteorological parameter data will be submitted within 90 days after the end of the quarter it was collected in.

6.2.6. Data review, verification and validation

- Meteorological parameter data from all sites undergoes daily, quarterly and annual review and validation as indicated in Sections 19, 22 and 23 and following *SOP 6040 Meteorological Data Review* and *SOP 6041 Meteorology Data Final Validation and Submission*.
- Annual CTS results are summarized by designated staff and verified/validated by the QA Coordinator.

Section 7. Data Quality Objectives and Measurement Performance Criteria

EPA has defined the Data Quality Objectives (DQO) in Vol IV of the EPA QA Handbook for meteorological parameter monitoring performed in support of various networks such as NCore, SLAMS and PAMS. DQOs are qualitative and quantitative statements that define the suitable type of data to collect and to 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 are used to define quality of data collected to support the intended monitoring objective.

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

The Vermont AQCD DQOs are to determine accurate, precise, representative air pollutant concentrations and concurrent meteorology 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 and emissions 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 and meteorological sensors within a set of established MQOs designed to control measurement uncertainty below the levels required for the DQOs.

The applicable acceptance criteria used to assess the meteorological MQO indicators (parameter, method, range, units, and resolution) are specified in Table 7.1. Date completeness MQO is 75%.

Verification and accuracy are based on Manufacturer's specifications and procedures for sensors specifically for EPA-related ambient monitoring applications. Representativeness is addressed in Table 7.2.

Table 7.1 Vermont MQOs for NCore, NATTS and SLAMS Meteorological Measurements

Measurement Parameter	Method	Operating Range/Units	Resolution
Ambient Temperature	Thermistor	-30 - 50 °C	0.1
Relative Humidity	RH Sensor Thin Film Capacitor	0 - 100 %	0.5
Wind Speed	Sonic Anemometer	0.5 - 50.0 m/s	0.1
Wind Direction	Sonic Sensor	0 - 360 Degrees	1.0
Vector/Scalar	DAS calculations	0-50 0-360	0.1 1.0
Solar Radiation	Pyranometer	0 - 1200 W/m^2	10
Precipitation	Tipping Bucket	0.01 inches (per tip)	0.01
Barometric Pressure	Barometric Pressure Sensor	450-825 mm Hg	1

Table 7.2 Verification and Accuracy Criteria for NCore, NATTS and SLAMS Meteorological Measurements

	Verification (Biannual)			Accuracy (Annual)		
Measurement	**Type**	**Corrective Action Criteria**	**Acceptance Criteria**	**Type**	**Corrective Action Criteria**	**Acceptance Criteria**
Ambient Temperature	Comparison of Ambient value to Alicat standard (NIST Traceable)	±0.5 °C	±0.5 °C	CTS and comparison to Alicat Standard (NIST traceable) or vendor recalibration	±0.5 °C	±0.5 °C
Relative Humidity	Comparison of Ambient value to Fisher Electronic RH Sensor (NIST traceable)	±5%	±7%	CTS and Fisher digital RH sensor (NIST traceable) or vendor recalibration	±5%	±7%
Wind Speed (Sonic Anemometer)	Functional: Bag/shroud and blocked access tests	Bag: 0 m/s Blocked Access:50 m/s ±2.5 m/s	same	CTS or vendor recalibration	±0.25 m/s for CTS/site averages <5m/s or 5%. Not to exceed 2.5m/s for averages > 5 m/s*	same
Wind Direction (Sonic Anemometer)	Functional: Bag/shroud and blocked access tests Cross Arm Alignment to True North	NS axis: 180 or 10 ±5° EW axis: 90 or 160±5° (model dependent)	same	Cross Arm Alignment to True North and CTS or vendor recalibration	CTS/site: ±5° * Cross arm alignment ±5°	same
Solar Radiation	Functional: Cap or Flashlight test	Cap:0 W/m^2 Flashlight: >1000 W/m^2	Same	CTS or vendor recalibration	±5% of mean observed interval	±5% of mean observed interval
Precipitation	Functional: manual tipping check, fixed volume test with graduated cylinder	±7% of input volume	±10% of input volume	Fixed volume test with graduated cylinder or vendor recalibration	±7% of input volume	±10% of input volume
Barometric Pressure	Comparison of Ambient value to Alicat standard (NIST Traceable)	±2.0 mmHg	±2.3 mmHg	CTS and Comparison to Alicat standard (NIST Traceable) or vendor recalibration	±2.0 mmHg	±2.3 mmHg

*Applicable only to CTS and Monitoring site WS averages > 1 m/s

Section 8. Special Training Requirements

Personnel working with meteorological sensors will receive training from experienced staff members and from vendor sponsored training courses as available. Personnel associated with the meteorological network are required to read Vermont's Meteorological Monitoring QAPP, SOPs, instrument operating manuals and EPA QA Handbook, Vol IV. Additional training is available from EPA Guidance Documents, videos, websites (AMTIC), NESCAUM and AirKnowledge.gov courses. The Air Monitoring Section supervisor is responsible for assuring that personnel are properly trained to perform the required meteorological instrumentation tasks.

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 resources for training opportunities:

- AirKnowledge (airknowledge.gov)
- 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., TAPI)
- KnowledgeWave (training for Microsoft products)

Section 9. Documentation and Records

9.1. Data Acquisition

9.1.1. Continuous meteorological measurement output will be acquired, averaged, stored, evaluated and reported to AQS using Agilaire 8832 or 8872 data loggers at each site and AirVision software reporting system. Data will be downloaded from sites hourly. All continuous data review, local storage and reporting will be performed using the Agilaire AirVision system (*SOP 8000 AirVision*).

9.1.2. Calculated meteorological parameters (sigma theta, vector and scalar wind) are made within the datalogger.

9.2. Electronic Logbook

9.2.1. A web-based data entry site is used to document each routine task (i.e., audit/calibration). The following information will be recorded: site location, date, operator name, sensor unit ID, standard unit ID, all settings and observations made, reference and sensor values levels, percent error and any maintenance performed. The information is stored in the dedicated Air Monitoring 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 web forms that are available via any internet browser and password protected. Whenever possible, records are entered upon completion of the task.

9.3. Record Retention

9.3.1. Consistent with the statute of limitations specified in *40 CFR Part 31.42*, and NATTS guidelines all paper records will be retained for at least six years from the end of the year they are generated. 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 5 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 meteorological 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 un-validated will be identified as "un-validated and subject to change" (for example on AirNow and Vermont AQCD website).

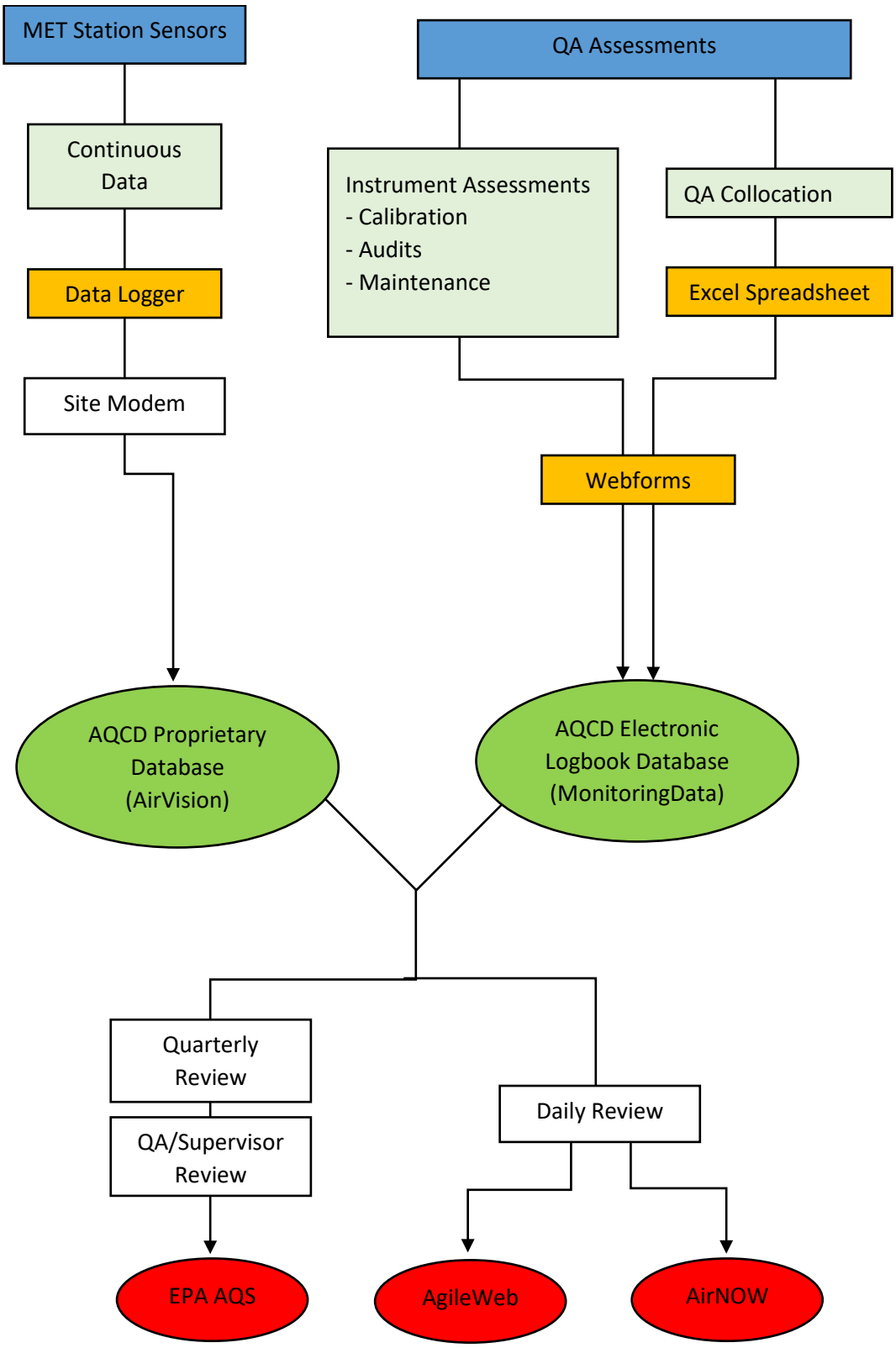
9.4.3. The data reports submitted to EPA are listed in Table 9.1. Summaries of these reports will also be provided to the AQCD at Staff Meetings.

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 meteorological data into AQS	within 90 days of the end of the quarter
Annual network review	July 1
Annual QAPP review/revision	November 1

Figure 9.1 Data Flow Diagram



Section 10. Sampling Design

Air pollutant monitoring and siting criteria are established in 40 CFR, Parts 53 and 58. Vermont AQCD's monitoring sites have been sighted in accordance with these guidelines. The specific installation and siting for Vermont AQCD meteorological towers, tripods and sensors is consistent with the EPA QA Handbook Volume IV. Siting requirements will be met as the limitations of the site allow and with EPA approval. AQCD's monitoring locations are shown in the map in Figure 6.1.

A complete list of parameters monitored at sites is shown in Table 6.2. 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 with specific site locations are identified in the Vermont Annual Air Monitoring Network Plan, 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. Meteorological Monitoring Site Selection

10.1.1. The overall data quality objectives of the meteorological monitoring network are the determination of representative meteorology in areas of high population density and background/transport concentrations for NAAQS compliance at each site and to identify pollution trends and transport effects. These objectives meet obligations for participation in the NCore, NATTS and SLAMS networks.

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

10.1.3. Specific sensor installation heights at each monitoring site are identified in Table 10.1.

Table 10.1 Meteorological Sensor Height

Parameter	Bennington	Burlington Main St.	Rutland	Underhill
WS/WD	10 m (tower)	3 m (Tripod)	10 m (tower)	10 m (tower)
Temperature/RH	10 m (tower)	3 m (Tripod)	10 m (tower)	10 m (tower)
BP	10 m (tower)	3 m (Tripod)	10 m (tower)	10 m (tower)
Precipitation	4.0 m (shelter roof)	4.0 m (shelter roof)	4.0 m (shelter roof)	4.0 m (shelter roof)
Solar radiation	3.7 m (shelter roof)	3.9 m (shelter roof)	3.9 m (shelter roof)	5.6 m (shelter roof)

Note: all measurements indicate sensor distance above ground level.

10.2. Parameters Measured

10.2.1. Based on the monitoring objectives and monitoring network participation identified above, the meteorological parameters measured in the VT AQCD network covered by this QAPP are WS (m/s), WD (°), Temperature(°C), BP (mmHg), RH (%), precipitation (inches/hr), solar radiation (W/m^2).

10.3. Sensors

10.3.1. Meteorological sensors operated in the network are consistent with EPA QA Handbook, Vol IV. and are identified in Table 6.2.

10.4. Sampling Frequency

10.4.1. All meteorological measurements are made continuously. One-minute averages are calculated from instantaneous sensor outputs, which are then averaged for each clock hour.

Section 11. Monitoring/Sample Method Requirements

EPA has not identified Reference Methods for meteorological sensors, so all methods, siting and installation are consistent with EPA QA Handbook, Vol IV and manufacturer's recommendations. Table 6.2 includes a list of sensors operated by Vermont AQCD.

11.1. Wind Speed and Wind Direction

11.1.1. The Met One Model 50.5 solid state ultrasonic wind sensor is used to measure wind speed and wind direction. The sonic anemometer operates on the principal that the speed of the wind affects the time it takes for sound to travel from one point to a second point. If the sound is traveling in the direction of the wind, then the transit time is decreased. If the sound is traveling in a direction opposite the wind, then the transit time is increased. Sonic pulses are generated at the transducers and are received by opposing transducers. Mathematics derived for these sonic pulses provide a wind velocity measurement in each of the corresponding axes. The wind sensor uses a microprocessor-based, digital electronic measurement system to control the sample rate and compute the wind speed and wind direction. The sonic sensor has a heater that is activated at 3 °C and will keep the arms ice-free at temperatures as low as -30 °C.

11.1.2. The Met One AIO2 sonic anemometer operated on the same principle as the Model 50.5.

11.1.3. The Met One AIO2 uses an internal Fluxgate compass module that is low power and compact. It employs a pair of magneto-resistive sensors, which change with varying magnetic field strengths, to sense the Earth's magnetic field. The AIO2 microprocessor measures the output of the internal compass and then corrects the wind direction data for the orientation of the sensor. The output of the AIO2 wind direction is relative to magnetic North.

11.2. Temperature

11.2.1. Temperature is a measurement of how warm or cold an object or environment is, with reference to a standard scale.

11.2.2. The Met One Model 083E (combined Temp/RH) is used to measure temperature. The operating range is set to ±50 °C with an accuracy of 0.1 °C. The temperature sensor is a thermistor bead encased in a corrosion-resistant aluminum sheath and enclosed in Model 075B radiation shield to protect the sensor from solar radiation, precipitation, and corrosive, airborne particles. The shield includes a solar powered aspiration fan with a battery backup.

11.2.3. The Met One AIO2 temperature sensor uses a precision Thermistor to provide highly accurate and stable temperature readings.

11.3. Relative Humidity

11.3.1. Relative humidity is a ratio of the amount of moisture in the air at a given temperature to the amount of moisture the air is capable of holding at that temperature.

11.3.2. The Met One Model 083E humidity probe is used to measure relative humidity. This sensor can operate within ±50 °C and within 0 and 100% RH. A one-micron thick dielectric polymer layer absorbs water molecules through a thin metal electrode and causes capacitance change proportional to relative humidity.

11.3.3. The Met One AIO2 RH sensor is a capacitive polymer sensor which is constructed to provide excellent resistance to wetting, dust, dirt, oils, and common environmental chemicals.

11.4. Barometric Pressure

11.4.1. Barometric or atmospheric pressure is the pressure caused by the weight of air above any given area on the earth. Altitude and temperature affect barometric pressure. Barometric pressure is low at high altitudes because there is less air pushing down onto the earth. Barometric pressure decreases as temperature rises. This is due to the air being less dense at higher temperatures. The Met One Model 092 Barometric Pressure Transducer is used to measure barometric pressure data. The transducer consists of a solid-state pressure transducer and a low power embedded CPU. These features allow for long-term stability and high accuracy.

11.4.2. The Met One AIO2 barometric pressure sensor is a stable transducer using nanotechnology, yielding a linear and repeatable reading with low hysteresis. This piezo-resistive pressure sensor module is mounted on an electronic circuit board within the sensor. A microcontroller controls the operation of the sensor and the data interface. The microcontroller polls the pressure sensor module once per second for the barometric pressure and the ambient temperature. The raw readings are temperature corrected by the microcontroller.

11.5. Solar Radiation

11.5.1. Global or diffuse solar radiation from sunlight is measured using a pyranometer in units of energy flux, usually W/m^2. The Met One Model 096 pyranometer is used for measuring solar radiation. It is designed for measuring short wave irradiance on a plane surface (radiant flux, W/m^2) which results from the sum of direct solar radiation and diffuse radiation incident from the hemisphere above the instrument. The sensing element is a silicon solar cell mounted in a cosine corrected miniature head, which delivers excellent spectral absorption and long-term stability characteristics. The solar cell is specially formulated to transmit solar radiation over a wide range of wavelengths (0.4 – 1.1 microns).

11.6. Precipitation

11.6.1. Precipitation refers to all liquid or solid water particles that fall from the earth's atmosphere. This occurs when the atmosphere becomes so saturated with water vapor that water condenses and drops to the earth's surface. Precipitation comes in many different forms such as rain, snow, sleet, and hail. Small amounts of dew, frost, and rime may also be included in the total amount of precipitation collected by a rain gauge.

11.6.2. The Met One Model 375 8" Rain & Snow Precipitation Gauge has a heating element in base and cone for freezing temperature conditions. The heating elements are thermostatically controlled (4.4 °C) to melt and measure the water content of snow and frozen rain but avoid evaporative loss. Two-mesh screens cover the collection funnel to keep insects, leaves and other foreign material from clogging or entering the gauge. The large screen is removed in early winter to allow frozen precipitation to contact the heated funnel. Precipitation enters the gauge through a collection funnel and flows into one side of two-sided tipping bucket located inside. When one side fills, its weight tips the next bucket into position and activates a reed switch that sends a signal to the data logger for counting. Each tip indicates 0.01 inch of precipitation. The measured water is continually drained out the base of the gauge.

Section 12. Sample Handling and Custody Requirements

There are no sampling Handling and Custody Requirements for routine data collected by the Meteorological monitoring systems.

Data from the CTS is downloaded directly from the system's datalogger using MetOne's Comet software to a local computer hard drive in a single text file. The file for each collocated installation is stored on the SOV Y drive in the folder Y:\AP_Monitoring\Data\MET and subfolders therein.

Section 13. Analytical Methods Requirements

No analytical methods are utilized for the monitoring, calibration, and auditing of meteorological instrumentation.

Section 14. Quality Control Requirements

Quality Control is the system of technical activities that measures performance of the network meteorological sensors against established standards to ensure that measurement uncertainty is maintained within acceptance criteria for the attainment of the DQO.

To assure the meteorological data quality, two distinct interrelated tasks are be performed: (1) QA activities including developing SOPs, DQOs and MQOs, roles and responsibilities, performing network/data oversight and reviews, and implementing corrective actions. MQOs are listed in Table 7.1 and other activities are addressed in various sections of this QAPP; (2) QC procedures including verification checks, performance audits, manufacturer calibrations/certifications, and routine checks for all meteorological sensors covered by this QAPP (see Table 7.2).

14.1. Inspection/verification checks

14.1.1. Routine inspection and verification checks are identified in Section 15 (with criteria in Table 7.2) and include inspection/verification of new and recertified sensors, weekly observations for damage or obstructions, data representativeness and biannual verification of sonic WS/WD, solar sensors and the precipitation tipping mechanism.

14.2. Performance Audits (criteria listed in Table 7.2)

14.2.1. Biannual performance checks are performed following SOP 4002.

- The temperature and BP sensor performance are verified using a NIST traceable Alicat standard.
- The relative humidity sensor performance is verified biannually using a NIST traceable Fisher electronic RH Sensor.

14.2.2. Annual

- The temperature sensor at each site undergoes a 1-point comparison to the Alicat standard (at ambient temperature).
- CTS – Following *SOP 4003 Meteorological System Accuracy Audit*, the Met One AutoMet system is setup and operated at each site to perform an independent 1 to 2-week collocation comparison consistent with guidelines in the EPA QA Handbook Vol IV. The CTS components are listed in Appendix B. This annual comparison is mainly to confirm acceptable operation of the network sonic WS/WD sensors but is also used to evaluate temperature, BP, RH and solar radiation performance. The CTS acceptance criteria for comparing the WS and WD averages between the AutoMet and site sensors is listed in Table 14.1 below. The CTS acceptance criteria for the other parameters are listed in Table 7.2.

Table 14.1 Acceptance Criteria for CTS WS/WD

Parameter	Average Difference (for wind speeds > 1 m/s)	Standard deviation of Differences
WS	±0.25 m/s for averages <5m/s or 5% Diff. Difference not to exceed 2.5m/s for averages > 5 m/s	0.2 m/s
WD	±5°	2°

14.3. Factory Calibrations

14.3.1. The CTS AutoMet system sensors are certified (NIST traceable) either by verification using NIST traceable standard or by Met One annually.

14.3.2. The Network Sensors are calibrated/recertified by Met One as necessary based on malfunction, failing biannual verification/audit or annual CTS criteria or at a minimum of every 5 years.

Section 15. Equipment Testing, Inspection and Maintenance Requirements

All newly acquired and recertified meteorological sensors undergo visual inspection and verification prior to installation at Vermont AQCD monitoring sites. Sensors are carefully inspected for functionality and visible damage. Any problems are documented, and the manufacturer notified for repair or replacement. Upon installation at each site, sensor function and data representativeness/comparability are verified prior to putting the sensor back in service.

Weekly visual and data observations are performed during routine site visits by AQCD staff to ensure that meteorological instruments are not damaged or obstructed and are functioning properly. Any unusual values are investigated and confirmed with testing if necessary and reported to the QA Coordinator or Supervisor to establish a corrective action plan.

Staff are responsible for routine site maintenance and sensor maintenance/repair following manufacturer recommendations. Many of the AQCD meteorological sensors, by design, do not require routine parts replacement. The instruments typically either work properly or not. As a result, there is minimal preventive maintenance. All maintenance/repair will be documented on the appropriate webforms and/or unit history note.

The independent CTS AutoMet meteorological sensors (listed in Appendix B) are verified annually using NIST traceable standard or recalibrated/certified by Met One and are acceptance testing/verified prior to site installation for the 1 to 2-week CTS test period. The QA Coordinator is responsible for overseeing these activities identified below.

15.1.1. WS – AutoMet sensor verified at 3 different speeds using an RM Young Wind Speed Calibrator (synchronous motor) Model 053.

15.1.2. WD – AutoMet sensor verified at 8 compass directions (at a minimum) using a Met One WD calibration wheel Model 042.

15.1.3. Temperature/BP – AutoMet sensors are verified by comparison to an Alicat standard.

15.1.4. RH – AutoMet sensor verified by comparison to the digital Fisher RH sensor.

15.1.5. Solar – AutoMet sensor is verified by functional cap and flashlight test.

15.1.6. All observations, biannual verification checks, audit and preventive maintenance are documented on the appropriate webforms and performed according to the schedule in Table 15.1 below.

Table 15.1 Summary of Instrument Testing, Inspection, and Maintenance

	Time Period			
Parameter	As Needed	Weekly	Biannual Checks	Annually
Ambient Temperature	Corrective Actions	General Inspection	Performance Audit	Manufacturer certification/CTS
Relative Humidity	Corrective Actions	General Inspection	Performance Audit	Manufacturer certification/CTS
Wind Speed (Sonic anemometer)	Corrective Actions	General Inspection	Functional check	Manufacturer certification/CTS
Wind Direction (Sonic anemometer)	Corrective Actions	General Inspection	Functional Check Orientation Verification	Manufacturer certification/CTS
Solar Radiation	Corrective Actions	General Inspection	Functional Check Level Check	Manufacturer certification/CTS
Precipitation	Corrective Actions	General Inspection	Functional Check Volume verification Level Check Heater Check	Manufacturer certification/Calibration
Barometric Pressure	Corrective Actions	General Inspection	Performance Audit	Manufacturer certification/CTS

Section 16. Instrument Calibration and Frequency

16.1. Site sensors

16.1.1. All sensors will be returned to the Manufacturer for recalibration/certification when malfunction occurs, or annual CTS performance audit criteria or biannual verification check/audit exceeds acceptance criteria or every 5 years.

16.2. QA

16.2.1. The CTS AutoMet components listed in Appendix B will be calibrated/certified every year prior to performing the annual collocated testing at each site. Temperature, BP or RH sensor calibration relationships may be updated in CTS data logger/controller, if necessary (on a case-by-case basis), based on direct verification against applicable AQCD NIST traceable standards.

16.2.2. Field Audit Standards

- Temperature, BP- the NIST traceable Alicat standard will calibrated/certified annually by the manufacturer.
- RH- the NIST traceable Fisher RH sensor will be verified against AutoMet RH sensor after its annual certification and/or recertified by the manufacturer as necessary.
- Other NIST traceable standards may be used as appropriate.

Section 17. Inspection/Acceptance Requirements for Supplies and Consumables

As indicated in Section 15, all new sensors are inspected and verified before being operated at each site.

Purchases of all equipment 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.

Section 18. Data Acquisition Requirements for Non-Direct Measurements

Although internal data is most often used for comparison in temporal or spatial analyses, occasionally other non-direct measurement data from outside the VT AQCD network maybe used to determine representativeness and verify data.

18.1. CWOP

18.1.1. The State of Vermont AQCD participates in the Citizens Weather Observation Program (CWOP) through AirNow Tech. Daily quality checking is provided by Philip Gladstone. Reports are received daily for all five AQCD meteorological stations comparing data to other regional sites. These reports should be reviewed for any irregularities relative to other sites.

18.2. National Resources

18.2.1. Information and data from used for validation from outside sources include the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) and National Climate Data Center (NCDC). Both meteorological data measurements and satellite imagery may be used.

18.3. AirNow Tech

18.3.1. Data from neighboring stations may be used for review of suspect data. Data in AirNow are available in real-time but may not be fully verified and validated.

Section 19. Data Management

19.1. Continuous Meteorological Data

19.1.1. Continuous data is acquired from each meteorological sensor through the Met One met-card interface using Agilaire data loggers operating at each site. The data logger calculates a 1-minute base average from instantaneous values, which it uses to calculate 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 and 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 Met Parameter Report summarizes the previous day's data grouped by parameter to facilitate network-wide comparisons of same parameters (Figure 22.1 Example AirVision Daily Parameter Report).

19.1.6. The findings of the daily review are summarized by monitoring staff and delivered via email to all members of the monitoring section.

19.1.7. Staff also will report unusual values to the QA Coordinator or Supervisor.

19.2. Field Work Records

19.2.1. Field records and data handling associated with regular field work (maintenance, audit) is the responsibility of the staff performing the activity.

19.2.2. Field information is recorded directly to the Monitoring database using web-based data input forms, preferably while still on site.

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

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

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

19.2.6. Paper datasheets, so long as they exist, are filed in the Monitoring office in folders by year, site and date.

19.3. Data Review and Submittal

19.3.1. Weekly, level 1 data review is performed using the AirVision system to review performance trends and validity of the ambient results collected.

19.3.2. Quarterly, level 2 review is performed using the AirVision and Monitoring database systems to review data and summarize the quarterly data for report to the QA Coordinator and Supervisor for verification.

19.3.3. Quarterly, 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 within 90 days of the end of the quarter in which the data was collected.

19.3.4. Summary data reports can be created using standard AirVision reports.

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

19.4. Data Integrity

19.4.1. 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 are made to a copy of the data.

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

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

19.4.4. AQS is the final and permanent repository for all AQCD meteorological 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 6 years from the end of the calendar year in which the work was performed.

19.5. CTS

19.5.1. Hourly average results are from the site Agilaire data logger and the AutoMet data logger for each site/installation are compared graphically using available data review tools (Excel, SQL, etc.)

19.5.2. The absolute error is calculated for each pair of hourly WS and WD averages > 1m/s. The overall mean and standard deviation of this error is determined for comparison to the criteria in Table 14.1.

19.5.3. The results are used to generate scatter plots and timeseries for each parameter compared during the CTS.

19.5.4. A report summarizing the results are provided to the QA Coordinator and Supervisor for review.

Section 20. Assessment and Response Actions

20.1. Systems Audits and Network Review

20.1.1. Annually a CTS audit will be performed at each permanent meteorological site to mainly evaluate, verify and confirm acceptable operation of the sonic WS/WD sensors but also to independently verify temperature, BP, RH and solar radiation.

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

20.1.3. 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.

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

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

Table 20.1 Project Assessments

Assessment Type	Assessment Agency	Frequency
Technical Systems Audit	EPA Regional Office	every 3 years
Systems Audits	QA Coordinator	Approx. 1/year/staff
Network Review and Plan Report	EPA Regional Office Air Division	annually
Annual CTS Performance Evaluation	Staff/QA Coordinator	annually
Semi-Annual Functional Checks/Audit	Air Monitoring Staff	2 per year, 5-7 months apart
Data Quality Assessment	Air Monitoring Staff	Weekly/quarterly/annually

Section 21. Reports to Management

Reports to management are listed in Table 21.1. These reports are available to other staff and the public upon request. Other reports will be provided upon request.

Table 21.1 Reports to Management

Report	Frequency	Preparer	Recipient(s)
AQS Quick Look	Quarterly	QA or Environmental Analyst	Supervisor
AQS Precision and Accuracy	Quarterly	QA or Environmental Analyst	Supervisor
Quarterly Data Validation	Quarterly	Environmental Analyst	Supervisor and QA Coordinator
Quarterly Data Summary	Quarterly	QA Coordinator	Supervisor
Annual CTS Performance Evaluation	every year at a minimum	Environmental Analyst	Supervisor and QA Coordinator
Annual Network	Annual	Supervisor	AQCD staff
Annual Air Quality	Annual	Environmental Analyst	AQCD Staff
System Audit	As Generated	QA Coordinator	Supervisor

Section 22. Data Review, Validation and Verification Requirements

22.1. Continuous Meteorological Data is reviewed, validated, and reported following *SOP 6040 Meteorological Data Review* and *SOP 6041 Meteorology Data Final Validation and Submission*.

22.1.1. Daily, data acquisition from the AirVision system is checked for completeness and automatically generated flags. Parameter summary reports of 1-hour averages of the previous day's data are automatically sent by email to Monitoring staff via the Agilaire AirVision system (Figure 22.1).

22.1.2. Gaps in data polling are apparent in the Daily Parameter Report. Polling failures are addressed as soon as possible by direct manual poll of the datalogger to the AirVision database. If the data is not recovered by direct poll, the site computer stores a redundant database onsite. Missing data can be imported from that system.

22.1.3. Data quality may be generally assessed from the daily report. Data that does not meet the established validation criteria 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 conditions, or if the instrument/sensor has malfunctioned.

22.1.4. Data flagged with M indicates that someone manually assigned the maintenance flag for auditing or other maintenance or testing procedures. 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.

22.1.5. If a meteorological sensor malfunctions or fails the biannual verification or audit (Table 7.2), data is invalidated back to an obvious failure. Failure is typically apparent based on reviewing data trends and comparisons to local and regional MET data.

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

22.1.7. 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. CTS

22.2.1. Hourly average results for each site and AutoMet system recorded during the 1 to 2-week CTS verification are processed, reviewed and verified using available data review tools. The overall average absolute difference and standard deviation are calculated for 1-hour average site and AutoMet WS and WD results for hours where both recorded WS> 1 m/s. Results are compared to criteria in Table 14.1.

22.2.2. Hourly average results for temperature, BP, RH and solar radiation for each site and the AutoMet system recorded during the 1 to 2-week CTS verification are processed, reviewed and verified using Excel. The overall average differences for the site and AutoMet results are determined and compared to criteria in Table 7.1

22.2.3. Time series and scatterplots are generated for visual comparison and outlier verification. Outliers are investigated, verified and removed from the assessment as appropriate.

Figure 22.1 Example AirVision Daily Parameter Report

Daily Parameter Report

5/5/2019

		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		
Parameter	SiteName																									Avg	Max	Hr.
AMBTEMP	BENNINGTON	11.9	11.9	11.7	11.5	10.9	10.8	11.4	11.8	13.1	14.3	15.1	15.0	14.8	14.9	14.5	13.7	13.1	12.5	11.7	11.7	11.5	11.3	11.1	11.4	12.5	15.1	10
	BURLINGTON	9.0	8.4	8.0	7.7	7.2	7.4	8.3	10.3	12.0	13.6	14.5	15.8	17.1	17.7	17.7	18.5	18.8	19.0	18.1	17.0	15.8	14.8	13.9	13.2	13.4	19.0	17
	RUTLAND	10.7	10.3	9.6	9.0	8.5	8.6	9.5	11.6	14.8	17.1	18.2	18.7	18.5	17.9	17.0	16.2	15.3	14.6	14.1	13.6	13.4	13.1	12.9	12.9	13.5	18.7	11
	UNDERHILL	7.1	7.3	6.5	5.9	5.7	5.8	7.9	10.4	12.4	13.8	15.3	16.9	18.0	18.2	18.5	18.4	18.1	16.8	15.4	14.1	13.3	12.6	12.1	11.4	12.5	18.5	14
BARPRESS	BENNINGTON	736	736	736	736	736	736	736	737	737	737	737	737	737	736	736	736	736	736	736	737	737	737	737	737	736	737	07
	BURLINGTON	753	753	753	753	753	754	754	754	754	753	753	753	753	752	752	751	751	751	751	752	752	752	752	752	752	754	05
	RUTLAND	742	742	742	742	742	742	742	742	742	742	742	742	742	741	741	741	741	741	742	742	742	742	742	742	741	742	00
	UNDERHILL	724	723	723	723	723	724	724	724	724	724	724	724	723	723	723	722	722	722	723	723	723	723	723	723	723	724	00
RAINFALL	BENNINGTON	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	07
	BURLINGTON	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	00
	RUTLAND	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	00
	UNDERHILL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	00
REL_HUM	BENNINGTON	94.5	90.9	91.2	92.5	93.8	94.7	94.0	92.6	89.1	83.0	77.9	77.3	78.8	77.8	77.9	79.8	80.9	85.2	90.9	91.2	92.9	94.2	95.0	90.5	87.7	95.0	22
	BURLINGTON	78.6	81.6	82.9	82.9	83.0	83.0	81.8	76.8	68.9	62.7	60.8	55.9	49.2	43.8	38.4	38.9	39.5	40.2	45.7	59.2	65.5	68.8	71.2	73.2	63.8	83.0	04
	RUTLAND	90.4	93.8	97.2	98.3	97.6	98.2	95.7	82.2	67.3	55.2	52.0	52.3	55.0	61.7	64.8	68.1	72.5	74.8	75.5	77.0	78.2	78.9	78.4	77.7	76.7	98.3	03
	UNDERHILL	81.5	80.9	82.2	83.7	82.6	78.7	73.8	66.2	56.2	46.3	40.2	40.0	38.9	37.9	36.6	37.7	42.3	47.9	55.9	60.9	63.6	67.5	68.4	71.5	60.0	83.7	03
SIGMA_TH	BENNINGTON	31.0	19.3	9.5	19.1	11.1	9.9	23.2	21.7	16.4	11.6	18.3	13.2	10.8	14.3	14.5	12.8	14.5	21.6	25.6	28.0	16.8	12.7	14.0	28.6	17.4	31.0	00
	BURLINGTON	39.8	48.0	50.1	39.7	47.7	28.6	30.8	50.0	40.4	27.8	23.7	21.9	24.7	24.4	19.5	20.8	21.8	24.9	22.7	27.7	25.9	25.0	25.3	30.5	30.9	50.1	02
	RUTLAND	18.4	13.1	22.5	15.2	20.4	24.4	16.7	22.4	30.5	32.0	20.2	21.3	18.0	18.9	16.3	15.2	15.7	16.0	17.2	15.5	15.6	16.9	17.5	15.0	18.9	32.0	09
	UNDERHILL	9.2	11.2	21.7	21.2	19.9	16.4	23.6	28.6	24.5	28.8	32.5	33.2	36.4	30.3	29.7	30.6	31.7	31.4	35.6	20.2	27.8	38.1	39.2	31.8	27.2	39.2	22
SOL_RAD	BENNINGTON	-2	-2	-2	-2	-1	16	63	128	295	259	171	109	111	114	80	51	43	17	2	-2	-2	-2	-2	-2	60	295	08
	BURLINGTON	5	5	5	5	9	61	172	351	465	527	713	756	823	523	537	378	244	133	28	6	5	5	5	5	240	823	12
	RUTLAND	12	12	12	12	14	51	146	266	411	482	638	609	468	484	373	163	137	55	18	13	12	12	12	12	184	638	10
	UNDERHILL	-1	-1	-1	-1	2	50	161	330	426	506	629	693	739	506	463	299	218	89	18	0	-1	-1	-1	-1	213	739	12
TR_TEMP	BENNINGTON	22.5	22.6	22.3	22.1	22.0	21.9	21.9	22.0	22.5	23.3	23.8	23.5	23.1	23.0	22.7	22.5	22.1	22.0	21.8	21.8	21.8	21.8	21.8	21.7	22.3	23.8	10
	BURLINGTON	23.5	23.5	23.1	22.3	22.3	22.8	22.4	23.7	25.3	24.6	24.7	24.6	24.4	24.9	24.4	25.0	24.2	24.4	24.3	24.2	24.1	24.7	25.1	24.9	24.0	25.3	08
	RUTLAND	23.9	23.5	23.6	23.6	23.6	23.6	23.6	23.5	24.8	24.9	25.1	24.9	24.7	24.5	24.3	24.2	24.3	24.3	24.3	24.2	23.6	23.4	23.4	23.5	24.0	25.1	10
	UNDERHILL	24.2	24.2	24.3	24.2	24.1	24.0	24.2	25.3	26.3	25.8	25.8	25.5	25.3	25.3	25.5	25.4	25.7	25.9	26.4	25.9	24.5	24.6	24.5	24.4	25.0	26.4	18
WDVEC	BENNINGTON	67.8	52.3	145.1	247.1	334.4	234.2	13.5	24.3	1.3	342.1	91.8	84.3	81.0	97.7	99.4	94.1	98.1	95.0	71.8	18.3	297.6	226.8	262.6	84.1	131.	342.	09
	BURLINGTON	19.3	1.5	34.6	44.5	42.8	27.3	30.7	358.2	281.2	261.2	267.9	277.0	276.4	278.9	260.8	256.4	247.5	220.1	182.0	179.9	189.9	166.6	162.3	154.4	175.	358.	07
	RUTLAND	351.2	5.1	300.2	329.6	219.5	225.5	222.4	181.7	271.6	9.9	185.3	151.3	151.5	177.0	166.4	165.6	165.6	164.0	161.2	163.0	162.7	174.8	178.9	173.6	185.	351.	00
	UNDERHILL	62.7	63.8	50.6	52.1	35.5	37.1	342.8	327.1	296.1	265.9	173.8	176.7	157.3	172.0	183.0	162.0	169.8	163.7	139.8	182.9	148.2	138.4	148.4	190.4	160.	342.	06
WSVEC	BENNINGTON	.3	.8	.3	.2	.1	.4	.3	.4	.9	1.2	1.5	2.8	2.6	2.5	2.7	2.7	2.6	1.1	.2	.6	.2	.3	.4	.4	1.0	2.8	11
	BURLINGTON	.3	.2	.4	.6	.5	.5	.8	.5	.8	1.3	1.7	2.7	2.0	1.6	1.9	1.3	1.1	.6	.7	1.4	1.4	1.6	1.7	1.9	1.1	2.7	11
	RUTLAND	.6	.7	.2	.6	.0	.3	.7	.5	.4	.1	1.3	2.3	2.9	3.8	3.8	3.3	3.4	3.0	2.6	3.0	2.4	2.1	1.9	2.1	1.7	3.8	13
	UNDERHILL	.9	.7	.5	.8	.8	.7	.2	.6	.9	1.1	1.5	1.4	1.3	1.9	1.7	1.7	1.5	1.4	.8	1.1	1.3	1.2	1.3	1.3	1.1	1.9	13

Section 23. Verification and Validation Methods

Vermont meteorological data will be assessed with a three-tiered review approach, with each review referring to the critical and operational criteria identified in Table 7.1 and 7.2.

23.1. Level 1 validation (Daily/Ongoing Review)

23.1.1. Daily review of AirVision Parameter Report 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 data trends is performed by all staff.

23.2. Level 2 validation (Quarterly Review)

23.2.1. Level 2 validation is detailed in *SOP 6040 Meteorological Data Review* and performed by monitoring staff assigned this subset of data.

23.2.2. Review of QA assessments (as available) and ambient data in more detail with a particular focus on trends by site and parameter 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 parameter.

23.3. Level 3 validation (Final Quarterly Review)

23.3.1. Level 3 validation is detailed in *SOP 6041 Meteorology Data Final Validation and Submission* and is performed by the QA Coordinator.

23.3.2. Level 3 review includes reading the quarterly report generated during level 2 review, as well as more extensive review of QA assessments, CTS results and subsets of data to include periods in question which may be due to maintenance, aberrant values, 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 with Supervisor 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 for upload to AQS are created in the proper format, and the upload is completed within 90 days of the end of the quarter in which the data was collected.

Section 24. Reconciliation with User Requirements

Data is reconciled with DQO/MQOs identified in Table 7.1 through quarterly validation review procedures performed by the monitoring staff and QA Coordinator, which includes AirVision reports and related excel graphs for each parameter.

Monthly summary report generated in AirVision:

Current Date: 5/30/2019 3:57 PM — Monthly Report

Site Name: BENNINGTON 003 : 0004 — April 2018 — Avg Interval: 1 hour

Parameter: Amb_Barometric 64101 — Units: MMHG 059 — Method: 014

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	737	736	735	735	734	734	735	736	737	738	739	739	739	739	739	740	740	740	741	741	742	741	741	741	742	738	24
02	741	741	740	740	741	741	742	742	742	742	742	742	742	741	741	740	741	741	741	741	741	742	742	742	742	741	24
03	742	742	742	742	743	742	742	742	742	742	741	741	741	740	739	739	738	738	737	736	736	735	734	733	743	739	24
04	733	732	730	730	729	728	727	726	725	724	723	722	722	724	725	725	725	726	727	729	730	731	732	733	733	727	24
05	734	735	736	736	737	737	737	738	738	738	738	738	738	738	739	739	739	739	739	740	740	741	741	741	741	738	24
06	741	741	741	741	740	740	740	740	739	739	737	736	734	732	731	731	731	731	732	731	731	731	731	731	741	735	24
07	732	732	732	732	733	733	734	735	735	735	736	736	736	736	735	736	736	737	737	737	737	737	737	737	737	735	24
08	737	736	736	736	736	736	736	736	736	736	736	736	735	735	735	735	736	736	736	737	737	738	738	739	739	736	24

Validation reports generated in the Monitoring database:

QA Validation Report: 2018 Q2

Bennington, Airport

MET

4/16/2018	MET4	HIgh WS; On reviewing minute data, it does not look suspect.

PM2.5

4/30/2018	FPCON10	4/30/18 - 7/20/18 06-16 hours have J qualifier assigned on work days (construction in area). Airport

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

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, June 19, 2019.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 53: Ambient Air Monitoring Reference and Equivalent Methods. 40 CFR Part 53, June 19, 2019.

Electronic Code of Federal Regulations, Title 40: Protection of Environment, Part 58: Ambient Air Quality Surveillance. 40 CFR Part 58, June19, 2019.

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.

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, May 2013.

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 Objectives and Validation Templates. United States Environmental Protection Agency, July 2014.

Technical Assistance Document For The National Air Toxics Trends Stations Program, Revision 3. Batelle-Columbus OH. Prepared for Office of Air Quality Planning and Standards (C304-06), U.S. Environmental Protection Agency, Research Triangle Park, NC, October 2016.

Appendix A. **Standard Operating Procedures**

Appendix B. **CTS Components-Met One AutoMet 466A**

466A system has a dedicated controller/data logger and 3m tripod.

Parameter	**Measurement method**	**Met One Model #**	**Range; Accuracy; Resolution (with units)**
Ambient Temperature	Thermistor	083D-1-35 (with 075B solar shield)	Range: -50°C - +50°C Accuracy: <±0.10°C throughout range Resolution: 0.1°C
Relative Humidity	Thin Film capacitor	083D-1-35 (with 075B solar shield)	Range: 0-100% relative humidity Accuracy: <±2% between 10-100% RH Resolution: 0.1%
Barometric Pressure	Pressure sensor	090D	Range: 660-812 mmHg (26”-32”Hg) Accuracy: <±1 mmHg or ±0.125% FS Resolution: Infinite
Solar Radiation	Pyranometer (silicon photodiode)	096-1	Range: 0-3000 W/m^2 solar radiation flux density Accuracy: <±5% Resolution: 10 W/m2
Wind Speed	Cup Anemometer	010C-1	Range: 0-50 m/s Starting threshold: 0.22 m/s Accuracy: <±1% or 0.7 m/s Resolution: 0.1 m/s
Wind Direction	Vane	020C-1	Range: 0-360° (540°) Threshold: 0.22 m/s Accuracy: <±3° Resolution: 1°