QUALITY ASSURANCE PROJECT PLAN

Community-Based Air Sensor Network

State of Alaska
Department of Environmental Conservation
Division of Air Quality
Air Monitoring and Quality Assurance Program

Prepared By:
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555 Cordova Street
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Quality Assurance Project Plan Identification & Approval

Title: ***Quality Assurance Project Plan for the State of Alaska Community-Based Air Sensor Network***

The attached Quality Assurance Project Plan for the State of Alaska Community-Based Air Sensor Network is hereby recommended for approval and commits the Alaska Department of Environmental Conservation to follow the elements described within.

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Abbreviations, Terms, and Definitions

AAAQS	Alaska Ambient Air Quality Standards
ADEC	Alaska Department of Environmental Conservation. The department of state government with primary responsibility for management and oversight of provisions of the Clean Air Act, including EPA's National Ambient Air Quality Standards.
AMQA	Air Monitoring and Quality Assurance Program of ADEC. Responsible for coordinating all aspects (quality assurance, data collection, and data processing) with respect to ambient air quality and meteorological monitoring of the ADEC Division of Air Quality.
AQI	Air Quality Index. The AQI is an index for reporting daily air quality and what associated health concerns the public should be aware of. The AQI focuses on health effects that might happen within a few hours or days of breathing polluted air. The AQI rates the air quality in 6 steps from good to hazardous.
ARP	American Rescue Plan
BAM 1020	Met-One Inc. Beta Attenuation Monitor model 1020 continuous monitoring sampler. This sampler can sample for coarse and fine particulate matter.
°C	Degrees Celsius
CBSA	Core base statistical area
Criteria Pollutant	Any air pollutant for which the EPA has established a National Ambient Air Quality Standard for regulation under the Clean Air Act.
CO	Carbon monoxide
CV	Coefficient of variation
DAS	Data acquisition system
DQO	Data quality objective
EPS3	Environmental Program Specialist 3
EPA	U.S. Environmental Protection Agency
EPM1	Environmental Program Manager 1
FEM	Federal equivalent method
FRM	Federal reference method
>	Greater than
<	Less than
LOC	Limit of concentration
LOD	Limit of detection
m	Meter
µg	Microgram
µg/m^3	Microgram per cubic meter
µg/sm^3	Microgram per standard cubic meter
mB	Millibar

m/s	Meters per second
MSA	Metropolitan statistical area
MOA	Memorandum of agreement
QuantAQ MODULAIR™	Ambient air quality sensor by QuantAQ that monitors particulate matter and gaseous pollutants, meteorology is optional.
NAAQS	National Ambient Air Quality Standards
NO and NO_2	Nitrogen oxides
NRMSE	Normalized root mean square error
O_3	Ozone
OPC	Optical particle counter
Pb	Lead
%	Percentage
+/-	Plus or minus
PM_{10}	Particulate matter less than or equal to 10 microns in size
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns
ppb	Part per billion
QA	Quality assurance
QAPP	Quality Assurance Project Plan. A plan which identifies data quality goals and identifies pollutant-specific data quality assessment criteria.
QC	Quality control
QuantAQ	Manufacturer of MODULAIR™ ambient air quality sensor
R^2	R-squared
RH	Relative humidity
RMSE	Root mean square error
SD	Standard deviation
SO_2	Sulfur dioxide
SOP	Standard operating procedure
VSCC	Very sharp cut cyclone

Distribution List

An electronic copy of this Quality Assurance Project Plan (QAPP) has been distributed to the individuals listed in in Table 1. The document is also available via Alaska Department of Environmental Conservation's (ADEC) Air Monitoring and Quality Assurance (AMQA) Program's webpage and is available for distribution upon request by additional agencies or groups who are working with the same sensor technology.

Table 1. Distribution List

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Project/Task Organization

This document presents the QAPP for the ADEC AMQA Program's Community-Based Air Sensor Network that is currently being implemented by the State of Alaska. AMQA is partnering with local and tribal governments, native health corporations, and educational institutions to house and maintain the QuantAQ MODULAIR™ air quality sensor pods. AMQA manages the network and makes the data available to the public on the AMQA website. The organizational structure of the ADEC Division of Air Quality for the implementation of the AMQA Program is

shown in Figure 1. The Quality Assurance (QA) Manager is organizationally independent from routine project operations and data collection activities. The QA Manager does not participate in fieldwork or data generation and reports directly to the Division Director on QA matters, ensuring impartial oversight and authority to halt activities if quality standards are not met.

Figure 1. Outline of Project Responsibilities

AMQA:

- **Project Management**
  - Positions involved: Program Managers
- **Planning** – Define study objectives, sensor selection, community outreach, establish partner communities, prepare QAPP
  - Positions involved: EMP1, EPS3s
- **Operations** – Sensor calibration, data collection, equipment maintenance, troubleshooting, repairs, data collection, communications, reporting
  - Positions involved: EPS3s
- **Quality Assurance/Quality Control** – Automated data validation, data quality assessment, sensor audits
  - Positions involved: EPS3s, QA Manager
- **Analysis** – Data analysis, documentation, community calls
  - Positions involved: EPM1, EPS3s
- **Reporting** – Quarterly grant reports, quarterly network calls, website reporting, community data reports
  - Positions involved: EPM1, EPS3s

Partner Communities with AMQA:

- **Site Selection and Installation** – Identify sites, equipment installation, visual inspections, site reports
  - Positions involved: EPM1, EPS3s, community partners
- **Sensor Upkeep** – General maintenance and troubleshooting
  - Positions involved: EPM1, EPS3s, community partners
- **Sensor Audits** – Audit site selection, installation, maintenance, sensor removal
  - Positions involved: EPM1, EPS3s, Partner Communities

EPA and Partner Communities:

- **Guidance**
  - Positions involved: EPA and Partner Communities
- **Feedback**
  - Positions involved: EPA and Partner Communities

AMQA Responsibilities:

Planning

- Define Study Objectives – Goals and metrics will be identified to collect baseline air quality data in rural Alaskan communities throughout the state to improve data coverage and increase outreach and education.
- Sensor Selection – Specifications for monitoring, communication, and storage of available sensors will be analyzed. Sensors within AMQA's inventory, as well as commercially available sensors, will be considered. Sensor purchases will be based on the following criteria: availability, cost, quality, suitability for Alaska's climate, experiences in previous AMQA studies, sensor reputation, and product availability and lead time.
- Public Outreach – Information on the study design, purpose, and operation will be prepared and distributed to the public in multiple formats.
- Identify Partner Communities – AMQA will select candidate Partner Communities based on existing air quality data access, geospatial distribution, population size, and sensor feasibility.
- Identify Sites – Monitoring site locations will be selected based on instrument siting requirements, low-cost sensor siting guidance, representativeness of community ambient air, and practical considerations of local conditions.
- Prepare QAPP – A Quality Assurance Project Plan will be prepared which addresses project management, data acquisition, validation, and analysis.

Operations

- Equipment Installation – Calibrated sensors will be sent to Partner Communities for deployment and installation. ADEC staff will either provide remote or in-person assistance when feasible. ADEC will provide mounting equipment, extension cables, and training on how to deploy a sensor.
- Sensor Calibration – The sensors will be calibrated by the manufacturer prior to shipment to AMQA to ensure a current calibration and proper operation of components. AMQA will conduct a collocation study with all sensors and Federal Equivalent Method (FEM) instrument or Federal Reference Method (FRM) instrument to verify sensor performance before deployment.
- Data Collection – Data collected by sensors is transmitted via cellular modem or Wi-Fi network to a cloud-based database. Data will be reviewed and stored in a data management system to facilitate retrieval and analysis.

Analysis

- Data Analysis – Real-time data will be reviewed for anomalous events to review with Partner Communities. Long-term trends will be analyzed for notable trends in ambient air quality for the communities.
- Documentation – AMQA will document data findings and include discussions on results. Reports and data analysis will be publicly available on the AMQA website and sent to Partner Communities.

Partner Community Responsibilities:

Planning

- Public Outreach – The Partner Communities will be contacted to aid in the distribution of information that best fits their community's needs.
- Identify Partner Communities– The Partner Communities will be able to choose to participate in the study and engage as Partner in work.
- Identify Sites – The Partner Communities will be contacted for inquiries about potential sites for monitor placement.

Operations

- Equipment Installation – The Partner Communities might assist in deployment of sensors or lead independent installments with remote training and assistance if it is not feasible for ADEC to access the site or community.
- Equipment Maintenance – The Partner Communities will assist in maintaining the equipment with visual inspections, power cycles, and general appearance and upkeep (removing bird nests, snow, etc.).

Problem Definition and Background

The ADEC AMQA Program is establishing a community-based ambient air quality sensor network using QuantAQ MODULAIR™ and MODULAIR™-PM sensor pods. The network's purpose is to provide baseline air quality data for areas not covered by Alaska's regulatory monitoring network. Almost every community in the state can be affected by wildland fire smoke, road dust from gravel roads, or other windblown dust. Wintertime inversions often worsen air quality due to home-heating emissions and local power generation. Industrial emissions, such as those from oil and gas development, are also a concern in some communities.

QuantAQ MODULAIR™ pods measure particulate matter (PM_1, $PM_{2.5}$, PM_{10}), carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), and ozone (O_3). MODULAIR™-PM pods measure particulate matter (PM_1, $PM_{2.5}$, PM_{10}) only.

AMQA is responsible for planning and overseeing Alaska's regulatory monitoring network, which focuses on criteria pollutants prescribed by the Clean Air Act. The primary pollutants of concern in Alaska are $PM_{2.5}$ and PM_{10}, followed by CO, lead (Pb), O_3, sulfur dioxide (SO_2), and NO_2. Other criteria pollutants occur at lower concentrations due to small population centers, limited stationary sources, sparse industrial activity, and reduced sunlight for pollutant formation.

Historically, air monitoring in Alaska has focused on the largest population centers: Anchorage, Fairbanks, and Juneau. Over the past decade, stagnant or reduced funding has forced the program to decommission sites and limit monitoring to required regulatory locations under EPA Core Based Statistical Area (CBSA) requirements. The current network includes eight sites: four in the Anchorage metropolitan statistical area (MSA), three in the Fairbanks MSA, and one in Juneau.

Beyond these CBSAs, larger communities with populations between 1,000 and 10,000 serve as regional transportation hubs ("hub" communities). These hubs connect smaller communities via commercial or private transport. ADEC allocates resources – staff time, travel funds, equipment, supplies, data access fees– to these hubs and select smaller communities to maximize monitoring coverage and benefit the greatest number of Alaskans.

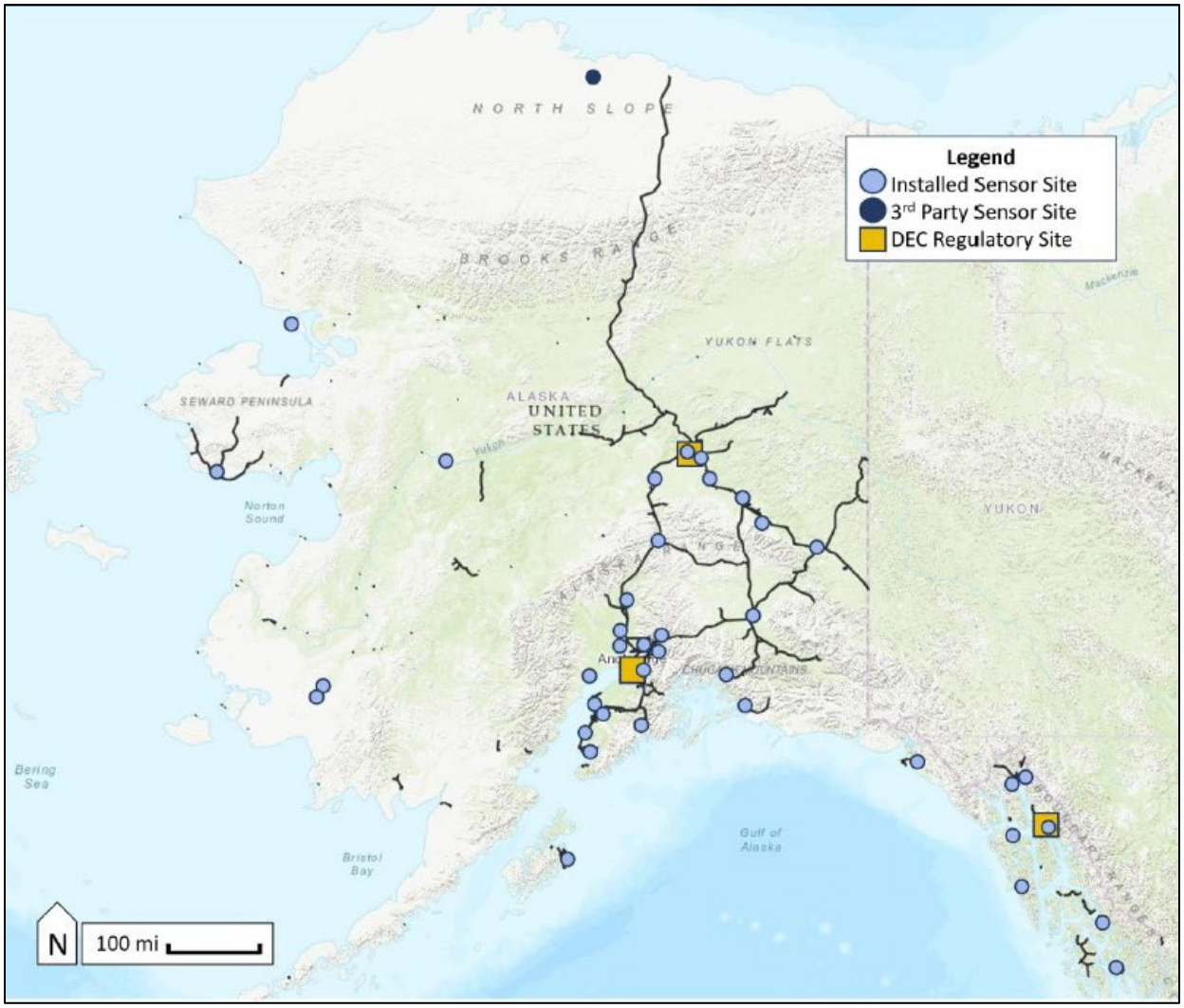

Figure 2. QuantAQ MODULAIR™ Monitoring Sites as of March 2026

Project Description

AMQA manages this project to expand access to air quality data across Alaska. The objective of this project is to provide a network of publicly available air quality data across Alaska, to help understand impacts and sources of air pollution on historically underserved communities, and to make that information easily available to the communities themselves. Common influences include wildfire smoke, road dust from gravel roads, and other windblown dust, which affect nearly every community. Wintertime inversions can worsen air quality due to home heating emissions and local power generation. Emissions from industrial activities such as oil and gas development pose concerns in some communities.

Partner Communities

Communities are selected based on location, population density, interest, and available resources (e.g., electricity for the sensor pod and access to a compatible cellular or Wi-Fi network). ADEC will prioritize partnering with tribal organizations and native health corporations for deployment.

Technology

AMQA uses QuantAQ MODULAIR™ and MODULAIR™-PM ambient air sensor pods. MODULAIR™ pods measure PM (PM_1, $PM_{2.5}$, PM_{10}), CO, NO, NO_2, and O_3. MODULAIR™-PM pods measure PM (PM_1, $PM_{2.5}$, PM_{10}) only. Both pods are continuous samplers that record concentrations every minute.

Timeframe

Pods are planned to operate for three to five years, depending on equipment performance and available funding. American Rescue Plan (ARP) funding (spring 2023) supports three years of monitoring, with deployment expected from summer 2023 through summer 2026, subject to procurement and staffing; though ARP funding is expiring, ADEC plans to continue to operate the current sensor network, as funding allows. Inflation Reduction Act (IRA) funding (summer 2025) will expand monitoring in interior wildfire areas and the Municipality of Anchorage. ADEC plans to continue to operate the current network of sensors, as staffing and funding allows.

Data Collection

Pods will sample particulate matter and gaseous pollutants at locations representative of community conditions (e.g., neighborhoods, clinics, tribal offices, schools) for three to five years.

Data Users

Anticipated users include AMQA staff, community leaders, and residents. AMQA will use long-term data for baseline assessments and trend analysis. Communities may use the data to plan outdoor activities such as school recess, hunting, fishing, or recreation. Local organizations may use it for education and outreach.

Project Update

Since 2023, ADEC has continued to expand the Community-Based Air Monitoring project throughout the state. As of March 2026, ADEC has deployed 39 pods in 41 communities; refer to Figure 2 for a map of communities hosting an ADEC QuantAQ pod. Data is displayed on a near-

real-time basis on ADEC's Air Quality Index map (https://experience.arcgis.com/experience/8655256b056a48f6a19788d43cdab30f). Refer to Figure 3 for a picture of the dashboard. ADEC is planning to expand into six communities in the Interior over the summer 2026 season, to fill the gap where the lack of cellular coverage has hindered expansion and to provide valuable data to communities impacted by wildland fire smoke. ADEC has also begun auditing community-deployed pods and is working through issues arising from an aging fleet of pods, including planning maintenance and replacement efforts.

Generally, pod issues have typically been addressed by basic troubleshooting with community partners, addressing power-supply or connectivity issues, retrieving the pod for maintenance or calibration by the manufacturer, or verification at a regulatory site before redeployment. Audit pods are generally deployed to a community to verify the community pod is functioning properly, but there have been instances where the audit pod identified issues with the community pod and the community pod required calibration by the manufacturer.

Sensor data is provided to participating communities twice a year, or more often if it is requested. ADEC sends out summer and winter data reports to each hosting community; the reports give an overview of each community's sensor performance, data preview, and air quality education resources. ADEC also hosts quarterly engagement calls with the sensor network's participants, sharing data insights, challenges and successes, and deployments over the previous quarter. Feedback from communities has been sparse but is positive when received. Communities generally seem very happy to have the air quality data available to them. ADEC plans to continue to operate the current network of sensors into the future, as staffing and funding allows.

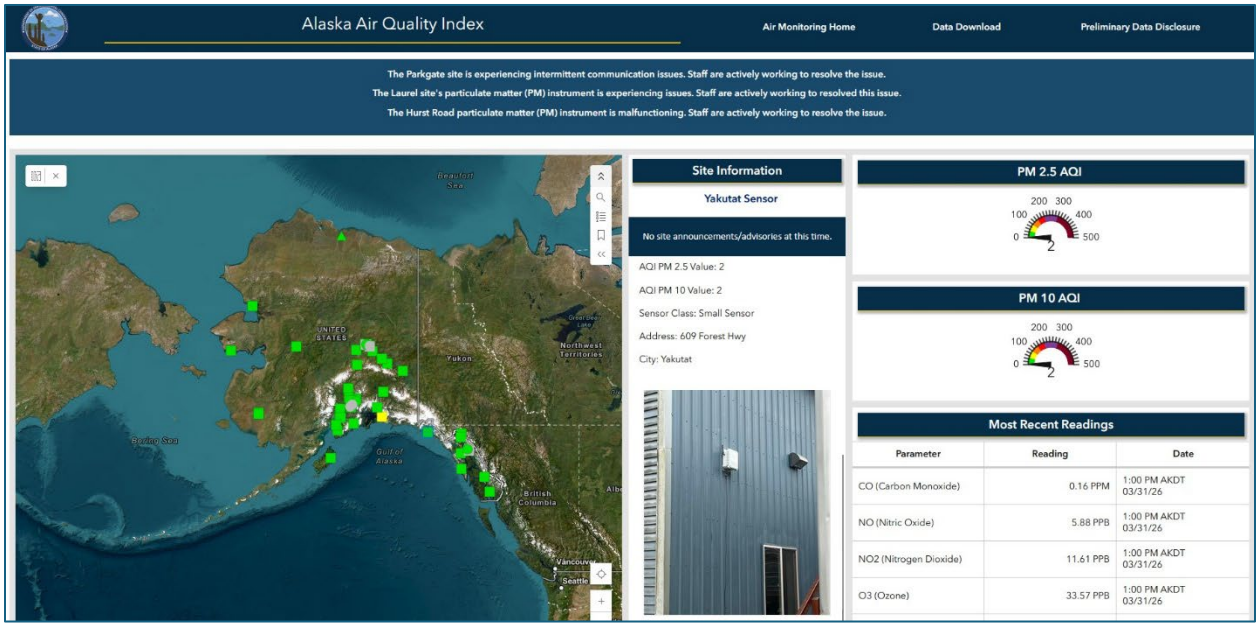

Figure 3 ADEC Air Quality Index Webpage

Quality Objectives and Criteria for Measurement Data

The following data quality objectives (DQOs) guide assessment of data quality: precision, bias, linearity, error, representativeness, comparability, and completeness. These objectives help evaluate and control the measurement process to minimize uncertainty.

Based on ADEC's experience, the study adopts the DQOs summarized in Table 2 below:

Table 2. Data Quality Objectives

Data Quality Objective	Quality Control Activities and Checks	Performance Goal
Precision	Deploy audit pods periodically for collocation with community sensors.	Standard Deviation (SD) ≤ 5 µg/m^3 --- or --- Coefficient of Variation (CV) ≤ 30%
Bias	Assess bias through collocation studies and audit pods.	Slope 1.0 ± 0.35 Intercept (b) -5 ≤ b ≤ 5
Linearity	Evaluate linearity using collocation studies and audit pods.	Coefficient of Determination (R^2) ≥ 0.70

Data Quality Objective	Quality Control Activities and Checks	Performance Goal
Error	Assess error during collocation; if high error occurs, retrieve pods for service or qualify data for trend-only use.	Root Mean Square Error (RMSE) ≤ 7 µg/m^3 --- or --- Normalized Root Mean Square Error (NRMSE) ≤ 30 %
Representativeness	Review sample design for spatial and temporal variability under baseline and impacted conditions.	Each pod includes a documented site characterization addressing local biases and representativeness.
Comparability	Compare methods to prior studies and reference method (FRM) during collocation.	N/A
Completeness	Calculate percentage of valid measurements within the time range of interest; invalid or missing data do not count toward completeness.	≥ 75% of 1-min readings for valid hourly average ≥ 75% of 24-hour readings for valid daily average ≥ 75% of quarterly data is valid for quarter completeness

Table 3. QuantAQ MODULAIR™ and MODULAIR™-PM Technical Specifications

Parameter	Units	Range	Accuracy
PM_1	µg/m^3	0 to 2,000	R^2 = 0.899; CV = 0.29
$PM_{2.5}$	µg/m^3	0 to 2,000	R^2 = 0.936; CV = 0.14
PM_{10}	µg/m^3	0 to 2,000	R^2 = 0.810; CV = 0.32
Particle size distribution	µm	0.35 to 40.0	Not yet determined
O_3	ppb	0 to 500	5 ppb or 20%
CO	ppb	0 to 13,000	40 ppb or 20%
NO	ppb	0 to 5,000	5 ppb or 20%
NO_2	ppb	0 to 5,000	6 ppb or 35%
Temperature*	Degrees C	-40 to 85	+/- 0.2°C
Relative Humidity*	% RH	0 to 100	+/- 2%

* Temperature and relative humidity are measured inside the flow cell and should not be interpreted as true ambient measurements.

Table 4: QuantAQ MODULAIR™ and MODULAIR™-PM Operating Specifications

Parameter	MODULAIR™	MODULAIR™-PM
Weatherproof rating	IP67	IP68
Operating temperature	-20 to 45°C	-20 to 50°C
Operating humidity	5 to 95%, non-condensing	5 to 95%, non-condensing
Dimensions	11.04” x 9.04” x 5.72”	6.59” x 6.59” x 5.11”
Weight	6 lb (2.72 kg)	4 lb (1.8 kg)

Training

ADEC Staff

Air monitoring personnel will receive training on sensor operation, setup, siting, installation, maintenance, and troubleshooting for MODULAIR™ and MODULAIR™-PM pods.

Partner Communities

Partner Communities include any organization or individual (e.g., tribal councils, local organizations, community members) who volunteer to assist with sensor deployment and upkeep. No standardized qualifications are required. Training is offered at project initiation and throughout the engagement.

Partners seeking a more active role receive introductory training covering project goals, equipment, siting criteria, responsibilities, and communication methods. ADEC tailors training to each Partner’s interest and availability.

Training Documentation:

The Project Manager ensures completion and documentation of all required training, ensuring that records are maintained on the AMQA network drive in a secure, centralized location.

Table 5. Training Topics, Providers, Recipients

Project Function	Description of Training	Training Provided by	Training Provided to
Equipment Handling	Proper handling, moving, and transporting of pods and components.	• AMQA	• AMQA Staff • Partner Communities
Equipment Handling – Packing for Shipment	Packing pods and accessories using dedicated materials to prevent damage.	• AMQA	• AMQA Staff • Partner Communities
Equipment Handling – Annual Maintenance	Routine inspections and cleaning.	• AMQA • Sensor company online tutorials and guidance documents	• AMQA Staff
Equipment Handling – Basic Troubleshooting	Power checks, power cycling, interpreting status lights, antenna positioning.	• AMQA	• Partner Communities
Equipment Handling – Advanced Troubleshooting	Downloading error logs via command prompts; internal repairs.	• AMQA • Quant Technical Support	• AMQA Staff • Partner Communities only as needed
Collocation Studies	Setting up collocations with MODULAIR™/MODULAIR™-PM sensors and FRM instruments; reviewing and analyzing results; applying corrective actions.	• AMQA • QuantAQ MODULAIR™ SOP • Outside agency documentation	• AMQA Staff
Data Processing	Averaging interval samples, generating summary statistics, and creating time-series plots.	• AMQA	• Partner Communities
Data Analysis	Data reduction, identifying limitations, outlier detection, trend analysis, and comparisons using tools such as AirNow and AQS.	• AMQA	• Partner Communities

Documents and Records

Data Transmission and Storage:

Sensor data are transmitted via cellular network or Wi-Fi to QuantAQ's Cloud. AMQA's AirVision Data Acquisition System (DAS) downloads data hourly via API requests and backs up nightly on ADEC servers. Hourly concentrations and $PM_{2.5}$ AQI values are displayed on AMQA's real-time AQI website.

Reporting and Public Access:

AMQA issues semi-annual interim reports summarizing network progress and publishes seasonal (winter and summer) community reports detailing sensor performance, air quality trends, and notable events. Reports are distributed to partners, posted on the ADEC website, and stored on the AMQA server. Summary data are presented during quarterly network calls, and presentation slides are posted online. Raw data are available upon request via email (amqa-data-request@alaska.gov) or phone.

Memoranda of Agreement (MOAs):

ADEC establishes MOAs with Partner Communities to define responsibilities and address equipment liability. If reimbursement is needed for utilities, labor, or installation parts, agreements allow up to $500 per fiscal year. MOAs cover the three-year guaranteed deployment term and may be extended as needed.

Standard Operating Procedures (SOPs):

QuantAQ provides SOPs on its website; AMQA develops internal SOPs for applied use and publishes them on the ADEC website. All SOPs are stored on the AMQA server.

Field Documentation and Record Retention:

Field notes, troubleshooting logs, and shipping records are digitized and retained on the AMQA server for the project duration. Project records—including interim and final reports, validated monitoring data, QA/QC data, billing receipts, and presentations—are retained for the length of the project and ten years after completion. The AMQA server is backed up nightly.

Roles and Responsibilities:

The Data Manager oversees retention of training documentation and project records for the project duration plus ten years. The QA Manager maintains all SOPs (stored on the AMQA network drive and posted online).

QAPP Review and Updates:

The QAPP is reviewed annually by the QA Manager and Project Manager to confirm suitability and effectiveness. Minor revisions are documented in a revision history and shared with approving authorities. Significant changes (scope, technology, objectives, performance criteria) require resubmittal for re-approval before implementation. Revised QAPPs are stored on the AMQA network drive and posted on the AMQA website.

Network Description (Sampling Process Design)

Selection of Partner Communities

The ADEC ambient air quality monitoring network is designed to protect the health and welfare of Alaska residents and visitors. The State of Alaska 2020 Ambient Air Quality Network Assessment (ADEC, 2020) committed to collecting baseline air quality data in hub communities lacking monitoring. Alaska has only four communities with populations over 15,000: Anchorage, Fairbanks, Wasilla/Palmer, and Juneau. AMQA operates permanent monitors in Anchorage, Fairbanks, and Juneau.

To meet the 2020 Assessment's objectives, hub communities with populations under 3,000 were reviewed for geospatial distribution and partner availability. Monitoring aims to capture year-round air quality trends to assess potential risks, so pods will remain deployed for at least one year.

Community selection under the ARP grant depends on partnerships with tribal councils, rural location, and access to a cellular or Wi-Fi network compatible with sensor technology. Additional funding will expand geospatial coverage and leverage tribal partnerships to increase statewide monitoring.

Selection of Monitoring Sites and Placement of Sensor Pods

Monitoring sites are chosen through partnerships with local tribes or native corporations, if possible. Pod placement follows standard siting criteria to ensure data represent the community ambient air quality. When possible, pods will be installed in central community spaces such as clinics, tribal offices, or schools. Sites should minimize bias, protect equipment from damage, and reflect true ambient conditions. The AMQA real-time AQI website displays all deployed and actively reporting pods statewide.

Key siting considerations include pod height and nearby physical influences (e.g., pollutant sources, obstructions). If a site becomes inaccessible, AMQA will maintain remote operations as long as feasible; personnel will not be put at risk to retrieve equipment.

Guidance based on standard air quality siting requirements:

- Maintain at least 10 feet of lateral and vertical separation from air outlets or fans; avoid exhaust vents and heating outlets.
- Locate away from pollutant sources, such as:
  - Smoking areas
  - Boiler exhausts
  - Chimneys

- Idling zones
- Equipment staging areas
- Diesel engines

- Ensure a minimum of 180° unobstructed airflow (pods may be wall-mounted but not in corners).
- Avoid areas prone to vandalism or tampering.
- Install between 10 to 40 feet above ground.
- Ensure connectivity to a cellular data network (AT&T, T-Mobile, Verizon, 4G, 5G, LTE) or secure Wi-Fi network.
- Place within 50 feet of a power outlet.
- If possible, deploy under a roof overhang to reduce snow accumulation.

Sampling Methods

QuantAQ Modulair™

This section describes sample collection and continuous measurement methods for MODULAIR™ and MODULAIR™-PM pods to ensure reliable data capture for trend analysis.

For gaseous measurements, MODULAIR™ pods use AlphaSense electrochemical sensors combined with QuantAQ proprietary algorithms. These pods measure CO, NO, NO_2 and O_3. The electrochemical sensor reacts with the target gas, producing an electrical output proportional to gas concentration. An additional electrode compensates for environmental effects, mitigating temperature and humidity impacts. QuantAQ algorithms process these outputs to calculate concentrations in parts per billion (ppb).

For particulate matter, MODULAIR™ and MODULAIR™-PM pods use a nephelometer and an optical particle counter (OPC) (AlphaSense OPC-N3). The OPC counts and sizes particles above 350 nm using a laser and photodetector, sorting counts into PM_1, $PM_{2.5}$, and PM_{10} bins. Assumptions include spherical particle shape and standardized density (Hagan and Cross, 2024). The nephelometer measures total light scattered by particles across a wide range of angles and converts this signal to mass via correlation with reference measurements in laboratory or ambient collocation studies.

Pods do not use heated inlets; instead, data are corrected for environmental factors during automated processing using mathematical correction factors for water density, aerosol density, and water activity (based on relative humidity readings).

Applicable SOPs:

- ADEC Data Validation and Verification SOP – Rev. 0 (August 2022)

- Manufacturer SOPs for QuantAQ MODULAIR and MODULAIR-PM (current versions maintained by QuantAQ and available on the QuantAQ documentation site)

The QA Manager maintains and updates AMQA SOPs. Manufacturer SOPs are maintained by QuantAQ and referenced for consistency.

Current SOP versions are stored on the AMQA network drive and posted on the ADEC AMQA website. All project personnel receive electronic access upon onboarding and are notified of updates via email and Teams announcements.

Data Collection, Processing, and Utilization

Although pods record data at 1-minute intervals, analyses use 1-hour averages for trend identification and AQI calculations. Raw data 1-minute data are reported to the QuantAQ Cloud and is stored locally on a microSD card for up to two years for redundancy and averaging.

AMQA automatically downloads hourly data from the QuantAQ Cloud into the AirVision DAS for long-term storage. The DAS is backed up nightly. Minute-level data are retained for one month, then deleted; hourly data are stored indefinitely.

Damaged or Broken Sensor Pods

If a sensor pod is damaged, worn, or broken, AMQA staff will report incidents to the Project Manager and perform repairs. Replacement parts will be purchased as needed. To minimize data gaps, AMQA will keep an inventory of spare pods ready for deployment.

Sampling Handling and Custody

A strict “Chain of Custody’ system is not implemented for this project because such procedures apply to discrete sample transfers, which are not relevant for continuous, in-situ sensor measurements.

To ensure identity and integrity of environmental data, AMQA maintains an internal tracking system for all pods moved to and from the field. This system, managed by SalesForce (or similar tracking software), records key identifiers and operational details, including: the sensor pod serial number, State Tag number, deployment location and dates, maintenance and replacement schedules, hours of operation when available, and audit status.

Analytical Method

Analytical methods typically involve laboratory analysis of samples collected under field conditions. This project does not require laboratory analysis.

Quality Control

MODULAIR™ and MODULAIR™-PM pods do not support direct instrument calibrations or built-in quality control testing. Instead, ADEC will use audit pods for instrument-to-instrument performance reviews. Audit pods - MODULAIR™ or MODULAIR™-PM units - will be collocated with an FRM monitor and then deployed to sampling sites for temporary collocation studies with on-site pods.

Audit pods will be housed at AMQA's NCore site (Fairbanks), Garden site (Anchorage), and Floyd Dryden site (Juneau). Additionally, one to two pods of each type will remain permanently stationed at these sites for ongoing comparisons between regulatory instruments, audit pods, and permanent pods. Community pods will be audited as time and funding allow. Data quality objectives (Table 2) serve as performance benchmarks.

Collocation - Definition & Purpose

Collocation is defined as:

"*The process by which a reference monitor, Federal Reference Monitor (FRM)/(FEM), and non-reference monitor (sensor) are operated at the same time and place under real world conditions for a defined evaluation period. Sensor performance can be evaluated, and data accuracy improved by comparing sensor data with reference monitor data*" (U.S. Environmental Protection Agency).

Inter-sensor comparisons may also occur, where a MODULAIR™ or MODULAIR™-PM pod is collocated with an audit pod previously validated against an FRM/FEM instrument. This approach confirms functionality of other pods in the network.

Collocation - Schedule

AMQA will conduct collocation studies when:

- Multiple pods are purchased together (prior to deployment).
- Pods are retrieved from the field for maintenance (before redeployment).

Collocation - Siting

Requirements for collocation with a reference instrument or audit pod:

- Trial location should exhibit measurable pollution, ideally with weekly peaks above 10 ppb for gases and 10 $\mu g/m^3$ for particles.
- Pods must be within 1 meter of the reference station inlet (or audit pod).

- Avoid reflective or oxidizing surfaces and HVAC exhausts.
- Maintain ≥ 0.5 m clearance from floors.
- Ensure free airflow, unaffected by turbulence from barriers or other instruments.

Full siting criteria are listed in the Selection of Monitoring Sites and Placement of Sensors section.

Collocation - Data Analysis

Collocation data will be analyzed using linear regression to compare pod readings against FRM/FEM or audit pod values. Correlation strength is expressed as R^2; values closer to one indicate stronger agreement (Figure 4).

Sensor Audits

The audit pods will be housed at ADEC's NCore regulatory site in Fairbanks, the Garden regulatory site in Anchorage, and the Floyd Dryden regulatory site in Juneau. If a deployed sensor presents unusual or questionable data, the audit pod may be deployed as a collocation in the field location to assess validity of the data. All sensors in the network will be audited by an audit pod. There may be instances where a permanent pod will be used temporarily as an audit pod, depending on the network's current needs; procedures will adhere to the specifics outlined in this section. Audits should last for between 7-10 days. Once the audit is complete, the audit pod should be returned to its home regulatory site to run for at least 7-10 days before being deployed again. Audit and local pod data will be assessed using linear regression analysis with the first 24 hours of data removed from the dataset due to sensor stabilization; (Gaseous sensors exhibit poor readings that settle back to normal within the first 12-24 hours after a pod is installed in a new location). The data quality objectives are used as quality control of the performance of sensors (Table 2).

Corrective Actions: If audit results fail to meet DQO thresholds (Table 2), or indicate bias beyond acceptance limits, AMQA will initiate corrective actions that may include retraining partner personnel if siting or operational issues are implicated, retrieving and servicing or replacing components, and repeating collocation for 7-10 days to confirm performance. Effectiveness is documented when re-audit metrics meet DQOs. All actions and outcomes are logged in Salesforce software (or similar tracking software) and referenced in reporting.

Correction Factor

ADEC is developing a correction factor for MODULAIR^{TM}-PM data to align particulate measurements more closely with FEM/FRM standards.

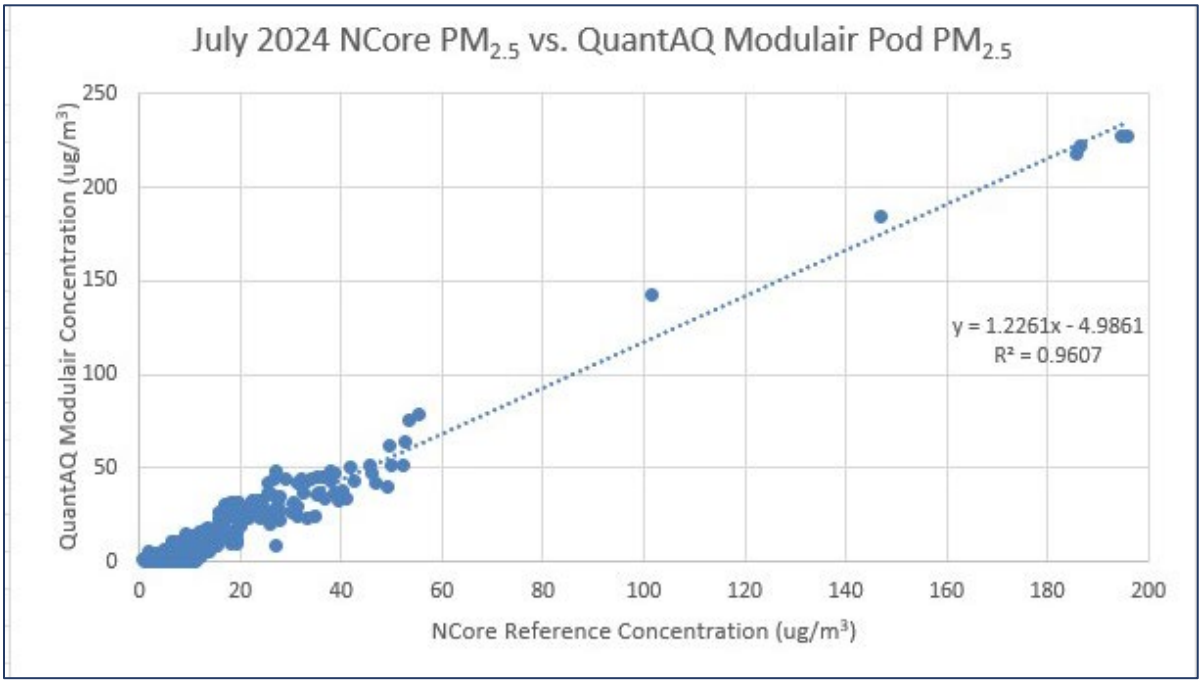

Figure 4: Example of Linear Regression Showing Strong Correlation Between Reference and Sensor

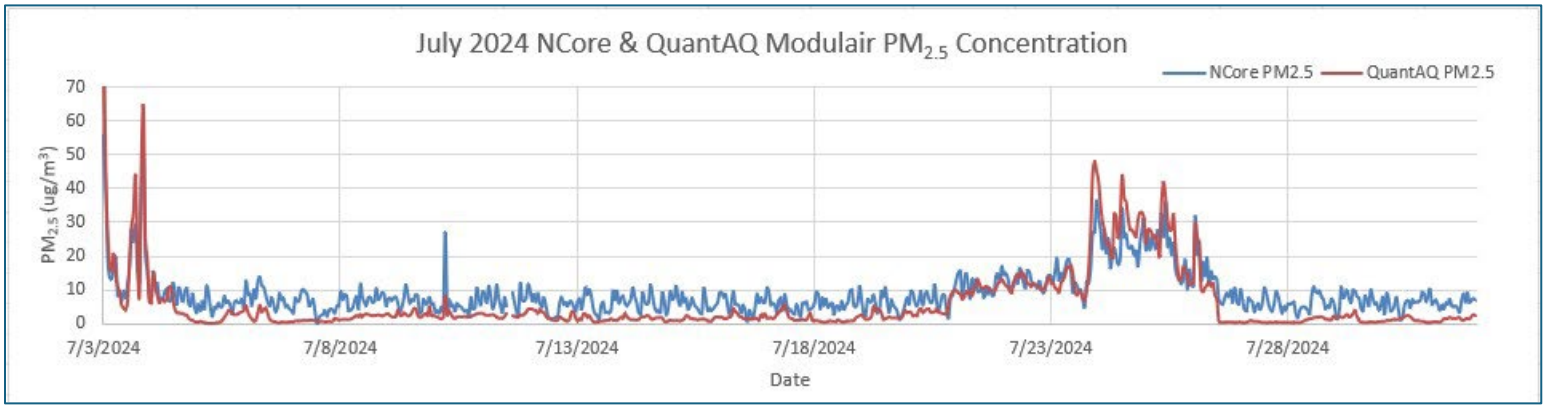

Figure 5: Comparison Example of $PM_{2.5}$ Concentration Between FEM Instrument and Collocated QuantAQ MODULAIR™ Sensor

Instrument/Equipment Testing, Inspection, and Maintenance

This section outlines procedures for inspecting, testing, and accepting instruments, supplies, and consumables that directly or indirectly affect data quality.

Acceptance Testing of Equipment

Equipment is tested to confirm compliance with purchase specifications, including verification that data meet DQOs (Table 2), temperature stability, and linearity

Maintenance of Equipment

AMQA is responsible for sensor maintenance but may request assistance from Partner Community contacts for equipment retrieval or basic troubleshooting. Maintenance and repair activities are tracked in AMQA digital systems, including AirVision and SalesForce (or similar tracking software).

Sensor pods undergo intermittent visual inspections by Partner Community contacts, with additional checks triggered by data communication issues. During inspections, all actions, observations, and notes must be documented in SalesForce (or similar tracking software) under the corresponding community and sensor. Example observations include:

- Power cable is securely connected at both sensor and outlet, intact and undamaged.
- LED indicator light is 'breathing' cyan (slow pulsing), signaling proper function, cellular connectivity, and QuantAQ Cloud connection. Other LED colors or patterns may indicate system failure, firmware update, or network issues (see Table 6).
- Replace any electrical interfaces showing corrosion, rust, heat, or water damage (e.g., power blocks, cords, ports).
- Address missing parts, frayed cords, or loose fittings.
- Capture photographs of any issues and the entire pod if changes or disturbances are observed.

Critical Spares and Replacement Logging: AMQA maintains critical spares—including spare pods, power supplies, power cords, and external antennas—to minimize downtime and ensure continuity of monitoring. Inspection results and component replacements will be logged under the sensor within SalesForce (or similar tracking software), maintaining traceability between maintenance actions and subsequent verification outcomes.

Table 6: QuantAQ MODULAIR™ LED Indicator Status and Meaning

LED Color	Pattern	Mode	Description
Green	Blinking	Looking for internet	Device is attempting to connect to the cellular network; no action required.
Green	Breathing	Cloud not connected	Device has cellular connectivity but cannot connect to the cloud.
Cyan	Blinking	Connecting to the cloud	Device is connecting to the cloud; occurs at startup; no action required.

LED Color	Pattern	Mode	Description
Cyan	Breathing	Connected	Device is fully connected to the internet and QuantAQ Cloud.
Magenta	Blinking	Firmware Update	Device is undergoing an over-the-air firmware update; DO NOT power off.
White	Breathing	Cellular Off	Cellular connection is disabled; if not intentional, notify QuantAQ.
Red	Blinking	System Failure	System failure likely due to faulty firmware or corrupted memory; contact QuantAQ for next steps.

Instrument Calibration and Frequency

MODULAIR™ and MODULAIR™-PM sensors arrive factory-calibrated. QuantAQ does not provide specific guidance for post-factory calibration, and in-situ calibration is not emphasized by the manufacturer. QuantAQ recommends pods return yearly to the manufacturer for maintenance and calibration.

To verify performance and accuracy, AMQA conducts collocation studies at regulatory monitoring sites before and after hub community deployments. These studies bracket the data as quality control checks. When space or power is limited, an alternative approach—called "harmonization"—collocates all sensors together, then deploys one representative control sensor at a regulatory site for comparison.

Collocation studies compare PM_{10} and $PM_{2.5}$ measurements between pods and a reference FEM MetOne BAM 1020 instrument equipped with a $PM_{2.5}$ very sharp cut cyclone (VSCC) and PM_{10} inlet. Each study runs for 10–60 days, targeting at least 75% data comparison between each sensor pod and the reference instrument. Data gaps may occur due to troubleshooting, power outages, or unforeseen issues. After each study, correlation analysis is performed to assess sensor performance before and after deployment.

Collocation documentation includes:

- Pod serial number
- Collocation duration (start and end dates/times)
- Audit pod serial number
- Data comparison results and R^2 values

Verification and Acceptance: Pre-deployment collocation (typically 10–60 days) and post-maintenance verification (7–10 days) will be conducted against FEM/FRM instruments or designated audit pods.

Acceptance criteria (Table 2 DQOs): $PM_{2.5}$ $R^2 \geq 0.70$; slope 1.0 ± 0.35; intercept −5 to +5 µg/m³; RMSE ≤ 7 µg/m³. For gases (CO, NO, NO_2, O_3), verification requires absence of QA failure flags (Table 7) and stable performance during the verification interval.

Recordkeeping and Traceability: All verification runs, dates, sites, devices IDs, regression outputs, QA flags, and corrective actions are logged in SalesForce (or similar tracking software) and archived on the AMQA network drive.

Inspection/Acceptance of Supplies and Consumables

The following consumables are required for annual cleaning and maintenance of MODULAIR™ and MODULAIR™-PM pods:

- Compressed air duster
    - Used to gently remove dust and particulates from sensitive components and instrumentation. Do NOT use compressed air to clean particulate matter sensors.
- Dielectric grease
    - Applied to prevent water infiltration into electrical connections (e.g., extension cords).

Inspection and Acceptance: All supplies and consumables—including power blocks, cords, enclosures/seals, dielectric grease, and external antennas—are accepted following visual inspection for corrosion, heat damage, or water intrusion. Basic electrical continuity checks are performed where applicable. Manufacturer lot/date codes are verified when available. The Data Manager oversees inventory control, and EPS3 staff confirm acceptance upon field receipt.

Non-Direct Measurements

Once sensor pods have been sited, GPS coordinates will be recorded and posted on the ADEC data website and entered into internal tracking systems (AirVision, SalesForce, or similar tracking software, etc.).

Data Management

Sensor data are stored on microSD cards in each pod and transmitted hourly to the QuantAQ cloud (QuantAQ.com). The AirVision DAS downloads sensor data hourly to ADEC servers, where hourly data are retained indefinitely and minute-level data for one month. The AMQA real-time AQI website displays the latest 12 hours of data, and full datasets are available upon request.

Data integrity is maintained through automated system logs and periodic manual checks in AirVision and SalesForce (or similar tracking software). Errors are logged, flagged for review, and corrected, with all corrections documented. Nightly backups are performed, and backup logs are reviewed regularly.

Project records -- including reports, validated data, QA/QC data, and training documentation -- are retained on the AMQA server for the duration of the project and ten years after completion. The Project Manager is responsible for record retention.

File naming conventions and version control are maintained in AirVision DAS and SalesForce (or similar tracking software). Access to data is restricted to authorized AMQA staff. All personnel involved in data management receive training on relevant methods and procedures.

Assessments and Corrective Actions

Assessments are evaluation processes used to measure performance and effectiveness of systems and their components. These may include audits, performance evaluations, management system reviews, peer reviews, inspection, and surveillance activities.

Data Quality Assessments

Data quality assessments involve statistical and scientific tests to determine validity, evaluate system performance, and assess whether the dataset meets project goals. In addition to formal tests, practical checks are applied, such as:

- Behavior
    - If patterns deviate from expected diurnal trends or known factors, the sensor pod will be investigated for noise or anomalies.
- Audits
    - See the Sensor Audits section for details.

Completeness

Completeness measures the proportion of valid data obtained compared to what is expected under normal conditions. Although sensors are non-regulatory, a 75% completeness criterion is standard for data validity. For example, an hour of data requires at least 75% valid sub-hour measurements.

Bias, Precision, and Accuracy

Bias is a "systematic or persistent distortion of a measurement process that causes uncertainty in one direction" (U.S. Environmental Protection Agency).

Precision is defined as a "measure of mutual agreement among individual measurements of the same property" (U.S. Environmental Protection Agency).

Accuracy is a term that is frequently used to represent closeness to truth and incorporates the properties of bias and precision.

Sensor Performance Update

After more than a year of continuous operation in multiple communities, MODULAIR™ units have performed at acceptable levels with some exceptions:

- Data capture outside operating temperature specifications (Table 4) is unreliable, with internal sensors malfunctioning and PM_{10} concentrations spiking to false maximums.
- PM_{10} sensors exhibit significant influence from moisture (ice fog, haze, mist), causing hygroscopic effects that inflate particulate readings. These false high values are nullified in the AMQA AirVision DAS.

Despite these exceptions, overall data capture remains high and provides valuable insights into pollutant trends. Sensors have successfully recorded environmental events (dust storms, inversions, lightning-caused wildfires) and anthropogenic impacts (home heating, diurnal patterns, human-caused fires). These trends confirm the sensors' utility as survey tools, particularly for PM monitoring.

Assessments, including data quality reviews, internal audits, and corrective action evaluations, are performed as described in this QAPP. Frequency depends on project needs and resource availability. Assessment results and corrective actions are documented by the Project Manager and communicated to project management through established reporting channels. Follow-up actions are tracked until resolved and recorded in project files.

Data Review, Validation, and Verification Requirements

AMQA will conduct data review, validation, and verification of sensor data without separate QC staff. Environmental Program Specialist 3 (EPS3) personnel review and analyze the data, while the Quality Assurance Manager will oversee the process to ensure adherence to QA/QC criteria outlined below.

Data review, verification, and validation are standardized techniques used to accept, reject, or qualify data objectively and consistently.

Data review, Validation, and Verification

Air quality and meteorological data undergo four validation levels. Each dataset is labeled at the level completed before advancing to the next, ensuring transparent determination of data validity.

- **Level 0:** Raw data obtained directly from pods by the QuantAQ Cloud. QuantAQ automatically flags data using criteria in Table 7. Data failing these criteria are flagged as invalid on the QuantAQ Cloud before the AirVision DAS receives them via API. The DAS automatically flags or nullifies records for less than 75% data capture or erroneous values.
- **Level 1:** Quantitative and qualitative reviews of accuracy, completeness, and internal consistency. EPS3 staff examine outliers and anomalies and assign quality control flags as needed.
- **Level 2:** Comparisons with independent datasets (e.g., pods at NCore station, audit pods, or other meteorological systems).
- **Level 3:** Detailed analysis and final screening to verify no inconsistencies among related data. Graphics may be used to confirm consistency (e.g., diurnal patterns vs. other parameters; strip chart review). Datasets that pass Level 3 are suitable for comparison with reporting thresholds or regional analyses.

Table 7: MODULAIR™ Flags and Nullification Codes for Data

Code	Value	Description	What to do?
FLAG_STARTUP	1	This flag is set when the device powers on.	Remove any rows where this flag is set.
FLAG_OPC	2	This flag is set when the OPC has indicated the data failed to transfer correctly. This can be caused by the fan being off, the laser being off, or the checksum not validating properly.	Remove any rows where this flag is set.

Code	Value	Description	What to do?
FLAG_NEPH	4	This flag is set when the nephelometer has indicated that the data failed to transfer correctly.	Remove any rows where this flag is set.
FLAG_RHTP	8	This flag is set when the relative humidity and temperature sensor has failed.	Remove any rows where this flag is set.
FLAG_CO	16	This flag is set when the CO sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_NO	32	This flag is set when the NO sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_NO2	64	This flag is set when the NO2 sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_O3	128	This flag is set when the O3 sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_CO2	256	This flag is set when the CO2 sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_SO2	512	This flag is set when the SO2 sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_H2S	1024	This flag is set when the H2S sensor has failed, or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.

Quality Control

Validated datasets are compared to audit pod data (see the Sensor Audits section). Audit results primarily inform whether corrective actions or repairs are needed. Audit data also supports evaluation of individual datasets and overall network performance.

Calibration

QuantAQ MODULAIR™ and MODULAIR™ -PM sensors are factory-calibrated (see the Instrument Calibration and Frequency section) AMQA does not perform sensor calibrations.

Data Reduction and Processing

Data are processed according to project needs. A standard step is averaging 1-minute measurements to 1-hour values. Additional reduction supports AQI calculations. Upon public request, AMQA provides raw data and, when appropriate, reduced datasets tailored to user needs.

Routine data reduction and validation occur after at least six months of deployment. Depending on findings, AMQA may compile a trend report and publish it on the ADEC website.

Data Verification and Validation Methods

The verification and validation processes in this QAPP ensure that the Alaska Community-Based Air Sensor Network meets its quality assurance criteria. AMQA staff perform these activities in accordance with the requirements below, under the oversight of the Project Manager.

Data Verification -- Two-Step Process:

1. Identify project needs for records, documentation, and technical specifications for data generation, and determine their location and source.

2. Verify records produced or reported against method, procedural, or contractual requirements, including field and analytical operations (e.g., sample collection, receipt, preparation, analysis and verification record review).

The ADEC community network provides baseline air quality data for areas not covered by the State's regulatory monitoring network. Raw data, processed data, visualizations, and reports are stored in the AMQA AirVision DAS, on project websites, and on the AMQA network drive. Reports and data are distributed regularly to network participants and upon request. A final project report will be submitted to the EPA, including descriptions of the validation and verification process and associated QA/QC procedures.

Data review, validation, and verification follow QAPP requirements. Data are assessed for completeness, accuracy, and adherence to DQOs. Records that fail to meet DQOs or validation criteria are flagged and excluded from reporting. All decisions to accept or reject data are documented in project files.

Data usability is determined by whether the dataset meets established DQOs and validation criteria. This determination is documented in project records or associated reports.

Data Validation Methods

Before AMQA reports or uses the data for decisions related to air quality, pollution abatement, or control, the data are verified and certified by the Project Manager in consultation with the Quality Assurance Manager.

For data to be considered valid, the following conditions must be met:

- Air monitoring instrumentation must be calibrated and operated according to approved standard methods.
- Data must include backup documentation that meets QAPP specifications and identifies station name, station number, date, time, operator, instrument ID, parameter, scale, and units.

Data meeting these criteria will be considered valid. Data that do not meet these criteria will be invalidated or appropriately qualified ("flagged").

Reconciliation with user Requirements

Data review

As part of the review and validation process, the Project Manager evaluates all data to confirm alignment with QAPP objectives. Decisions to accept or reject data will be made before its inclusion in presentations or reports. Data entry errors will be corrected, and outliers flagged for further review.

Data usability

DQOs and validation procedures are designed to enable the Project Manager to identify and correct issues in data collection and reporting. If validation measures or QA reviews indicate questionable integrity or unmet DQOs, the affected dataset (or portion) must be flagged as unacceptable for inclusion in the Program Data File.

The Project Manager determines whether corrective actions are needed and ensures implementation of QA recommendations. The Project Manager has authority to question data, assign training, and recommend sensor replacement when necessary.

AMQA monitors air quality to establish baseline datasets for previously unmonitored areas of Alaska. If data suggest potential violations of the National Ambient Air Quality Standards (NAAQS) or Alaska Ambient Air Quality Standards (AAAQS), AMQA and other Division of Air Quality programs will investigate further. Investigations may include developing emissions inventories to identify sources or conducting additional monitoring studies using advanced technologies. If air quality impacts are confirmed, ADEC will develop or modify control

strategies to prevent or mitigate pollution episodes, track trends, and maintain a database for research and evaluation of air pollution effects.

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