Muscogee (Creek) Nation
Office of Environmental Services

Quality Assurance Project Plan (QAPP)

PurpleAir Sensor - Ambient Air Quality Program (AAQP) Project

FY 2023-2025

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Approval Page

PurpleAir QAPP – MCNOES AAQP

Plan Prepared by: Kristy Lawson, Environmental Specialist II

The following individuals have reviewed and approved the PurpleAir Quality Assurance Project Plan (QAPP) for the Muscogee (Creek) Nation Office of Environmental Services (MCNOES) Ambient Air Quality Program (AAQP). By signing, each person verifies, approves, and commits to the MCNOES AAQP to follow the elements described within this QAPP.

Muscogee (Creek) Nation:

Name: David W. Hill
Title: Muscogee (Creek) Nation / **Principal Chief**

Signature: David W Hill Date: 10/22/2024

Name: James Williams
Title: Environmental Director / **Overall QAPP Manager**

Signature: James Williams Date: 10-17-24

Name: Judith Ausmus
Title: Environmental Specialist II / **QAPP Manager**

Signature: Judith E. Ausmus Date: 10/15/24

Name: Kristy Lawson
Title: Environmental Specialist II / **Project Manager**

Signature: Kristy Lawson Date: 10/15/24

U.S. Environmental Protection Agency – Region 6

Name: Aunjanee Gautreaux
Title: Project Officer – CAA 105 PPG, EPA Region 6

Signature: Aunjanee Gautreaux Date: 10/24/24

Name: Juan Bonilla
Title: Division Quality Assurance Officer – EPA Region 6

Signature: Juan Bonilla Date: 10/24/24

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Table of Contents

1.0 PROJECT MANAGEMENT (Group A) **7**

1.1 Cover and Approval Page (EPA QA/R-5 A1) / Section 1 7
1.2 Table of Contents (EPA QA/R-5-5 A2) / Section 2 7
1.3 Distribution List (EPA QA/R-5 A3) / Section 3 8
1.4 Project Organization (EPA QA/R-5 A4) / Section 4 9
1.5 Problem Definition/Background (EPA QA/R-5 A5) / Section 5 12
1.6 Project/Task Description and Schedule (EPA QA/R-5 A6) / Section 6 15
1.7 Quality Objectives & Criteria for Measurement Data (EPA QA/R-5 A7) / Section 7 17
1.8 Special Training Requirements/Certifications (EPA QA/R-5 A8) / Section 8 20
1.9 Documents and Records (EPA QA/R-5 A9) / Section 9 22

2.0 DATA GENERATION AND ACQUISITION (Group B) **25**

2.1 Sampling Design (Experimental Design) (EPA QA/R-5 B1) / Section 10 25
2.2 Sampling Methods (EPA QA/R-5 B2) / Section 11 27
2.3 Sample Handing and Custody (EPA QA/R-5 B3) / Section 12 28
2.4 Analytical Methods (EPA QA/R-5 B 4) / Section 13 28
2.5 Quality Control Requirements (EPA QA/R-5 B5) / Section 14 28
2.6 Instrument/Equipment Testing, Inspection, and Maintenance (EPA QA/R-5 B6) / Section 15 31
2.7 Instrument/Equipment Calibration and Frequency (EPA QA/R-5 B7) / Section 16 33
2.8 Inspection/Acceptance Requirements for Supplies & Consumables (EPA QA/R-5 B8) / Section 17 33
2.9 Data Acquisition Requirements (Non-Direct Measurements) (EPA QA/R-5 B9) / Section 18 34
2.10 Data Management (EPA QA/R-5 B10) / Section 19 34

3.0 ASSESSMENT AND OVERSIGHT (Group C) **35**

3.1 Assessments/Oversight & Response Actions (EPA QA/R-5 C1) / Section 20 35
3.2 Reports to Management (EPA QA/R-5 C2) / Section 21 36

4.0 DATA REVIEW & USABILITY (Group D) **37**

4.1 Data Review, Verification, & Validation Requirements (EPA QA/R-5 D1) / Section 22 37
4.2 Verification and Validation Methods (EPA QA/R-5 D2) / Section 23 38
4.3 Reconciliation with User Requirements (EPA QA/R-5 D3) / Section 24 38

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1.0 PROJECT MANAGEMENT (Group A)

*The elements in this group **(Table 1: (Group A) – Project Management Elements)** address project management, including project history and objectives, roles and responsibilities of the participants, etc. These elements document that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planning outputs have been reported.*

Table 1: (Group A) - Project Management Elements

A1	Title and Approval Sheet
A2	Table of Contents
A3	Distribution List
A4	Project/Task Organization
A5	Problem Definition/Background
A6	Project/Task Description
A7	Quality Objectives and Criteria
A8	Special Training/Certification
A9	Documents and Records

1.1 Title and Approval Page (EPA QA/R-5 A1) / Section 1

On the Title and Approval Sheet, include the title of the plan, the name of the organization(s) implementing the project, the effective date of the plan, and the names, titles, signatures, and approval dates of appropriate approving officials may include:

- *Organization's Project Manager*
- *Organization's QA Manager*
- *EPA Project Manager*
- *EPA QA Manager*
- *Others (e.g., field operations manager, laboratory managers, State and other Federal agency officials)*

The Title and Approval Page resides on page 3.

1.2 Table of Contents (EPA QA/R-5-5 A2) / Section 2

*Provide a Table of Contents for the document, including sections, figures, tables, references, and appendices. Apply a document control format **(Figure 2: Example Document Control Format)** on each page following the Title and Approval Sheet when required by the EPA Project Manager and QA Manager.*

Figure 1: Example Document Control Format

Section No. ________
Revision No. _______
Date _______________

The Table of Contents resides on page 5.

1.3 Distribution List (EPA QA/R-5 A3) – Section 3

List the individuals and their organization who need copies of the approved QA Project Plan and any subsequent revisions, including all persons responsible for implementation (e.g., project managers), the QA manager, and representatives of all groups involved. If equivalent electronic information systems can be used, paper copies need not be provided to individuals.

Table 2: QAPP Distribution List (USEPA and MCNOES)

Name	Title	Organization	Contact Information
Aunjanee Gautreaux	Project Officer – Region 6	USEPA	qautreaux.aunjanee@epa.gov (214) 665-7127
Juan Bonilla	Division Quality Assurance Officer – Region 6	USEPA	bonilla.juan@epa.gov 214-665-2226
James Williams	MCNOES Program Director	MCNOES	jwilliams@muscogeenation.com 918-549-2587
James Hayes	Environmental Specialist II / Grant Manager	MCNOES	jhayes@muscogeenation.com 918-549-2582
Judith Ausmus	Environmental Specialist II / Quality Assurance Manager	MCNOES	judith.ausmus@muscogeenation.com 918-549-2579
Sonny Hill	Environmental Specialist II / Finance	MCNOES	rhill@muscogeenation.com 918-549-2578
Kristy Lawson	Environmental Specialist II / Quality Assurance Officer	MCNOES	klawson@muscogeenation.com 918-549-7729
Michael Fish	Environmental Specialist I / Field Technician	MCNOES	mifish@muscogeenation.com 918-549-2589
Barry Barnett	Environmental Specialist I / Field Technician	MCNOES	babarnett@muscogeenation.com 918-549-2543
Eli Barnett	Environmental Specialist I / Field Technician	MCNOES	elbarnett@muscogeenation.com 918-549-7792

The individuals in this list will be notified/receive copies of any QAPP revisions or amendments during the project. Revisions and amendments must be approved before implementation and distribution. Please note that if the Primary Quality Assurance Organization (PQAO) for which the QAPP is being prepared includes multiple organizations, the distribution list for the QAPP may need to be abridged. In this case, include the above information for the key project personnel, including upper management and QA staff, from all organizations within the PQAO. Then, add a disclaimer, such as the following: "The QAPP will be distributed to other personnel and operators beyond this list, following the organizational chart(s) presented in Section 1.4 Project Organization of this QAPP".

1.4 Project Organization (EPA QA/R-5 A4) / Section 4

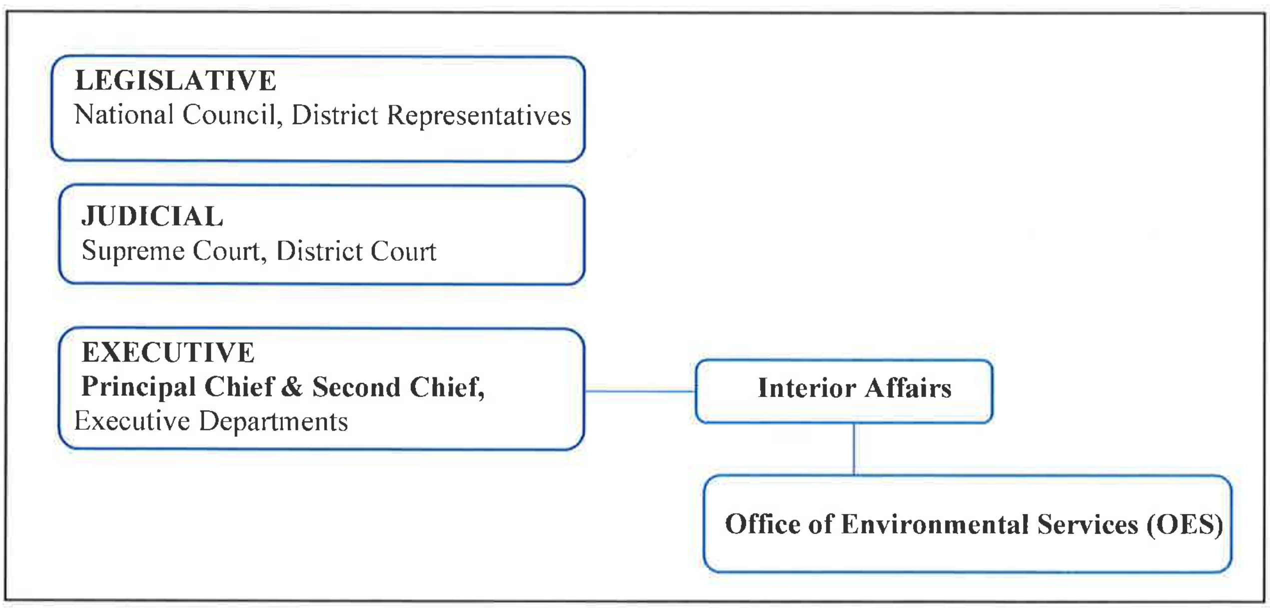
Identify the individuals or organizations participating in the project and discuss their specific roles and responsibilities. Include the principal data users, the decision-makers, the project QA manager, and all persons responsible for implementation. The project Quality Assurance Manager must be independent of the data-generating unit. (This does not include being independent of senior officials, such as corporate managers or agency administrators, who are nominally, but not functionally, involved in data generation, data use, or decision-making.) Identify the individual responsible for maintaining the official, approved QA Project Plan. Provide a concise organizational chart showing the relationships and lines of communication among all project participants. Include other data users outside the organization generating the data but for whom the data are intended. The organization chart must also identify subcontractor relationships relevant to environmental data operations, including laboratories providing analytical services.

1.4.1 MCN Tribal Organization

The Muscogee (Creek) Nation (MCN) is a self-governed Native American tribe in Okmulgee, Oklahoma. The MCN is one of the Five Civilized Tribes and is the fourth largest tribe in the U.S., with over 100,000 citizens. The government side of the tribe consists of an executive branch, a legislative body, and a tribal court system, as seen in ***Figure 2: Tribal Organization of the Muscogee (Creek) Nation***. The MCN is diverse and has many facets, including culture, tourism, gaming, businesses, health, environment, and higher learning institutions.

The MCN Department of Interior Affairs is tasked with implementing and managing numerous tribal resources, including transportation, land, natural resource management, and tribal construction. Departments under the Interior Affairs Office include the Division of Agriculture and Natural Resources, Office of Environmental Services (OES), Federal Roads, Geospatial or Geographic Information System (GIS), Oil & Gas, Realty, Risk Management, Tribal Construction, Tribal Driveways, and Transit.

Figure 2: Tribal Organization of the Muscogee (Creek) Nation



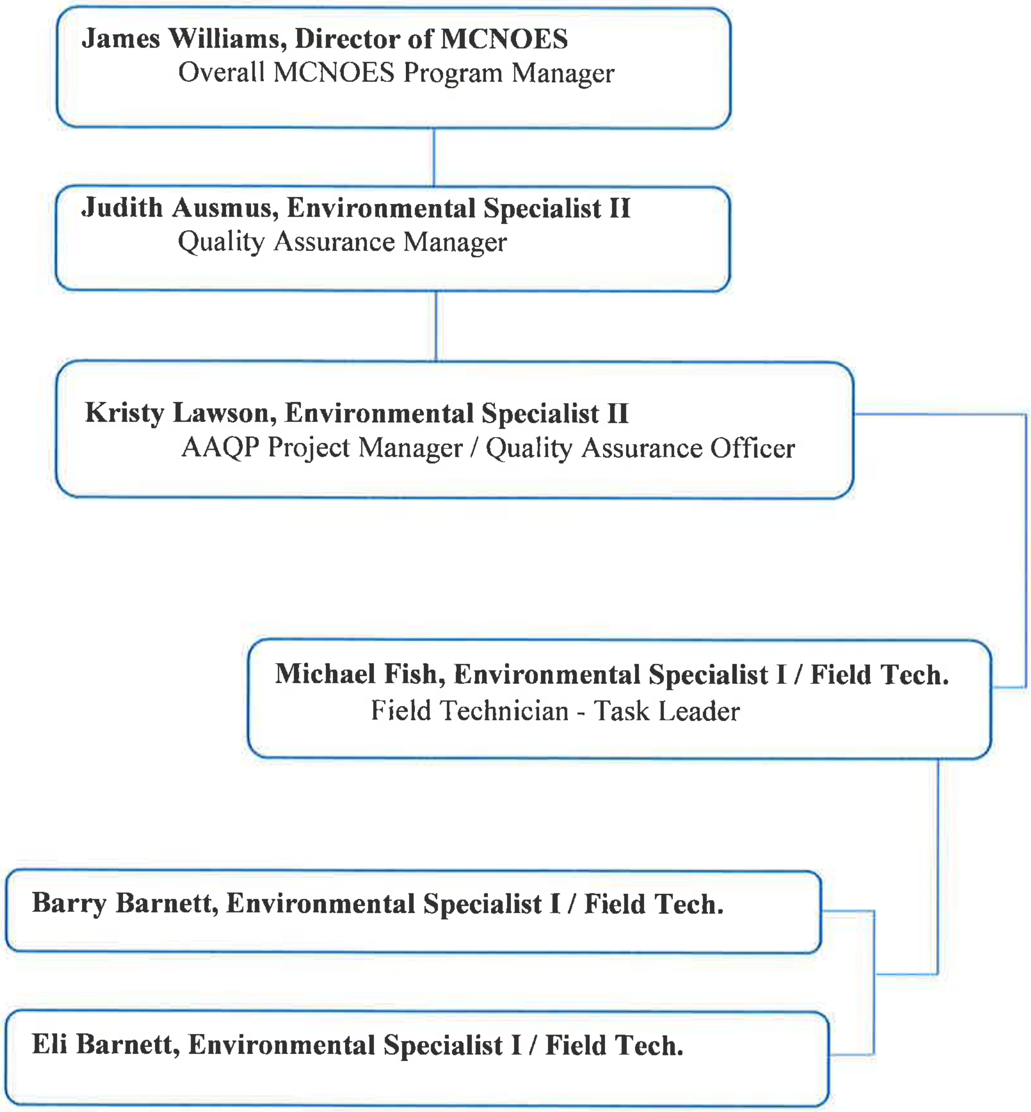
1.4.2 MCNOES Ambient Air Quality Program (AAQP)

The Muscogee (Creek) Nation (MCN) Ambient Air Quality Program (AAQP) is a part of the Office of Environmental Services (OES). ***Figure 4: Individuals Participating in the MCNOES PurpleAir AAQP Project*** provides a visual breakdown of tasks assigned to each member of the AAQP. The PurpleAir sensors will be operated by three (3) staff members plus two (2) cross-trained employees within this program: the Quality Assurance Manager (QAM), the Quality Assurance Officer (QAO), and three (3) Field Technicians. Since the MCN Reservation consists of eleven (11) counties, multiple Field Technicians will be cross-trained to assist with maintenance. These staff members will maintain and update quality assurance documents, installation, maintenance, and data retrieval and analysis from the PurpleAir sensors. The specific roles and responsibilities are described below.

- The overall **MCNOES Program Director** (James Williams) will supervise the project's organizational and managerial aspects.
- The **Grant Manager** (James Hayes) will assist the AAQP Project Manager in planning and executing the grantmaking process by working with the finance team to stay within the annual budget, supporting program staff in researching funding opportunities, managing documents and deadlines, and helping track grantee results.
- The **Quality Assurance Manager (QAM)** (Judith Ausmus) will oversee and review all work products submitted by the Project Manager(s). In addition, the QA Manager will oversee this project's statutory requirements.
- The **Finance Manager** (Sonny Hill) will facilitate communication between the MCNOES and MCN Financial Department to ensure quarterly funding is drawn down. The Finance Manager's responsibilities also include assisting with writing budget proposals for various MCNOES grants.
- **Project Manager / Quality Assurance Officer (QAO)** (Kristy Lawson) will oversee and monitor technical activities performed by the project Task Leader. The QAO will collect and verify data from the PurpleAir sensors following the requirements of this QAPP. They will oversee that the monitor is functioning correctly and process and analyze the data. The QAO will also upload verified data to the AAQP online database and the Quality Review and Exchange System for Tribes (QREST) database. The QAO is responsible for contacting the PurpleAir manufacturer to fix equipment malfunctions or failures.
- **Field Technicians** (Michael Fish, Barry Barnett, and Eli Barnett) will help maintain and oversee the monitors' proper functioning. MCNOES Field Technicians travel to all eleven (11) MCN counties within the MCN Reservation, conducting various program deliverables and environmental services for MCN citizens.

The MCNOES AAQP will quality-assure and correct the data collected before it is formally reported to the MCNOES director, tribal council, community, and other relevant parties.

Figure 3: Individuals participating in the MCNOES PurpleAir Ambient Air Quality Project



1.4.3 Environmental Protection Agency (EPA) - Region 6

Responsible for QAPP review, technical assistance, and approval of the QAPP for implementation.

1.5 Problem Definition/Background (EPA QA/R-5 A5) / Section 5

State the specific problem to be solved, the decision to be made, or the outcome to be achieved. Include sufficient background information to provide this project's historical, scientific, and regulatory perspective.

The MCNOES AAQP began in 2021, with a Level 4 Emission Inventory of all eleven (11) counties within the MCN Reservation. With data collected from the emission inventory, the MCNOES AAQP applied for Clean Air Act (CAA) 105 funding to accomplish the tasks associated with this project. The MCNOES has worked closely with the U.S. Environmental Protection Agency (EPA) on several regulatory and education/outreach services that help to protect the health and welfare of the 100,000+ citizens within the MCN Reservation. Air pollution sources on the Reservation include wildfires, open burning, lumber mills, hot mix asphalt plants, boilers, unpaved roads, gravel mining and rock crushing operations, gas stations, airports, mobile sources, aerial application of pesticides, agricultural operations, and many other types of pollutant sources.

Low-cost sensors are becoming more popular for personal use, research, and even for augmenting regulatory networks. Low-cost sensors are desirable because they can provide data for more locations and at finer time scales at a much lower cost than methods used for regulatory purposes. While the data from sensors are not designed for regulatory purposes, they may be of sufficient quality to be used for qualitative purposes and potentially even for some quantitative purposes as long as data uncertainty is adequately understood and communicated.

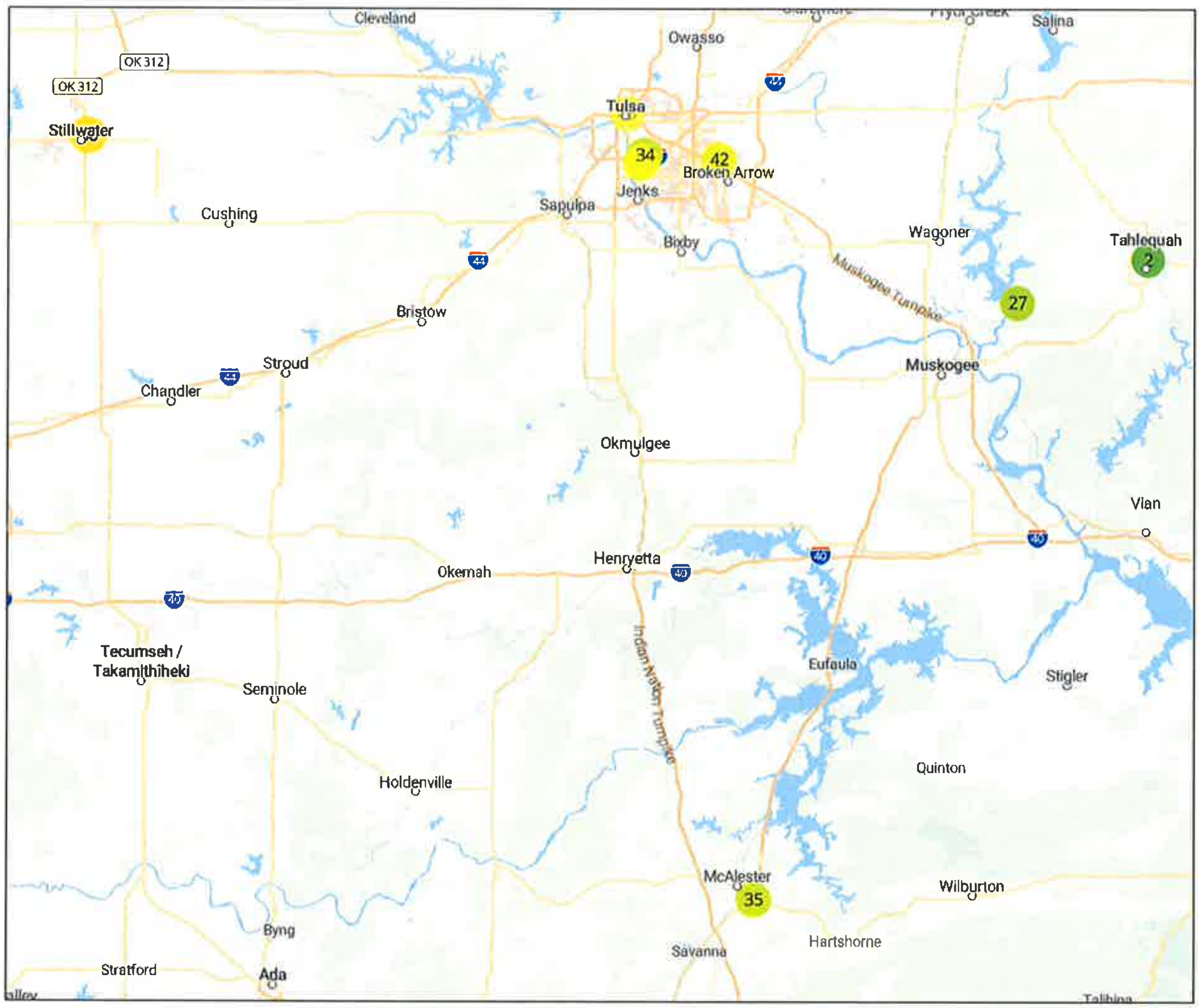
One of the more popular sensors currently being marketed is a particulate sensor produced by PurpleAir. PurpleAir sells that PurpleAir Flex air quality sensor; it uses a fan to draw ambient air past a pair of Plantower PMS6003 laser sensors that count particles and bin them in six size fractions between 0.3 and 10 µm in diameter. These particle counts are put through a proprietary algorithm to calculate particulate concentrations at the 1, 2.5, and 10 µm size fractions. Temperature and relative humidity sensors are incorporated to help provide information on potential meteorological effects on the data. PurpleAir also provides a website where data from its sensors are updated in real-time. Due to the widespread availability of the PurpleAir, a robust network across the U.S. and many other countries has already been developed.

Particulates less than or equal to 2.5 micrometers (termed "fine" particles, in contrast to the larger "coarse" PM10 particles, which include all particles less than 10 micrometers in aerodynamic diameter) are generally emitted from activities such as industrial and residential combustion and from vehicle exhaust. Fine particles are also formed in the atmosphere from gases such as sulfur dioxide (SO2), nitrogen oxides (NOx), and volatile organic compounds (VOCs). These are emitted from combustion activities and then become particles due to chemical transformations in the air. Health effects from inhalation include increased hospital admissions and emergency room visits (primarily among the elderly and individuals with cardiopulmonary disease); increased respiratory symptoms and disease (among children and individuals with cardiopulmonary disease such as asthma); changes in lung tissue and structure and respiratory tract defense mechanisms; and premature death.

The PA-II (older model) and the newer PurpleAir Flex sensor have been evaluated by independent organizations and found to have a high precision within their methodology and good correlation to Federal Reference Method (FRM) and Federal Equivalent Method (FEM) equipment. Despite this good correlation, the relationship is typically biased higher than the regulatory method and results in poor agreement with FRM/FEM methods out of the box. This is a known limitation of the PurpleAir; however, correction factors may be developed/implemented to bring the data produced by the PurpleAir sensors into closer agreement with data produced by FRM/FEM methods. Meteorological conditions, specifically relative humidity, have been found to impact data produced by particulate sensors, including the PA-II and the PurpleAir Flex. Oklahoma has drastic variability in weather, and the Gulf of Mexico often exerts a great deal of influence, particularly over the southern and eastern portions of the state. For the project, the MCNOES AAQP staff will determine if a single correction factor is appropriate or if multiple correction factors may be more appropriate depending on region and season.

The MCNOES AAQP PurpleAir Project was developed in response to the lack of PM monitoring within the MCN Reservation, as seen in ***Figure 4: Current PurpleAir Monitoring Locations***. The MCNOES AAQP staff will add an additional nine (9) sensors, increasing the spatial coverage of real-time air quality information. The PM2.5 data from these air sensors is not as reliable as data from FRM/FEM; however, they will help to provide insight into the air quality in the region and help to educate citizens about their local air quality.

Figure 4: Current PurpleAir Monitoring Locations



All the monitors and sensors used by the MCNOES AAQP are currently non-regulatory. They will help the program increase awareness about air quality within the MCN Reservation. These PurpleAir sensors will also help to inform citizens about the dangers of wildfire events, woodstove use, open burning, and agricultural debris burning. The nine (9) new PurpleAir site locations are listed in ***Table 3: Muscogee (Creek) Nation PurpleAir Monitoring Site Addresses***. These are MCN Indian Community Centers, which provide youth council meetings, cultural classes, community meetings, peer fellowship, and a place for MCN citizens to come together to socialize with other community members.

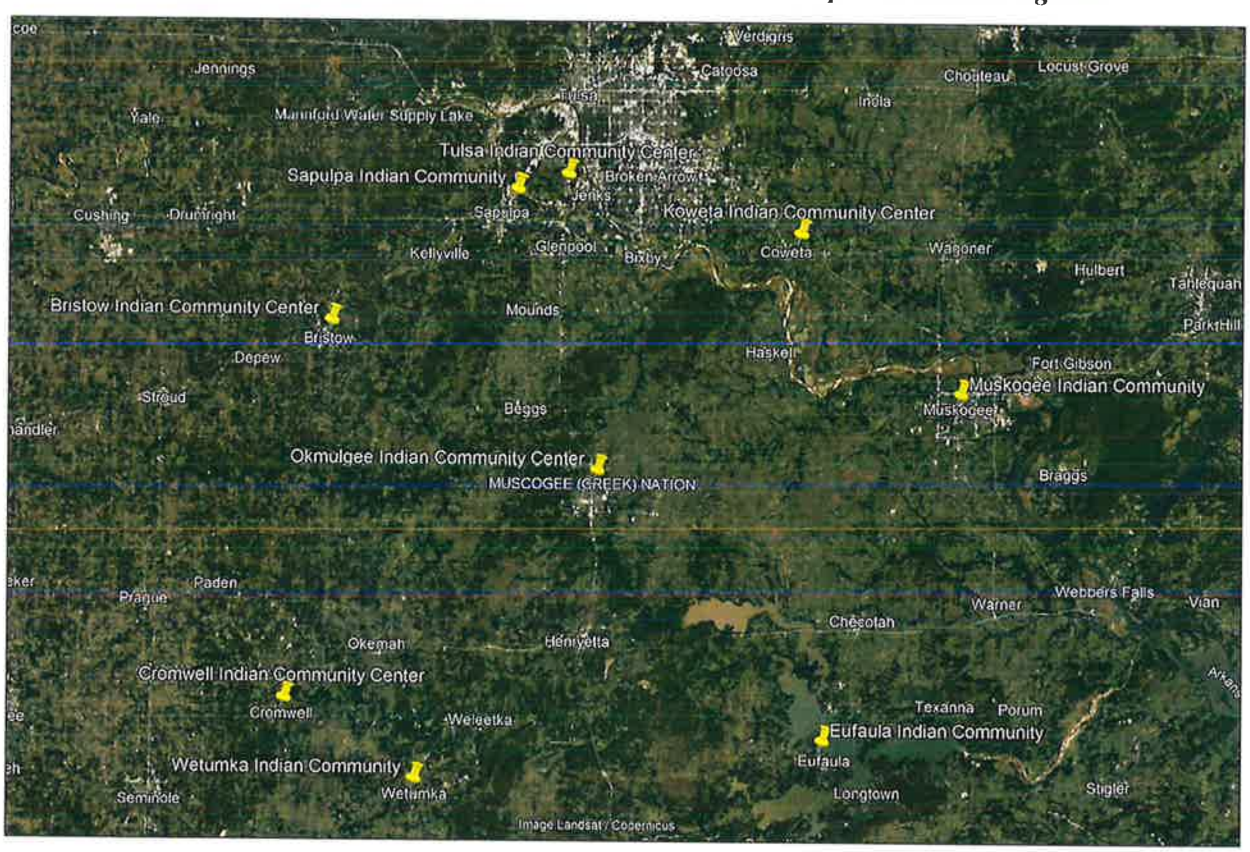
Table 3: Muscogee (Creek) Nation PurpleAir Monitoring Site Addresses

#	Facility	Address
1	Tulsa Indian Community Center	8611 South Union Ave, Tulsa, OK 74132
2	Sapulpa Indian Community Center	1020 North Brown Street, Sapulpa, OK 74066
3	Bristow Indian Community Center	710 South Main, Bristow, OK 74010
4	Cromwell Indian Community Center	417 North Shawnee, Cromwell, OK 74837
5	Wetumka Indian Community Center	608 North Creek Street, Wetumka, OK 74883
6	Eufaula Indian Community Center	800 Birkes Road, Eufaula, OK 74432
7	Muskogee Indian Community Center	335 North 4th Street, Muskogee, OK 74401
8	Koweta Indian Community Center	30901 East 141st Street, Coweta, OK 74429
9	Okmulgee Indian Community Center	2900 North Osage Place, Okmulgee, OK 74447

The MCNOES will install all nine (9) sensors following the step-by-step directions provided by PurpleAir.

Figure 5: Muscogee (Creek) Nation Ambient PM2.5 PurpleAir Monitoring Sites shows where these sensors will be located within the MCN Reservation. These locations will benefit our department and increase the spatial coverage of real-time air quality information for the state of Oklahoma.

Figure 5: Muscogee (Creek) Nation Ambient PM2.5 PurpleAir Monitoring Sites



1.6 Project/Task Description and Schedule (EPA QA/R-5 A6) / Section 6

Provide a summary of all work, products to be produced, and the implementation schedule. Provide maps or tables that show or state the geographic locations of field tasks. This discussion need not be lengthy or overly detailed but should give an overall picture of how the project will resolve the problem or question described in A5.

The MCNOES AAQP staff will install nine (9) PurpleAir sensors in nine (9) counties within the MCN Reservation. Specific information demonstrating how the locations of the monitors meet our objectives and the rationale for the locations can be found in Section 1.5 / A5. The MCNOES AAQP staff will collaborate with Cherokee Nation to find places for an additional two (2) PurpleAir sensors in Rogers and Mayes Counties. The measurement goal of this ambient air quality monitoring program is to estimate the concentration, in units of micrograms per cubic meter ($\mu g/m^3$), of particulate matter with a mean aerodynamic effective diameter less than 2.5 microns in the ambient air characteristic of the air breathed on tribal land. The method is an automated system that provides readings every 15 minutes, 24 hours a day, using a wifi-connected PurpleAir Flex sensor that uploads readings to the PurpleAir website. Data from the continuous sensors will also be downloaded and reviewed on a biweekly (every two weeks) schedule or more frequently, as thoroughly described in subsequent sections of this QAPP. Additional sensor information is listed below.

PurpleAir Sensors measure particulate matter between 0.3 µm and 10 µm in diameter. They also measure the temperature, humidity, and pressure of the sensor. PurpleAir Flex sensors use Plantower PMS*6003 series laser counters to measure particulate matter in real-time (the asterisk "*" represents a number determining the version of the laser counter). Each laser counter within a pair alternates five-second readings averaged over two minutes. Each laser counter uses a fan to draw a sample of air past a laser beam. The laser beam is reflected off any present particles onto a detection plate. The reflection is measured as a pulse by the detection plate. The length of this pulse determines the size of the particle. The number of pulses determines the particle count. These particle measurements infer the mass concentrations of PM1.0, PM2.5, and PM10 for standard indoor and outdoor atmospheric particles. The product data manual from the manufacturer Plantower can provide more information.

1.6.1 PurpleAir Flex Air Quality Sensor

The PurpleAir Flex is one of PurpleAir's latest air quality sensors, measuring real-time PM2.5 concentrations for residential, commercial, or industrial use. Containing a full-color LED, the resulting flow indicates real-time air quality at a glance and can be installed indoors or outdoors. Built-in WiFi enables the air quality monitor to transmit data to the real-time PurpleAir Map, which is stored and made available to any smart device.

- **Equipment**
  The PurpleAir Flex sensors come with mounting screws and zip ties. The PurpleAir Flex sensors are equipped to measure particulate matter 2.5 micrometers or less (PM2.5). They also contain a combined temperature/humidity/pressure sensor.

- **WiFi Range / Power Usage & Supply**
  The WiFi range is typically about 100 feet. The range can vary depending on anything that impedes a direct path between the sensor and the WiFi router. Before mounting your sensor, use a WiFi-enabled device to test your WiFi's signal strength at the potential installation location.

- **Super Supply**

All PurpleAir sensors run on 5 volts; the current draw is 180mA. This means the power consumption of a sensor is approximately 1 watt. The daily consumption would be 0.0216 kWh.

The PurpleAir sensor's power supply will work with an AC input of 10-240V.

- **Air Quality Index (AQI)**
  The Air Quality Index (AQI) is a measurement scale used to report the levels of common air pollutants. The AQI provides a standardized way of communicating air quality information to the public that is easy to understand and helps people make informed decisions about their health and activities. The PurpleAir Flex has an LED that will glow the color associated with the current air quality (green, yellow, orange, red, purple, maroon).

- **PurpleAir Data**
  Data from the PurpleAir sensors are easily obtained from EPA's Fire and Smoke Map. The data is corrected using an EPA correlation factor designed specifically for the PurpleAir sensor and PM2.5 concentrations. Data displayed on the map go through a quality control screening and are averaged to an hourly concentration. EPA's correction equation is applied to reduce bias in the sensor readings. EPA's Fire and Smoke map also applies the NowCast algorithm, displaying the data in the corresponding AQI color. If needed, data can be downloaded from the PurpleAir website using the PurpleAir Data Download Tool -

  https://community.purpleair.com/t/purpleair-data-download-tool/3787.

  This is an open-source tool for downloading data from the PurpleAir API.

- **Monitor Operation and Manufacturers' Literature**
  Important information is found in the manufacturers' literature and operating manuals. All supporting documentation, including this QAPP, all attachments, and instrument manuals, will be available electronically on the system network in a resources folder.

1.6.2 Community Outreach

Data collected from the PurpleAir sensors will be linked to the MCN and MCNOES websites so that it is easily accessible by MCN citizens and community members (via a PurpleAir widget). This widget also communicates the current AQI for PM based on the PurpleAir measurements. These sensors and data may also be used as a teaching tool for after-school and summer youth programs. Data can be viewed or downloaded directly from the PurpleAir website by the public at any time. It is a long-term goal for the AAQP to utilize this data to send text alerts to the community when the AQI for PM reaches unhealthy levels (above 150).

Data collected from the PurpleAir sensors can also be used for the following purposes:

- As educational tools to help people understand the basic principles of air quality.
- As a component of presentations, explain sensors and the data collected.
- To provide community members with an easy way to view current air quality conditions.
- To identify additional air quality concerns.

1.6.3 Schedule Overview

Measurements will be made following the requirements and limits described in Section 1.6 / A6. The results of QC checks will be entered into our database and calculated to determine whether QC results are within limits and identify out-of-limits results. All valid hourly PM2.5 data must be bracketed by passing QC checks (before and after, following the schedule in Section 1.7 / A7 and 2.5 / B5). The hourly data will be downloaded at least every two weeks (biweekly), and all data will be reviewed when imported into the database.

The PM2.5 data will undergo the final data validation process at least every quarter using our validation methods, detailed in Section 4.2 / D2. Assessments will be conducted as frequently as necessary to meet the project objectives.

1.7 Quality Objectives & Criteria for Measurement Data (EPA QA/R-5 A7) / Section 7

Discuss the project's quality objectives and performance criteria for achieving those objectives. EPA requires a systematic planning process to define these quality objectives and performance criteria.

As noted in EPA's QAPP guidance, "when a study is to be based either entirely or in part on secondary data (data that was previously collected for a different intended use). This section of the QA Project Plan explains the criteria for determining which data sources are sufficient to support the current project's goals." (EPA, 2002) Therefore, the following discussion presents the criteria that we will use to determine which data sources will be utilized to meet project objectives.

The EPA has developed and refined a framework for planning data collection known as the Data Quality Objective (DQO) process. Using the DQO process to prepare environmental data collection can help improve effectiveness and efficiency. The DQO process is a course of action for planning environmental data collection operations that allows the data user(s) to decide what data quality (and quantity) will be adequate for decision-making and directs the development of a statistical design to collect the data that will meet those needs. The DQO process emphasizes decision-making and quantifies the uncertainty acceptable in data used in decisions. The DQO process provides a logical structure that focuses data collection planning on the intended use of the data. There are seven steps to the DQO process (see ***Table 3 Data Quality Objective Process***). The output from each step is used in developing a statistical data collection design.

The DQO process should be used at the planning stage of a data collection operation before any samples are taken. The outputs of the DQO process provide the information needed by the planning team responsible for the project and form the inputs to the data collection planning process. Only with this type of effective communication of the data user's requirements can the data collection planning team hope to provide a design that will meet the user's needs. In general, EPA's policy is to use the DQO process to plan all data collection efforts that will require or result in a substantial commitment of resources.

Table 3: Data Quality Objective Process

1	State the problem to be resolved.
2	Identify the decision to be made.
3	Identify the inputs needed for the decision.
4	Define the boundaries of the study.
5	Develop a Decision Rule
6	Specify acceptable limits on uncertainty.
7	Optimize the design for obtaining the data.

1.7.1 Data Quality Objectives (DQO)

The primary Data Quality Objective (DQO) is to collect data that can be used to inform citizens about local air quality and, in the future, help inform decision-makers.

1. **Stating the Problem**
   The MCN Reservation lacks adequate PM sensors/monitoring sites; the MCNOES AAQP will add an additional nine (9) PurpleAir sensors to increase the spatial coverage of real-time air quality information, and two (2) additional PurpleAir sensors will be added through a collaboration with Cherokee Nation. Eleven (11) PurpleAir sensors will be installed within the MCN Reservation. These sensors will provide insight into the region's air quality and help educate citizens about their local air quality.

2. **Identifying the Decision**
   First, the results will be used to calculate an estimated air quality index and, based on the results, to generate health advisories for the MCN Reservation using the AQI recommendations (especially for vulnerable population groups such as children and elders). Our goal is to create information that can be used continuously to provide real-time information to the public to guide decisions on outdoor activities for vulnerable populations.

   Second, the MCNOES AAQP will assess the results to decide whether additional monitoring should be pursued. This may involve purchasing additional PurpleAir sensors or regulatory monitor(s).

   Third, the MCNOES AAQP will use the data to establish a baseline to track air quality changes over time. We are very interested in how air quality changes with continued development in our community and the surrounding area.

3. **Identifying the Inputs to the Decision**
   The intended use of the data defines the type of data needed, and the data gathered is the input to the decisions. The data gathered will follow all EPA recommendations and industry practices regarding schedule, siting, and QC to be adequate compared to other monitoring locations. After validation, our office may use data to compare our PM2.5 measurements with the National Ambient Air Quality Standards (NAAQS).

4. **Defining the Boundaries of the Project**
   The spatial boundary is determined by the sites where the monitors are placed, with the associated assumptions about the representativeness of these locations.

5. **Deciding on a Decision Rule**
   Consistent with our objective to provide information to the community, we will evaluate daily averages as we gather the data and issue public health advisories based on the AQI if results indicate that any population is at risk. This would automatically be posted to the MCN and MCNOES Air websites via the PurpleAir widget. The MCNOES AAQP aims to set up an automatic text-alert system to inform tribal members of hazardous AQI days with levels above 150.

6. **Specify Acceptable Limits on Uncertainty**
   Fundamental to scientific data collection in the real world is the principle that perfect data of an unlimited quantity is impossible to attain. As a result, it is necessary to establish criteria for both the performance and air quality monitoring and the acceptability of the produced data to ensure that the data are of sufficient quality and quantity to fulfill the project purpose, objectives, and DQOs.

   Two sources of variability or error influence project data quality - sampling error and measurement error. Other sample and measurement errors can be of two types: random, arising from normal variability or our physical world from unknown and/or unpredictable causes, or systematic, a consistent (non-random) bias between the observed and actual measurement values. Significantly, all sources and types of error compound with one another. The combined/total error from all sources and types is measurement uncertainty. MCNOES AAQP staff employs the DQO quality system planning process to establish the criteria. This means limiting measurement uncertainty so that the resulting data meets the project's purpose and objectives.

   - **Sampling error** as it applies to this project results from the variability of external influences on the quantity of pollutant concentrations in ambient air. These influences can range from broad scope, such as the spatial impacts from isolating mountain ranges and valleys, to much smaller-scale impacts, such as those resulting from airflow-modifying trees or buildings. The very near proximity of a pollutant source to a monitor, such as a major highway or an industrial facility, can also result in sampling error. Similarly, temporal variability in pollutant concentration can influence project data collection. For example, smoke from an unpredictable wildfire in a distant state that impacts a monitor or monitors is a temporal sampling error.

   - **Measurement error** is the difference between the measurement value an instrument reports and the actual value. This type of error results from internal causes such as instrument wear or malfunction, electrical power variability, sample flow problems, need maintenance, electronic drift over time, operator error, laboratory analysis error, or a data communication problem.

7. **Optimizing the Design**
   The final step of the DQO process uses the results of the first six steps to select a sampling program design that achieves the desired goals at the least cost. This includes finalizing analytical methods and determining sample numbers and techniques. The MCN will optimize the design to fit its budget and needs. As the MCNOES AAQP develops and grows, the QAPP will be revised and reissued for review and approval.

1.7.2 Data Quality Indicators (DQIs)

Sensor data used for informational investigations should use the following Data Quality Indicators (DQIs):

1. **Precision** refers to the random error of a given measurement. One way of quantifying precision is by comparing multiple measurements of the same thing, in this case, the level of PM2.5 in the ambient air. PurpleAir sensors make duplicate measurements of ambient PM2.5, recorded as two

"channels": A and B. The precision can be determined by calculating the difference between these two channels.

2. **Bias** is a systematic error in a set of measurements or the difference between the measurements and the actual value. EPA scientists have quantified the typical bias of PurpleAir sensors and developed a correction equation (see above).
3. **Data completeness** measures data coverage over time. The measurements must represent reality since PM2.5 levels often change over time (e.g., they are more elevated at night or during inversion events).

1.7.3 Measurement Quality Objectives:

Measurement quality objectives (MQOs) are the acceptance or performance criteria for individual DQIs. They are designed to evaluate and control various phases (sampling, preparation, analysis) of the measurement process to ensure that total measurement uncertainty is within the range prescribed by the DQOs.

DQI	Acceptance/Performance Criteria
Precision	The sensor channel measurements (A and B) are within 70% or 5 µg/m3 of each other.
Bias	The EPA correction equation must be applied to PurpleAir sensor data.
Data Completeness	An hour is considered complete if the sensor reports at least four of the six (67%) 10-minute windows in an hour. A day is considered complete if 80% of the hourly data are complete.

1.8 Special Training Requirements/Certifications (EPA QA/R-5 A8) / Section 8

Identify and describe any specialized training or certifications personnel need to complete the project or task. Discuss how such training will be provided and how the necessary skills will be assured and documented. See Section 4 of the QA Handbook for more air monitoring training program information.

Project personnel will have access to workshops and courses hosted by EPA and other similar resource agencies. Personnel qualifications and training records are maintained in personnel files and accessible for review during audit activities. Adequate education and training are integral to any monitoring program that strives for reliable and comparable data. The training aims to increase the effectiveness of employees and the MCNOES.

Management will provide sufficient time to the personnel directly involved in this project to read and understand this QAPP and the reference documents. The AQP will also monitor the availability of the training courses offered by EPA's Air Pollution Training Institute and Region 6 facilities, Northern Arizona University's Institute for Tribal Environmental Professionals (ITEP), and private consulting firms. Such institutions conduct professional services and ensure certification of the courses they offer. When circumstances warrant, staff members may be enrolled in one or more training courses these institutions provide.

Additionally, those actively involved in this monitoring program must have completed the following Quality Assurance courses offered by EPA:

- Introduction to EPA Quality System Requirements
- Introduction to Quality Management Plans (QMPs)
- Introduction to Quality Assurance Project Plans (QAPPs)
- Introduction to Data Quality Objectives (DQOs)

The operation of the PurpleAir sensors is intended for the general public and is considered user-friendly. Outside of the essential support from the PurpleAir manufacturer, there is no additional training for operating the PurpleAir sensor. These monitors do not require extensive upkeep or frequent calibration outside their recommended 2–3-year lifespan when they must be sent into PurpleAir for recalibration.

Cross-training will be conducted so that more than one employee can adequately perform some essential functions. Due to high turnover rates in many tribal environmental programs, developing detailed standard operating procedures (SOPs) is critical for ensuring a smooth transition from one person to the next. The importance of good SOPs cannot be overemphasized.

1.8.1 Training Courses / Air Quality Resources

The purpose of this section is to describe any special or non-routine training or certifications necessary to complete the project successfully. Discuss plans for providing essential training, how training records will be documented, and where this information will be stored.

Over the years, several courses have been developed for personnel involved in ambient air monitoring and quality assurance. Such training may include classroom lectures, workshops, teleconferences, and on-the-job training. Formal and informal training is offered through the following organizations:

- **Institute for Tribal Environmental Professionals (ITEP)**
  http//:www.nau.edu/itep/

  ITEP assists Indian Tribes in managing their environmental resources through practical training and education programs.

  ITEP and the Tribal Air Monitoring Support (TAMS) center offer in-person and online courses, including air toxics monitoring, meteorological monitoring, writing a QAPP, data loggers, air quality computations, data management, ambient air quality monitoring, permitting, Tribal Emissions Inventory Software Solution (TEISS), Geographic Information Systems (GIS), wildland smoke, and more. ITEP offers data analysis courses with the NAAQS. Tribes should consider the courses they want to attend and plan travel costs.

  ITEP courses are available for some types of monitors, but not all. Where appropriate, neighboring tribes, tribal consortiums, or state or local agencies may also offer assistance. Federal agencies such as the U.S. Forest Service and National Park Service sometimes operate monitors and may assist. Additionally, ITEP can provide individualized training for their Tribe as part of their Professional Assistance program.

- **EPA Air Pollution Training Institute (APTI)**
  http://www.apti-learn.net

  APTI provides technical air pollution training to state, tribal, and local air pollution professionals, although others may benefit from it. The curriculum is available in classroom, telecourse, self-instruction, and web-based formats.

- **Air & Waste Management Association (AWMA)**
  http://www.awma.org/

  AWMA offers a variety of products and services to help meet the professional development and educational needs of environmental professionals, university students, grades K-12 students and teachers, and the general public.

- **American Society for Quality Control (ASQC)**
  http://asq.org/training

  ASQC advocates for quality. It is a knowledge-based global community of quality control experts, with nearly 100,000 members dedicated to promoting and advancing quality tools, principles, and practices in their workplaces and communities.

- **EPA Quality Staff**
  http://www.epa.gov/quality/

  EPA develops generic training on quality-related issues and organizes national conferences that include training. Attendance at conferences and training is free.

- **EPA Regional Offices**
  http://www.epa.gov/tribal-air/regional-tribal-air-quality-resorces

  EPA also provides a wealth of technical experience and often holds meetings, conferences, and training activities. Most Tribes are in contact with one or more Regional Offices.

- **Regional Planning Organizations (RPOs)**
  http:www.epa.gov/visibility/visibility-regional-planning-organizations

  RPOs evaluate technical information to understand better how their States and Tribes affect visibility across the county, pursue the development of regional strategies to reduce emission and regional haze and help states meet the consultation requirements of the Regional Haze Rule. RPOs have been diminishing in recent years due to lack of funding.

- **National Monitoring Programs**
  Many of the websites representing the national monitoring programs advertise training and need to be reviewed at some regular frequency to take advantage of these opportunities.

- **Instrument Manufacturers**
  Some manufacturers offer regular training courses at their facilities or services to set up the monitoring and training of staff for a daily fee.

In addition, the EPA provides a tribal website that describes upcoming training and links to other training opportunities that might interest tribes. http://www.epa.gov/tribal-air

1.9 Documents and Records (EPA QA/R-5 A9) / Section 9

Describe the process and responsibilities for ensuring the appropriate project personnel have the most current approved version of the QA Project Plan, including version control, updates, distribution, and disposition. Itemize the information and records that must be included in the data report package and specify the reporting format for hard copy and any electronic forms. Records can consist of raw data, data from other sources such as databases or literature, field logs, sample preparation and analysis logs, instrument printouts, model input and output files, and results of calibration and QC checks. Identify any other records and documents applicable to the project that will be produced, such as audit reports, interim progress reports, and final reports. Specify the level of detail of the field sampling, laboratory analysis, literature or database data collection, or modeling documents or records needed to *provide a complete description of any difficulties encountered. Specify or reference all applicable requirements for the final disposition of records and documents, including location and length of retention period.*

The MCNOES understands that properly documenting a project's activities takes time. The MCNOES AAQP is committed to comprehensively documenting all data collection, analysis, validation, and reporting activities. This time commitment will be factored into the responsibilities of the Quality Assurance Manager (QAM) and Quality Assurance Officer (QAO).

Copies of the PurpleAir user Manuals, QAPP, SOP, and other procedures/protocols will be kept electronically on the Environmental Services (O:) drive. The most current QAPP will be provided to all sampling personnel before sensor mobilization. Up-to-date hard copies will also be kept in the QAM and QAO offices.

Any calibration or maintenance records for the monitors will be kept in the MCNOES main office. Since data is automatically recorded on the PurpleAir website, no field data notebook exists for PurpleAir monitoring activities. Reports generated from the PurpleAir data will be prepared semi-annually, with a comprehensive report prepared annually or at the end of the grant cycle.

1.9.1 Semi-Annual Reports:

Semi-annual reports will be prepared and submitted to the grant project officer at EPA Region 6. They will describe the progress in meeting environmental outputs and outcomes on a semi-annual reporting basis, project/program assessment, and submission of short data summaries. Region 6 will establish a reporting schedule upon approval for funding.

1.9.2 Final Reports:

The annual/final report will include a summary of the project, advances achieved applicable to environmental outputs and outcomes and the cost of the project, the final success, and lessons learned from the project that could help others overcome structural, organizational, and/or technical obstacles related to implementing a similar project elsewhere.

Note: Issues and problems in monitoring operations that may have caused the loss of data will be reported to the EPA Region 6 Tribal Air Programs Project Officer promptly. Such losses will be reported if there is a loss of 120 hours of data if the loss will affect the 75% data completeness goal for the entire year of monitoring.

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2.0 DATA GENERATION AND ACQUISITION (Group B)

*The elements in this group **(Table 4: (Group B) – Data Generation and Acquisition Elements)** address all aspects of data generation and acquisition to ensure that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and documented. The following QA Project Plan elements describe the requirements related to the actual methods or methodology to be used for the following:*

- *Collection, handling, and analysis of samples; Final EPA QA/R-5 15 March 2001*
- *Data obtained from other sources (e.g., contained in a computer database from previous sampling activities, compiled from surveys taken from the literature); and*
- *The management (i.e., compiling, handling) of the data.*

The methods described in these elements should have been summarized earlier in element A6. The purpose here is to provide detailed information on the methods. If the designated methods are well documented and readily available to all project participants, citations are adequate; otherwise, detailed copies of the methods and/or SOPs must accompany the QA Project Plan in the text or as attachments.

Table 4: (Group B) - Data Generation and Acquisition Elements

B1	Sampling Process Design (Experimental Design)
B2	Sampling Methods
B3	Sample Handling and Custody
B4	Analytical Methods
B5	Quality Control
B6	Instrument/Equipment Testing, Inspection, and Maintenance
B7	Instrument/Equipment Calibration and Frequency
B8	Inspection/Acceptance of Supplies and Consumables
B9	Non-direct Measurements
B10	Data Management

2.1 Sampling Design (Experimental Design) (EPA QA/R-5 B1) / Section 10

Describe the experimental data generation or data collection design for the project, including as appropriate:

- *The types and numbers of samples required,*
- *The design of the sampling network,*
- *The sampling locations and frequencies,*
- *Sample metrics,*
- *Measurement parameters of interest, and*
- *The rationale for the design*

This section describes the process of installing the PurpleAir sensor and the rationale for its placement. Sensor location depends on the need, availability of power, and Wi-Fi access. PurpleAir sensors are placed in fixed locations and rarely moved, although individual sensors could be replaced if malfunctions occur. A record of the area for each sensor will be kept on the shared Environmental Services (O:) drive and updated as needed.

The following sections provide guidance for the installment, connection, and sensor registration.

2.1.1 Installation Guidance

The following is the guidance provided by the PurpleAir website for proper installation (PurpleAir, 2021):

- Choose a location that is convenient to reach, has access to a power outlet, and falls within range of the Wi-Fi network.
- If possible, mount the sensor away from vents, local sources of pollution such as BBQs, and any foliage that would increase the likelihood of insects getting inside the laser counters.
- Install the sensor vertically, with the open end facing the ground. The housing protects the device from the elements while allowing air to flow freely past the two laser counters.
- Be sure to mount the sensor high enough off any surface that would allow rainwater to splash up into the underside of the sensor.
- The power supply should be mounted so that it will not be submerged in water or covered by snow.
- Use either cable ties or a screw to mount the sensor and power supply, and fashion a "drip loop" to prevent water from running down the wires and into the electronics.
- PurpleAir outdoor sensors can withstand direct sun without being damaged. Mounting the sensor in a shady spot will produce temperature readings unaffected by direct sunlight. Please note that temperature readings are already elevated by as much as 10 degrees Fahrenheit due to heat generated by the Wi-Fi module inside the sensor.
- Connect the power supply to a power outlet and tuck the wires away.

2.1.2 Connecting the sensor to Wi-Fi:

The following is the guidance the PurpleAir website provides for connecting the sensor to Wi-Fi.

1. It's best to configure your sensor to Wi-Fi with the router, computer/phone/tablet, and sensor in the same room. After plugging in your device and confirming it is receiving power (look for the dim red glow inside the sensor housing or indoor sensors; make sure the device itself is glowing), open the list of available Wi-Fi networks on a Wi-Fi-enabled device.
2. Connect to the sensor's network, PurpleAir—****. The **** is a 2–4-character code determined by your sensor. (It may take up to 10 minutes for this network to appear after the sensor is plugged in.)
3. Depending on your operating system or device, you may get a pop-up window or a message to sign in to the network. If you receive a message to sign in to the network, press it to make the pop-up window appear. The pop-up window will list all available Wi-Fi networks.

   Note: If the pop-up window does not appear, after making sure you have selected the "PurpleAir-****" network and waiting a bit if you still don't get the pop-up, try opening a web browser and loading a webpage. If you are indeed connected to the PurpleAir network, this will load the sensor interface with the Wi-Fi settings for the sensor. Another option is to open a webpage and enter the default IP address for the sensor in the address bar: http://192.168.4.1/config.
4. Choose the Wi-Fi network you would like the sensor to connect to, enter the password for that network, and click **Save**. At the bottom of the list, you can also select a hidden Wi-Fi network.

5. The Wi-Fi status bar will turn green once your PurpleAir sensor is connected to Wi-Fi and transmitting data. Once your device is configured to your local Wi-Fi network, it will no longer appear in the list of available networks - the fact that it has disappeared means that the sensor is successfully configured to Wi-Fi.

2.1.3 Registering the sensor on the PurpleAir Map:

1. Go to www.purpleair.com/register.
2. Enter the sensor's Device ID exactly as printed on the sensor's label.
3. Enter the associated email address, which is usually used to purchase the sensor. If you do not know the correct email address, please contact us for help or to associate a new email address. PurpleAir will need the Device ID to help you.
4. Complete the rest of the registration form. For additional help, you can view a full explanation of registration fields or read our registration tips below.
5. Click register and look for a green "successful registration" notice. A registration confirmation email is sent to the Associated Email and Owner's Email. This email includes a link to view your sensor on the PurpleAir map.

2.2 Sampling Methods (EPA QA/R-5 B2) / Section 11

Describe the procedures for collecting samples and identify the sampling methods and equipment, including any implementation requirements, sample preservation requirements, decontamination procedures, and materials needed for projects involving physical sampling. Identify sampling methods by number, date, and regulatory citation where appropriate. If a technique allows the user to select from various options, then the method citations should state precisely which options are being selected.

Describe specific performance requirements for the method. For each sampling method, identify any support facilities needed. The discussion should also address what to do when a failure in the sampling or measurement system occurs, who is responsible for corrective action, and how the effectiveness of the corrective action shall be determined and documented. Describe the process for the preparation and decontamination of sampling equipment, including the disposal of decontamination by-products; the selection and preparation of sample containers, sample volumes, and preservation methods; and maximum holding times for sample extraction and/or analysis.

PurpleAir Sensors use laser counters to measure particulate matter in real-time. A laser counter uses a fan to draw a sample of air past a laser beam. Any air particles reflect light from the laser beam onto a detection plate, like dust shimmering in a sunbeam. The reflection is measured as a pulse by the detection plate, and the pulse length determines the particle size, while the number of pulses determines the particle count. These particle counts are used to calculate the mass concentrations of PM1.0, PM2.5, and PM10 for standard indoor and outdoor particles.

Most PurpleAir models (PurpleAir Classic, Flex, and Zen) have two sensors that measure and report particle concentrations in six sizes between 0.3µm and 10µm diameter. Temperature, relative humidity, and pressure values are also recorded. The manufacturer calibrates the sensors to associate a particle size with particle mass and estimate the total mass for PM1.0, PM2.5, and PM10. Readings are then uploaded to the cloud approximately every 80 seconds, and they are stored for download and display on the PurpleAir Map – https://www2.purpleair.com/.

2.3 Sample Handing and Custody (EPA QA/R-5 B3) / Section 12

Describe the requirements for sample handling and custody in the field, laboratory, and transport, taking into account the nature of the samples, the maximum allowable sample holding times before extraction or analysis, and available shipping options and schedules for projects involving physical sampling. Sample handling includes packaging, shipment from the site, and storage at the laboratory. Examples of sample labels, custody forms, and sample custody logs should be included.

The sensors identified in the QAPP will not collect physical samples. The PurpleAir sensors upload readings automatically to the PurpleAir website, where data can be viewed and downloaded. This upload is automatic and softcopy, so a chain of custody record is not required. Data will be uploaded to the AQS and stored on the MCNOES server, with periodic updates and verification as needed.

2.4 Analytical Methods (EPA QA/R-5 B 4) / Section 13

Identify the analytical methods and equipment required, including sub-sampling or extraction methods, laboratory decontamination procedures and materials (such as hazardous or radioactive samples), waste disposal requirements (if any), and any specific performance requirements for the method. Where number, date, and regulatory citation may identify appropriate analytical techniques. Address what to do when a failure in the analytical system occurs, who is responsible for corrective action, and how the effectiveness of the corrective action shall be determined and documented. Specify the laboratory turnaround time needed if it is essential to the project schedule.

List any method performance standards. If a method allows the user to select from various options, then the method citations should state precisely which options are being selected. For non-standard method applications, such as for unusual sample matrices and situations, appropriate method performance study information is needed to confirm the method's performance for the particular matrix. If previous performance studies are unavailable, they must be developed during the project and included in the project results.

No laboratory work will be performed under the QAPP. Measurements taken are not designed to be replicable, do not follow published methods, and are meant only as part of an investigation.

2.5 Quality Control Requirements (EPA QA/R-5 B5) / Section 14

Identify QC activities needed for each sampling, analysis, or measurement technique. List the associated method or procedure, acceptance criteria, and corrective action for each required QC activity. Because standard methods are often vague or incomplete in specifying QC requirements, simply relying on the cited method to provide this information is usually insufficient. QC activities for the field and the laboratory include but are not limited to, blanks, duplicates, matrix spikes, laboratory control samples, surrogates, or second-column confirmation.

State the analysis frequency for each type of QC activity and the spike compounds' sources and levels. State or reference the required control limits for each QC activity and corrective action needed when control limits are exceeded and how the effectiveness of the corrective action shall be determined and documented.

Describe or reference the procedures to calculate applicable statistics (e.g., precision and bias). Copies of the formulas are acceptable if the accompanying narrative or explanation specifies how the calculations will address potentially tricky situations such as missing data values, "less than" or "greater than" values, and other standard data qualifiers.

Data collection involves many activities beyond simply turning on the sensor and collecting measurements. Users will need additional preparation before and during data collection activities to ensure that valuable data are collected. Quality Control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements. QC activities ensure that measurement uncertainty can be estimated and is less than the measurement quality objectives to meet the DQOs. These activities/tasks include:

2.5.1 Frequent Data Review

Reviewing data frequently (e.g., daily, weekly) lets you detect problems early, notice trends in the data, ensure that maintenance activities are completed, and become familiar with recurring patterns. For instance, creating a time series plot (i.e., a plot with the pollutant concentrations on the y-axis and the date and time on the x-axis) can be an excellent place to start. You might see typical patterns and develop a general sense of air quality in an area under different conditions. When typical conditions are known, it becomes easier to identify times when sensor readings are atypical and why these atypical readings are occurring.

2.5.2 Maintenance

Air sensors require preventive maintenance to ensure proper functionality and reliable data collection. Maintenance can include regularly scheduled cleaning of surfaces or inlets to prevent the buildup of bugs or dust, replacing filters, or replacing sensor detector components as they age. It can also include examining site conditions for changes (e.g., vandalism, overgrown trees).

2.5.3 Troubleshooting

Air sensor problems will likely occur, and they may require troubleshooting to resolve them and continue collecting data. Troubleshooting might include visiting the sensor, contacting the manufacturer, seeking guidance from other air sensor users, or other activities.

2.5.4 Quality Control (QC) Checks

It is essential to frequently review the data for problems such as outliers, drift, etc. Some sensor manufacturers may offer a software package or online user interface that provides some automated checks of the data to assist in this process. Note that computerized checks may not catch subtle problems or may flag a real-life event as insufficient data. Do not solely rely on automatic QC checks to identify issues with the data.

- **Common Quality Control Checks**

  Quality Control (QC) procedures include collocation, data correction, maintenance, automatic data checks, data review, and any other steps to reduce errors from sensors or instruments during a project.

  The following table details recommended QC checks that can be performed on an air sensor and its data. The checks are designed to catch problems early, correct them, and produce a functional, high-quality data set.

Table 5: Recommended Quality Control Checks

Quality Control Check	Description
Units	Check that the sensor reports data in the correct units of measure.
Time	Check that the sensor reports data correctly and in the right time zone. Also, check times after seasonal changes (e.g., daylight savings time).
Timestamp	Determine the timestamp, which is the time when data are tagged by an instrument. Measurements and data averages will have times that either represent the beginning of the period (time beginning) or the end of the period (time ending).
Matching Timestamps	Check each dataset's time zones and timestamps to ensure they are similar when comparing measurements made by different instruments.
Data Review	Check data frequently (e.g., daily, weekly) to detect problems early, identify trends in the data, ensure that maintenance activities were completed, and become familiar with recurring patterns.
Data Completeness	Completeness measures the amount of data a sensor collects compared to the amount of data possible if the sensor operated continuously, without data outages, during a period (e.g., one hour, one day).
Automatic Data Checks*	The software can check data for problems and outliers. Note that some data checks may not catch subtle problems or may flag an infrequent but real event. Do not solely rely on automatic QC to check data quality.
Manual Data Validation	Evaluate the data quality during the project's collection phase to identify and correct potential problems. To accomplish this, data must be analyzed to identify seasonal, day/night, weekday/weekend patterns, and weather changes. An absence of expected patterns may indicate a problem with the sensor or measurement approach.

- **<u>Common Automatic Data Checks</u>**

Automatic Data Check	Description
Range	Check the minimum and maximum concentrations expected and recognize some air sensors may report slightly negative values.
Rate of Change	Check the difference in data values from an air sensor between two consecutive periods (e.g., hours). Flag the data if the difference, or rate of change, exceeds the value set by the user.
Sticking	Check if data values are "stuck" at the same value for a specified number of hours. Establish criteria for the number of consecutive hours for which data can be reported at the same value.
Duplicate Sensor Comparison	Some sensors incorporate two identical sensing components inside, providing two separate pollutant concentration measurements. Check the agreement between the readings and flag data if the difference exceeds an acceptable threshold.
Buddy System	Check the difference between data values obtained from a single location and the average data values obtained from other nearby locations.
Parameter-to-Parameter	Check two or more pollutants for known or expected physical or chemical relationships.

2.5.5 Quality Control Requirements

The PurpleAir readings uploaded to the PurpleAir website will be checked biweekly (every two weeks) to ensure the sensors are correctly functioning. Sensors on the PurpleAir do not have a flow requirement and do not require temperature/pressure verifications.

Channels A and B's graphs will be reviewed weekly to identify potential sensor malfunction or damage. Agreement between the A and B channels provides confidence in measurement. Temperature and relative humidity readings will not indicate correlation, accuracy improvement needs, or degradation.

The US-wide correction factor developed by the USEPA will be used to minimize errors from raw data. The development of the correction factors used data aggregated to 24-hour averages. Points were removed if these 24-hr averages A & B PM2.5 channels differed by $\geq\pm$ 5μg m^{-3} and $\geq\pm$62% (95% confidence interval on % error [2* standard deviation (% error)])

The resulting equation that will be applied to raw PurpleAir data to calculate corrected PM2.5 measurements is as follows (USEPA, 2020):

PM2.5 corrected = 0.524*[PA_cf1(avgAB)]-0.0852*RH+5.72

PM2.5 = μg m^{-3}
RH = Relative Humidity (%)
PA_cf1 (avgAB) = PurpleAir higher correction factor data averaged from the A and B channels.

2.5.6 Periodic Collocation

Collocation refers to the process of operating a regulatory grade reference monitor (FRM/FEM) and non-reference monitor (air sensor) at the same time and location under real-world conditions for a defined evaluation period. Collocation can help quantify the accuracy of a sensor, while periodic checks can help ensure that accuracy does not change over time or in different conditions. Users should develop a periodic collocation approach to check the quality of the air sensor's measurements.

If the sensor is not reporting or not meeting precision data requirements (Section 1.7/A7), the user should take the following corrective steps:

1. Check the Wi-Fi connectivity at the site.
2. Physically inspect the sensor. Confirm the power cord is connected and does not look damaged. Inspect the internal sensor inlets inside the sensor housing for debris.
3. clean the sensor with compressed air if physical debris appears present. A vacuum hose may also be effective.
4. If these steps do not resolve the issue, contact PurpleAir for a repair or replacement if within the warranty period or replace the sensor.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (EPA QA/R-5 B6) / Section 15

Describe how inspections and acceptance testing of instruments, equipment, and components affecting quality will be performed and documented to ensure their intended use as specified. Identify and discuss the procedure by which final acceptance will be performed by independent personnel (e.g., personnel other than those performing the work) and/or *by the EPA project manager. Describe how deficiencies are to be resolved, when re-inspection will be performed, and how the effectiveness of the corrective action shall be determined and documented.*

Describe or reference how periodic preventive and corrective maintenance of measurement or test equipment or other systems and their components affecting quality shall be performed to ensure availability and satisfactory performance of the systems. Identify the equipment and/or systems requiring periodic maintenance. Discuss how the availability of critical spare parts, identified in the operating guidance and/or design specifications of the systems, will be assured and maintained.

The following sections include information about the instrument/equipment, testing, inspection, maintenance, and Standard Operating Procedures (SOPs).

2.6.1 Instrument / Equipment Information

The PurpleAir monitors come with mounting screws and zip ties. The PurpleAir Flex sensors are equipped to measure particulate matter 2.5 micrometers or less (PM2.5). They also contain a combined temperature/humidity/pressure sensor. Further details of the PurpleAir sensor technology can be found on the PurpleAir website.

- **Laser Particle Counter**
  PurpleAir uses PMS5003 and PMS1003 laser particle counters. These sensors count suspended particles of 0.3, 0.5, 1.0, 2.5, 5.0, and 10um. The sensor processes These particle counts using a complex algorithm to calculate the PM1.0, PM2.5, and PM10 mass concentration in ug/m3. PMS5003 and PMS1003 sensors come factory calibrated.
- **ESP8266 and Arduino**
  PurpleAir sensors use an ESP8266 chip to talk to the particle counter and provide all functionality, including connecting to a Wi-Fi network and uploading data to the cloud. This ESP8266 chip runs code developed using Arduino. PurpleAir firmware has remote update features, meaning we can modify the software, and the Arduino air quality sensor device will download the new version and update itself. Each Arduino air quality sensor device periodically checks for updates.
- **BME280 Sensor**
  Each PurpleAir sensor includes a BME280 pressure, temperature, and humidity sensor, for which graphs of these values are also provided on the PurpleAir website. As the BME280 sensors are just for general interest, their values do not provide ideal sensing, and these measurements will not be recorded.
- **Power Supply**
  PurpleAir sensors are powered by a 5v USB power source.
- **Software**
  All readings from the PurpleAir monitors are linked to the PurpleAir website, which does not require a software download. No software is needed when data enters the Quality Review and Exchange System for Tribes (QREST).

2.6.2 Equipment Testing, Inspection, and Maintenance

Equipment will be inspected quarterly for dirt, debris, vegetation, trash, or other objects that may obstruct or impact the monitors' readings. If malfunction becomes apparent through the data, the equipment will also be inspected for damage or blockage.

2.6.3 Standard Operating Procedures for PurpleAir Flex

The guidance provided in the following SOPs will be followed by MCNOES AAQP staff.

1. Install PurpleAir following the manufacturer's directions. https://community.purpleair.com/t/sensor-start-up-guide/182
2. Check that the data goes to EPA's Fire and Smoke Map. If not, check the PurpleAir map to see whether both channels work. If there is a problem with one or more sensors, remove the unit from the field, clean it by vacuuming the sensor, recheck the instrument in the lab, and replace any sensors before returning the unit to the field.
3. If data collection is less than 75% when the sensor is expected to be operating, reestablish the wi-fi connection or move the sensor to a different location.

2.7 Instrument/Equipment Calibration and Frequency (EPA QA/R-5 B7) / Section 16

Identify all tools, gauges, instruments, and other sampling, measuring, and test equipment used for data generation or collection activities affecting quality that must be controlled and, at specified periods, calibrated to maintain performance within specified limits. Describe or reference how calibration will be conducted using certified equipment and/or standards with known valid relationships to nationally recognized performance standards. If no such nationally recognized standards exist, document the basis for the calibration. Identify the certified equipment and/or standards used for calibration. Indicate how calibration records shall be maintained and traceable to the instrument.

Regular calibration is not required for PurpleAir operations and, therefore, will not be performed by AAQP staff. If the two sensors fail to match, the data does not pass the QA checks, and it does not show on the EPA Fire and Smoke map, the sensors will be removed for cleaning and reevaluated. The typical lifespan of the PurpleAir sensor is 2-3 years, at which point the monitor may be sent to the manufacturer for recalibration, or a replacement monitor may be purchased.

2.8 Inspection/Acceptance Requirements for Supplies & Consumables (EPA QA/R-5 B8)/Section 17

Describe how and by whom supplies and consumables (e.g., standard materials and solutions, sample bottles, calibration gases, reagents, hoses, deionized water, potable water, electronic data storage media) shall be inspected and accepted for use in the project—state acceptance criteria for such supplies and consumables.

The PurpleAir sensors do not require any additional supplies or consumables. If replacement sensors are needed, shipping boxes will be examined for damage before acceptance.

2.9 Data Acquisition Requirements (Non-Direct Measurements) (EPA QA/R-5 B9) / Section 18

Identify any data types needed for project implementation or decision-making obtained from non-measurement sources such as computer databases, programs, literature files, and historical databases. Describe the intended use of the data. Define the acceptance criteria for using such data in the project and specify any limitations on using the data.

Field data acquisition is not needed as the PurpleAir sensors operate passively. The monitors are connected through Wi-Fi to the PurpleAir website, and readings are recorded and uploaded every 15 minutes. Data will be reviewed weekly to ensure that each sensor's channels, A and B, read similarly.

Data that is automatically uploaded to the PurpleAir website will be downloaded and stored on the Environmental Services (O:) drive. Data from permanent and temporary PM2.5 monitoring sites can be used to compare to the PurpleAir sensor. There should be general trends that track all sensors/monitors in the network unless there is a nearby source of PM2.5 unique to a given location.

2.10 Data Management (EPA QA/R-5 B10) / Section 19

Describe the project data management process, tracing the path of the data from their generation to their final use or storage (e.g., the field, the office, the laboratory). Describe or reference the standard record-keeping procedures, document control system, and the data storage and retrieval approach on electronic media. Discuss the control mechanism for detecting and correcting errors and preventing data loss during data reduction, data reporting, and data entry to forms, reports, and databases. Provide examples of any forms or checklists to be used.

Identify and describe all data handling equipment and procedures to process, compile, and analyze the data. This includes methods for addressing data generated as part of the project and data from other sources. Include any required computer hardware and software and address specific performance requirements for the hardware/software configuration. Describe the procedures that will be followed to demonstrate the acceptability of the hardware/software configuration required.

PurpleAir sensor data is easily obtainable from the manufacturer's website following the procedures provided at http://community.purpleair.com/t/purpleair-data-download-tool/3787.

3.0 ASSESSMENT AND OVERSIGHT (Group C)

*The elements in this group **(Table 3: (Group C) – Assessment and Oversight Elements)** address the activities for assessing the effectiveness of project implementation and associated QA and QC activities. The assessment aims to ensure that the QA Project Plan is implemented as prescribed. The assessment consists of external activities, including a planned review system and audit procedures by personnel not actively involved in the inventory development process. The fundamental concept of this component is an independent objective review by a third party to assess the effectiveness of the internal Quality Control program and the quality of the inventory and to reduce or eliminate any inherent bias in the inventory process.*

Table 3. (Group C): Assessment and Oversight Elements

C1	Assessments and Response Actions
C2	Reports to Management

3.1 Assessments/Oversight & Response Actions (EPA QA/R-5 C1) / Section 20

Describe each assessment used in the project, including the frequency and type. Assessments include, but are not limited to, surveillance, management systems reviews, readiness reviews, technical systems audits, performance evaluations, audits of data quality, and data quality assessments. Discuss the information expected and the success criteria (i.e., goals, performance objectives, acceptance criteria specifications, etc.) for each assessment proposed. List the approximate schedule of assessment activities. Identify potential participants and their exact relationship within the project organization for any planned self-assessments (utilizing personnel from within the project groups). For independent assessments, identify the organization and person(s) that shall perform the assessments if this information is available. Describe how and to whom the results of each assessment shall be reported.

Define the assessors' scope of authority, including stop work orders and when they are authorized to act.

Discuss how response actions to assessment findings, including corrective actions for deficiencies and other non-conforming conditions, will be addressed and by whom. Include details on how the corrective actions will be verified and documented.

Copies of the PurpleAir user manuals, QAPP, SOP, and other procedures/protocols will be kept as electronic copies in the O: drive (Environmental Services>CAA>CAA 105>PurpleAir Monitoring). Up-to-date hard copies will also be kept in the MCNOES office. Additionally, network backups will be performed weekly.

Any calibration or maintenance records for the monitors will be kept in the MCNOES office. Since data is automatically recorded to the PurpleAir website, no field data notebook exists for PurpleAir monitoring activities.

Preliminary method collocation data will be evaluated early in the study to help define expectations of precision and accuracy.

PurpleAir/T640 collection data may have preliminary evaluations performed as often as quarterly to help refine analytical tools and provide initial impressions. If a change is determined to be necessary as a result of these reviews, the study plan may be modified.

3.2 Reports to Management (EPA QA/R-5 C2) / Section 21

Identify the frequency and distribution of reports issued to inform management (EPA or otherwise) of the project status; for example, reports on performance evaluations and system audits, results of periodic data quality assessments, and significant quality assurance problems and recommended solutions. Identify the preparer and the recipients of the reports, as well as any specific actions recipients are expected to take as a result of the reports.

The MCNOES AAQP staff understands that properly documenting the project's activities takes time. The MCNOES AAQP is fully committed to documenting all activities relating to data collection, analysis, validation, and reporting. This time commitment must be factored into the responsibilities of the AAQP Project Manager and the Environmental Specialists.

Reports generated from the PurpleAir data will be prepared semiannually, with a comprehensive report prepared at the end of the grant cycle. This study is being conducted for internal purposes. Staff must provide a report to be shared with management after the study. Management will determine if and how the study results will be shared with external entities.

4.0 DATA REVIEW & USABILITY (Group D)

*The elements in this group **(Table 4: (Group D) – Data Validation & Usability)** address the QA activities that occur after the project's data collection phase. Implementation of these elements determines whether the data conforms to the specified criteria, thus satisfying the project objectives. These sections describe how you will review and interpret the data. Data review encompasses the processes of verification and evaluation/validation, as well as reconciling for usability in supporting project objectives and decisions.*

Table 4: (Group D) - Data Validation & Usability

D1	Data Review, Verification, and Validation
D2	Verification and Validation Methods
D3	Reconciliation with User Requirements

4.1 Data Review, Verification, & Validation Requirements (EPA QA/R-5 D1) / Section 22

This section aims to identify the criteria used to review and validate data objectively and consistently, that is, to accept, reject, or qualify it.

Describe the criteria you will use to decide whether to accept, reject, or qualify any data. These are the final checks on the data to determine if they satisfy the quality objectives and measurement criteria listed in Section 2.5.

Data verification is the process of evaluating the completeness and correctness of the data set against the methods and procedures. Data validation is a sample-specific process that extends the evaluation of data beyond methods and provides guidelines to determine the quality of the data set relative to the end use. It focuses on the project's specifications or needs, is designed to meet the needs of the decision makers/data users, and should not potentially unacceptable departures from the QA Project Plan. The potential effects of the deviation can be evaluated during the data quality assessment. The criteria used to review and validate data have been detailed in the above sections, predominantly in 1.7/A7 and 2.5/B5. The MCNOES AAQP is responsible for all data review, verification, and validation conducted under this QAPP.

Criteria	PurpleAir PA Flex PM Sensor
Maximum Highest Acceptable Value	500 µg/m3, values above this still indicate extreme smoke concentrations but may not reflect an actual value.
Minimum Lowest Acceptable Value	0 µg/m3, the sensor cannot produce a negative value. The BAM 1020 used for comparison can return a negative number, indicating excellent air quality.
Individual Sensors Above Expected	If emissions are perceived as uniform in the sample area, then all sensors should be returning comparable concentrations. Check the agreement between channels A and B. Determine if site-specific emissions are near the affected sensor.
Individual Sensors Below Expected	If emissions are perceived as being uniform in the sample area, then all sensors should be returning comparable concentrations. Check agreement between channels A and B. Determine if sensor location contributes to a low value.
All Sensors Show Similar Concentrations	Sensor data can be used for decision-making within limits of data quality.
Data Recording Method	Data will be accessed from https://www2.purpleair.com/ using the

	PurpleAir download tool. All data will be handled electronically.
Data Analysis	Data from each sensor can be entered into an Excel Workbook for graphing and reporting purposes.

4.2 Verification and Validation Methods (EPA QA/R-5 D2) / Section 23

Describe the process used for verifying and validating data, including the chain of custody for data throughout the life of the project or task. Discuss how issues shall be resolved and the authorities responsible for resolving such issues. Describe how the results are conveyed to data users. Precisely define and interpret how validation issues differ from verification issues for this project. Provide examples of any forms or checklists to be used. Identify any project-specific calculations required.

This section describes how the MCNOES AAQP verifies and validates data collection operations. Verification is conducted as an ongoing process through careful logging of field/database operations and evaluating both parameter and QC data as it is available (i.e., not waiting until data review is scheduled but reviewing data as it is available). Validation consists of "stepping back" from the process and evaluating whether the data we are gathering is helpful for our purpose.

Data fed to the PurpleAir website via Wi-Fi will be verified before being uploaded to QREST. Any outlying data will be investigated for cause.

Channel A and B readings will be compared to verify that the PurpleAir sensor is not misfunctioning. The readings between the nine (9) PurpleAir sensors will be compared, as well as the readings from other PurpleAir sensors in the area, for validation. The environmental specialists and the QAO conduct the data verification and validation, which are reviewed by the QAM and the Director of the MCNOES.

4.3 Reconciliation with User Requirements (EPA QA/R-5 D3) / Section 24

The purpose of this section is to describe how you will evaluate the study results to see if they meet the requirements defined (in Sections 1.7 and 2.5) by the data user.

Describe how the results obtained from the project or task will be reconciled with the requirements defined by the data user or decision maker. Outline the proposed methods to analyze the data and determine possible anomalies or departures from assumptions established in the planning phase of data collection. Describe how reconciliation with user requirements will be documented, how issues will be resolved, and how limitations on the use of the data will be reported to decision-makers.

Issues that require corrective action are identified in the form of memos, and corrective action is conducted and documented. Such communications are logged as part of the data review process in the database logbook and validation report.

The final data validation report and file package include all relevant information to support the determination of the data's validity.

Appendix A: List of Acronyms

AAQP	Ambient Air Quality Program
API	Application Programming Interface
APTI	Air Pollution Training Institute
ASQC	American Society for Quality Control
AWMA	Air & Waste Management Association
AQI	Air Quality Index
DQI	Data Quality Indicators
DQO	Data Quality Objectives
EPA	Environmental Protection Agency
FEM	Federal Equivalent Method
FRM	Federal Reference Method
GIS	Geographic Information System
ITEP	Institute for Tribal Environmental Professionals
LED	Light-Emitting Diode
MCN	Muscogee (Creek) Nation
MQO	Measurement Quality Objectives
NAAQS	National Ambient Air Quality Standards
NOx	Nitrogen Oxides
OES	Office of Environmental Services
PA	PurpleAir
PM1.0	Particulate Matter 1.0 micrometers or smaller
PM2.5	Particulate Matter 2.5 micrometers or smaller
PM10	Particulate Matter 10 micrometers or smaller
PMS	Particulate Matter Sensor
PQAO	Primary Quality Assurance Organization
QA	Quality Assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
QREST	Quality Review and Exchange System for Tribes

RPO	Regional Planning Organization
SO2	Sulfur Dioxide
SOP	Standard Operating Procedures
TAMS	Tribal Air Monitoring Support
TEISS	Tribal Emissions Inventory Software Solution
VOC	Volatile Organic Compound

Appendix B: Definitions

AQI: Air Quality Index. An EPA-developed index for reporting daily (24-hour average) air quality and relating it to health effects For more information on the AQI and how it works, please see https://airnow.gov/aqi/aqi-basics.

AirNow: A web-based (airnow.gov) source for air quality information including interactive maps of local air quality. AirNow presents air quality information in the form of a NowCast of the AQI.

AirNow Fire and Smoke Map: The AirNow Fire and Smoke Map provides information for people to use to help protect their health from wildfire smoke. The Map displays current particle pollution air quality information for your location; fire locations and smoke plumes; smoke Forecast Outlooks, where available; and recommendations for actions to take to protect yourself from smoke. These recommendations were developed by EPA scientists who are experts in air quality and health. The Map is a collaborative effort between the U.S. Forest Service (USFS)-led Interagency Wildland Fire Air Quality Response Program and the U.S. Environmental Protection Agency (EPA).

Air Sensor: Air sensor (or simply "sensor") is a simplified way of referring to a class of technology that has expanded on the market in recent years and has common traits of directly reading a pollutant in the air, being smaller in size, and often sold at a price that supports a wider number of monitoring locations than possible in the past. Many groups refer to this class of technology as "low-cost air sensors," "air sensor devices," and "air quality sensors."

Environmental Justice: the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

EPA Correction Factor: a multi-linear correction equation (including temperature and relative humidity) for PurpleAir PM2.5 data. an extended U.S.-wide correction equation, developed by EPA scientists, that reduces the bias in the sensor data correcting for the overestimation. The corrected data are more comparable to the permanent and temporary monitor data. More information here: https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=349513&Lab=CEMM.

Fine Particulate Matter (PM2.5): fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller. For context, the average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle. See: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.

NAAQS: National Ambient Air Quality Standards. The EPA sets limits for ambient levels of several air pollutants knows to be harmful to human health: lead (Pb), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), coarse particulate matter (PM10), and fine particulate matter (PM2.5).

NowCast: The real-time weighted average that AirNow applies to the air quality data displayed on its maps. AirNow uses this weighted average to balance the need to be responsive to rapidly changing air quality conditions with the longer exposure time (24 hours) used in studies on air pollution and health. The NowCast is not available on the PurpleAir Map.

PurpleAir[1]

[1] Disclaimer: Any mention of trade names, products, or services does not imply an endorsement by the U.S. Government or the U.S. Environmental Protection Agency.

[1] Disclaimer: Any mention of trade names, products, or services does not imply an endorsement by the U.S.

PurpleAir Map: a web application that displays a network of community owned, PurpleAir sensors. Each sensor uploads data to the PurpleAir map in real time. See: https://community.purpleair.com/t/map-start-up-guide/90.

PurpleAir Sensor: PurpleAir Sensors use laser counters to measure particulate matter in real time. A laser counter uses a fan to draw a sample of air past a laser beam. Any particles in the air will reflect some light from the laser beam onto a detection plate, like dust shimmering in a sunbeam. The reflection is measured as a pulse by the detection plate, and the length of the pulse determines the size of the particle while the number of pulses determines the particle count. These particle counts are used to calculate the mass concentrations of PM1.0, PM2.5, and PM10 for standard indoor and outdoor particles.

Regulatory monitor: in the context of air quality monitoring, a regulatory monitor is an air monitoring instrument that has gone through a formal review process and been approved by the EPA as a Federal Reference Method (FRM) or a Federal Equivalent Method (FEM). These data collected by these monitors can be compared to the NAAQS, if the monitor siting, operation, and data handling meet regulatory requirements

Regulatory monitoring: monitoring using a regulatory monitor that also meets all the requirements for siting, quality assurance, data handling and storage, and other regulations. When all the requirements for regulatory monitoring are met, we have high confidence that the measurements accurately represent a locations air quality, and thus we can use the data to determine if the area is meeting or exceeding the NAAQS.

Government or the U.S. Environmental Protection Agency.

Appendix C: Additional Resources / References

Resource Description	URL:
EPA's Sensor Toolbox guide to siting and installing air sensors	https://www.epa.gov/air-sensor-toolbox/guide-siting-and-installing-air-sensors
The Enhanced Sensor Guidebook, Clements, A., R. Duvall, D. Greene, AND T. Dye. The Enhanced Air Sensor Guidebook. U.S. Environmental Protection Agency, Washington, DC, 2022	https://www.epa.gov/air-sensor-toolbox/how-use-air-sensors-air-sensor-guidebook
AirNow Fire and Smoke Map Technical Q&A:	https://document.airnow.gov/airnow-fire-and-smoke-map-questions-and-answers.pdf
PurpleAir's Guide	https://www.purpleair.com/sensors

Montana Department of Environmental Quality. 2017. Montana Ambient Air Monitoring Program Quality Assurance Project Plan. https://deq.mt.gov/Portals/112/Air/AirMonitoring/Documents/2017_MT_QAPP_VOL_I_DRFT_WATERMARK.pdf

Tribal Air Monitoring Support Center: (n.d.). Technical Guidance for the Development of Tribal Air Monitoring Programs. https://datatools.tamscenter.com/hosted_files/QAQC/QC_QAPP_BAM_PM2.5_CTCR.pdf

USEPA. 2020. Air Sensors PurpleAir, AirNow Fire and smoke Map, and their use Internationally. [PowerPoint}. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab_CEMM&dirEntryId=350379

USEPA. 2021. Technical Approaches for the Sensor Data on the AirNow fire and Smoke Map https://www.epa.gov/air-sensor-toolbox/technical-approaches-sensor-data-airnon-fire-and-smoke-map

Wisconsin Department of Natural Resources / Air Monitoring. 2020. Quality Assurance Project Plan for PurpleAir Sensor Study QAPP 111.0. https://dnr.wisconsin.gov/sites/default/files/topic/AirQuality/PurpleAirSensorStudy.QAPP.pdf

Nez Perce Tribe / Environmental Restoration & Waste Management Division / Air Quality Program. 2023. Quality Assurance Project Plan Air Sensors. https://gaftp.epa.gov/R10Tribalair/QAPP%20Materials/QAPP%20Examples/Category4_EducationOutreach/NPTSensorsQAPP2023Ver0signed.pdf

PurpleAir. 2021. Our Technology. https://www2.purpleair.com/pages/technology

PurpleAir. 2021. Startup Guide for PurpleAir Sensor. https://www2.purpleair.com/pages/install

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Appendix D: Experimental Design Description Sheet:

Use this experimental design description sheet to plan your experiment and data collection. Sections can be adapted as needed.		
Consideration	Response	
What are the main sources of PM2.5 in your area?		
Are you interested in comparing indoor and outdoor air measurements?	Location	Reason
What time resolution are you interested in following?	_______ Daily Average ________Sub-daily/hourly	
How often will you verify the sensor is reporting to the AirNow Fire and Smoke Map?	___ Daily ___ Weekly ___ Monthly	
What method(s) are being used to document sensor siting and any troubleshooting?	e.g., Field datasheet, internal data log or other.	

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Appendix E: PurpleAir Field Sheet

Sensor Log	
PurpleAir Serial no.	
Receiving and Setup:	
Date sensor(s) received	
All expected parts received?	
Any noticeable damage?	
Does the LED light turn on when the sensor is connected to power?	
Sensor deployment:	
Deployment date	
Address or latitude and longitude of sensor	
Deployment height	
Any obstructions near the sensor?	
Picture taken that shows sensor and surroundings?	
Sensor registered and set to public?	
Sensor maintenance	
Sensor showing up on the fire and smoke map?	
Indicate dates when you confirmed the sensor is reporting to the Fire and Smoke map:	
Site visit date, issue, and whether the issue was resolved:	
Site visit date, issue, and whether the issue was resolved:	

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Appendix F: Standard Operating Procedures (SOPs) for PurpleAir Sampling / Experimental Design

This section describes the process of installing the PurpleAir sensor and the rationale for the location of their placement. Sensor location depends on the need, availability for power, and wi-fi access. PurpleAir sensors are placed in fixed locations, and would rarely be moved, although individual sensors could be replaced if malfunctions occur. A record of location for each sensor will be kept on the shared Environmental Services (O:) drive and updated as needed.

The following sections provide guidance for the installment, connection, and sensor registration.

1. Installation Guidance

The following is the guidance provided by the PurpleAir website for proper installation (PurpleAir, 2021):

- Choose a location that is convenient to reach, has access to a power outlet, and falls within range of the Wi-Fi network.
- If possible, mount the sensor away from vents, local sources of pollution such as BBQs, and any foliage that would increase the likelihood of insects getting inside the laser counters.
- Install the sensor in the vertical position, with the open end facing toward the ground. The housing is designed to protect the device from the elements while allowing air to flow freely past the two laser counters.
- Be sure to mount the sensor high enough off of any surface that would allow rainwater to splash up into the underside of the sensor.
- The power supply should be mounted so that it will not be submerged in water or covered by snow.
- Use either cable ties or a screw to mount the sensor and power supply, and fashion a "drip loop" to prevent water from running down the wires and into the electronics.
- PurpleAir outdoor sensors can withstand direct sun without being damaged. Mounting the sensor in a shady spot will produce temperature readings that are not affected by direct sunlight. Please note that temperature readings are already elevated by as much as 10 degrees Fahrenheit due to heat generated by the Wi-Fi module inside the sensor.
- Connect the power supply to a power outlet and tuck the wires away.

2. Connecting the Sensor to Wi-Fi

The following is guidance provided by the PurpleAir website, for connecting the sensor to Wi-Fi.

- It's best to configure your sensor to Wi-Fi with the router, computer/phone/tablet, and sensor in the same room. After plugging in your device and confirming it is receiving power (look for the dim red glow inside the sensor housing, or for indoor sensors, make sure the device itself is glowing), on a Wi-Fi-enabled device, open the list of available Wi-Fi networks.
- Connect to the sensor's network, PurpleAir-****. The **** is a 2–4-character code determined by your sensor. (It may take up to up to 10 minutes after the sensor is plugged in for this network to appear.)

- Depending on your operating system or device, you may get a pop-up window or a message to sign in to the network. If you receive a message to sign in to the network, press it to make the pop-up window appear. The pop-up window will list all available Wi-Fi networks.

  Note: If the pop-up window does not appear, after making sure you have selected the "PurpleAir-****" network and waiting a bit, if you still don't get the pop-up, try opening a web browser and loading a webpage. If you are indeed connected to the PurpleAir network, this will load the sensor interface with the Wi-Fi settings for the sensor. Another option is to open a webpage and in the address bar, enter the default IP address for the sensor: http://192.168.4.1/config.

- Choose the Wi-Fi network you would like the sensor to connect to, enter the password for that network, and click **Save**. A hidden Wi-Fi network can be entered by selecting the option at the bottom of the list.

- The Wi-Fi status bar will turn green once your PurpleAir sensor is connected to Wi-Fi and transmitting data. Once your device is configured to your local Wi-Fi network, it will no longer appear in the list of available networks - the fact that it has disappeared means that the sensor is successfully configured to Wi-Fi.

3. Registering the Sensor on the PurpleAir Map

The following is guidance provided by the PurpleAir website, for registering the sensor on the PurpleAir Map.

- Go to www.purpleair.com/register.
- Enter the sensor's Device-ID exactly as printed on the sensor's label.
- Enter the associated email address, which is usually the email that was used to purchase the sensor. If you do not know the correct email address, please contact us for help or to associate a new email address. PurpleAir will need the Device-ID in order to help you.
- Complete the rest of the registration form. For additional help, you can view a full explanation of registration fields or read our registration tips below.
- Click register and look for a green "successful registration" notice. A registration confirmation email is sent to the Associated Email and Owner's Email. This email includes a link to view your sensor on the PurpleAir map.

Appendix G: Standard Operating Procedures (SOPs) for PurpleAir Data Download

How to Download Purple Air Data and Interpret Data

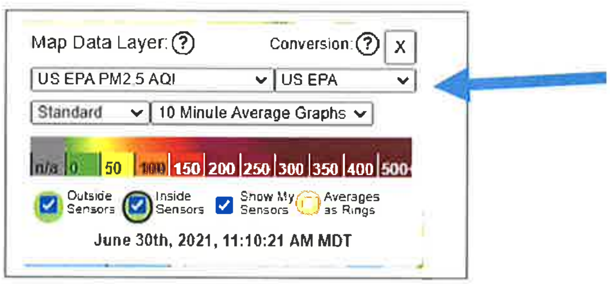
1. Go to the Purple Air website: https://www2.purpleair.com/

   Click on View the Map to get to the Purple Air Map. Or you can click on the link below as well.

   Map: https://www.purpleair.com/map?opt=1/mAQI/a10/cC0#4.58/34.72/-111.09

2. Select a sensor location and click on it.

3. Go to Map Data Layer. The Map Data Layer can be found on the lower left-hand side of the map where you will see the color-coded US EPA PM2.5 Air Quality Index as default. Under conversion, select US EPA conversion factor/correction equation.

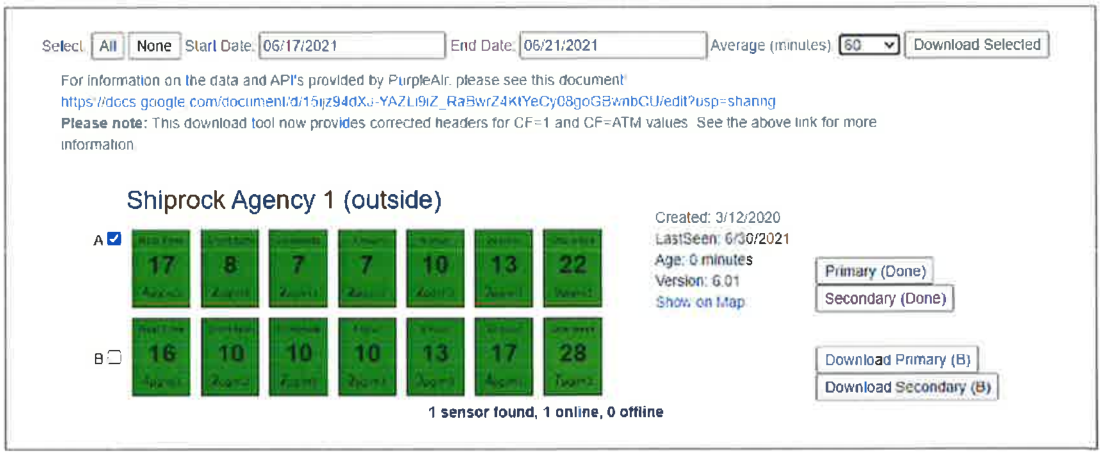


4. Next, navigate to the right-hand side of the screen and click on the download icon which will take you to the **Sensor Data Download Tool** website.

The Sensor Data Download tool will allow you to download data from the sensor's Channel A and Channel B measurements. It will also allow you to view Primary data and Secondary data. Primary Data is where you will find PM (PM_1, $PM_{2.5}$, PM_{10}) sample values as well as Temperature and Relative Humidity sample values. **Keep in mind that CF-1 values correspond to correction factor for indoor measurements and ATM corresponds to atmospheric or outdoor measurements in units of micrograms per cubic meter (μg/m^3) of air**. Secondary Data is where you will find particle counts in units of microns (micrometer) per deciliter of air as well as outdoor measurements for PM_1 and PM_{10} in units of μg/m^3.

The UptimeMinutes column tells you how long the sensor has been in operation and the RSSI_dbm corresponds to "Received Signal Strength Indicator." RSSI is a measurement of how well your device can hear a signal from an access point or router. It's a value that is useful for determining if you have enough signal to get a good wireless connection. Since RSSI varies greatly a more standardized, absolute measure of signal strength is measured in decibels, or dBm on a logarithmic scale. There's a lot of math we could get into, but basically, the closer to 0 dBm, the better the signal is. The dBm unit, which means decibels relative to the reference power 1 mW. For example, a power of 10 µW = 0.01 mW corresponds to -20 dBm (= 20dB less than 1 mW).

5. To begin downloading data from the Sensor Data Download Tool, first select your Start and End date. Then you want to select your averaging intervals either 10-minute, 15-minute, 30-minute, 60 minute, up to 1440 minutes which is a 24-hour average.

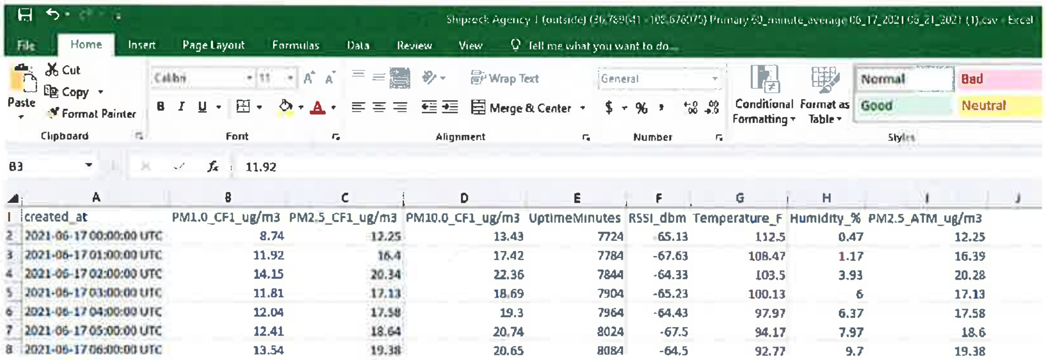


6. In the example above, the date range begins 6/17/21 and ends 6/21/21. The average interval is 60 minutes, which is basically 1-hour averages.

7. Next, you want to select which channel to report data into a .CSV download file. You can select a single Channel and both Primary and Secondary data. Or you can select All which will give you data from both Channel A and B to include both Primary and Secondary data. As you can see in the picture above, for this example, Channel A is selected to report both Primary and Secondary data.

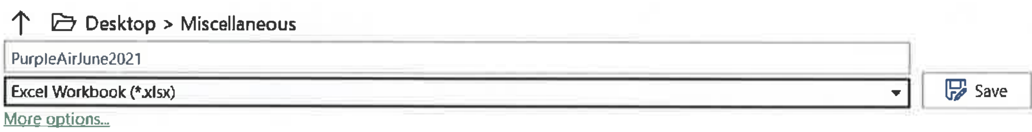
8. A *.CSV file containing the data will be generated in the lower left-hand side of the web browser and you should be able to click on the file and open it.

9. Click on the up arrow on the file and open the file to view the data. Data should look like this.

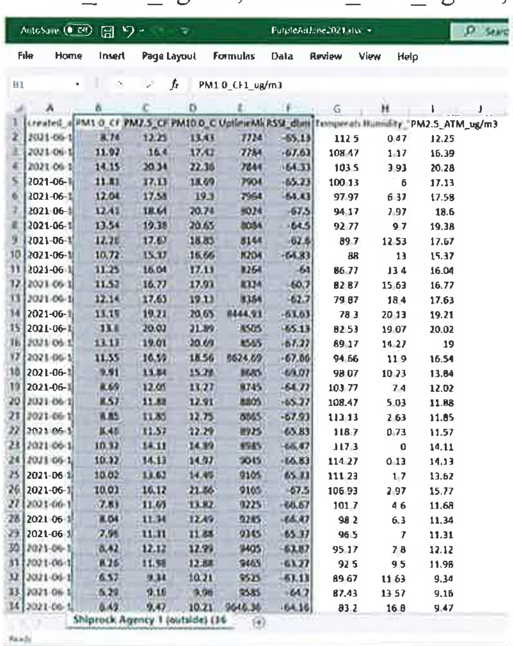


	A	B	C	D	E	F	G	H	I
1	created_at	PM1.0_CF1_ug/m3	PM2.5_CF1_ug/m3	PM10.0_CF1_ug/m3	UptimeMinutes	RSSI_dbm	Temperature_F	Humidity_%	PM2.5_ATM_ug/m3
2	2021-06-17 00:00:00 UTC	8.74	12.25	13.43	7724	-65.13	112.5	0.47	12.25
3	2021-06-17 01:00:00 UTC	11.92	16.4	17.42	7784	-67.63	108.47	1.17	16.39
4	2021-06-17 02:00:00 UTC	14.15	20.34	22.36	7844	-64.33	103.5	3.93	20.28
5	2021-06-17 03:00:00 UTC	11.81	17.13	18.69	7904	-65.23	100.13	6	17.13
6	2021-06-17 04:00:00 UTC	12.04	17.58	19.3	7964	-64.43	97.97	6.37	17.58
7	2021-06-17 05:00:00 UTC	12.41	18.64	20.74	8024	-67.5	94.17	7.97	18.6
8	2021-06-17 06:00:00 UTC	13.54	19.38	20.65	8084	-64.5	92.77	9.7	19.38

10. As you can see, the time stamp is in Coordinated Universal Time or UTC time. UTC time is the world time standard that regulates clocks and time. It is commonly used by the scientific community in many technical fields. For example, meteorologists, the aviation industry use this time, and it is used to synchronize time across internet networks. One way to convert the time stamp to the time in your area is to use a formula in Microsoft Excel. Begin by saving the file as an *.xlsx file by selecting File, Save As from the menu. From the file type dropdown box, select Excel Workbook (.xlsx). If you want, you can also type in a new file name. Then click on the Save icon.

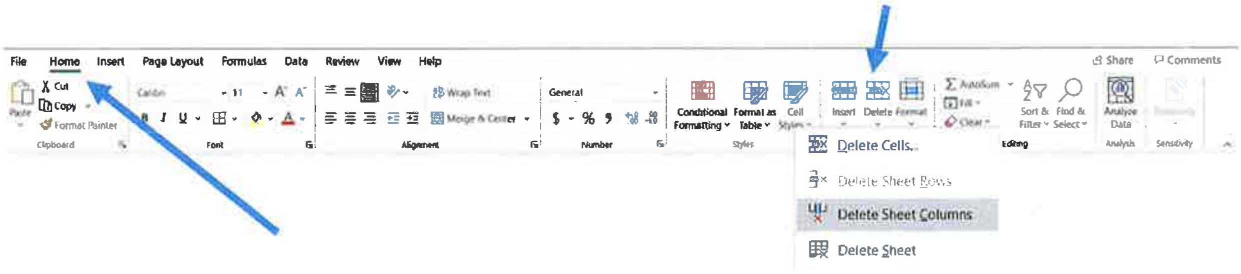


11. In this data analysis example, we are focusing on PM2.5, Temperature, and Relative Humidity data. We need to begin by removing the columns that are not necessary for this particular data analysis. From within the *.xlsx file that is now open, click and drag to highlight Column B through Column F. The five columns with the following headers should now be highlighted: PM1.0_CF1_ug/m3, PM2.5_CF1_ug/m3, PM10.0_CF1_ug/m3, UptimeMinutes, and RSSI_dbm.

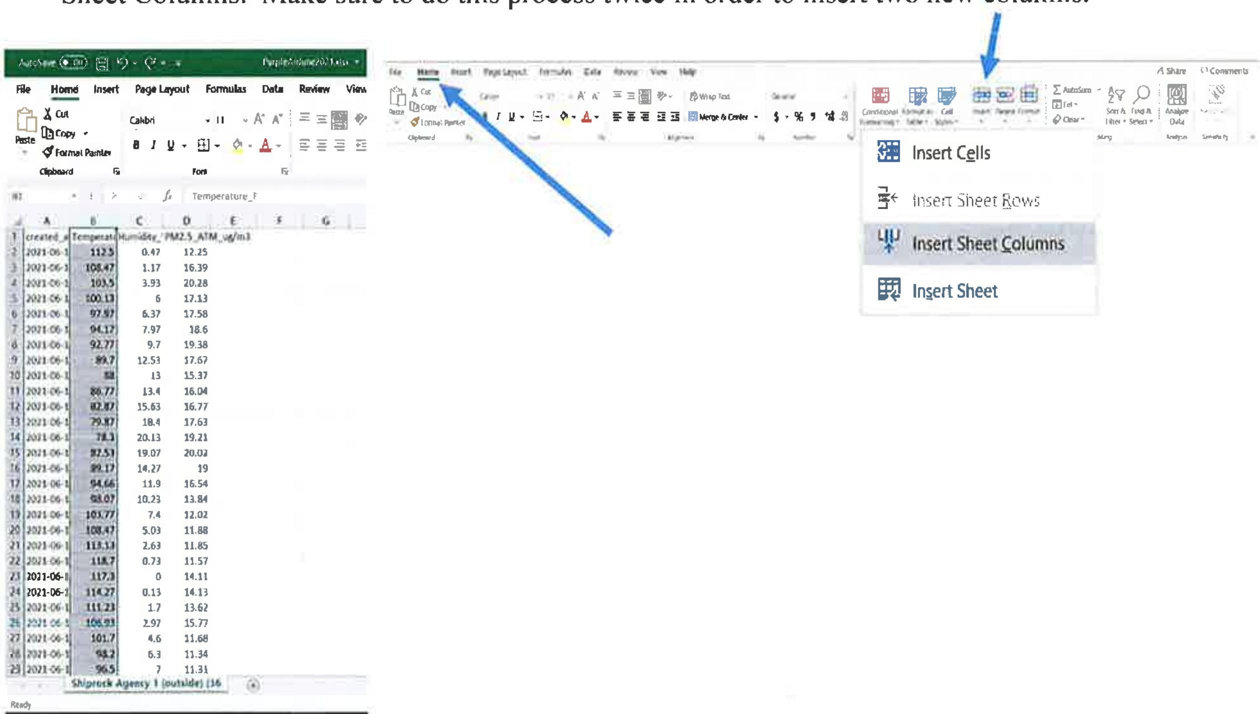


	A	B	C	D	E	F	G	H	I
1	created_a	PM1.0_CF	PM2.5_CF	PM10.0_C	UptimeMi	RSSI_dbm	Temperat	Humidity_	PM2.5_ATM_ug/m3
2	2021-06-1	8.74	12.25	13.43	7724	-65.13	112.5	0.47	12.25
3	2021-06-1	11.92	16.4	17.42	7784	-67.63	108.47	1.17	16.39
4	2021-06-1	14.15	20.34	22.36	7844	-64.33	103.5	3.93	20.28
5	2021-06-1	11.81	17.13	18.69	7904	-65.23	100.13	6	17.13
6	2021-06-1	12.04	17.58	19.3	7964	-64.43	97.97	6.37	17.58
7	2021-06-1	12.41	18.64	20.74	8024	-67.5	94.17	7.97	18.6
8	2021-06-1	13.54	19.38	20.65	8084	-64.5	92.77	9.7	19.38
9	2021-06-1	12.26	17.67	18.85	8144	-62.6	89.7	12.53	17.67
10	2021-06-1	10.72	15.37	16.66	8204	-64.83	88	13	15.37
11	2021-06-1	11.25	16.04	17.13	8264	-64	86.77	13.4	16.04
12	2021-06-1	11.52	16.77	17.93	8324	-60.7	82.87	15.63	16.77
13	2021-06-1	12.14	17.63	19.13	8384	-62.7	79.87	18.4	17.63
14	2021-06-1	13.15	19.21	20.65	8444.93	-63.63	78.3	20.13	19.21
15	2021-06-1	13.8	20.02	21.89	8505	-65.13	82.53	19.07	20.02
16	2021-06-1	13.13	19.01	20.69	8565	-67.27	89.17	14.27	19
17	2021-06-1	11.55	16.59	18.56	8624.69	-67.86	94.66	11.9	16.54
18	2021-06-1	9.91	13.84	15.28	8685	-69.07	98.07	10.23	13.84
19	2021-06-1	8.69	12.05	13.27	8745	-64.77	103.77	7.4	12.02
20	2021-06-1	8.57	11.88	12.91	8805	-65.27	108.47	5.03	11.88
21	2021-06-1	8.85	11.85	12.75	8865	-67.93	113.13	2.63	11.85
22	2021-06-1	8.45	11.57	12.29	8925	-65.83	118.7	0.73	11.57
23	2021-06-1	10.32	14.11	14.89	8985	-66.47	117.3	0	14.11
24	2021-06-1	10.32	14.13	14.97	9045	-66.83	114.27	0.13	14.13
25	2021-06-1	10.02	13.62	14.45	9105	-65.33	111.23	1.7	13.62
26	2021-06-1	10.03	16.12	21.86	9165	-67.5	106.93	2.97	15.77
27	2021-06-1	7.83	11.69	13.82	9225	-66.67	101.7	4.6	11.68
28	2021-06-1	8.04	11.34	12.49	9285	-66.47	98.2	6.3	11.34
29	2021-06-1	7.96	11.31	11.88	9345	-65.37	96.5	7	11.31
30	2021-06-1	8.42	12.12	12.99	9405	-63.87	95.17	7.8	12.12
31	2021-06-1	8.26	11.98	12.88	9465	-63.27	92.5	9.5	11.98
32	2021-06-1	6.57	9.34	10.21	9525	-63.13	89.67	11.63	9.34
33	2021-06-1	6.29	9.16	9.98	9585	-64.7	87.43	13.57	9.16
34	2021-06-1	6.49	9.47	10.21	9646.36	-64.16	83.2	16.8	9.47

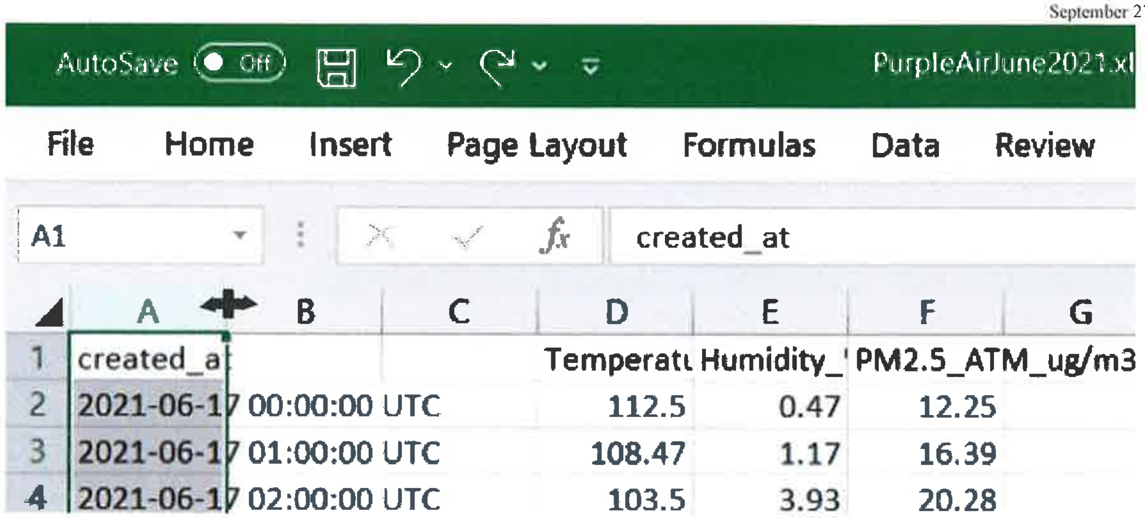
Right-click anywhere within the highlighted area and select Delete. Alternately, you can go to Home in the menu and select Delete, Delete Sheet Columns.



12. Insert two new columns to the left of Column B. You do this by first clicking on Column B to highlight it. Then right-click anywhere within the highlighted area and select Insert. Repeat this process to insert two new blank columns. Alternately, you can go to Home in the menu and select Insert, Insert Sheet Columns. Make sure to do this process twice in order to insert two new columns.



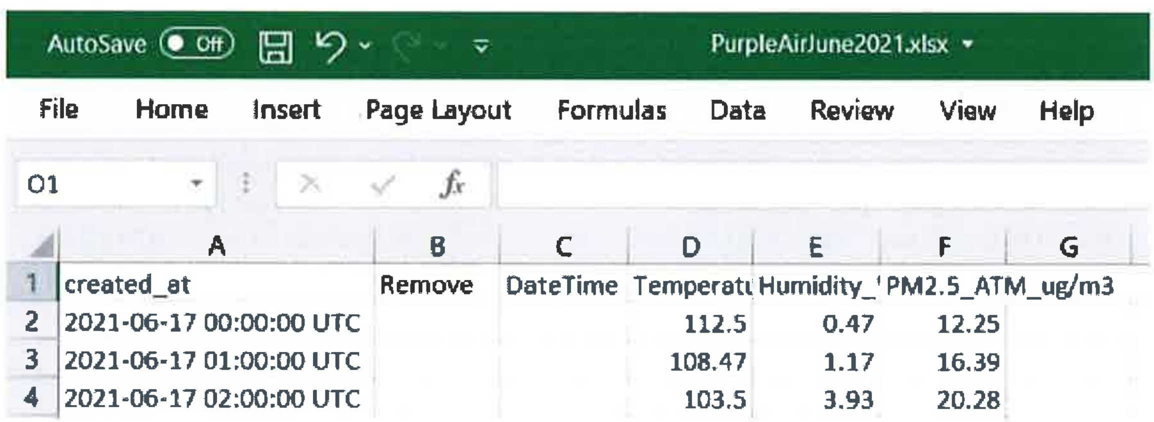
13. Increase the column size of Column A. To do this, click on Column A to highlight it. Then hover your mouse on the vertical line between Column A and B until the icon turns to two-sided arrow. Then double-click.



14. Type in the following new column headers for the new columns.

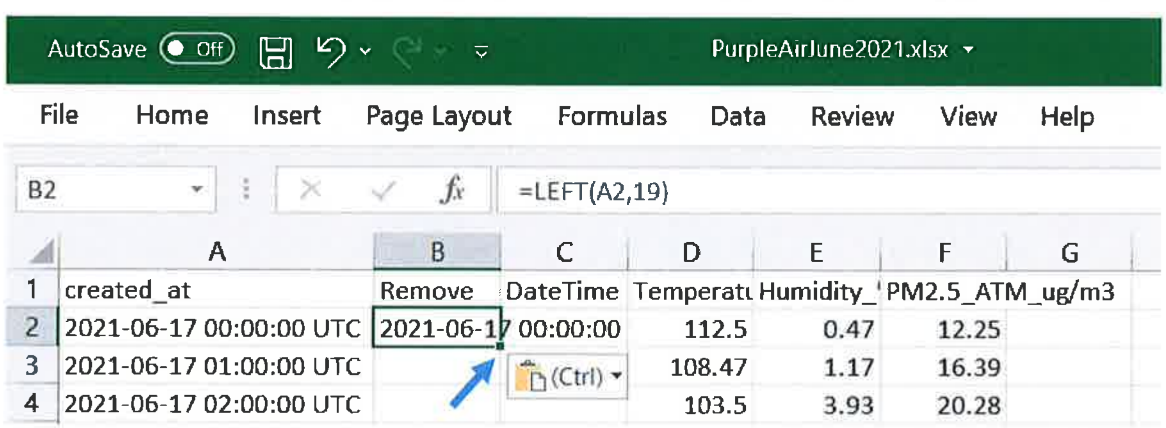
    Column B: Remove

    Column C: DateTime



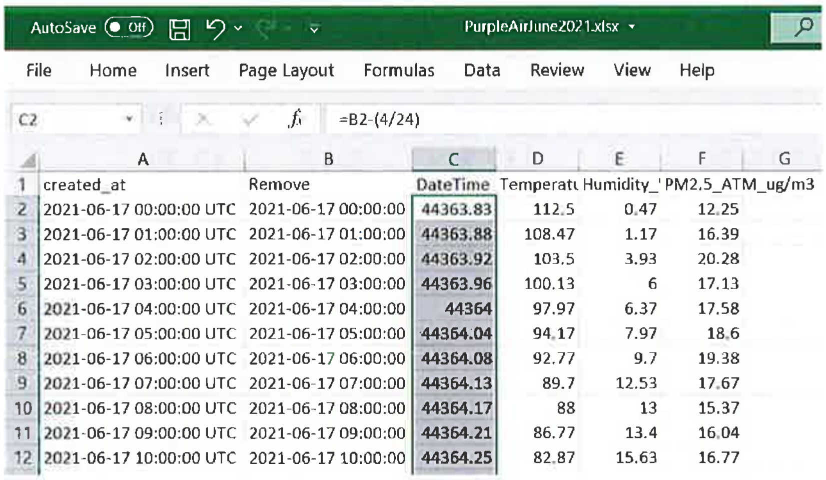
15. In the first cell of Column B, cell B2, copy and paste the following formula: =LEFT(A2,19)

    Then, double click on the bottom right corner of the cell (there is a little box shown there), to fill the formula down the entire column. Then increase the size of Column B just like you did for Column A.



16. For this example, the Purple Air sensor is located in Mountain Daylight Time (MDT) zone, so UTC is 6 hours ahead of MDT. We convert the timestamp in UTC to MDT by subtracting 6 hours using a formula. In the first cell of Column C, cell C2, copy and paste the following formula: =B2-(6/24)

    Then, double click on the bottom right corner of the cell (there is a little box shown there), to fill the formula down the entire column. Your screen should now look similar to this.



	A	B	C	D	E	F	G
1	created_at	Remove	DateTime	Temperatu	Humidity_	PM2.5_ATM_ug/m3	
2	2021-06-17 00:00:00 UTC	2021-06-17 00:00:00	44363.83	112.5	0.47	12.25	
3	2021-06-17 01:00:00 UTC	2021-06-17 01:00:00	44363.88	108.47	1.17	16.39	
4	2021-06-17 02:00:00 UTC	2021-06-17 02:00:00	44363.92	103.5	3.93	20.28	
5	2021-06-17 03:00:00 UTC	2021-06-17 03:00:00	44363.96	100.13	6	17.13	
6	2021-06-17 04:00:00 UTC	2021-06-17 04:00:00	44364	97.97	6.37	17.58	
7	2021-06-17 05:00:00 UTC	2021-06-17 05:00:00	44364.04	94.17	7.97	18.6	
8	2021-06-17 06:00:00 UTC	2021-06-17 06:00:00	44364.08	92.77	9.7	19.38	
9	2021-06-17 07:00:00 UTC	2021-06-17 07:00:00	44364.13	89.7	12.53	17.67	
10	2021-06-17 08:00:00 UTC	2021-06-17 08:00:00	44364.17	88	13	15.37	
11	2021-06-17 09:00:00 UTC	2021-06-17 09:00:00	44364.21	86.77	13.4	16.04	
12	2021-06-17 10:00:00 UTC	2021-06-17 10:00:00	44364.25	82.87	15.63	16.77	

    Here are formulas for other time zones that you can copy and paste into your spreadsheet.

    Eastern Daylight Time: =B2-(4/24)
    Central Daylight Time: =B2-(5/24)
    Mountain Daylight Time: =B2-(6/24)
    Pacific Daylight Time: =B2-(7/24)
    Alaska Daylight Time: =B2-(8/24)

    Eastern Standard Time: =B2-(5/24)
    Central Standard Time: =B2-(6/24)
    Mountain Standard Time: =B2-(7/24)
    Pacific Standard Time: =B2-(8/24)
    Alaska Standard Time: =B2-(9/24)

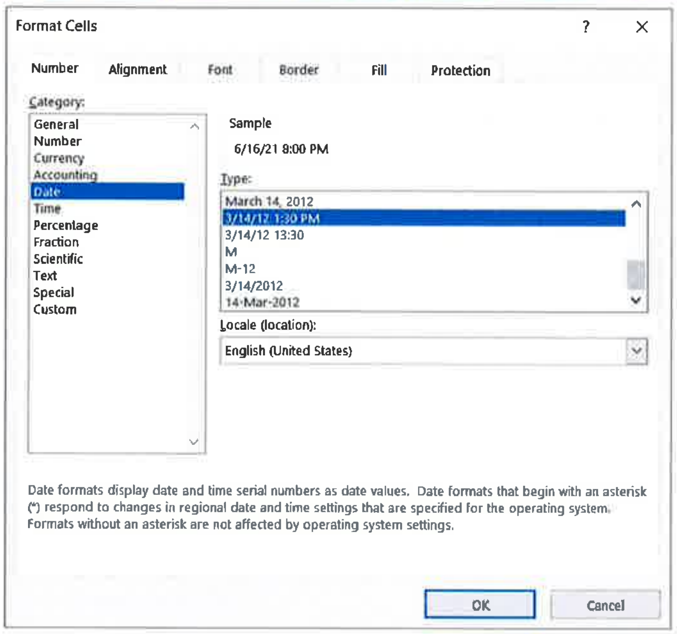
    To find what your time zone is in UTC and vice versa, here is a link to a UTC converter: https://savvytime.com/converter/utc-to-pdt

    To convert 24-hour time to standard time and vice versa, see link below:

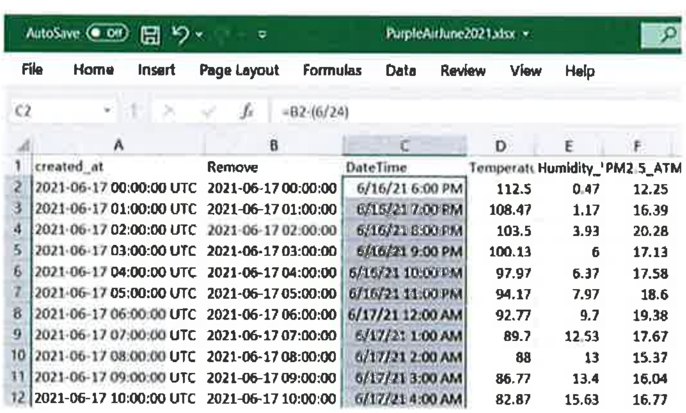
17. The date/times are in number format. We need to change that to date/time format. While the DateTime column (Column C) is still highlighted, right-click anywhere in the highlighted are and select Format Cells. Alternately, you can go to Home in the menu and select Format, Format Cells.

In the screen that opens, select Date. Then in the right side of that screen select a Type of 3/14/12 1:30 PM.

https://www.calculatehours.com/Military_Time_Converter.html

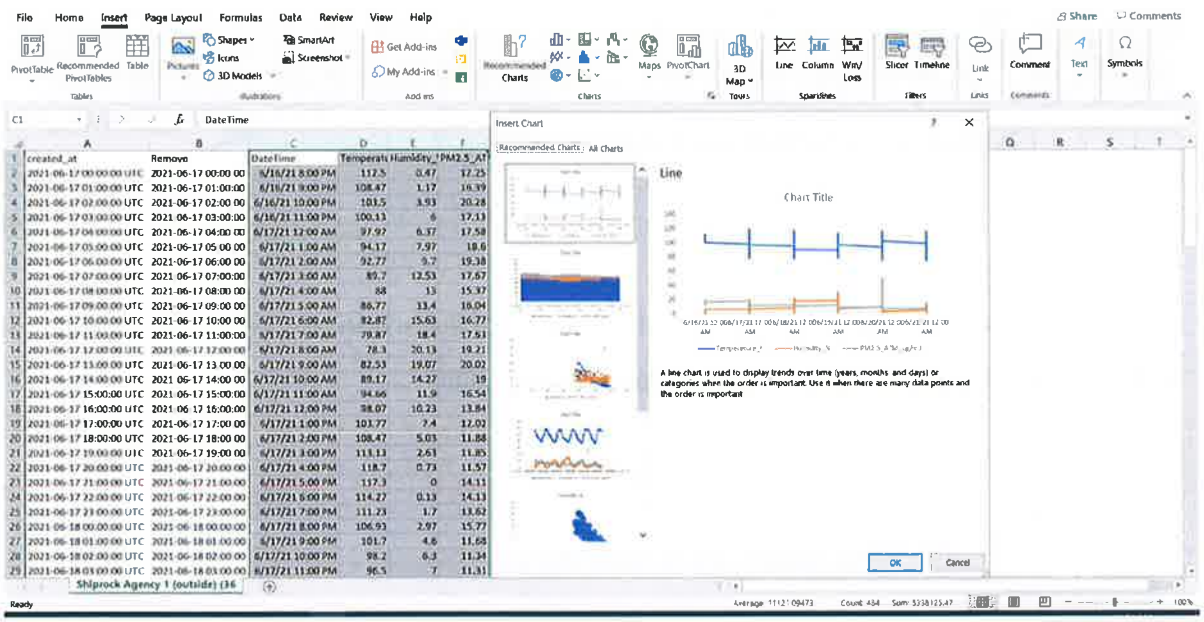


Then click the OK button.

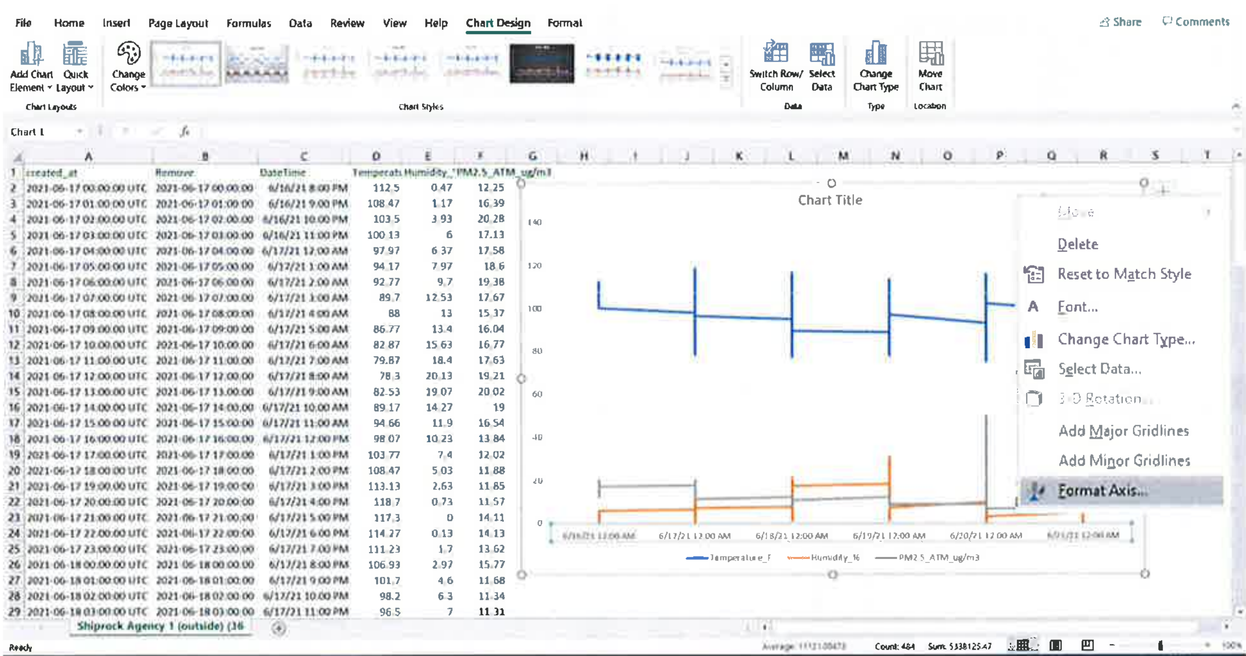


	A	B	C	D	E	F
1	created_at	Remove	DateTime	Temperatu	Humidity_'	PM2.5_ATM
2	2021-06-17 00:00:00 UTC	2021-06-17 00:00:00	6/16/21 6:00 PM	112.5	0.47	12.25
3	2021-06-17 01:00:00 UTC	2021-06-17 01:00:00	6/16/21 7:00 PM	108.47	1.17	16.39
4	2021-06-17 02:00:00 UTC	2021-06-17 02:00:00	6/16/21 8:00 PM	103.5	3.93	20.28
5	2021-06-17 03:00:00 UTC	2021-06-17 03:00:00	6/16/21 9:00 PM	100.13	6	17.13
6	2021-06-17 04:00:00 UTC	2021-06-17 04:00:00	6/16/21 10:00 PM	97.97	6.37	17.58
7	2021-06-17 05:00:00 UTC	2021-06-17 05:00:00	6/16/21 11:00 PM	94.17	7.97	18.6
8	2021-06-17 06:00:00 UTC	2021-06-17 06:00:00	6/17/21 12:00 AM	92.77	9.7	19.38
9	2021-06-17 07:00:00 UTC	2021-06-17 07:00:00	6/17/21 1:00 AM	89.7	12.53	17.67
10	2021-06-17 08:00:00 UTC	2021-06-17 08:00:00	6/17/21 2:00 AM	88	13	15.37
11	2021-06-17 09:00:00 UTC	2021-06-17 09:00:00	6/17/21 3:00 AM	86.77	13.4	16.04
12	2021-06-17 10:00:00 UTC	2021-06-17 10:00:00	6/17/21 4:00 AM	82.87	15.63	16.77

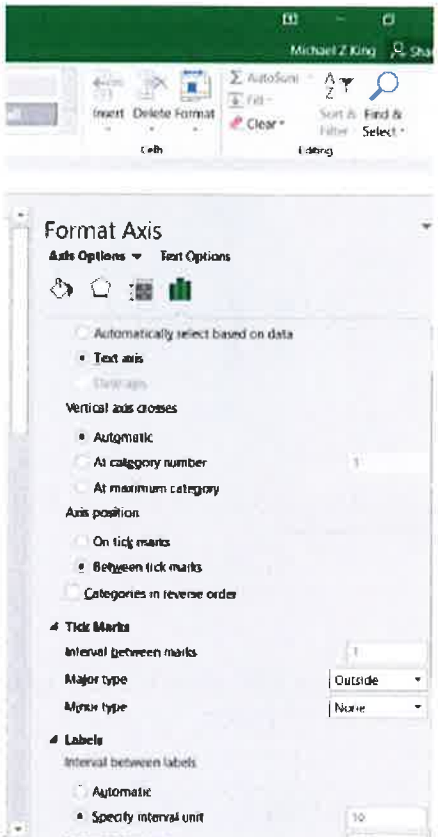
18. Now highlight Columns C through F and go to the top tool menu bar and select **Insert** and **Recommended Charts** to chart the data. For this example, I selected the first recommended chart.



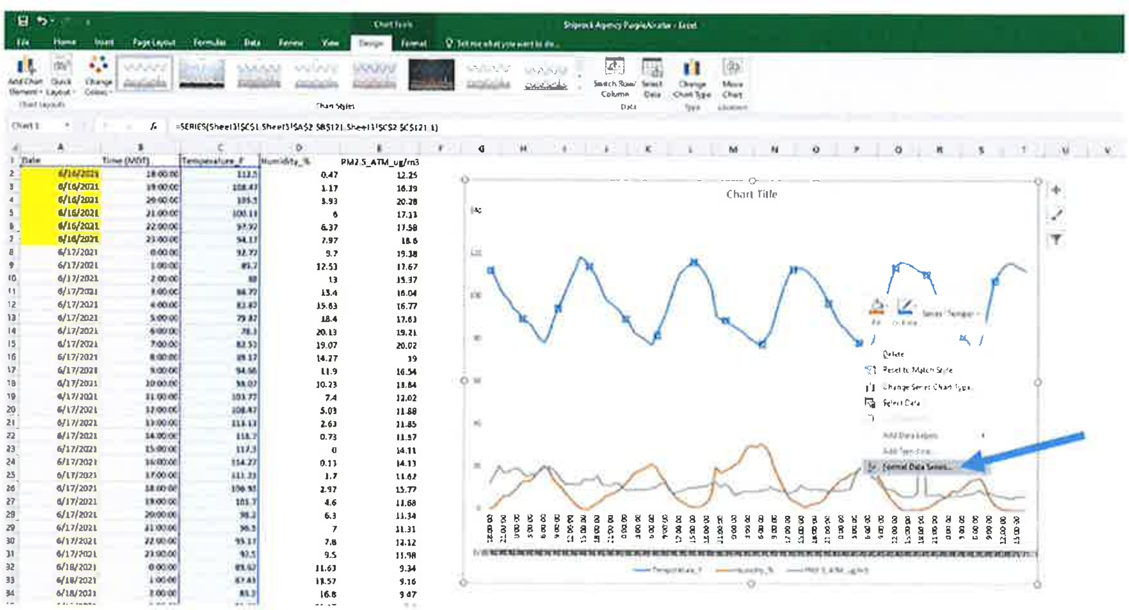
19. You should now see the chart in your Excel worksheet. First, we need to fix the X-Axis by right clicking on the X-axis labels and select **Format Axis.**



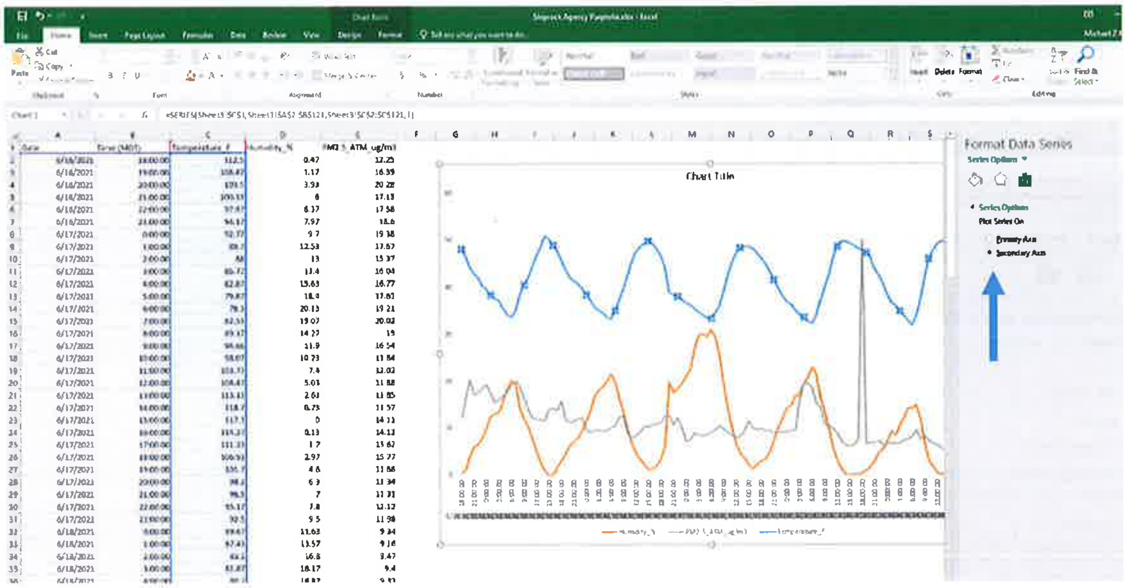
Within Format Axis under Axis Options, scroll down to Axis Type select **Text Axis**. Under Tick Marks scroll to Major Type set to **Outside**. Under Labels select **Specify Interval Unit** and set to **10**. Lastly, uncheck the box next to **Multi-level Category Labels**.



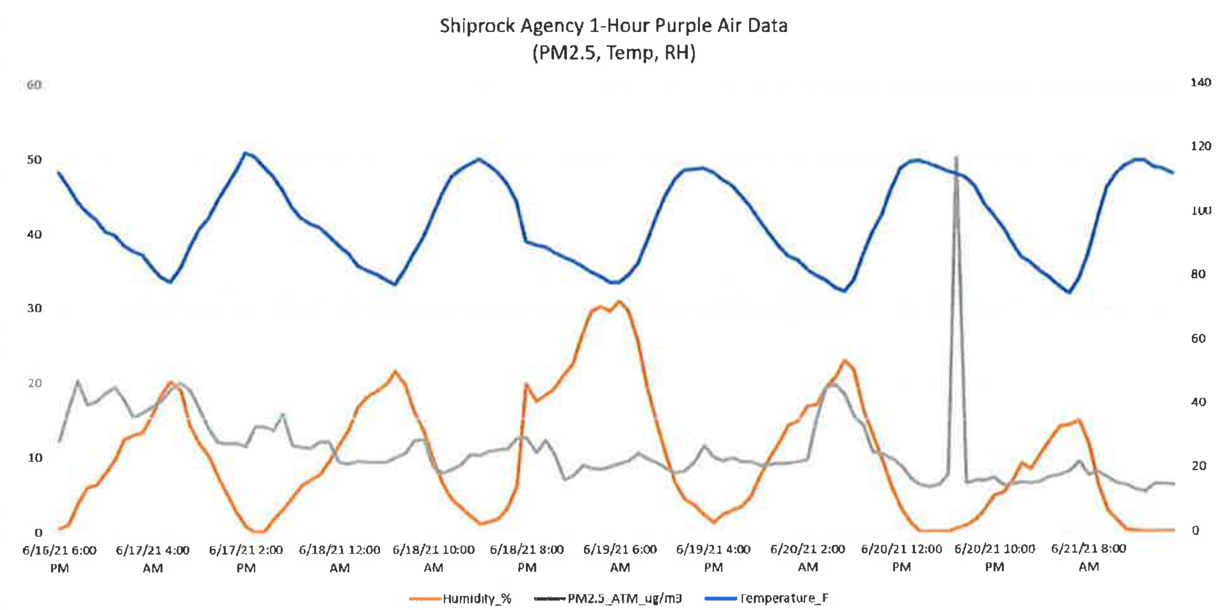
20. Notice the Temperature is plotted high on the Y-axis. You can fix this by plotting the Temperature on the secondary Y-axis. First click on the Temperature data on the chart and right click your mouse to select **Format Data Series**.



You will then select plot series on Secondary Axis.



21. Click on Chart Title and add a Title to your chart. Your chart should now look similar to the chart below.



Appendix H: Standard Operating Procedures (SOPs) & Quality Control Requirements for PurpleAir Sensors

There are many activities involved in data collection beyond simply turning on the sensor and collecting measurements. Users will need additional preparation before and during data collection activities to ensure that useful data are collected. Quality Control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item, or services against defined standards to verify that they meet the stated requirements. QC activities are used to ensure that measurement uncertainty can be estimated and is less than the measurement quality objectives so that the DQOs can be met. These activities/tasks include:

1. Frequent Data Review

Reviewing data frequently (e.g., daily, weekly) lets you detect problems early, notice trends in the data, ensure that maintenance activities are completed, and become familiar with recurring patterns. For instance, creating a time series plot (i.e., a plot with the pollutant concentrations on the y-axis and the date and time on the x-axis) can be a good place to start. You might see typical patterns and develop a general sense of air quality in an area under different conditions. When typical conditions are known, it becomes easier to identify times when sensor readings are atypical and why these atypical readings are occurring.

2. Maintenance

Air sensors require preventive maintenance to ensure proper functionality and reliable data collection. Air sensor maintenance can include regularly scheduled cleaning of surfaces or inlets to prevent the buildup of bugs or dust, replacing filters, or replacing sensor detector components as they age. Maintenance can also include examining site conditions for any changes (e.g., vandalism, overgrown trees).

Equipment will be inspected quarterly for dirt, debris, vegetation, trash, or other objects that may obstruct or impact the monitors readings. If malfunction becomes apparent through the data, the equipment will also be inspected for damage or blockage.

3. Troubleshooting

Problems with air sensors will likely occur and may require troubleshooting to resolve the problem and to continue collecting data. Troubleshooting might include visiting the sensor, contacting the manufacturer, seeking guidance from other air sensor users, or other activities.

4. Quality Control (QC) Checks

It is important to frequently review the data for problems such as outliers, drift, etc. Some sensor manufacturers may offer a software package or online user interface that offers some automated checks of the data to assist in this process. Note that automated checks may not catch subtle problems or may flag a real-life event as bad data. Do not solely rely on automatic QC checks to identify issues with the data.

- **Common Quality Control (QC) Checks**

Quality Control (QC) procedures are activities that include collocation, correction of data, maintenance, automatic data checks, data review, and any other steps taken to reduce error from the sensor or instruments during a project.

The following table details recommended QC checks that can be performed on an air sensor and its data. The checks are designed to catch problems early, correct them, and produce a useful, high-quality data set.

Recommended Quality Control Check	Description
Units	Check that the sensor reports data in the correct units of measure.
Time	Check that the sensor reports data at the correct time and in the right time zone. Check times after any seasonal time changes (e.g., daylight savings time).
Timestamp	Determine the timestamp, which is the time when data are tagged by an instrument. Measurements and data averages will have times that either represent the beginning of the time period (time beginning) or the end of the period (time ending).
Matching Timestamps	Check the time zones and timestamps for each dataset to make sure they are similar when comparing measurements made by different instruments.
Data Review	Check data frequently (e.g., daily, weekly) to detect problems early, identify trends in the data, ensure that maintenance activities were completed, and become familiar with recurring patterns.
Data Completeness	Completeness measures the amount of data a sensor collects compared to the amount of data that was possible to collect if the sensor operated continuously, without data outages, during a period (e.g., 1-hour, 1-day).
Automatic Data Checks*	Software can check data for problems and outliers. Note that some data checks may not catch subtle problems or may flag an infrequent but real event. Do not solely rely on automatic QC to check data quality.
Manual Data Validation	Evaluate the data quality during the collection phase of the project to identify and correct potential problems that may arise. To accomplish this, analyze data to identify seasonal, day/night, and weekday/weekend patterns and weather changes. An absence of expected patterns may indicate a problem with the sensor or with the measurement approach.

- **Common Automatic Data Checks**

Common Automatic Data Check	Description
Range	Check the minimum and maximum concentrations expected and recognize some air sensors may report slightly negative values.
Rate of Change	Check the difference in data values from an air sensor between two consecutive time periods (e.g., hours). Flag the data if the difference, or rate of change, exceeds the value set by the user.
Sticking	Check if data values are "stuck" at the same value for a specified number of hours. Establish criteria for the number of consecutive hours for which data can be reported at the same value.
Duplicate Sensor Comparison	Some sensors incorporate two identical sensing components inside which provide two separate pollutant concentration measurements. Check the

	agreement between the readings and flag data if the difference exceeds an acceptable threshold.
Buddy System	Check the difference between data values obtained from a single location and the average data values obtained from other nearby locations.
Parameter-to-Parameter	Check two or more pollutants for known or expected physical or chemical relationships.

5. Quality Control Requirements

The PurpleAir readings uploaded to the PurpleAir website will be checked biweekly (every two weeks) to ensure properly functioning sensors. Sensors on the PurpleAir do not have a flow requirement and do not require temperature/pressure verifications.

The graphs of the channel A and B will be reviewed weekly to identify potential sensor malfunction or damage. Agreement between A and B channels provides confidence in measurement. Temperature and relative humidity readings will not be used as an indicator of correlation or accuracy improvement needs or as an indicator of degradation.

The US-wide correction factor developed by the USEPA will be used to minimize error from raw data. The development of the correction factors used data aggregated to 24-hour averages. Points were removed if these 24-hr averages A & B PM2.5 channels differed by $\geq\pm$ 5$\mu g\ m^{-3}$ and $\geq\pm 62\%$ (95% confidence interval on % error [2* standard deviation (% error)])

The resulting equation that will be applied to raw PurpleAir data to calculate corrected PM2.5 measurements is as follows (USEPA, 2020):

$$\text{PM2.5 corrected} = 0.524*[\text{PA\_cf1(avgAB)}]-0.0852*\text{RH}+5.72$$

PM2.5 = $\mu g\ m^{-3}$
RH = Relative Humidity (%)
PA_cf1 (avgAB) = PurpleAir higher correction factor data averaged from the A and B channels

6. Periodic Collocation

Collocation refers to the process of operating a regulatory grade reference monitor (FRM/FEM) and non-reference monitor (air sensor) at the same time and location under real-world conditions for a defined evaluation period. Collocation can help quantify the accuracy of a sensor while periodic checks can help ensure that accuracy is not changing over time or in different conditions. Users should develop a periodic collocation approach to check the quality of the air sensor's measurements.

If the sensor is not reporting or not meeting precision data requirements (Section 1.7/A7) the user should take the following corrective steps:

- Check the Wi-Fi connectivity at the site.
- Physically inspect the sensor. Confirm the power cord is connected and does not look damaged. Inspect the internal sensor inlets inside the sensor housing for debris.
- If there appears to be physical debris present, clean the sensor with compressed air. A vacuum hose may also be effective.
- If these steps do not resolve the issue, contact PurpleAir for a repair or replacement if within the warranty period or replace the sensor.