Quality Assurance Project Plan

Evaluating Homeowner PM Exposure from Woodstove Emissions in Villages within the [ORGANIZATION NAME] Region

Prepared by:

[PROJECT MANAGER NAME]

[POSITION TITLE]

[ORGANIZATION NAME]-[DEPARTMENT NAME]

Date: 02/24/2025

Revision: 0

1. Project Plan Identification and Approval

The Air Quality Project Officials

Signature: _____ Date: _____
[PROJECT MANAGER NAME], [POSITION TITLE]
[ORGANIZATION NAME]-[DEPARTMENT NAME]

Signature: _____ Date: _____
[PROJECT MANAGER SUPERVISOR'S NAME], [POSITION TITLE]
[ORGANIZATION NAME]-[DEPARTMENT NAME]

Signature: _____ Date: _____
[PROJECT OFFICER NAME], [POSITION TITLE]
[EPA DIVISION]

Signature: _____ Date: _____
[QUALITY ASSURANCE MANAGER NAME], [POSITION TITLE]
[EPA DIVISION]

Contents

2. 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.

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."

EPA Correction Factor: a multi-linear correction equation (including temperature and relative humidity) for PurpleAir $PM_{2.5}$ 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 is 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 ($PM_{2.5}$): 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 known to be harmful to human health: lead (Pb), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), coarse particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$).

PurpleAir[1]

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, $PM_{2.5}$, and PM10 for standard indoor and outdoor particles.

[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.

3. Project Organization Roles & Responsibilities:

3.1 Project Manager:

[PROJECT MANAGER NAME], Project Manager: As the sole [ORG] staff on this project, [PROJECT MANAGER NAME] is responsible for all aspects of the project including:

1. Developing the project QAPP
2. Finding PA hosts, coordinating with these site partners, and distributing indoor PA monitors
3. Periodically downloading PA SD card data
4. Applying QA checks to downloaded data per the requirements in the QAPP. Note that although this project is too small to have dedicated independent QA staff, the Project Manager is committed to following the QAPP and objectively applying the QA requirements.
5. Data reduction, analysis, and visualization
6. All activities related to voluntary IAQ interventions- Including but not limited to:
    1. Developing community workshops with participants/ interested parties in the village.
    2. Collaborating with local IGAP/environmental coordinators in the village to establish community interest/ buy in
    3. Educating homeowners on how wood smoke can produce unhealthy indoor air, on EPA Burnwise informational guidelines, assisting homes in implementing Burnwise techniques.
    4. education on Purple Air sensors and how IAQ is important to health/wellbeing.
    5. Help community members understand unsafe levels of $PM_{2.5}$ and how to mitigate associated risks.
    6. Workshops on how air purifiers can help $PM_{2.5}$ levels in home and best practices for air purifier use.
    7. Providing community with accessible data that is easy to understand and conceptualize.
7. Project reporting to EPA R10; including quarterly reports, annual reports, and monthly project evaluation meetings with EPA project officer.

3.2 Site Partners:

1. Provide a safe physical location for the PurpleAir Monitor
2. Install the monitor as directed by the Project Manager
3. Coordinate with the Project Manager
4. Perform minor maintenance activities under the direction of Project Manager. This includes how to restart the system following a power outage.

4. Definition/Background:

4.1 Reason for initiating this project:

Woodstoves are a major contributor to particle pollution, without proper ventilation $PM_{2.5}$ has the potential to remain in the home. Most homes in the [ORG] region lack appropriate ventilation systems regardless of the age of the building. Many of the homes in the project also have a Toyostove in addition to a woodstove, these stoves can also result in poor indoor air quality markers. Village homes often experience overcrowding due to limited housing options and having a culture of multigenerational living

spaces. $PM_{2.5}$ exposure can result in many negative health impacts. PurpleAir sampling conducted during the duration of this project will act to inform homeowners of their $PM_{2.5}$ exposure levels. This knowledge is important for community members in the [ORGANIZATION NAME] region because a large majority of the homes use woodstoves as their primary heat source. Indoor air quality is rarely looked at in Alaska, but it is important due to extended periods of time spent indoors during harsh winters.

4.2 Decisions to be made and expected outcomes:

After gathering $PM_{2.5}$ data for the first year of the study, the [ORG] project manager will be able to provide a scope on participant exposure within the selected homes. The results will guide [DEPT] to provide appropriate remediation recommendations and educational resources for homeowners. Additionally, this data will serve as insight on the scope of indoor $PM_{2.5}$ exposure within [ORG] communities. Many of the homes in the villages are built in a similar fashion, including similar levels of ventilation and methods of heating. The baseline information obtained from monitoring indoor $PM_{2.5}$ levels in the first year of the study will be used to:

- Identify air quality issues and trends in tribal homes to better promote health and safety of occupants.
- Educating Homeowners and tribal members on health impacts of exposure to $PM_{2.5}$ and poor indoor air quality
- Provide recommendations and remediation techniques including installing portable air purifiers following testing and data collection.

In the second year of the study, the project will monitor indoor $PM_{2.5}$ in the same homes but with cleaner air interventions installed. This information will be used to evaluate the effectiveness of those interventions. The combined data from the studied homes should be able to give insight into a broader community level exposure. This data collected will help guide the community to seek out ways to improve indoor air quality and resident health. The Decision: Are IAQ interventions such as Burnwise and air cleaners worth the effort?

4.3 Action limits and applicable criteria necessary:

We anticipate that the results of the indoor $PM_{2.5}$ testing will show a range of $PM_{2.5}$ levels across multiple Air Quality Index (AQI) levels. Air quality interventions will be evaluated based on their impact on AQI.

5. Project Description:

In an effort to protect indoor air quality and mitigate adverse health impacts in the [ORGANIZATION NAME ([ORG])] communities, [DEPARTMENT [(DEPT)]] proposes to launch an air quality project to capture fine particulate matter ($PM_{2.5}$) data in homes using woodstoves. These results will act to inform homeowners of PM exposure levels and associated risks within the residence. The results will guide [DEPT] to provide appropriate remediation recommendations and educational resources for homeowners. Additionally, this data will serve as insight on the scope of indoor $PM_{2.5}$ exposure within [ORG] communities. Year one of this two-year project will conduct $PM_{2.5}$ testing in [VILLAGE NAME]. The project will supply PurpleAir monitors to a total of twenty-five homes. Ten PurpleAir monitors were purchased using EPA Clean Air grant funding and the remaining fifteen sensors were supplied by [ORG] [DEPT]. To get a broad data set the monitors will be set up for a 2-year period.

Project manager will aim to collect data from SD cards every 3 months. Data collection periods may vary and be upwards of 4-5 months depending on weather conditions and the availability of community participants.

The following year the same homes will be evaluated with implemented recommendations and remediation to evaluate changes in PM levels and exposure. Due to the increased use of woodstoves in winter months it is important that the monitor be up and running during the coldest months of the year. An 8-10 month initial testing period for year one will provide a clear picture of months with the highest exposure and provide insight into what means of remediation should be taken per household. For year two of the project the same homes will be tested with implemented air purifiers to see if low cost and accessible air purifiers are able to reduce particulate pollution and improve indoor air quality.

5.1 Project Sites or Study Area:

The project will take place in the [ORGANIZATION NAME] Region; [DESCRIBE THE REGION HERE]

5.2 Time Period:

The sensors will be deployed for the duration of the 2-year project, with a possible 4-month variation due to set up and take-down periods. Project start is October 2024 following grant award. Project manager will deploy sensors by January 2025. The first data collection trip will fall between April and May. Interventions will begin following data analysis results from the first SD card collection. Interventions are projected to begin summer of 2025. There will be a second data collection trip that will take place during July-August 2025. At the start of the second year, air purifiers will be deployed to all participating homes within 3 months of funding start. 3–5-month variation of data collection will take place the second year of the project.

- For indoor $PM_{2.5}$ evaluations we are expecting elevated levels of concern during winter months when woodstove use is elevated. Wildfire season may also cause a rise in indoor $PM_{2.5}$ levels. Road dust is also of concern in villages and may also be a source of higher Particulate matter levels in summer months.

5.3 Data Users:

The data collected from this project will be used by [ORGANIZATION NAME], [ORG] [DEPARTMENT NAME], village councils, and homeowners.

*Expectations and use are limited to informal evaluations and should not be represented as definitive measurements to be used for anything other than informational investigations, education, and awareness. **Important Note: The air sensors are non-regulatory and the data they collect are not eligible for comparison to the NAAQS. This equipment is not to be used for confined space evaluations for safety considerations. The EPA does not endorse using this equipment to meet any requirements related to health and safety.**

6. Data Quality Objectives and Indicators:

6.1: Data Quality Objective(s) (DQO):

- Tolerable limits on data
    - Moderate uncertainty is acceptable in translating the measured $PM_{2.5}$ levels to the AQI and exploring trends and patterns.
    - Sensors, including the PurpleAir Sensor, typically measure particles using light scatter, operate at lower flowrates, and do not dry the sampled particles like permanent and temporary monitors operated by clean air agencies. These methodological differences can lead to inaccuracies compared to permanent and temporary monitors. EPA scientists have found that air sensors often report data that overestimates, or underestimates pollutant concentrations compared to the permanent or temporary instruments that are operated in the same location.
    - Comparing the two channels provides a check on the sensor accuracy: if the two channels are reporting different levels of $PM_{2.5}$, that means one of the channels is malfunctioning. If the two channels agree well, that gives confidence in the accuracy.

- PurpleAir Sensors, without the use of the EPA correction equation, measure the same trends in $PM_{2.5}$ concentrations as collocated monitors, but they tend to overestimate the $PM_{2.5}$ mass concentrations and respond nonlinearity at high smoke concentration (>200 µg/m3).

6.2 : Data Quality Indicators:

Sensor data used for informational investigations (Type 2 as defined in Section 5) should use the following 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 of the level of $PM_{2.5}$ in the ambient air. PurpleAir sensors make duplicate measurements of ambient $PM_{2.5}$ which are recorded as two "channels": A and B. The precision can be determined by calculating the difference in these two channels.
   Examples of poor precision and good precision are illustrated in Figure 1

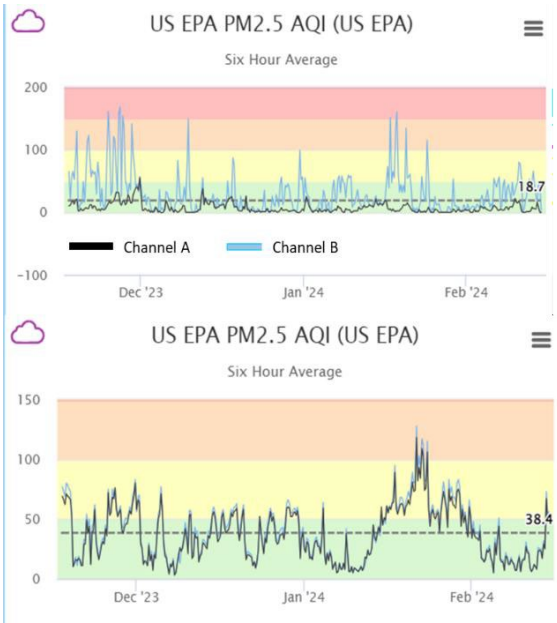


Figure 2: Comparison of Purple Air sensor measurements with poor precision (top) and measurements with acceptable precision (bottom). The precision is determined based on how well the two channels (A in black and B in blue) agree with each other.

2. **Bias** is a systematic error in a set of measurements, or the difference between the measurements and the true value. EPA scientists have quantified the typical bias of PurpleAir sensors and developed a correction equation (see above).

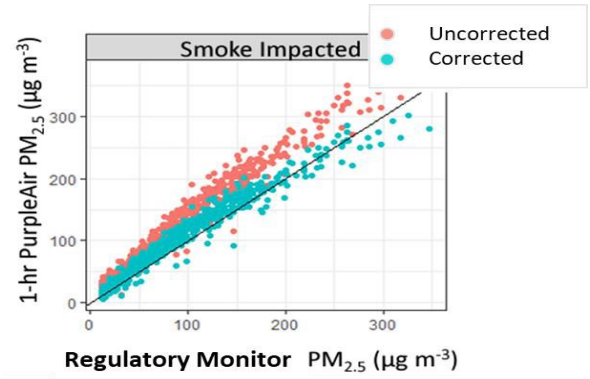


Figure 3: Scatter plot of PurpleAir measurements (y-axis) compared to collocated measurements from regulatory monitors (x-axis). The black line shows where the data would fall if the monitor types agreed perfectly. The plot illustrates how the PurpleAir correction equation reduces the positive bias in the sensor measurements compared to regulatory monitor measurements.

3. **Data completeness** is a measure of data coverage over time. Since $PM_{2.5}$ levels often have patterns over time (e.g., more elevated at night or during inversion events), it is important that measurements are representative of reality.

6.3: Measurement Quality Objectives:

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

7. Documents and Records:

7.1 Documents:

1. Project QAPP. [PROJECT MANAGER NAME], the Project Manager, is the only sampling personnel on the project. She will manage QAPP version control in coordination with the EPA project officer. In the event an additional member assists in the sampling process all aspects of the QAPP will be distributed to review prior to data collection.
2. Site Partner Packet: This packet includes [ORG] [DEPT] contact information and project manager contact information for the partners to reach out if issues or questions arise. The second page of

the document discusses what the PurpleAir sensor is and does with information sourced from the PurpleAir website. The third page gives a small explanation of what Particulate matter is and shows a diagram to show particle size comparison. Pages three and four have information that was collected from the EPA particulate matter webpages. The fourth page explains a brief overview of potential health impacts associated with particulate matter exposure. Page five explains where the sensor should be set up and how to maintain the sensor. The last page explains more about the AQI light on the PurpleAir sensor and considerations of leaving the light on. See Appendix A.

3. Data reports. These will include graphs showing daily, monthly, and seasonal patterns in indoor $PM_{2.5}$ levels. After year two of the project, we will report on the impact of remediation/intervention strategies on indoor $PM_{2.5}$. These reports will be provided for each individual residence, as well as aggregated (and anonymized) for all participating residences.
4. Data processing code. The Project Manager will use the open-source software R to automate processing the raw sensor data. These R script will be saved as an R "project" on the Project Manager's laptop, as well as backed up to the project folder on the [ORG] online drive.

7.2 Records:

1. Field data sheets to record relevant information on sensor siting and checks (Appendix B)

7.3 Project Monitoring Data:

1. Sensor metadata. The Project Manager will transcribe the field data sheets into an Excel spreadsheet. This spreadsheet will be backed up to the project folder in the [ORG] online drive, as well as saved on the Project Manager's laptop. The physical field data sheets will be scanned and sent to Project Manager's laptop to be saved on the [ORG] drive. The physical copies will be saved in a folder in the Project Manager's office.
2. Sensor raw data files. The PurpleAir Sensor raw data will be downloaded from each sensor's SD card to the Project Manager's laptop during site visits. These files will be backed up to the project folder on [ORG]'s online drive as well as saved to the Project Manager's laptop.
3. Processed data files. The raw data will undergo multiple reduction and processing steps to produce the final data products as outlined in Appendix C. Each of the data levels will be saved as .csv files to the Project Manager's laptop and periodically backed up to the project folder in the [ORG] online drive.

8. Experimental Design:

Twenty-five sensors will be deployed in [VILLAGE NAME] an Alaska Native village in the [ORGANIZATION NAME] Region. The homes in this village range in size and age but all have woodstoves as a main source of heat. We considered several factors that would be likely to impact indoor air quality, and placed sensors in a variety of homes to collect information representative of the larger community and region.
These factors include home age, home size, type of heating device (woodstove, kerosene/oil/diesel Toyostove), and number of residents in a home.

The monitors will be deployed for the duration of the 2-year project, to be varied by up to 4 months due to set up and take down period. Data from the sensors will be collected from internal SD cards every 3-5 months due to interior Alaska having limited Wi-Fi capabilities. The ideal collection times will be every 3 months, but trips may vary due to harsh winter weather restricting travel and participant availability. The second year a HEPA air purifier will be deployed into each participating home to gather

post intervention data. This project will evaluate sub-daily/hourly data to see if there are peaks of $PM_{2.5}$ with woodstove use. The data will also look at seasonal changes in indoor air quality.

8.1 Participant Programmatic Requirements:

- Selected homes use wood-burning stove as a heat source.
- Partners are interested in improving indoor air quality by allowing the installation of a PurpleAir monitor in their home.
- Homeowners are willing to learn about PM sources and attend workshops on Burnwise techniques and exposure mitigation.
- Participant is willing to contact the project manager if issues occur.

8.2 Data privacy:

The homeowners will have a choice to make the data private or public. If the data is private, it will aid in providing that home with a scope of occupant exposure to PM and poor air quality. If the data is made public it can be used as a scope of other homes' indoor air quality, both in the same village and other interior Alaska villages.

8.3 Site location physical requirements:

- Home must have appropriate access to power to run both the sensor and air purifier.
- Location to install the sensor that meets the following criteria (additionally, see guidance in Appendix A):
    - near the typical breathing zone height (3 – 6 ft)
    - away from air pollution sources (e.g. cooking) and air pollution sinks (e.g. air cleaners), to get a more representative measure of indoor air quality.
    - in the open with free air flow and not placed behind furniture or tucked away in corners, ideally with 270_{o} unobstructed flow at the sensor and no less than $180\ _{o}$ of flow.
    - Away from windows, doors, and heating, ventilation, and air conditioning (HVAC) ducts that can introduce rapidly changing temperature and relative humidity conditions, which may adversely impact some sensors and may not be representative of average indoor concentrations.

9. Sampling Methods:

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 $PM_{2.5}$ for standard indoor and outdoor particles.

Most PurpleAir models (including the Zen model used in this project) are equipped with two sensors which measure and report particle concentrations in six sizes between 0.3µm and 10µm diameter. Temperature, relative humidity, and pressure values are also recorded. The sensors are calibrated by the manufacturer to associate a particle size with particle mass and estimate total mass for $PM_{1.0}$, $PM_{2.5}$ and

PM_{10}. In the absence of a Wi-Fi connection, the sensors store data to their internal SD cards on a 2-minute timestep.

Site partners will be trained to identify issues and take corrective actions for scenarios summarized in the Table below. The Extreme winter weather results in a regular occurrence in power outages in the rural tribal villages. Homeowners can use the partner guide (see appendix A) to aide in restart following malfunction.

Table 1: Summary of common issues and corrective actions

Issue	Corrective Action
Power outage (regular occurrence due to extreme winter weather in rural Tribal communities)	Check that sensor reboots once power is restored
Sensor is not operating as expected	1. 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. 2. If there appears to be physical debris present, clean the sensor with compressed air. A vacuum hose may also be effective.

10. Quality Control Requirements

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 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.

10.1 QC activities:

- The Project Manager will conduct quarterly site visits to the Village where the sensors are deployed. During these site visits the Project Manager will:
    - Physically inspect the sensors and address any issues. Common issues include dust/debris/insects in the sensor housing, the sensor becoming unplugged, or problems with how the sensor is mounted (broken zip ties, etc). If there appears to be physical debris present, clean the sensor with compressed air.
    - Download the data from all sensor SD cards. The Project Manager will screen the raw data to detect any significant issues with the PA sensors. Data will be reviewed to identify blank/null readings, unexplainable spikes, duplicate data, and deviation thresholds between the two channels. These QC checks will occur after each data collection trip and the project manager will communicate with community partners if sensors appear to be malfunctioning. If any issues are detected, the Project Manager will further troubleshoot and replace the sensor if the budget allows. Before purchasing a new sensor, the project manager will reach out to PurpleAir customer service for further guidance and warranty guidance.
    - During data reduction and processing in R, the MQOs from section 5.3 will be applied to the data. Any data that does not meet the MQOs will be flagged. If the data does not meet

the precision criteria, the data will be further inspected and compared to previous data from that location as well as data from sensors sited in similar locations to determine if one of the channels can still be used. If the data does not meet the completeness criteria for an hour/day, the data from that hour/day will not be used. In the case that one channel goes down for longer than 48 hours during the duration between data collection trips, the live channel will still be used to inform the homeowner of exposure levels with the understanding that there was not a secondary channel to verify data results. Homeowners are informed that the data collected is experimental and will not be used to directly connect health outcomes but rather be used as a guide to understand the extent of PM exposure in village homes.

11. Instrument/Equipment Testing, Inspection, and Maintenance

The Project Manager will inspect the PurpleAir sensors before deployment for any physical defects. To ensure all Purple Air sensors used in this project are collecting data appropriately, the [ORG] project manager will set up all twenty-five sensors in the [ORG] [DEPT] office for a test period of 24 hours. The monitors will be collocated, allowing the project manager to identify any outliers and inaccuracies prior to the sensors being deployed. In the event a sensor(s) is portraying faulty data, the project manager will seek assistance from both the EPA technical assistance group and Purple Air technical assistance. A second test period may be conducted to ensure the sensor(s) that displaced skewed data in previous trials have been rectified. Project manager will ensure all sensors in program are reporting a normal distribution of data prior to final install.

12. Data Review and Verification

12.1 Sensor Malfunctions:

Site partners will report to [ORG] project manager if the sensor appears to be malfunctioning or if the community experienced a power outage. Data should also be excluded for any periods where the sensor was known to be malfunctioning (site partner notes issue, site visit inspection indicates improper siting or debris in the sensor housing).

12.2 Data Verification:

Verification can be defined as confirmation through examination and provision of objective evidence that specified requirements have been fulfilled. The Project Manager will review data generated by this project to identify any obvious data recording errors or omissions and take corrective action in a timely manner. The review will focus on determining whether adequate data were obtained.

"Common sense' tests of data quality will be utilized to assess parameters concentrations, such as:

- Baseline average: If the average of the baseline concentration for a parameter is unreasonable, the data should be flagged.
- Behavior: If there are patterns in the data that do not reflect diurnal patterns or other known factors, the data will be flagged. These include spikes, discontinuities, drop-outs, and values outside of a reasonable range.

*Data verification guidelines were adapted from the ADEC QAPP

Appendix A: Site Partner Packet

[ORG] [DEPT] Indoor Air Quality Project-[VILLAGE] 2025

Thank you for volunteering to be part of this program! This handout is for your reference and is designed to help the study be as effective as possible. I am so excited to be working with you all to help improve indoor air quality.

Below is my contact information. Feel free to reach out with any questions or concerns!

[PROJECT MANAGER NAME]

Environmental Health specialist/air quality project manager

[ORGANIZATION NAME]-[DEPARTMENT NAME]

Email:

Phone:

*If you are unable to reach me you may contact the [DEPT] work group number at [PHONE] or [EMAIL] for further assistance.

What is a PurpleAir sensor?

The information below can be found at:

https://community.purpleair.com/t/what-do-purpleair-sensors-measure-and-how-do-they-work/3499

Measurements taken by PurpleAir sensors include:

- Particulate matter
- Temperature
- Relative humidity
- Pressure

-Particulate matter measurements are taken from Plantower laser counters, which provide measurements for particles between 0.3µm and 10µm in diameter.

Can my Sensor Detect Something Specific in the Air?

PurpleAir sensors only differentiate particulates by size. They cannot tell if something specific is in the air.

Why is my Sensor Not Detecting Something?

PurpleAir sensors primarily measure particulate matter (PM) between 0.3µm and 10µm in diameter. This information can then be used when estimating PM levels.

PM estimates provided by PurpleAir sensors include:

- PM1 - this includes particulates up to 1µm in diameter
- PM2.5 - this includes particulates up to 2.5µm in diameter
- PM10 - this includes particulates up to 10µm in diameter

PM2.5 and PM1 estimates from PurpleAir sensors have been found to be highly precise. However, it has been demonstrated that they drastically underestimate PM10 pollution levels.

If something is outside the size range detected by the sensor's laser counters (0.3-10µm), it may not be detected. If something is above 2.5µm, it may also be underrepresented or not detected.

What is Particulate Matter (PM)?

The information below can be found at:

https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

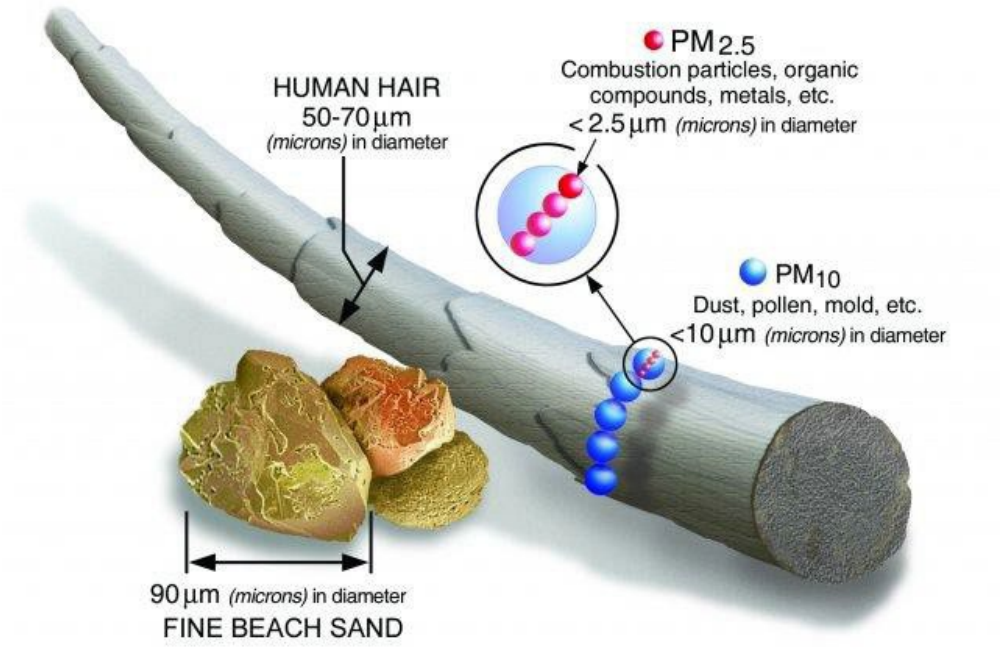
https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm

https://www.epa.gov/burnwise/wood-smoke-and-your-health

What is PM, and how does it get into the air?

PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

Size comparisons for PM particles:



Particle pollution includes:

- **PM_{10}** : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- **$PM_{2.5}$** : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

- How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle.

Sources of PM

These particles come in many sizes and shapes and can be made up of hundreds of different chemicals.

Some are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires.

Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles.

What are the Harmful Health Effects of PM?

Particulate matter contains microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems. Some particles less than 10 micrometers in diameter can get deep into your lungs and some may even get into your bloodstream. Of these, particles less than 2.5 micrometers in diameter, also known as fine particles or $PM_{2.5}$, pose the greatest risk to health.

Smoke from wood-burning stoves and fireplaces contain a mixture of harmful gases and particle matter (PM2.5). Breathing these small particles can cause asthma attacks and severe bronchitis, aggravate heart and lung disease, and may increase the likelihood of respiratory illnesses.

Exposure to Particulate Matter can affect both your lungs and your heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including:

-premature death in people with heart or lung disease

-nonfatal heart attacks

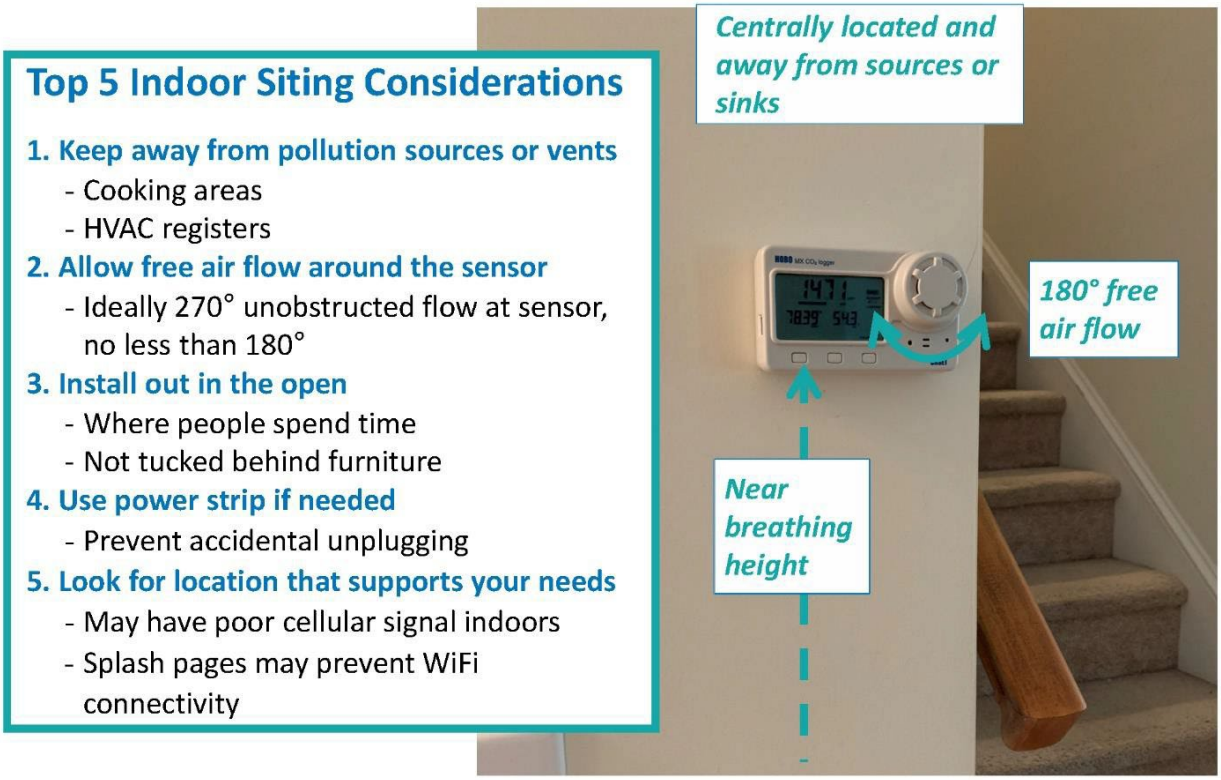
-irregular heartbeat

-aggravated asthma

-decreased lung function

-increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

Where should your sensor go?



-[ORG] [DEPT] will do the initial install/set up of the PurpleAir sensors to ensure appropriate location. If you need to move the sensor to another location, please contact [PROJECT MANAGER NAME] at [ORG] [DEPT] for recommendations.

How do I maintain the sensor?

- Make sure the power comes back on after any outages
    - After a power outage, unplug and plug the sensor back in. When you plug the sensor back in it will light up blue and a red light on the bottom of the sensor with flash on. The sensor is working properly if a blue light on the bottom of the sensor begins to flash. This light will continuously flash roughly every two minutes (This light indicates that the sensor is running and logging data)
- Periodically (~1x/week) check the sensor and make sure it is free of dust/debris
    - If your sensor becomes noticeably dirty or if you notice build up on the inside of the sensor, please contact [PROJECT MANAGER NAME] at [ORG] [DEPT] for cleaning guidance. The machinery can be easily damaged if cleaned improperly.
- Be careful with the SD card. If it gets removed or damaged, contact [PROJECT MANAGER NAME] at [ORG] [DEPT] for guidance or a replacement.

- Contact [PROJECT MANAGER NAME] with [ORG] [DEPT] if you have any other questions or concerns about the sensor maintenance.

Should I have the AQI light on?

- It's up to you whether you'd like to have this real-time indicator of indoor air quality. All you have to do is double tap to turn the light on and off. Single taps allow you to adjust the brightness.
- However, there are several reasons why the light may not be accurate, or may indicate worse air quality than you're really breathing:
    - AQI is based on a 6-hour average. There may be short-term (minutes/hours) "spikes" in air pollution that will result in the sensor changing color to red or purple (unhealthy/hazardous). But these health thresholds are based on longer-term (days/weeks) exposure.
    - AQI is based on outdoor air quality
    - The PurpleAir sensors tend to report higher levels of pollution than the types of monitors used in health effects studies
- When [ORG] [DEPT] collects the sensor data, we'll apply data corrections and ensure the data meet quality standards.
- If you do decide to keep the AQI light on, please inform me if the light remains dark red/purple long-term (days/weeks). I will come out to evaluate the data and help the household introduce interventions to reduce pollution.

AQI Color Scale:

The Air Quality Index	
Index Values	AQI Category
0 - 50	Good
51 - 100	Moderate
101 – 150	Unhealthy for Sensitive Groups
151 – 200	Unhealthy
201 – 300	Very Unhealthy
301 –500	Hazardous

Appendix B: Field Data Sheet

PurpleAir Serial no.	
Receiving and Setup:	
Date of office collocation test (batch #)	
Any issues detected?	
Sensor deployment:	
Deployment Date	
Address	
Location Name	
Deployment height	
Any obstructions near the sensor?	
Picture taken that shows sensor and surroundings?	
Activities conducted in this space:	
Nearby sources:	
Approximate number of people who occupy this space:	
In a room with a door to outside?	
Are there air cleaners in use?	
Sources of heat:	
LED light on or off?	

Appendix C: Data Reduction Flow

Data Level	Description	Timeframe	Timestep	Number of sensors/locations	Filename convention	Fields	Processing Steps
L0	Raw data from SD cards	Since last data download (~3-4 months)	2 minutes	Single sensor/location	Data/ Raw_SD/ PA_SD_location_ date_downloaded	UTC_datetime, mac address, tmpr, humidity, pressure, pm2_5_cf_1, pm25_cf_1_b	Load SD files from sensors into R and combine. Reformat dates and numeric fields. Convert datetime from UTC to local. Add location code based on mac address. Apply A and B comparison QC check. Calculate mean pm25. Save to dataL1 folder as PA_L1_QC_startDate_endDat e.
L1	2 min QC data	Since last data download	2 minutes	All sensors	Data/ QC_SD/ PA_QC_date_dow nloaded	Local_datetime, location, tmpr, humidity, pressure, PM25_mean	average 2 minute PM25, tmpr, pressure, humidity to hourly. Apply data completeness check. Apply EPA bias correction. Save as PA_Hourly_date.
L2	Hourly data	Since last data download	60 minutes	All sensors	Data/QC_Hourly/ PA_Hourly_date	Local_datetime, location, tmpr, humidity, pressure, PM25_hourly	Take hourly data and compute daily mean, max, min for PM2.5, temperature, pressure, humidity. Produce diurnal plots.
L3	Data products + visualization	All data	Daily	All sensors		Daily max hourly PM2.5, daily min hourly PM2.5, daily mean PM2.5 diurnal patterns,	Use to make graphs/visuals of seasonal patterns, range of PM2.5 levels between different locations.