

Quality Assurance Project Plan:
Region 10 Sensor Technology for Rural Community
Air Monitoring

Air Planning & State and Tribal Coordination Branch
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EPA Region 10

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**Initial Review and Approval
of the Quality Assurance Project Plan for the Region 10 Sensor Technology for Rural
Community Air Monitoring Program:**

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1. QA Project Plan Identification and Approval:

See cover page and page 1.

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>.

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 (real-time forecast of air quality – see definition below) 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 U.S.-wide correction equation, developed by EPA scientists, that reduces the bias in PurpleAir Sensor data. The corrected data are more comparable to the permanent and temporary monitor data. The correction equation takes into account temperature, relative humidity, and whether the PM_{2.5} is likely from wildfire smoke. 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. 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. More information here: <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), sulphur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), coarse particulate matter (PM₁₀), and fine particulate matter (PM_{2.5}). More information here: <https://www.epa.gov/criteria-air-pollutants/naaqs-table>.

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.

PurpleAir Map¹: a web application that displays a network of community owned, PurpleAir Sensors. Each sensor uploads data to the PurpleAir Map in real time. More information here:

<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 PM_{1.0}, PM_{2.5}, 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.

3. Project Organization and Roles and Responsibilities:

Region 10 staff in the Air and Radiation Division are responsible for monitoring and oversight of air quality protection in Alaska, Idaho, Oregon, Washington, as well as on Reservations in the Region. The team involved in this sensor loan program will work with loanees from rural communities or communities with environmental justice concerns.

3.1 Loanee Partner

PurpleAir Sensors will be available to Tribal partners, community groups, schools, libraries, businesses, and other organizations throughout Region 10. The main purpose of this sensor loan program is to improve spatial coverage of air quality data and to provide educational opportunities for individuals or groups interested in air quality and particulate matter (PM). The information gathered by this program is educational and not regulatory.

Partner loanees are selected based on requests from the individual or organization and evaluations by EPA of existing monitoring coverage and environmental justice concerns in the area. Selection of a partner is based on the specifics of the proposed project and the availability of sensors.

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.*

3.2 EPA Region 10 Personnel:

EPA Region 10 personnel are responsible for the coordination of the loan program, including: purchasing the sensors; providing the sensors to loanees; the storage, maintenance, and shipment of the sensors to the requesting partner; technical assistance with sensor set-up and operation, technical assistance with data interpretation; providing air quality lesson plans, and other educational materials when appropriate. Individual responsibilities are as follows:

1. India Young, Tribal Air Team Sensor Loan Program Lead. Overall project lead. Responsible for outreach and promotion to communities, training, partnership collaboration with other air quality programs, and sharing program successes.
2. Sarah Waldo, Senior Air Monitoring Specialist, responsible for consulting with communities on their air monitoring goals, troubleshooting, and technical support.
3. Will Wallace Quality Assurance Coordinator, custody of instrumentation and shipping to partners. Provide technical assistance on use and siting.
4. Althea Godfrey, SEE, Smoke Management and Burn Ban Coordinator, Sensor Loan Program Support. Coordination with loanees, especially Tribes.
5. Erin McTigue, Smoke Management Coordinator. Provide support and connections to partners and resources on wildfire smoke issues. Track projects to share lessons learned with broader fire/smoke community.

4. Program Background:

The popularity of commercially available and relatively accurate low-cost sensors for PM_{2.5} has expanded the coverage of air quality monitoring. These measurements, while non-regulatory, are useful for making decisions about personal outdoor activities, and for understanding and communicating local air quality. Notably, the AirNow Fire and Smoke Map integrates measurements from PurpleAir Sensors.

However, the general expansion of low-cost sensors by private citizens is concentrated in urban and affluent areas. To address this disparity, Region 10 established a sensor loan program for rural communities or communities with environmental justice concerns. This program expands our existing Tribal Portable Air Monitoring Program and the Regional-State-Tribal Innovation Project - funded Region 10 Sensor Loan Program in Tribal Communities. Our existing programs have expanded spatial coverage of air quality data on several rural Reservations, and a sensor loan program for rural or communities with EJ concerns will help expand our regional reach and address the inequitable gap in air monitoring coverage.

5. Sensor Loan Program Description:

This program is designed to provide the capability for loanees to monitor PM_{2.5} in areas where they are concerned about or interested in their local air quality. The monitoring objectives (and thus the quality assurance needs) for these projects will fall into one of two types:

1. Type 1: Real-time informational/educational use only. Loanees will access sensor readings via the publicly available AirNow Fire and Smoke Map.
2. Type 2: Informational investigations (e.g., air quality trends, scoping candidate sites for additional monitoring). Loanees or State, Local, and Tribal air quality agencies

will download sensor time series data to analyze.

The program will also make use of other air quality awareness and educational tools. The program will provide EPA Air Quality Flag kits to partners who are interested and have the capability to display the AQI Flags (e.g., schools, libraries, or community centers). It will also leverage the R10-specific air quality lesson plans and Air Quality 101 training videos developed under previous R10 sensor loan programs. In cases where loanees do not opt out of sharing the sensor data publicly, the availability of sensor data will also benefit the broader community including organizations interested in air quality modeling, smoke forecasting, and air quality communication.

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. Program Goals and Objectives:

The goals of this program are to increase spatial coverage of PM_{2.5} measurements using low-cost sensors, to increase awareness and understanding of PM_{2.5} pollution via sensor measurements and expansion of the EPA Air Quality Flag Program, and to use sensors as an educational tool.

6.1: Data Collection and Data Quality Objectives (DQOs)

The main intended use of the sensor data is for education and awareness (Type 1 as defined in Section 5). Secondary uses include informational investigations such as air quality or smoke modeling and forecasting, and to help State, Local, or Tribal air agencies determine if an area would benefit from additional monitoring (Type 2 as defined in Section 5). Sensor monitoring data may be used to compare local ambient conditions to the Air Quality Index (AQI), or to determine air quality trends and patterns. Loanees who site sensors in their communities will be making hyper-local measurements of ambient PM_{2.5} levels. The data from sensors deployed outdoors must be made publicly available on the AirNow Fire and Smoke Map as well as the PurpleAir Map. Similarly, the loanee(s) may use the EPA Air Quality Flag system to communicate about ambient PM_{2.5} levels. Making the data public means the information is accessible to the community. Exceptions may be made on a case-by-case basis if there are data sovereignty or privacy concerns. The PurpleAir Sensors collect the type of data needed for these projects, that is, local measurements of ambient PM_{2.5} levels.

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. 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 nonlinearly at high

smoke concentration ($>200 \mu\text{g}/\text{m}^3$). For the sensor data used in the Fire and Smoke Map, EPA has applied an extended U.S.-wide correction equation, developed by EPA scientists, that reduces the bias in the sensor data correcting for the overestimation. This corrected data is more comparable to the permanent and temporary monitor data giving the public a more consistent picture of air quality with additional information especially in areas where there are no regulatory monitors.

6.2: Data Quality Indicators (DQIs):

Sensor data used solely for education/awareness (Type 1 as defined in Section 5) do not have any quantitative DQIs.

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 $\text{PM}_{2.5}$ in the ambient air. PurpleAir Sensors make duplicate measurements of ambient $\text{PM}_{2.5}$ which are recorded as two “channels”: A and B. The precision can be determined by calculating the difference in these two channels.
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).
3. **Data completeness** is a measure of the data coverage over time. Since $\text{PM}_{2.5}$ levels often have patterns over time (e.g., more elevated at night or during inversion events), it is important that the measurements are representative of reality.

6.3: Measurement Quality Objectives (MQOs):

Measurement quality objectives are the acceptance or performance criteria for each DQI listed above. The MQOs are designed to ensure the measurement uncertainty does not exceed what is acceptable for the DQOs. Projects using the sensors for informational/educational use only (Type 1 as defined in Section 5) will be accessing data that has already had these indicators applied via the AirNow Fire and Smoke Map. Sensor data used for informational investigations (Type 2 as defined in Section 5) must have the same quality tests applied as data imported into the AirNow Fire and Smoke Map, listed in the table below. Any data not meeting the MQOs must be invalidated and excluded from the dataset used for the informational investigation.

DQI	Acceptance/Performance Criteria
<i>Precision</i>	The two sensor channel measurements (A and B) are within 70% or $5 \mu\text{g}/\text{m}^3$ of each other.
<i>Bias</i>	The EPA correction equation must be applied to PurpleAir Sensor data.
<i>Data Completeness</i>	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. Training:

All loanees (both Type 1 and Type 2 as defined in Section 4) will be required to meet with R10 personnel to go over this QAPP, the sensor siting guide from EPA's Sensor Toolbox, and other relevant PurpleAir operation documents (listed in Appendix A). EPA is in the process of updating sensor SOPs and other guidance documents. Operational set-up guides are available. These resources cover the best practices for sensor siting, operation, and data collection.

Users interested in informal investigations (Type 2 as defined in Section 4) will do additional training on data management and analysis (unless already qualified).

Additionally, optional educational materials and trainings are available to all interested loanees. These include Air Quality 101 Training and interactive lesson plans.

8. Documents and Records:

The most current QAPP will be provided to all sampling personnel prior to sensor mobilization.

Optional additional records for Type 2 projects or interested loanees. Copies of relevant records will be retained according to EPA requirements.

- Project plan: Experimental design description (Appendix C).
- Field data sheets: Record relevant information for sensor siting and checks. (Appendix B).
- Raw data: Depending on the project objectives (i.e., if the objectives fall into Type 2 as defined in Section 5), R10 staff or the sensor loanee may periodically download, process, and save sensor data from the PurpleAir website.

9. Experimental Design:

For informational/educational real-time only uses of sensors (Type 1), the experimental design is simply to install the sensor and ensure it is running. These expectations are formalized in the Revocable License Agreement/Loan Agreement signed by the loanee and R10 personnel and in the signed cover sheet included with this QAPP.

For informational investigations, loanees will complete the form in Appendix C.2: Experimental Design Considerations. This step ensures that a plan has been developed for effective use of the loaned equipment.

The basis for determining whether to use this equipment will be evaluated by the following questions:

1. Are there PM_{2.5} monitors or sensors reporting to the Fire and Smoke Map in the vicinity of the loanee?
2. Is there access to an appropriate location with power and Wi-Fi access for meaningful sampling?
3. How will the data collected from this monitoring be used?
 - Will the sensor be located indoors, outdoors, or will the loanee be deploying paired indoor/outdoor sensors?

- Will the data be public or private? If private, how will the loanee use the data?
- Will the data be used to inform any decisions on outdoor activities?
- Is an EPA Air Quality Flag kit useful and appropriate for this location?

The information gathered by this equipment is informational only and will not be used for comparison to the National Ambient Air Quality Standards (NAAQS), enforcement, compliance, or other legal actions. Instead, these data will be used to educate and inform. In some cases, data may be used to indicate whether further studies or data collection are necessary and whether pollutant levels are approaching or exceeding healthy air thresholds. Loanees or others who view the sensor data may use it to inform decisions about outdoor activities at their own discretion. Every site is unique, and thus, EPA R10 staff will work with loanee partners to develop an appropriate experimental design plan tailored for each concern.

As in any data collection methodology, it is important to ensure that:

- A representative sample is being obtained.
- The accuracy and precision of the measurement is understood.
- The impact of interfering compounds or extreme conditions on measurements (e.g., humidity) are understood.
- Measurements are within the manufacturer's recommended operating range.
- A plan for handling data outliers is in place.
- The instrument is not used in a situation in which it is vulnerable to damage.
- The data makes sense based on knowledge and experience.

10. Sampling Methods:

The goal of sampling is to expand sensor PM_{2.5} measurements in rural communities or communities with environmental justice concerns. Communicating local air quality data via online maps or the EPA Air Quality Flag Program will inform communities about their air quality. The sensor data may also be used in some cases to indicate whether further studies or data collection are necessary and whether pollutant levels are approaching or exceeding healthy air thresholds.

Sampling will consist of real-time readings of particulate matter, which are recorded to the sensor SD card and telemetered to an online database via a WiFi connection. PurpleAir Sensor measurements will be publicly displayed on the PurpleAir Map. The AirNow Fire and Smoke Map imports data from sensors registered as “outdoor” from the PurpleAir interface and displays quality controlled and corrected PM_{2.5} measurements. The data from publicly displayed sensors can be downloaded from the PurpleAir website. Data can also be downloaded directly from the MicroSD card located within the PurpleAir sensor if WiFi is not available in the location of deployment.

Sampling Procedures for Ambient or Indoor Air Using the PurpleAir Sensor:

- Preliminary contact with the property owner, resident, or responsible person should be made, setting a time frame and allowing sufficient time for the assessment. If advance notice is not possible, initial contact may be made just prior to data

- collection.
- The loanee or sensor installer should notify the responsible resident upon arrival at the site.
- Location in coordinates, description, or address should be noted on the field data sheet.
- Follow operation procedures using appendix A and the most current set-up guidance available.
- For indoor installations of the sensor, an appropriate area within the building should be selected for the sampling location. The objective is to take measurements where people spend most of their time.
- Take a picture of the installation to verify proper siting.
- As needed, the data should be downloaded and retained by the loanee or R10 staff.

11. Quality Control:

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.

11.1: Quality Control Requirements:

Loaneees should confirm their sensor is reporting to the AirNow Fire and Smoke Map on a daily, weekly, or monthly basis, depending on the loanee's data needs. The Fire and Smoke Map filters out sensor data that does not meet the data requirements for precision. The appropriate frequency will be determined based on the objectives of the project and defined as part of the questionnaire in Appendix C2.

11.2: Sampling/Measurement System Corrective Action:

If the sensor is not reporting or not meeting precision data requirements (see Section 6), for two consecutive checks (two days, weeks, or months depending on the loanee's data needs as described above), the user should take the following corrective steps:

1. Check the WiFi 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 for debris.
3. If there appears to be physical debris present, clean the sensor with compressed air. A shop vacuum or vacuum hose placed on the bottom of the sensor for 2-3 minutes may also be effective.
4. If none of these steps resolve the issue, contact EPA for further assistance.

12. Instrument/Equipment Testing, Inspection, and Maintenance Requirements:

Sensors should be visually inspected for damage upon receipt. Regular sensor checks and as-needed maintenance are described above in Section 13.

13. Instrument/Equipment Calibration and Frequency:

No calibration is required for PurpleAir Sensors.

14. Data Acquisition Requirements for Outside Data:

Outside data is that collected other than by direct measurement with the instruments covered in this QAPP. Information from the National Weather Service, city, county, state, regional air agencies, and tribal offices can be a useful supplement to any actual readings collected on-site.

15. Data Management:

Sensor data used solely for education/awareness (Type 1 as defined in Section 5) will be accessed via the AirNow Fire and Smoke Map and no additional data management by the loanees is required.

Sensor data used for informational investigations (Type 2 as defined in Section 5) should download the data from the PurpleAir website.

16. Data Verification:

Sensor data used solely for education/awareness (Type 1 as defined in Section 5) and accessed via the AirNow Fire and Smoke Map should be verified by comparing to observed conditions (e.g., can you see or smell smoke?) as well as by comparing to other nearby sensors/monitors on the Map as applicable.

Sensor data used for informational investigations (Type 2 as defined in Section 5) should be verified by comparing the data to nearby sensor/monitor data as applicable.

Appendix A: PurpleAir Specifications and Other Technical Information

PurpleAir Sensor Set-up Guidance and User Manuals

- EPA's Sensor Toolbox guide to siting and installing air sensors: <https://www.epa.gov/air-sensor-toolbox/guide-siting-and-installing-air-sensors>
- From the manufacturer: <https://www.purpleair.com/sensors>
- AirNow Fire and Smoke Map Technical Q&A: <https://document.airnow.gov/airnow-fire-and-smoke-map-questions-and-answers.pdf>

Checklist of Equipment Received from EPA R10:

	PurpleAir Sensor
	Micro USB connector
	SY 2A USB Outdoor Power Supply
	17-foot power cable

Appendix B: Sensor Log

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:	

Appendix C: Sensor Use Questionnaires

C.1: Considerations for Using PurpleAir Sensors

Considerations for Using PurpleAir Sensor		
<p>Is it appropriate to use a PurpleAir Sensor for this purpose? You should be able to answer yes to each of the following questions and fill in the Actions.</p>		
Question	Response Y/N	Action
Does the incident to investigate represent an ongoing occurrence?		List brief history of occurrences.
Do we have an understanding of what materials in the air might be contributing to the concern? Is it fine Particulate Matter (PM _{2.5})/dust/soot?		Indicate what these suspected compounds are.
Do we have access to an appropriate location for meaningful sampling?		Is there permission to set up sampling and if so, are there optimal dates and times (list)?
Are you willing to spend several hours reading training documents and/or watching training videos to ensure appropriate installation of the sensor and use of the data?		List names of who would be available to do this work and when they were trained.
Do you have an initial understanding of how you would use the information gathered from this effort?		Describe your plan for how you would use the information gathered.

C.2 Experimental Design Considerations

Experimental Design Considerations		
In planning your experiment and data collection, the following should be established and listed:		
Consideration	Response	
What are the main sources of PM _{2.5} 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.	