# Quality Assurance Project Plan for Monitoring Air Pollution in Underserved South Atlanta (MAP-USA)

**US EPA Grant # [redacted]**

**Prepared by**
**Center for Sustainable Communities and**
**Georgia Institute of Technology**

**Prepared for**
**US EPA Region IV**

**Period of Performance: 9/1/23-5/31/26**

**Approval Page:**

(required prior to project start)

DocuSigned by:

[redacted] ______________________ Date: 1/28/2025 | 11:48 AM PST

Program Leader and QAM

[redacted] – President, Center for Sustainable Communities and Quality Assurance Manager MAPP Project

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[redacted] ______________ Date: 1/28/2025 | 1:54 PM PST

Project Manager

[redacted], Center for Sustainable Communities

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[redacted] ____________________ Date: 1/30/2025 | 10:55 AM EST

Data Verification and Analysis Researcher

[redacted] – Assistant Professor, Georgia Tech School of Economics

______________________________________ Date: ____________________

Education Programming Lead (TBD)

______________________________________ Date: _____________________ EPA

EPA Project Manager/Officer

[redacted] US EPA Region IV Air Grant Coordinator/Administrative Project Officer

________________________________________ Date______________________ EPA

Project Officer, [redacted]

________________________________________Date_________________________ EPA

Region 4 Designated Approving Official

# Table of Contents

**TABLE AND FIGURE PAGE LOCATION**

# 1.0 PROJECT MANAGEMENT

## 1.1 Distribution List

**Name**: [redacted]
**Title**: Program Leader and President/ QA Manager Organization:
**Center** for Sustainable Communities
**Contact Information**: [redacted]

**Name**: [redacted]
**Title**: Project Manager
**Organization**: Center for Sustainable Communities
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**Name**: [redacted]
**Title**: Project Technician (Assistant Project Manager and Principal Technologist)
**Organization**: Center for Sustainable Communities
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**Title:** Project Officer
**Organization:** US EPA Region IV
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## 1.2 Project Organization

While the entire team is committed to assuring the quality of the air pollution data to be collected, the project manager and project technician share primary and daily responsibility for implementing the QAPP**.** They will report to the Senior Program Manager and consult and receive feedback from other expert members of the team. The Senior Program Manager has the approval authority for the QAPP.

Besides [redacted], there are no other QA personnel signed, but all are trained on QAPP content and are responsible for its implementation.

**MAP-USA Program Leader and Quality Assurance Manager (Project QAM + Senior Manager):**

[redacted], President of the Center for Sustainable Communities, will oversee all program and administrative activities, including allocating budget, installing and operating the enhanced monitoring network, promoting and directing the teacher/community fellowship and student internship programs, coordinating the contributions of the other collaborators at Georgia Tech (i.e., sub awardees), and integrating all program components together. He will also work directly to advance the programs' objectives including guiding and advising teachers, community partners, and students; collecting and analyzing data; preparing reports; and transferring data and knowledge to interested stakeholders. As Senior Program Manager, [redacted] will also serve as Quality Assurance Manager (QAM) based on both academic background and years as a regulatory inspector and quality assurance practitioner. [redacted] will have oversight of operations but will not perform operational tasks or actions. *In this role,* [redacted] *will be responsible for the overall implementation and oversight of the QAPP, as outlined in this procedure.*

**Responsibilities for Planning, Documenting, Coordinating, and Assessing QAPP Effectiveness**

- **Quality standards**: Establishing and implementing quality standards for products and services
- **Quality testing**: Monitoring quality testing and identifying gaps
- **Compliance**: Staying current on laws and regulations to ensure compliance
- **Quality control**: Overseeing other quality control staff, including quality control inspectors and other quality assurance professionals
- **Quality assurance systems**: Conducting internal audits of the organization's quality assurance systems to identify areas for improvement
- **Process review**: Reviewing processes to align them with current trends
- **Report creation**: Creating reports to track employee progress and formulate strategies that increase productivity and track employee training
- **Employee support and training**: Assisting in the recruiting process where they train, motivate, and monitor company employees to ensure they meet standards.
- **Quality standards training**: Helping create training programs to teach employees about quality standards
- **Data analysis**: Analyzing data to improve products, services, and processes
- **Process optimization**: Optimizing processes to improve efficiency
- **Project progress tracking**: Tracking progress on projects and managing deadlines

The QAM shall establish and maintain continuous and routine line of communication to EPA Project Manager, [redacted], and Technical Manager, [redacted].

**Project Manager (Project Operations Manager):** The Center for Sustainable Communities' [redacted] will direct the daily administration of the program. This includes purchasing equipment and supplies, directing and scheduling personnel, coordinating all activities, and maintaining records and accounts. Independence from environmental information is maintained procedurally. The project manager will lead operations and perform oversight and QA functions.

**Project Technician:** The Center for Sustainable Communities' [redacted] will be responsible for the installation, operation, and maintenance of the sensor network. She will assure the data quality by properly following Standard Operating Procedures as described in this Quality Assurance Project Plan and transferring data to the publicly accessible database (i.e., purpleair.com) for use by the community and other project partners in a timely manner.

**Georgia Tech Principal Investigator:** [redacted], Assistant Professor in Georgia Tech's School of Economics, will be responsible for verifying the quality of the monitoring data via expert review and statistical analysis, advising the writing of annual data reports, and facilitating the work of the other investigators within the Georgia Tech subaward and their collaborations with the Center for Sustainable Communities and other program partners.

**Other Key Project Positions:** [redacted], Assistant Professor in the School of Economics at Georgia Tech and Co-PI on the Georgia Tech subaward, will assist [redacted] in the analysis of air quality data and co-advise a PhD student (TBD), who will also be assisting with the project. Subcontractor [redacted] serves as grants administrator and financial manager. The QAM shall establish and maintain a continuous and routine line of communication [redacted] and [redacted].

See Figure 1. MAP-USA Organization Chart

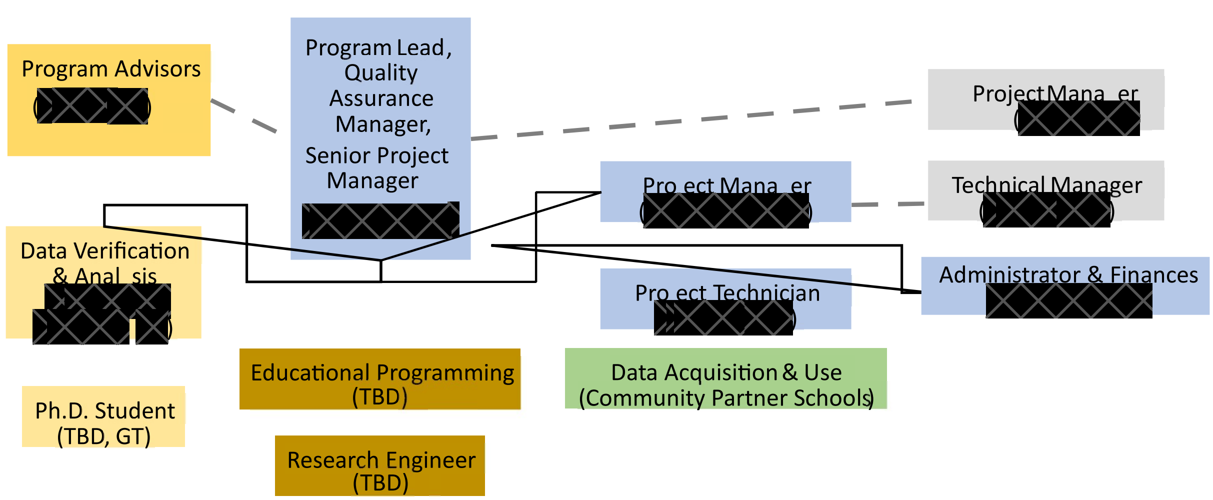


*Figure 1. MAP-USA Organization Chart*

## 1.2.1 Communications & Project Organization Chart Explanation

The QAM is the focal point for all project communications and will receive input (i.e. emails, calls, in-person discussion) from each functional unit of the project. This includes program advisors, data verification and analysis team members, the project technician, community partner and school representatives, and administrator and finances team members. All team members have been in contact with the program manager and can access one another via online communication. The program manager shall respond in a timely manner to each inquiry (i.e. within 48 hours) to ensure that appropriate actions will be taken to continue the advancement of the project.

Individuals will bring non-conformances and discrepancies to the attention of the QAM. The QAM shall review and provide feedback to individuals in a timely manner. If necessary and appropriate, the QAM will report non-conformances and discrepancies to EPA representatives. The QAM Manager shall be the primary contact for EPA representatives.

## 1.3 Problem Definition/Background

This project addresses the need for air quality monitoring in the underserved communities in South Atlanta, Georgia. Nested within a large metropolitan area of almost 6 million people, more than one million people reside in the urban region, which consists of the City of Atlanta and its several neighboring communities. Spatially, the core region is divided into northern and southern halves by the East-West transect of Interstate I-20. The northern half is relatively prosperous and majority white, and the southern half is relatively poor, majority non-white, and subject to additional health disparities. Recent studies of the southside have connected past racial bias in real-estate lending practices (a.k.a. “redlining”) as a potential cause of these current disparities in air quality and health outcomes that have left a persistent legacy of environmental injustice. It is in this context, then, that it is remarkable to find that the southern half of the Atlanta urban region is also distinguished by the absence of any public or private air quality sensors, for which this project will fill the gap. We will be evaluating the outcomes and results of the project to formulate a corrective action plan.

No other QA planning documents are required or identified.

## 1.4 Project/Task Description and Schedule

The Center for Sustainable Communities (CSC) will operate a network of air quality sensors at eleven public schools located in under-resourced neighborhoods on the south side of Atlanta, Georgia. The CSC, supported by experts at the Georgia Institute of Technology, will also develop leadership and analytical capacity in the community through technical training and educational programs that will be co-developed with the teachers and delivered to the students at the schools where the sensors are located. The objective of this project is to empower these underserved communities to collect data AND use it to draw conclusions on the causes and effects of poor air quality.

The project will focus on measuring fine particle pollution (PM2.5) in the local communities. The impetus for the focus on PM2.5 is fivefold: 1) PM2.5 is a widely pervasive pollutant that can cause significant health impacts; 2) Even in areas that meet the current National Ambient Air Quality Standard (NAAQS) for PM2.5, there can be wide variations in exposure to PM2.5 due to proximity to sources such as roadways and commercial and industrial facilities; 3) Due to compounding disparities of health, race, socioeconomics, housing, and occupational factors, outcomes related to PM2.5 exposure can also vary widely within a population; 4) PM2.5 may be a useful proxy for other environmental hazards within a community (e.g., air toxins); and 5) Commercially available sensors for measuring PM2.5 are relatively inexpensive, easy to install and maintain, and are well suited for use by “non-experts.”

Within the South Atlanta region, sensors will be placed at 10 high schools identified with majority nonwhite students and students receiving free or reduced-price lunch. 5 of the schools that were selected are located within 500 meters of an interstate highway and are matched to 5 similar high schools more than 1000 meters from an interstate. This valuable data will allow the CSC and the South Atlanta community, with the aid of researchers at Georgia Tech, to examine the effect of the interstate highway on ambient air quality and determine if the history of redlining in South Atlanta may be maintaining present-day environmental injustices. Concurrently, teachers will work with education specialists from Georgia Tech to develop curriculum and tools that will allow students at each school to learn about and develop an understanding of air. This facilitation includes providing each school with one additional monitor with which teachers and students can design and conduct their own experiments looking at particle pollution and how it varies depending on multiple factors, such as measurements taken indoor vs. outdoor or near a roadway vs. in a park.

**Table 1. Schedule:**

| Action | 2023 | 2024 | | | | 2025 | | | | 2026 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 |
| Prepare and submit QAPP | ■ | ■ | ■ | ■ | | | | | | | |
| Project Launch | | | | ■ | | | | | | | |
| Procure sensors | | | | ■ | | | | | | | |
| Partner School / Teaching Fellows Recruitment | | | | | ■ | ■ | ■ | | | | |
| Prepare school monitoring sites | | | | | ■ | ■ | | | | | |
| Partially Operating Monitoring Network | | | | | ■ | ■ | ■ | | | | |
| Colocation of MAP-USA low-cost sensor at GA EPD | | | | | | ■ | | | | | |
| Fully Operating Monitoring Network | | | | | | | | ■ | ■ | ■ | ■ |
| Develop/Implement/Evaluate/Revise Curriculum | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |
| Recruit Student Interns | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |
| Quarterly Report | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Final Report | | | | | | | | | | | ■ |

**Table 2. Milestones:**

| Status | Milestone | Date |
|---|---|---|
| ✓ | Proposal Submitted | 3/25/2022 |
| ✓ | Notice of Award | 8/1/2023 |
| ✓ | Project Grant # Assigned | 8/11/2023 |
| ✓ | Submit QAPP | 10/23/23 |
| | QAPP Approved and Project Launched | 11/1/2023 |
| | Subcontracts Awarded | 9/1/2024 |
| | Procurement of sensors complete | 8/1/2024 |
| | Recruitment and selection of first 2 schools / Teaching Fellows (Jackson HS and Douglas HS) | 11/15/2024-6/15/2025 |
| | 1-year colocation of MAP-USA at GA EPD monitoring site | 1/1/2025 – 12/31/2025 |
| | Complete first 2 school monitoring sites prep | 12/31/2024 |
| | Commence air quality monitoring at first 2 schools and curriculum development with initial Teaching Fellows | 2/1/2025 |
| | Complete recruitment of all 10 partner schools / Teaching Fellows | 6/15/2025 |
| | Complete all 11-school monitoring site prep | 6/15/2025 |
| | Full operational 11-school monitoring network | 9/1/2025 |
| | Test curriculum and revise in partner schools w/ student interns | Academic Year 2024/2025 |
| | Implement curriculum in partner schools w/ student interns | Academic Year 2025/2026 |
| | Quarterly Reports (10 total) | 12/31/2023 |
| | | 3/31/2024 |
| | | 6/30/2024 |
| | | 9/30/2024 |
| | | 12/31/2024 |
| | | 3/31/2025 |
| | | 6/30/2025 |

| | | |
|---|---|---|
| | | 9/30/2025 |
| | | 12/31/2025 |
| | | 3/31/2026 |
| | Final Report (1 total) | 6/30/2026 |

Despite budget and resource constraints, the MAP Team shall ensure that all project objectives and missions are carried out in accordance with this procedure. If resource constraint becomes excessive, the MAP Team shall develop a tactical plan to ensure the project is carried out in the best possible manner to ensure project and data integrity.

## 1.5 Quality Objectives and Criteria for Measurement Data

The overarching objective of the project is the establishment of a network of low-cost sensors to measure the concentration of PM2.5 in and around the southern half of the Atlanta urban core. This will "mirror" the already established network of PM2.5 sensors in the northern half of the region. While the whole metro area includes four monitoring sites that use approved Federal Reference Methods (FRM) or Federal Equivalent Methods (FEM) and are managed by air quality professionals at the Georgia Environmental Protection Division, most of the sensors deployed in the north Atlanta pollution network are the same type of low-cost sensors that will be used for this project. The use of these same sensor devices provides continuity between the new network in South Atlanta and the existing network in North Atlanta, including the operation and deployment of the sensors, the sensitivity and accuracy of the devices used, and the procedures for managing and storing the data.

The original EPA Request for Applications for Enhanced Air Quality Monitoring for Communities (EPA-OAR-OAQPS-22-01) stated "applicants should use commercially available technology and/or proven methods to monitor …air pollutants." Considering this requirement, along with availability, cost, quality, and the technical capabilities of the community-based team, MAP-USA will use PurpleAir PAII-SD air quality sensors to measure the hourly concentration of PM2.5 pollution. These small, low-cost, and low-power sensors have been used widely in residential, commercial, and industrial applications. They use a built-in Wi-Fi capability to transmit data to the PurpleAir map (professionally managed by PurpleAir), where it is stored and made available to any smart device. Additionally, they use an incorporated SD card and real-time clock to record and store data locally. The sensors come "factory calibrated" and are warranted for 1-year.[1]

To improve overall accuracy; including bias and precision, the MAP Team will evaluate the recommendations provided in this report, including the following:

[1] PurpleAir particulate matter (PM) sensors are increasingly used in the United States and other countries for real-time air quality information, particularly during wildfire smoke episodes. Uncorrected PurpleAir data can be biased and may exhibit a nonlinear response at extreme smoke concentrations (>300 $\mu g/m^3$). This bias and nonlinearity result in a disagreement with the traditional ambient monitoring network, leading to the public's confusion during smoke episodes. These sensors must be evaluated and corrected for bias during times with high smoke concentrations to ensure that accurate data are reported. The MAP Team shall strive to ensure the most high-quality data possible is collected, analyzing precision, bias, representativeness, completeness, comparability and sensitivity. The MAP Project shall incorporate the recommendations of the national research project where possible to improve Purple Air Sensor PM 2.5 Sensor Report (14).

- Correct T & RH to improve PurpleAir performance in terms of MBE, RMSE, and correlation
- Perform a simple linear correction to significantly improve performance
- Evaluate PurpleAir conclusions to counteract over-reports of AQI category
- Add more high concentration data to improve model performance at high concentrations

Further, the report compares the national data set of sensors with regulatory-grade sensors. Results show that PurpleAir sensors, when corrected, accurately display NowCast AQI categories 90% of the time as opposed to uncorrected PurpleAir data, which are accurate only 75% of the time.

**Table 3. Purple Air Sensor Description**

| **PurpleAir PA-II-SD** (w/ power supply) | **Dimensions** | 3.5 in x 3.5 in x 5 in (including mounting bracket) |
|---|---|---|
|  | **Power Demand** | 5V USB Micro, 0.18A continuous, 600mA peak |
| | **Pollutants Measured** | Particle sizes 0.3, 0.5, 1, 2.5, 5, and 10 µm |
| | **Reporting Interval** | 120 seconds |
| | **Range (PM2.5)** | 0 to 500 µg/m³ |
| | **Max error (PM2.5)** | ±10% at 100 to 500µg/m³ & ±10µg/m³ at 0 to 100µg/m³ |
| | **Data Storage** | Purpleair.com (WiFi) & locally w/ 16GB micro-SD card |

These sensors will be deployed at the selected monitoring sites using the extensive instructions provided by the manufacturer (https://community.purpleair.com/t/sensor-start-up-guide) and following the US EPA's Standard Operating Procedure for the Purple Air PA-II-SD PM Sensor guidelines (SOP ID: JAMCD-SFSB-SOP-3561-3, Effective Date: Jan 8, 2020). See *Appendices A and B*.

The spatial representativeness of sensors has been a topic of previous studies. Works include the representativeness of a sensor located next to an industrial area (10), multiple sensors of a national network (6), and sensors part of an urban network (11). These studies demonstrated various capabilities] in reflecting air quality of a given sensor based on its spatial location, which provide useful insights in sensor allocation for this project. Building on the representativeness calculation of single sensors (see above), we proposed a methodology to calculate the combined representativeness of a monitoring network composed of regulatory reference sensors in our earlier work (8). The MAP Team shall review the number of sensors and geographic layout to ensure accurate representativeness (14).

For air-sensor data to be actionable, sensors must be evaluated, and in some cases, corrected, to provide accurate data over a wide range of concentrations and environmental conditions [7,8.9]. To evaluate and improve the performance of $PM_{2.5}$ air sensors, they are typically run alongside conventional $PM_{2.5}$ air sensors to compare reported concentrations [12,13, 14]. It is important to evaluate the range of pollutant and environmental conditions that the sensors will be used to monitor, as performance can be variable over different concentration ranges and influenced by environmental conditions, including relative humidity (RH) and temperature (15). Sensor evaluations, compared against air sensors, are critical to gain actionable $PM_{2.5}$ data.

In the first year of the project, one sensor will be co-located at the Atlanta metro area South Dekalb air quality monitoring station. This is made possible with the support of the Georgia Environmental Protection Division. At this station, the GA EPD operates both a FEM monitor for measuring daily 24-hour average PM2.5 concentrations (Teledyne T640/T640X) and a continuous monitor for measuring hourly PM2.5 concentrations (Tapered Element Oscillating Microbalance or TEOM). Measurements from the low-cost sensor will be compared to these professionally managed sensors and used to assess the accuracy, precision, and bias of the sensors and to provide context about the performance of the larger MAP-USA network.[2]

Sensitivity must also be recognized in the sensor network. Team Map will ensure environment and concentration variability impacts are minimized on sensor functionality and accuracy.[3]

Finally, the budget also allows for the purchase of 10 additional sensors to be used in the MAP-USA network and one additional sensor to be co-located at the GA EPD station. In the first 3 months of the monitor deployment at the schools, one additional monitor will be co-located at each of the 10 monitoring sites, which will allow the team to assess the ability of the sensors to measure pollutant concentrations consistently and improve representativeness in the network. During the remaining monitoring periods, these extra sensors may be used by the teachers and student interns at the partner schools to conduct special pollutant monitoring investigations (e.g., inside school buildings or near roadways) in studies designed by them and will also be available as "spares" if any of the 10 main community-based sensors fails or becomes inaccessible.

The primary quality objectives for the air quality data measurements, then, are:

1. Use commercially available technology and/or proven methods to monitor air pollutants;

2. Use a consistent, standard protocol for siting, deploying, and operating the sensors at all locations;

3. Check monitor performance by comparing to other collocated sensors of similar type and other collocated sensors of known quality (e.g., Federal Reference and Equivalent Methods);

4. Make additional sensors available in case of primary monitor failure to meet the minimum reporting objective of 75% data completeness for each quarterly period.

For the education programs, the recruitment and retention rates of the teacher fellows and student interns are evidence of continued community engagement. These metrics will be documented in the quarterly reports. To measure the impact of the educational curriculum, investigators at Georgia Tech will track its use in classes, and given that the learning modules will be computer based, will develop short online quizzes to indicate information retention that students can take as they begin and complete the modules.

[2] This process will also allow for the MAP-USA team to compare the sensors with the regulatory sensors at the GA EDP.

[3] It was hypothesized in one study that the low-cost sensor networks may have different sensitivity to aerosol from other sources, and thus care must be taken in their calibrations and use for evaluating the impact of air quality mitigation policies.  In another study, using time series decomposition of PM2.5 data into short-term and baseline components using the Kolmogorov–Zurbenko (KZ) filter and analyzing the extracted frequency signals, it was determined that PA sensor data is more sensitive to meteorological conditions than anthropogenic activities in both short-term and baseline components.

## 1.5.1 Objectives and Project Decisions

Program success begins with the acquisition of the commercially proven air quality sensors. If MAP-USA is able to acquire 21 sensors as described above (or their current equivalent version/model) from the manufacturer by the appointed scheduled date, then it will have met the first objective.

If the Project Technician responsible for deploying and maintaining the sensors follows the extensive instructions provided by the manufacturer (https://community.purpleair.com/t/sensor-start-up-guide, included as Appendix A) and the US EPA's Standard Operating Procedure (SOP) for the Purple Air PA-II-SD PM Sensor guidelines (SOP ID: J-AMCD-SFSB-SOP-3561-3, Effective Date: Jan 8, 2020, included as Appendix B), then consistency among the 10 schools and 1 GA EPD reference site will be ensured, and the second and third data quality objectives will be met.

If any deviations from the manufacturer's instructions or EPA SOP are necessary, the technician will note all variances in the accompanying field notebook. The SOP describes the procedures for operating and recovering data from the PurpleAir PA-II-SD particulate matter sensor. In the SOP, instructions are provided for deployment, startup, wireless connection, operational verification, data download, and data import into Microsoft Excel. It also describes how data from the PurpleAir sensors can be compared with collocated reference grade sensors to evaluate accuracy, precision, and bias of the sensor measurements relative to the reference concentrations, as well as variability in the response between the sensors.

In any quarterly reporting period, if each monitor in the network provides a minimum of 75% validated data, then the fourth quality objective will be met. In case of instrument failure, data from a replacement monitor installed at the same location and following the applicable SOP may be substituted.

## 1.5.2 Action Limits/Levels

The PurpleAir PA-II-SD air quality sensors that will be used to measure hourly concentrations of PM2.5 pollution come "factory calibrated" and have no user adjustable settings. Under normal operations, the devices begin monitoring when initially powered-up and continue unabated until powered-down. In addition to a continuously powered connection to a standard electrical outlet, it is critical that each monitor in the network will also have constant access to a Wi-Fi connection capable of reporting data in near-real time to the central online and publicly accessible PurpleAir data repository. The sensor's physical range of measurement for PM2.5 is 0 to 500 $\mu g/m^3$, and the manufacturer reports that the sensor's max error for PM2.5 measurements are ±10% at 100 to 500$\mu g/m^3$ & ±10$\mu g/m^3$ at 0 to 100$\mu g/m^3$.

See Table 4.

**Table 4. Analytical Parameters and Target Limits** Matrix/Media:

| Analytical Parameter[1] | Project Action Limit/Level (applicable units) |
|---|---|
| Sensor reporting any data | Yes / No |
| Range | Value > 0 μg/m$^3$ or Value < 500 μg/m$^3$ |
| Accuracy vs. same sensor type | \| Difference \| < 20μg/m$^3$ at 0 to 100μg/m$^3$ and 20% at 100 to 500μg/m$^3$ |
| Accuracy vs. FRM/FEM sensor | \| Difference \| < 10μg/m$^3$ at 0 to 100μg/m$^3$ and 10% at 100 to 500μg/m$^3$ |

## 1.5.3 Measurement Performance Criteria/Criteria

The data quality indicators will be met when the commercially available sensors (Purple PA-II-SD) have been acquired, installed in the field according to the manufacturer's instructions and the SOP, and assessed to be functioning properly. To ensure that the 75% validated objective is met, any missing hourly data values not recorded in the online PurpleAir database, data values reported as out of range of the sensor, or in the case of co-located sensors, readings that are not within the accepted error range, will warrant that the technician physically inspect the monitor within 72-hours of detection of the data-reporting-error to ensure that a) it is properly mounted, b) it is receiving power, c) it is connected to the WI-FI network, and d) it is transmitting data.

Each PurpleAir PA-II-SD sensor will include an onboard micro-SD card in which pollutant data will also be stored. In the event that the technician finds that the cause of the missing data is that the Wi-Fi or the transmission of the data has failed, the technician will power-down the sensor and recover data from the micro-SD card before attempting further corrective actions (e.g., rebooting the Wi-Fi or repowering the sensor). If the sensor is no longer powered-up or has detached from its proper mounting, the technician will also attempt to recover all data from the micro-SD card prior to taking further actions. Any data reported that is outside of the operating range of the sensor will be flagged as "out of range," and a second sensor, if available, will subsequently be collocated at the site to evaluate the functioning of the instrument. Alternatively, the sensor in question will be relocated to a different site where another sensor has been operating without error, and it will be compared to that instrument.

The sensors that are collocated with each other will then report concurrently in time measurements of PM2.5 to be no more different than by 20 μg/m$^3$ for measurements of PM2.5 between 0 to 100μg/m$^3$, and no more different than by 20% for measurements of PM2.5 between 100 and 500μg/m$^3$. For any sensor that is collocated at a professionally managed monitor meeting the federal required or equivalent method (FRM/FEM) for PM2.5 measurements, the tolerance for difference shall default to the sensor manufacturer's reported max error. Sensors not operating within these limits will be removed from the network and further tested or replaced.[4]

## 1.5.4 Corrections for Bias, Accuracy, Precision, Potential Overestimation

The MAP-USA project will work to ensure a high level of data quality by applying correction factors as necessary. These correction factors will help to eliminate bias, overestimation, and related inaccuracies observed during previous uses of PurpleAir sensors and as a result of research into data quality. These correction factors are documented by researchers and EPA representatives.

For the purposes of this project, the correction factors shall be derived from previous research papers, which provide extensive guidance on correction factors and related data management techniques and approaches (5).

**EPA Definitions**

- **Bias**: An inadequacy in experimental design that leads to results or conclusions not representative of the population under study.
- **Accuracy**: closeness of a measurement to the true value.
- **Precision**: The ability of an instrument to measure a process variable and to repeatedly obtain the same result.

In the context of this project, precision refers to how closely all sensor readings are grouped together. A more precise sensor has a narrow distribution of readings at a given pressure. When assessing indoor air quality (IAQ) sensors, building experts come across many technical terms. The accuracy of the sensor is the closeness of a measured value to a known value. Precision can be described as the reproducibility of measurements. Purple Air Sensors can be up to 90% accurate when properly corrected.

Previous projects in this field of work have resulted in the development of an effective quality assurance methodology – the U.S. correction model -- for cleaning PM2.5 data from the PurpleAir sensor by removing poorly performing sensors and short-term outlier concentration measurements using channel A and B comparisons.

The U.S. correction model improves PurpleAir measurement performance, reducing the 24-hour averaged PM2.5 data RMSE from 8 to 3 µg m-3 across the country. A single U.S. correction model for the PurpleAir sensor includes additive correction terms using [rcf_1] PM2.5 and on-board RH data. The correction model performed well when evaluated against regulatory measurements across the U.S.,

[4] If control limits are exceeded, an immediate investigation shall be conducted to determine the cause of the out-of-limit condition. The QAM will then lead an investigation to determine the cause of the out-of-control event. The QAM will brief the core team on the occurrence and prepare a written report that includes proposed corrective action, if any. The designated MAP Technician shall carry out corrective actions if required to correct a hardware deficiency. The collective MAP Team shall review the proposed corrective action. The QAM Manager is responsible for overseeing the implementation off all corrective measures necessary to correct the out-of-control condition(s). The QAM shall report back on the effectiveness of all corrective actions implemented.

reducing the bias to ±3 µg m-3 when validated on a state-by-state basis (Figure 4) and reducing the bias to ±1 µg m-3 when evaluated against regulatory requirements.

**1.5.5 Representation, Completeness and Other Potential Data Inaccuracies**

Concerning representativeness, according to a 2021 study, studies have found that PurpleAir sensors do not accurately represent particle distributions (13). The study also found that PurpleAir sensors behave more like nephelometers than particle counters. PurpleAir sensors are low-cost tools that measure fine particulate matter (PM) concentrations. They are often used in the United States and other countries for real-time air quality information, especially during wildfire smoke episodes. According to AMT, the raw data from PurpleAir sensors has significant biases and must be calibrated to generate accurate data. Puget Sound Clean Air Agency, WA has also found that raw Purple Air data are about two times higher than the real values.

**Other important pieces of information to consider when looking at Purple Air data include:**

- Uncorrected PurpleAir data can be biased[5]
- Uncorrected PurpleAir data may exhibit a nonlinear response at extreme smoke concentrations (>300 µg/m3)
- The temperature and humidity data recorded are for the sensor itself and are not meant to reflect environmental readings
- As established in a 2019 study, PurpleAir sensors are aggregated for hourly and daily averages to assess completeness (15)

**1.5.6 Sensitivity**

PurpleAir sensors have two optical sensors, channel A and B. When corrected, PurpleAir sensors can accurately report NowCast AQI categories 90% of the time. However, raw PurpleAir data have significant biases, so the sensors must be calibrated to generate accurate data.

Air sensors can become less sensitive over time, causing readings to become less accurate. Some air sensors are only usable for one to two years. Low sensitivity can be caused by a delay reaction time of the sensor. This can be affected by the placement of the unit and the size of the room. For example, if the unit is installed at a lower position in the room, it may have a low sensitivity.

**Other factors that can impact the accuracy of data include:**

- Installation location
- Placement density

[5] The MAP USA project will be both aware and correct for these inaccuracies.

- Direct sunlight
- Air vents, such as an A/C or heater vent

The US EPA's Air Sensor Toolbox provides information on the performance, evaluation, and use of air sensor technology. A growing trend in air sensor applications is to improve the data quality from sensors through applying multiple linear regression, machine learning, or other complex algorithms.

## 1.6 Personnel Training/Certification

Personnel should have basic knowledge and operational experience on the use and functionality of the PurpleAir PA-II-SD PM sensor. If lacking experience, then personnel will be trained either in the field or lab with the manufacturer's instructions, which includes standard operating procedure, appropriate instrumentation, general laboratory workings, field site safety practices, and handling instruments of the field. When possible, training shall be directed in a workshop or classroom. Otherwise, training will be self-directed upon receiving instruction manuals. Following training, a quiz will be administered. Training and quiz results will be formally documented and provided in the quarterly reports. All field training activities will be coordinated, conducted, and documented under the supervision of the QAM Manager.

Personnel will also be trained on QAM sensors, equipment, and financial management procedures as needed. Personnel efficiency will be assured through an annual refresher training for all topics accompanied by a quiz.

### 1.6.1 Training Records and Skill Evaluation

Training records shall be stored and maintained in accordance with EPA Region 4 operating procedure No. LSASDPROC-1003-R1.

## 1.7 Documents and Records

### 1.7.1 QA Project Plan Distribution

Upon the sponsor's final approval of this QAPP, it will be emailed to all senior project personnel, including the QAM, project manager, project technician, the education leader, data verification and analysis leader, and the program advisors. As part of the educational programming, the QAPP and the importance of data quality and management will also be shared with the Teaching Fellows, upon their recruitment, and emphasized during subsequent trainings.

### 1.7.2 Field Documentation and Records

The project technician will maintain a field notebook marked in black ink with all records of sensor deployment, start-up, shut-down, data transfer, and maintenance activities. Field notes will include observations about nearby or transient pollution sources, weather or special events, instrument operation, location, device ID, date and time, and observer(s) name(s). These notes will be maintained for the lifetime of the project plus seven years.

### 1.7.3 Records Management and Document Control Processes

Records will be maintained and stored in accordance with EPA Records Management Policy Directive No COI 2155.5. Document control is formally established and sustained through implementation of US EPA Science and Ecosystem Support Division Operating Procedure No SESDPPROC-001-R7, effective February 4, 2015.

### 1.7.4 Laboratory Documentation and Records

Data from the sensors will be uploaded to the PurpleAir Map database at 2-minute intervals via Wi-Fi and made to be publicly accessible. The PurpleAir Map site includes features that allow users to view and download real-time data as well as aggregates of 10-min, 30-min, 1-hr, 6-hr, 1-day, and 1-week averages. Additionally, the sensor's raw data will be recorded locally on the included 16GB SD card and manually downloaded to the project laptop once per month and archived (via cloud storage, CD, etc.).

Raw data files will not be edited. Any files that contain any analyses will be saved into a different file with a new name, and all analyses will be recorded into the field notebook. At a minimum, the recovered data files will be reviewed to look for data gaps and deviations from the expected data file's structure (missing lines, columns, or cells within the data file). Unexplained data gaps and deviations will be investigated, and troubleshooting procedures will be implemented where possible. Unexpected or unusually high or low data values will be flagged and further investigated. Across the network, data collected concurrently by co-located sensors will be intercompared, and variations will be used to estimate the uncertainty in the sensors to measure pollutant concentrations. All efforts will be recorded in the field notebook, and procedures will be updated as necessary to eliminate data loss or errors.

### 1.7.5 Quarterly and/or Final Reports

According to the schedule in *Section 1.6*, ten (10) Quarterly Reports and one (1) Final Report will be provided. They will describe the activities completed in setting up and operating the monitoring sites and other program actions; data collected during the preceding 3-month period; and notes about any anomalies or variances from data expectations based on the sensor manufacturer's instructions, the Standard Operating Procedure, or project objectives.

## 1.8 The MAP Data Quality Objective Process and Mitigation of Sources of Variability

### 1.8.1 Design of Quality System Objectives

The MAP-USA Project will utilize the procedure Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4 [ref# 6, EPA] to determine data quality objectives and acceptance criteria.

Steps are listed below:

1. **Step 1.** State the Problem.
   - Define the problem that necessitates the study; identify the planning team and examine the budget and schedule.
2. **Step 2**. Identify the Goal of the Study.
   - State how environmental data will be used in meeting objectives and solving the problem, identify study questions, and define alternative outcomes.

3. **Step 3.** Identify Information Inputs.
   - Identify data & information needed to answer study questions.
4. **Step 4**. Define the Boundaries of the Study.
   - Specify the target population & characteristics of interest, define spatial and temporal limits and scale of inference.
5. **Step 5.** Develop the Analytic Approach.
   - Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings.
6. **Step 6.** Specify Performance or Acceptance Criteria.
   - Specify probability limits for false rejection and false acceptance decision errors.
   - Develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use.
7. **Step 7**. Develop the Plan for Obtaining Data.
   - Develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use.

### 1.8.2 Data Quality Objectives and Assessment Factors

Objectives and factors are listed as follows:

- **Soundness**: The extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended application.
- **Applicability and Utility**: The extent to which the information is relevant for the EPA's intended use.
- **Clarity and Completeness**: The degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations, and analyses employed to generate the information are documented.
- **Uncertainty and Variability**: The extent to which the variability and uncertainty (quantitative and qualitative) in the information, or the procedures, measures, methods, or models are evaluated and characterized.
- **Evaluation and Review**: The extent of independent verification, validation, and peer review of the information or of the procedures, measures, methods or models.

### 1.8.3 Sources of Variability

Sources of variability will be properly evaluated to determine their causes and actions taken to eliminate. Operational performance of sensors will be periodically evaluated to prevent sources of variability from going undetected and result in an eventual impact of data quality. Historical operations performance of data trends shall be evaluated to prevent initial introduction of potential variability sources.

### 1.8.4 Identification of Environmental Project Operations

The sensor network will be installed in a manner to ensure that it is protected from extreme conditions, including weather patterns particular to the Southeast climate zone. The QA Technician will ensure sensors are capable of adequately monitoring atmospheric conditions while exposed to ambient conditions. The sensors will be installed in environmental conditions as specified in its operating and installation procedures. The QAM will verify compliance with these procedures.

## 2.0 DATA GENERATION AND ACQUISITION

### 2.1 Sampling Design (Experimental Design)

MAP-USA will partner with 10 public high schools located on the southside of Atlanta, Georgia. These schools were carefully selected to (a) be geographically distributed across the region, (b) cover South Atlanta with PurpleAir sensors at a similar density to the PurpleAir network operating in North Atlanta, (c) be located in minority and lower income neighborhoods that have been historically underserved, and (d) meet the scientific objective of establishing controlled air monitoring pairs that differ in their proximity to the interstate to test the redlining impact on air quality. The targeted schools, their student profiles, and their location in relation to the existing PM2.5 monitoring network in Atlanta are shown in the table below. If a partnership with any one of the schools cannot be secured, subsequent analyses will be conducted to find a similar replacement.

**Table 5. Schools of Interest**

| School | # Students | % Nonwhite | % Hispanic | % Black | % Reduced lunch | Match pairs |
|---|---|---|---|---|---|---|
| Douglass HS | 1059 | 1.00 | 0.05 | 0.95 | 0.79 | A |
| Mays HS | 1256 | 1.00 | 0.06 | 0.93 | 0.79 | A |
| Booker T. Washington HS (alt) | 741 | 1.00 | 0.02 | 0.97 | 0.79 | A |
| Maynard Jackson HS | 1361 | 0.87 | 0.06 | 0.77 | 0.79 | B |
| Cedar Grove HS | 1088 | 0.99 | 0.03 | 0.94 | 0.99 | B |
| Mount Zion HS | 1296 | 0.98 | 0.21 | 0.71 | 0.93 | C |
| Jonesboro HS | 1385 | 0.97 | 0.21 | 0.69 | 0.93 | C |
| Martha Ellen Stilwell School for Performing Arts | 576 | 0.97 | 0.12 | 0.77 | 0.93 | D |
| Elite Scholars Academy | 686 | 0.99 | 0.16 | 0.70 | 0.93 | D |
| Hapeville Charter Career | 597 | 0.98 | 0.10 | 0.87 | 0.62 | E |
| Fulton Leadership Academy | 298 | 1.00 | 0.03 | 0.95 | 0.61 | E |

*School demographics from Urban Institute's Education Data Explorer (https://educationdata.urban.org/data-explorer).*

The PurpleAir sensors will sample the air and produce data indicating the concentrations of PM2.5 in units of $\mu g/m^3$ of the local area in 2-minute intervals. The data will be stored locally on a micro-SD card and will also be uploaded to the PurpleAir Map database via Wi-Fi such that it is publicly accessible.

If a sampling site becomes inaccessible, an "Impact Assessment Evaluation" shall all be performed to determine the overall impact on the project's mission and objectives. The Impact Assessment Evaluation will be performed by the Project Manager, Research Lead and QAM. The report shall include which sensor was affected, its location, the overall sensor outage impact, and proposed corrective measures.

The MAPS-USA Team shall collectively decide on the proposed corrective action with an emphasis on maintaining safety and research integrity.

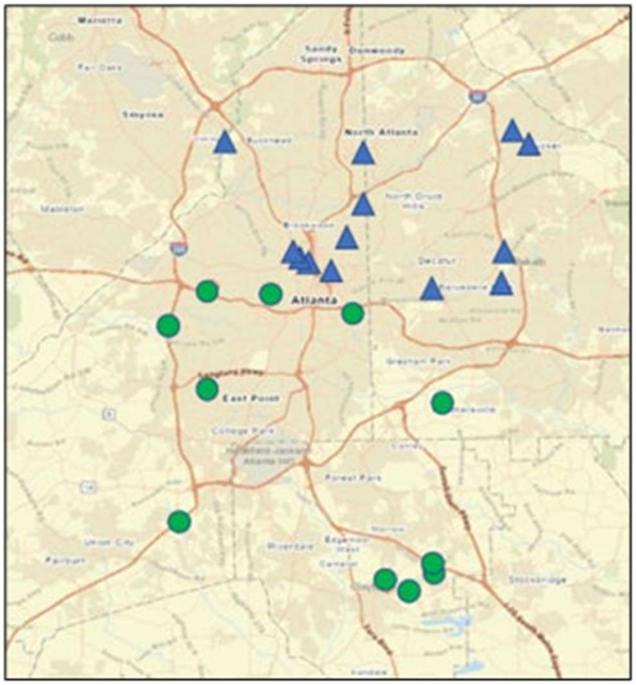


*Figure 2. Location of existing PurpleAir monitoring network (blue triangle) and schools where MAP-USA will add monitors (green circle)*

## <u>2.2 Sampling Methods</u>

Once the partnership with a school is established, the goal will be to select a safe and secure site near the school where the PM2.5 measurements will be representative of the neighboring area. Where possible, the same sampler location requirements that are required for a Federal Reference Method sampler, as described in *40 CFR Part 58, Appendix E - Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring,* will be followed. Exceptions to these guidelines will be documented in the field notebook and subsequent reports. The most notable requirements are listed as follows:

- The PM2.5 sampler must have unobstructed air flow for a minimum of 2 meters in all horizontal directions and 1 meter vertical spacing from supporting structures (i.e. a roof);
- The sampler inlet must be placed at a height of 2 to 7 meters above ground level;
- For the PM2.5 samplers that are collocated with other samplers, the spacing between the sampler inlets must be at least 1 meter apart and no more than 4 meters apart;
- The heights of the inlets should be within 1 meter, measured in the vertical direction

As an added measure, the PM2.5 sampler will be placed where the operator can reach it safely, regardless of weather conditions, and in a location secure from vandals, wildlife, and harsh weather. The site must have access to a stable electrical power source (operating at 105125 Volts AC and frequency of 59-61 Hz) and a reasonably stable Wi-Fi internet connection.

Other detail procedures specific to setting up and operating the PurpleAir PA-II-SD PM2.5 sensors are noted in the *Standard Operating Procedure for the Purple Air PA-II-SD PM Sensor* (J-AMCD-SFSB-

SOP-3561-3, Effective Date: Jan 8, 2020), included here as an *Appendix B*. Setup guidance from the PurpleAir manufacturer is also available at the PurpleAir website, https://community.purpleair.com/t/sensor-start-up-guide/182, and are also included here in *Appendix A*.

## 2.3 Sample Handling and Custody

PurpleAir sensors use laser counters to measure particulate matter in real time, and no actual air or media (e.g., filters) samples are collected or require storage. As the manufacturer states:

> *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 are used to infer the mass concentrations of PM1.0, PM2.5, and PM10 for standard indoor and outdoor atmospheric particles.*

## 2.4 Analytical Methods

### 2.4.1 Field Measurements Methods

The PurpleAir sensors come factory calibrated, and it is not possible to calibrate the laser counters postproduction. Further, the manufacturer requires no preventive maintenance. However, if it is suspected that a sensor might be misreporting, the manufacturer recommends attempting to clean the laser counters with a shop vacuum or canned compressed air. The manufacturer reports the life expectancy of a sensor is roughly two years.

The technician will be responsible for checking daily, via the PurpleAir Map website, that each sensor is reporting data. Any interruptions in reporting will be noted and will initiate further investigations to rectify operations. The minimum goal is to exceed the 75% uptime benchmark that the US EPA requires for FEM and FRM monitoring. Even if the sensor appears to be operating and reporting correctly, the technician will visit each sensor site monthly to ensure that the sensor continues to be mounted and operating correctly.

### 2.4.2 Field Analyses Methods

Other than determining if the sensor is properly uploading data to the PurpleAir database and/or storing data locally on the micro-SD card, the field operator will not conduct field analyses of the data. Data that is downloaded from a micro-SD card in the field shall be verified as complete and identical to data on the micro-SD card before deleting any data for storage management purposes.

The project technician will maintain a field notebook marked in black ink with all records of sensor deployment, start-up, shut-down, data transfer, and maintenance activities. Field notes will include observations about nearby or transient pollution sources, weather or special events, instrument operation, location, device ID, date and time, and observer(s) name(s). These notes will be maintained for the lifetime of the project plus seven years.

### 2.4.3 Laboratory Analyses Methods (Off-Site)

Data from the sensors will be uploaded to the PurpleAir Map database at 2-minute intervals via Wi-Fi and made to be publicly accessible. The PurpleAir Map site includes features that allow users to view and download real-time data as well as aggregates of 10-min, 30-min, 1-hr, 6-hr, 1-day, and 1-week averages are critical. Additionally, the sensor's raw data will be recorded locally on the included 16GB SD card and manually downloaded to the project laptop once per month to be archived (via cloud storage, hard drives, etc.). Raw data files will not be edited. Any files that contain analyses will be saved into a different file with a new name, and all analyses will be recorded into the field notebook.[6]

### 2.5 Quality Control Requirements

An assessment will be designed, performed, and documented to validate corrective action effectiveness.

### 2.5.1 Field Sampling Quality Control

PurpleAir sensors use laser counters to measure particulate matter in real time, and no actual air or media (e.g., filters) samples are collected or require storage.

### 2.5.2 Field Measurement/Analysis Quality Control

#### 2.5.2.1 Field Measurement QC

The project technician will conduct a visual inspection of the monitoring site and sensors at least once per month or more frequently if the device appears to be not functioning or reporting false data based on analyses of online data (see section, *2.5.3 Laboratory Analysis Quality Control,* below). The inspection will check the following:

1. The sensor is properly mounted and free of any obstructions that may affect airflow;
2. The sensor is receiving power and is functioning;
3. The micro-SD card is seated and receiving data;
4. The sensor is connected to the Wi-Fi network; and
5. The sensor is transmitting data to the PurpleAir database at 2-min intervals.

#### 2.5.2.2 Field Analysis QC (Screening and Definitive)

Should the inspection reveal any abnormal conditions, the technician will attempt corrective repairs and re-evaluate. If the sensor cannot be made functional, the sensor will be disconnected from the network until suitable repairs can be completed or the sensor is replaced.

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[6] All data collected by air monitoring sensors is considered important, critical, and essential to success of the mission and objectives of the project. All data shall be properly categorized and recorded in accordance with this procedure.

### 2.5.3 Laboratory Analysis Quality Control

At a minimum, the recovered data files – either downloaded from the PurpleAir database or from each sensor's micro-SD card – will be reviewed to assess data gaps and deviations from the expected data file structure (missing lines, columns, or cells within the data file). Unexplained data gaps and deviations will be further investigated, and troubleshooting procedures will be implemented where possible. Unexpected or unusually high or low data values will be flagged and further investigated. Across the network, data collected concurrently by co-located sensors will be intercompared, and variations will be used to estimate the uncertainty in the sensors to measure pollutant concentrations. All efforts will be recorded in the field notebook, and procedures will be updated as necessary to eliminate data loss or errors. See section *1.5.3 & 1.8.1 Measurement Performance Criteria/Acceptance Criteria*.

### 2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Upon first receiving the sensors, they will be receipt inspected per procedure and installed as per the PurpleAir Guide. Post installation, testing will be performed to ensure functionality. In order to demonstrate acceptability of the hardware configuration, the PurpleAir Installation Guide and Procedure will be utilized. This will also assure that applicable information resource management requirements are satisfied.

The project technician will conduct a visual inspection of the monitoring site and sensor at least once per month or more frequently if the device appears to be not functioning or reporting false data based on analyses of online data (see section *2.5.3 Laboratory Analysis Quality Control* below). The inspection will check the following:

1. That the sensor is properly mounted and free of any obstructions that may affect the airflow to the sensor;
2. That the sensor is receiving power and functioning;
3. That the micro-SD card is seated and receiving data;
4. That the sensor is connected to the Wi-Fi network; and
5. That the sensor is transmitting data to the PurpleAir database at 2-min intervals.

Should the inspection reveal any abnormal conditions, the technician will attempt corrective repairs and re-evaluate. If the sensor cannot be made functional, the sensor will be disconnected from the network until suitable repairs can be completed or the sensor is replaced. All inspection results will be documented.

### 2.6.1 Field Measurement Instruments/Equipment

The following equipment shall be provided/present at each monitoring location:

- PurpleAir PA-II-SD PM Sensor
- PurpleAir supplied USB/AC Adaptor *(outdoor rated version)*
- PurpleAir supplied micro-USB to USB power cord
- Micro to SD card adapter
- Micro SD Card(s) (*known success with Lexar 300x 16GB micro-SDHC or SanDisk Ultra Class 10 UHS-I 16GB microSD Memory Card*)
- A pair of tweezers
- Laptop computer, with SD card slot and Microsoft Excel installed

- GFCI power outlet and surge-protected power strip or weatherproof power station/box (able to provide power to the sensor, and contains Underwriters Laboratories (UL) listed extension cords and a UL listed surge protector).

The attending technician will also bring or be equipped with the following:

- Instrument or research logbook or form
- Safety Glasses
- Safety Shoes
- Work Gloves, *depending on attachment apparatus*
- Sensor attachment materials (*site specific*)

### 2.6.2 Laboratory Analysis Instruments/Equipment (Off-Site)

Offsite analysis of any data shall be conducted using any computing device (e.g., desktop computer, laptop computer, mobile device) that has access to the internet and the PurpleAir online database (https://www2.purpleair.com). All sensor data reported from PurpleAir sensors can be collected from the PurpleAir database using the PurpleAir API. Instructions for accessing data through the API are available at the PurpleAir website (https://community.purpleair.com/t/making-api-callswith-the-purpleair-api/180), and further documentation for using the API is available at: https://api.purpleair.com/.

## 2.7 Instrument/Equipment Calibration and Frequency

The PurpleAir sensors come factory calibrated, and it is not possible to calibrate the laser counters postproduction. Further, the manufacturer requires no preventive maintenance. However, if it is suspected that a sensor might be misreporting, the manufacturer recommends attempting to clean the laser counters with a vacuum, shop vacuum, or canned compressed air. The manufacturer reports the life expectancy of a sensor is roughly two years.

## 2.8 Data Acquisition Requirements (Non-Direct Measurements)

Data collected through MAP-USA is intended to be compared with other air quality data that may be publicly available in the Atlanta, GA metropolitan region. However, MAP-USA is not responsible for collecting this other data and does not warrant its quality.

Principally, data collected through MAP-USA will be uploaded and made publicly available on the PurpleAir map website: https://map.purpleair.com. Within the publicly available data, real-time and archived pollutant concentrations may be compared to pollutant concentrations uploaded to the site from other users that have also deployed PurpleAir sensors. Data from these other sensors may also be available for download through the PurpleAir API (https://community.purpleair.com/t/making-api-calls-with-the-purpleairapi/180). Data from other sources, such as the those collected by government agencies, may also be used in subsequent analyses comparing MAP-USA data collected in south Atlanta with other sites in the Atlanta metropolitan area and beyond. Sources for such data include the US EPA's AirNow site (https://www.airnow.gov/) and the Georgia Environmental Protection Division's Ambient Air Monitoring site (https://airgeorgia.org). Any subsequent use of other data for analyses by MAP-USA will be cited and documented.

## 2.9 Data Management

Data from the sensors will be uploaded to the PurpleAir Map database at 2-minute intervals via WI-FI and made to be publicly accessible. The PurpleAir Map site includes features that allow users to view and download real-time data as well as aggregates of 10-min, 30-min, 1-hr, 6-hr, 1-day, and 1-week averages. Additionally, the sensor's raw data will be recorded locally on the included 16GB SD card and manually downloaded to the project laptop once per month and archived (via cloud storage, CD, etc.).

Raw data files will not be edited. Any files that contain any analyses will be saved into a different file with a new name, and all analyses will be recorded into the field notebook. At a minimum, the recovered data files will be reviewed by the project technician to look for data gaps and deviations from the expected data file's structure (missing lines, columns, or cells within the data file). Unexplained data gaps and deviations will be investigated, and troubleshooting procedures will be implemented where possible. Unexpected or unusually high or low data values will be flagged and further investigated. Across the network, data collected concurrently by co-located sensors will be intercompared, and variations will be used to estimate the uncertainty in the sensors to measure pollutant concentrations. All efforts will be recorded in the field notebook, and procedures will be updated as necessary to eliminate data loss or errors.[7]

### 2.9.1 Checklists and Forms

In order to ensure proper data management and operations, all applicable checklists and forms, as they are created, will be added to this section accordingly. They will be added to the procedure to properly document control.

## 3.0 ASSESSMENT, RESPONSE ACTIONS, AND OVERSIGHT

The project technician will be responsible for ensuring daily that the network and each individual sensor in the network is reporting properly by checking the PurpleAir website. Sensors failing to report data will warrant that the technician physically inspect the monitor within 72-hours of detection of the data reporting-error. The project technician will report weekly to the QAM to provide status updates regarding the operation of the sensor network and to resolve any issues that may require additional resources (e.g., replacement of a sensor or access to a school monitoring site). Each quarter, the QAM will compile a report that summarizes the data collected during the 3-month period and include notes regarding any significant data anomalies or departures from the Standard Operating Procedures conducted during the monitoring period. Such reporting mechanisms will be put in place to ensure the project status is captured, and any QA issues that arise during implementation and through assessments will be addressed as identified. The report will be provided to the EPA Representatives and distributed via email to the other members of the project team.

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[7] If variability in the data is detected, it shall be evaluated to try and determined its source. Once source of variability is determined, action shall be taken to mitigate the source of the variation without producing harm to the overall data collection process. If variability source cannot be determined, the variation shall be noted, and data collection continued in a manner that does not affect overall data quality. The MAP Team shall continue to locate the source of variation and eliminate, which may include sensor replacement or relocation.

In order to confirm that the quarterly reports are successful, the QAM will enforce compliance with procedures throughout the lifecycle of the project by ensuring that personnel are trained in all necessary skills to complete tasks. Checklists and signoffs will be included at appropriate stages in the project based on criticality of execution.

## 4.0 DATA REVIEW AND USABILITY

Through the use of data to conduct analyses related to their research on environmental justice, Professors [redacted] and [redacted] – Professors at Georgia Tech -- will review the raw data and data summaries to verify that the records are complete and the data are valid. Subsequent use of the data in publications intended for academic journals will also be subject to scientific peer review.

Principally, Professors [redacted] will review the quarterly data reports provided by the Program Manager to determine when each sensor in the network was deployed and operating. Under normal operating conditions, each sensor should be reporting data to the PurpleAir database continuously in 2-minute increments. In verifying the data, [redacted] will download the data using the PurpleAir API and examine the record for missing data. Any missing data should be accounted for in the quarterly data reports (e.g., from notes indicating when the sensor may have first been installed and made operational or taken out of operation for servicing). Any discrepancies between the data recorded on the PurpleAir site and the quarterly reports will be communicated back to the Project Manager and Project Technician for further investigation. [redacted] will also examine the data specifically looking at daily maxima and daily minima PM2.5 pollutant concentrations and comparing them with other measurements of PM2.5 (either within the wider Atlanta metro area PurpleAir network or to sensors operated in the Atlanta metropolitan area by the GA EPD). Concentrations at any individual sensor that unreasonably exceed (e.g., greater than $2\sigma$) the range of pollutant concentrations measured in the metro Atlanta area will be noted and discussed with the project team to seek potential explanations (e.g., observed burning of yard waste near a sensor). Any clear and obvious data reporting errors (e.g., negative pollutant concentrations or pollutant concentrations that exceed the operating range of the sensor) will be flagged and omitted from any subsequent analyses. Absent any other reasonable explanation for data anomalies, all data reported to the PurpleAir site will be considered valid and suited for further analyses in which PM2.5 air quality data may be used.

After the implementation phase of the project is completed, data quality assessment procedures will commence. Such procedures include statistical analysis, instrument accuracy verification for bias and precision, and establishment of proper data correction tools. The MAP-USA team will work with schools and communities to explain the data and begin to develop air quality improvement solutions.
The MAP-USA project team recognizes the US EPA's recommendation to apply a correction factor to PM2.5 concentrations measured by PurpleAir PM2.5 sensors during smoke events (3). It is further understood by MAP-USA that the default on the PurpleAir map does NOT apply the correction factor to data deposited, displayed, or downloaded on or from the site, but that the US EPA does apply a correction factor to PurpleAir AQI data displayed on the *AirNow Fire and Smoke Now* product. As all MAP-USA data will be hosted on the PurpleAir site, MAP-USA will follow the PurpleAir default convention to NOT apply any correction factors to its data.

## 5.0 REFERENCES

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Karoline K. Barkjohn, Conceptualization, z,[1,*] Amara L. Holder, Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing,[1] Samuel G. Frederick, Formal analysis, Validation, Writing – review & editing,[2,3] and Andrea L. Clements, Conceptualization, Funding acquisition, Methodology, Writing – review & editing[1] Paul A. Solomon, Academic Editor, Melissa M. Lunden, Academic Editor, and Caroline L. Parworth, Academic Editor

## 6.0 APPENDICES

### APPENDIX A.

PurpleAir; *Sensor Startup Guide* and *Map Startup Guide* – downloaded from https://community.purpleair.com; 10/10/2023.

### APPENDIX B.

U.S Environmental Protection Agency, Office of Research and Development, Center for Environmental Measurement and Modeling, Air Methods and Characterization Division, Source and Fine Scale Branch; *Standard Operating Procedure for the Purple Air PA-II-SD PM Sensor*; SOP ID: J-AMCD-SFSB-SOP3561-3; Effective Date: Jan 8, 2020.