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DATE: September 19, 2018

TO: SJVUAPCD Governing Board

FROM: Samir Sheikh, Executive Director/APCO  
Project Coordinator: Sheraz Gill/Jaime Holt



RE: **ITEM NUMBER 15: UPDATE ON THE DISTRICT'S  
LOW-COST AIR MONITORING SENSOR ACTION  
PLAN**

**RECOMMENDATION:**

Receive an update on the District's low-cost air monitoring sensor action plan including the development and implementation of the low-cost sensor testing laboratory and the steps being taken to develop resources for use by the public.

**BACKGROUND:**

At the October 2017 Governing Board meeting, your Board provided direction for the District to facilitate good citizen science for utilizing personal low-cost air quality sensors through a multi-faceted approach. Although the technology for low-cost sensors has improved in recent years, the technology, the manner by which these sensors are utilized, and lack of training poses certain limitations.

The new low-cost sensor initiative includes testing the performance of these sensors in Valley conditions, working in partnership with community groups and businesses interested in using low-cost sensors, and developing and providing educational materials regarding the interpretation and accuracy of data produced from low-cost sensors. The purpose of this item is to provide an update on the District's low-cost air monitoring sensor plan including the development and implementation of the low-cost sensor testing laboratory and the steps being taken to develop resources for use by the public.

## **DISCUSSION:**

As the use of low-cost air monitoring sensors by individuals becomes more prevalent, it is important for the District to engage Valley residents interested in using such devices. This engagement can be helpful in assisting Valley residents with proper installation, operation, and interpretation of the data obtained.

Air monitoring sensor technology has been developing at a rapid pace over recent years, increasing the number of analyzers that the general public can use to measure particulate matter, ozone, or other pollutants at their own home or business. In addition, these sensor technologies are becoming more affordable, making them more accessible to Valley citizens who wish to conduct personal air monitoring. As a result, there are now more options for personal air monitoring equipment than ever before.

Although the technology for low-cost sensors has improved, certain limitations remain. However, with public education, these limitations can be minimized if combined with proper means to communicate the air quality information that these sensors can reliably provide.

Under the District's air monitoring program, significant effort is made to ensure that the data collected is of high quality and is defensible when being compared against federal air quality standards. To ensure this high level of data quality, the District:

- Follows strict federal guidelines for regularly scheduled maintenance, calibrations, and certifications
- Undergoes regular independent audits by the California Air Resources Board (ARB) and the federal EPA
- Provides extensive training to staff to gain the level of expertise needed to maintain, operate, and calibrate our high precision monitoring equipment for the proper management of the District's expansive air monitoring network

Since low-cost sensor technologies do not follow these strict and costly maintenance and calibration guidelines, over time the data accuracy can diminish and drift from known performance standards. Other factors that impact the accuracy and the validity of air quality data collected include the placement of sensors, the low precision of components, and data collection and interpretation limitations. Given these limitations, the potential use of low-cost sensor data to assist in making regulatory decisions impacting various pollution sources and businesses should be approached with caution. While low-cost sensor data can be helpful in providing a more robust spatial understanding of air quality trends and fluctuations, using their reported data without the support of higher grade monitoring information, proper procedures, and sound technical oversight could limit the usefulness of the data in understanding community air quality and developing effective emissions reduction strategies.

Anticipating that the use of personal air monitoring sensor technology will continue to grow over the coming years, and since the District has extensive experience with siting, operating, and maintaining high-level air monitoring equipment, the District is in a position to provide valuable education and guidance to citizens and community groups who are interested in using these sensor technologies.

Recognizing the need to proactively respond to these issues, at the October 2017 Governing Board meeting, your Board established the following action plan for the District to develop and implement as the use of low-cost sensor technology continues to become more prevalent, especially as community air monitoring expands throughout the region under the implementation of AB 617 and related efforts.

- Work in partnership with other agencies to test the accuracy of various sensor technologies available to the general public
- Collocate personal air quality sensors at various District air monitoring sites to compare accuracy
- Define and share with the public the information that can reliably be ascertained from personal air quality sensors. For instance, for some sensors, the information may only be probative in establishing relative trends in air quality versus providing an accurate absolute measurement of air pollutant concentrations.
- Develop educational materials and guidance documents on the proper placement of monitoring equipment, considering the air quality area of interest
- Provide guidance for how data should be interpreted and used, making clear that collected data will not be used in the framework of regulatory monitoring
- Engage in partnerships and oversight with community groups and businesses who wish to use personal air monitoring sensors for monitoring projects
- Provide public education and training disseminating above information to the public through web-based tools and/or public meetings

The District has already begun to take action in implementing a number of areas within this action plan, including testing low-cost sensor technology across the Valley through collocation with regulatory-grade monitors, developing educational materials and guidance documents, and engaging with community groups and businesses interested in using low-cost sensor technology.

### ***District's New Technical Evaluation of Sensor Technology (TEST) Program***

To further enhance the District's ability to test the wide variety of low-cost sensor technology in the conditions of the San Joaquin Valley, consistent with your Board's direction, the District has established the Technical Evaluation of Sensor Technology (TEST) Program. The District has augmented the in-house laboratory facility to test various particulate matter and gas parameter sensors against regulatory-grade

monitors. Continuing to build this capacity within the District's office will provide us with the ability to observe the performance of multiple sensors at the same location, providing a valuable comparison not only against regulatory-grade monitors but comparing the sensors against each other as well. Low-cost sensors will also be placed at District air monitoring sites across the Valley to broaden our understanding of how these sensors perform in varying air quality and meteorological conditions across the region when compared with collocated regulatory monitors. As described below, low-cost sensors have already been collocated at several regulatory air monitoring sites.

While these low-cost sensors are not regulatory monitors by design, quality, or ongoing maintenance/calibration, the further development of the District's sensor testing laboratory and resulting analysis from the TEST program will provide valuable information as the use of low-cost sensor technology for community air monitoring networks is considered under the AB 617 program. The resulting performance tests will provide guidance on which low-cost sensors may be best suited for various monitoring applications.

The South Coast Air Quality Management District (South Coast) has developed an extensive testing program for low-cost air quality sensor technology through its Air Quality Sensor Performance Evaluation Center (AQ-SPEC). Through these efforts, South Coast has produced a number of reports detailing the performance of a variety of low-cost sensors. Although the testing and analysis reports resulting from the AQ-SPEC program are very valuable, none of the testing has been conducted under air quality and meteorological conditions representative of the air the San Joaquin Valley, particularly with respect to PM<sub>2.5</sub>. Coupled with the extensive testing conducted by South Coast, evaluating low-cost sensors through TEST under Valley conditions will be key for making recommendations for Valley-specific air monitoring projects, including AB 617 implementation.

As low-cost sensor technology continues to be developed, the testing of these technologies in the meteorological and air quality conditions of the San Joaquin Valley will be key to determining their role and potential use in AB 617 and citizen science efforts throughout the Valley. TEST sensor evaluations will be made publically available as ongoing performance evaluations are conducted by District staff. Based on these reports, the District will also develop general education materials on the use of low-cost sensors for various monitoring applications, and will provide guidance on the proper use of these sensors as well as considerations on how to interpret and use the collected data within the proper context.

### ***Preliminary TEST Program Evaluation of Low-Cost Sensors in the Valley***

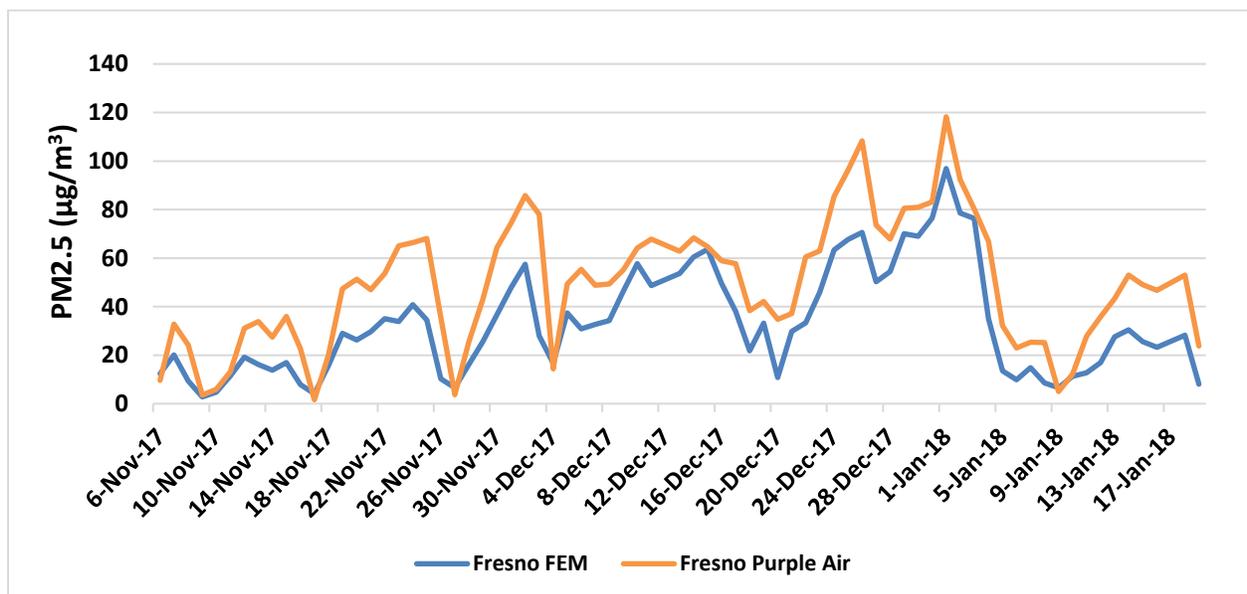
The following summarizes preliminary information gained from the evaluation of low-cost sensors in the Valley through the TEST program.

PurpleAir Sensors:

Soon after the October 2017 Governing Board meeting, the District partnered with the National Aeronautics and Space Administration (NASA) and CARB to collocate PurpleAir particulate matter sensors at various regulatory air monitoring sites in the Valley, providing a valuable comparison of data from these low-cost sensors to regulatory data. Through this partnership, PurpleAir sensors were placed at the Modesto, Fresno-Garland, Visalia, Bakersfield-California CARB regulatory air monitoring sites, and the District's Bakersfield-Municipal regulatory air monitoring site. The PurpleAir sensors were operational at Fresno-Garland, Visalia, Bakersfield-California, and Bakersfield-Municipal in November 2017, and was on-line at Modesto in March 2018.

With some data now available for comparing PM2.5 data from the PurpleAir sensors against collocated regulatory monitors at the selected air monitoring sites, an analysis was conducted to measure the accuracy of these low-cost sensors. Overall, the comparative analysis indicates that the PurpleAir sensors seem to perform adequately when concentrations are lower, however, as concentrations increase, the PurpleAir sensor consistently reports concentrations significantly higher than regulatory PM2.5 data. This was observed during the high pollution levels during this last winter season, which was impacted by wildfire emissions and prolonged periods of poor dispersion. The following figure displays the comparison of 24-hour average PM2.5 data between the PurpleAir sensor and the regulatory PM2.5 monitor at the Fresno-Garland site during the peak of this last 2017-2018 winter season.

**Figure 1 Comparison of 24-hour Average PM2.5 Concentrations from PurpleAir Sensor and Regulatory Monitor at Fresno-Garland during 2017-2018 Winter Season**

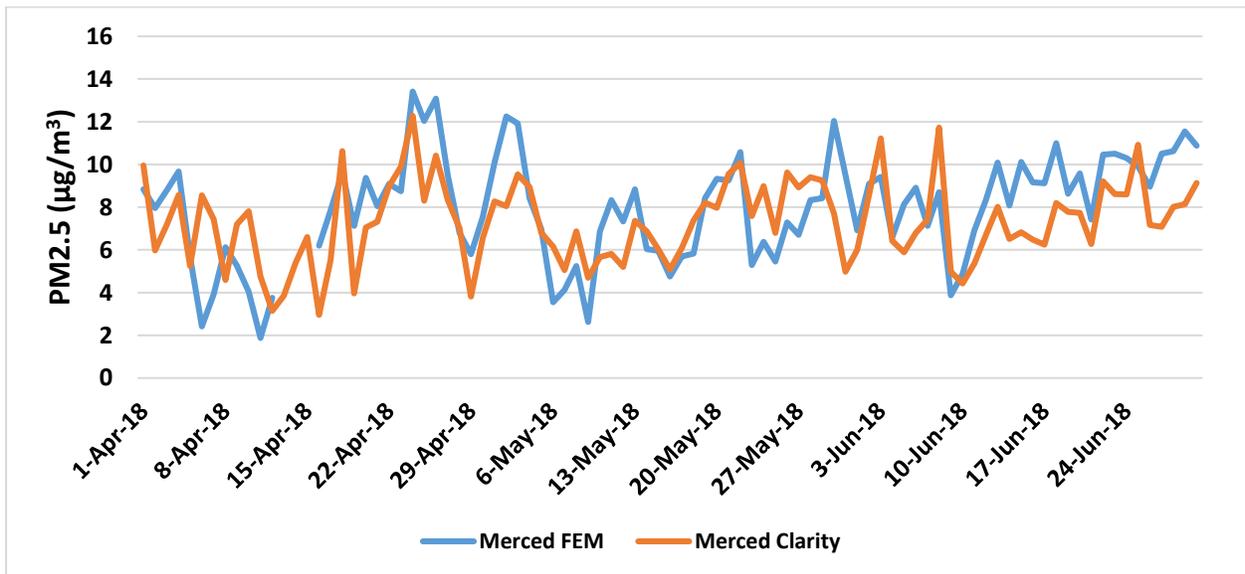


Clarity Sensors:

In late 2017, the District also collaborated with the Clarity Movement Company to test their low-cost sensor technology in the conditions of the Valley. The Clarity sensors are designed to measure particulate matter, gas parameters, temperature, and relative humidity within a compact solar-powered unit. These sensors were placed at the District's Manteca, Tracy, Merced, Clovis, and Tranquillity air monitoring sites. The Clarity sensors, which began operating in March 2018, are unique in that they are able to adjust their measurement algorithms as regulatory data in the area is made available. This allows the sensors to correct their estimation methods based on more precise readings in the area, minimizing any bias that may be formed over time.

Since the Clarity sensors have only been evaluated through the TEST program for approximately six months, the dataset available for analysis is limited, however, some early observations can still be drawn. When compared to regulatory data, the data from the Clarity sensors does not appear to have a consistent bias, but rather fluctuates from day-to-day. In addition, the Clarity sensor also appears to track fairly well with regulatory monitors during high concentration events, e.g. wildfires, which was observed during the 2018 wildfire season. The following figure compares data collected from the Clarity sensor and the regulatory PM2.5 monitor operating at the Merced air monitoring site during the 2nd quarter of 2018.

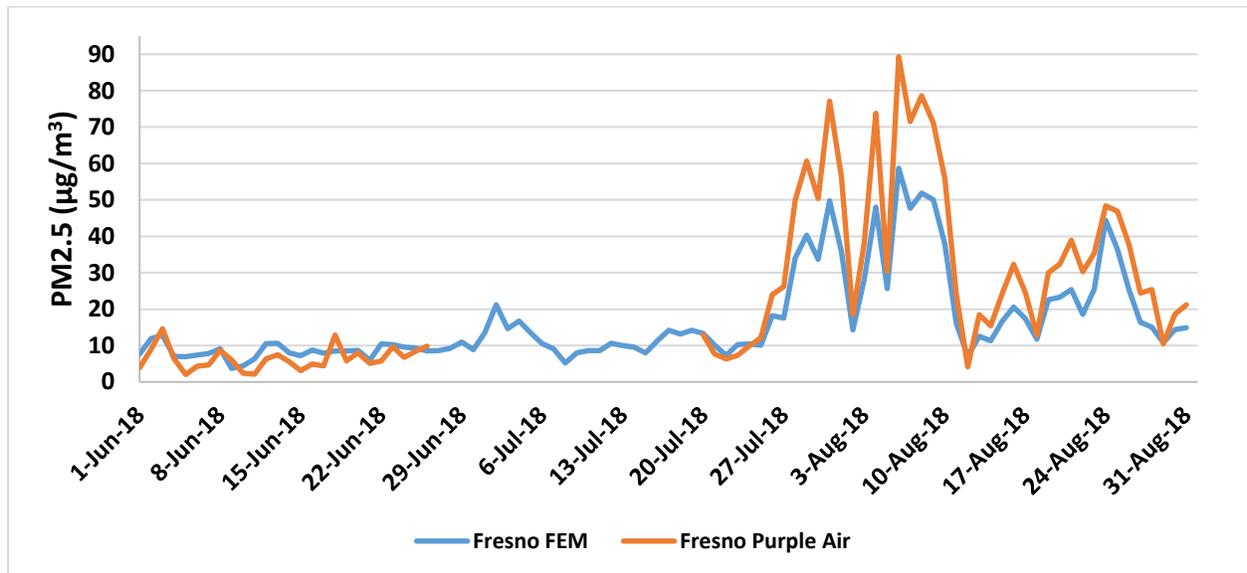
**Figure 2 Comparison of 24-hour Average PM2.5 Concentrations from Clarity Sensor and Regulatory Monitor at Merced**



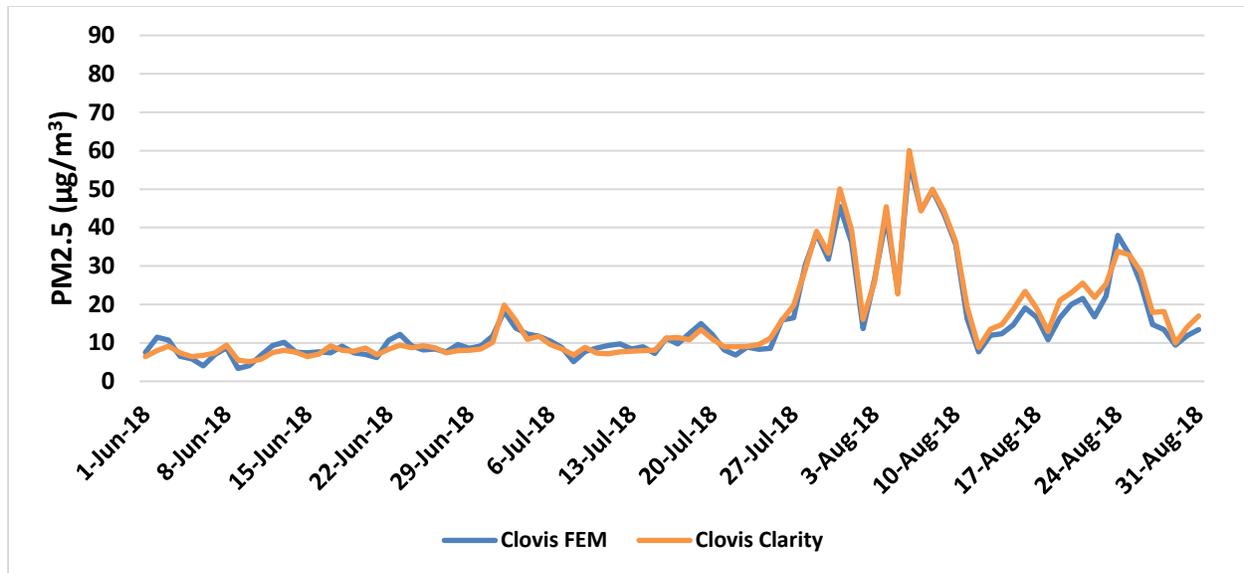
Low-Cost Sensor Performance during 2018 Wildfire Season:

The high PM2.5 concentrations that were experienced in the Valley during the active 2018 wildfire season provided prime conditions to test the performance of the PurpleAir and Clarity sensors when operating in extreme air quality conditions. The following figures display the performance of the PurpleAir sensor at the Fresno-Garland air monitoring site during the months of June – August 2018, as well as the performance of the Clarity sensor at the Clovis air monitoring site during the same time period. As these figures indicate, the Clarity sensor, with its self-correcting algorithm process, exhibited enhanced performance over the PurpleAir sensor during the peak PM2.5 concentrations of the wildfire season. Note that the PurpleAir sensor was not operating at the Fresno-Garland site during the period of June 26 to July 20, 2018.

**Figure 3 Performance of PurpleAir Sensor at Fresno-Garland Air Monitoring Site during 2018 Wildfire Season**



**Figure 4 Performance of Clarity Sensor at Clovis Air Monitoring Site during 2018 Wildfire Season**



### ***Partnering to Deploy Community Air Monitoring***

As the implementation of AB 617 continues to be developed by CARB, the use of low-cost sensor technology will likely be utilized in communities. However, as part of a robust monitoring campaign that includes regulatory-grade monitoring, low-cost sensors may help fill this need by providing data in more areas of the community while helping to reduce deployment and operational costs.

With the potential benefits and limitations of low-cost sensors in mind, the use of these technologies in conducting community monitoring will be based on the air monitoring needs of the area, pollution sources of interest in the community, and whether low-cost sensors would provide data of value based on the assessment of community needs and concerns. The District, through implementation of monitoring requirements under AB 617, will define in its forthcoming community air monitoring plans the potential role that different analyzers and sampling technologies will be used in the deployment of community air monitoring networks, potentially including the use of low-cost sensors, regulatory-grade monitors, and other air quality sampling technologies.

In addition to partnering with other agencies and sensor technology manufacturers, the District will seek to provide technical and monitoring assistance to local community groups and businesses as they develop and implement a number of community air monitoring projects in the coming years. For example, as approved through CARB's Community Air Grants Program, CARB has awarded \$2.3 million to eight projects in the San Joaquin Valley, many of which include community monitoring components. As discussed earlier, community groups who wish to implement low-cost air monitoring

sensor networks need to be aware of the limitations of these sensors, proper sensor siting practices, and careful collection, interpretation, and use of the data. If coupled with District monitoring assistance, good operating practices, and inclusive stakeholder engagement, the upcoming community monitoring campaigns could assist in the implementation of AB 617.

***Providing Guidance and Education Regarding Use and Limitations of Low-Cost Sensors***

To provide assistance to Valley residents and communities who wish to deploy and operate low-cost sensors, the District is developing educational materials and guidance documents on how to place and establish an air monitoring network, how to operate a variety of low-cost sensors, and how to properly interpret and use the data collected. The District will work with other agencies and organizations to leverage similar resources to address the proper use and limitations of low-cost sensors. The District may also hold public workshops to provide training, best-practices, and raise awareness of limitations of various low-cost sensors.

As more low-cost sensor performance analysis becomes available through the TEST program, results of sensors operating in the conditions of the San Joaquin Valley will be key in providing meaningful guidance for residents to consider as they implement their air monitoring projects. The District will also seek to partner with other agencies such as EPA, CARB, and South Coast to continue to expand the understanding of low-cost sensor performance in the region.

To make this information easily accessible, the District is developing a webpage dedicated to providing the public information related to low-cost sensors including:

- Educational and guidance materials related to use of low-cost sensors
- Evaluations of low-cost sensors conducted through District's TEST program
- Links to other available low-cost sensor resources
- Information on the District's regulatory air monitoring network and new air monitoring resources