# Technical Evaluation of Sensor Technology (TEST) Program

*PurpleAir PA-II Sensor*
*2022 – 3rd Quarter*

## *Introduction and Sensor Profile*

This analysis report is focused on assessing the performance of the PurpleAir PA-II sensor as a part of the District's Technical Evaluation of Sensor Technology (TEST) Program.  The PurpleAir PA-II sensor uses an optical laser-based particle counting methodology to estimate the mass of varying diameters of particulate matter, including PM1, PM2.5, and PM10.  The PA-II sensor also measures temperature, pressure, and relative humidity.

## *Background and Approach of Evaluation Test*

In November of 2017, NASA began an air quality study to compare the performance of PurpleAir sensors to regulatory PM2.5 monitors.  The study is focused on the conditions in the San Joaquin Valley and is based at California Air Resources Board (CARB) air monitoring sites of, Fresno-Garland, Modesto-14ᵗʰ St, Visalia-Church, and Bakersfield-California.  In 2019, the District began operating PurpleAir sensors at the District's Clovis-Villa air monitoring site and in the Shafter and South Central Fresno AB 617 communities.

The data sets analyzed for this report compare PM2.5 data collected from PurpleAir sensors and Federal Equivalent Method (FEM) monitors that are collocated at the CARB and District air monitoring sites listed above.  The scatter plots and time series graphs below show how the datasets compare for both hourly values and the 24-hour average.

## *Overview of Analysis Findings from Current Period*

The analysis for this report covers the time period of July 1, 2022, through September 30, 2022 (2022 – 3ʳᵈ quarter).  During this period, hourly data was removed from the calculation of bias when either the PurpleAir sensor or regulatory monitor did not have a valid hourly sample.  For the 24-hour averages, only days with 18 or more valid hourly samples (75% or greater completeness) are included.

Seasonally, PM2.5 is typically highest during the winter months and lowest during the summer months.  Weather systems influence PM2.5 levels by either trapping pollutants near the surface or dispersing them.  Generally, California's experiences weather patterns that alternate between high pressure systems and low pressure systems that move through the region every two to four days.  High pressure systems dominated much of the 3ʳᵈ quarter of 2022 wherein strong atmospheric stability and long stretches of triple digit temperatures presided over the Valley.  Indeed, only two low pressure systems brought improved dispersion, lower temperatures, and a bit of precipitation during the quarter – one during the first week of July and the other during the third week of September.  Under the hot and stagnant conditions, ozone concentrations rose on the clear-sky days.  In contrast, an influx of monsoonal moisture and remnants of Hurricane Kay provided cloud cover over the area at the end of July through early August.  The clouds blocked sunlight, decreased ozone formation and lowered temperatures across the Valley during that period.  Wildfires also impacted air quality during

the 3rd quarter.  Smoke from wildfires in the Sierra Nevada and in southern California infiltrated the Valley in mid-July and early September and PM2.5 concentrations increased as a result.

During the 2022 3rd quarter, the PurpleAir sensors and the MetOne BAM 1020 FEM monitors responded similarly to the fluctuations in concentrations.  The Clovis #1 and #2 PurpleAir sensors correlated pretty will with the Clovis FEM monitor whereas the Clovis #3 PurpleAir sensor measured higher compared to the Clovis FEM.  It should be noted that extremely high outlier values were removed from the Clovis #3 data set as they did not correlate with any of the other sensors and FEMs in this analysis.  The PurpleAir sensors at Modesto and South Central Fresno tended to measure lower compared to the respective Modesto and Fresno-Garland FEM monitors.

## *Site Specific Analysis of PurpleAir PA-II Sensor Performance*

**Modesto-14th St.**

For the 24-hour average, PurpleAir data had a -2.8 µg/m³ low bias during the July 1, 2022, through September 30, 2022, period.  For the hourly average, PurpleAir data had a low bias of -2.7 µg/m³ over the same period.
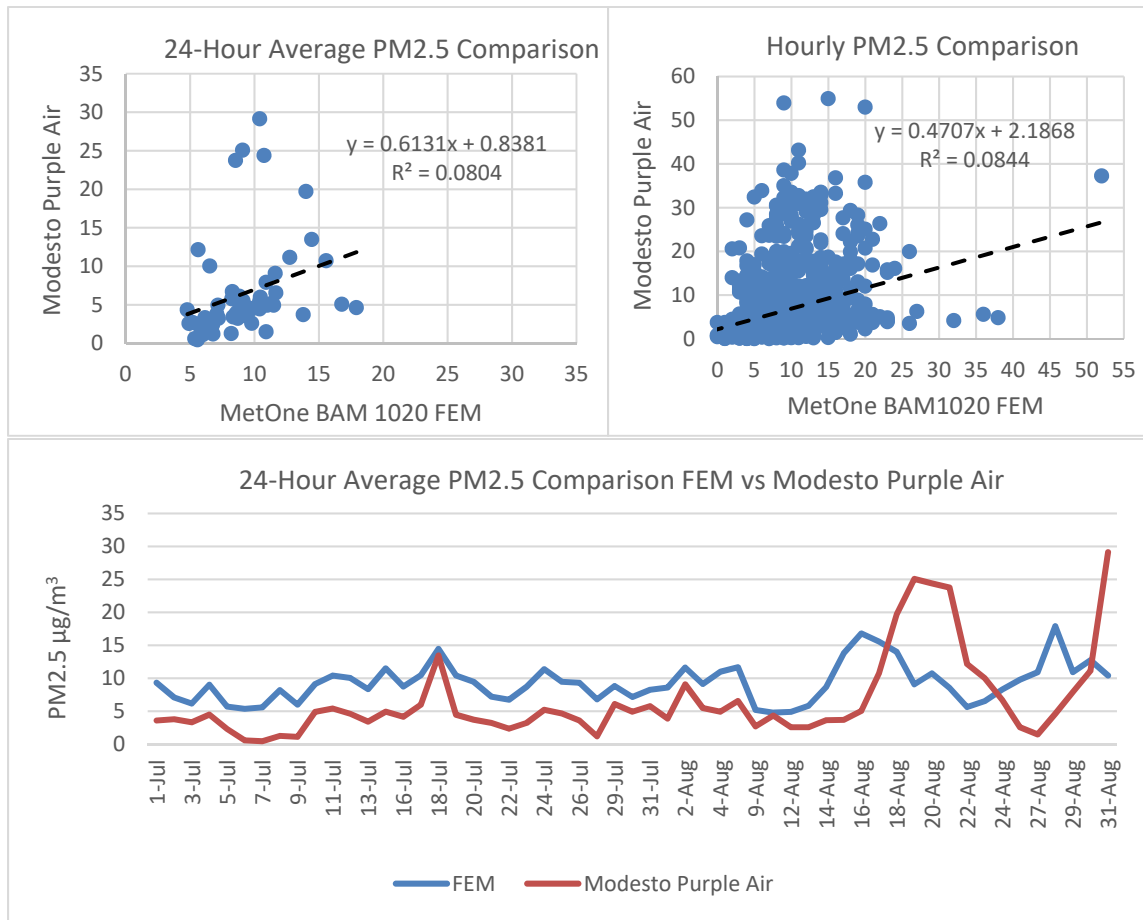
**Clovis-Villa #1**

For the 24-hour average, PurpleAir data had a 0.4 µg/m³ high bias during the July 1, 2022, through September 30, 2022, period.  For the hourly average, PurpleAir data had a high bias of 0.5 µg/m³ over the same period.
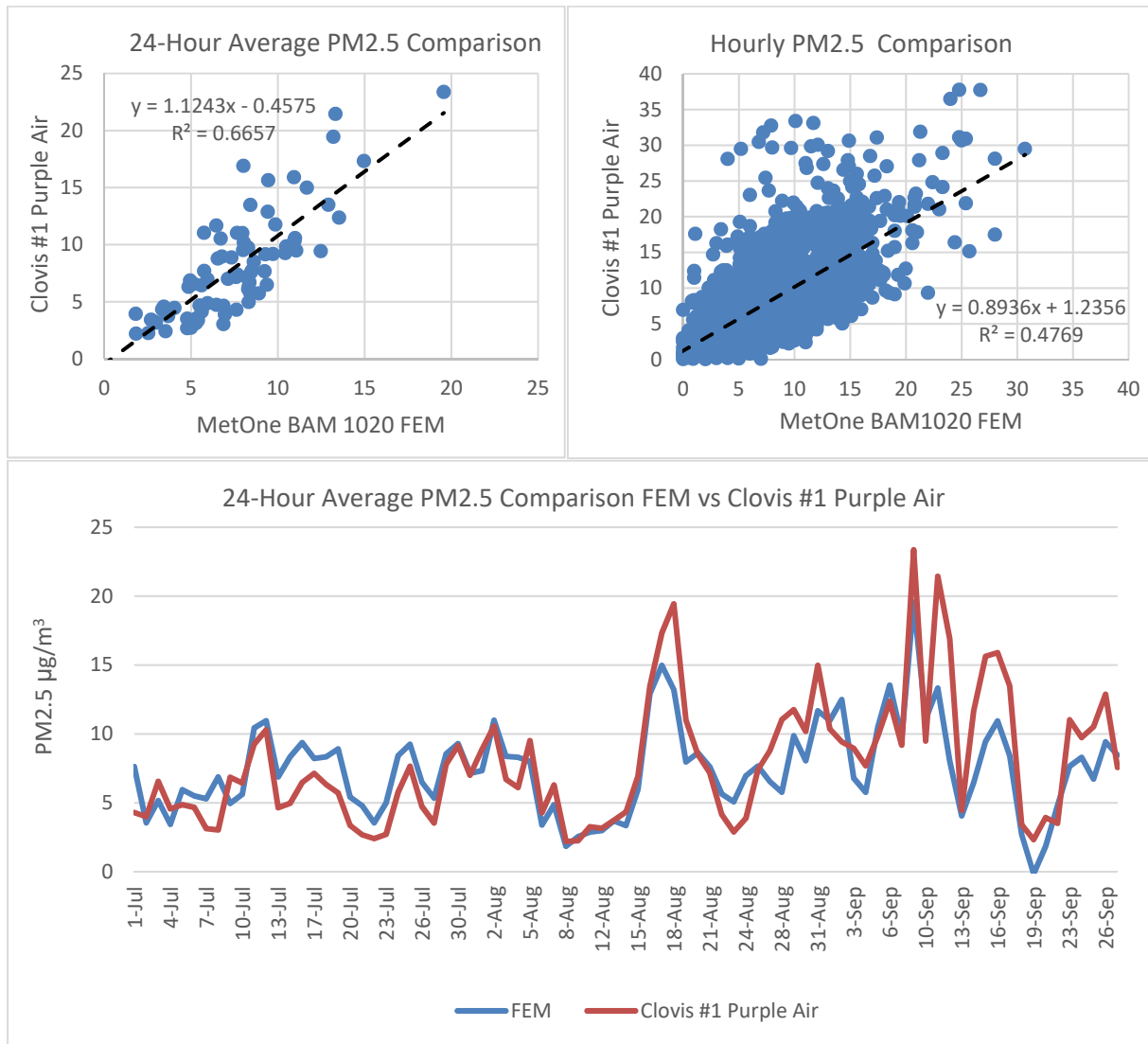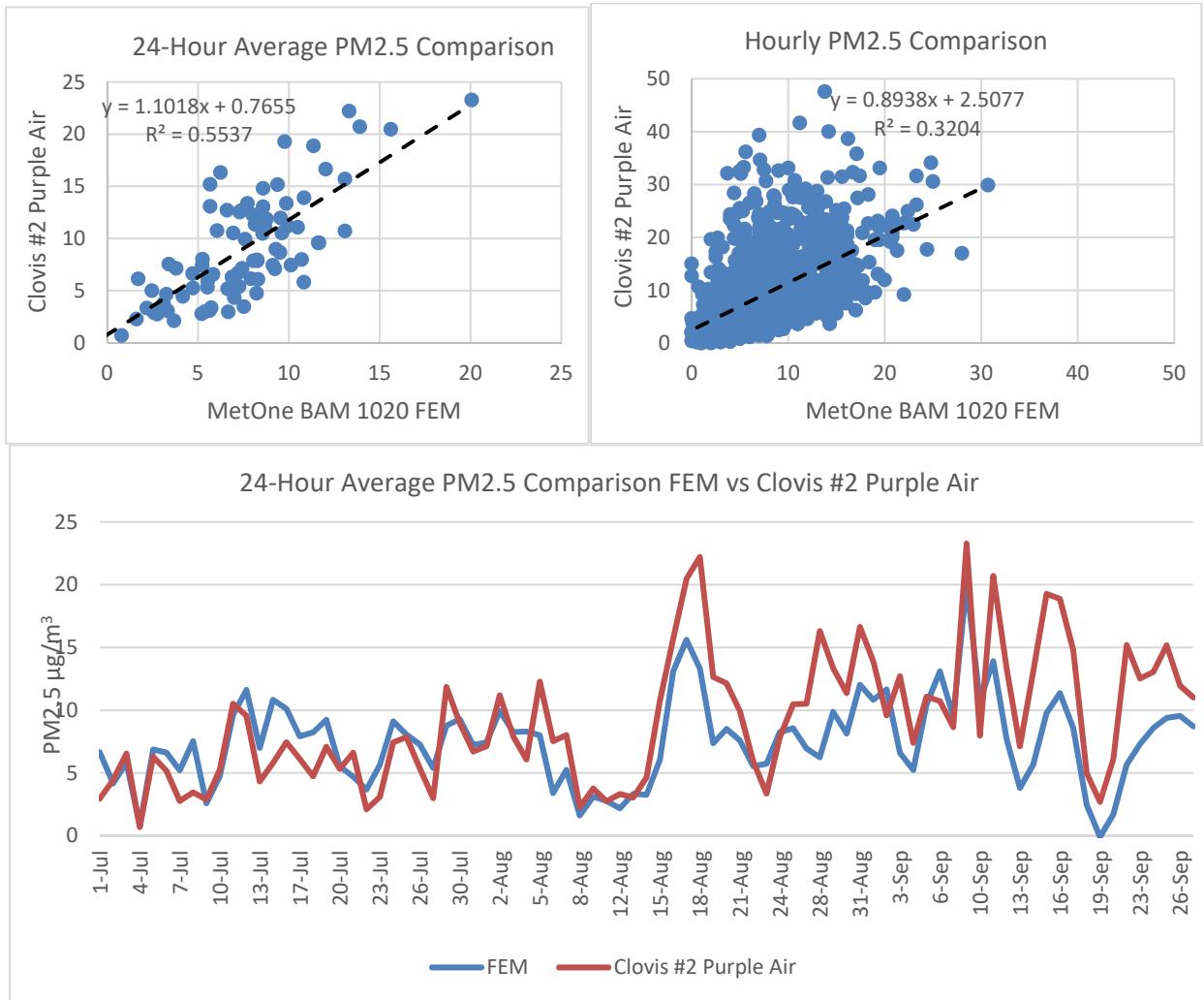
**Clovis-Villa #2**

For the 24-hour average, PurpleAir data had a 1.7 µg/m³ high bias during the July 1, 2022, through September 30, 2022, period. For the hourly average, PurpleAir data had a high bias of 1.5 µg/m³ over the same period.

## Clovis-Villa #3

For the 24-hour average, PurpleAir data had an 8.1 µg/m³ high bias during the July 1, 2022, through September 30, 2022, period.  For the hourly average, PurpleAir data had a high bias of 8.2 µg/m³ over the same period.



**24-Hour Average PM2.5 Comparison**

$y = 1.1762x + 6.7509$  
$R^2 = 0.4093$

**Hourly PM2.5 Comparison**

$y = 0.7714x + 9.872$  
$R^2 = 0.0691$

**24-Hour Average PM2.5 Comparison FEM vs Clovis #2 Purple Air**

— FEM    — Clovis #3 Purple Air

## South Central Fresno – Roosevelt High School

For the 24-hour average, PurpleAir data had a -4.7 µg/m³ low bias during the July 1, 2022, through September 30, 2022, period.  For the hourly average, PurpleAir data had a low bias of -4.7 µg/m³ over the same period.
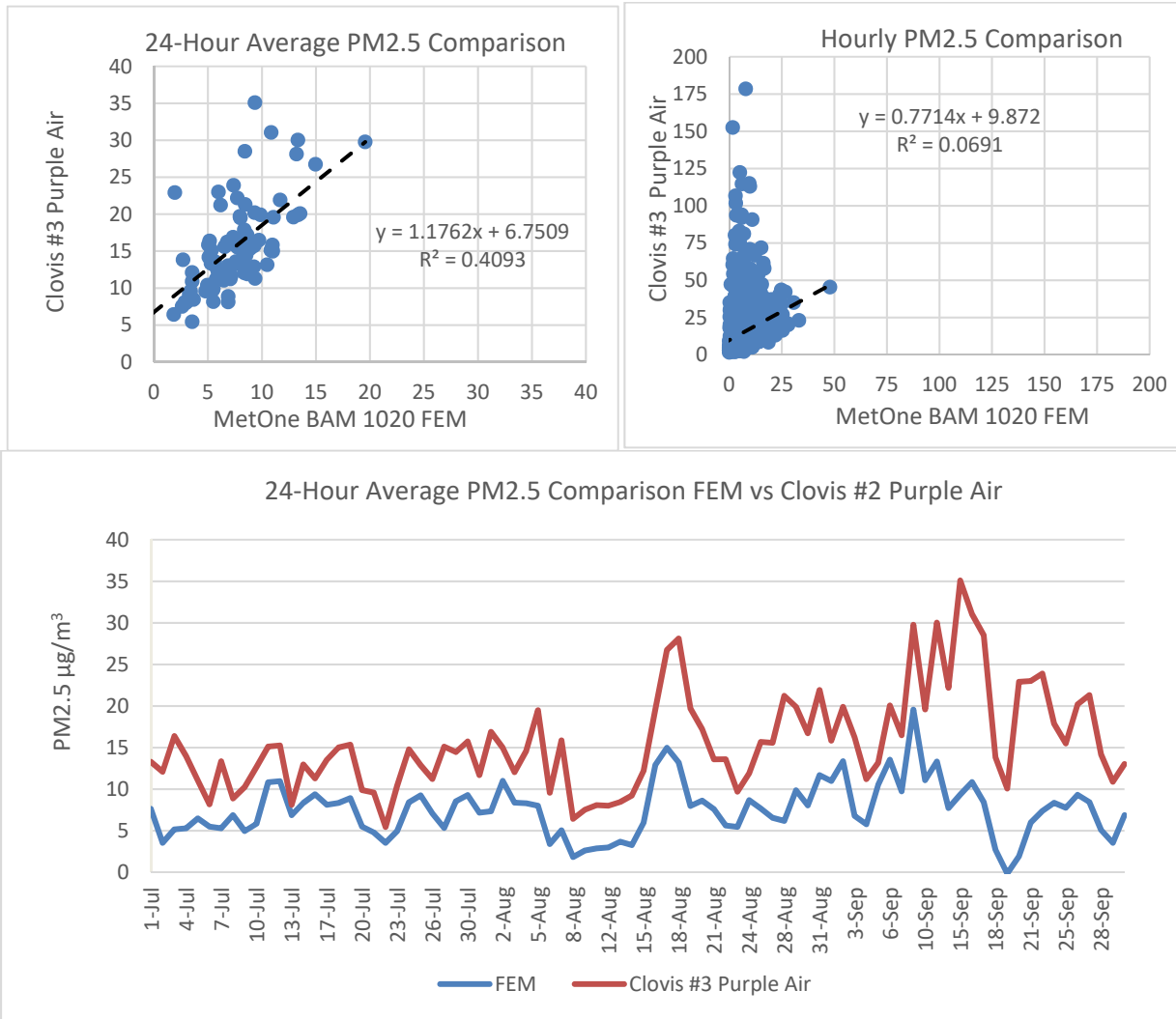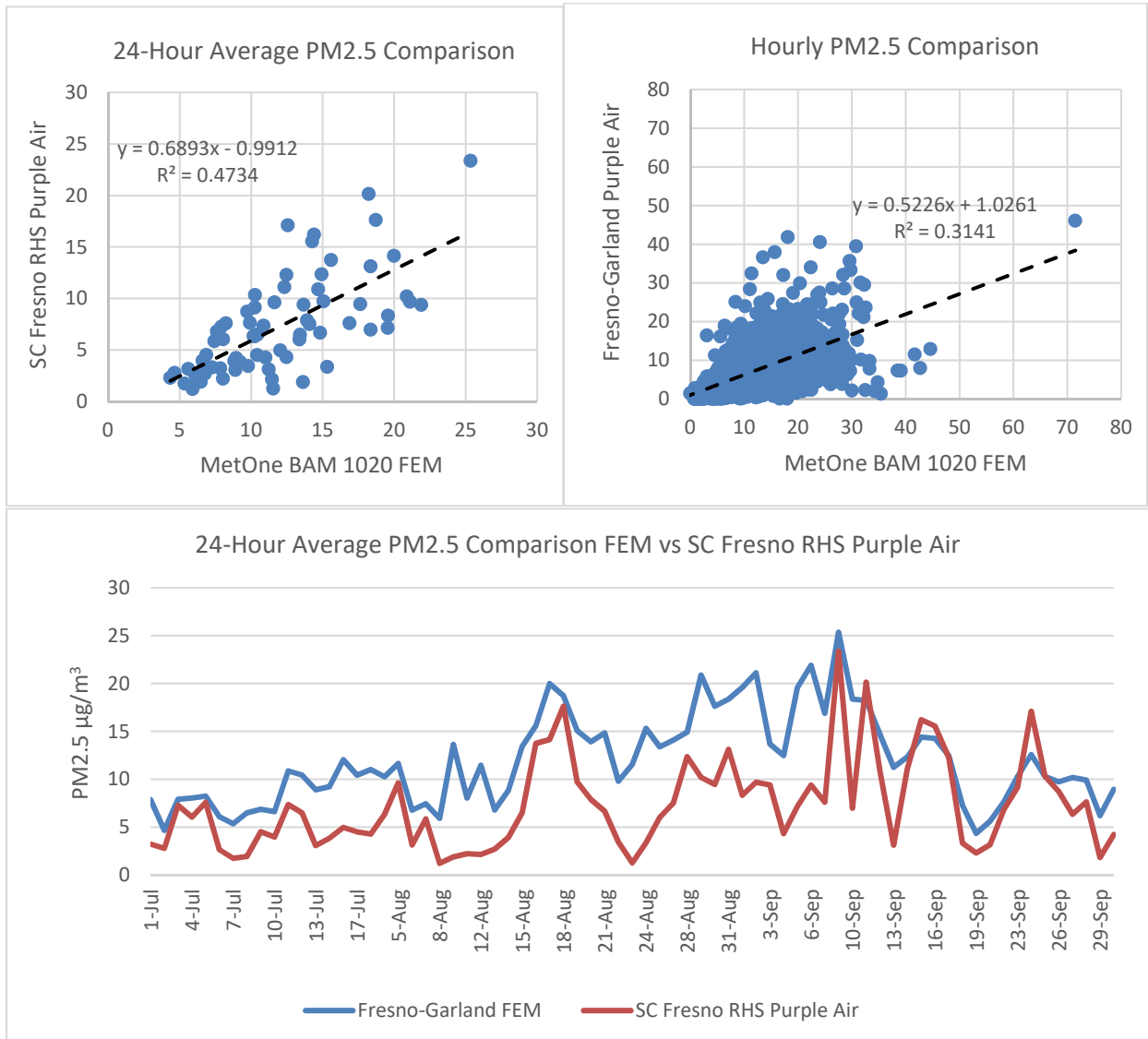
### 24-Hour Average PM2.5 Comparison

$y = 0.6893x - 0.9912$
$R^2 = 0.4734$

*SC Fresno RHS Purple Air* (y-axis)
*MetOne BAM 1020 FEM* (x-axis)

### Hourly PM2.5 Comparison

$y = 0.5226x + 1.0261$
$R^2 = 0.3141$

*Fresno-Garland Purple Air* (y-axis)
*MetOne BAM 1020 FEM* (x-axis)

### 24-Hour Average PM2.5 Comparison FEM vs SC Fresno RHS Purple Air

*PM2.5 µg/m³* (y-axis)

Legend: —— Fresno-Garland FEM    —— SC Fresno RHS Purple Air

## *Non-Reporting Sites*

### Modesto-14th St
Data from this sensor was not available for the period September 1 through 30, 2022. This sensor will be included in future analysis reports if the data becomes available.

### Bakersfield-California
Data from this sensor was not available for the July 1, 2022, through September 30, 2022 period. This sensor will be included in future analysis reports if the data becomes available.

### Visalia-Church
Data from this sensor was not available for the July 1, 2022, through September 30, 2022 period. This sensor will be included in future analysis reports if the data becomes available.

### Shafter #2
Data from this sensor was not available for the July 1, 2022, through September 30, 2022 period. This sensor will be included in future analysis reports if the data becomes available.

### Fresno-Garland
Data from this sensor was not available for the July 1, 2022, through September 30, 2022 period. Data from this sensor is not expected to resume.

## *Statistical Summary*

The following tables provides a statistical summary of the PM2.5 data collected during the analysis period of this report.

**Table A – Fresno-Garland, Visalia-Church, Bakersfield-California, and Modesto-14th Sites**

| Statistic | Fresno-Garland | Visalia-Church | Bakersfield-CA | Modesto-14th |
|---|---|---|---|---|
| FEM Avg. 24-hr | | | | 9.3 |
| Sensor Avg. 24-hr | | | | 6.6 |
| FEM Max 1-hr | | | | 52 |
| Sensor Max 1-hr | | | | 54.9 |
| FEM Max 24-hr | PurpleAir sensor at this site did not report during this period | PurpleAir sensor at this site did not report during this period | PurpleAir sensor at this site did not report during this period | 17.9 |
| Sensor Max 24-hr | | | | 29.1 |
| 1-hr $R^2$ | | | | 0.0844 |
| 1-hr Slope | | | | 0.4707 |
| 1-hr Intercept | | | | +2.1868 |
| 24-hr $R^2$ | | | | 0.0804 |
| 24-hr Slope | | | | 0.6131 |
| 24-hr Intercept | | | | 0.8381 |

**Table B – Clovis-Villa Site**

| Statistic | Clovis-Villa PurpleAir #1 | Clovis-Villa PurpleAir #2 | Clovis-Villa PurpleAir #3 |
|---|---|---|---|
| FEM Avg. 24-hr | 7.4 | 7.5 | 7.4 |
| Sensor Avg. 24-hr | 7.8 | 9.0 | 15.6 |
| FEM Max 1-hr | 30.7 | 30.7 | 48 |
| Sensor Max 1-hr | 37.8 | 47.6 | 178.4 |
| FEM Max 24-hr | 19.6 | 20.1 | 19.36 |
| Sensor Max 24-hr | 23.4 | 23.3 | 35.1 |
| 1-hr $R^2$ | 0.4769 | 0.3204 | 0.0691 |
| 1-hr Slope | 0.8936 | 0.8938 | 0.7714 |
| 1-hr Intercept | +1.2356 | +2.5077 | +9.872 |
| 24-hr $R^2$ | 0.6657 | 0.5537 | 0.4093 |
| 24-hr Slope | 1.1243 | 1.1018 | 1.1762 |
| 24-hr Intercept | -0.4575 | +0.7655 | +6.7509 |

**Table C – South Central Fresno and Shafter Sites**

| Statistic | South Central Fresno | Shafter |
|---|---|---|
| FEM Avg. 24-hr | 12.0 | PurpleAir sensor at this site did not report during this period |
| Sensor Avg. 24-hr | 7.2 | |
| FEM Max 1-hr | 71.5 | |
| Sensor Max 1-hr | 46.1 | |
| FEM Max 24-hr | 25.3 | |
| Sensor Max 24-hr | 23.4 | |
| 1-hr $R^2$ | 0.3141 | |
| 1-hr Slope | 0.5226 | |
| 1-hr Intercept | 1.0261 | |
| 24-hr $R^2$ | 0.4734 | |
| 24-hr Slope | 0.6893 | |
| 24-hr Intercept | 0.9912 | |