Technical Evaluation of Sensor Technology (TEST) Program

PurpleAir PA-II Sensor
2021 – 1st 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.

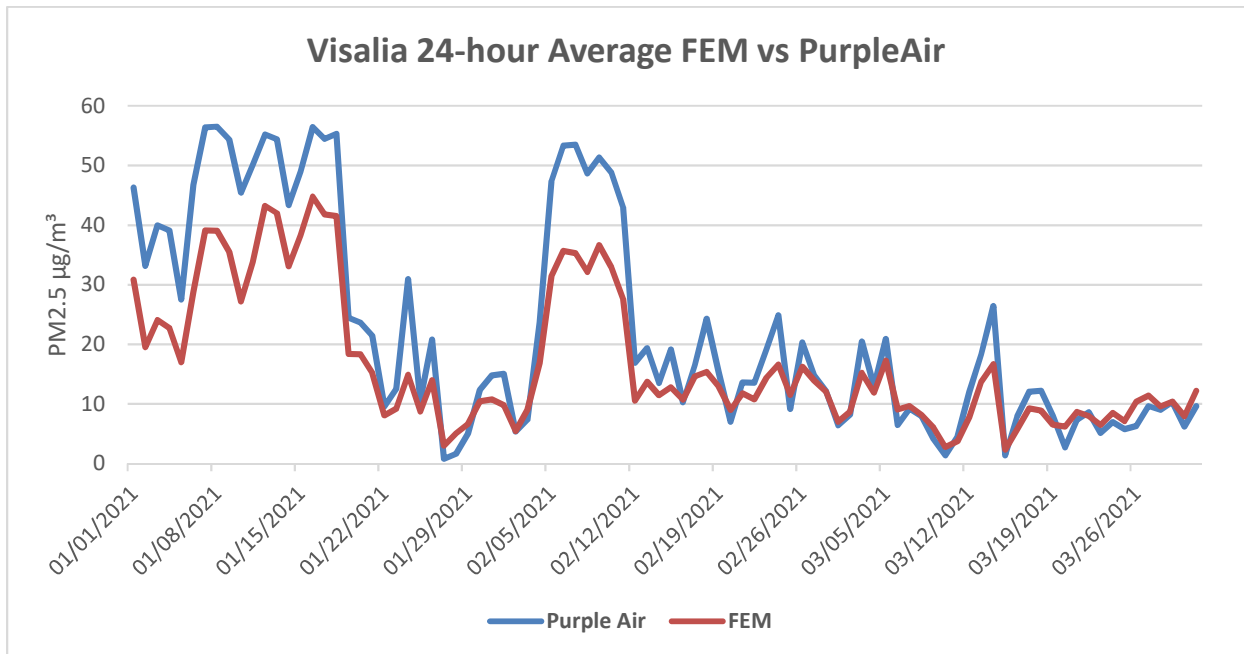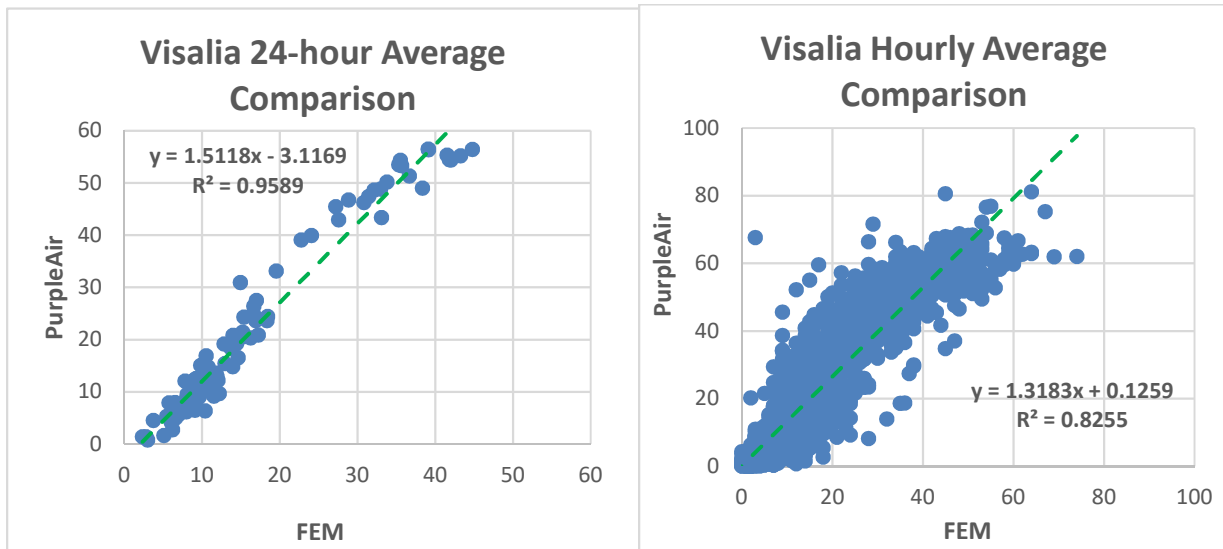### Overview of Analysis Findings from Current Period

The analysis for this report covers the time period of January 1, 2021, through March 31, 2021 (2021 – 1st 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. Generally, California's weather pattern is characterized by high pressure systems and low pressure systems that move through the region every two to four days in alternating fashion, however the beginning of the quarter did not start out that way. The first 2 ½ weeks of January were dominated by strong high pressure which kept PM2.5 concentrations elevated during that period. By the third week of January, the weather pattern became more active as low pressure systems began making their way into California. With the exception of a four day stretch of stable conditions during early February, an alternating pattern of high and low pressures systems rendered overall better dispersion conditions across the Valley through the end of the quarter. Indeed, the high pressure systems that developed over the region during February and March were weaker and short-lived compared to those that dominated during January. Thus PM2.5 levels had decreased significantly by the time quarter one ended.

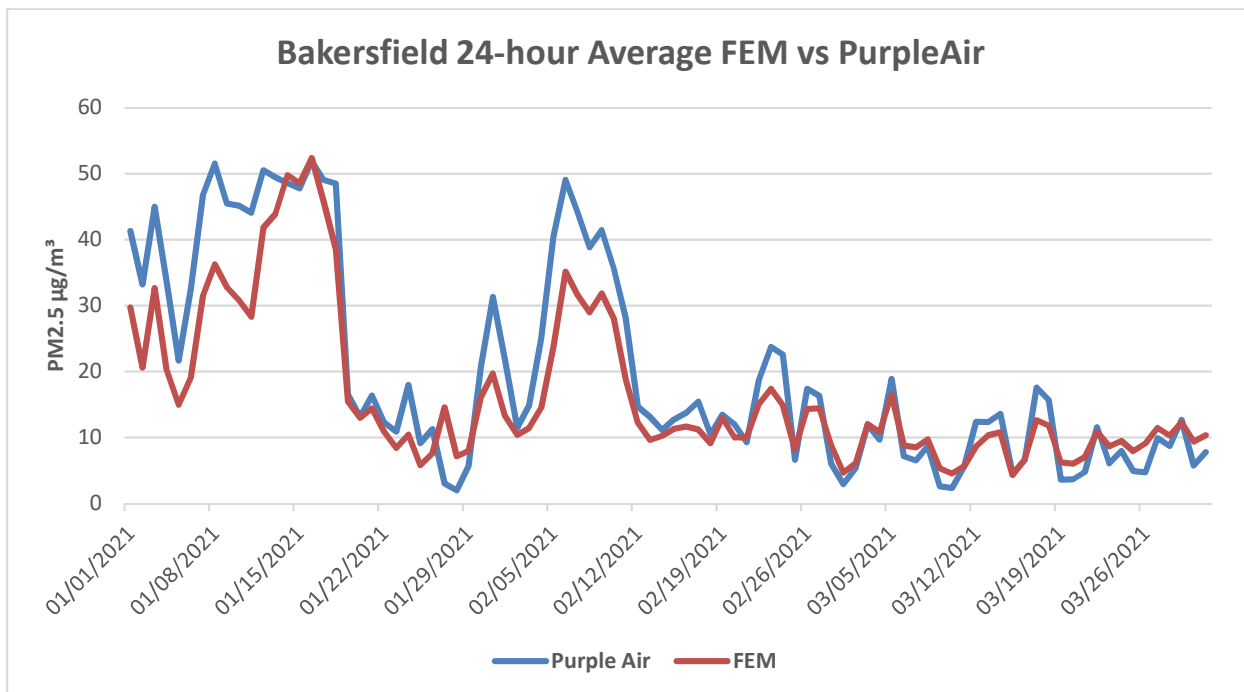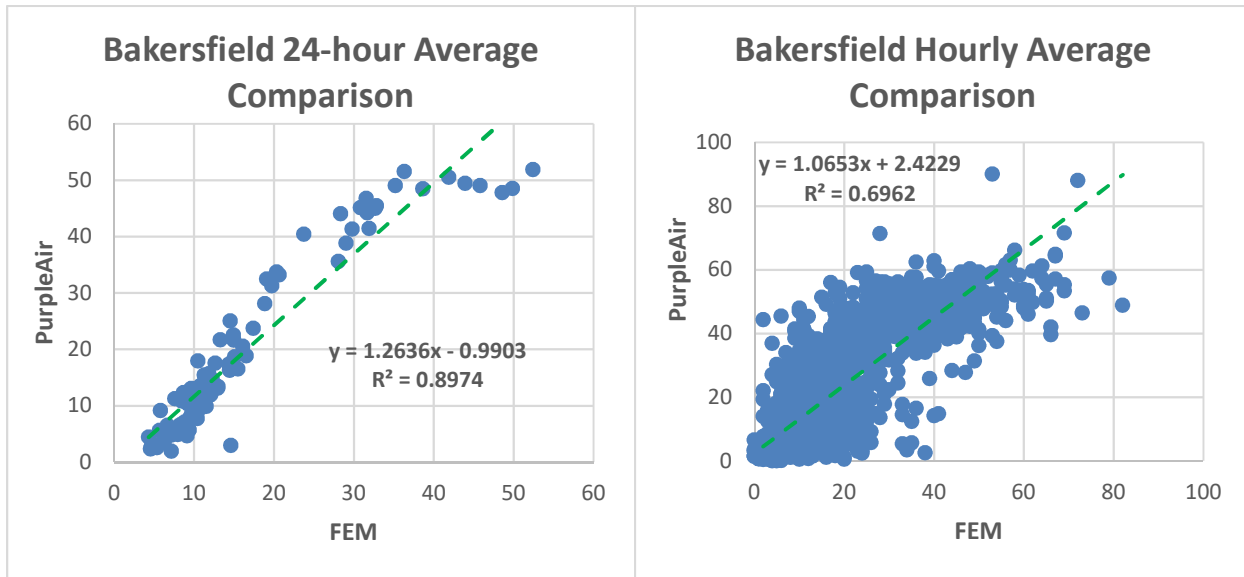## *Site Specific Analysis of PurpleAir PA-II Sensor Performance*

Visalia-Church

For the 24-hour average, PurpleAir data had a 5.5 µg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 5.5 µg/m³ over the same period.

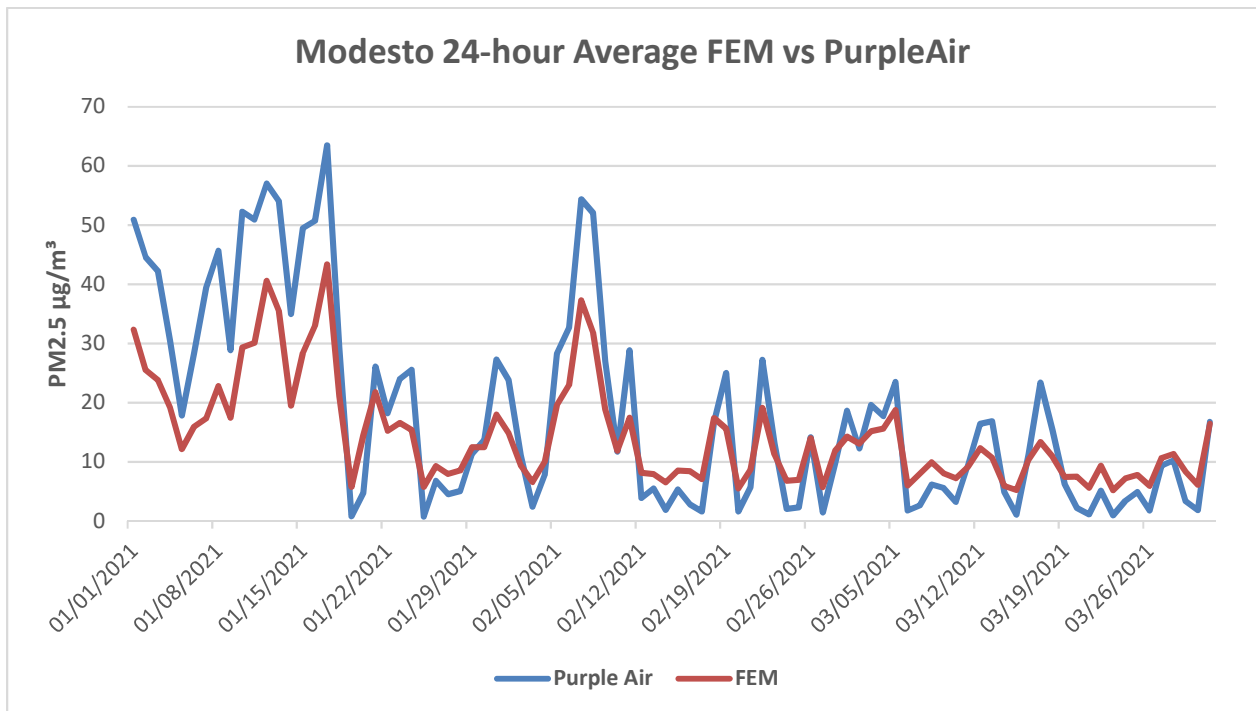### Visalia 24-hour Average Comparison

$y = 1.5118x - 3.1169$
$R^2 = 0.9589$

Visalia Hourly Average Comparison

$y = 1.3183x + 0.1259$
$R^2 = 0.8255$

Visalia 24-hour Average FEM vs PurpleAir

Purple Air   FEM

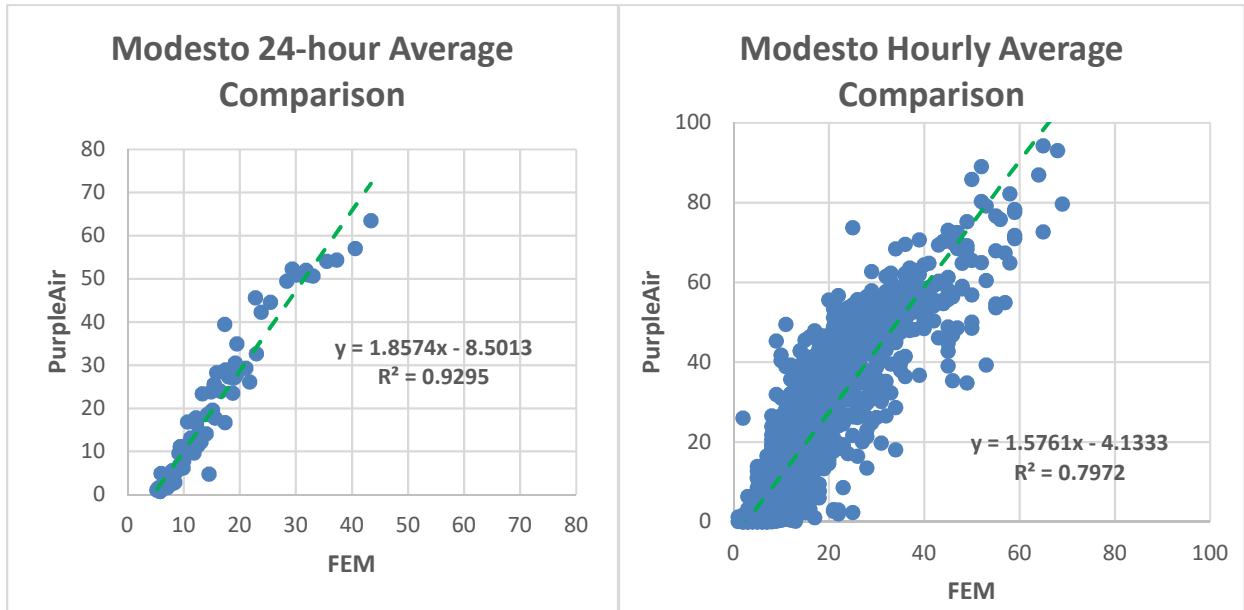**Bakersfield-California**

For the 24-hour average, PurpleAir data had a 3.4 µg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a High bias of 3.4 µg/m³ over the same period.
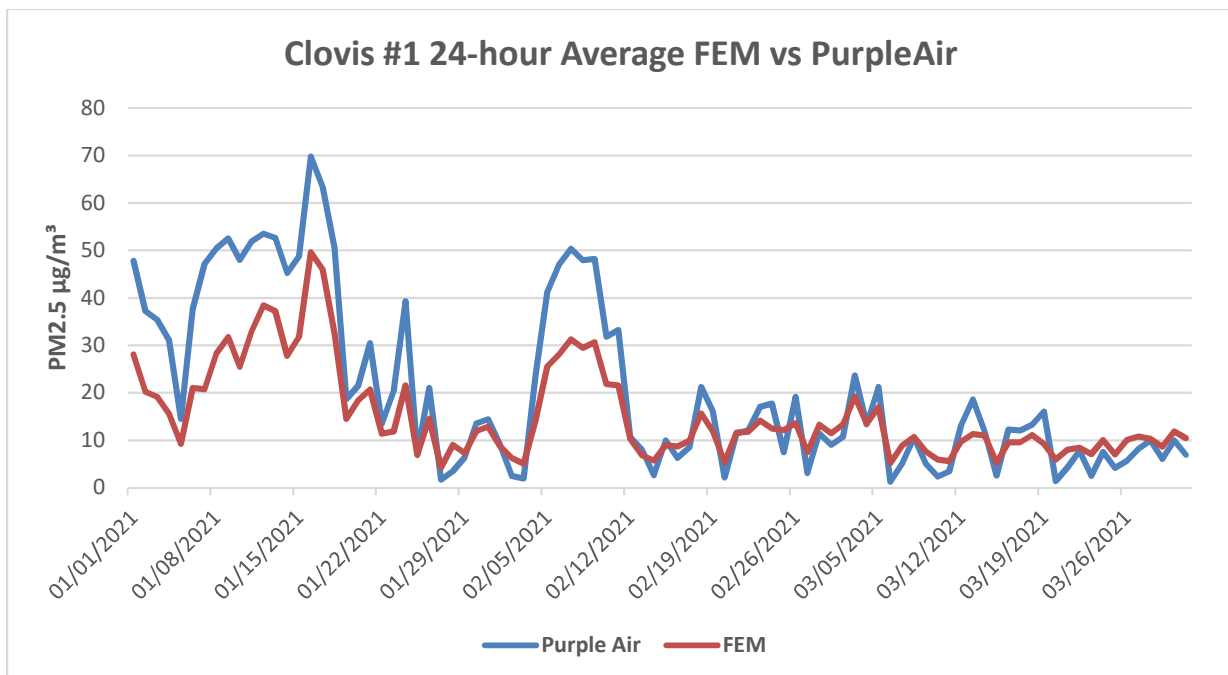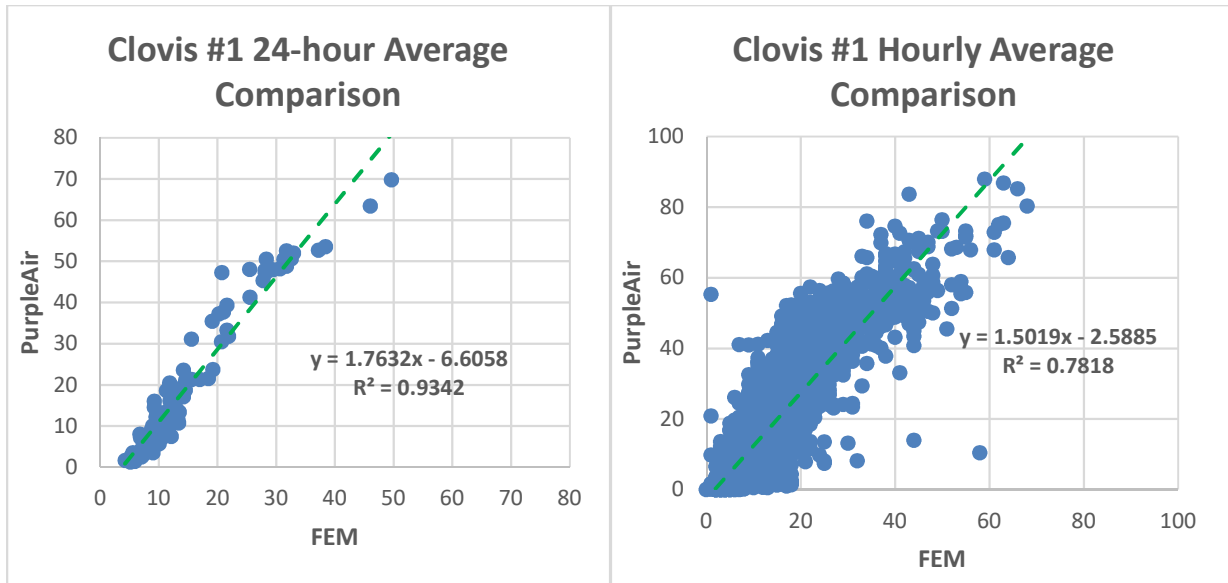
Modesto-14th St.

For the 24-hour average, PurpleAir data had a 3.7 µg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 3.7 µg/m³ over the same period.

Modesto 24-hour Average Comparison

$y = 1.8574x - 8.5013$
$R^2 = 0.9295$

Modesto Hourly Average Comparison

$y = 1.5761x - 4.1333$
$R^2 = 0.7972$

Modesto 24-hour Average FEM vs PurpleAir

Clovis-Villa #1

For the 24-hour average, PurpleAir data had a 5.2 µg/m^3 high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 5.2 µg/m^3 over the same period.

Clovis-Villa #2
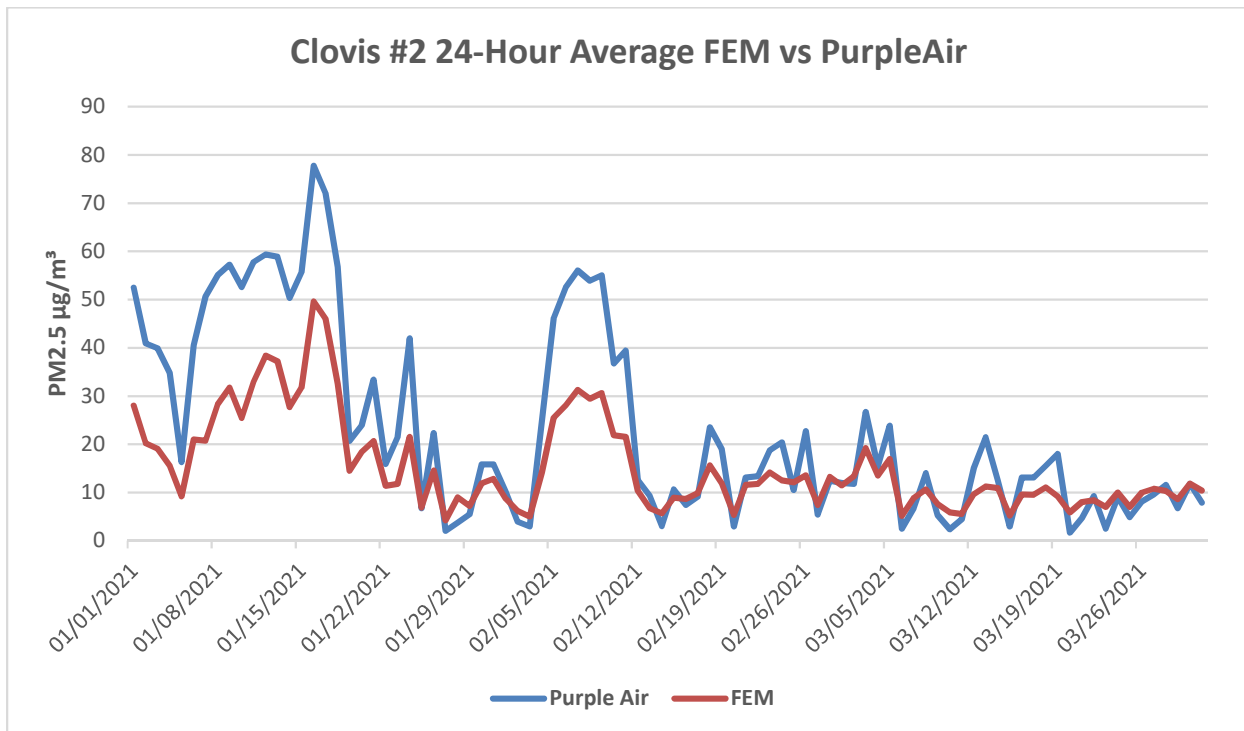
For the 24-hour average, PurpleAir data had a 7.7 μg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 7.7 μg/m³ over the same period.

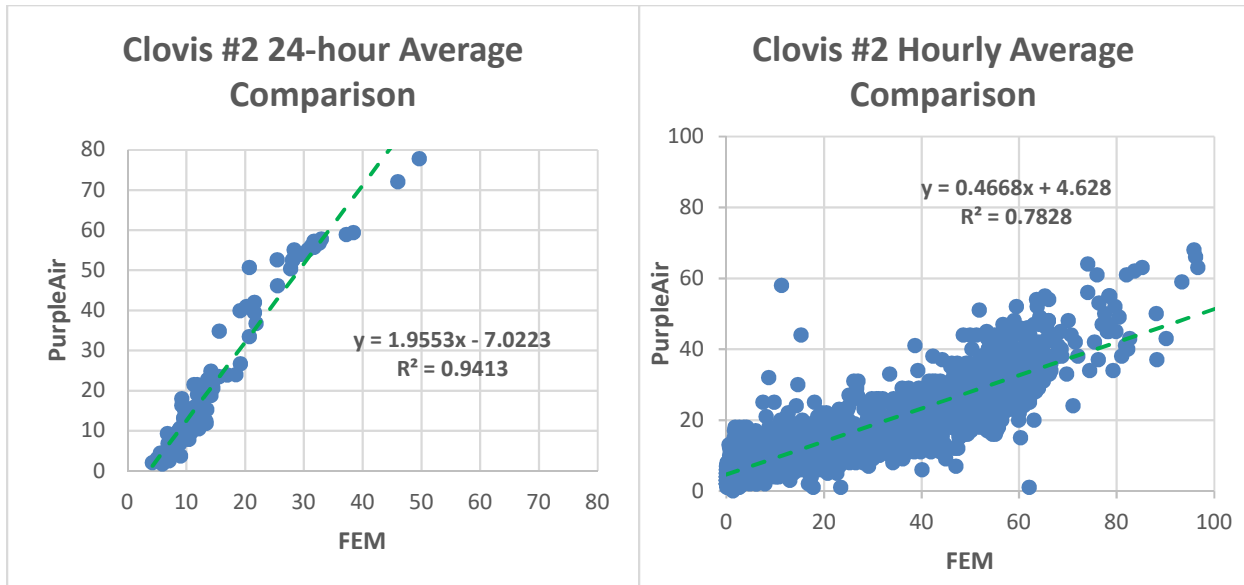**Clovis #2 24-hour Average Comparison**

$y = 1.9553x - 7.0223$
$R^2 = 0.9413$

Clovis #2 Hourly Average Comparison

$y = 0.4668x + 4.628$
$R^2 = 0.7828$

Clovis #2 24-Hour Average FEM vs PurpleAir

Purple Air   FEM

Clovis-Villa #3

For the 24-hour average, PurpleAir data had a 14.4 µg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 14.5 µg/m³ over the same period.
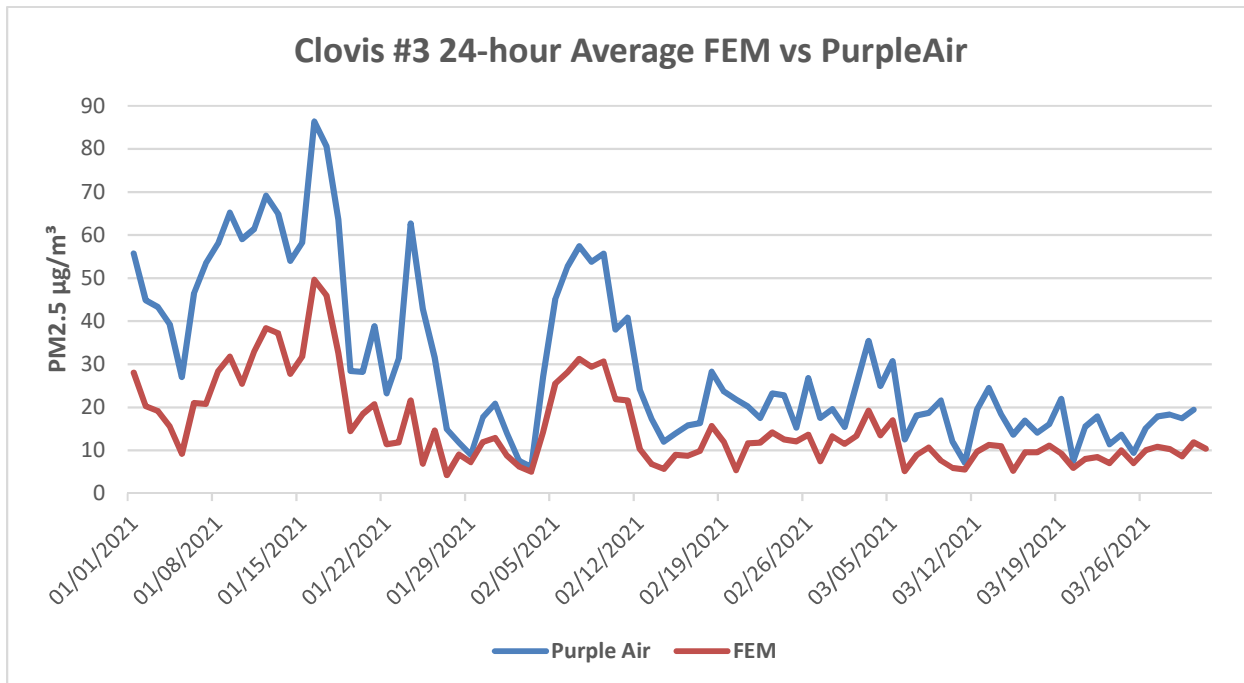
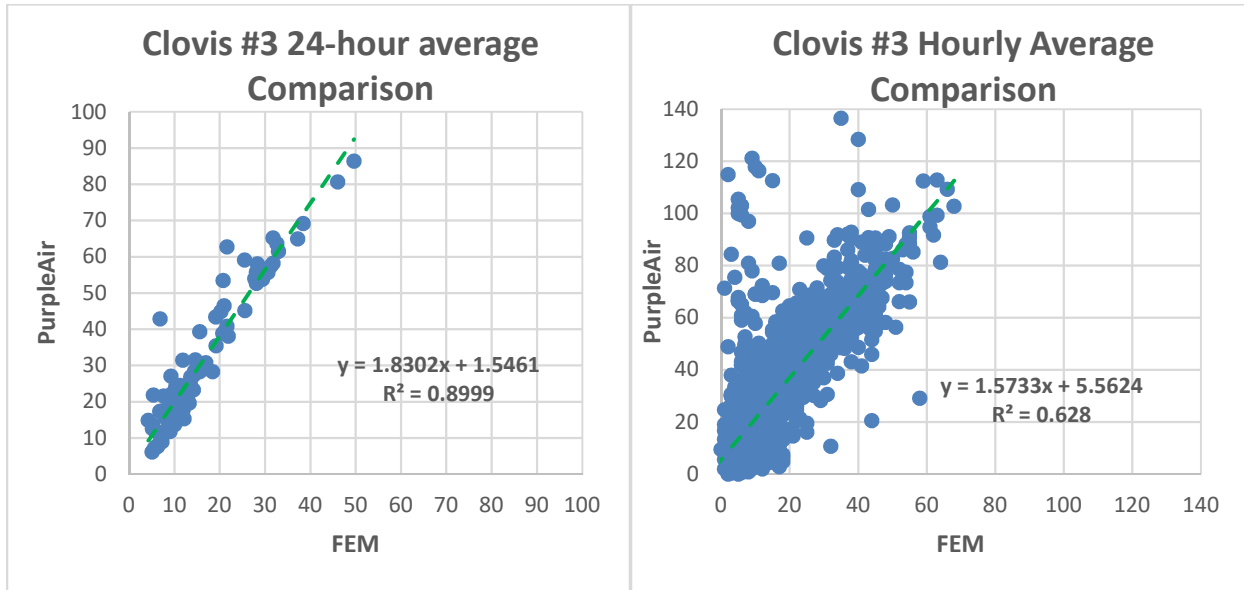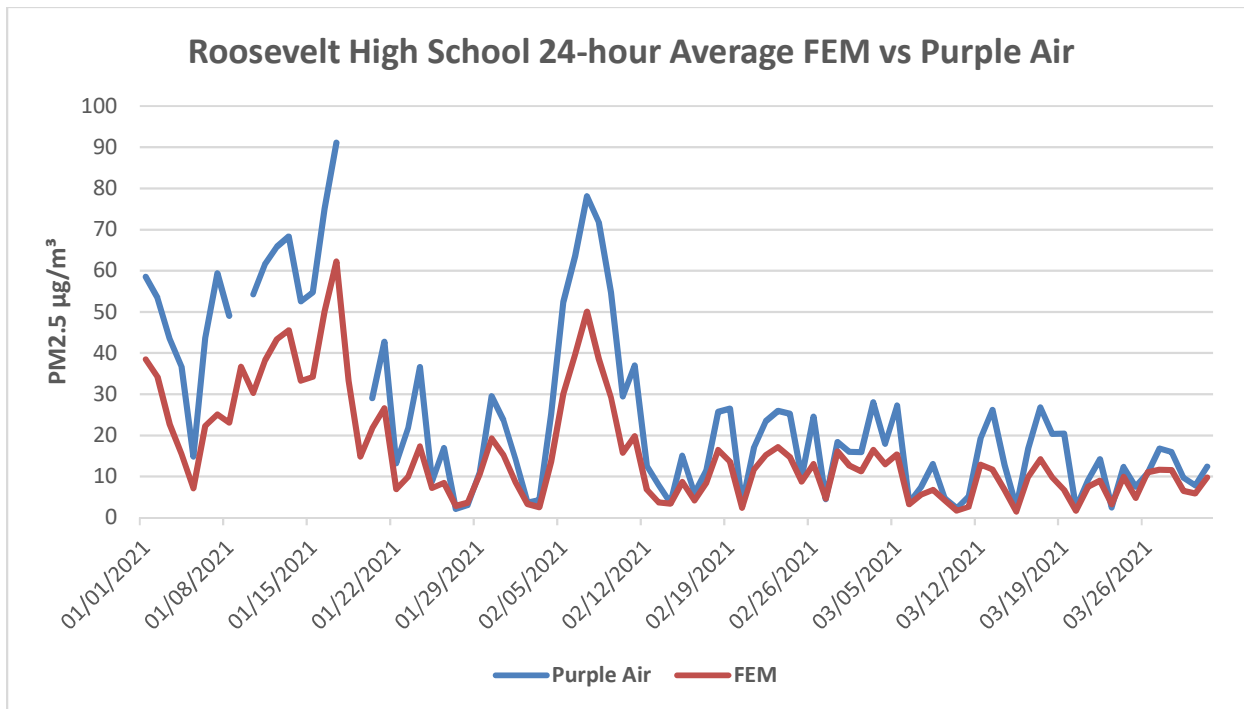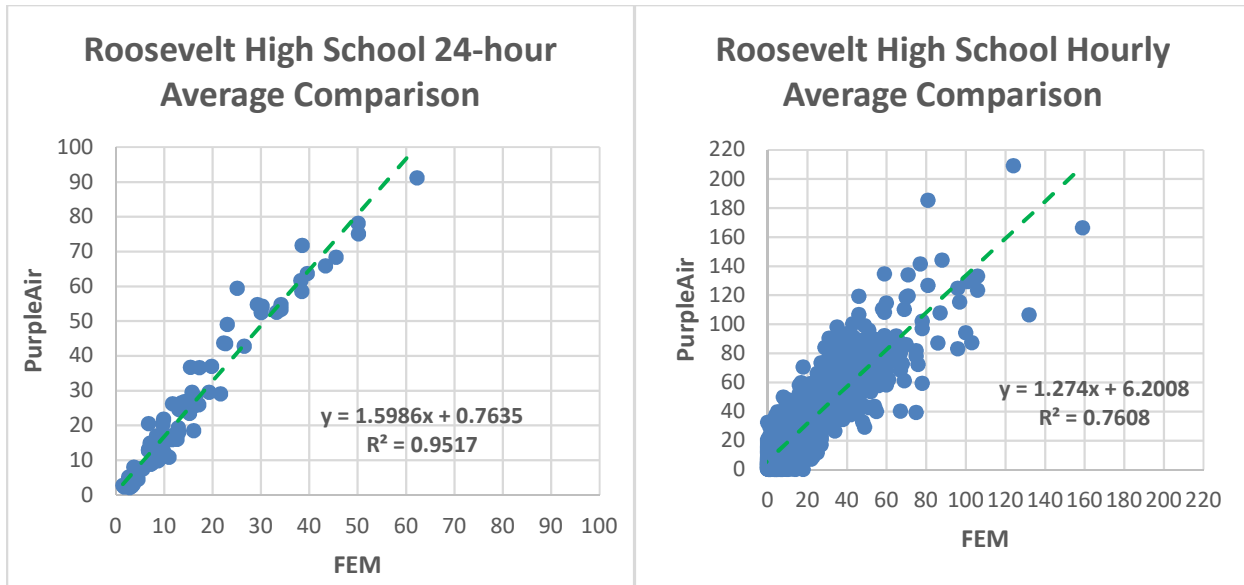**South Central Fresno – Roosevelt High School**

For the 24-hour average, PurpleAir data had a 9.6 µg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 9.4 µg/m³ over the same period.

Roosevelt High School 24-hour Average Comparison

$$y = 1.5986x + 0.7635$$
$$R^2 = 0.9517$$

Roosevelt High School Hourly Average Comparison

$$y = 1.274x + 6.2008$$
$$R^2 = 0.7608$$

Roosevelt High School 24-hour Average FEM vs Purple Air

Purple Air   FEM

Shafter #2

For the 24-hour average, PurpleAir data had a 13.6 µg/m³ high bias during the January 1, 2021, through March 31, 2021, period. For the hourly average, PurpleAir data had a high bias of 13.6 µg/m³ over the same period.

Non-Reporting Sites
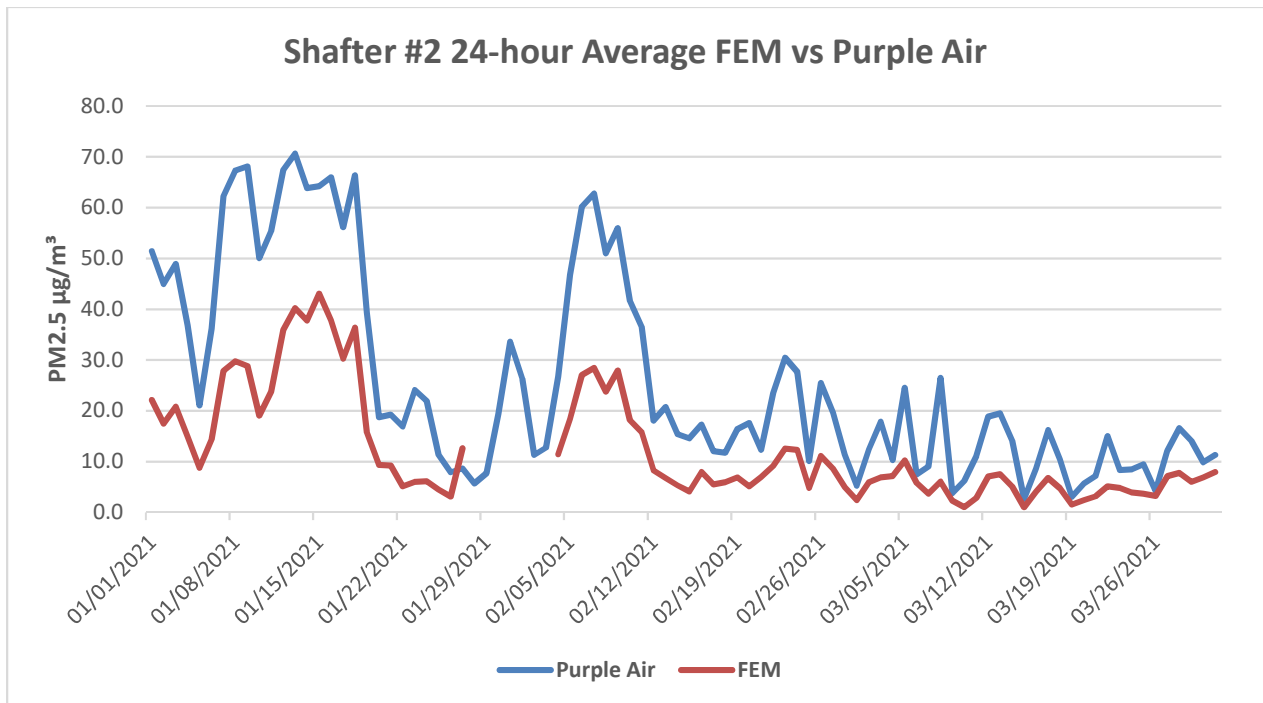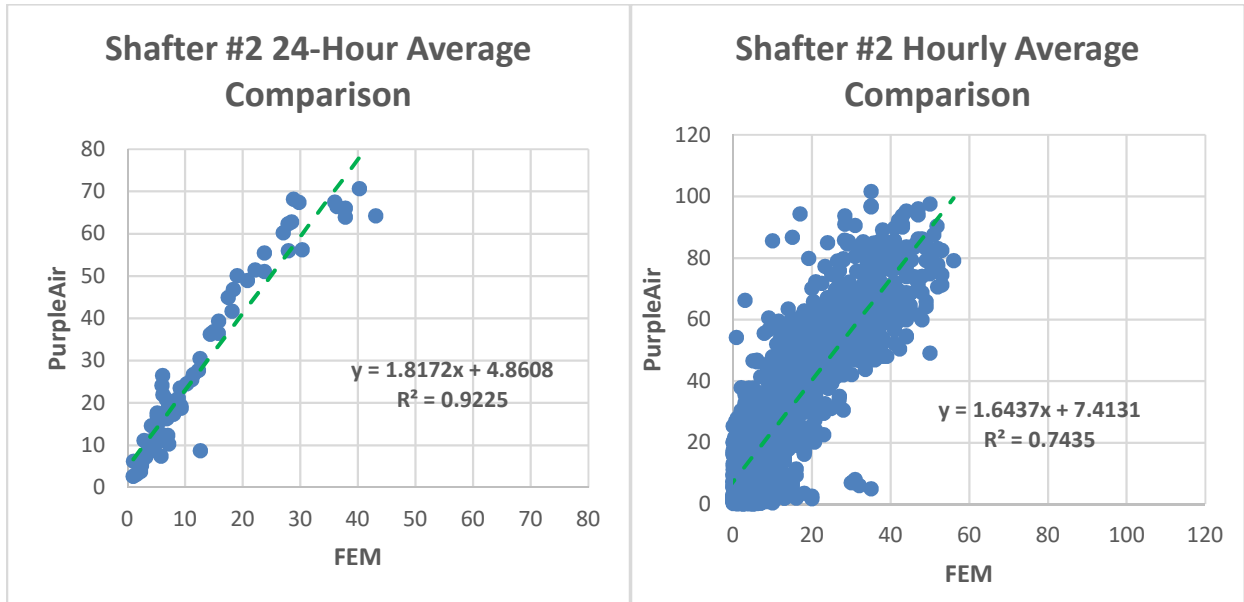
Fresno-Garland
Data from this sensor was not available for the January 1, 2021, through March 31, 2021, period. This sensor will be included in future analysis reports if the data becomes available.

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		16.8	16.6	14.5
Sensor Avg. 24-hr		22.3	20.0	18.2
FEM Max 1-hr		74.0	90.0	69.0
Sensor Max 1-hr	PurpleAir sensor at this site did not report during this period	81.10	90.11	94.20
FEM Max 24-hr		44.8	52.4	43.4
Sensor Max 24-hr		56.5	51.9	63.5
1-hr R^2		0.8255	0.6962	0.7972
1-hr Slope		1.3183	1.0653	1.5761
1-hr Intercept		0.1259	2.4229	-4.1333
24-hr R^2		0.9589	0.8974	0.9295
24-hr Slope		1.5118	1.2636	1.8574
24-hr Intercept		-3.1169	0.9903	-8.5013

Table B – Clovis-Villa Site

Statistic	Clovis-Villa PurpleAir #1	Clovis-Villa PurpleAir #2	Clovis-Villa PurpleAir #3
FEM Avg. 24-hr	15.4	15.4	15.4
Sensor Avg. 24-hr	20.6	23.1	29.9
FEM Max 1-hr	68.0	68.0	68.0
Sensor Max 1-hr	87.9	107.39	136.47
FEM Max 24-hr	49.6	49.6	49.6
Sensor Max 24-hr	69.8	77.8	86.4
1-hr R^2	0.7800	0.7828	0.6280
1-hr Slope	1.5019	0.4668	1.5733
1-hr Intercept	-2.5900	4.6280	5.5624
24-hr R^2	0.9300	0.9413	0.8999
24-hr Slope	1.7632	1.9553	1.8302
24-hr Intercept	-6.6058	-7.0223	1.5461

Table C – South Central Fresno and Shafter Sites

Statistic	South Central Fresno	Shafter
FEM Avg. 24-hr	16.0	12.2
Sensor Avg. 24-hr	25.6	25.8
FEM Max 1-hr	159.0	56.0
Sensor Max 1-hr	209.10	101.55
FEM Max 24-hr	62.30	43.10
Sensor Max 24-hr	91.10	70.70
1-hr R^2	0.7608	0.7435
1-hr Slope	1.2740	1.644
1-hr Intercept	6.2008	7.413
24-hr R^2	0.9517	0.9225
24-hr Slope	1.5986	1.8172
24-hr Intercept	0.7635	4.8608