

# CITIZEN SCIENCE AIR MONITOR (CSAM)



## Operating Procedures



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## Introduction

### Citizen Science Air Monitor (CSAM)

The Citizen Science Air Monitor (CSAM) is an air monitoring system designed for measuring nitrogen dioxide (NO<sub>2</sub>) and particulate matter (PM) pollutants simultaneously. This self-contained system consists of a CairPol CairClip NO<sub>2</sub> sensor, a Thermo Scientific *personal* DataRAM PM<sub>2.5</sub> monitor, and a Honeywell temperature and relative humidity (RH) sensor. The CSAM's design provides for easy data retrieval from all three devices in a single step through a key-lock access door.

These operating procedures explain what you need to do to collect quality data using the CSAM for your monitoring project. Two sets of procedures are detailed here. Procedures for verifying proper operation of the CSAM are provided in Section 1 and should be performed only by an experienced operator. The Section 2 procedures are for the field operation of the CSAM by citizen volunteers.

### Pollutants Measured and Their Sources

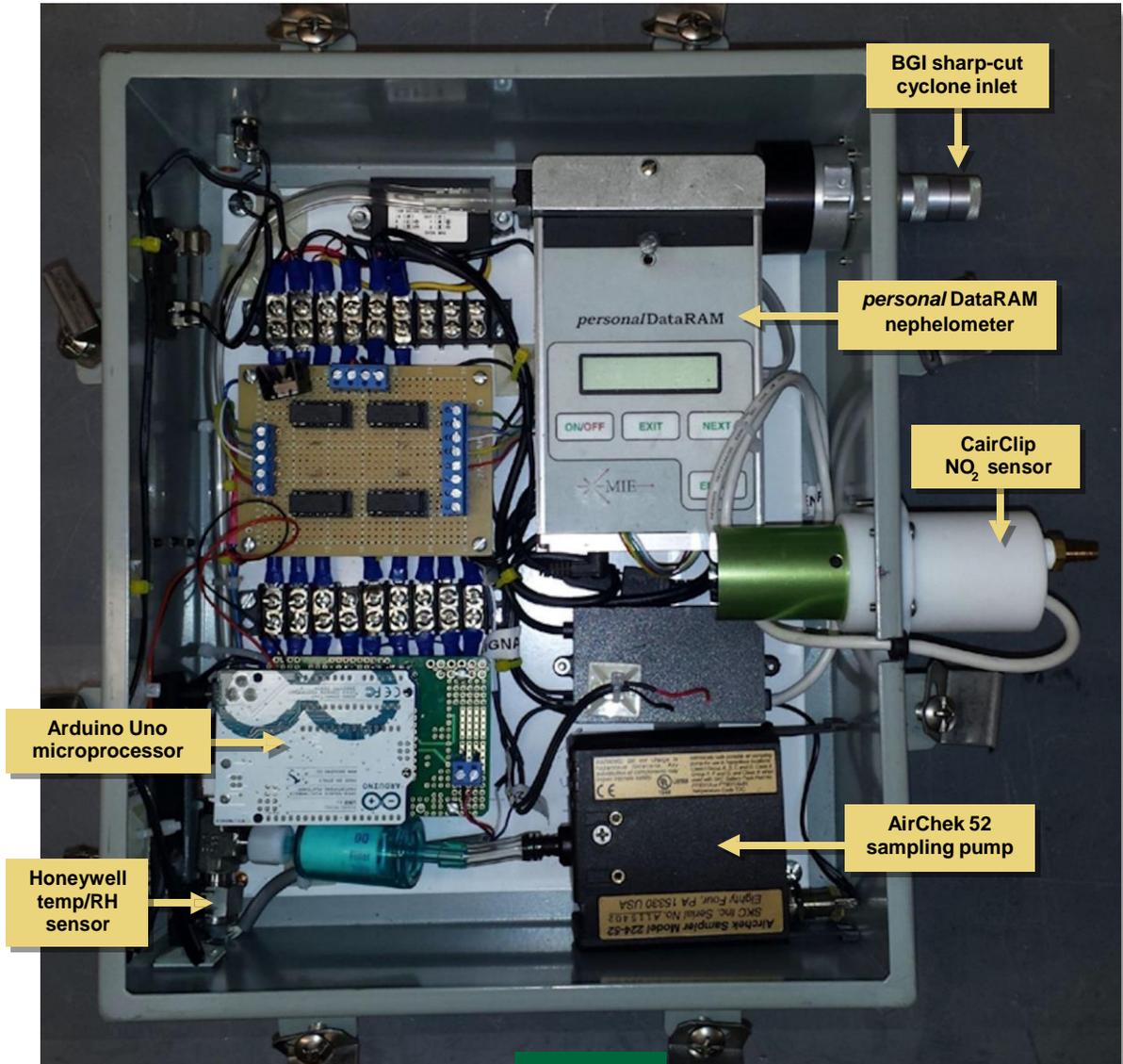
NO<sub>2</sub> is a highly reactive gas that can irritate the lungs and cause bronchitis, pneumonia, and other respiratory problems. NO<sub>2</sub> pollution is both man-made and naturally occurring. It occurs naturally as a result of atmospheric processes. It also forms from fuel combustion and forms quickly from automobile emissions. Therefore, significant increases in NO<sub>2</sub> concentrations are often found near major roadways. Power plants and other industrial processes also emit NO<sub>2</sub>.

PM consists of particles of various sizes such as soot, smoke, dirt, and dust. These particles are often generated and released into the air from sources such as power plants, industrial and agricultural processes, automobiles, and fires. PM can adversely affect breathing and aggravate respiratory and cardiovascular conditions, with the smallest particles posing the greatest health risk. PM also contributes to atmospheric haze that reduces visibility.

For more information on these air pollutants visit the U.S. Environmental Protection Agency's Web site at <http://www.epa.gov/airquality/urbanair/>.

### CSAM Components

Figure 1 shows the inside of the CSAM and its separate components. Each component is detailed in the following subsections. The experienced operators conducting the performance checks will need a thorough understanding of these components, while a general familiarity of instrument operation should be sufficient for the citizen volunteer operators, who likely will not need to access the inside of the CSAM. Understanding the components that comprise the CSAM, however, will help the citizen scientists evaluate the quality of collected data and identify operational problems. Table 1 lists the measurement units reported by each component.



**Figure 1**

Measurement	Reporting Unit
NO <sub>2</sub> concentration	Parts per billion (ppb)
PM concentration	Micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ )
Temperature	Degrees Celsius ( $^{\circ}\text{C}$ )
Relative humidity (RH)	Percent (%) at $^{\circ}\text{C}$

**Table 1**

## CSAM-NO<sub>2</sub>

CSAM measurements of NO<sub>2</sub> are made using a CairPol CairClip NO<sub>2</sub> sensor. The CairClip uses a gas-specific inlet filter combined with dynamic air sampling in an integrated system to measure real-time gas concentration in parts per billion (ppb). The CSAM-NO<sub>2</sub> unit's detection limit—the lowest concentration the instrument is likely to detect—is approximately 20 ppb NO<sub>2</sub>.

## CSAM-PM

The CSAM-PM component measures real-time PM in micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) using a Thermo Scientific *personal* DataRAM nephelometer, a device that uses light to measure the concentration of suspended particles in a liquid or gas. Air is pumped to the nephelometer by an SKC AirChek 52 personal sampling pump. The nephelometer uses a BGI sharp-cut cyclone inlet (SCC 1.062), which excludes particles with a diameter above a certain size. In this case, the CSAM-PM samples for PM<sub>2.5</sub>, which consists of particles less than 2.5 micrometers in diameter, or “fine” particles. Fine particles come from all types of combustion activities, such as motor vehicles, power plants, and wood burning, and pose the greatest health risk because they can lodge deeply in the lungs. The CSAM-PM unit operates at a flow rate of 1.5 liters per minute (L/min). It is important to understand that a change in flow rate will change the diameter of the particles being sampled and thus affect data quality. If a change in flow rate is noted, the unit should be removed from operation, and an experienced operator should perform the flow rate check and adjustment detailed in Section 1. The CSAM-PM has a detection limit of 0.1  $\mu\text{g}/\text{m}^3$ .

## Temperature and Relative Humidity

The CSAM also contains a Honeywell temperature and RH sensor (HIH-4602-A/C series). Temperature (°C) and RH (% at °C) data are recorded along with the PM and NO<sub>2</sub> concentration data. The recommended CSAM operating ranges for temperature and RH are 32–104 °F and 0–90% RH (with no formation of water droplets), respectively. Abrupt changes in temperature and RH can affect the performance of your CSAM, particularly the CSAM-NO<sub>2</sub> sensor component. Therefore, temperature and RH data collected concurrently with concentration data can help you recognize any performance issues caused by environmental conditions.

## Microprocessor

Data from all components—PM, NO<sub>2</sub>, and temperature and RH—are collected and stored using an Arduino Uno microprocessor. The Arduino Uno has a USB connection and a power jack. This microprocessor uses software developed by EPA to allow operators to retrieve all data from the unit in one easy step. Data will be stored on a secure digital (SD) memory card located in the microprocessor that the citizen operators access and remove for data download as described in Section 2.

## Section 1: Verifying CSAM Performance

**The procedures in this section should be carried out only by an experienced operator.**

The performance checks and maintenance procedure described in this section will help make sure the CSAM produces the desired results during the study. It is recommended that an experienced operator conduct the performance checks before deploying the instrument in the field and after it is removed from the field at the end of the study. In addition, the filter of the CSAM-NO<sub>2</sub> component should be changed by an experienced operator. If at any time a citizen volunteer operator suspects a CSAM is not functioning properly, it should be removed from operation and undergo troubleshooting, maintenance, and performance checks as described in this section.

### What You Will Need

#### Included in CSAM Package

- CSAM
- Secure digital (SD) card (standard size)
- SD card reader
- AC-DC adapter with power supply cable or CSAM battery pack
- USB cable
- Macro-enabled Microsoft Excel spreadsheet created specifically for processing CSAM data (on accompanying CD)
- High-efficiency particulate air (HEPA) filter with tubing attached for PM zero drift check
- Rotameter for flow rate measurement with tubing attached
- CSAM Monitoring Record
- Red dongle (for CairClip maintenance – see procedure)

#### Not Included

- Personal computer (PC) running a Windows operating system (preferably Windows 7 or greater)
- Arduino software (to be downloaded from the Arduino web site – see procedure)
- Microsoft Excel
- Long Phillips screwdriver (for CairClip maintenance – see procedure)
- Flat-head screwdriver (to adjust PM flow rate – see procedure)
- Source of NO<sub>2</sub>
- Teflon tubing (and proper fittings) for NO<sub>2</sub> zero and span drift check

### CSAM Performance Checks

Table 2 identifies the recommended checks—zero and span drift for the CSAM-NO<sub>2</sub>, flow rate and zero drift for the CSAM-PM, temperature, and RH—and the acceptable ranges for accuracy and precision for CSAM applications. Zero and span drift checks verify that the monitor is functioning within the operating range and that it responds with the desired sensitivity to changes in input concentration. The flow rate check verifies the rate at which the sample gas

flows through the instrument. The flow rate is checked using a flow meter to ensure that the monitor is receiving the proper amount of air to yield a representative sample.

Measurement (Sensor)	Performance Check	Accuracy	Precision	Corrective Action (by an Experienced Operator)
NO <sub>2</sub> concentration (CSAM-NO <sub>2</sub> )	Zero/span drift	± 20%	± 20%	Perform calibration and troubleshooting
PM concentration (CSAM-PM)	Flow rate	1.5 L/min ± 10%	± 10%	Adjust set screw on pump
	Zero drift	< 20% of ambient following local aerosol normalization	± 10%	Perform troubleshooting
Temperature/RH (Honeywell sensor)	Compared with local data*	± 5% (temp) ± 10% (RH)	± 2% (temp) ± 5% (RH)	Perform troubleshooting

\*The following web sites are sources of local weather data:  
<http://www.weather.com/weather/hourbyhour//USNJ0355:1:US>  
<http://w1.weather.gov/obhistory/KEWR.html>

**Table 2**

## Software Installation and CSAM Setup

To conduct the performance checks, you must first download and install the Arduino software on a computer and then connect the computer to the CSAM so that the recorded data for each check are available for manual entry at the end of each check.

### Procedure: Download and Install the Arduino Software

1. Go to the Arduino web site at <http://arduino.cc/en/Main/Software> to begin your download.
2. On the **Download** tab (Figure 2), click **Arduino 1.0.6**.
3. On the next screen (Figure 3), click **Windows Installer**.
4. Read the license agreement and click the **I Agree** button (Figure 4).
5. When the **Arduino Setup: Installation Options** window opens (Figure 5), make sure all the boxes are checked and click **Next**. These should already be checked by default.

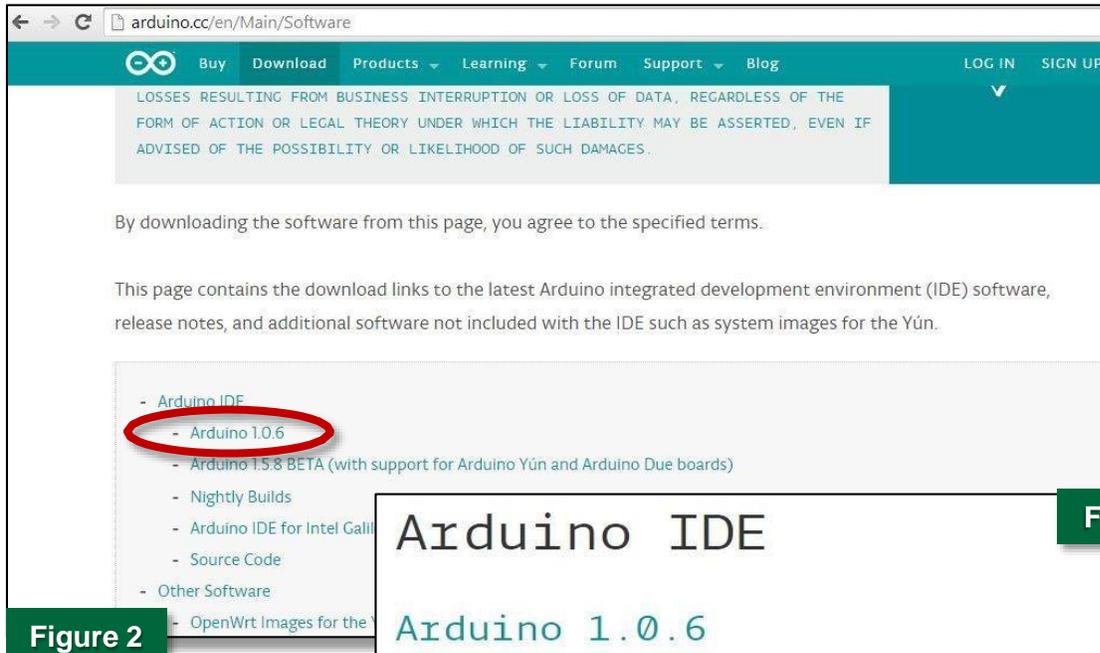


Figure 2



Figure 3

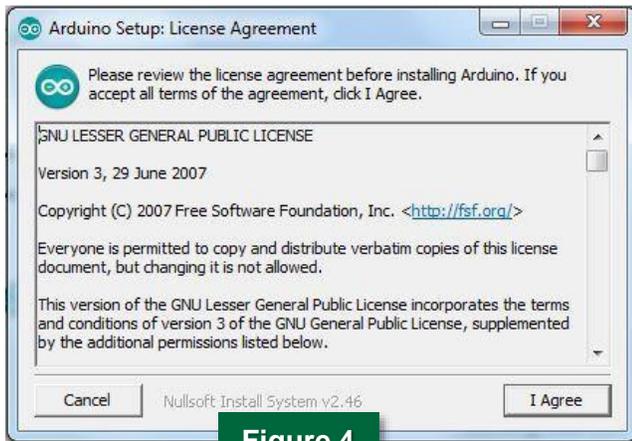


Figure 4

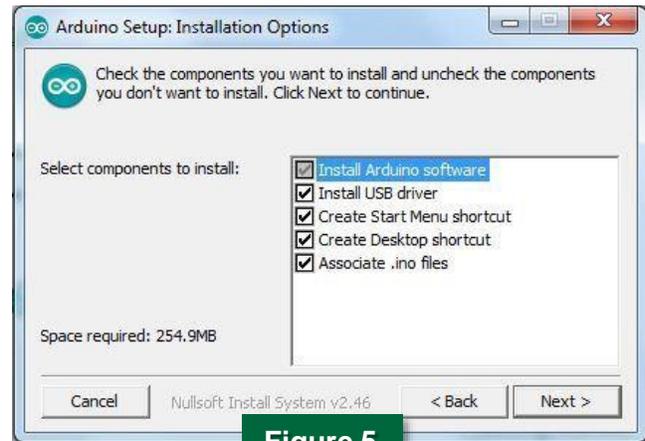


Figure 5

6. In the **Arduino Setup: Installation Folder** window (Figure 6), click **Install** to install the software at the default location.
7. When prompted (Figure 7), click **Install** to complete installation.

Consult the Arduino instructions at [www.Arduino.cc/en/guide/Howto](http://www.Arduino.cc/en/guide/Howto) if you encounter any problems with installation.

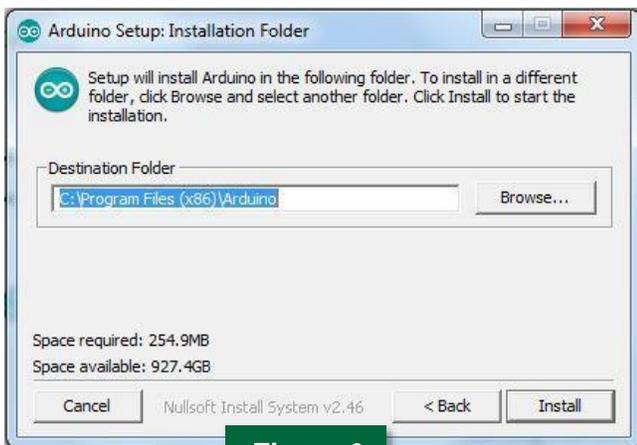


Figure 6



Figure 7

## Procedure: Set Up the CSAM

1. Turn on the CSAM by plugging the power supply cable into the CSAM and connect to a wall outlet with the AC adaptor or to the battery case as shown in Figure 8.
2. Open the access door (Figure 9) and make sure the SD card is in the SD card slot (Figure 10).

**Note:** The access door switch, as shown in Figure 10, detects when the door is opened and shuts down the power to the unit. You will need to apply consistent pressure to the switch to simulate the door being closed. This can be done by wedging folded up paper between the switch and the case.

## Cautions

- ❖ Always get rid of static electricity before touching electronics by touching a metal object such as the CSAM case. Certain clothing (e.g., wool sweaters) are known to generate static electricity.
- ❖ Do not touch circuitry or wiring while the CSAM is running.

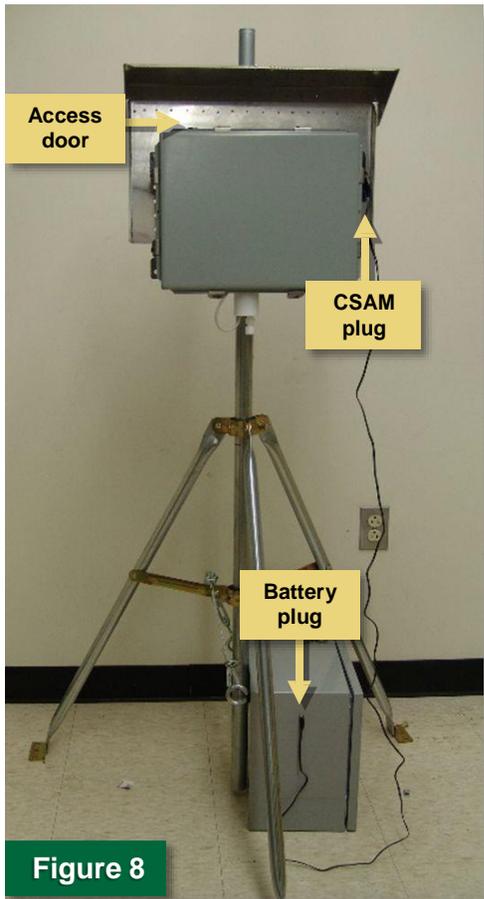


Figure 8

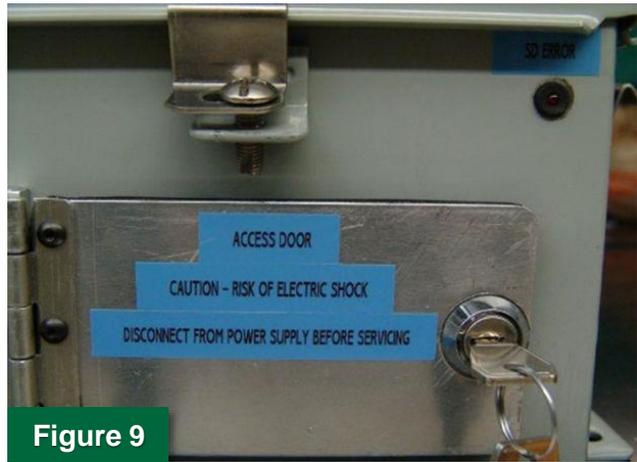


Figure 9

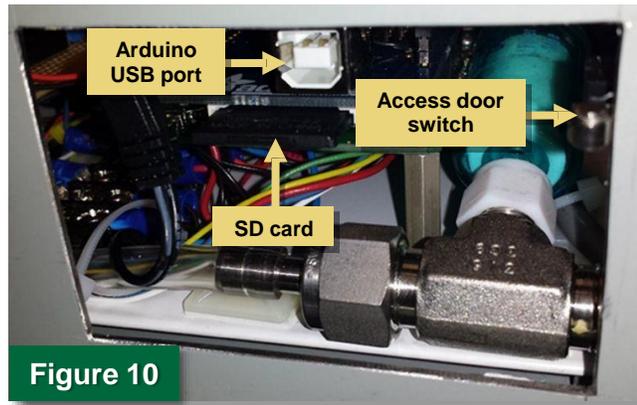
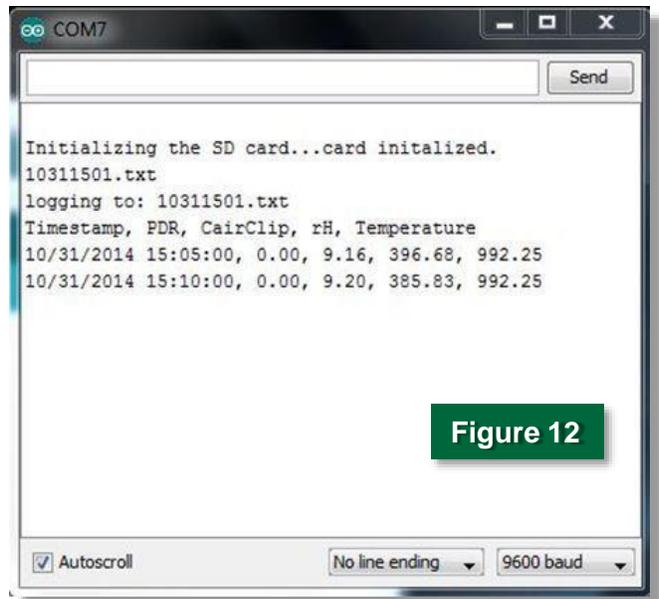
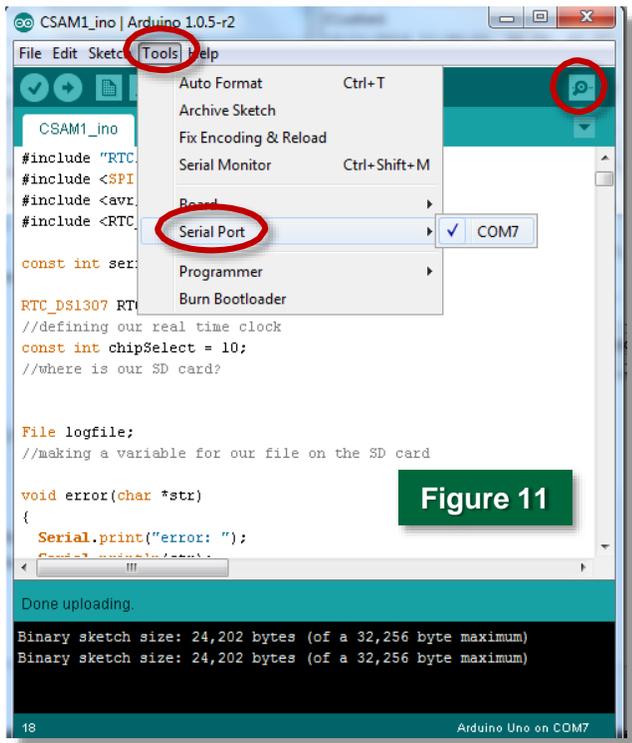


Figure 10

3. Connect a USB cable to the Arduino USB port (Figure 10) and to a computer with the Arduino software.
4. Launch the Arduino software by clicking on the Windows desktop icon that was created during installation.
5. On the **Tools** tab, click **Serial Port** in order for the software to detect the connected CSAM (Figure 11).
6. Click the magnifying glass in the top right corner (Figure 11) to open a window where the data are reported on the screen in 5-minute averages, as shown in Figure 12.



The CSAM is now ready to record performance-check data as described in the following procedures.



## Recording Performance Check Data

A CD with a Microsoft Excel macro-enabled spreadsheet, **CSAM Data Analysis [Serial No. XX].xlsm**, accompanies each CSAM (Figure 13). The CSAM unit's two-digit serial number is part of the file name so that the spreadsheet can easily be matched with its associated unit if more than one CSAM is deployed in the field.

This spreadsheet was created specifically for entering CSAM performance-check data and processing field data relative to the performance data. It is recommended that acceptable performance of each CSAM unit be verified at the beginning and the end of the study, and space is provided for both start and end checks. However, if no check is performed at the end of the study, the processing macro, activated by clicking the **Load Data, Perform Calculations, Graph Processed Data** button, will assume that both start and end check data are identical.

Each sensor—PM, NO<sub>2</sub>, and temperature/RH—has four cells associated with it:

- ❖ **Zero/Low Voltage:** sensor output in millivolts (mV) while sensor is exposed to zero or a very low level of what the sensor measures.
- ❖ **Zero/Low Set Point:** concentration corresponding to the zero/low voltage output.
- ❖ **Span Voltage:** sensor output at 80% of its full measurement range in millivolts.
- ❖ **Span Set Point:** concentration corresponding to the span voltage output.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	<b>CSAM Unit 04</b>													
2	Start Check Date:													
3														
4	<b>PM</b>			<b>NO<sub>2</sub></b>			<b>Relative Humidity</b>			<b>Temperature</b>				
5	Zero / Low Voltage	<input type="text"/>	mV	Zero / Low Voltage	<input type="text"/>	mV	Zero / Low Voltage	<input type="text"/>	mV	Zero / Low Voltage	<input type="text"/>	mV		
6	Zero / Low Set Point	<input type="text"/>	µg/m <sup>3</sup>	Zero / Low Set Point	<input type="text"/>	ppb	Zero / Low Set Point	<input type="text"/>	%	Zero / Low Set Point	<input type="text"/>	°C		
7	Span Voltage	<input type="text"/>	mV	Span Voltage	<input type="text"/>	mV	Span Voltage	<input type="text"/>	mV	Span Voltage	<input type="text"/>	mV		
8	Span Set Point	<input type="text"/>	µg/m <sup>3</sup>	Span Set Point	<input type="text"/>	ppb	Span Set Point	<input type="text"/>	%	Span Set Point	<input type="text"/>	°C		
9														
10														
11														
12	End Check Date:													
13														
14	<b>PM</b>			<b>NO<sub>2</sub></b>			<b>Relative Humidity</b>			<b>Temperature</b>				
15	Zero / Low Voltage	<input type="text"/>	mV	Zero / Low Voltage	<input type="text"/>	mV	Zero / Low Voltage	<input type="text"/>	mV	Zero / Low Voltage	<input type="text"/>	mV		
16	Zero / Low Set Point	<input type="text"/>	µg/m <sup>3</sup>	Zero / Low Set Point	<input type="text"/>	ppb	Zero / Low Set Point	<input type="text"/>	%	Zero / Low Set Point	<input type="text"/>	°C		
17	Span Voltage	<input type="text"/>	mV	Span Voltage	<input type="text"/>	mV	Span Voltage	<input type="text"/>	mV	Span Voltage	<input type="text"/>	mV		
18	Span Set Point	<input type="text"/>	µg/m <sup>3</sup>	Span Set Point	<input type="text"/>	ppb	Span Set Point	<input type="text"/>	%	Span Set Point	<input type="text"/>	°C		
19														
20														
21	<b>Load Data, Perform Calculations, Graph Processed Data</b>													
22														
23														

**Figure 13**

At the end of each performance check, the experienced operator should manually enter the information into the appropriate spreadsheet cells. It is also recommended that the performance information be recorded in a laboratory notebook and on the CSAM Monitoring Record (see the CSAM Quality Assurance Guidelines). After the performance data has been entered, the citizen scientists can then use the spreadsheet to load and process the collected data. The spreadsheet automatically interprets the voltage data produced by the CSAM and converts it to the measurement units required for processing and analyzing the data (NO<sub>2</sub> [ppb], PM [µg/m<sup>3</sup>], temperature [°C], and RH [% at °C]).

The spreadsheet is locked for editing to prevent accidental modification. While the sheet is locked, only the **Load Data, Perform Calculations, Graph Processed Data** button is functional, and the rest of the sheet cannot be manipulated. Project leaders should use the default password to unlock the file for entering performance-check data and then relock the file, creating a new password, before citizen scientists use it to process the collected field data, as described in the following procedures.

## Procedure: Unlock Spreadsheet

1. On the **Review** tab, click **Unprotect Sheet**, as shown in Figure 14.

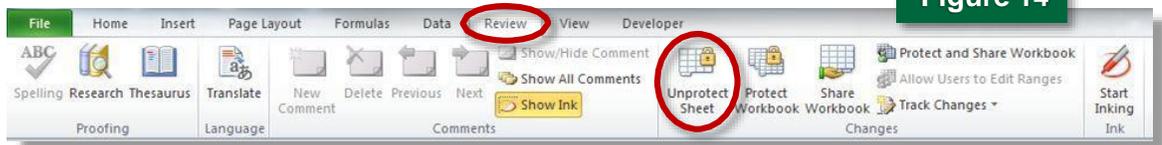


Figure 14

2. When prompted for a password (Figure 15), enter the default password “**CSAMXX**,” where XX is the two-digit serial number of the unit.
3. Click **OK**.



Figure 15

The spreadsheet is now ready for entering data.

## Procedure: Relock Spreadsheet and Create New Password

1. On the **Review** tab, click **Protect Sheet**, as shown in Figure 16.

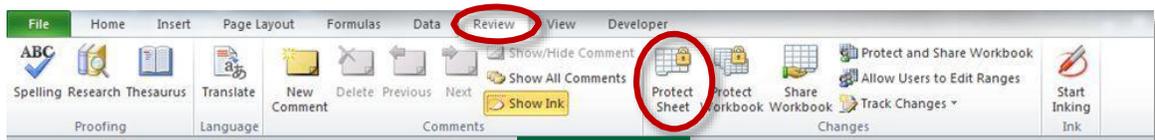


Figure 16

2. In the **Protect Sheet** dialog box, make sure **Select unlocked cells** is checked (Figure 17).
3. Enter a password in the **Password to unprotect sheet** field.
4. Reenter the password when prompted, as shown in Figure 18.

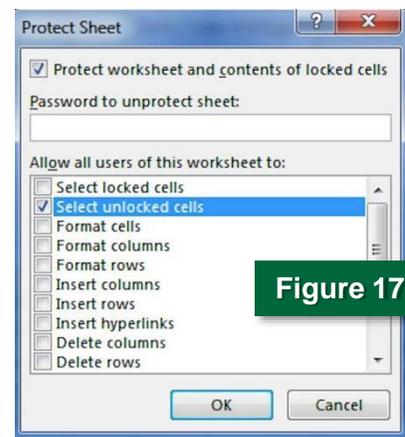


Figure 17

The spreadsheet is now ready for use by the citizen scientists.



## Conducting the Performance Checks

The following procedures are to be performed while the CSAM is running and connected to a computer with the Arduino software installed and open, as described in the CSAM Setup section above, and the **CSAM Data Analysis [Serial No. XX].xism** spreadsheet open. The date of the checks should be typed into the appropriate spreadsheet cell, either **Start Check Date** or **End Check Date**.

During each check, the voltage values (mV) are reported on the Arduino software screen in 5-minute averages, as shown in Figure 19. The voltage values to be entered in the spreadsheet for each check will be the last values listed on the screen at the end of the designated testing period. The PM span voltage and concentration values and all temperature and humidity data are preset in the spreadsheet.

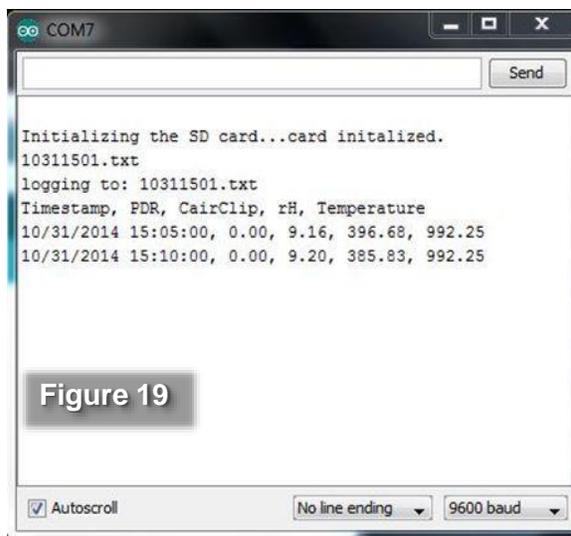


Figure 19

### Procedure: Check CSAM NO<sub>2</sub> Zero and Span

1. Use the supplied tubing to attach the unit to a source of zero air for the zero check (Figure 20) and allow the unit to sample for 15 minutes.
2. Record the final zero voltage and concentration values in the appropriate spreadsheet cells and on the CSAM Monitoring Record or other project documentation.
3. Attach the unit to a source of NO<sub>2</sub> (Figure 20) using Teflon tubing at a concentration that is 80% of full range (upper range limit 250 ppb) for the span check and allow the unit to sample for 15 minutes.
4. Record the final span voltage and concentration values in the appropriate spreadsheet cells and on the CSAM Monitoring Record or other project documentation.
5. If the results do not meet the quality assurance requirements listed in Table 2, return the CairPol CairClip to the manufacturer for calibration.

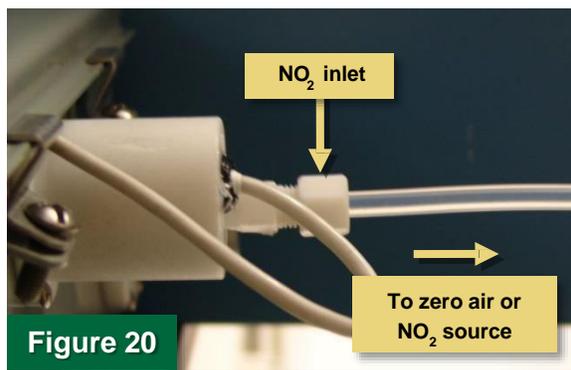
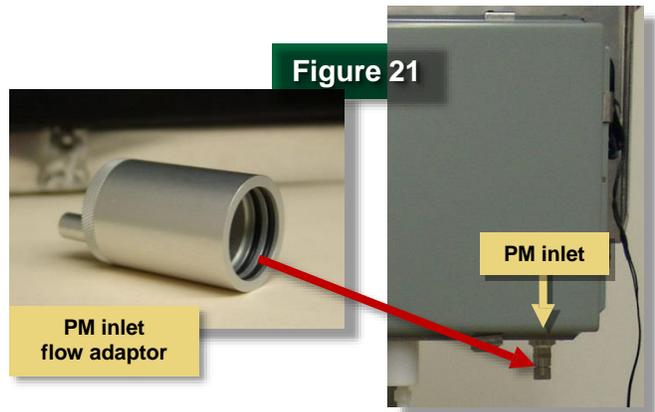


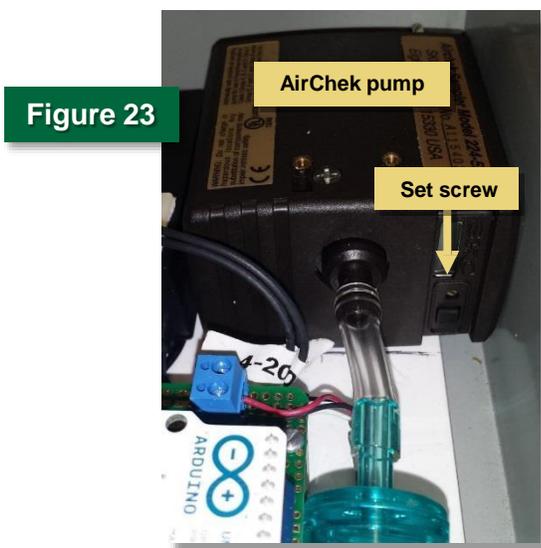
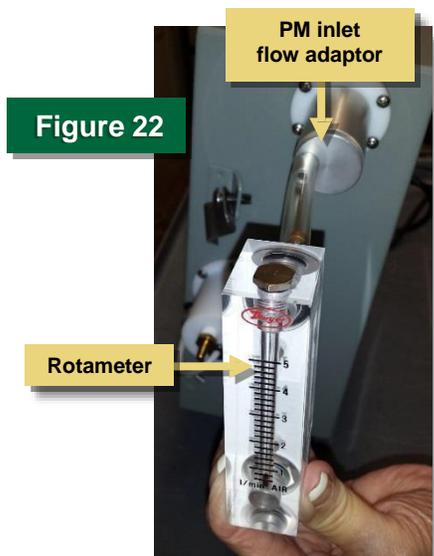
Figure 20

## Procedure: Check CSAM PM Flow Rate

1. Attach the flow adaptor to the PM cyclone inlet, as shown in Figure 21, by fitting it over the inlet and pressing until it fits securely.
2. Connect the supplied rotameter with tubing attached to the CSAM-PM inlet (Figure 22).
3. Allow the unit to sample at least 5 minutes or until the flow rate is stable within  $1.5 \text{ L/min} \pm 10\%$ .



4. If the value is outside the specified  $1.5 \text{ L/min} \pm 10\%$  limit, adjust the flow rate using the set screw on the AirChek pump (Figure 23). Turn the screw clockwise to increase flow and counterclockwise to decrease the flow.
5. After each adjustment allow the flow to stabilize for 5 minutes and reevaluate.
6. Record the final flow rate on the CSAM Monitoring Record or other project documentation.



### Procedure: Check CSAM PM Zero

1. If not already in place, attach the flow adaptor to the cyclone as shown in Figure 21 in the previous procedure.
2. Connect the supplied HEPA filter with tubing attached to the CSAM-PM inlet (Figure 24).
3. Allow the unit to sample through the filter for 15 minutes.
4. Record the final zero voltage and enter zero (0) for the concentration value in the appropriate spreadsheet cells and on the CSAM Monitoring Record or other project documentation.

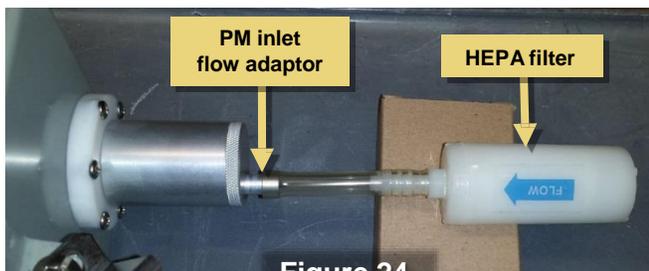
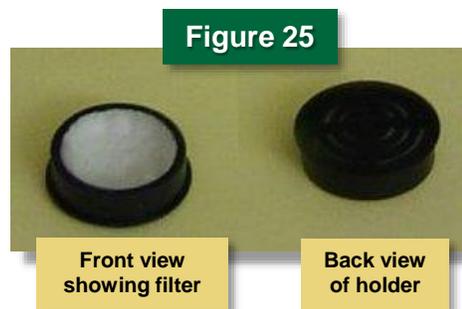


Figure 24

### CSAM-NO<sub>2</sub> Maintenance

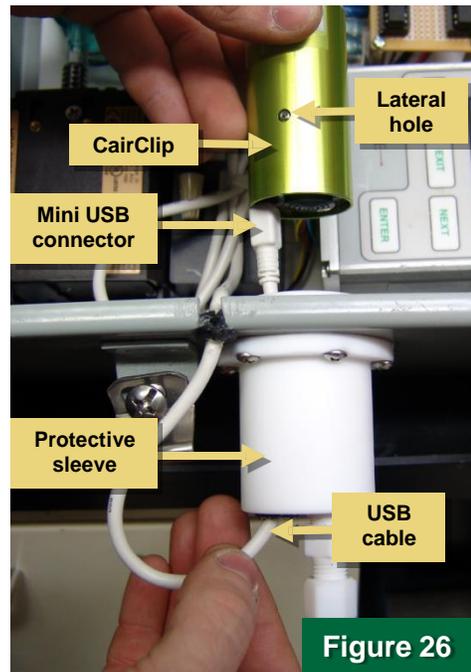
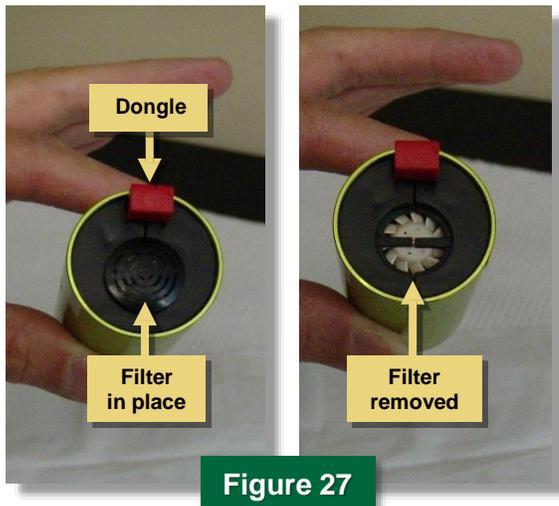
If the CSAM-NO<sub>2</sub> (CairClip) is regularly exposed to dust, it is recommended that the removable filter be changed every 4 months. The filter comes premounted in its holder and is removed and replaced as a single unit (Figure 25). The CairClip is contained in a protective Teflon sleeve on the CSAM. In order to perform this procedure, the CSAM must be opened and the CairClip removed from the protective sleeve.



### Procedure: Change CSAM NO<sub>2</sub> Filter

1. Disconnect the CSAM from its power supply.
2. Remove the CSAM cover using a Phillips screwdriver to loosen the screws of the brackets and then sliding the brackets off the cover edges.
3. Hold onto the white mini USB cable on the front of the CSAM to prevent its fitting from working loose, and from inside the CSAM gently wiggle the CairClip backwards until it comes out of the sleeve (Figure 26).
4. Disconnect the mini USB cable.

5. Insert the red dongle provided with the CSAM into the CairClip as shown in Figure 27. The dongle prevents the small fan inside the device from turning.



6. Remove the filter/filter holder assembly from the back of the CairClip by gently pulling the filter holder with your fingers.
7. Place a new filter/filter holder assembly into the opening and gently press until it is secure.
8. After changing the filter, remove the red dongle and reconnect the mini USB cable to the CairClip.
9. Align the USB plug with the cable insertion hole, and while feeding the mini USB cable gently into the hole, reinsert the CairClip into the protective sleeve and gently but firmly press the CairClip into the sleeve hole until it can go no further. Be sure the lateral hole, shown in Figure 26 remains outside of the sleeve.
10. Close the unit by replacing the cover on the CSAM, refitting its brackets, and tightening the screws.
11. Note the date of the filter change in a laboratory notebook or other designated project documentation.

## Section 2: Field Operation

**These procedures are expected to be carried out by volunteer citizen operators.**

Field operation of the CSAMs is expected to be carried out by volunteer citizen scientists. The citizen scientists setting up and attending to the CSAMs at field locations need to know how to change and recharge the CSAM's battery, set up the unit properly at its outdoor or indoor location, initiate data collection, and retrieve and process the data. The procedures in this section detail the activities required for using the CSAM successfully for field data collection and retrieval.

The CSAM is designed to run for one week (continuously for 7 days) on a fully charged battery. Therefore, an operator should visit the test site at least once a week to replace and/or recharge the battery, download data, and inspect the unit's functionality.

### What You Will Need

#### Included in CSAM Package

- CSAM
- Access door key
- Two standard size secure digital (SD) cards
- SD card reader
- AC-DC adapter with power supply cable or CSAM battery pack
- USB cable
- Macro-enabled Microsoft Excel spreadsheet created specifically for processing CSAM data (on accompanying CD)
- High-efficiency particulate air (HEPA) filter
- Teflon tubing and proper fittings (indoor setup)
- Metal tubing protector (indoor setup)
- Rain shield (outdoor setup)
- Tripod (outdoor setup)
- Battery charger

#### Not Included

- Personal computer (PC) running a Windows operating system (preferably Windows 7 or greater)
- Arduino software (to be downloaded from the Arduino web site – see procedure)
- Microsoft Excel
- Weatherstripping (indoor setup)
- 9/16-inch socket driver
- Laboratory tape
- Permanent marker

## Battery Changing and Charging

Changing and charging any battery should be performed with caution. The batteries used in the CSAM (LiFePO<sub>4</sub>) carry a large amount of energy in a very small space. A damaged battery can potentially cause explosion, fire, or burns. Inspect the batteries carefully on site visits, and replace any battery that exhibits signs of malfunction such as smoke, excess heat, foul odor, etc. Always completely remove the batteries from the battery case before charging.

### Cautions

- ❖ Always get rid of static electricity before touching electronics by touching a metal object such as the CSAM case.
- ❖ Do not short circuit the red (+) and black (-) terminals with any metal tools or objects.
- ❖ Do not get the batteries wet.
- ❖ Do not heat the batteries above 60 °C (140 °F) or expose it to fire.
- ❖ Do not disassemble, crush, or modify the batteries.
- ❖ Stop using a battery if you detect any unusual condition such as excess heat or foul odor, or if you observe any physical damage.
- ❖ Do not charge the battery while it is powering the CSAM.
- ❖ Never charge the batteries while they are inside the battery case.

### Procedure: Change Battery

1. Unplug the CSAM from the battery case (Figure 28).
2. Unlock both the top and bottom of the battery case with the key provided (Figure 29). The case contains two batteries labeled with a date written on laboratory tape, two red cables, two black cables, and mounting hardware.



Figure 29

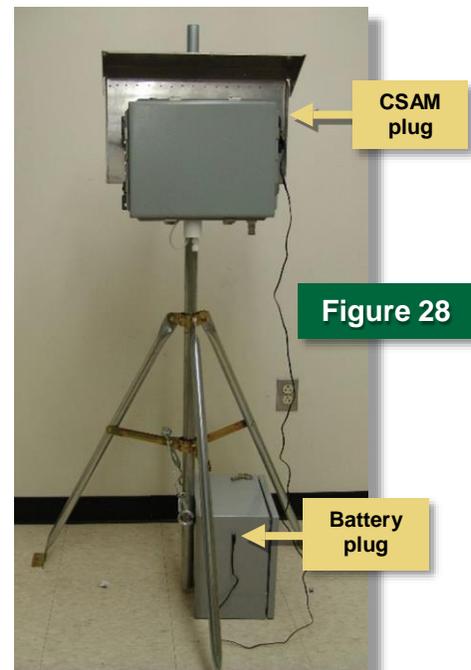
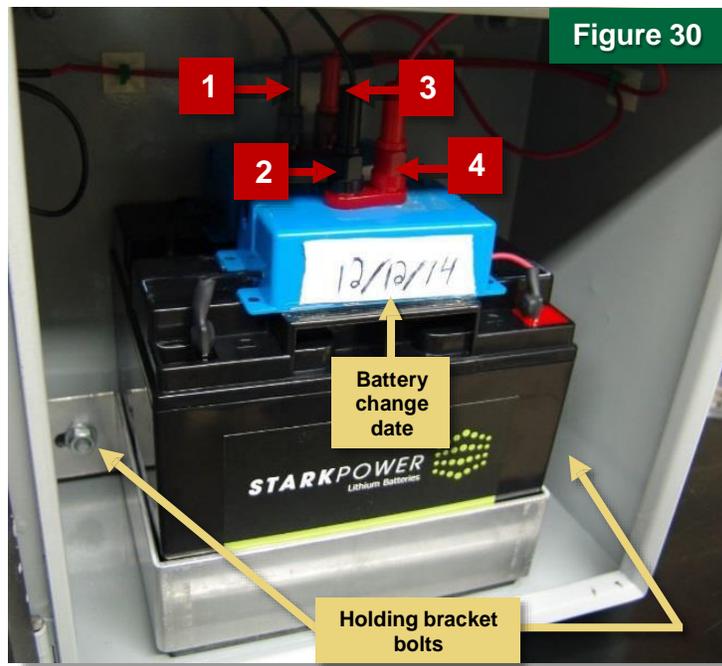
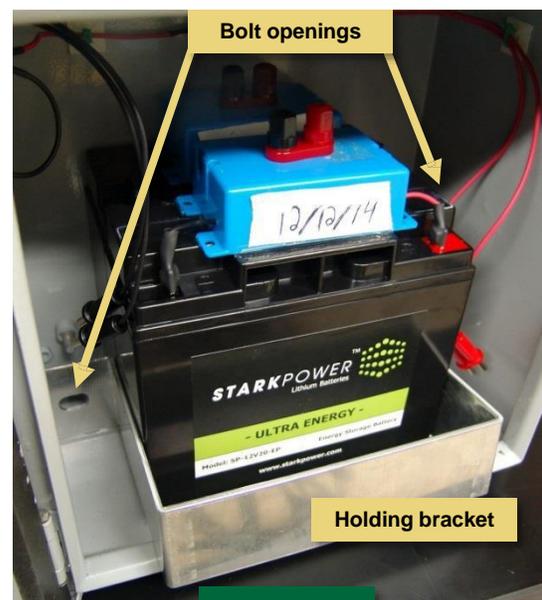


Figure 28

3. Check the date on the battery labels (Figure 30). If the CSAM is not expected to be visited again before the date labeled on the batteries, the batteries must be changed.
4. Making sure not to short circuit the red (+) and black (-) terminals with any metal tools or objects, disconnect the batteries from the unit by first disconnecting the black wire from each battery (1, 2) and then the red wire from each battery (3, 4), as shown in Figure 30.



5. Loosen the bolts on the holding bracket by turning them counterclockwise using a 9/16-inch socket driver (not provided) until the bracket is loose enough for the batteries to be lifted out of the case (Figure 31).
6. Remove the batteries from the case and set them aside.
7. Take two fully charged batteries out of the boxes used for transport.
8. Using laboratory tape and a permanent marker such as a Sharpie, add a label with a date 7 days in the future. This date is the latest these batteries should be attempted to be used without being replaced or recharged.



**Figure 31**

9. Place the two fully charged batteries into the battery case, and place the holding bracket around the bottom of the batteries, as shown in Figure 31.
10. Insert the bolts in the openings in the holding bracket and tighten by turning them clockwise using the 9/16-inch socket driver until the batteries are held firmly in place.
11. Connect the batteries to the unit by first connecting the black wire from each battery (1, 2) and then the red wire from each battery (3, 4) as shown in Figure 30.
12. Place the depleted batteries in the empty boxes that contained the fully charged batteries for transport to the recharging location.
13. Close and lock the battery case.
14. Plug the CSAM into the battery case to resume operation.
15. Log the time and date of the battery change in the field operations notebook or other designated project documentation.

## Procedure: Charge Battery

1. Place the battery to be charged on a flat surface that is free of clutter or debris within the provided charger's reach of a standard 110 V AC wall outlet.
2. Making sure not to short circuit the red (+) and black (-) terminals with any metal tools or objects, connect the black charger cable to the black (-) terminal and the red charger cable to the red (+) terminal.
3. Plug the charger into the 110 V AC standard wall outlet (Figure 32). When the LED on the charger turns green, the battery is fully charged. This can take up to 20 hours per battery, but does not require constant supervision.
4. When the battery is fully charged, unplug the charger from the wall before disconnecting the battery.
5. Disconnect the black charger cable from the black (-) terminal and the red charger cable from the red (+) terminal, making sure not to short circuit the terminals with any metal tools or objects.

## Cautions

- ❖ Always connect the charger to the battery before plugging it into the wall outlet.
- ❖ After the battery is fully charged, be sure to unplug the charger from the wall outlet before disconnecting the battery.

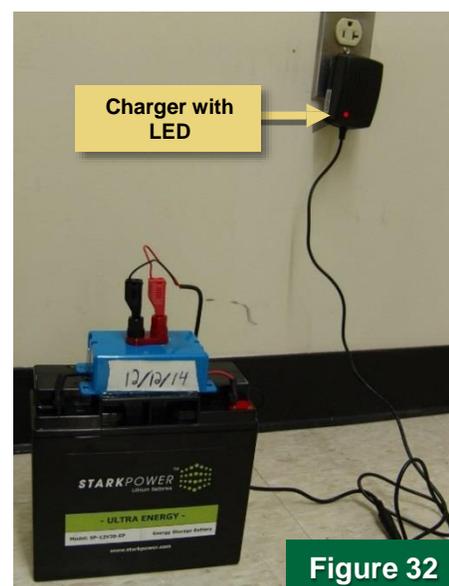


Figure 32

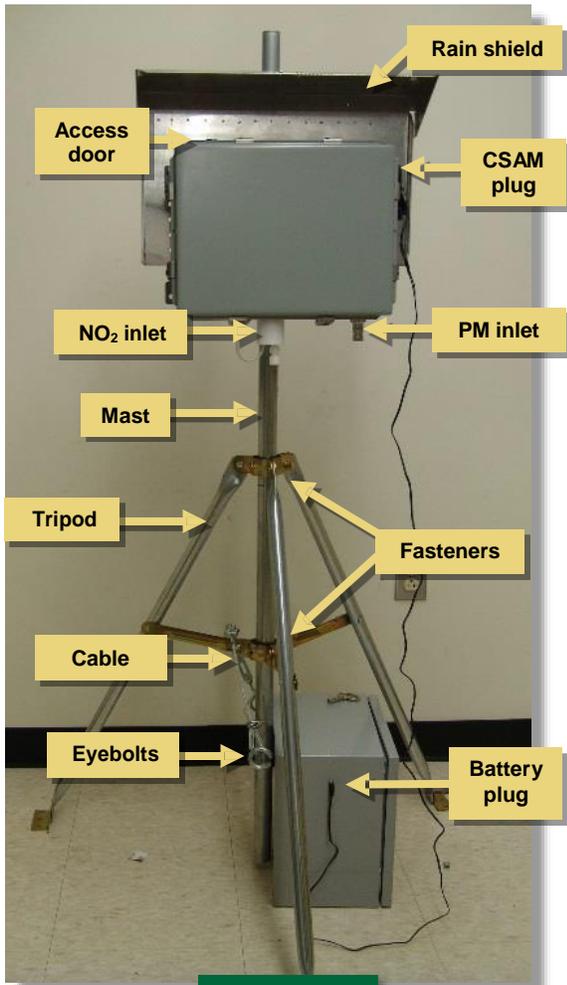
6. Label the battery “Full Charge” with the date using laboratory tape and a permanent marker.
7. Place the battery in the battery box for storage and transport.
8. Repeat as needed until all batteries are fully charged.

## CSAM Setup

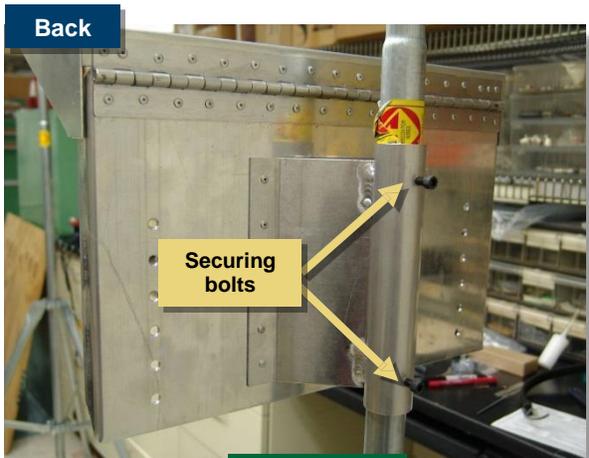
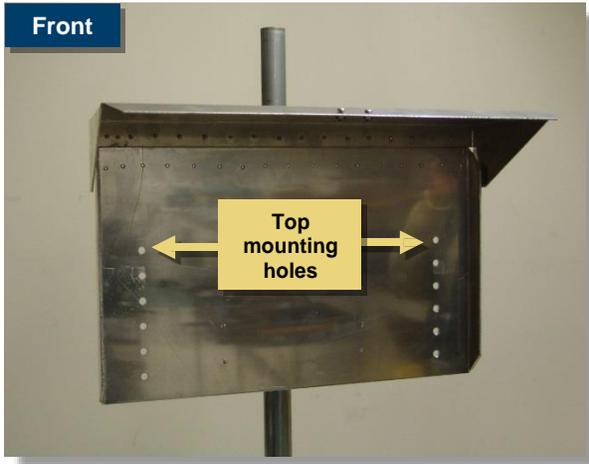
The CSAM can be set up for outdoor or indoor use. See the Quality Assurance Guidelines for site selection and positioning requirements for the CSAM unit. Sites should be selected by the project team at the beginning of the project. The procedures provided here are for an outdoor rooftop or ground location or for indoor window placement. The required equipment differs for each location, as noted in “What You Will Need” at the beginning of this section.

### Procedure: Place on Rooftop or Ground

1. Select a flat roof or ground location that has no obstructions within at least 3 meters (10 feet) of the equipment. It should not be placed under trees or where water from gutters or down spouts would impact it.
2. Make sure no electrical or physical hazards are in the immediate vicinity of the setup. Select a location that is at least 1 meter from any vertical wall if at all possible so that air flow around the monitor is not impeded.
3. Unfold the tripod, insert the mast pole into the top hole of the tripod, and extend the mast downward until it rests on the surface of the rooftop or ground (Figure 33).
4. Screw in the two sets of fasteners around the mast until it is held securely.
5. Place the battery box at the bottom of the tripod and secure it to the tripod mast using the cable with turnbuckle. The cable should be placed over a tripod brace, as shown in Figure 33, and connected to the eyebolts on the battery case to prevent the setup from tipping or blowing over. The cable can be tightened or loosened using the turnbuckle.
6. Once the tripod is secure, install the rain shield on the mast approximately 5 feet above the surface of the roof by sliding the mast through the back of the shield and tighten the bolts on the back (Figure 34) until the rain shield is secure.
7. Lift the top of the rain shield and push it backwards so it is out of the way when installing the CSAM.

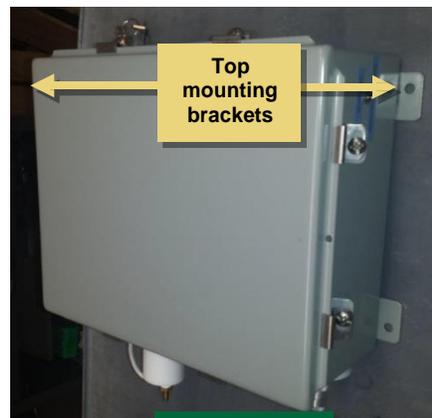


**Figure 33**



**Figure 34**

8. Fasten the CSAM in the top mounting holes of the rain shield (Figure 34) by placing the bolts provided through the top mounting brackets of the CSAM (Figure 34). The PM and NO<sub>2</sub> inlets should be pointing downwards and the access door should be on top as shown in Figure 33. Make sure the CSAM is centered over one of the tripod legs to stabilize the setup and keep it from tipping over.
9. When ready to initiate data collection, plug the CSAM into the battery case.



**Figure 35**

## Procedure: Place in Window

1. Place the CSAM unit on a flat, stable surface near a window.
2. Connect the provided Teflon tubing to the NO<sub>2</sub> inlet as shown in Figure 36. Teflon or stainless steel is the preferred tubing choice.
3. Connect the adaptor to the PM Inlet (Figure 37), and then attach the provided tubing, as shown in Figure 38.

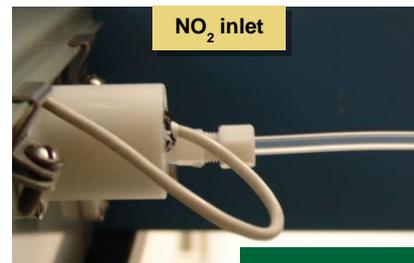


Figure 36

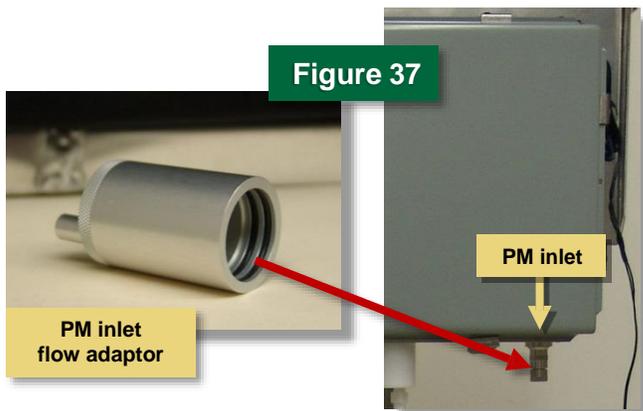


Figure 37

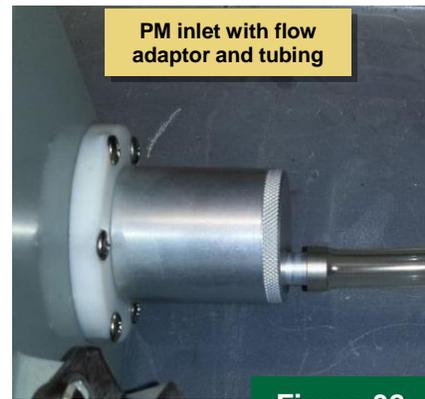


Figure 38

4. Open the window and run the sampling lines through the metal tubing protector, as shown in Figure 39, so that the ends of the sampling lines are outside the window and the tubing protector rests on the window sill. The tubing protector will prevent damage (such as crushing or crimping) to the sampling lines when the window is closed.
5. Fill the opening between the sill and window sash with weatherstripping (not provided) as needed to prevent outside air from getting inside.
6. When ready to initiate data collection, plug the CSAM into the battery case or use the provided AC adaptor (Figure 40) to connect to a wall outlet.

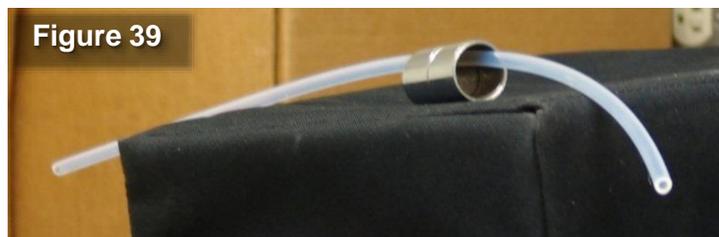


Figure 39



Figure 40

## Routine Data Collection

Once the CSAM is set up properly, data collection can begin. The CSAM can collect data continuously for 7 days on battery power. The unit automatically saves data files every 24 hours at midnight, with file names based on the date and time (military) data collection began. For example, the file name 12080000.TXT denotes that sampling for a 24-hour period began on December 8 (1208) at midnight (0000). The following procedures will guide you through initiating data collection and retrieving and processing the data.

### Procedure: Collect Data

1. Connect the CSAM to a power supply either by plugging the AC-DC adaptor into a wall outlet or by plugging it into the CSAM battery pack.
2. Use the key provided with the CSAM unit to open the access door (Figure 41).
3. Make sure the SD card is inserted properly into its slot (Figure 42). The LED at the top right of the access door (Figure 41) will light up if the card is not inserted correctly.
4. Close and lock the access door and put the key in a secure location.

The CSAM will begin taking data automatically. You should hear the pumps making a quiet buzzing sound.

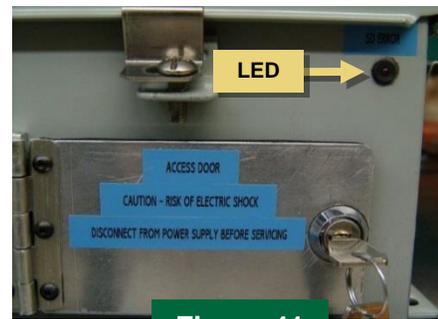


Figure 41

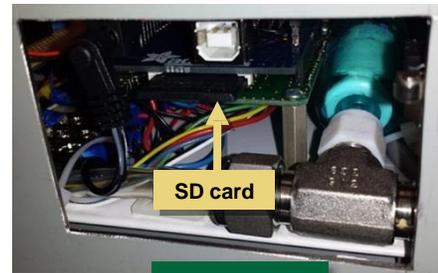


Figure 42

### Procedure: Retrieve Data

**Note:** This procedure is required only if the CSAM unit will continue collecting data in the field. If the unit is being removed from field operation, data retrieval can be carried out at the data processing location.

1. Disconnect the CSAM from its power supply.
2. Open the access door (Figure 41). The CSAM will cease monitoring.
3. Pull out the SD card (Figure 42) for transport to the data processing location.
4. Insert a new SD card into the slot. If not properly inserted, the LED at the top right of the access door (Figure 41) will illuminate.
5. Close and lock the access door to resume sampling.

## Processing Data

This procedure explains how to create a new Excel spreadsheet for processing and interpreting your collected data. A CD with a Microsoft Excel macro-enabled spreadsheet, **CSAM Data Analysis [Serial No. XX].xlsm**, accompanies each CSAM (Figure 43). This spreadsheet was created specifically for processing field data relative to the performance-check data, which allows you to assess the quality and usability of the collected data. The CSAM unit's two-digit serial number is part of the file name so that the spreadsheet can easily be matched with its associated unit if more than one CSAM is deployed in the field.

The CSAM Data Analysis spreadsheet contains the performance-check data recorded at the start, and possibly the end, of the study by an experienced operator. You will use this spreadsheet in combination with the data text files generated by the CSAM to create the data-processing spreadsheet, as described in the procedure below. The spreadsheet is locked so that the performance-check data cannot be accidentally changed. The **Load Data, Perform Calculations, Graph Processed Data** button is the only active part of the spreadsheet and is all that is needed for creating the spreadsheet containing the processed data.

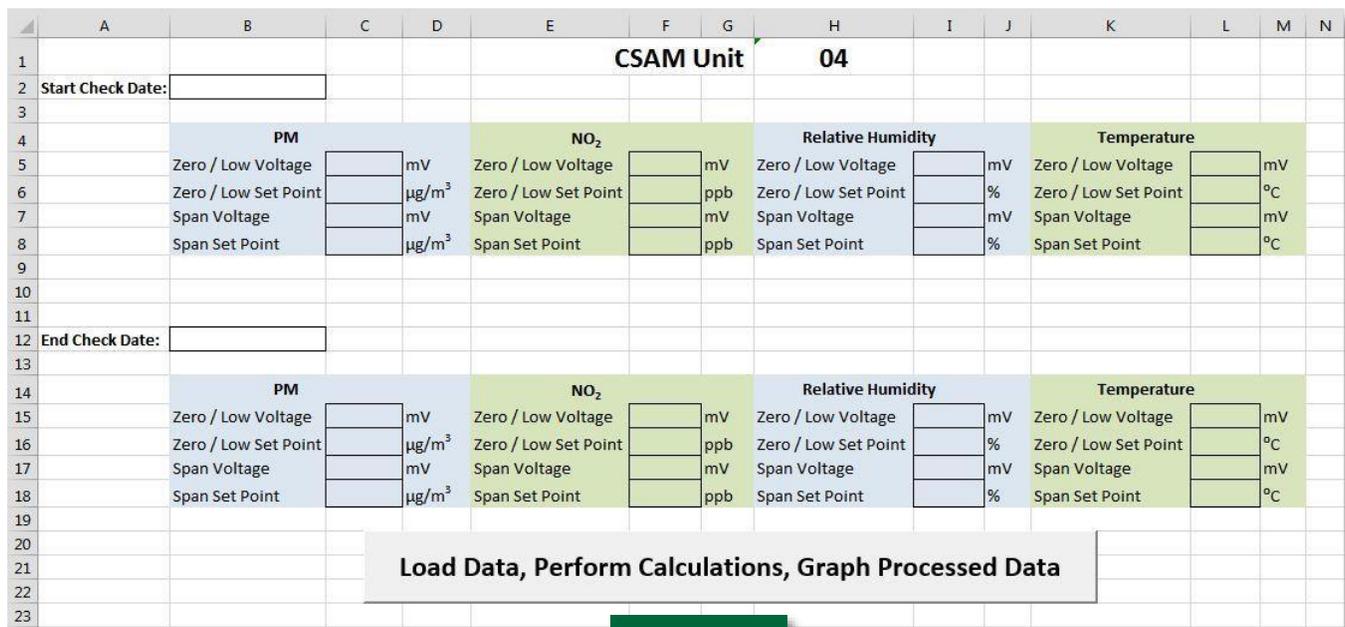


Figure 43

The new spreadsheet created during this procedure will be saved automatically in a folder named **CSAM Output** in your main **Documents** folder. The spreadsheet file name will be based on the time and date the spreadsheet was created. The example file used here to explain this procedure is named **(2014-Dec-17)14.36.37.ProcessedDataFile.xlsx**.

This spreadsheet automatically converts the voltage data (raw data) produced by the CSAM to the measurement units (final data) required for interpreting the data (NO<sub>2</sub> [ppb], PM [ $\mu\text{g}/\text{m}^3$ ], temperature [ $^{\circ}\text{C}$ ], and RH [% at  $^{\circ}\text{C}$ ]). The generated spreadsheet has multiple tabs:

- ❖ The **Files** tab (Figure 44) lists the data text files, in order by date and time created by the CSAM, that were selected to be processed. This tab also shows where the newly created spreadsheet was saved, i.e., **Net My Documents\CSAM Output**.

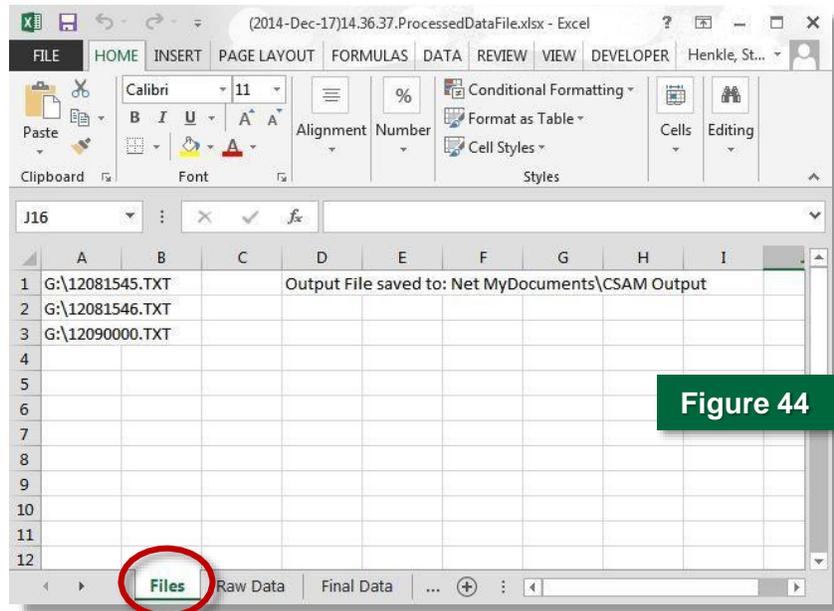


Figure 44

- ❖ The **Raw Data** tab (Figure 45) shows the data recorded by the CSAM in its originally collected format using the CSAM's programmed voltage values (mV).

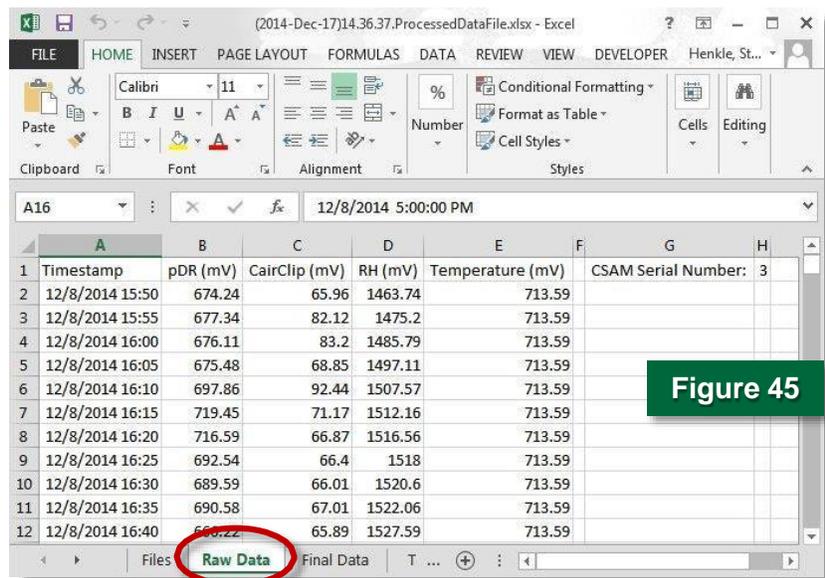


Figure 45

- ❖ The **Final Data** tab (Figure 46) contains the processed data from all sensors reported in the concentration and temperature and RH units needed for understanding the data.

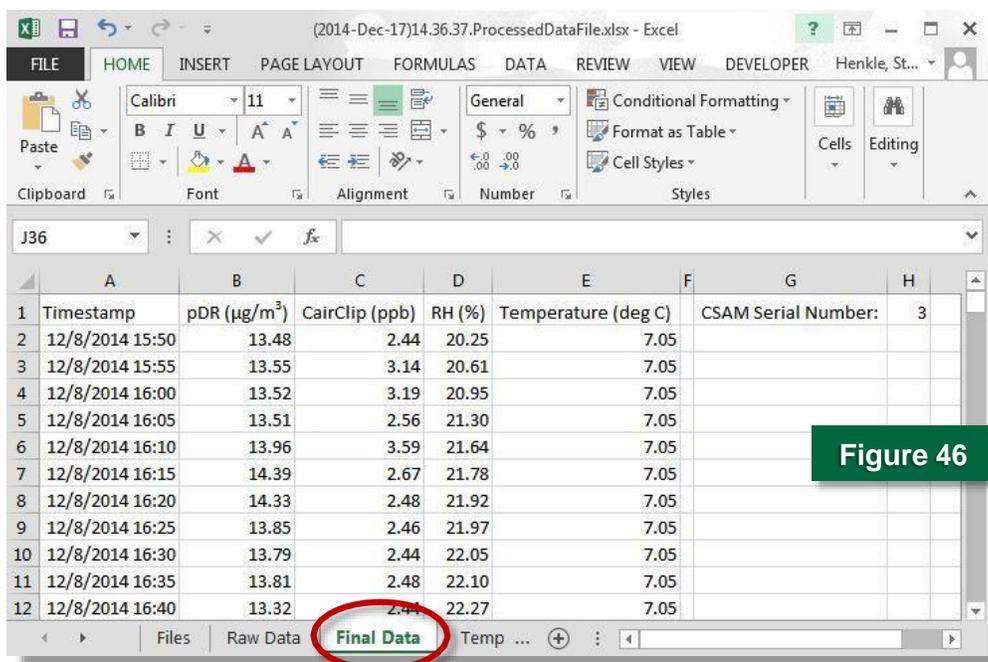


Figure 46

- ❖ The last four tabs—**Temperature**, **RH**, **CairClip**, and **pDR**—contain full-page graphs of the data from each sensor. As an example, the graphed data from the RH sensor is shown in Figure 47.

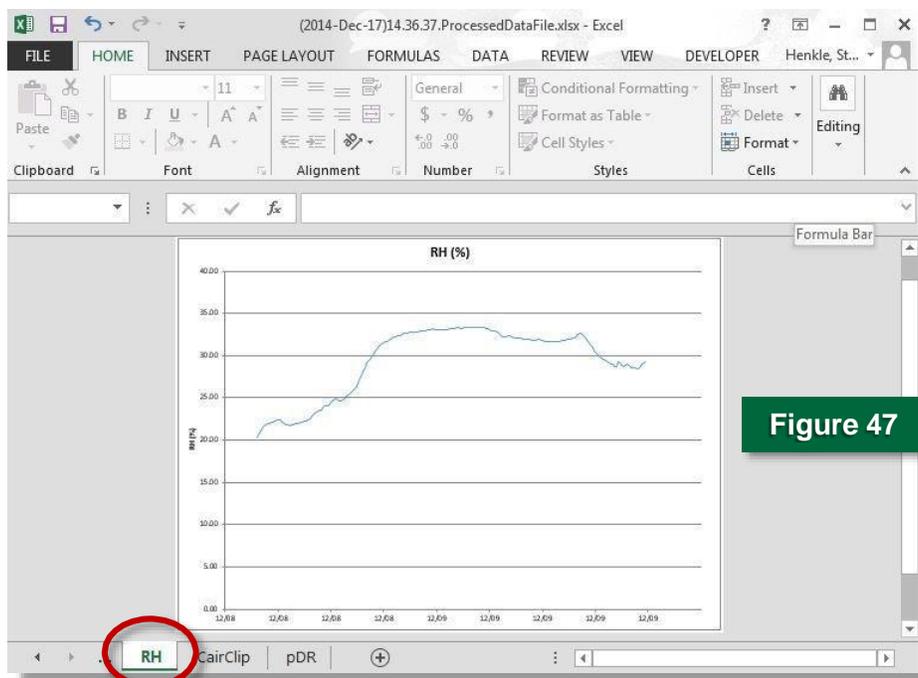
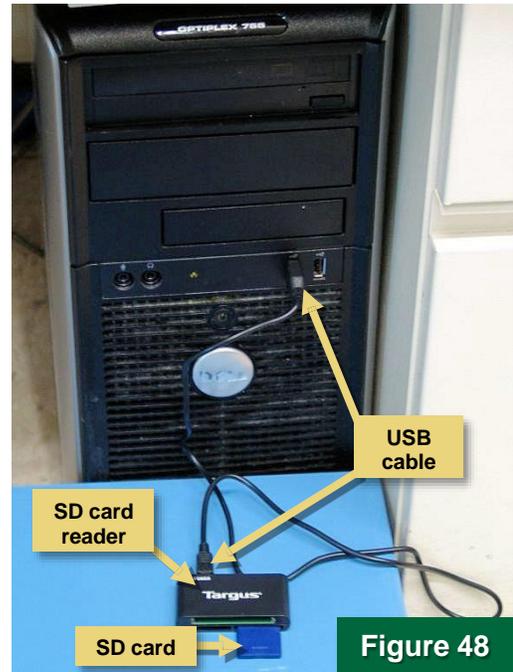


Figure 47

## Procedure: Process Data

1. Plug the provided SD card reader into the computer using a USB cable (Figure 48).
2. Insert the SD card into the reader.
3. Create a new folder on your computer to contain the files.
4. Using Windows Explorer, transfer the files from the SD card to the newly created folder.
5. After transferring the files, pull the SD card out of the reader and reserve it for the next use with the CSAM.
6. Open the **CSAM Data Analysis.xlsm** macro-enabled Excel spreadsheet (Figure 43).
7. Click the **Load Data, Perform Calculations, Graph Processed Data** button.
8. When prompted, select all the CSAM data files you want to process at once by holding down the **Shift** or **Control** keys while clicking each file.
9. Click **OK**. The new spreadsheet file of processed data will be created in your main **Documents** folder as described above.



## For Additional Help

CairPol, Technical Data Sheet CairClip NO<sub>2</sub>, <http://www.cairpol.com/images/pdf/NO2/technical%20datasheet%20no2%2015072013.pdf>, last accessed October 30, 2014.

Thermo Scientific Personal DataRAM pDR-1000AN Instruction Manual, [http://www.envirosupply.net/manuals/ThermoElectron\\_PersonalDataRAM\\_pDR-1000AN-1200.pdf](http://www.envirosupply.net/manuals/ThermoElectron_PersonalDataRAM_pDR-1000AN-1200.pdf), last accessed December 17, 2014.

Thermo Scientific Personal DataRAM pDR-1000AN Monitor brochure, <http://www.thermoscientific.com/en/product/personal-dataram-pdr-1000an-monitor.html>, last accessed December 17, 2014.

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U.S. Environmental Protection Agency, *Air Sensor Guidebook*, EPA 600/R-14/159, June 2014, Office of Research and Development, National Exposure Research Laboratory, <http://www.epa.gov/airscience/docs/air-sensor-guidebook.pdf>, last accessed October 30, 2014.

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