| U.S Environmental Protection Agency<br>Office of Research and Development<br>**Center for Environmental Measurement & Modeling**<br>***Air Methods & Characterization Division***<br>***Source & Fine Scale Branch*** | |
|---|---|
| **STANDARD OPERATING PROCEDURE** | |
| SOP Title: Sensit SPod Fenceline Sensor and Canister Grab Sample System Deployment and Operation | |
| SOP ID: J-AMCD-SFSB-SOP-4380-2 | Effective Date: August 1, 2022 |
| SOP was Developed: ☒ In-house ☐ Extramural: enter organization | |
| SOP Discipline: Field | Subdiscipline: Field Measurement |
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## Revision History

| Revision No. | Name | Date of Revision | Description of Change(s) |
|---|---|---|---|
| J-AMCD-SFSB-SOP-4380-0 | Original SOP | 08/24/2021 | Issuance |
| J-AMCD-SFSB-SOP-4380-1 | Revision 1 | 05/09/2022 | Added Data Analysis Code Appendix E |
| J-AMCD-SFSB-SOP-4380-2 | Revision 2 | 08/01/2022 | Improved QA and training documentation |
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**SOP Title:** Sensit SPod Fenceline Sensor and Canister Grab Sample System Deployment

## 1. *Scope and Applicability*

A fenceline Sensor Pod (SPod) refers to any air sensor-based system deployed near a potential ground-level air pollution source to improve understanding of emissions. Sensit Technologies (Valparaiso, IN) produces the SENSIT® SPOD, a specific type of fenceline sensor. This SOP provides supporting information for the deployment, operation, basic data processing, and quality assurance (QA) and quality control (QC) of the SENSIT® SPOD fenceline sensor, with canister grab sample (CGS) acquisition system. This SOP is designed to supplement the user manual "*SENSIT SPOD Sensor Operation Manual and Configuration Guide, Version 1.1, April 2020*",[1] and the *SENSIT SPOD Sensor Maintenance Guide, Version 1, May 2020*".[2] The SENSIT® SPOD (hereafter called "SPod") is modeled after the EPA SPod volatile organic compounds (VOC) fenceline sensor.[3-10] The SPod and CGS system deployed together are referred to as "SPod/CGS". This SOP covers these topics:

- SPod/CGS pre-deployment QA/QC procedures
- SPod/CGS field deployment, operation, and QA/QC procedures
- CGS installation, shipping, and handling
- SPod basic data analysis procedures

The target audience for this SOP is field and data analysis personnel utilizing this technology. This SOP does not describe the operation of support equipment, such as generators, transport trailers, meteorological stations, gas cylinders and dilution systems, or distance measurement devices.

## 2. *Summary of Method*

In general, an SPod is a lower-cost sensor system that combines wind field and air pollutant concentration measurements to detect emission plumes and help locate and assess the source of emissions at or near the fenceline of facilities. An SPod typically combines components such as air sensors, a microcomputer, an anemometer, and communication in a single field package. An SPod may have a battery and the capability to operate using solar power if required. This SOP is for a commercial version of the SPod made by SENSIT Technolgies.[1] This SPod package contains a photoionization detector (PID) sensor that produces a non-speciated, approximately-calibrated concentration measure of a subset of VOCs and hazardous air pollutants (HAPs) that can be ionized with a 10.6 eV PID, as well as sensors for measuring temperature (temp), relative humidity (RH), and pressure (press). In the current configuration, the effective PID detection sensitivity ranges from approximately 0.02 parts per million (ppm), by volume, to 2 ppm under best operating conditions. Other components of this SPod package include a sonic anemometer, photovoltaic power source, onboard operating and data logging system containing a secure digital (SD) flash memory card, and wireless capability cell phone modem for remote communication. The SPod can be deployed with a CGS acquisition system (called SPod/CGS system). The SPod/CGS system is part of EPA's Next Generation Emissions Measurement (NGEM) program.

The SPod/CGS system can be operated in the field to remotely collect 1.4L CGS samples, where the sample acquisition is triggered by elevated SPod PID signal or other means. Because of the rapidly changing nature of near-source plumes, an approximate 20 second duration "canister grab sample" is typically conducted using the SPod/CGS system[10] but canister time integration can be adjusted with minor modifications. Canister sample collection specifics are detailed in the project-specific quality assurance project plan (QAPP). Acquired CGSs are sent to the laboratory identified in the QAPP for analysis, typically by EPA Method TO-15A (US EPA 1999).[11]

## 3. Definitions/Acronyms

Table 3.1: Common terms used in this SOP listed in alphabetical order

| Term | Definition |
|---|---|
| **2D Sonic** | two-dimensional sonic anemometer |
| **AMCD** | Air Methods and Characterization Division |
| **BCP** | background correction procedure used in fenceline monitoring applications |
| **Cal-check** | SPod calibration check. |
| **CEMM** | Center for Emission Measurement and Modeling |
| **CGS** | Canister grab sample |
| **COC** | chain of custody |
| **Deg C** | unit of temperature, degrees Celsius (aslo °C) |
| **DQI** | data quality indicator |
| **CGS** | evacuated canister |
| **eV** | electron Volt |
| **GPS** | global positioning system |
| **HAP** | hazardous air pollutant |
| **LPM** | Litter per minute |
| **mV** | millivolt |
| **NGEM** | Next Generation Emission Measurement |
| **Node** | single SPod location |
| **ORD** | Office of Research and Development |
| **ppb** | part per billion, always meaning "by volume" in this SOP |
| **PID** | photoionization detector |
| **PN** | part number |
| **ppm** | part per million, always meaning "by volume" in this SOP |
| **Press** | atmospheric pressure (typically mbar) |
| **QA** | quality assurance |
| **QAM** | Quality Assurance Manager |
| **QC** | quality control |
| **QAPP** | quality assurance project plan |
| **RH** | relative humidity (%) |
| **Sec Dat** | secondary data check (QA reasonableness check) |
| **SD** | secure data card for storing SPod data |
| **SDI** | source direction indicator plot |
| **SFSB** | Source and Fine Scale Branch |
| **SOP** | standard operating procedure |
| **SPod** | fenceline Sensor Pod, a lower cost fenceline sensor system, (here SENSIT® SPOD) |
| **SPOD** | SENSIT® SPOD, a specific type of fenceline SPod |
| **TBD** | To be determined |
| **Temp** | temperature of the air measured by a SPod sensor in deg C |
| **VOC** | volatile organic compound |
| **WS** | wind speed (typically mph for Sensit SPod) |
| **WD** | wind direction (degrees from north) |

## 4. Health and Safety Warnings

The SPod/CGS is designed to detect and assess emissions plumes. The current SPod/CGS design works only in "near-fenceline" applications where localized emission plumes may be present. The source to separation distance for a fenceline application is defined here as 50 m to 500 m. Since the SPod is not certified as intrinsically safe, it cannot be deployed in potentially hazardous environments because the unit's electronics (as with any sensor or vehicle) have could potentially act as an ignition source and trigger an explosion if a large flammable gas concentration exists.

**WARNING: Since the SPod is not certified as intrinsically safe, it cannot be used in potentially explosive environments**.

The general health and safety precautions for field measurement activities are described in separate health and safety plans and are not detailed in this SOP. Aside from safe area siting, the primary safety hazard associated with SPod-deployment and use is the physical handling of heavy gas cylinders that may be used on the EPA test range and the installation of SPod/CGS mounting poles and fixtures at the deployment location. Canisters and SPod units may be shipped in boxes or a rugged, heavy carrying case. Safety precautions must be taken when handling the boxes and carrying case as to not cause personal injury. Proper safety precautions and safety equipment must be used for handling and/or installation functions along with "dig safe" procedures and proper site permitting. These safety and site permission functions should be covered in the project-specific safety plan related to the deployment.

In general, care must be taken to secure equipment, so it does not produce a falling or tipping hazards under high wind or potentially interfere with unrelated site equipment or operations. Caution must also be used when deploying near roadways due to vehicle hazards and care must be taken to minimize or eliminate the possibility of creating driver distraction hazards while selecting the deployment site. General precaution with use of electrical equipment or in the field or installations near power lines must be followed and all necessary site safety checks must be performed, and permissions acquired. Typically, SPod PID operation is checked with low concentrations [500 parts per billion (ppb) or 1.0 parts per million (ppm) by volume] of isobutylene, but if other gases are used, care must be taken with potentially hazardous aspects of these gases and details should be described in project-specify safety plans.

## 5. *Cautions/Interferences*

There are two types of method interferences for the 10.6 eV PID-based SPod/CGS systems: physical and analytical.

### *5.1. Physical Interferences:*

Physical interference refers to external conditions or component malfunctions that may negatively affect SPod/CGS operation. For the purposes of this SOP, physical interferences may result in loss of operation of all or part of the SPod/CGS system. The loss of operation (loss of data) for the SPod may be temporary or permanent in nature but a loss of data integrity for an acquired canister sample is permanent, generating a laboratory analytical sample that carries the appropriate QA flag depending on the issue. The following are examples of physical interferences affecting SPod/CGS performance:

- Operational temperatures outside of -10°C to 50°C will cause operational failure without special preparations.[1]
- The SPod/CGS system requires cellular signal for data transmission.
- Heavy rain or dew (condensation) may result in water collecting on the PID sensor or inlet screen causing the SPod to enter into a temporary nonoperational state or a state that produces erroneous data (analytical interference).
- Physical obstructions, such as freezing rain, accumulated dirt, or insects may impact the inlet to the SPod PID sensor or the CGS, and therefore affect operation.
- A loss of power as may occur if the solar panel is blocked by snow or experiences >3-5 cloudy days (if solar power without second battery is used).
- Physical interferences include component malfunctions or operational issues with the SPod sensors or communications systems that may require unit reset (power off/power on) to clear. If a sensor ceases to operate or begins to operate in an unstable fashion, a physical fault is likely, and replacement may be required.
- The performance of the SPod sonic anemometer may be impacted by the presence of physical interferences (trees, telephone poles, etc.) in vicinity of the SPod/CGS. The unit must be positioned and oriented correctly to ensure data validity.

- CGS sampling units and canisters may develop a vacuum leak leading to a loss of sample integrity. Vacuum pressure for each canister must be measured and recorded on chain of custodies (COCs) before shipment in the lab and after shipment shortly before and shortly after sampling to ensure no leaks occurred in the CGS system during field operation. Post-sampling canister pressures will also be measured in the lab after shipment back to the lab to ensure sample did not leak during return shipment.

*5.2. Analytical Interferences:*

Analytical interferences refer to the issues that prevent the SPod/CGS from performing its design function (detecting fenceline emission plumes) when no physical interferences are present. In fenceline sensor applications where the SPod/CGS system is proximate to the source under study, wind-advected emission plumes create a rapidly time-varying signal on the SPod PID sensor, which can be mathematically isolated from the VOC background and drift signals and assessed as part of data analysis procedures.[9,10] The following analytical interferences can affect this fenceline-style data analysis:

- Degradation of sensor sensitivity over time. Over time, the PID sensor may lose sensitivity creating analytical and CGS trigger level uncertainty. This interference is avoided using periodic in-field sensor calibration checks with 1.0 ppm isobutylene gas as described in this SOP.
- A serious potential analytical interference is associated with source signal that does not originate from the source under observation. For example, a truck may park temporally near a sensor location and the exhaust from the truck could create signal on the SPod and possibly trigger a canister. The protection against this analytical interference is proper siting, investigation of the signal character, and use of supporting speciation and auxiliary sensor, or observation data. The specific procedures involved in minimizing this type of analytical interference is described in the project-specific QAPP.
- Because these are lower cost NGEM systems, general PID sensor or electronic malfunction may occur. Under certain conditions, it is possible for a sensor to fail creating a temporally sustained erroneous signal. It is also possible to receive an artifact signal caused by electronic noise from an SPod system or communication malfunction. These conditions may manifest as an unrealistically stable and very low sustained reading or erratic and unrealistically high signal at the upper end of the output, or non-physical signal data point noise-like spikes. As described in this SOP, QA screening must occur to flag these conditions and remove them from analysis. Over progressive design revisions and with the implementation of sensor heaters[3-6] the frequency of these malfunction states have decreased over time for the EPA SPod and are believed to be even less frequent in the Sensit SPod (subject of this SOP). Operation in extreme RH environments make this this type of malfunction more prevalent.[1]
- An important potential analytical interference for the SPod is associated with low temporal frequency PID sensor baseline drift with RH and temp. This low frequency (slow temporal response) signal is convolved with airshed (background) VOC levels present in the atmosphere that can exhibit similar temporal variability. Under certain ranges of conditions, it is theoretically possible to use the measured RH and temp as part of a post-processing model attempting to separate background drift from real background VOC signal, but this is not covered in this SOP. For fenceline sensor applications, a background correction procedure (BCP) that separates the higher frequency (temporally sharp) emission plume signal from the slower drift and air shed signal is utilized (and described).[10]
- Under sudden atmospheric changes, (e.g. a thunderstorm outflow, sharp RH, temp, and/or press swing, condensation) there is potential for high frequency artifact signal to be produced. This form of a "sharp artifact drift signal" may look similar to certain types of near-field emissions plumes and represents an analytical interference. The frequency of occurrence of this type of event is low and procedures described in this SOP assist in identifying and flagging these events for removal from the processed dataset.
- The CGS apparatus or individual CGS may become contaminated during shipment, during sampling, or after sampling a high concentration air sample. Pre-deployment canister blank testing must be

performed on the SPod/CGS system to ensure that contaminants are not present in the sampling device. A background sample should be taken using the SPod/CGS system directly after field installation or after a suspected high concentration sample to ensure the sampling apparatus has not become contaminated to minimize carry over effects during subsequent sampling.

- The CGS sample may carry a combination of chemical species from the source under study and from interfering sources resulting in source assessment and attribution complexity. This analytical interference is assessed on a case-by-case basis utilizing project-specific information and statistical analysis across a sample set. These procedures are not described in this SOP.
- The SPod/CGS system is subject to a false trigger of the CGS. A Type 1 false trigger of CGS system can occur when the trigger threshold is crossed by some malfunction (electronic noise signal spike or power surge) or by a background drift issue. Because the CGS acquisition and its laboratory analysis are independent of SPod operation, a Type 1 false trigger typically represents a valid CGS but is not necessarily related to a local source of emission (potentially a background sample). A Type 2 false trigger of the CGS system is defined as being caused by a real emission plume or elevated airshed air pollutant PID signal that is not related to the source under study (e.g., caused be by an interfering source). A Type 2 false trigger is typically a valid sample but not necessarily representative of the primary source under study. Type 1 and Type 2 false trigger flags are assigned in post analysis using a combination of sensor data, wind conditions, secondary data, field notes, and laboratory speciated analysis. These procedures are project and case-specific and not described in this SOP.

## 6. Personnel Qualifications/Responsibilities

There are six types of trained personnel required to successfully deploy and manage an SPod/CGS which are described in the following subsections: (6.1) SPod/CGS Field Operator, (6.2) SPod Data Analyst, (6.3) SPod/CGS Advanced Operator, (6.4) VOC Laboratory Lead (or VOC Specialist), (6.5) Site Engineering Lead, and (6.6) Data Synthesis Lead. In all cases, the trained person has signed the appropriate training form and has passed the training assessment. The person has ensured that the fully signed forms documenting training have been transmitted the to the appropriate project and QA managers and has retained a copy for their records.

### *6.1. SPod/CGS Field Operator:*

This trained person has met the laboratory and field safety training requirements of their organization and has secured legal site access permission to visit and manage the hands-on operation for one or more SPod/CGS systems. The person has read and understood this SOP, Reference 1 and 2, and the site-specific QAPP. The person understands daily SPod operation and calibration check procedures. The person has mastered the CGS change-out, pressure checks, proper COC documentation, and canister shipping procedures. The person understands how to perform simple replacement and orientation of equipment on a developed site and is able to perform simple maintenance around the site (e.g., weed whacking). The person has signed the appropriate training form contained in Appendix A (specifically form A1) and has transmitted the form to the project manager (as per QAPP) QA and retained a copy for their records.

### *6.2. SPod Data Analyst:*

This trained person has read and understood this SOP, References 1, 2, and 10 and the site-specific QAPP. The person has the proper software and suitable computer for basic SPod data analysis and can access the data. The person can produce first level summaries of data, can screen for gross QA issues or malfunctions, and will communicate results as per QAPP. The person has signed the appropriate training form contained in Appendix A (specifically form A2) and has transmitted the form to the project manager (as per QAPP) and retained a copy for their records.

### *6.3. SPod/CGS Advanced Operator:*

This trained person meets criteria 6.1 and 6.2, has read additional references, and has the ability, tools, and training to properly site and orient solar-powered and tripod-based (temporary) SPod/CGS systems at locations they may legally access. The person has the software and computer capability and knowledge to change the settings of the SPod/CGS system for site specific needs. The person can perform more advanced data analysis and execute more complicated QA screening procedures outlined in this SOP to diagnose specific issues that may need attention. The person can properly maintain records and order supplies (such as isobutylene calibration check gas) that are needed for operation of the systems in various projects. The person has signed the appropriate training form contained in Appendix A (specifically form A3) and has transmitted the form to the project manager (as per QAPP) and retained a copy for their records.

*6.4. VOC Laboratory Lead (or Specialist):*
Not described in this SOP, this person has mastered the procedures for cleaning, shipping, documenting, and analyzing CGSs. The person can summarize data and maintain laboratory equipment and records as per QAPP and related SOPs. This training is recorded separately with documentation kept by the VOC analysis laboratory.

*6.5. Site Engineering Lead:*
Not described in this SOP, this person has the project management and engineering training, experience, and the operational authority to set up (and/or commission set up of) semi-permanent monitoring sites, power drops, security, and legal site access and insurance agreements (as needed). A Site Engineering Lead may not be required for temporary siting with solar power. This training is recorded separately with documentation kept by the organization employing the Site Engineering Lead.

*6.6. Data Synthesis Lead (or Specialist):*
Not described in this SOP, scientific investigator(s) combine information for SPod, CGS analysis, and other metadata to form conclusions about sources and emission events. This person must have a well-developed knowledge of roles 6.1-6.5 as well as experience in analysis of complex datasets that combine concentration measurements with wind field analysis. The documentation of training for this role is evidence by named service in this capacity in the QAPP as approved by the Quality Assurance Manager (QAM).

## *7. Equipment and Supplies*

Refer to the manual[1] page 6 and Appendix F for images of the SPod fenceline sensor covered in this SOP. The user must read and follow this manual and the calibration and maintenance guide,[2] which are augmented by procedures described in this SOP. SPod/CGS installation requires the following primary equipment and supporting apparatus. For long-term deployments, more robust mounting fixtures are required. This SOP assumes security at the fenceline or other provisions are in place to prevent unauthorized access to the system. This SOP does not cover laboratory equipment and supplies needed to clean and analyze CGSs. Equipment requirements include temporary or semi-permanent installation gear (Section 7.1). Equipment in 7.2 (calibration gear) is required and 7.3 (CGS gear) is optional and used only if canisters are to be acquired. The following forms are required for all deployments and testing activities.

- SPod/CGS Settings Configuration Form (Appendix B)
- SPod Calibration with Zero and Calibration Check Form (Appendix C)
- SPod/CGS Site Deployment Form (Appendix D)

*7.1. SPod (no CGS) using Tripod or Fixed installation, solar power or land power:*

- Safety equipment (as per safety plan)
- Sensit SPod with high sensitivity Ion Science 10.6 eV PID, anemometer, secure digital (SD) card SIM card, 4G Modem, Cellular activation, and web access [Sensit part numbers (PNs) 937-00000-52, 360-00631, 360-00571,500SPOD0-01,500-SPOD0-10]. [*See Appendix F, Figure F1, image of SPod*]
- Sensit SPod to computer USB connection cable
- Computer with SPod analysis software, R code, and "CoolTerm" program for adjusting settings
- Compass, GPS, camera, Teflon tape, bubble level
- Flathead screwdriver, crescent wrench, other basic hand tools
- SPod physical mounting system (e.g., clamps) for pole, fence, or tripod

- Sensit solar panel and connection cables (for solar-powered installations)
- SPod tripod (for shorter-term installations) [*see Figure Appendix F, Figure F2 SPod on tripod with no CGS and solar power*]
- Land power with ground fault interrupt 15-amp 110 V outlet (for land-powered installations)
- Sensit low voltage outdoor SPod power supply (for land-powered applications)
- Weather-proof power cord and connection system (for land-powered-applications)
- Pallet-based or fixed pole mounting system for longer deployments (Jacobs Technology) [*see Appendix F, Figure F3 SPod with quad CGS and solar panel on Jacobs pallet system*]
- Sandbags, concrete blocks, and ratchet-strap tie-downs for securing tripod or pallet to ground
- Calibration equipment described in 7.2

*7.2. SPod Calibration Equipment (Required):*

- Equipment in 7.1 suitable for specific deployment type (temporary or semi-permanent)
- Air, ultrazero VOC free (e.g., Airgas PN: AI UZP58, size 58DAL, CGA C10, documented VOC <10ppp)
- 1.0 ppm ± 2% isobutylene calibration cylinder certified standard spec (e.g., Airgas PN: X02NI99CPI600T9, size 58DAL nitrogen balance, CGA C10)
- Gas cylinder regulator, flow rate 0.5 LPM that is verified to mate with selected disposable cylinder (e.g., Airgas PN: Y1147045-AG)
- Sensit SPod calibration flow-through check sensor cap (Sensit PN 880-00066)
- 5 feet of 0.25-inch Teflon tubing with 0.25-inch Swagelok nut, ferrule, and union to connect cylinder value to SPod calibration check sensor cap [*see Appendix F, Figure F4 field calibration example*]

*7.3. SPod/CGS for Triggered Canister Acquisition (optional):*

- All equipment in 7.1 or 7.2
- Sensit SPod CGS trigger system (Sensit technologies), [*see Appendix F, Figures F5 and F6*]
- Trigger solenoid(s) (up to four), and connection cabling (Sensit technologies)
- Sampling inlet(s) for application, typically 2 µm sintered fret, Swagelok fittings, 180 deg turn and rain umbrella for 30 second triggered grab samples
- CGS and canister fixturing system (Jacobs Technology)
- Specified quantity of 1.4 L Silonite coated canisters (Entech Instruments, PN: 01-29-MC1400SQT)
- Vacuum pressure gauge with Micro-QT® fitting (Entech, PN: 01-29-70010QT)
- Canister shipping container
- SPod/CGS Canister COC Forms (from QAPP)

## *8. Reagents and Standards*

Reagents and standards needed for laboratory analysis of CGS are not described in the SOP.
To execute zero and span calibrations, a supply of VOC-free air and a low ppm-level isobutylene gas standard are required. In Section 7.2, two small format field cylinders were specified:

- Air, ultrazero VOC free (e.g., Airgas PN: AI UZP58, size 58DAL, CGA C10)
- 1.0 ppm ± 2% isobutylene calibration cylinder certified standard spec (e.g., Airgas PN: X02NI99CPI600T9, size 58DAL nitrogen balance, CGA C10)

Other forms zero air generation and isobutylene gas standards may be used, such as:

- 1.0 ppm ± 5% isobutylene in air balance (e.g., PortaGas PN 315-120013)
- 0.5 ppm ± 2% isobutylene in air balance (e.g., Airgas PN X02AI99CP580082A2)
- 5.0 ppm ± 5% isobutylene in N2 air balance (e.g., Airgas PN X02NI99C15A6H87)- requires ultrazero air dilution to below 2.0 ppm using calibrated mass flow controllers.

## 9. ***Procedures***

The following procedures describe SPod/CGS set up, operation, select QA/QC procedures, and basic data analysis. Some procedures will vary as noted depending on equipment configuration [e.g., sections 7.1, 7.2, and 7.3 (optional)].

### *9.1. SPod/CGS Settings Configuration and Example Data File:*

As described in the SPod user manual[1], the Sensit SPod/CGS internal system settings can be configured for a variety of power and communication options and selection of the types and threshold levels for canister triggering. To configure this SPod/CGS system, an SPod/CGS Advanced Operator (Section 6.3) must connect a computer with a CoolTerm terminal emulator program to the SPod and follow the procedures in the SPod user manual starting on page 35. This connection requires a special USB to SPod cable that is described in the manual and supplied with the unit. For details on the connection procedure and description and management of settings, refer to the user manual. The settings may be changed based on the project and should be described in the QAPP.

Prior to deployment, the settings of each SPod must be verified to ensure that they are set as per project requirements. Figure 9.1.1 shows a screen image of an SPod's settings that are displayed during unit start-up with CoolTerm communication active. The screen is visible within the first 10 secs of start-up and can also be accessed through the settings menu by entering "YES" before the start-up countdown ends and also by entering "DISPLAY" on the command line. The device settings (e.g., this screen image) must be recorded on the SPod/CGS Settings Configuration Form (Appendix B) and submitted to project records. Any change in settings requires proper documentation through creation of another configuration form. The current example shows an SPod with no CGS set up for solar power, basic PID sensor heater enabled at a set point of 15, and with no PID offset applied. Other settings and sub menus are described in the user manual.[1]

```
SPOD Firmware v5.94

Checking For Sampler...SPOD Can v1.9

Sensor ID: SPOD01181
With MET, Filter: 10
System DATE,05/24/22 18:48:41
Network Time: Enabled, UTC
Battery Voltage: 14.37
Power Source: Solar Power
Output Mode: Streaming
Communication Mode: Cellular, Unlocked
Network Selection: Automatic
Cellular Protocol: Periodic HTTP Power Down with TLS
Output Data Rate: 10
Cellular Output Ratio: 90
Server Address: https://api.sensitconnect.net/sensors-data/addSensorsData
Access Point Name: zipitwireless.com.attz
GPS Mode: Disabled
PID1 Hours: 134
Sensor Heater: Enabled
Temp Set: 15
Dew Point Control: Disabled
PID1 Offset(ppb): 0.00, Not Constrained
```

Figure 9.1.1: Screenshot of SPod settings

The output file from the SPod is a comma delimited text file. With the above configuration, the file will appear as shown in Figure 9.1.2 with (b) showing the data in the form and with the headers applied by the EPA R-processing software. The column labels differ here slightly from that expression found in the user manual but are so structured to help in discrimination of the raw and processed data forms, with the latter described in Section 9.5.

```
SPOD00106,DATE,12/21/19  07:59:08,PID1,109.07,224.30,T,-3.50,RH,79.40,P,1014.00,WS,0.50,WD,211.10,TC,1506,25,1507,BATT,14.27,CHRG,0.13,RUN,79.89,TRIG,0,0,0,0
SP[illegible]6,DATE,12/21/19  07:59:18,PID1,107.93,223.49,T,-3.50,RH,79.40,P,1014.00,WS,0.50,WD,201.30,TC,1510,24,1507,BATT,14.24,CHRG,0.04,RUN,80.87,TRIG,0,0,0,0
SP[illegible]6,DATE,12/21/19  07:59:29,PID1,107.92,223.48,T,-3.40,RH,79.40,P,1014.00,WS,0.60,WD,199.10,TC,1510,24,1510,BATT,14.24,CHRG,0.01,RUN,78.48,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  07:59:39,PID1,108.25,223.71,T,-3.50,RH,79.40,P,1014.00,WS,0.60,WD,201.40,TC,1510,24,1507,BATT,14.21,CHRG,0.00,RUN,76.25,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  07:59:49,PID1,108.20,223.67,T,-3.50,RH,79.40,P,1014.00,WS,0.60,WD,190.20,TC,1510,23,1507,BATT,14.20,CHRG,0.00,RUN,78.10,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  07:59:59,PID1,107.95,223.50,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,197.90,TC,1510,22,1507,BATT,14.18,CHRG,0.00,RUN,80.85,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:09,PID1,107.87,223.44,T,-3.50,RH,79.40,P,1014.00,WS,0.50,WD,193.50,TC,1510,21,1507,BATT,14.16,CHRG,0.00,RUN,78.44,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:19,PID1,107.62,223.26,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,195.80,TC,1505,21,1507,BATT,14.16,CHRG,0.00,RUN,74.47,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:29,PID1,108.40,223.82,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,195.20,TC,1503,22,1507,BATT,14.12,CHRG,0.00,RUN,77.01,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:39,PID1,108.95,224.21,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,199.80,TC,1503,23,1507,BATT,14.13,CHRG,0.00,RUN,80.70,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:50,PID1,112.63,226.83,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1503,24,1507,BATT,14.35,CHRG,145.71,RUN,79.22,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:01:13,PID1,113.08,227.15,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1504,24,1507,BATT,14.45,CHRG,158.91,RUN,81.04,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:01:43,PID1,115.98,229.21,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1507,24,1507,BATT,14.42,CHRG,153.93,RUN,81.07,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:01:53,PID1,125.74,236.17,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1512,23,1507,BATT,14.41,CHRG,53.67,RUN,50.93,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:04,PID1,133.48,241.68,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1512,22,1507,BATT,14.38,CHRG,18.71,RUN,53.99,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:14,PID1,142.52,248.12,T,-3.30,RH,79.70,P,1014.00,WS,0.80,WD,170.10,TC,1511,23,1513,BATT,14.35,CHRG,6.53,RUN,67.16,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:24,PID1,149.72,253.25,T,-3.50,RH,79.70,P,1014.00,WS,0.60,WD,173.10,TC,1510,22,1507,BATT,14.33,CHRG,2.28,RUN,75.74,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:34,PID1,152.41,255.17,T,-3.50,RH,79.70,P,1014.00,WS,0.70,WD,171.20,TC,1510,21,1507,BATT,14.31,CHRG,0.79,RUN,79.10,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:44,PID1,153.33,255.82,T,-3.50,RH,79.70,P,1014.00,WS,0.80,WD,167.30,TC,1505,21,1507,BATT,14.28,CHRG,0.28,RUN,76.97,TRIG,0,0,0,0
```

(b)

| SPod S/N | Date (mm/dd/yy) | Time (hr:min:sec) | RawPID (ppb) | RawPID (mV) | Temp (deg C) | RH (%) | Pres (mBar) | WS (mph) | WD (deg) | S1 Temp (arb) | S1 Heat (0-255) | S1 Set (arb) | Bat Volt (V) | Charge Current (mA) | Operate Current (mA) | Trig Port Stat | Trig Flag Stat | Trig Active Flag | Trig Sample Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPOD00106 | 12/21/19 | 7:59:08 | 109.07 | 224.3 | -3.5 | 79.4 | 1014 | 0.5 | 211.1 | 1506 | 25 | 1507 | 14.27 | 0.13 | 79.89 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 7:59:18 | 107.93 | 223.49 | -3.5 | 79.4 | 1014 | 0.5 | 201.3 | 1510 | 24 | 1507 | 14.24 | 0.04 | 80.87 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 7:59:29 | 107.92 | 223.48 | -3.4 | 79.4 | 1014 | 0.6 | 199.1 | 1510 | 24 | 1510 | 14.24 | 0.01 | 78.48 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 7:59:39 | 108.25 | 223.71 | -3.5 | 79.4 | 1014 | 0.6 | 201.4 | 1510 | 24 | 1507 | 14.21 | 0 | 76.25 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 7:59:49 | 108.2 | 223.67 | -3.5 | 79.4 | 1014 | 0.6 | 190.2 | 1510 | 23 | 1507 | 14.2 | 0 | 78.1 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 7:59:59 | 107.95 | 223.5 | -3.5 | 79.5 | 1014 | 0.5 | 197.9 | 1510 | 22 | 1507 | 14.18 | 0 | 80.85 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:00:09 | 107.87 | 223.44 | -3.5 | 79.4 | 1014 | 0.5 | 193.5 | 1510 | 21 | 1507 | 14.16 | 0 | 78.44 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:00:19 | 107.62 | 223.26 | -3.5 | 79.5 | 1014 | 0.5 | 195.8 | 1505 | 21 | 1507 | 14.16 | 0 | 74.47 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:00:29 | 108.4 | 223.82 | -3.5 | 79.5 | 1014 | 0.5 | 195.2 | 1503 | 22 | 1507 | 14.12 | 0 | 77.01 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:00:39 | 108.95 | 224.21 | -3.5 | 79.5 | 1014 | 0.5 | 199.8 | 1503 | 23 | 1507 | 14.13 | 0 | 80.7 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:00:50 | 112.63 | 226.83 | -3.5 | 79.5 | 1014 | 0.5 | 198 | 1503 | 24 | 1507 | 14.35 | 145.71 | 79.22 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:01:13 | 113.08 | 227.15 | -3.5 | 79.5 | 1014 | 0.5 | 198 | 1504 | 24 | 1507 | 14.45 | 158.91 | 81.04 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:01:43 | 115.98 | 229.21 | -3.5 | 79.5 | 1014 | 0.5 | 198 | 1507 | 24 | 1507 | 14.42 | 153.93 | 81.07 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:01:53 | 125.74 | 236.17 | -3.5 | 79.5 | 1014 | 0.5 | 198 | 1512 | 23 | 1507 | 14.41 | 53.67 | 50.93 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:02:04 | 133.48 | 241.68 | -3.5 | 79.5 | 1014 | 0.5 | 198 | 1512 | 22 | 1507 | 14.38 | 18.71 | 53.99 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:02:14 | 142.52 | 248.12 | -3.3 | 79.7 | 1014 | 0.8 | 170.1 | 1511 | 23 | 1513 | 14.35 | 6.53 | 67.16 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:02:24 | 149.72 | 253.25 | -3.5 | 79.7 | 1014 | 0.6 | 173.1 | 1510 | 22 | 1507 | 14.33 | 2.28 | 75.74 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:02:34 | 152.41 | 255.17 | -3.5 | 79.7 | 1014 | 0.7 | 171.2 | 1510 | 21 | 1507 | 14.31 | 0.79 | 79.1 | 0 | 0 | 0 | 0 |
| SPOD00106 | 12/21/19 | 8:02:44 | 153.33 | 255.82 | -3.5 | 79.7 | 1014 | 0.8 | 167.3 | 1505 | 21 | 1507 | 14.28 | 0.28 | 76.97 | 0 | 0 | 0 | 0 |

Figure 9.1.2: (a) Raw data from SPod output text file, (b) same information with EPA headers from R-Code processing, described subsequently.

### *9.2. SPod/CGS Error Debugging:*

If a communication or operation issue arises with the SPod/CGS, an SPod/CGS Advanced Operator (Section 6.3) may access internal error codes to assist in debugging as described in the SPod user manual.[1] These procedures are not described in this SOP.

### *9.3. Cal-check and Single Point Span Calibration with Zero:*

This procedure describes the calibration and testing of the 10.6 eV PID sensor contained in the SPod using equipment and supplies referenced in Section 7.2. and the gas standards discussed in Section 8. Other sensors that are part of the SPod either do not require routine calibration or provide secondary (non-critical) data and are not covered in this SOP. Depending on project-requirements, non-PID sensors may be subject to calibration/testing procedures as per the QAPP. There are two types of standard PID sensor procedures, the calibration check (Cal-check) and the single point span calibration with zero. The steps of these procedures are described in Appendices C1 and C2, respectively. Each procedure tests the response of the PID to 1.0 ppm concentration of isobutylene, delivered to the sensor while in the SPod housing at a flow rate of 0.5 LPM. Note that an alternate concentration of 500 ppb may be used based on project specific requirements. The concentration should be below 2.0 ppm as this represents the effective range of the PID sensor (when using the default Ion Science HS sensor).

#### *9.3.1. Cal-check:*

A Cal-check is a simple in-field procedure that is performed in a similar fashion to 9.3.2 but the zero gas point is not used and the computer connection is not required (no settings are changed). The Cal-check verifies SPod PID functionality, approximate sensor responsivity, PID calibration factor, and can verify CGS trigger operation (if desired).

As described in Section 5.2, the field-deployed baseline levels of the SPod PID can vary due to sensor drift (analytical interference) in addition to real changes in air shed VOC concentrations.[10] This baseline drift, coupled with the unknown composition of the emission plume make absolute SPod calibration difficult. The in-field Cal-check procedure provides a snap-shot view of the sensor's response to the 1 ppm isobutylene that carries a defined PID response factor of 1.0. This response does not equate to the sensor's response to plumes observed at the site that carry an unknown composite response factor. Acquisition of CGSs can assist in understanding the plume composition and PID sensor response by using a combination of individual response factors based on speciated laboratory analysis. To perform the Cal-check, ensure that the materials described in Section 7.2 are in hand and perform the steps outlined in Appendix C1 with refences to operational manuals.[1,2] The physical connection of the disposable cylinders, CGA C10 regulators, and tubing with adequate ventilation is covered in basic field operator training and is not described here.

*9.3.2. Single Point Span Calibration with Zero:*

Prior to entering the field, each SPod should be calibrated following the procedures of Appendix C2 and reference 2 with 1.0 ppm isobutylene (or other as specified in the QAPP). It is typically the case that procedure 9.3.1 precedes full calibration in order to document response prior to settings change (following Appendix C1). The current procedure uses a VOC-free zero gas and 1.0 ppm isobutylene span gas (Section 7.2) to zero the unit and calibrate the PID response at a single point. Since SPod system settings will be altered, the full calibration procedure requires computer communication via "Cool Term" as indicated in the operation and calibration manual.[1,2] This procedure is the minimum requirement for pre-deployment calibration and the project specific QAPP may call for additional procedures or assessments for specific compounds. Calibration may also be performed in the field if necessary.

*9.4. SPod Deployment and Site Documentation:*

- ***<u>Warning!</u> The SPod/CGS fenceline sensor is not intrinsically safe so cannot be located in a potentially hazardous area where explosive atmospheres may exist.***
- ***<u>Warning!</u> The SPod/CGS and solar panel (if used) must be robustly secured under heavy wind load. Securing equipment to the ground using pegs, spikes, or other ground penetration cannot be attempted without permission and approved ground survey.***

The selection of optimal SPod/CGS siting for remote observation of a potential source is critical to project success. When choosing a specific deployment location, it is important to select an area with an unimpeded wind flow that is proximate to the potential source under study (typically 50 m to 300 m distance). An open line of site to the potential source area is highly recommended. This is important to ensure efficient transport of potential emission plumes from the source to the sensor location and to collect wind data that is an accurate representation of the site conditions. It is critical to take care in the alignment and securing of the anemometer on the SPod to true north direction using hand-held GPS and comparative measures.

The SPod/CGS should be deployed in a location with relatively flat terrain and away from local obstructions (e.g., trees, buildings, hills). If the SPod/CGS deployment site must be near a potential obstruction, ensure that the unit is located at a horizontal distance that is at least two times the height of the obstruction if you are upwind of the obstruction in the direction of the source under observation, and six times the height of the obstruction if downwind. In some cases, the SPod may be attached to a tall pole or structure that provides an open line of site in the direction of the source but has obstructed wind flow in the opposite direction (due to the mounting structure). This situation must be documented, and special data anlysis screening used since only the unimpeded wind sectors can be considered (flag off-axis values). Since the SPods are typically located at ground level, they are not effective at monitoring elevated sources like tall emission stacks. Deployments very near intersections (within 20 meters for example) or where vehicles/trucks may idle or launch under load are not recommended and special QA procedures may be required.

For solar-powered deployments, the SPod should be oriented so that the solar panel is facing south (this should be verified using a compass, GPS, or smart phone), and the area should be free of shade for 8 hours. Each SPod, CGS trigger system, and canister (if used) must be properly fixtured to the site apparatus (e.g., installed pole, pallet/pole system, or heavy tripod) and that site apparatus must itself be secured so that it does not blow over under wind load. Due to "dig safe" utility restrictions on ground penetrations, securing a pallet/pole system or tripods and/or solar panel (if used) is typically accomplished using sandbags, concrete blocks and ratchet straps. Securing equipment to the ground using pegs, spikes, or other ground penetration

cannot be attempted without permission and approved ground survey. Avoid placing equipment too close to roadways for technical reasons and because the equipment can cause a driving distraction hazard.
After connecting and securing the SPod/CGS system and power supply (land or solar) and checking the integrity and robustness of fixturing, the unit is ready to turn on. Push the power button and look for the blinking green light.[1] Access the internet through a secondary computer to verify data feed on the website and with the password described in project-specific documentation. Fill out the Site Deployment Form (Appendix D). The system is now operational and after a one-hour warm-up time, is ready for QA testing (Section 9.5). If errors are noted in startup, see Procedure 9.2

*9.5. SPod/CGS In-field and Pre-deployment QA Testing:*
This section describes QA procedures for the SPod/CGS system that may be performed prior to or during field deployment (in-field). Standard pre-deployment tests help ensure that the equipment is in good working order and that all fixturing, and power supply variables are known before incurring travel expenses to the field. If a deployment is local and/or temporary, pre-deployment checks may be accomplished in the field as part of the actual deployment. This is done at risk since if the units fail the deployment test, the deployment cannot continue. As noted, many of the tests described in this section are the same as tests performed periodically while deployed (in-field) and are documented in the same manner.

*9.5.1. SPod Single Unit QA Table:*
This QA procedure uses an automated data analysis program written in "R" to read in (Appendix E1) and generate (Appendix E2) a summary table of basic statistical information for a single SPod for a specified time interval. The SPod Data Analyst must first retrieve the data file for the day to be analyzed from the data repository (Sensit Connect site, or potentially from EPA Viper[14], with code modifications required). The retrieval can be a partial day. The typical analysis time for a QA table is 60 minutes, but an analysis period of 60 seconds is also used for calibration procedures. As described in Appendix E4, a 24-hour QA table may also be generated in the Sensit Shiny app. A QA table on newly generated or historic data can help verify functionality of the SPod's sensor systems or to assist in auditing of SPod data during a study.

Once an SPod is operating and stabilized (i.e., >2 hours of operation in deployment conditions), transfer a daily data file to a computer configured for SPod data analysis and execute SPod R-Script as per Appendices E1 and E2 to generate the QA table (see example Table 9.5.1). The SPod Data Analyst will review and complete the table and append it to the forms required for procedures 9.3 (Appendices C1 and C2), 9.4 (Appendix D), or for QA audits or other procedures described in the QAPP. If parameters are out of tolerance, the SPod Data Analyst and/or SPod/CGS SPod Field Operator must notify the appropriate party and take corrective action as per QAPP technical lead instructions.

The Analyst must review the QAPP for recommended QA acceptance criteria (Section 11, Table 11.2) for each parameter line and place a "check mark" or "X" to indicate pass or fail, along with applicable notes. Note that QA parameter tolerance guidance is only valid for cases where the SPod is deployed outdoors, no strong source is present, and calibration procedures are not taking place. Typically, a 60-minute QA table time period is used but a 1-minute version of the QA table is associated with calibration activities (Section 9.3). In the table, "N" equals 360 for a one-hour period (at 10 seconds per data point). Data completeness [Data Comp (%)] tracks the level of missing data in the subject period and is a simple percentage of "N". The following other parameters not found in Figure 9.1.2(b) are now defined:

- A Raw value is the value reported in the data file
- The BCP PID (mV) and BCP PID (ppb) are derived from the background correction (BCP) algorithm applied to the respective Raw value time series.
- Raw PID (mV) – BCP PID (mV) is point by point subtraction of Raw and BCP time series single in mV and is a measure of the amount of baseline correction performed in mV.
- Raw PID (ppb) - BCP PID (ppb) is point by point subtraction of Raw and BCP time series single in ppb and is a measure of the amount of baseline correction performed in ppb.

Table 9.5.1 Example SPod Single Unit QA Table (Attach to Appendix C or D or document as per QAPP)

QA Table ID: SPOD00106_2019_12_17_14_00_00_15_00_00

Start End

Enter date and time range for analysis, run script, print table and fill out, make PDF record

SPod S/N: SPOD00106

Date: 2019-12-17

Start and End Time: 14:00:00 EST to 15:00:00 EST

Output Date: 2021-08-19

R Code Version: 1.1_071921

SPod Data Analyst Name and Signature: ____ Analyst Identification ____

Notes: Analyst Notes

## Single Unit QA Table

Analyst checks against QAPP

Table 1: Hourly Audit Stats: 2019-12-17 14:00:00 EST to 2019-12-17 15:00:00 EST

| | Mean | Median | Std.Dev | Min | Max | N | Data.Comp | QA.Pass |
|---|---|---|---|---|---|---|---|---|
| Raw PID (mV) | 167.5 | 167 | 3.1 | 161.1 | 181.2 | 336 | 93.3 | ✓ |
| Raw PID (ppb) | 29.3 | 28.7 | 4.3 | 20.3 | 48.6 | 336 | 93.3 | ✓ |
| BC PID (mV) | 4.3 | 4 | 2.5 | -1 | 17.2 | 336 | 93.3 | ✓ |
| BC PID (ppb) | 6.1 | 5.6 | 3.5 | -1.4 | 24.1 | 336 | 93.3 | ✓ |
| Raw PID (mV)-BC PID (mV) | 163.2 | 163.2 | 1 | 161.4 | 165.1 | 336 | 93.3 | ✓ |
| Raw PID (ppbv)-BC PID (ppbv) | 23.3 | 23.2 | 1.4 | 20.7 | 25.9 | 336 | 93.3 | ✓ |
| Temp (deg C) | 2 | 2 | 0.2 | 1.4 | 2.7 | 336 | 93.3 | ✓ |
| RH (%) | 51.1 | 50.9 | 0.9 | 49 | 53.3 | 336 | 93.3 | ✓ |
| Pres (mBar) | 1002 | 1002 | 0 | 1002 | 1002 | 336 | 93.3 | ✓ |
| WS (mph) | 2.6 | 2.6 | 0.8 | 0.4 | 5.5 | 336 | 93.3 | ✓ |
| WD (deg) | 283.2 | 323.7 | 114.4 | 0.5 | 358.7 | 336 | 93.3 | ✓ |
| S1 Temp (arb) | 1715.2 | 1714.5 | 21.2 | 1645 | 1770 | 336 | 93.3 | ✓ |
| S1 Heat (0-255) | 27.1 | 27 | 7.1 | 15 | 49 | 336 | 93.3 | ✓ |
| S1 Set (arb) | 1714.5 | 1713 | 9.4 | 1688 | 1744 | 336 | 93.3 | ✓ |
| Bat Volt (V) | 14.3 | 14.3 | 0.1 | 14.1 | 14.5 | 336 | 93.3 | ✓ |
| Charge Current (mA) | 92.9 | 0.1 | 194.4 | 0 | 788.2 | 336 | 93.3 | ✓ |
| Operate Current (mA) | 82.6 | 82.8 | 7.4 | 50.4 | 100.9 | 336 | 93.3 | ✓ |
| Trig Port Stat | 0 | 0 | 0 | 0 | 0 | 336 | 93.3 | ✓ |
| Trig Flag Stat | 0 | 0 | 0 | 0 | 0 | 336 | 93.3 | ✓ |
| Trig Active Flag | 0 | 0 | 0 | 0 | 0 | 336 | 93.3 | ✓ |
| Trig Sample Flag | 0 | 0 | 0 | 0 | 0 | 336 | 93.3 | ✓ |

*9.5.2. SPod Collocated Unit QA Table:*

If two or more SPod/CGS systems are collocated (operating side by side), additional cross-unit QA comparisons can be conducted. Execute procedure 9.5.1. for both units for the same time periods and generate the SPod/CGS QA Testing Form for each unit. Run R-script contained in Appendices E1 and E2 for both units individually followed by Appendix E3 to automatically compare the collocated and time-aligned data from the two units and generate Table 9.5.2. Table 9.5.2 is example shown with preliminary field from protype versions of this sensor with the values displayed showing the difference between SPod 106 and SPod 105 for the selected 1-hour time period. In this example, there is a significant difference between the wind direction measurement by the units indicated that the orientation of one of the units is incorrect and corrective action must be taken.

The SPod Data Analyst will review and complete the table, referring to the QAPP for acceptance tolerances (currently under development but typically +/-20% for non-PID values). The Analyst appends forms required for procedures, such as 9.4 (Appendix D), or for weekly QA audits or other procedures described in the QAPP. It is possible for the collocated comparison to include time periods during which an SPod PID Cal-check was performed (procedure 9.3.1). In this event, it is important to ensure that both units that were subjected to procedure 9.3.1 in exactly the same manner within the comparison window or the results will likely differ because of this introduced artificial concentration. It is not recommended to perform this comparison for time periods that include full calibration (procedure 9.3.2) events since SPod PID settings were altered.

Ideally, PID values should be similar between the units (particularity BC PID values) but the final assessment of similarity typically focuses on values above methods detection limit which requires another additional SPod data analysis as per Appendix E4 and the QAPP.

Table 9.5.2: Example SPod Collocated Unit QA Table (Attach to Appendix D or record as per QAPP)

QA Table ID: SPOD00105_2019_12_17_14_00_00_15_00_00_SPOD00106_2019_12_17_14_00_00_15_00_00

Date: 2019-12-17 *Unit 1* *Unit 2*

*Enter date and time range for analysis, run script, print table and fill out, make PDF record*

Start and End Time: 14:00:00 EST to 15:00:00 EST

Output Date: 2021-08-19

R Code Version: 1.1_071921

SPod Data Analyst Name and Signature: *Analyst Identification*

Calculation: SPOD00106 - SPOD00105

Notes: *Wind direction comparison out of anemometers out of alignment, corrective action required.*

Collocated Unit QA Table

*Analyst checks against QAPP*

Table 1: (SPOD00106 - SPOD00105 ) : 2019-12-17 14:00:00 EST to 2019-12-17 15:00:00 EST

| | Mean | Median | Std.Dev | Min | Max | N | Data.Comp | QA.Pass |
|---|---|---|---|---|---|---|---|---|
| Raw PID (mV) | 70.8 | 70.2 | 1.0 | 68.6 | 73.0 | -7 | -2 | ✓ |
| Raw PID (ppb) | 18.3 | 17.6 | 1.6 | 14.8 | 22.8 | -7 | -2 | ✓ |
| BC PID (mV) | 0.7 | 0.3 | 0.4 | -0.5 | 2.1 | -7 | -2 | ✓ |
| BC PID (ppb) | 1.4 | 0.9 | 0.8 | -0.7 | 4.7 | -7 | -2 | ✓ |
| Raw PID (mV)-BC PID (mV) | 70.1 | 70.1 | 0.9 | 68.7 | 71.9 | -7 | -2 | ✓ |
| Raw PID (ppbv)-BC PID (ppbv) | 17.0 | 16.8 | 1.2 | 14.8 | 19.4 | -7 | -2 | ✓ |
| Temp (deg C) | -1.0 | -1.0 | 0.1 | -1.2 | -0.6 | -7 | -2 | ✓ |
| RH (%) | 0.6 | 0.6 | 0.0 | 1.1 | 0.7 | -7 | -2 | ✓ |
| Pres (mBar) | -0.4 | 0.0 | -0.5 | 0.0 | -1.0 | -7 | -2 | ✓ |
| WS (mph) | 0.1 | 0.2 | 0.0 | 0.2 | 0.7 | -7 | -2 | ✓ |
| WD (deg) | 65.5 | 15.5 | -39.5 | -0.8 | -1.1 | -7 | -2 | ✗ |
| S1 Temp (arb) | -42.6 | -44.5 | 7.1 | -49.0 | -18.0 | -7 | -2 | ✓ |
| S1 Heat (0-255) | -0.8 | -1.0 | 2.2 | 0.0 | 1.0 | -7 | -2 | ✓ |
| S1 Set (arb) | -43.3 | -44.0 | 3.3 | -51.0 | -27.0 | -7 | -2 | ✓ |
| Bat Volt (V) | 0.2 | 0.3 | 0.0 | 0.1 | 0.1 | -7 | -2 | ✓ |
| Charge Current (mA) | 26.6 | -81.9 | 138.7 | 0.0 | 504.7 | -7 | -2 | ✓ |
| Operate Current (mA) | -18.8 | -19.1 | 0.4 | -15.2 | -22.8 | -7 | -2 | ✓ |
| Trig Port Stat | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -7 | -2 | ✓ |
| Trig Flag Stat | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -7 | -2 | ✓ |
| Trig Active Flag | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -7 | -2 | ✓ |
| Trig Sample Flag | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -7 | -2 | ✓ |

### *9.6. CGS Deployment and QA Procedures:*

This SOP covers basic procedures for field use of canisters with an SPod/CGS system. Additional procedures associated with canister preparation, shipping, and general system cleanliness checks utilized by the EPA/ORD/CEMM/AMCD VOC Laboratory are described in J-AMCD-AAB-SOP-675-0 "Standard Operating Procedure for Cleaning Air Sampling Canisters with the Entech 3100A Canister Cleaner", SOP ID J-AMCD-AAB-SOP-675-0,[12] and "Standard Operating Procedure for Remotely Operated Canister Systems (ROCS)[13], SOP ID J-AMCD-SFSB-SOP-4231-0.[13] Canister analysis is typically performed by method TO-15.[11] If another laboratory is used to supply CGSs, equivalent procedures must be documented in the QAPP.

The SPod/CGS system typically uses 1.4 L Entech Silonite® coated stainless steel canisters for acquisition of whole air grab samples that are cleaned and evacuated to a final pressure of 10 mTorr. The CGSs are typically shipped within 48 hours after cleaning in a carrying case or shipping box to the field along with the COC forms contained in the QAPP, a manual pressure gauge, and return shipping labels. Canisters must be shipped back to analysis laboratory within 2 weeks of being received in the field. Hold times in the laboratory upon return from field deployment is less than 2 weeks prior to analysis. Hold times may change depending on requirements stated in the QAPP.

*9.6.1. CGS Deployment Procedures:*

The following procedures are used to deploy canisters in the SPod/CGS system:

- First, remove a canister that will be used to take a sample from the shipping container. Note that one canister is labeled a “field blank” and should not be used to take a sample.
- Write the sample ID on the sampling COC and the canister tag as detailed in project QAPP. If sample labels have been prepared, affix appropriate sample ID label on sampling COC and canister tag.
- Check that the canister valve is screwed on tightly by twisting it clockwise.
- Using the supplied manual vacuum pressure gauge, measure the canister pressure and record the pressure on the sampling COC under “Initial Press.”. If the pressure is greater than -28” Hg, the canister valve has leaked. Do not use the canister for sampling. Note on canister tag and Sampling COC when canister is suspected to have leaked.
- To install canister on SPod/CGS unit: pull up outer casing of female Micro-QT® connector on the canister inlet, push the canister male valve as far as it will go, then release the outer casing. Secure the canister in place with the Velcro straps. Check that the connection is secure by gently pulling apart the two items. If they can’t be easily pulled apart the connection is secure. [see Figure F5]
- When removing the canister, check the CGS final pressure and record on the COC under “Final Pressure”.
- To prepare for return shipping, confirm that the canister QT valves are all tight (turn clockwise). To prepare canisters and sampling supplies for return shipment, place canisters in their individual boxes and place them in the shipping box. Canisters should be shipped upright.
- If returning the vacuum gauge, wrap it in bubble wrap and place it back in a Ziploc bag. Pack it into one of the canister boxes.
- Fill out bottom half of Shipment COC and sign (make a copy for records). Return shipment and sampling COCs in Ziploc bag and place back in shipping box.
- Close carrying case and affix return shipment sticker.
- Ship canister box back to EPA RTP within 2 weeks of initial delivery date to field site.

*9.6.2. CGS Trigger Test, Leak Check, and Field CGS Grab Tests:*

For deployments that use CGSs, it important to confirm that the canister acquisition system is working as intended. Prior to deployment, routine setup trials should be performed as part of basic system checks to ensure that the SPod/CGS unit can properly trigger a canister acquisition on command and by reaching intended PID threshold levels, if so configured. Trigger solenoid inlet cleanliness should also be established as outlined in the EPA CEMM AMCD “Standard Operating Procedure for a Remotely Operated Canister System”, to test for canister blank level contamination using clean laboratory air conditions.

In addition to initial SPod/CGS setup and commissioning trials, field versions of these procedures can be used to periodically confirm that the CGS trigger system is working properly, and that the CGS system is not leaking. These procedures can also be used to acquire a field CGS that can represent a valid field sample with some relation to source signal depending on wind transport condition and PID levels. These tests described below may be performed together or separately. These tests may be performed prior to deployment or at any time during deployment. If the system is set up to trigger on a specific PID level, be prepared to supply an appropriate concentration and duration for isobutylene gas spike to the unit and confirm the trigger execution. Note that execution of the SPod PID Calibration Check (Procedure 9.3.1) may produce a canister trigger event (depending on trigger level settings). During the trigger test, it is important to verify (usually by an audible click) that the CGS canister solenoid is opening for the proper period of time. If an CGS is attached to the unit, it will be triggered and may contain some quantity of isobutylene from the surrounding air. Note that the following tests are performed in open air conditions and will reflect concentrations (including potential source emissions).

Perform the following steps, suitably document results, and ensure the triggers are reset for next operation.

- Place the SPod/CGS system outdoors under ambient deployment conditions. Clearly describe the deployment conditions in notebooks, forms, and COCs as appropriate.
- Transport clean canister(s) to the position of the SPod/CGS system and allow the canisters to equilibrate temperature (keep out of direct sunlight).
- Write the sample ID on the sampling COC and the canister tag as detailed in project QAPP. If sample labels have been prepared, affix appropriate sample ID label on sampling COC and canister tag.
- Record the starting pressure in the CGS using a quick connect manual vacuum pressure gauge in the COC. The CGS pressure must be less than < -28".
- Write the sample ID on the sampling COC and the canister tag as detailed in project QAPP. If sample labels have been prepared, affix appropriate sample ID label on sampling COC and canister tag.
- Check that the canister valve is screwed on tightly by twisting it clockwise.
- To install canister on SPod/CGS unit: pull up outer casing of female Micro-QT® connector on the canister inlet, push the canister male valve as far as it will go, then release the outer casing. Secure the canister in place with the Velcro straps. Check that the connection is secure by gently pulling apart the two items. If they can't be easily pulled apart the connection is secure.
- To execute an CGS leak check procedure, leave the untriggered evacuated canister on the SPod/CGS inlet and wait at least 24 hours. Confirm via SPod CGS data field that the SPod did not trigger the canister during the waiting period.
- Perform the CGS leak check by removing the canister and rechecking the pressure to ensure there is no discernable change has occurred and record findings on the COC.
- If unit passes leak check, proceed to the next step. If unit failed, ensure all plumbing connections are tight, and repeat leak test. The canister inlet fitting may need to be replaced if leak test failure continues. Otherwise, further diagnostic leak testing may be necessary to determine the source of leak in the system. Suitably document canister condition on COC.
- If a trigger and blank test are to be performed, the same canister may be used. replace the canister on SPod/CGS inlet.
- Trigger the canister by performing by manual, or software trigger.[1]
- Remove the canister and measure the CGS pressure which must be between 5" and 15" or a trigger/inlet issue occurred and must be diagnosed.
- Record canister ID, initial and final canister pressure, and sampling start and end time on COC and transfer sample to VOC lab for analysis.
- Canister samples are typically analyzed by GC/MS for target VOCs specified in the QAPP.
- Acquired CGS target analyzed concentrations collected from the SPod/CGS unit during these tests must not be >20 pptv higher than reference sample. If contamination is confirmed, purge SPod/CGS units with humidified zero air for a few hours and repeat blank qualification test. If contamination issue persists, the components of the plumbing may need to be replaced.

### *9.7. SPod Default Data Analysis:*

This specifics of the data analysis for the Sensit SPod can depend on the deployment scenario, distance to source, number of sensor nodes, etc., and should be described in the project specific QAPP. An example of an R Shiny application developed to process Sensit SPod data is described in Appendix E4. This application synthesizes data over time from two collocated sensors at a single site (future revisions will include capability to process multiple sites). This App R code and all other processing code can be found at the EPA Bitbucket repository described in Appendix E4.

## 10. *Data and Records Management*

The following data and records will be generated in a typical SPod deployment. It is the responsibility of the SPod Operator and Data Analyst to generate proper forms, records, and notebook entries as part of general operation procedures and as specified in the QAPP. It is the responsibility of the Project Lead to ensure records are being kept and to organize and archive the data and records as required by the QAPP and the scientific data management plan (SDMP). Paper records and forms, COCs, scanned notebook pages, and digital photos shall be converted to PDF files for including in the project file. Typical data and records include:

- QAPP and site-specific safety plan
- SPod time series data in daily files (e.g., Sensit data.txt files EPA Viper files, as per QAPP)
- Training and certification records (Appendix A) Sensit SPod SOP Training Certifications
- SPod/CGS Setup Configuration Form (Appendix B)
- SPod Calibration with Zero and Calibration Check Form (Appendix C)
- SPod/CGS Site Deployment Form (Appendix D)
- QA tables as generated from procedures 9.5.1 and 9.5.2
- Calibration gas cylinder information
- Evacuated canister COC forms (as per QAPP)
- SPod daily analysis summary files as per Appendix E
- VOC laboratory raw analysis data (chromatogram files – retained by VOC laboratory lead)
- VOC laboratory reduced data and notes (Microsoft Excel files and PDFs)
- Secondary metrological data (e.g., from local airport) for reasonableness checks (various)

## 11. *Quality Assurance/Quality Control*

The following are default QA/QC procedures for Senit SPod deployment. Additional data acceptance tolerances and calibration details may be described in the project specific QAPP. This description is for the issuance of the SOP #J-AMCD-SFSB-SOP-4380-2. As Sensit SPod deployments commence and field data become available for review, adjustments to these QA procedures and acceptance tolerances will occur and be documented in future revisions to this SOP. In addition to the QA/QC summary contained in Table 11.1, current acceptance values for a 60-minute single unit QA table is contained in Table 11.2. Appendix E contains some additional procedures for processing and review daily data summaries.

Table 11.1. Summary of basic QA/QC procedures for prototype SPod/CGS set up and use

| Condition | Training Requirements | Procedure | Accepting Criteria | Corrective Action | Frequency |
|---|---|---|---|---|---|
| SPod/CGS device configuration | Sections 6.1, 6.2, 6.3 | Section 9.1 and Appendix B | SPod must be configured as per QAPP | Redo procedure and generate new form / repair unit if necessary | Prior to deployment and on any configuration change |
| SPod Cal-check | Sections 6.1, 6.2, 6.3 | Section 9.3.1 and Appendix C1 | ± 20% of calibration span value (1 ppm) | Perform 9.3.2 or repair unit if necessary | Upon deployment and once every three months if in use |
| SPod Span Calibration with Zero | Sections 6.1, 6.2, 6.3 | Section 9.3.2 and Appendix C2 | ± 10ppb (zero)<br>± 10% of calibration span value (1 ppm) | Repeat 9.3.2 or repair unit if necessary | Before deployment, on 9.3.1 fail and annually |
| SPod/CGS deployment form | Sections 6.1, 6.2, and 6.3 if necessary | Section 9.4, Section 9.3.2, and Appendix D | SPod must meet siting requirements pass Cal-check (9.3.1) and exhibit nominal operation | Improve siting, and/or Perform calibration and generate new form / repair unit if necessary | Once at deployment |
| QA Table generation | Section 6.2 | Section 9.5.1 and 9.5.2 for collocated SPods | Table 9.5.1 or 9.5.2 or tolerances described in the QAPP | Consult with project lead, calibrate, or repair unit if necessary | As part of installation procedures and once per week or as per QAPP |

| Condition | Training Requirements | Procedure | Accepting Criteria | Corrective Action | Frequency |
|---|---|---|---|---|---|
| SPod/CGS Canister leak and cleanliness check | Section 6.1 and 6.4 | Section 9.6 | Verification and documentation of leak check and SPod/CGS cleanliness | Perform maintenance as required | Prior to deployment and as per QAPP |

Table 11.2 contains current acceptance values for a 60-minute single unit QA table, described in Section 9.5.1. These values assume minimal VOC source impact and no calibration activity. Values labeled "±XX (Sec Dat)" refers to comparisons to secondary data (Sec Dat), such as from a nearby airport or collocated measurement. The acceptance tolerances for a number of parameters are to be determined (TBD). These values will be revised after additional field data is acquired. Certain measures are related to equipment operational state. A low Charge Current or low Bat Volt, for example, may mean that the land power or solar power are not properly connected or operating, and the sensor will stop working when the on-board battery is drained. A low S1 heat value (<15 in the setup example of Figure 9.1.1) may mean the sensor heater has failed or is not enabled. Sensor QA levels that detect unrealistically low PID signal variability or out-of-tolerance high and low signal levels help isolate certain types of sensor failure modes but are not comprehensive. Acceptance values for the collocated SPod QA table comparisons (Section 9.5.2) are in development and will be described in a future version of this SOP.

Table 11.2: Target acceptance values for 60-minute, 10 second SPod single unit QA table

| **SPod Single Unit QA Table** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Accetance values as of 8/24/21, no upwind source or Cal-check, "Ref" refers to secondary data comparison** | | | | | | | |
| **Parameter** | **Mean** | **Median** | **StdDev.** | **Min** | **Max** | **N** | **Data Comp.** |
| Raw PID (mV) | 30 to 300 | N/A | 1.0 to 30 | 10 | 400 | 360 | >90% |
| Raw PID (ppb) | 10 to 200 | N/A | 1.0 to 20 | 5 | 200 | 360 | >90% |
| BCP PID (mV) | -1.0 to 10 | N/A | < 5.0 | > -2.0 | 400 | 360 | >90% |
| BCP PID (ppb) | -1.0 to 10 | N/A | < 5.0 | > -2.0 | 200 | 360 | >90% |
| Raw PID-BCP PID (mV) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| Raw PID-BCP PID (ppbv) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| Temp (deg C) | ± 2 (Sec Dat) | N/A | N/A | ± 2 (Sec Dat) | ± 2 (Sec Dat) | 360 | >90% |
| RH (%) | ±20% (Sec Dat) | N/A | N/A | ±20% (Sec Dat) | ±20% (Sec Dat) | 360 | >90% |
| Pres (mBar) | ±20% (Sec Dat) | N/A | N/A | ±20% (Sec Dat) | ±20% (Sec Dat) | 360 | >90% |
| WS (mph) | ±20% (Sec Dat) | N/A | N/A | ±20% (Sec Dat) | ±20% (Sec Dat) | 360 | >90% |
| WD (deg) | ±15 (Sec Dat) | N/A | N/A | ±15 (Sec Dat) | ±15 (Sec Dat) | 360 | >90% |
| S1 Temp (arb) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| S1 Heat (0-255) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| S1 Set (arb) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| Bat Volt (V) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| Charge Current (mA) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| Operate Current (mA) | TBD | TBD | TBD | TBD | TBD | 360 | >90% |
| Trig Port Stat | 0 | N/A | N/A | 0 | 1 | 360 | >90% |
| Trig Flag Stat | 0 | N/A | N/A | 0 | 1 | 360 | >90% |
| Trig Active Flag | 0 | N/A | N/A | 0 | 1 | 360 | >90% |
| Trig Sample Flag | 0 | N/A | N/A | 0 | 1 | 360 | >90% |

## *12. References*

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### *Appendix A: Sensit SPod SOP Training Certifications*

Refer to Section 6 of this SOP. The below named training lead certifies that the below named operator or analyst has met the training, experience, and authorization requirements described in Section 6 for the Sensit SPod/CGS system. The training lead certifies that training was successfully tested (record initials). Prepare 1 form for each person and indicate N/A where training requirements have not been met or are inappropriate.

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**SPod/CGS Field Operator (Section 6.1):**

Name and organization of person trained: ___________________________
Signature of person trained: ___________________________
Name and organization of training lead: ___________________________
Signature of training lead: ___________________________
Date when training test was completed: ___________________________

Description of training test. The operator was observed to correctly complete the following: Passed

(1) Physical set up and connections of SPod, CGS, and power system ______
(2) Check/adjustment of anemometer to North (as per manual) for the specific siting ______
(3) Turn on and check of SPod error codes as per manual ______
(4) Cal Check Procedure Step 9.3.1 and completion of form in Appendix C1, Steps 1-5 ______
(5) CGS change-out Procedure 9.6.1 including COC completion ______

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**SPod Data Analyst (Section 6.2):**

Name and organization of person trained: ___________________________
Signature of person trained: ___________________________
Name and organization of training lead: ___________________________
Signature of training lead: ___________________________
Date when training test was completed: ___________________________

Description of training test. The operator was observed to correctly complete the following: Passed

(1) Data and sensor status view and download (Appendix E1) ______
(2) Operation of R-script for data analysis and QA Table generation (Appendix E2 and E3) ______
(3) Knowledge check of overall R-script shiny app application ______
(4) Completion of Analyst section of all forms and E-notebook documentation requirements ______
(5) Demonstration of sensor malfunction detection and corrective action notification ______

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**SPod/CGS Advanced Operator (Section 6.3):**
**SPod Data Analyst (Section 6.2):**

Name and organization of person trained: ___________________________
Signature of person trained: ___________________________
Name and organization of training lead: ___________________________
Signature of training lead: ___________________________
Date when training test was completed: ___________________________

Description of training test. The operator was observed to correctly complete the following: Passed

(1) Demonstration of SPod Operator and Data Analyst training ______
(2) Demonstration of SPod configuration change and completion of Appendix B ______
(3) Full calibration with zero Procedure 9.3.2 and completion of appendix C2 ______
(4) Demonstration of advanced SPod maintience procedures ______
(5) Demonstration of SPod documentation and E-notebook documentation requirements ______

***Appendix B: SPod/CGS Setup Configuration Form***

Procedure Step 9.1 (one form per SPod/CGS)
**<u>Required Training</u>**: To complete this procedure, personnel must be trained as at minimum an SPod/CGS Field Operator (Section 6.1), SPod Data Analyst (Section 6.2), and SPod/CGS Advanced Operator (Section 6.3).

(1) Operator name and signature____________________________________________
(2) Date and time (local):________________________________________________
(3) SPod S/N: ________________________________________________________
(4) CGS system S/N (if used):
____________________________________________________
(5) Solar or land power deployment?_______________________________________
(6) SPod deployment QAPP title/ID:________________________________________
(7) SPod deployment QAPP version date:____________________________________
(8) Has the QAPP been consulted for SPod/CGS settings configuration information (Yes/No)?_________
(9) How many CGS's to be used on this SPod?_________________________________________
(10) Connect to SPod and take a screen shot of the current device configuration and attach to this form
(11) Make changes and take a screen shot of the new device configuration and attach to this form
(12) Describe changes below, initial and date the attached forms, and create necessary records:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

## *Appendix C1: Calibration Check (Cal-check) Form*

Procedure Step 9.3.1 (Cal-check). To complete Steps 1-6 of this procedure, personnel must be trained as an SPod/CGS Field Operator (Section 6.1). To complete Steps 8-14, personnel must be an SPod Data Analyst (Section 6.2). Complete one form for each SPod. The standard calibration concentration is 1 ppm isobutylene in air balance, but other concentrations (such as 500 ppb) may also be used (record in Step 4). The default Cal-Check acceptance level is ± 25% of actual, unless otherwise specified in the QAPP. Consult Section 7 for necessary equipment supplies. Make sure the SPod has been operating for > 2 hours to allow sufficient time for PID to stabilize. Consult project safety plan and ensure adequate ventilation before gas release.

(1) Operator name and signature:______________________________________________________________
(2) Date, time, and SPod location:______________________________________________________________
(3) SPod S/N and CGS system S/N (if used):____________________________________________________
(4) Isobutylene gas cylinder information and concentration:_________________________________________
(5) Perform Cal-check by connecting 1 ppm (or other) isobutylene supply to SPod PID with sensor calibration cap and flow gas at 0.5 LPM for exactly three minutes (180 seconds). **Make sure to accurately record the start time (ST) and end time (ET) of the gas flow in the below form on line "Step 6."** Turn off gas, remove calibration cap, and return system to operation.

| Cal-Check Step | Cal-Check Description | Gas Flow Start Time (ST) Local (hr:min:sec) | Gas Flow End Time (ET) Local (hr:min:sec) | Mean Conc. (ppb) | Stdev Conc. (ppb) | Min. Conc. (ppb) | Max. Conc. (ppb) |
|---|---|---|---|---|---|---|---|
| 6 | Gas flow (flow 3 min. total) | | | N/A | N/A | N/A | N/A |
| 7 | Pre Cal-check Test (1 hour) | | | | | | |
| 8 | Analysis 1 (1 min.) (start at T+60 sec) | | | | | | |
| 9 | Analysis 2 (1 min.) (start at ST+75 sec) | | | | | | |
| 10 | Analysis 3 (1 min.) (start at ST+90 sec) | | | | | | |

(11) Analyst name and signature:_______________________________________________________________
(12) Date, time, and location analysis performed:__________________________________________________
(13) Download data and perform procedure 9.5 for a 1-hour (60 minute) time period directly prior to (but not including) the Cal-check "Step 6". Attach the output of the R-script QA table to this form and transcribe indicated results to above table (Step 7). This provides a snap-shot of current operation.
(14) Perform procedure 9.5 for a 1-minute (60 second) time period during the cal check. The analysis time period should begin <u>at exactly 1-minute (60 seconds) after the Cal-check ST</u>. Transcribe indicated results to the above table (Step 8) and attach the output of the R-script to this form and label "Cal-check Analysis 1".
(15) Perform procedure 9.5 for a 1-minute (60 second) time period during the Cal-check. The analysis time period should begin <u>at exactly 1.25-minutes (75 seconds) after the Cal-check ST.</u> Transcribe indicated results to above table (Step 9) and attach the output of the R-script this form and label "Cal-check Analysis 2".
(16) Perform procedure 9.5 for a 1-minute (60 second) time period during the cal check. The analysis time period should begin at exactly <u>1.5-minutes (90 seconds) after the Cal-check ST</u>. Transcribe indicated results to above table (Step 10) and attach the output of the R-script to this form and label "Cal-check Analysis 3".
(17) As per QAPP, determine if calibration or repair is required. Record determination and notes below.
Notes:_____________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

### *Appendix C2: Calibration with Zero Form*

Procedure Step 9.3.2 (calibration with zero). To complete this procedure, personnel must be trained as an SPod/CGS Advanced Operator (Section 6.3). Complete one form for each SPod. The standard calibration concentration is 1 ppm isobutylene in air balance, but other concentrations (such as 500 ppb) may also be used (record in Step 5). Consult Section 7 for necessary equipment supplies. Make sure the SPod has been operating for > 2 hours to allow sufficient time for PID to stabilize. Consult project safety plan and ensure adequate ventilation before gas release.

(1) Operator name and signature:______________________________________________________________
(2) Date, time, and SPod location:______________________________________________________________
(3) SPod S/N and CGS system S/N (if used):_______________________________________________________
(4) Zero gas cylinder Information:_____________________________________________________
(5) Isobutylene gas cylinder information and concentration:____________________________________________
(6) Connect computer to SPod and take a screen shot of the current device configuration as per 9.1 and attach to this form. This documents settings before calibration change.
(7) Make sure device has been operating for > 2 hours to allow sufficient time for PID to stabilize.
(8) Using the Sensit calibration cap, proper tubing, and 0.5 LPM flow rate, connect ultrazero VOC-free air cylinder to calibration cap and tubing and flow gas into open air to clear supply line for two minutes, turn off gas flow.
(9) Perform zero-point calibration by connecting ultrazero VOC-free air cylinder to SPod PID with sensor calibration cap and flow gas at 0.5 LPM for three minutes (180 seconds). **Make sure to accurately record the start time (ST) of the gas flow in the below table in "Steps 9, 10, and 11".** Keep gas flowing.
(10) After three minutes and while flowing gas, execute zero change on the device by sending the command "ZERO1".[2] **Make sure to accurately record the change time (CT) of settings adjustment in the below table.**
(11) Keep gas flowing for an additional two minutes after the change has been enacted. **Make sure to accurately record the end (ET) of the gas flow below form using local cell phone time**. Turn off gas flow but leave calibration cap in place.
(12) Switch regulator and tubing to the isobutylene calibration cylinder.
(13) Perform span calibration by flowing gas at 0.5 LPM for two minutes (120 seconds). **Make sure to accurately record the start time (ST) of the gas flow in the below table in "Steps 13, 14, and 15".** Keep gas flowing.
(14) After two minutes and while flowing gas, execute span change on the device by sending the command"SPAN1:XXX" where XXX is the concentration of isobutylene in the calibration cylinder. **Make sure to accurately record the change time (CT) of settings adjustment in the below table.**
(15) Keep gas flowing for an additional two minutes after the change has been enacted. **Make sure to accurately record the end (ET) of the gas flow below form using local cell phone time**. Turn off gas flow and remove calibration cap. Return the sensor to operating conditions (e.g., reconnect CGSs and reset triggers)
(16) Download data and perform procedure 9.5 for a 1-hour (60 minute) time period directly prior to (but not including) the Cal-check or the calibration steps. Attach the output of the R-script to this form and transcribe indicated results to below table (Step 13). This provides a snap-shot of operation before calibration change.
(17) Perform procedure 9.5 for a 1-minute (60 second) time period before the zero-point change time (CT) but while zero gas was flowing to document the zero gas level before settings change. The start time of the analysis should be set to Step 7, CT-75 seconds. Transcribe indicated results to the below table (Step 14) and attach the output of the R-script to this form and label "Zero Analysis Pre".
(18) Perform procedure 9.5 for a 1-minute (60 second) time period after zero-point change time (CT) but while zero gas is still flowing to document the zero gas level after the setting change. The start time of the analysis should be set to Step 7, CT+75 seconds. Transcribe indicated results to the below table (Step 15) and attach the output of the R-script to this form and label "Zero Analysis Post".
(19) Perform procedure 9.5 for a 1-minute (60 second) time period before the span-point change was made but prior to the end of span gas flow to document the span gas set point change. The start time of the analysis should be set to Step 11, CT-75 seconds. Transcribe indicated results to the below table (Step 16) and attach the output of the R-script to this form and label "Span Analysis Pre".
(20) Perform procedure 9.5 for a 1-minute (60 second) time period after span-point change time (CT) but while span gas is still flowing to document the span gas level after the setting change. The start time of the analysis should

be set to Step 11, CT+75 seconds. Transcribe indicated results to the below table (Step 17) and attach the output of the R-script to this form and label “Span Analysis Post”.

(21) Take a screen shot of the current device configuration as per 9.1 and attach to this form. This documents settings before after calibration change and prior to resuming operation.

| **Calibrate Step(s)** | **Calibration Description** | **Gas Flow Start Time (ST) Local (hr:min:sec)** | **Change Time (CT) Local (hr:min:sec)** | **Gas Flow End Time (ET) Local (hr:min:sec)** | **Mean Conc. (ppb)** | **Stdev Conc. (ppb)** | **Min. Conc. (ppb)** | **Max. Conc. (ppb)** |
|---|---|---|---|---|---|---|---|---|
| 9,10, and 11 | Zero Gas Flow (flow 5 min. total) | | | | N/A | N/A | N/A | N/A |
| 13, 14, and 15 | Isobutylene gas (flow 4 min total) | | | | N/A | N/A | N/A | N/A |
| 16 | Pre Calibration Test (1 hour) | | N/A | | | | | |
| 17 | Zero Analysis Pre (1 min.) (start at CT-75 sec) | | N/A | | | | | |
| 18 | Zero Analysis Post (1 min.) (start at CT+15 sec) | | N/A | | | | | |
| 19 | Span Analysis Pre (1 min.) (start at CT-75 sec) | | N/A | | | | | |
| 20 | Span Analysis Post (1 min.) (start at CT+15 sec) | | N/A | | | | | |

Notes:______________________________________________________________________________

***Appendix D: SPod/CGS Site Deployment Form***

Procedure Step 9. (one form per SPod/CGS)
**Required Training**: To complete Steps 1-26 of this procedure, personnel must be trained as an SPod/CGS Field Operator (Section 6.1). To complete Steps 27-35, personnel must be an SPod Data Analyst (Section 6.2).

(1) Operator name and signature________________________________________
(2) Deployment date and SPod start time:____________________________________
(3) Site name and GPS coordinates:______________________________________
(4) SPod S/N: __________________________________________________
(5) CGS system S/N (if used): ________________________________________
(6) Solar or land power deployment?_____________________________________
(7) SPod deployment QAPP title/ID:______________________________________
(8) SPod deployment QAPP version date:___________________________________
(9) Install SPod/CGS system and power on (do not install canisters):____________________
(10) Are there collocated SPod/CGSs? (Yes/No, list S/Ns)__________________________
(11) Are there other collocated systems? (Yes/No, describe)_______________________
(12) Was SPod North rotation orientation confirmed? (Yes/No)______________________
(13) Was SPod fixture integrity confirmed? (Yes/No)____________________________
(14) Was SPod working electrical power confirmed? (Yes/No)_______________________
(15) Was SPod cell signal confirmed? (Yes/No)________________________________
(16) Was SD data card operation confirmed? (Yes/No)____________________________
(17) Was site security confirmed? (Yes/No)__________________________________
(18) Was site safety check confirmed? (Yes/No)________________________________
(19) Take site photos documenting deployment, list file names, and append photos to this record:________

(20) Does the deployment meet siting requirements? (Yes/No)_______________________
(21) Execute Steps procedure 9.3.1 (Cal-check) as per Appendix C and append partially completed Cal-check to record the accurate start and end times of span gas flow for the SPod Data Analysist.
(22) Access the data repository from the field using procedures described in the QAPP and verify data is streaming without error and that Cal-check is likely within tolerance.
(23) Enter the approximate value of the Cal-check from cursory data inspection:________________
(24) How many CGS's to be used on this SPod?

(25) Install canisters as per procedure 9.6.1 and QAPP and complete COCs.
(26) The unit is now in unverified operation, add deployment notes or observations:______________

**To complete Steps 27-35, personnel must be trained an SPod Data Analyst (Section 6.2).**

(27) Execute Steps 19-23 of procedure 9.3.1 (Cal-check) as per Appendix C and complete associated forms
(28) Did the 1-hour Pre Cal-check Test pass QA tolerance as per Section 11 and QAPP? (Yes/No)_________
(29) Did the SPod pass Cal-check? (Yes/No)?____________________________________________________________
(30) Was a field calibration and zero performed?_____________________________________________________
(31) Date of last full SPod calibration (append form):_______________________________________________
(32) Date of last device configuration (append form):_______________________________________________
(33) If the answer to Step 10 is Yes, conduct procedure 9.5.2 on 1 hour of data and append QA table.
(34) Is the deployment operation verified? (Yes/No):______________________________________________
(35) SPod Data Analyst Notes:_______________________________________________________________________

____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________

### *Appendix E1: SPod Data Read-in and Processing*

This R code script (*SPod_Pre-processing_code.R*) should be used first on any data downloaded directly as a .csv file from the Sensit Connect site. The files must be saved in the following format: *SPOD_Data_Export_1136_2021-10-28.csv,* with the correct Sensit Sensor ID and date identified in the file name. The code runs 2 loops through the data, outputting processed files at a 10-second rate and a 5-minute rate for each day of data from a sensor. The script is designed to run through a folder of downloaded Sensit Connect files. In this script, the user must identify the following objects (see Figure E1 for an example):

- **Nodes:** The Sensit Device IDs for all units in that folder being processed
- **Data_Folder_Raw:** The folder on the analyst's device where the raw Sensit Connect files were downloaded to and stored
- **Data_Folder_Processed_10:** The folder on the analyst's device where the processed 10 second SPod files should be stored once created
- **Data_Folder_Processed_5:** The folder on the analyst's device where the processed 5-minute SPod files should be stored once created
- **Time_Start:** The day the analysis should start on raw Sensit Connect files (*yyyy-mm-dd*)
- **Time_End:** The day the analysis should end on raw Sensit Connect files *(yyyy-mm-dd*)

```
##############################################################################################################
# USER INPUT BELOW:

# Define Nodes: change to your node S/N here.  The raw data files need to have the node in the filename.
nodes <-
  c("106", "1037")

# Define File path to Sensit raw data folder (replace with your file path)
data_folder_raw <-
  "C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/Processed_Greensboro_Data/raw SC data/"

# Define File path to Sensit folder to store data sets (replace with your file path) for 10 sec output
data_folder_processed_10 <-
  "C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/Processed_Greensboro_Data/10_sec/011822_10sec/"

# Define File path to Sensit folder to store data sets (replace with your file path) for 5 min output
data_folder_processed_5 <-
  "C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/Processed_Greensboro_Data/5_min/011822_5min/"

# Build time frame of dataset (complete)
#replace dates below with the date range to process (can be multiple days/entire dataset)
time_start = ymd('2022-02-01')
time_end = ymd('2022-02-28') #update this one only in shiny version to keep all files read in#
range_days = as.list(seq(
  floor_date(time_start, unit = "days"),
  floor_date(time_end, unit = "days"),
  by = '1 day'
))

# ############################################################################################################
```

Figure E1: User Input section in *SPod_Pre-processing_code.R*

**<u>Link to Bitbucket repository:</u>** [https://bitbucket.epa.gov/projects/SSA/repos/sensit-processing-and-shiny-app-code/browse/Spod_Pre-processing_Code.R](https://bitbucket.epa.gov/projects/SSA/repos/sensit-processing-and-shiny-app-code/browse/Spod_Pre-processing_Code.R)
Note: These links require an EPA Bitbucket account and certain permissions to access. More information about using this bitbucket repository is found at the end of Appendix E4.

### *Appendix E2: SPod QA Single Unit QA Table 1*

This Rmarkdown code script (*2_Sensit_Connect_QA.Rmd*) creates a QA table for any specified time period of processed Sensit SPod data and allows the user to export a PDF of this compiled information to keep in the project record. The user must process the data with the processing code, *SPod_Pre-processing_code.R,* first, and then utilize the 10 second files created there in this script. These tables should be run on 1 minute of data for a calibration check and for 1 hour for comparison with a collocated SPod, described in Appendix E3. This same table can be found for 1 complete day of data in the Sensit Shiny App, described in Appendix E4. In this script, the user must identify the following objects (see Figure E2 for an example):

- **Hour_Start:** Date and time the QA table should begin processing, must use format *'YYYY-MM-DD HH:MM:SS'*
- **Hour_End:** Date and time the QA table should end processing, must use format '*YYYY-MM-DD HH:MM:SS'*
- **Filename:** Complete name of processed 10 second file to be analyzed

```
# # # USER INPUT: USER MUST INPUT HOUR HERE & IT MUST MATCH DATE FILE BELOW:
hour_start <- '2021-11-08 10:00:00'
hour_end <- '2021-11-08 11:00:00'
filename <- "Processed_Greensboro_Data/10_sec/011822_10sec/(10sec)_2021-11-08_1037.csv" # use to change node!
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```

Figure E2: User Input section in *2_Sensit_Connect_QA.Rmd*

**Link to Bitbucket repository:** https://bitbucket.epa.gov/projects/SSA/repos/sensit-processing-and-shiny-app-code/browse/2_Sensit_Connect_QA.Rmd
Note: These links require an EPA Bitbucket account and certain permissions to access. More information about using this bitbucket repository is found at the end of Appendix E4.

### *Appendix E3: SPod Co-deployed Unit QA Table 2*

This Rmarkdown code script (*3_Sensit_QA_2Sensors.Rmd*) utilizes two .csv files built from the QA tables made for two collocated sensors in script *2_Sensit_Connect_QA.Rmd*. This script subtracts the QA values for Sensor 1 from Sensor 2 and outputs a table with the differences between the sensors for each QA value listed to compare sensor agreement. This table can be exported as a PDF and printed for the project record. It is suggested to run this comparison on 1 hour of data. The analyst must first process the day of SPod data needed for both collocated sensors using the script *SPod_Pre-processing_code.R*, then create two 1 hour QA tables in .csv form for both Spods (exported to the analyst's device when script *2_Sensit_Connect_QA.Rmd* is used). These .csv files for each sensor are read into this script and used to make the subtraction calculations to determine the sensor agreement levels. In this script, the user must identify the following objects (see Figure E3 for an example):

- **Hour_Start**: Date and time the comparison table should begin processing, must use format *'YYYY-MM-DD HH:MM:SS'* and must be included in the time range of the QA table files supplied (filename1 and filename2)
- **Hour_End**: Date and time the comparison table should end processing, must use format '*YYYY-MM-DD HH:MM:SS'* and must be included in the time range of the QA table files supplied (filename1 and filename2)
- **Filename1:** Complete name of the .csv file for sensor 1 of the collocated pair to be compared
- **Filename2:** Complete name of the .csv file for sensor 2 of the collocated pair to be compared

```
# USER INPUT:
hour_start <- '2022-01-08 18:00:00 EST'
hour_end <- '2022-01-08 19:00:00 EST'

filename1 <- "C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/_SPOD1037_2022_01_08_18_38_00_18_39_00.csv"

filename2 <- "C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/_SPOD106_2022_01_08_18_38_00_18_39_00.csv"

#############
```

Figure E3: User Input section in *3_Sensit_QA_2Sensors.Rmd*

**Link to Bitbucket repository:** https://bitbucket.epa.gov/projects/SSA/repos/sensit-processing-and-shiny-app-code/browse/3_Sensit_QA_2Sensors.Rmd
Note: These links require an EPA Bitbucket account and certain permissions to access. More information about using this bitbucket repository is found at the end of Appendix E4.

### *Appendix E4: Sensit Shiny App*

This R Shiny app (*app.R*) has been developed to read in processed files of Sensit Connect data, build synthesized graphs of processed 5-minute data over time, and output more specific graphs for processed 10-second daily data. There are also tabs for multiple site photos to be uploaded, an interactive site map, and interactive plotly graphing capability where the analyst can select different SPod variables to compare. This App is developed with the Shiny Dashboard package and can be run by selecting "Run App" in R studio once *app.R* is read in. The analyst must have folders of processed 10 second data and processed 5-minute data in the working directory that the app is stored in, which have been processed by script *SPod_Pre-processing_code.R*. While this example version is built for a Sensit SPod deployment in Greensboro, the app also contains a user input section like the other scripts that allows it to be customizable for any Sensit SPod deployment of 2 collocated sensors at 1 location. These scripts are all stored on the previously described Bitbucket repository, and a quick explanation of this software is given at the end of this appendix. In this script, the user must identify the following objects (see Figure E4 for an example):

- **Sitename:** The name of the overall location where the sensors are located
- **Siteinfo:** Any information the user wants to be displayed on the home page of the app that describes the site
- **Imgs:** A single image file or a list of image files to be displayed in the image slider on the app home page
- **Latitude1:** The latitude of the collocated pair of Sensit SPods
- **Longitude1:** The longitude of the collocated pair of Sensit SPods
- **Node1:** The device ID of the first sensor in the collocated pair
- **Node2:** The device ID of the second sensor in the collocated pair
- **Pair:** The specific site name for the collocated pair to be displayed on the interactive site map (in future revisions, there will be options for multiple pairs)
- **Path5:** The complete path on the analyst's device where the processed 5-minute files are stored in a folder

```
##########################################################
### USER INPUT:
# Name of overall site location
sitename <- "Greensboro"
# Info about site to be displayed on first page
siteinfo <- "This site is the location of a research effort
             between EPA ORD and Region 4 at a terminal
             operations area in Greensboro, NC."
#site photos folder for home page
imgs <- list.files("C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/greensboro app MM/slickRtankpics",  full.names = TRUE)
# coordinates of sensor set 1
latitude1 <-  36.071515
longitude1 <- -79.919236
# list node names of Spods you want to track
# must match this format, just change numbers!
node1 <- "SPOD106"
node2 <- "SPOD1037"
# graph annotations
pair <- "site 01"
# 5 minfilepath
path5 <-  'C:/Users/mmacdo01/OneDrive - Environmental Protection Agency (EPA)/Profile/Desktop/Processed_Greensboro_Data/5_min/011822_5min/'
#########################################################
```

Figure E4: User Input section in *app.R*

If all packages are correctly loaded and the data is properly integrated, the app will deploy once the user selects "Run App" in the top right corner of the screen. The app will appear as a separate R Studio window on the analyst's device. A screenshot of the home page of the app is shown in Figure E5 below. The sidebar menu is on the left side of the screen, and these are the different analysis options the analyst can select between. The main page contains any site photos the user uploaded and can be scrolled through by clicking through the dots below the photos. Any site description the user entered is displayed in blue text below these photos. The Green banner at the top of the screen should display the site name the user has entered.

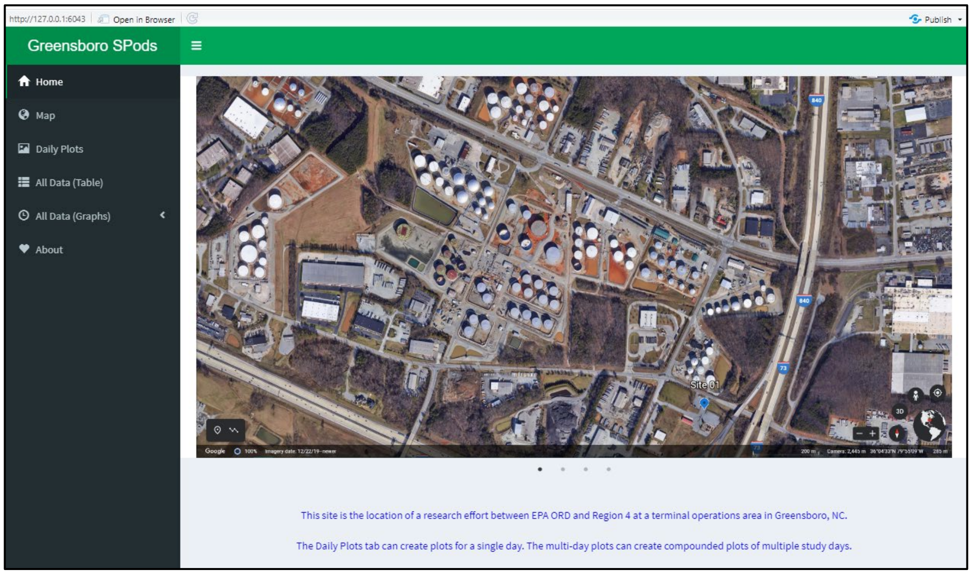



Figure E5: Home page in *app.R*

The user can select between several options to analyze the data in different ways using the sidebar menu options. If the user selects "home" on this tab, they will be taken back to this screen. More detail about each of these tabs is provided below:

<u>The **Map** tab:</u>
Selecting the map tab will take the user to an interactive site map made using the Leaflet R package. This map is generated in the app based on the latitude and longitude of the collocated pair, which will appear as a blue circle on the map. If the user hovers the mouse over this location, the site name will appear in a small white box. Figure E6 shows this map in more detail.

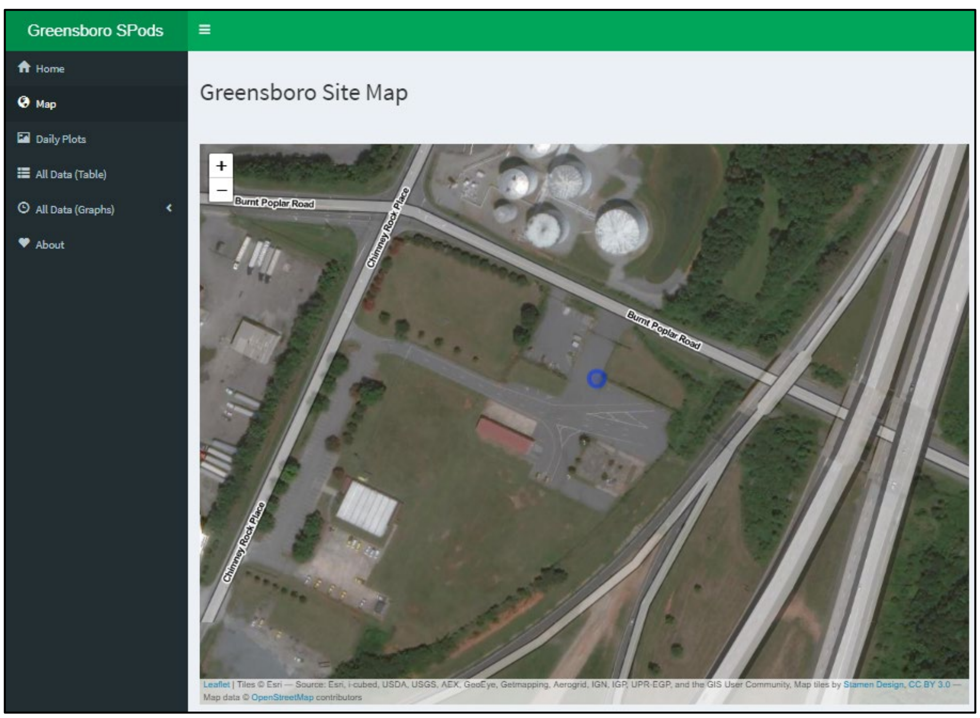
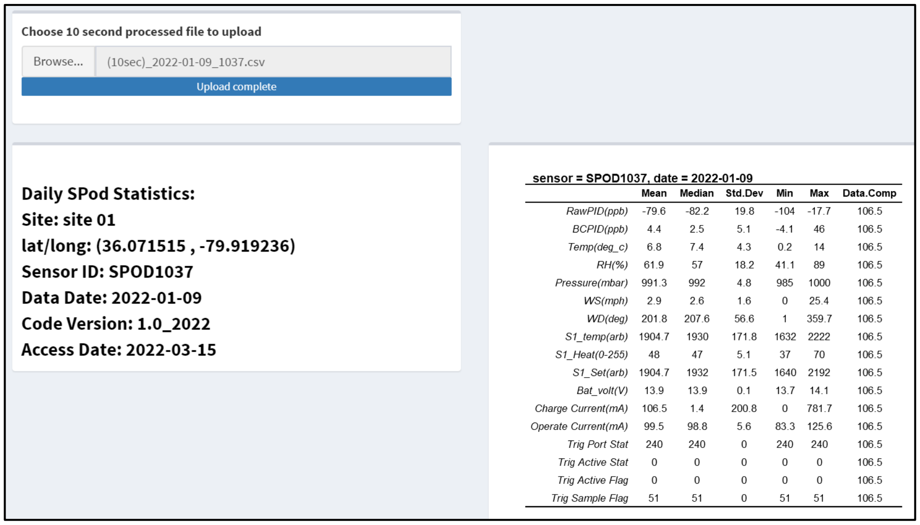



Figure E6: Map tab in *app.R*

<u>The **Daily Plots** tab:</u>
This tab is used for the analyst to create 10-second graphs of a particular day. When the analyst first clicks on this screen, an option to upload a "10 second processed file" appears. The analyst should be sure to select a 10-second file that has been created by the script *SPod_Pre-processing_code.R*. The file will upload, and the plots will populate based on this day of data for the sensor it describes. The user will find the following plots described in Figure E7 – E12. These figures inform the analyst of the SPod behavior that day based on sensor readings (PID, Temperature, Relative Humidity), baseline correction, Method Detection Limit [MDL] level, and wind information. Any strange values in these plots could inform the analyst that something was not operating properly on that day. These plots can also be useful for "zooming" in" on fast-moving elevated signal events that occurred on only a part of one day. Plots are labelled with the date and SPod Device ID so they can be used in screenshots.




| | Mean | Median | Std.Dev | Min | Max | Data.Comp |
|---|---|---|---|---|---|---|
| RawPID(ppb) | -79.6 | -82.2 | 19.8 | -104 | -17.7 | 106.5 |
| BCPID(ppb) | 4.4 | 2.5 | 5.1 | -4.1 | 46 | 106.5 |
| Temp(deg_c) | 6.8 | 7.4 | 4.3 | 0.2 | 14 | 106.5 |
| RH(%) | 61.9 | 57 | 18.2 | 41.1 | 89 | 106.5 |
| Pressure(mbar) | 991.3 | 992 | 4.8 | 985 | 1000 | 106.5 |
| WS(mph) | 2.9 | 2.6 | 1.6 | 0 | 25.4 | 106.5 |
| WD(deg) | 201.8 | 207.6 | 56.6 | 1 | 359.7 | 106.5 |
| S1_temp(arb) | 1904.7 | 1930 | 171.8 | 1632 | 2222 | 106.5 |
| S1_Heat(0-255) | 48 | 47 | 5.1 | 37 | 70 | 106.5 |
| S1_Set(arb) | 1904.7 | 1932 | 171.5 | 1640 | 2192 | 106.5 |
| Bat_volt(V) | 13.9 | 13.9 | 0.1 | 13.7 | 14.1 | 106.5 |
| Charge Current(mA) | 106.5 | 1.4 | 200.8 | 0 | 781.7 | 106.5 |
| Operate Current(mA) | 99.5 | 98.8 | 5.6 | 83.3 | 125.6 | 106.5 |
| Trig Port Stat | 240 | 240 | 0 | 240 | 240 | 106.5 |
| Trig Active Stat | 0 | 0 | 0 | 0 | 0 | 106.5 |
| Trig Active Flag | 0 | 0 | 0 | 0 | 0 | 106.5 |
| Trig Sample Flag | 51 | 51 | 0 | 51 | 51 | 106.5 |

Figure E7: Daily Plots in *app.R* (File upload, SPod Statistics and Daily QA table)

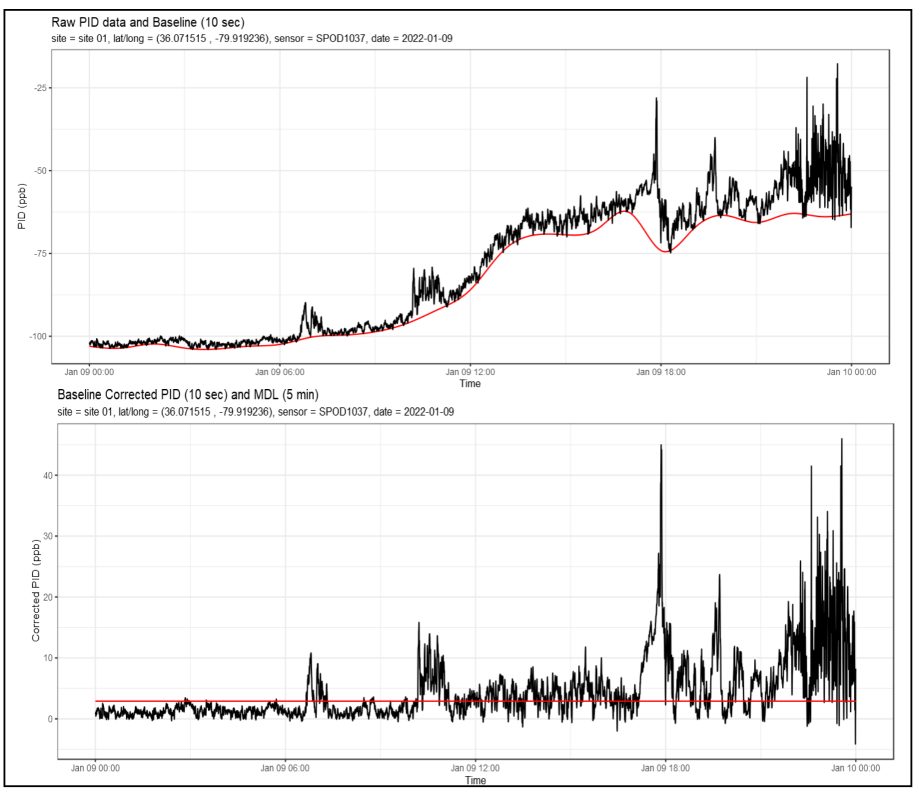



Figure E8: Daily Plots in *app.R* (Baseline Correction line and MDL line)

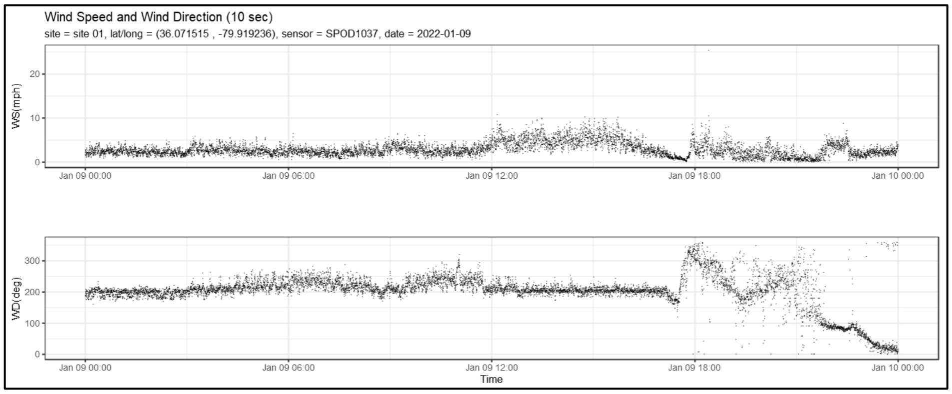



Figure E9: Daily Plots in *app.R* (Wind Speed and Wind Direction)

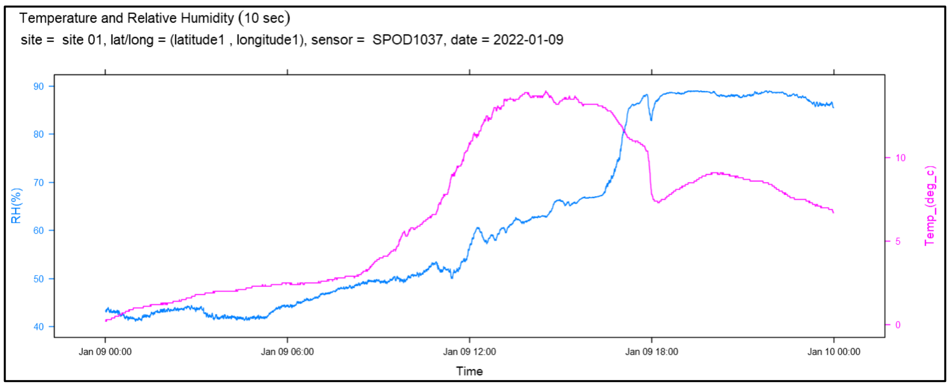



Figure E10: Daily Plots in *app.R* (Temperature and Relative Humidity)

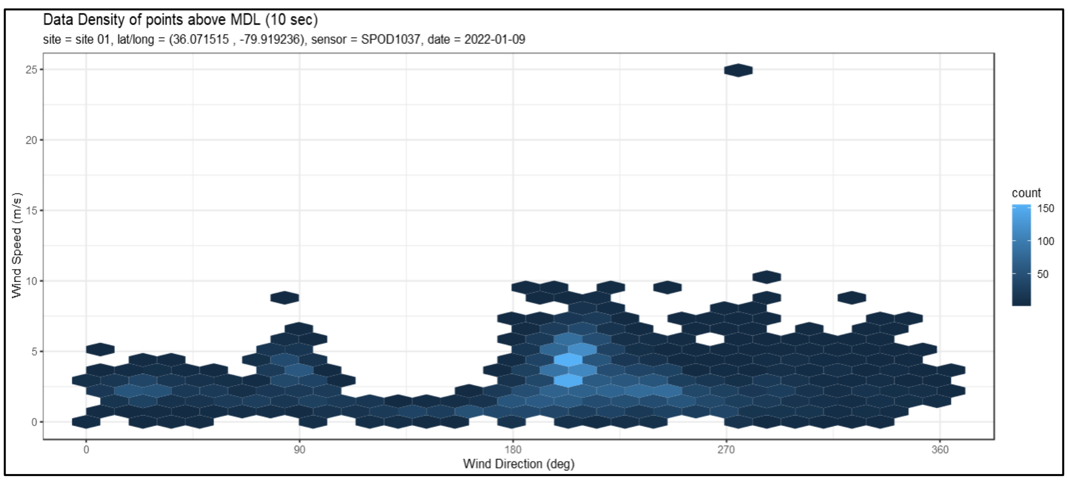



Figure E11: Daily Plots in *app.R* (10 Second Data Density above MDL by Wind Direction)

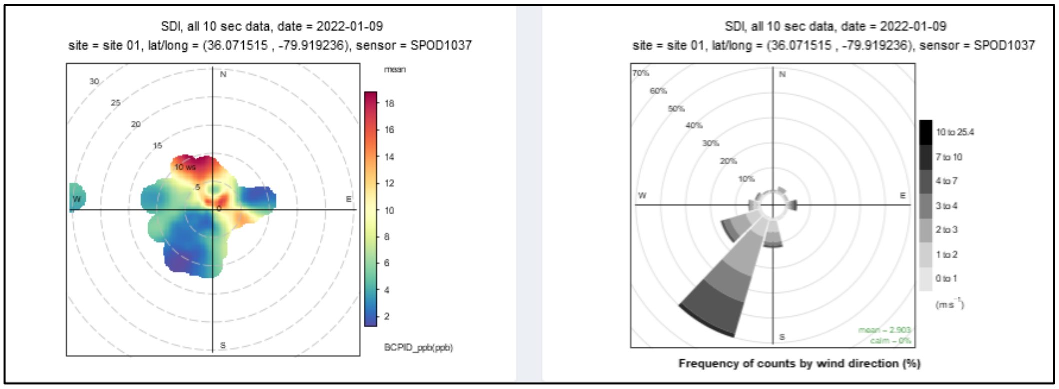



Figure E12: Daily Plots in *app.R* (Source Direction Indicator [SDI] plot and Wind Rose)

These graphs are meant to provide a basic idea for the analyst of the sensor operations for a selected day. The baseline (top panel of Figure E8) is calculated as a spline fit of the area under the curve of the SPod signal and subtracted away to remove any sensor drift. This also counteracts any negative offset below 0 ppb that the sensor could record. The MDL shown as a red line in the lower panel of Figure E8 is calculated as 3 times the daily median standard deviation value of 10 second values when aggregated into 5-minute values. It is meant to serve as an indicator of the daily noise level, and values above this are "Above MDL" or "In Detection". Pairing the wind speed and wind direction data (Figure E9) with PID signal traces shows if the PID changes in response to any wind conditions changing. In this example, the PID spikes when the wind shifts to be originating from the north. Daily relative humidity and temperature (Figure E10) can be indicative of environmental conditions affecting the sensor that day and are useful for the analyst to be aware of if there are any strange patterns in the daily PID signal trace. The density of points above MDL depicts which wind directions contain the greatest counts of points that are in detection (Figure E11). The SDI plot and wind rose provide the analyst with further information about the wind and signal direction during the analyzed day (Figure E12), both developed with the OpenAir package. Future revisions of this app will allow the analyst to export these graphs directly to a PDF for recordkeeping.

The **All Data (Table)** tab:

This tab allows the user to choose a date range for the 5-minute SPod files and search through an interactive table of results contained within those dates. By selecting the arrows next to a column name, the analyst can sort from lowest values to highest values of any variable in the table. The analyst can also use the search bar to query for specific values. The variable definitions for the table are contained in Table E1, and an image of an example table generated by this tab is depicted in Figure E13.

Table Results

Choose Date Range:

2021-11-01 to 2021-11-04

Show 10 entries Search:

| | SN | timeCut | day | rawPID_ppb | rawPID_mv | bcPID_ppb | pid.sd | MDL | temp | rh | pressure | wd | ws | s1temp | s1heat | set | bat_volt | chg.current | opp.current |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SPOD1037 | 11/1/2021, 7:44:00 AM | 2021-11-01 | 30 | 191 | 0.9 | 0.5 | 6.6 | 14.7 | 52.1 | 1008 | 91.2 | 0.2 | 2224.2 | 49.3 | 2223.6 | 13.4 | 1650.5 | 101.5 |
| 2 | SPOD1037 | 11/1/2021, 7:49:00 AM | 2021-11-01 | 27.5 | 188.8 | 0.4 | 0.4 | 6.6 | 15 | 51.4 | 1008 | 91.2 | 0.2 | 2238.5 | 47.8 | 2237.9 | 13.4 | 1645.2 | 99.7 |
| 3 | SPOD1037 | 11/1/2021, 7:54:00 AM | 2021-11-01 | 25.6 | 187.1 | 1.4 | 0.8 | 6.6 | 15.3 | 50.8 | 1008 | 91.2 | 0.2 | 2247.9 | 47.1 | 2247.9 | 13.5 | 1642.8 | 100.1 |
| 4 | SPOD1037 | 11/1/2021, 8:14:00 AM | 2021-11-01 | 13.1 | 175.7 | 9.4 | 6.3 | 6.6 | 11.2 | 62.4 | 1009 | 64.6 | 0.1 | 1961.3 | 87.3 | 2073.1 | 13.2 | 0 | 123.9 |
| 5 | SPOD1037 | 11/1/2021, 8:19:00 AM | 2021-11-01 | 2.9 | 166.4 | 3.1 | 2.2 | 6.6 | 10.9 | 64.4 | 1009 | 227.3 | 0.1 | 2064.7 | 48.9 | 2064 | 13.2 | 0 | 100.6 |
| 6 | SPOD1037 | 11/1/2021, 8:24:00 AM | 2021-11-01 | 4.9 | 168.2 | 8.6 | 4.4 | 6.6 | 10.7 | 65.6 | 1009 | 71.1 | 0.3 | 2054.6 | 42.9 | 2053 | 13.2 | 0 | 95.8 |
| 7 | SPOD1037 | 11/1/2021, 8:29:00 AM | 2021-11-01 | 7.5 | 170.6 | 12.9 | 7.4 | 6.6 | 10.4 | 66.3 | 1009 | 90.4 | 0.4 | 2039.1 | 40.9 | 2042 | 13.2 | 0 | 92.8 |
| 8 | SPOD1037 | 11/1/2021, 9:14:00 AM | 2021-11-01 | 1.5 | 165.1 | 3.9 | 2.1 | 6.6 | 10.2 | 65.9 | 1009 | 91.1 | 0.5 | 2035.9 | 42.5 | 2034.6 | 13.2 | 0 | 95.6 |
| 9 | SPOD1037 | 11/1/2021, 9:19:00 AM | 2021-11-01 | 0.1 | 163.9 | 2.7 | 1.4 | 6.6 | 10.1 | 66.7 | 1009 | 125.9 | 0.1 | 2030.7 | 41.5 | 2031.3 | 13.2 | 0 | 95.6 |
| 10 | SPOD1037 | 11/1/2021, 9:24:00 AM | 2021-11-01 | -0.2 | 163.6 | 2.9 | 1.7 | 6.6 | 10.3 | 67.4 | 1009.3 | 96 | 0 | 2040.4 | 42.1 | 2039.2 | 13.3 | 914.5 | 95.9 |

Showing 1 to 10 of 1,616 entries — Previous 1 2 3 4 5 … 162 Next

Figure E13: Table comprising All Data values for a given time period in *app.R*

Table E1: Data Dictionary for variables in *app.R* Table of All Data

| **Variable** | **Description** |
|---|---|
| SN | SPod Serial number or Device ID |
| timeCut | Time of 5-minute sample, in the format (MM/DD/YYYY HH:MM:SS) |
| day | Date of the 5 -minute sample, in the format (MM/DD/YYYY) |
| rawPID_ppb | The average PID reading in ppb read by the sensor |
| rawPID_mv | The average PID reading in mV read by the sensor |
| bcPID_ppb | The average background corrected PID reading calculated in the 10-second processing file |
| pid.sd | The standard deviation of 10-second values in the composite 5-minute sample |
| MDL | The MDL for that day |
| temp | The average temperature for that 5-minute period in degrees Celsius |
| rh | The average relative humidity for that 5-minute period in percent |
| pressure | The average pressure in that 5-minute period in mBar |
| wd | The average wind direction in degrees (vectorized) in that 5-minute period |
| ws | The average wind speed in mph in that 5-minute period |
| S1temp | The average sensor temp for that 5-minute period in arbitrary units |
| S1heat | The average sensor output for that 5-minute period, (0 = off while 255 = fully on) |
| set | The average sensor set point for that 5-minute period in arbitrary units |
| Bat_volt | The average battery voltage for that 5-minute period in Volts |
| Chg.current | The average charging current for that 5-minute period in mA |
| Opp.current | The average operating current for that 5-minute period in mA |
| trigportstatus | Port status: Key given in Sensit Manual, 0 indicates no sample collected or no port installed |
| trigactivestatus | Trigger Status: Key given in Sensit Manual, 0 indicates set to threshold trigger |
| trigactiveflag | Active Port: Key given in Sensit Manual, 0 indicates the ports are all off |
| trigsampleflag | Event Status: Key given in Sensit Manual, 0 indicates no events started or completed |

The **All Data (Graphs)** tab:
This tab becomes a dropdown menu if the user selects it. The user is first prompted to choose a date range of available data for the following composite graphs to be constricted to. This data range can span the entire set of data if the analyst requires it but note that more days of data will take longer to load. The subtabs of data that appear under this tab are described in more detail below.

The **Plotly Explorer** subtab:
This subtab allows the analyst to create two plotly graphs with the y-axis variables of their choosing. Definitions for these variables can be found in Table E1 above. Plotly is a powerful graphing package that incorporates interactive capability to zoom in, pan through a graph, and export the graph as a .png file. The toggles in the upper right hand of the plotly graph provide these options and are defined when hovered over. The analyst can select which y variables to plot on each graph from the two drop-down menus at the top of the page. To isolate a trace, the analyst can double-click it in the legend at the bottom of the graph. Figure E14 shows this capability.


Figure E14: Plotly Explorer tab with the baseline corrected PID graphed on the top panel and the raw PID ppb reading graphed on the lower panel in *app.R*.

<u>The **SDI Plots** subtab:</u>
This subtab builds 3 SDI plots for each sensor in the collocated pair using the OpenAir package. The SDI is an interpolation based on the mean baseline corrected PID level and wind directions. These graphs appear in the following order for each sensor: All Data, Data Below MDL, and Data Above MDL. These graphs can be used to better understand the signal pattern based on wind conditions at this site. The comparison of these graphs shows the sensor agreement overtime if the complete study is included in the date range. Figure E15 contains an example of this subtab.

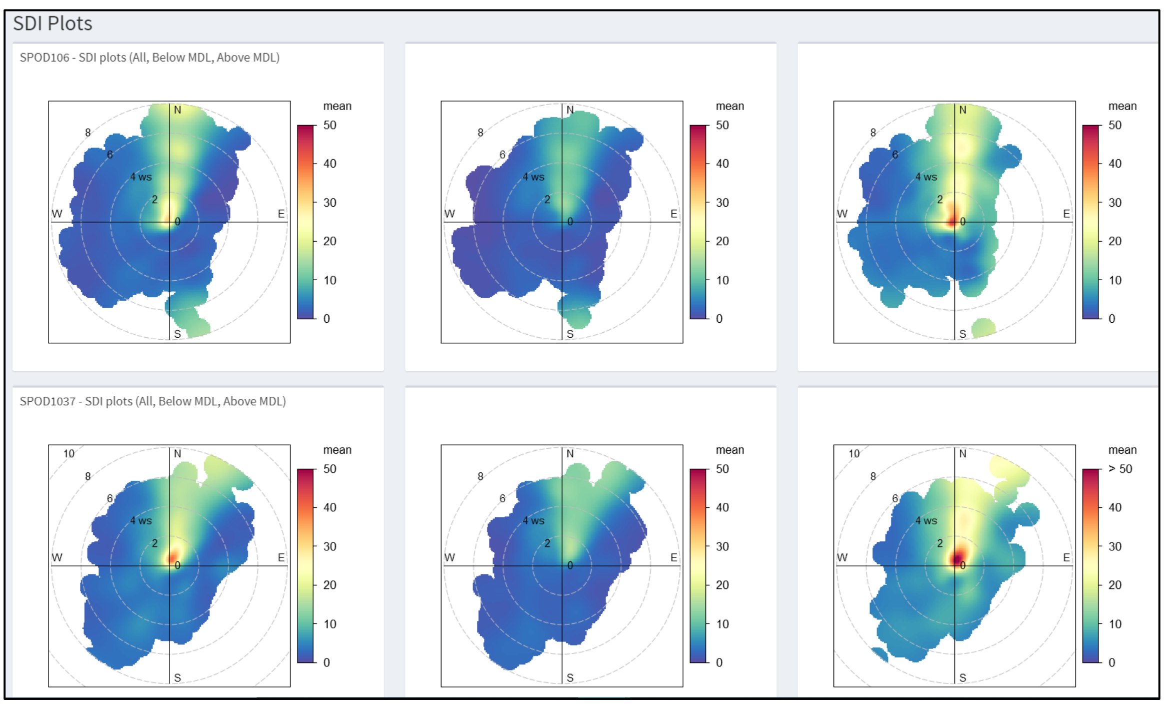



Figure E15: Composite SDI plots showing signal and wind patterns over time in *app.R*

<u>The **About** tab:</u>
The About tab contains the current version of the app and contact information for the app developer if any users have any questions ([macdonald.megan@epa.gov](mailto:macdonald.megan@epa.gov)).

Using **Bitbucket:**
This application along with the other pre-processing scripts are found in the following bitbucket repository: *SENTINEL Shiny App/Sensit Processing and Shiny App Code*. The user can copy and paste the code directly into their R Studio program or they can download the code as individual R files for each script by selecting the "download" button after clicking on the script from the source list. The Bitbucket repository is shown in more detail in figure E16 below. Analysts will need to have an EPA approved login to have access to this repository.

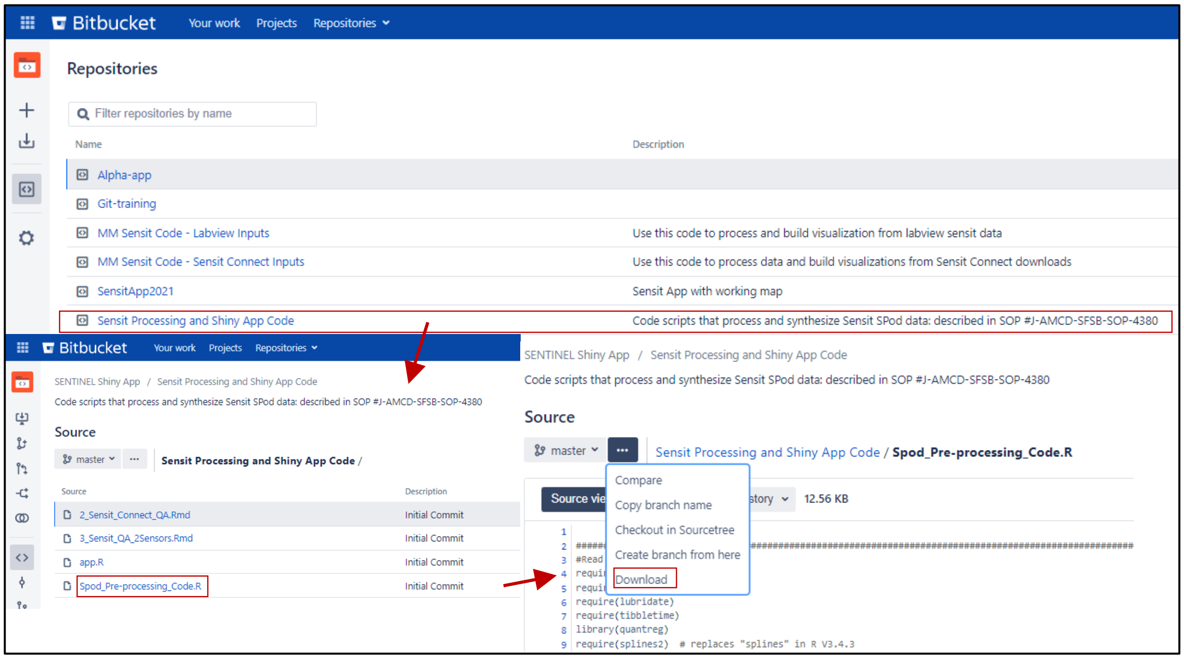


Figure E16: Demonstration of the Bitbucket process and landing pages

**Link to Bitbucket repository:** [https://bitbucket.epa.gov/projects/SSA/repos/sensit-processing-and-shiny-app-code/browse/app.R](https://bitbucket.epa.gov/projects/SSA/repos/sensit-processing-and-shiny-app-code/browse/app.R)
Note: These links require an EPA Bitbucket account and certain permissions to access.

***Appendix F: Reference Figures***


Figure F1. Sensit SPod unit with anemometer and PID sensor

Figure F2. Sensit SPod unit on tripod powered by solar panel

Figure F3. Sensit SPod units and canister system on pallet stand powered by solar panel

Figure F4. Sensit SPod units and calibration gas cylinder on pallet stand

Figure F5. Sampling hardware for collecting grab samples


Figure F6. EC sampling system attached to a Sensit Spod unit