NEON PREVENTIVE MAINTENANCE PROCEDURE:

SUBMERSIBLE ULTRAVIOLET NITRATE ANALYZER (SUNA)

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See configuration management system for approval history.

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Change Record

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A	09/14/2017	ECO-02640	Initial Release

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1 DESCRIPTION

1.1 Purpose

The National Ecological Observatory Network (NEON) sites host sensors that take measurements from air, wind, soil, and sun. Regular maintenance of sensors and infrastructure is necessary for the continued operation of the observatory, and to identify small problems before they escalate.

This document details procedures necessary for the preventive maintenance of the **Submersible Ultraviolet Nitrate Analyzer (SUNA)**.

1.2 Scope

The procedures detailed in this document are strictly preventive. Any corrective maintenance issues that are uncovered while performing preventive maintenance should be addressed using the corrective maintenance procedure associated with this subsystem. Refer to reference RD [03] for a list of maintenance procedure document numbers.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

The following applicable documents (AD) contain mandatory requirements and/or supplementary information that are directly applicable to the topic and/or procedures herein. Visit the NEON Document Warehouse for electronic copies of these documents.

AD [01]	NEON.DOC.004300	EHSS Policy and Program Manual
AD [02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD [03]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD [04]	NEON.DOC.003808	NEON Sensor Command, Control and Configuration (C3) Document: Buoy Meteorological Station and Submerged Sensor Assembly
AD [05]	NEON.DOC.001172	AIS Interconnect Map
AD [06]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure

2.2 Reference Documents

Reference documents (RD) contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.003880	AIS Maintenance Standard Operating Procedure – Aquatic Infrastructure
RD [04]	NEON. DOC.001570	NEON Sensor Command, Control and Configuration AIS Nitrate Analyzer
RD [05]	NEON.DOC.004257	ALL SYSTEMS STANDARD OPERATING PROCEDURE: Decontamination of Sensors, Field Equipment, and Field Vehicles
RD [06]	NEON.DOC.003880	NEON Preventative Maintenance Procedure: AIS In-stream Infrastructure for Wadeable Streams
RD [07]	NEON.DOC.004613	NEON Preventive Maintenance Procedure: AIS Lake Buoy

2.3 External References

The external references (ER) listed below may contain supplementary information relevant to maintaining specific commercial products for the SUNA sensor and subsystem. These documents are external to the NEON project and Battelle Ecology. If an issue with a product requires the involvement of the manufacturer, NEON Headquarters (HQ) will contact the manufacturer or provide Field Operations (FOPS) the authority to contact via the NEON Issue Management System.

ER [01]	Satlantic LP. SUNA Manual, Rev. E.

	http://satlantic.com/sites/default/files/documents/Satlantic-SUNA-V2-Manual-Rev-E.pdf
ER [02]	Xylem, YSI Incorporated-Integrated Systems and Services. Vertical Profile System (CR1000) Manual Version 3, St. Petersburg, FL. 19 December 2011: www.ysisystems.com
ER [03]	Seabird Scientific, UCI User Manual, 02/2017, Edition 11 (UCI170209). *http://www.seabird.com/sites/default/files/documents/UCI-1.2-User-Manual.pdf*

2.4 Acronyms

AD	Applicable Documents
AIS	Aquatic Instrument Systems
CVAL	Calibration, Validation and Audit Laboratory
DI	Deionized
EHS	Environmental Health, Safety and Security
ER	External References
ESD	Electro-static Discharge
FOPS	Field Operations
GRSM	Great Smoky Mountain
HQ	Headquarters
MBARI	Monterey Bay Aquarium Research Institute
NEON	National Ecological Observatory Network
PAR	Photosynthetically Active Radiation (sensor)
POE	Power Over Ethernet
PVC	Polyvinyl Chloride
RD	Reference Documents
S1	AIS Sensor Set 1 (Upstream sensor set)
S2	AIS Sensor Set 2 (Downstream sensor set)
SOP	Standard Operating Protocol
SUNA	Submersible Ultraviolet Nitrate Analyzer
UV	Ultraviolet (light)

3 SAFETY AND TRAINING

Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD [02]) and Environmental, Health, Safety and Security (EHS) Policy, Program and Management Plan (AD [01]). The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

All technicians must complete required safety training and protocol-specific training for safety and implementation of this protocol as required in Field Operations Job Instruction Training Plan (AD [03]). Refer to the site-specific EHS plan and safety training materials via the NEON Safety Document Portal. Conduct the appropriate Job Safety Analysis before performing any preventive maintenance.

Reference the *AIS Maintenance Standard Operating Procedure – Aquatic Infrastructure* (RD [03]) for additional safety precautions and instructions applicable to Aquatic Instrument Systems (AIS) sites.

4 SENSOR OVERVIEW – SUBMERSIBLE ULTRAVIOLET NITRATE ANALYZER

4.1 Associated Equipment

- Satlantic L.P., Submersible Ultraviolet Nitrate Analyzer (SUNA) V2 with integrated anti-fouling/hydro-wiper with titanium housing (NEON Part Number 0329950100) (Figure 1)
- 12v Merlot Grape (NEON data logger) with Grape shield
- Armored Power Over Ethernet (POE) cord (from Grape to the S2 Communication Box)
- Power Cable
- Sensor Cable with USB, Grape and Sensor connectors

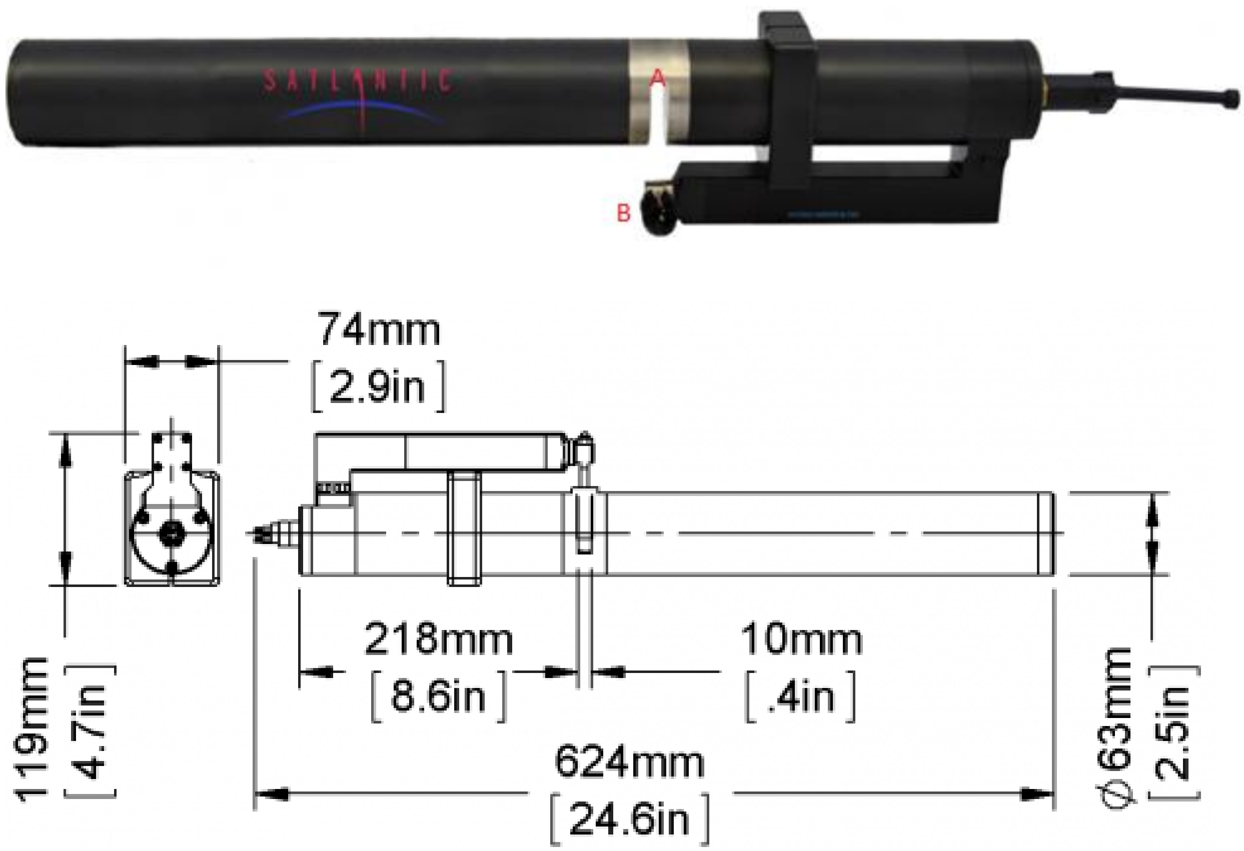


Figure 1. SUNA V2 Optical Path (A), Integrated Anti-fouling Wiper (B) and the sensor dimensions (C).

NOTE: New models have a titanium housing.

4.1.1 Grapes

Grapes contain ESD sensitive parts; therefore, all Grapes require ESD (antistatic) packaging and handling during inter- and intra-site transport, reception, and storage. As a rule, when handling (installing, removing, and servicing) these electrical components, all technicians must ground themselves. Wear an anti-static wristband connected to an established earth ground. See AD [04].

4.2 Sensor Specific Handling Precautions

The SUNA is an intricate spectrometer that is comprised of sensitive components, primarily the optics and electrical components. Damage to the optics may result in inaccurate nitrate measurements.

Never lift the sensor by the cables. Employ care to prevent damage to sensor housing; do not over-tighten the cable assembly. Damage to the sensor housing or cable assembly may result in electrical failure.

While removing, cleaning, or replacing the sensor, employ care when working with this sensor to prevent scratches on the optical windows or path material, which may alter light refraction and thus nitrate measurements.

4.3 Operation

The SUNA consists of a high-resolution spectrometer that is optimized for ultraviolet (UV) range wavelengths, a stable deuterium lamp, an on-board controller and a data storage device. Water flows through the enclosure, continuously flushing the optical path. Before each measurement, the integrated wiper sweeps the optical path to discourage buildup of biological constituents. For each measurement, the sensor reads light frames (absorbance of nitrate in water) and dark frames (background).

The sensor enters a sleep mode between measurements to conserve power and extend the life of the deuterium lamp. Configuration of this sensor is in accordance with RD [04] to collect a measurement at 15-minute intervals.

To take the measurement, the SUNA applies an UV light source across the water sample. The nitrate absorbs energy from the light. A spectrometer then measures how much light passed through the sample at each wavelength. The absorbance signal due to nitrate in the water is proportional to its concentration in the sample. It is critical to have a stable light source and a spectrometer capable of resolving the spectra for the nitrate in the water.

The SUNA internally converts all signals to digital data and applies algorithms developed by the Monterey Bay Aquarium Research Institute (MBARI) and Satlantic specific to this instrument prior to output.

4.4 Infrastructure

4.4.1 Wadeable Stream Sites

At wadeable stream sites, the SUNA is housed in a polyvinyl chloride (PVC) enclosure mounted onto a stainless steel anchor (Figure 2). The enclosure is slotted to provide adequate flushing while 1) securing the SUNA at the appropriate orientation in the stream and 2) providing protection from impact from debris. Reference RD [06] for more information on wadeable in-stream infrastructure.

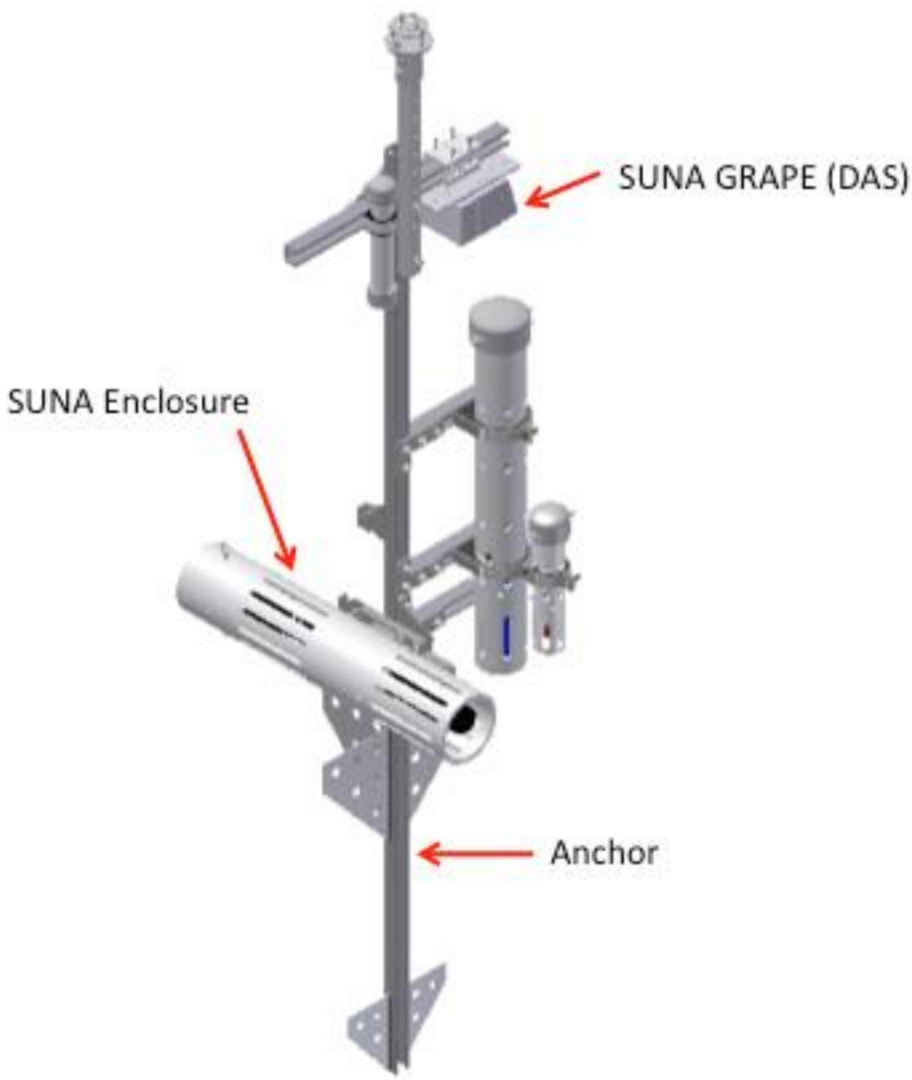


Figure 2. Schematic of infrastructure showing the location of the SUNA enclosure and Grape relative to the anchor.

NOTE: At high-water sites, the Grape is located on an arbor on the bank and not the in-stream infrastructure.

4.4.2 River and Lake Sites

At non-wadeable river and lake sites, NEON employs a buoy profile system. The SUNA (and the photosynthetically active radiation sensor (PAR)) suspends from a floating platform into the water. The enclosure is a dual PAR/SUNA mounting mechanism, which consists of a wire cage with plastic retainers. Figure 3 displays the PAR/SUNA mount fully extended in the water. When the mount retracts, it sits upon the floating platform of the buoy. During times of low flow, the SUNA enclosure can be moved down such that the measurement location is within 1cm (depth wise) of the Multisonde measurement point. The enclosure can be all the way down to the sediment if needed, as long as the enclosure (and sensor) do not start to become inundated with sediment. Section 6 provides additional information on the mount and how to review the SUNA from the enclosure.

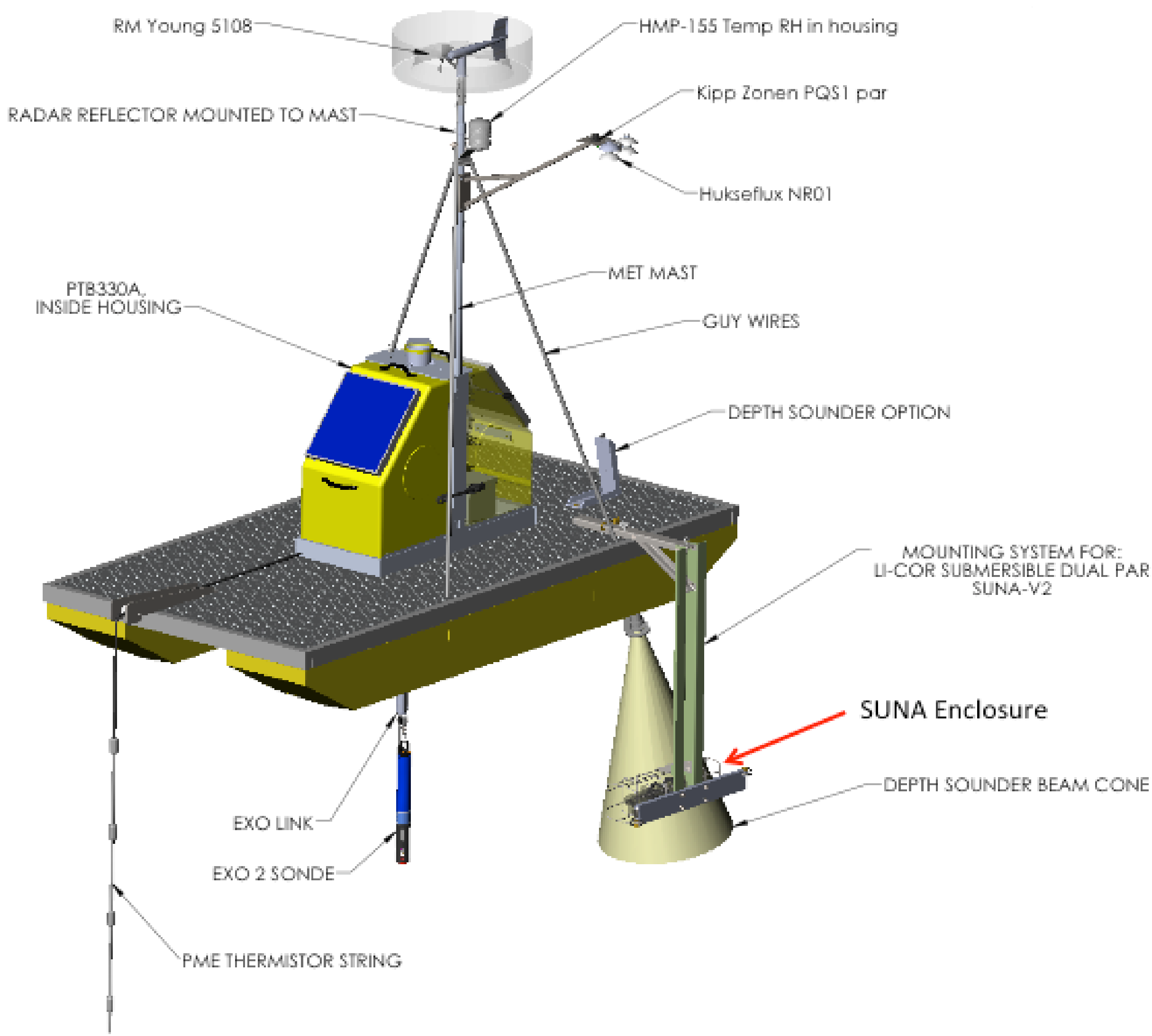


Figure 3. Schematic of buoy assembly showing the SUNA enclosure at the base of the mounting arm

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Equipment

Table 1. Preventative Maintenance Equipment

Maximo No.	Description	Quantity
Tools		
	USB-Power-SUNA Cable	1
NEON, AIS	PC Laptop with SUNACom V3.0.4 installed N:\Common\SYS\LabVIEW Programs\SUNAcom Installer http://www.seabird.com/uci Firmware	1
	1 Liter Nalgene wash bottle	2
GENERIC	5 Gallon Bucket	1
	5/16th Allen Wrench	1
	Scissors to remove Zipties	1
	Waders	1
Consumable items		
	Cotton Swabs	A/R
MX100642	Kimwipes or lint-free tissues (e.g., Opto-wipes)	4
	Parafilm	200 cm
	Deionized water stored in clean glassware	1 L
	>90% Isopropyl or ethyl alcohol (in a wash bottle)	100 mL
	Zip ties	A/R
	Powder-Free Nitrile Gloves	A/R

Maximo No.	Description	Quantity
	Vinegar	1 Bottle - A/R
Resources		
	SUNA User Manual	1
	SUNACom User Manual	1

5.2 Subsystem Location and Access

5.2.1 Wadeable Stream Sites

At wadeable stream sites, the SUNA is located at the downstream sensor station (1 total). The SUNA is placed at 60% depth of the water in either the thalweg or in a well-mixed location. The SUNA is co-located with other water quality measurement systems (Figure 2.

5.2.2 Lake and River Sites

At river and lake sites, a SUNA is located at the buoy location. In lake sites this is typically at the deepest location of the lake. In river sites this is typically as close to the thalweg as is feasible, constrained by either navigation pathways or the level of energy at mean to high flows.

To pull the SUNA arm out of the water for maintenance, don a life vest and gloves, and ensure there is a spotter on the buoy. Use HB00200000 Winch Support Assembly to assist in raising the SUNA infrastructure out of the water as described in RD [07].

5.3 Maintenance Procedure

NOTE: The wiper is initiated at the beginning of each burst of measurements. If the wiper is active, wait until it completes its rotation, returns to the parked position, and the sensor completes the current burst of measurements. This rotation should take less than three minutes to complete. If the wiper is already in the parked position, proceed with preventative maintenance.

Prior to conducting maintenance, technicians should review Section 5.3.1, Preventative Maintenance Procedure Sequence, to understand the order of the full maintenance procedure and have conducted the necessary Job Safety Analysis to conduct this procedure onsite.

Table 2. SUNA Preventative Maintenance Tasks Interval Schedule.

Maintenance	Bi-Weekly	Monthly	Quarterly	Bi-Annual	Annual	As Needed	Maintenance Type
SUNA Nitrate Analyzer							
Visual Inspection	X						P
Remove Debris from/Clean PVC Enclosure	X					X	P
Clean Sensor	X						P
Baseline Spectrum Calibration	X						P
Lamp Inspection	X						P
Lamp Replacement					X	X	P/R
Wiper Brush Check	X						P
Replace Wiper Brush						X	P/R
Electrical & Communication Infrastructure (DAS and PDS)							
Visual Inspection	X						P
Remote and Onsite Condition and /or Diagnostic Monitoring	X					X	P
Replace Cable Ties						X	R
Clean Biofouling from Cables/Wires	X					X	P/R
MISCELLANEOUS EQUIPMENT							
Subsystem Support Structure							
Visual Inspection	X						P
Verify Structural Integrity Bolt Connections and Unistrut			X			X	P

NOTE: The biweekly and annual inspections should be carried out regardless of whether they coincide or not. P = Preventive, R = Repair, X = Indicates preventive maintenance task time interval may increase due to environmental (seasonal/weather) or unforeseen/unanticipated site factors.

5.3.1 Preventative Maintenance Procedure Sequence

Preventive maintenance will occur at AIS sites once every two weeks. The following procedures detailed below will be implemented for the SUNA. SUNA preventive maintenance trips must include the following steps:

1. Verify system integrity (Section 5.3.2).
    a. Remove debris from the unistrut and SUNA enclosure.

        b. Check cables and connectors.
2. Remove sensor from enclosure (Section 6.2).
3. Connect the SUNA to the SUNACom software on laptop computer (Section 5.3.3).
4. Visually inspect optical area of sensor (Section 5.3.4).
5. Field calibrate SUNA (Section 5.3.5)
6. Check SUNA lamp hours
7. Replace sensor in enclosure (Section 6.2).
8. Reconnect the sensor cable on the Grape.
9. Reconnect the Ethernet cable on the Grape.
10. Redress cable assemblies as needed.
11. Verify the sensor and subsystem (Grape) is configured properly (Section 5.3.6).

5.3.2 Verify System Integrity

Visually inspect the sensor station for damage.

1. Check for debris collection on infrastructure (Figure 4).
    a. Remove debris as necessary.
        i. Allow snags to continue downstream.
        ii. Tumbleweeds or other vegetation or items that are not naturally part of the aquatic ecosystem may be removed from the stream and placed on the bank.

NOTE: AIS approves the removal of debris that snags/catches on the supporting infrastructure on S1 and S2, as appropriate. DO NOT remove or manipulate natural vegetation, unless it directly affects the system. If in doubt, take a picture of the vegetation and provide it to NEON HQ via the Issue Management/Reporting System for AIS personnel to review and determine a course of action.

1. Check cable assemblies (Figure 5).
    a. Visually inspect cable housings and report any damage by generating a trouble ticket.
    b. Visually inspect cable dressing and ensure the sensor cable has the appropriate relief and any slack is secured.
        i. Redress cables as needed.
2. Check connections.
    a. Visually inspect connections.
        i. Clean any corrosion.
    b. Gently feel that connections are secure.
    c. Report any excessive corrosion or loose connections by generating a trouble ticket.

Figure 4. Pictures of debris accumulating on sensor station after high flow event

Figure 5. Picture of damaged cable

Clean the SUNA enclosure and infrastructure as necessary according to RD[06].

5.3.3 Connecting to SUNACom Software

To calculate calibration drift and provide Calibration, Validation and Audit Laboratory (CVAL) with necessary data, technicians must record nitrate (NO_3) readings prior to cleaning, after cleaning, during calibration, and after calibration. Enter data collected in Fulcrum. Use the worksheet in Appendix A2 to collect additional data needed for CVAL, and record data in Fulcrum. Connect a laptop equipped with the Satlantic SUNACom software to the SUNA as shown in Figure 6.

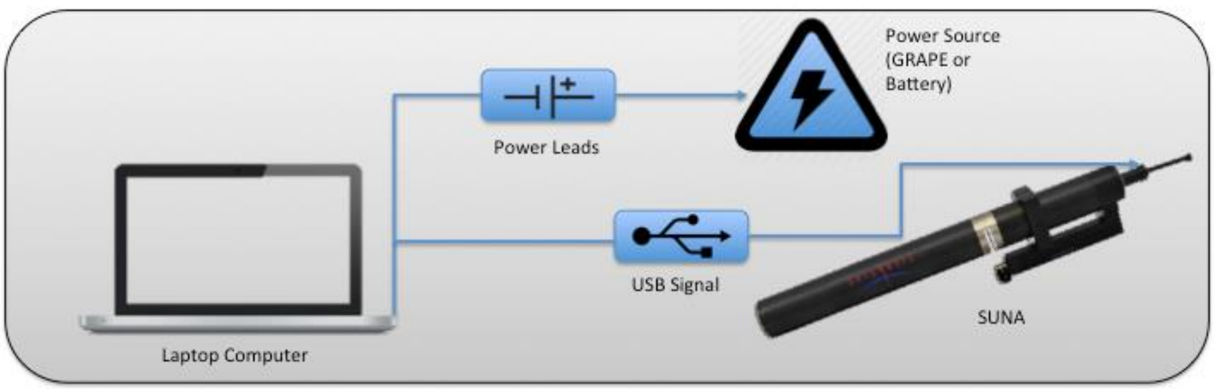


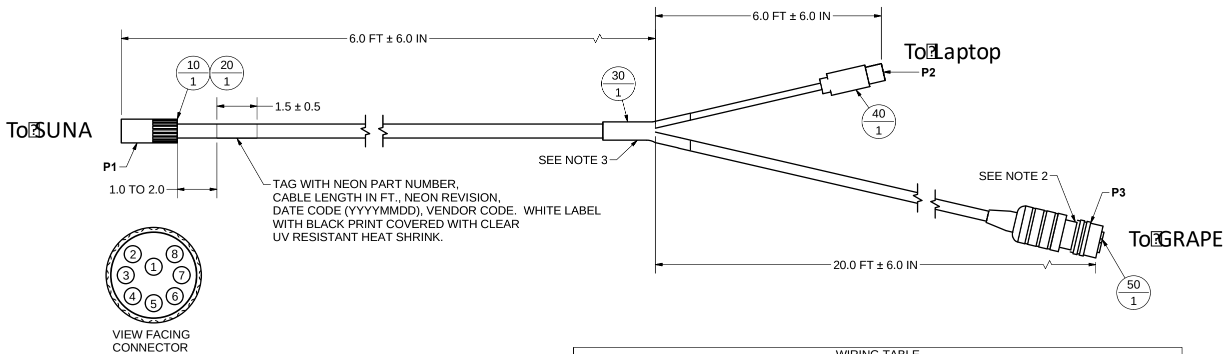
Figure 6. Schematic for connecting SUNA to a laptop via a split USB/power cable

1. De-energize the Grape. Disconnect the Ethernet cable (RJF) from the Grape prior to disconnecting (or connecting) the instrumentation. Reference AD [05] for the AIS Interconnect Map for the SUNA Grape and AD [01] and [06] for procedures on isolating the energy source and electrostatic discharge.
    a. For the buoy: Reference the Appendix for the Buoy Interconnect for SUNA power, which resides within the ports on the top PVC cylinder electronic housing. The ports for all instrumentation sit under the buoy t-frame within the yellow housing with solar panels. Reference AD [04] for information on the buoy profile wizard and met station wizard and buoy SUNA data stream for data verification later in the process.
2. Disconnect the sensor cable from the Grape.
3. Disconnect the power cable from the Sensor.

NOTE: The cable may be looped and suspended on the infrastructure.

4. Remove the SUNA from the enclosure (Section 6.2).

5. Plug in the SUNA.
    a. Attach sensor end of the cable assembly to SUNA (Figure 7 - Figure 8).



WIRING TABLE				
P1	P2	P3	SIGNAL	RESISTANCE
PIN 1 BLACK WIRE		PIN J GRAY WIRE	AUX PWR	1.0 OHMS
PIN 2 WHITE WIRE	BLACK WIRE	PIN D ORANGE WIRE, PIN K WHITE WIRE	GND	1.0 OHMS
PIN 5 ORANGE WIRE	YELLOW WIRE		TXD	
PIN 6 BLUE WIRE	ORANGE WIRE		RXD	

Figure 7. Schematic of cable assembly used to program and calibrate the SUNA nitrate analyzer

Figure 8. Photo showing the attachment of the sensor to the cable assembly.

b. Attach the power end of the cable assembly to the Grape, battery or other external power source (Figure 9).

Figure 9. Photo showing the connection of the cable assembly to the Grape for powering the sensor.

   c. Attach the USB end of the cable assembly to the field laptop computer

6. Launch SUNACom3.0.8.
7. Press the “Connect” button under the “SUNACom Dashboard” (Figure 10).
8. Select the appropriate comm port at the default baud rate. The baud rate usually defaults to 57600. (Figure 10).

NOTE: If unable to determine which port to use, verify laptop ports under device manager (they may differ when using different user laptops).

9. Click "Connect".
   a. If the serial port connection fails, close out the program and unplug the USB connection to the Laptop. Plug it back in and start the process again from Step 8.
   b. If the connection works, the window disappears and the connection mode is green. The bottom left corner of the display provides the nitrate readings in micromoles.

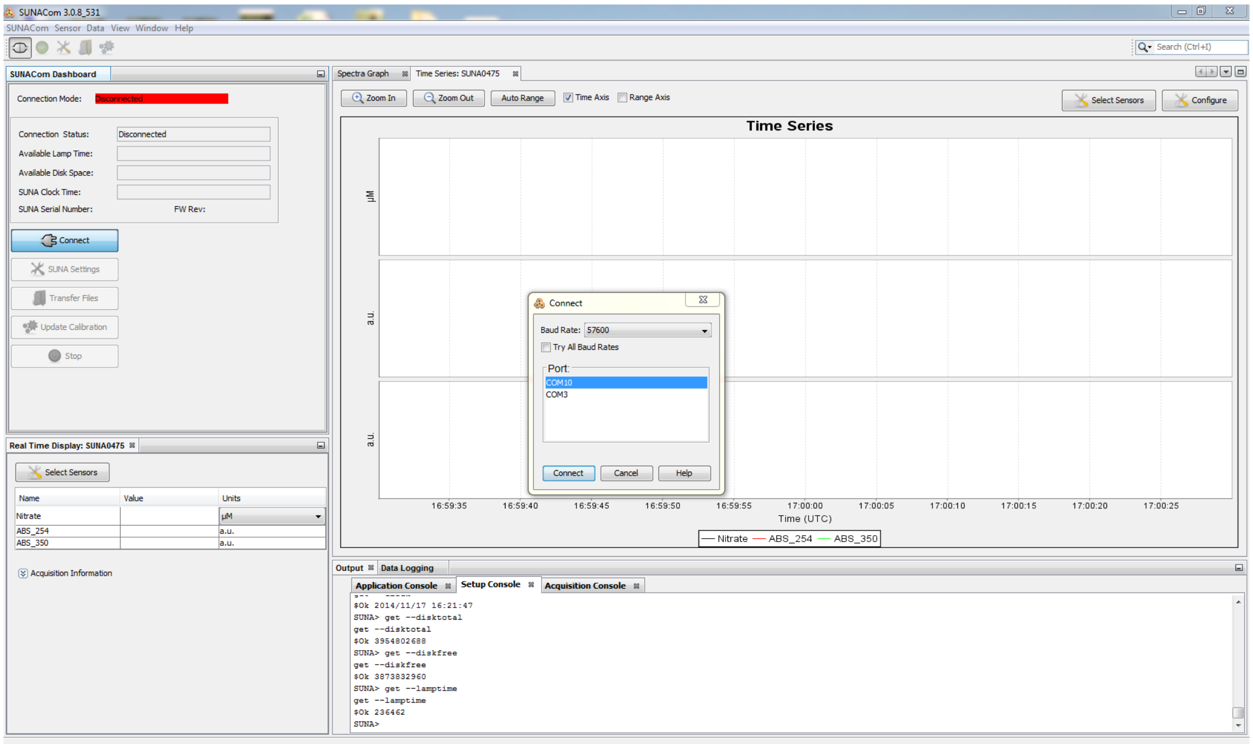


Figure 10. Screenshot of SUNACom software when connecting sensor

5.3.4 Sensor Inspection

1. Wear powder-free nitrile gloves.
2. Gently remove loose debris on the body by gloved hand.

NOTE: Further cleaning takes place during the calibration process (Section 5.3.5).

3. Visually inspect the optical windows for any scratches.
   a. Flush the optical ware with deionized (DI) water if necessary to see surface of optical windows.
   b. Record issues using the metadata sheet in Appendix A1 as necessary and report by generating a trouble ticket.

5.3.5 Sensor Calibration

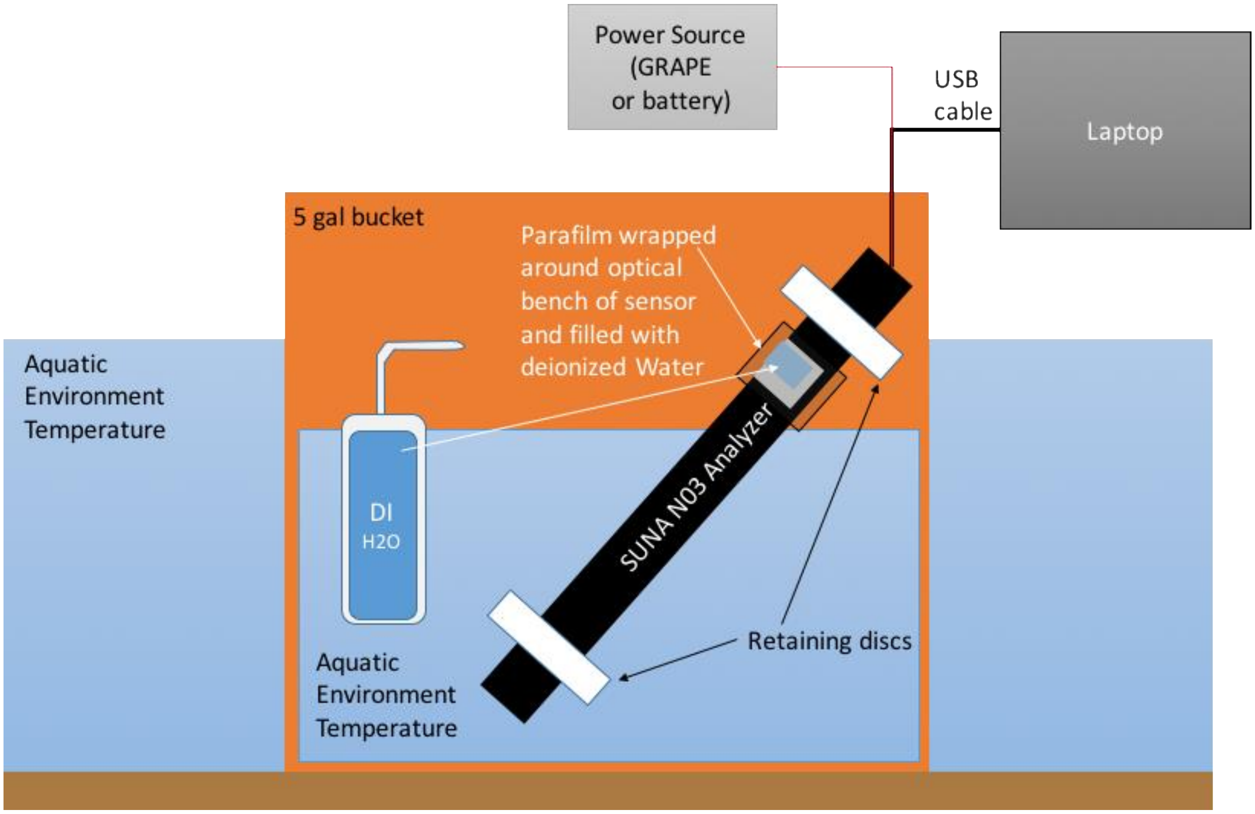


Figure 11. Overview of field calibration setup

5.3.5.1 Apparatus Setup

1. Set up water bath and equilibrate DI water with environment (Figure 11).
   a. Place approximately 18 inches of water into a 5-gallon bucket using water from the site (e.g., stream, river or lake).
   b. Place the bucket securely in the water at the site.
      i. Set the bucket near the water's edge.
      ii. Make sure the bucket is in 4 to 6 inches, but not more than 6 inches, of water so that it does not float.
   c. Place the wash bottle full of DI water into the water bath.

      PRO TIP: Place DI water with Sonde pH bottles in stream to align with stream water temperature.
   d. Let stand at least 30 minutes for the temperature of the DI water to reach the same temperature as the environment.
2. Fill SUNA optical bench with DI for calibration.
   a. Ensure application of powder-free nitrile gloves.

b. Verify the wiper is off via the SUNACom software (SUNA Settings>Wiper Settings: uncheck the box and click upload).
c. Carefully move the wiper away from the optical area as shown in Figure 12.
d. Cut and stretch a 40 cm piece of Parafilm and wind it around the optical bench of the sensor 3x as shown in Figure 13. Ensure there are no bubbles that may cause the DI water to leak upon application on the exterior parts of the Parafilm application.
e. Break a small hole in the top of the Parafilm and fill the optical area with DI water as shown in Figure 14**.** Use enough force to puncture the Parafilm, but gently enough to not cause leaks by forcing pressure onto the Parafilm around the optical bench.

Figure 12. Picture of wiper being moved clear of the optical bench

Figure 13. Photo of Parafilm placed over optical area on SUNA nitrate analyzer

Figure 14. Photo of inserting nozzle of wash bottle to fill the optical bench with DI water

5.3.5.2 Sensor Calibration

5.3.5.2.1 Pre-Cleaning Sensor Readings

NOTE: The SUNA must be set to Continuous Mode to perform the calibration update. The SUNA runs in Periodic Mode when sampling.

1. With the SUNA connected to the laptop (Section 5.3.3), press the "Settings" button under the "SUNACom Dashboard" (Figure 15).
2. Select "Continuous" from the Operational Mode drop down menu (Figure 15).
3. Configure the settings as shown in Figure 16 and press "Upload."
4. Press the Start button on the screen and collect data for 1 minute. (Watch the time interval at the bottom of the window until it reaches 60 seconds.)
5. After 1 minute, click "Stop".

6. Record the nitrate measurement value in the Quality Assurance Datasheet in Appendix A2 and/or in the Fulcrum app to record the reading. This is the SUNA pre-cleaning reading.

   NOTE: The cable may be looped and suspended on the infrastructure.

7. Remove the Parafilm and drain the water from the optical area.

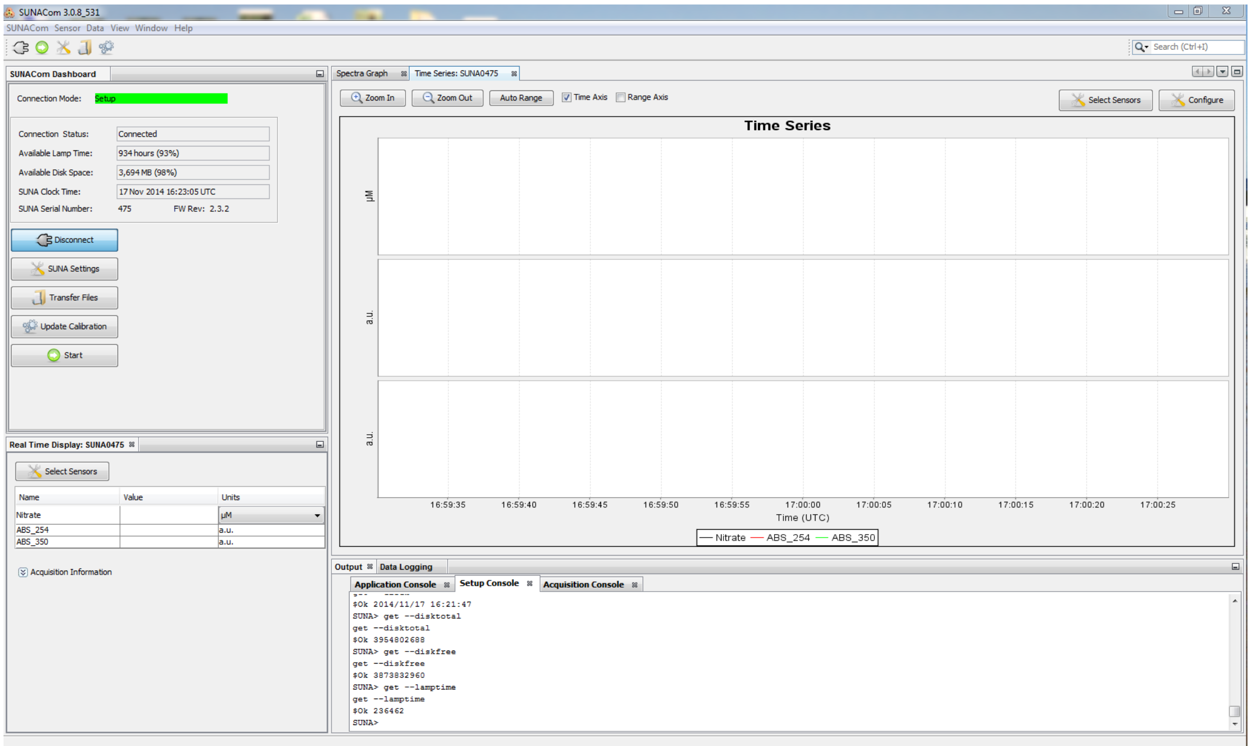


Figure 15. Screenshot of SUNACom main screen. Red arrow shows the SUNA Settings button.

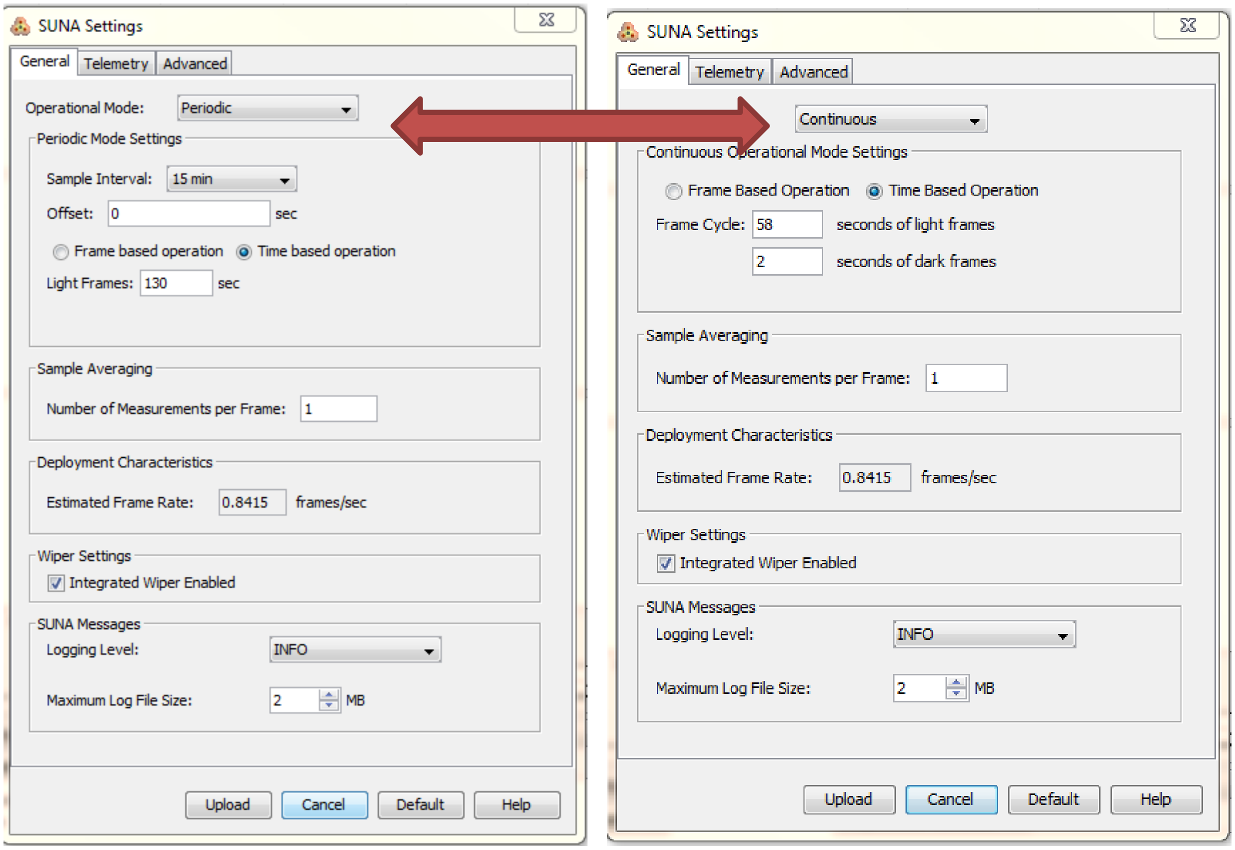


Figure 16. Screenshot of SUNA Settings menu window

5.3.5.2.2 Sensor Cleaning

1. Use isopropanol, cotton swabs and Kimwipes to clean the windows.
2. Use vinegar to clean debris or heavy biofouling on the exterior of the sensor.
3. Flush the optics with DI water.

NOTE: Use CAUTION not to scratch the windows!

5.3.5.2.3 Post-Cleaning/Pre-Calibration Sensor Readings

1. Repeat steps 2c through 2e under Section 5.3.5.1 Apparatus Setup
2. Press the Start button on the screen and collect data for 1 minute.
3. Stop the sensor.
4. Record the measurement value in the Quality Assurance Datasheet in Appendix A2 and/or in the Fulcrum app.

NOTE: This is the SUNA post-cleaning reading, which includes the process from Section 5.3.5.2.2 Sensor Cleaning (a more in-depth cleaning than previous conducted at the beginning of this procedure).

5. Remove the Parafilm and flush the optics with DI water.

NOTE: This measurement represents any sensor drift or change in lamp output.

5.3.5.2.4 Update Reference Spectrum

1. Repeat steps 2c through 2e under Section 5.3.5.1 Apparatus Setup.
2. From the main screen press the "Update Calibration" button (Figure 17) to launch the Calibration Wizard.
3. With fresh DI water in the optical bench, collect the blank spectral data following the steps in the Calibration Wizard (Figure 18).
4. Accept the calibration by hitting Next (Figure 19).
5. Press Finish to update the calibration file directly to sensor (Figure 20).
6. Provide calibration information to CVAL following the Field Calibration Data Transmission Instruction in Appendix A3.

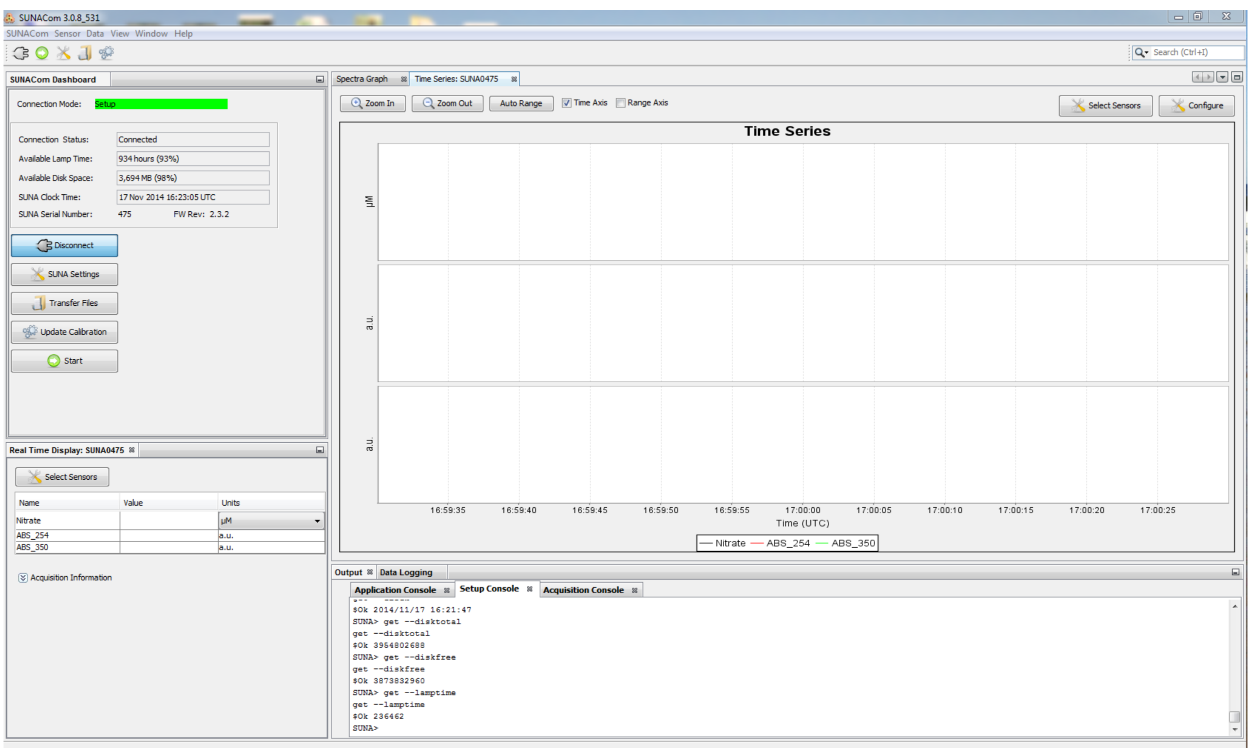


Figure 17. Screenshot of main screen showing the Update Calibration button

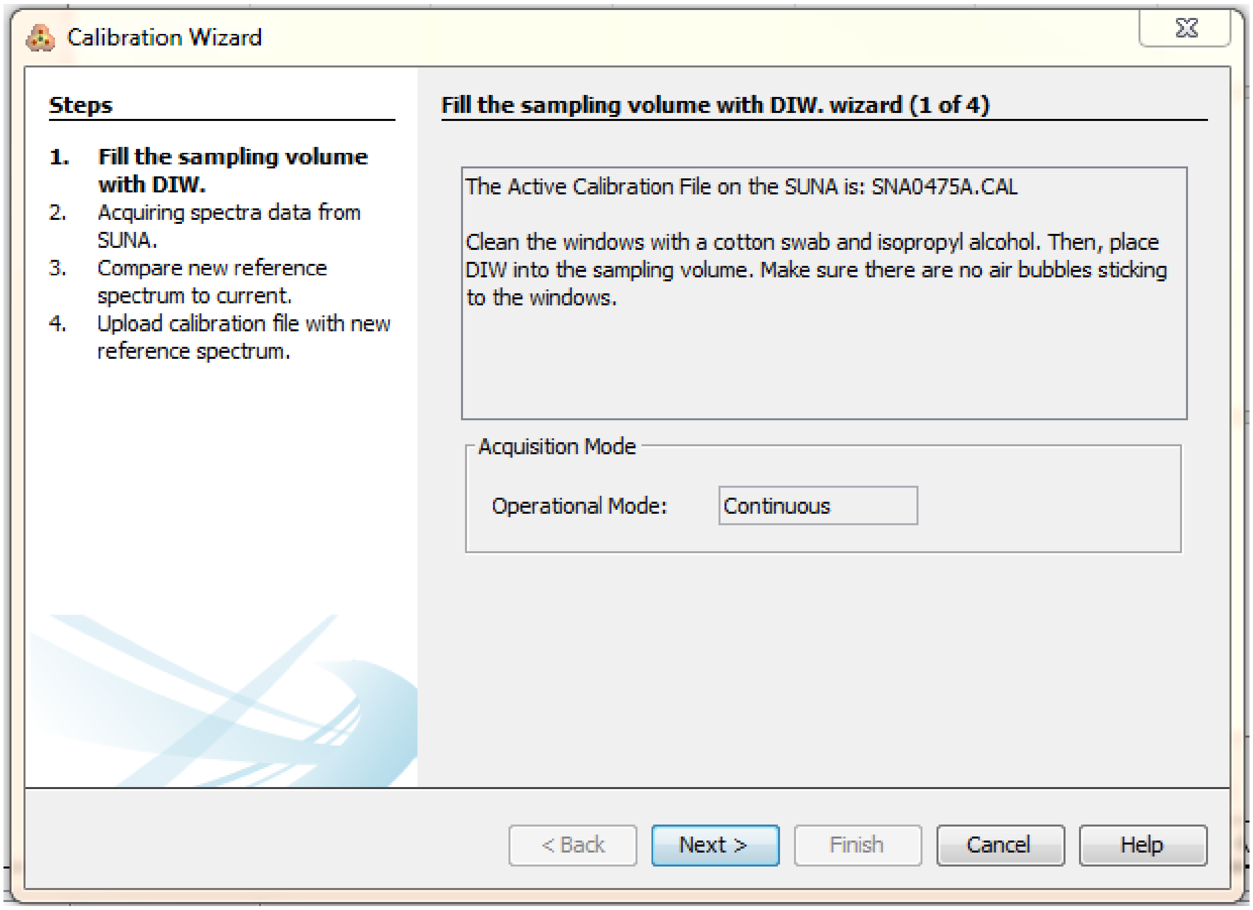


Figure 18. Screenshot of the Calibration Wizard launch

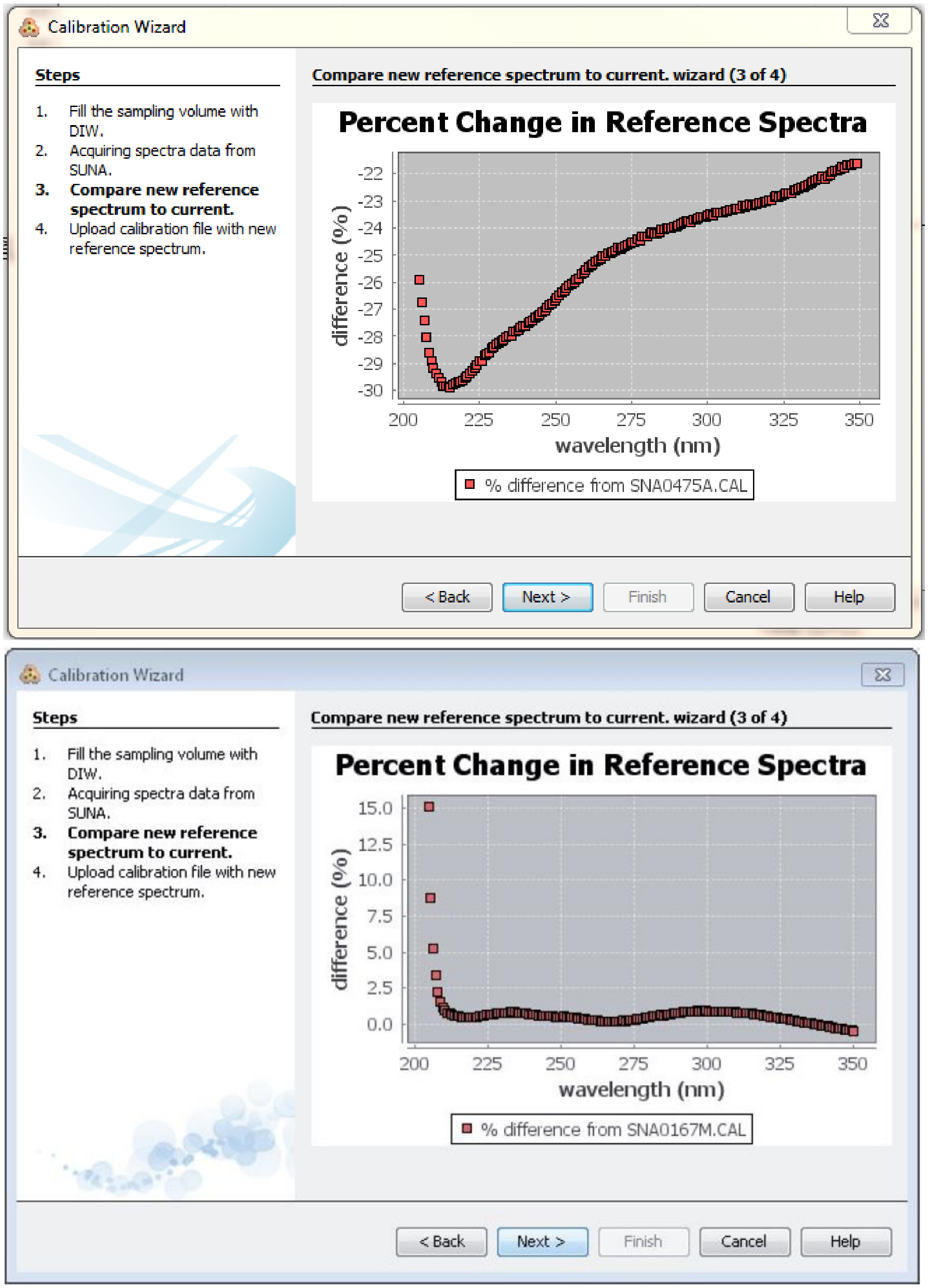


Figure 19. Screenshot examples of the analysis of the blank spectrum compared to last saved calibration file. The top spectrum shows a greater shift in baseline compared to the standard spectrum below. Both should be accepted before proceeding to the post-calibration check.

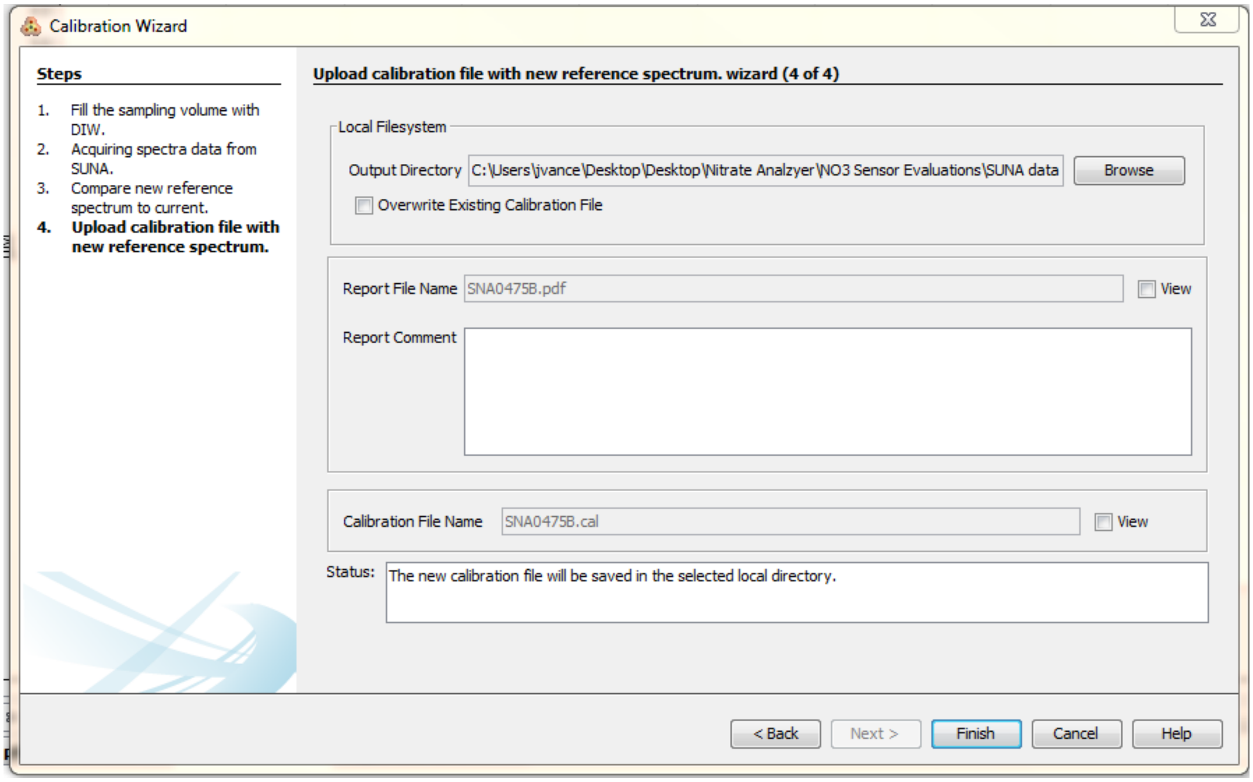


Figure 20. Screenshot of final step of the Calibration Wizard which uploads calibration file with new reference (blank) spectrum

5.3.5.2.5 Post-Calibration Sensor Readings

1. Repeat steps 2c through 2e under 5.3.5.1 Apparatus Setup.
2. Press the Start button on the screen and collect data for 1 minute.
3. Record the measurement value in the Quality Assurance Datasheet in Appendix A2 and/or in the Fulcrum app.
4. Stop the sensor.
5. If the nitrate measurement in DI is off from 0 by greater than +/- 2 µM repeat the Update Reference Spectrum instructions (Section 5.3.5.2.4)
    a. If the measurement fails this threshold criteria a second time, create a trouble ticket (JIRA) and proceed with the procedure.
6. Remove the Parafilm and flush the optics with DI water.

5.3.5.3 Wrap-up

NOTE: It is critical to place the sensor back into Periodic Mode for standard operations and data acquisition and turn the anti-fouling/hydro-wiper back on.

1. Change Operation Mode back to Periodic per RD [04] according to settings shown in Figure 21 and upload to the sensor.

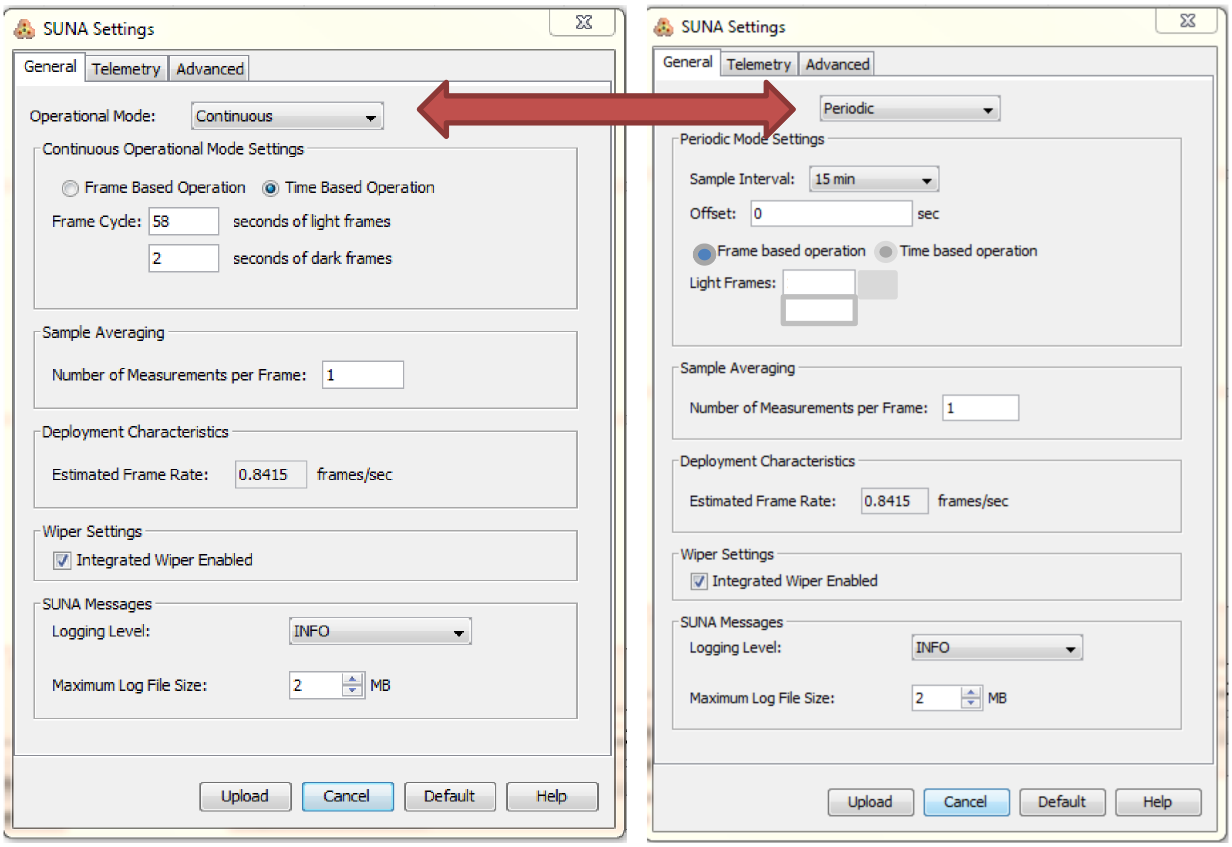


Figure 21. Change the SUNA configuration back to Periodic per RD [05]

2. Check Available Lamp Time and record the hours in the Quality Assurance Datasheet in Appendix A2 and/or in the Fulcrum app.
    a. If the Available Lamp Time is equal to, or less than 50 hours, initiate the SUNA sensor refresh by issuing a trouble ticket
    b. Once a replacement sensor has arrived at the DFS, follow the instructions in Section 6 to replace the field sensor and return spent unit to CVAL for servicing.
3. Return the anti-fouling/hydro-wiper back to its original position and turn it on via the SUNAcom software.
4. Close the SUNAcom software and disconnect the USB connection from the Laptop.
5. Remove Ethernet Cable from the Grape and disconnect the USB-power-sensor cable assembly from the SUNA and Grape.
6. Reconnect the field sensor power cable and reinstall the SUNA in the enclosure at sensor station 2 (S2). Reference AD [04] for in-stream sensors and the buoy interconnect mapping in Appendix A4.

5.3.6 Configuration Verification

The configuration of the SUNA must be verified after performing the field calibration in order to ensure proper operation and data transmission. The following steps describe the process for verifying the configuration according to RD [04].

1. Log onto the LC at the AIS site were work is being performed.
    a. Log-on to the LC: ssh user@<IP address>
        i. Password: resuresu
    b. Use the following command prompt in the LC terminal window: **`vd -s [sensor eeprom id] -r [stream number]`**
        i. Reference RD [04] for SUNA data stream numbers.
2. Execute the following in the command prompt: "**nc localhost 30200**", then press <**enter**>.
3. The network information for the Grapes on site will appear. Once this list appears, press: <**Control + c**> to exit the program or it will keep populating the network information.
4. Find the line stating "Grape-SUNA" and acquire the IP address for the SUNA. Figure 22 displays this information outlined in red.

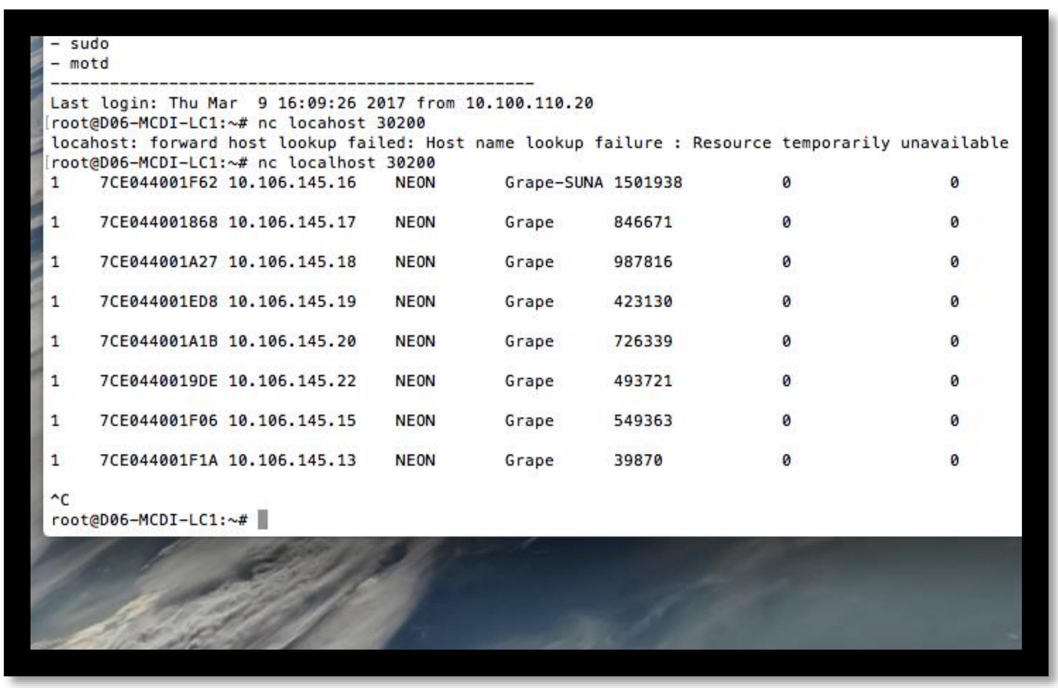


Figure 22. Screenshot of terminal window showing connection to the SUNA

5. Type "**telnet -8 IP**", e.g., "**telnet -8 10.106.145.16**" for McDiffett.
6. When "**Grape>**" appears, type "**connect a**" and press <**enter**>.
7. At the blank line start pressing "**$$$$$$$**" and press <**enter**>.

NOTE: Sometimes a combination of actions is necessary to achieve the next command line.

***NOTE: When you see a prompt that says* "SUNA>", you are now connected to the SUNA.**

8. After connecting to the SUNA, type "**get cfg**" and press <**enter**>.

NOTE: The backspace function is no longer available when working in the SUNA software.

9. Copy that list of parameters out of the terminal window into a text editor for quick reference. See Figure 23 for reference in this step.

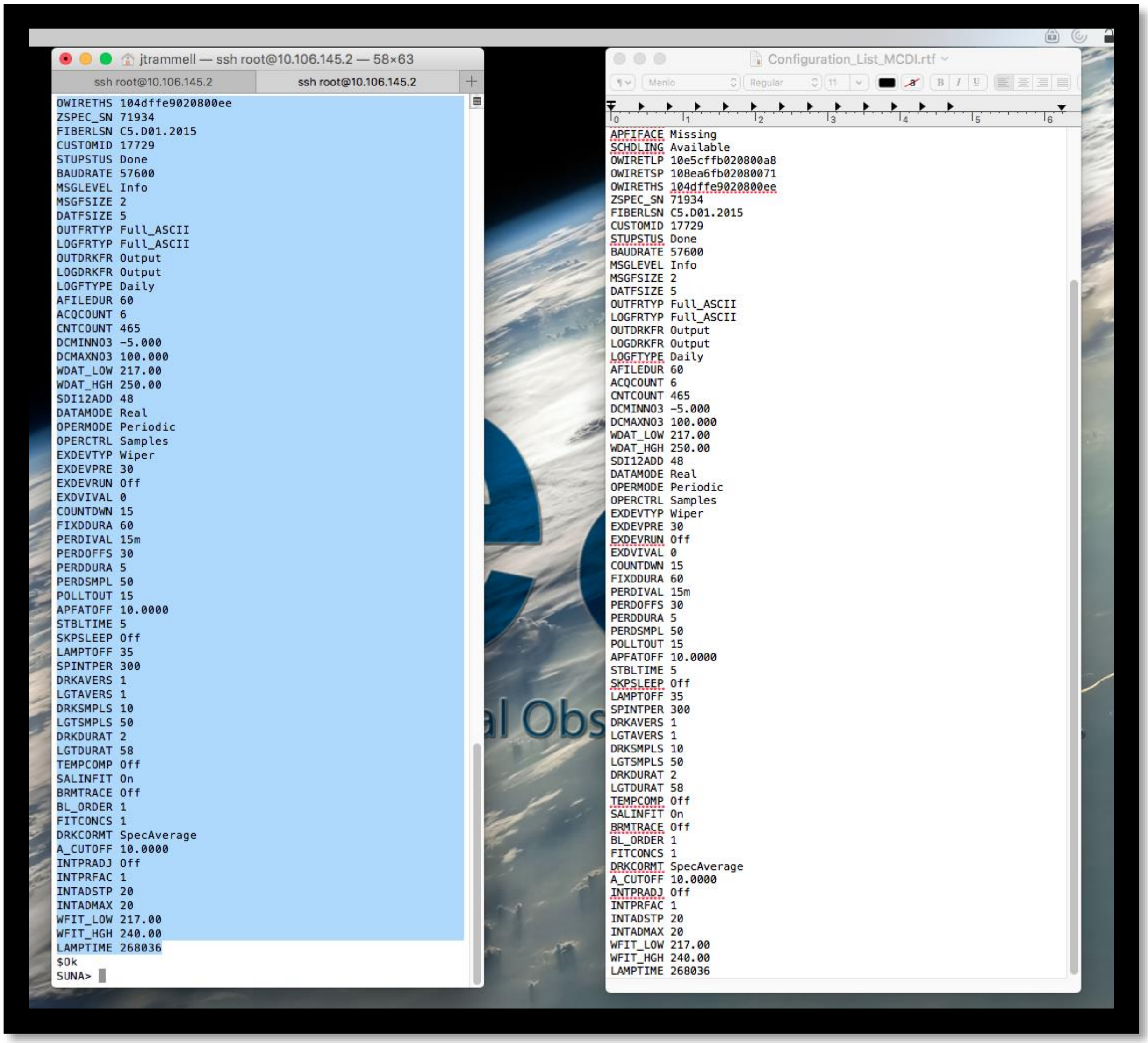


Figure 23. Screenshot showing the list of parameters to be copied from the terminal window into a text editor

10. Bring up the list of configurable parameters in another text editor beside the list you copied from your SUNA (Figure 24).

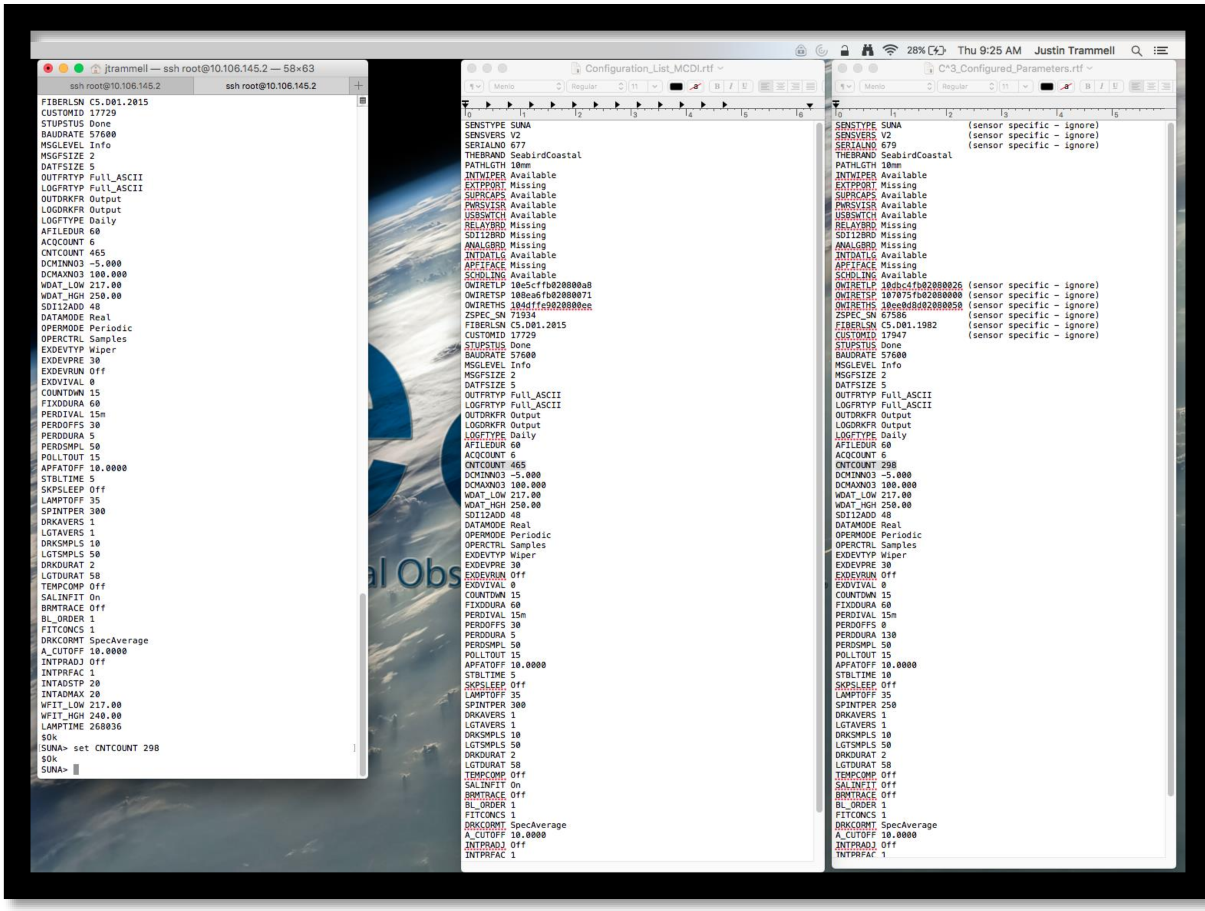


Figure 24. Screenshot of comparing two text editor windows to reduce errors

11. Go through each parameter. If there is something wrong, please submit a trouble ticket. If a setting is wrong, take a screenshot and submit a ticket quickly because there is a risk of losing data if the configuration is not correct.
12. To report data quality issues for the SUNA data stream(s), use the NEON issue management/reporting system and on the ticket, select the "PTB: FOPS-DQ" board and "AIS: FOPS Data Quality" component.

6 REMOVAL AND REPLACEMENT (SUBSYSTEM ONLY)

6.1 Equipment

Table 3. Equipment for Sensor Removal and Replacement

Maximo No.	Tools	Quantity
1	Open Ended Wrenches	Set
2	Ratchet set	Set
3	Allen Wrenches (5/16 Allen Wrench for SUNA)	Set
4	Tool lanyards	A/R
5	Torque Wrench	1
MX103120	Anti-static wristband	1
Maximo No.	**Consumable items**	**Quantity**
1	UV-resistant Zip ties	A/R
2	ESD bags	A/R
MX105865	3M Bag, ESD Shielded, 8 inch x 11 inch, Cushioned	
MX105931	3M Bag, ESD, Static Shield, 6 x 8 Inches, Zip Closure, Non-Cushioned	
MX105864	3M Bag, ESD Shield, 6 Inch X 7 Inch, Cushioned	
MX105866	3M Bag, ESD Shielded, 14 Inch X 15 Inch Cushioned	
MX105935	3M Bag, ESD, Static, 15 x 18 Inches, Zip-Closure Top	
3	Masking tape	1
4	Sharpie/Paint pen	1

NOTE: Maintain original product packaging, if possible, for use in future sensor swaps (calibration and validation), temporary storage, or to return faulty equipment.

6.2 Removal and Replacement Procedure

The Field Operations Manager is responsible for managing the removal and replacement of the sensors onsite for preventive maintenance and/or sensor swaps, as well as field calibration and validation of sensors, as appropriate. CVAL is responsible for the annual calibration and validation of select sensors and manages the Domain sensor swap schedules.

To minimize data downtime and optimize the availability of sound data, coordinate instrumentation and subsystem **annual** calibration, validation and preventive maintenance requirements to occur within the same timeframe.

Always disconnect the power prior to removing or replacing any components. Employ lock-out/tag-out procedures per NEON Safety.

6.2.1 Stream Sites

The SUNA requires two captive discs to hold it in place in the in-stream PVC housing. Do not remove the two captive discs from the sensor except when SUNA is leaving the site for replacement, calibration, or manufacturer maintenance, or as necessary so that the sensor can be appropriately replaced when removed for routine inspection, cleaning and biweekly field calibration. If the captive discs are removed, the proper orientation must be set and verified. If the screws of the captive discs develop corrosion sufficient to warrant replacement, replace the screw and reassemble the discs following the installation instructions.

Conduct the following removal and replacement procedures:

1. Disconnect the Ethernet Cable from the Grape powering the SUNA.

   NOTE: Always remove the Ethernet cable from the Grape prior to connecting and disconnecting sensor cables; this de-energizes the Grape (data acquisition device) to prevent damage to the mechanism.
2. Disconnect the sensor power cable from the Grape.
3. Disconnect the sensor cable from the SUNA and drape over the infrastructure.
   a. Remove zip ties that are securing the sensor cable to the anchor, using snips, as appropriate.
4. Using a 5/16th Allen wrench to remove the SUNA PVC enclosure from the in-stream anchor.
5. Remove the PVC housing from the anchor.

Figure 25. Photo of SUNA enclosure removal from the stream.

6. Pull the four lock pins from the enclosure to free the two captive discs (Figure 26 and Figure 27).

NOTE: Fouling may accumulate in the tracks, which may cause the SUNA to get stuck or cause difficulty re-inserting the SUNA into the PVC enclosure. Try to flush the PVC enclosure with water to dislodge any debris, if possible.

Figure 26. Remove the four locking pins

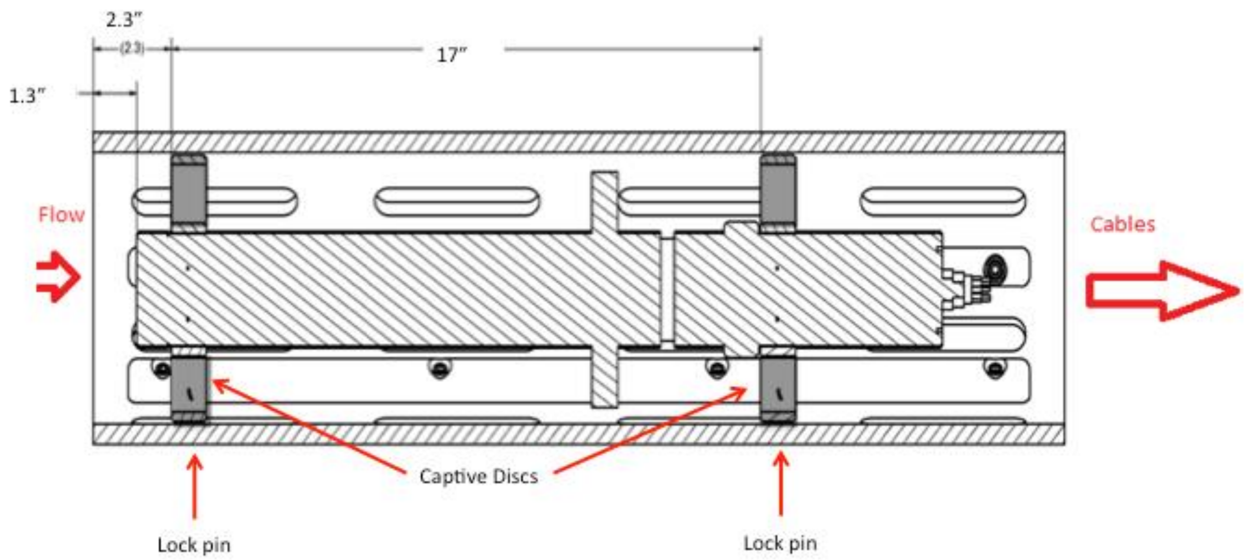


Figure 27. Schematic showing the positioning of the mounting discs on the sensor body

7. Slide the sensor assembly out of the enclosure by grabbing onto the wiper housing at the top of the sensor as shown in Figure 25**.**
8. Remove the two captive discs **ONLY IF** shipping the sensor back to HQ.

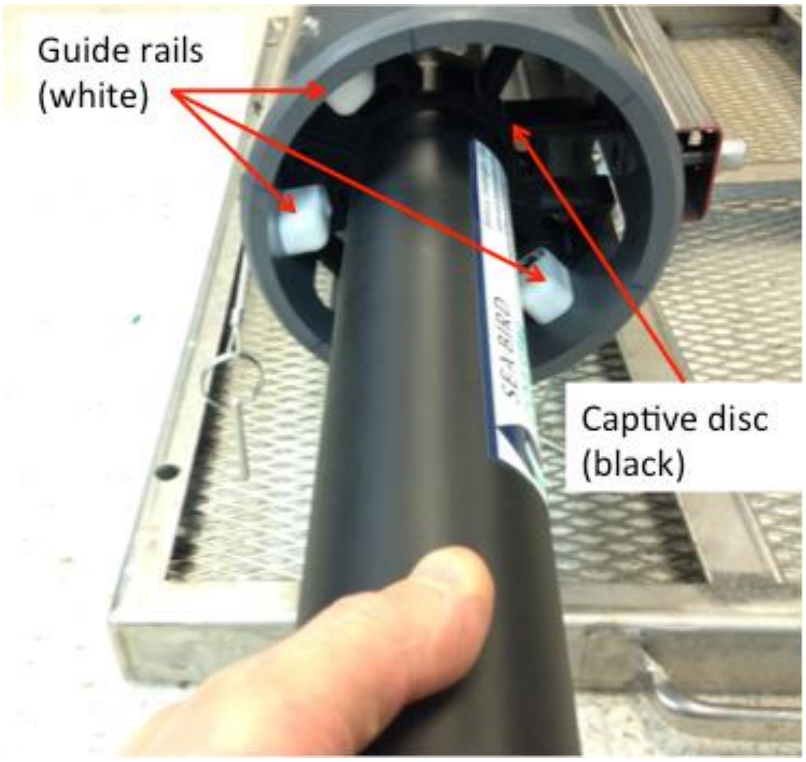


Figure 28. Picture showing the removal of the SUNA from the enclosure with the mounting disc and guide rails

6.2.2 Lake and River Sites

1. Bring the sensor enclosure to the surface access point:
    a. For Flint River buoy: Remove SUNA from standpipe.
    b. For all other buoys: Rotate the mounting arm from the submerged position to the deck of the buoy (Figure 29).

NOTE: there is risk of injury if any part of the body is caught between the mounting arm/lever and the track in which it rests in the upright position. Use caution when moving the levers into place and keep hands clear from areas of connection (**Figure 30*****).***

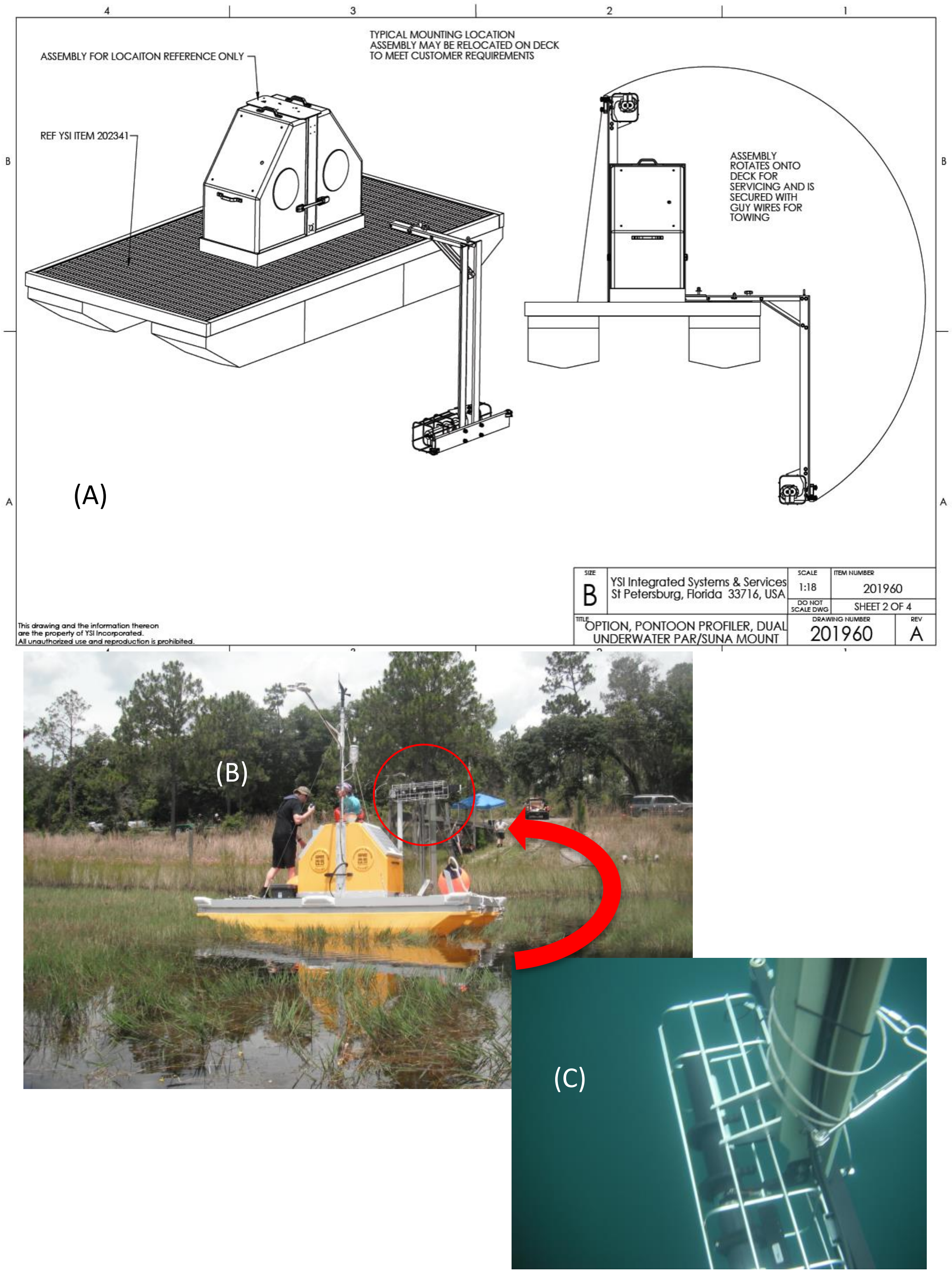


Figure 29. Mechanical drawing of the buoy platform (A) showing the rotation of the of the mounting arm for the SUNA enclosure; (B) the SUNA enclosure in the upright position and (C) the submerged position.

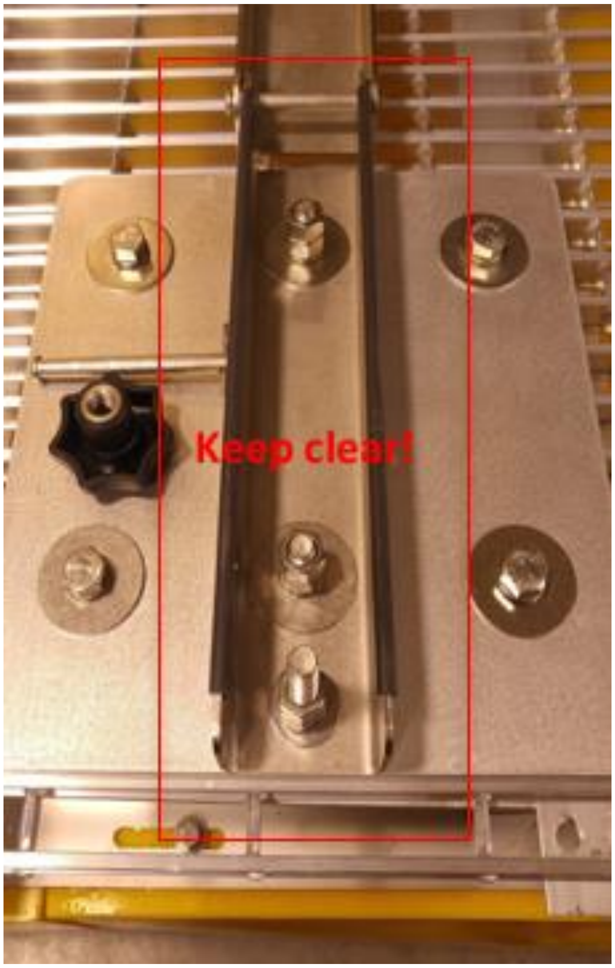


Figure 30. Photo of track that should be kept clear while raising the mounting arm.

NOTE: If the site buoy is equipped with a winch to assist the lifting of the SUNA mounting arm, follow the directions in* Figure 31*.

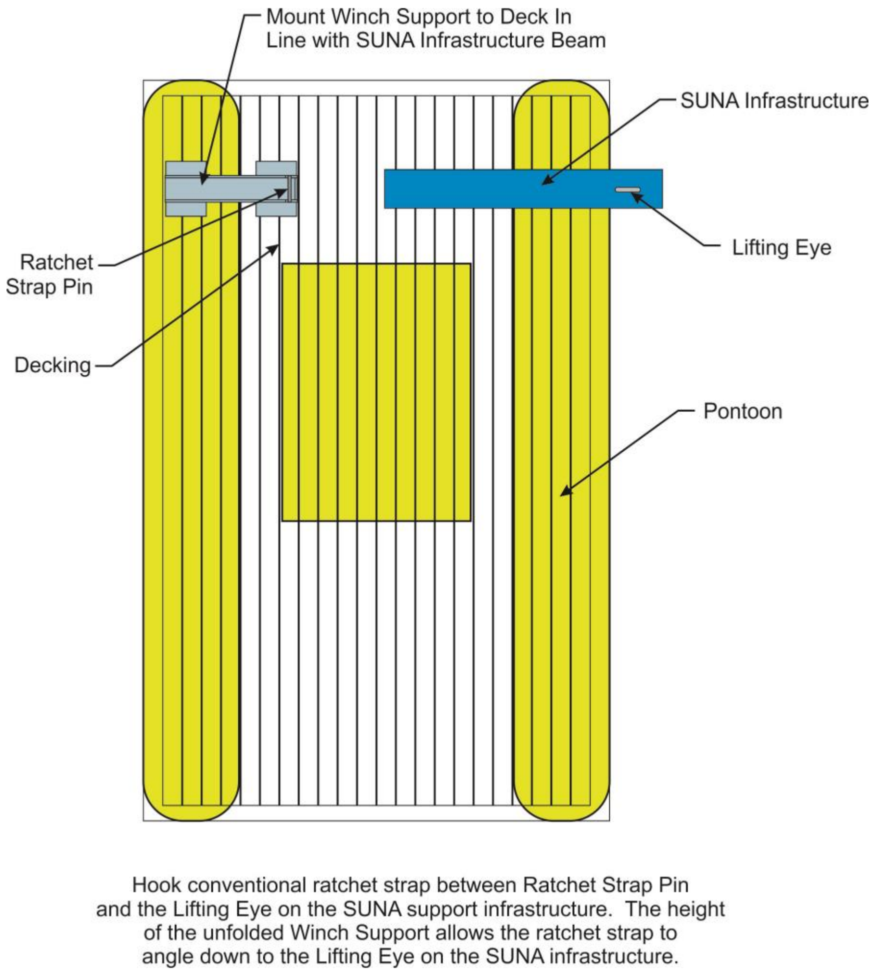


Figure 31. Schematic of buoy platform showing the winch support (HB00200000) used to assist in the lifting of the SUNA mounting arm. Directions are provided at the base of the illustration.

2. Disconnect the SUNA sensor cable.
3. Remove the SUNA from the enclosure by snapping it out of the SUNA deployment structure as shown in Figure 32.

Figure 32. Removing the SUNA from the buoy deployment structure

6.3 Cleaning & Packaging of Returned Sensor

NOTE: The asset tag must ship with the SUNA. In order to preserve the asset tags themselves, NEON recommends storing the tags in a Comm box on the device post as a standard practice. NEVER SHIP A SUNA WITHOUT ITS ASSET TAG!

In addition, the asset tag is important for the MAXIMO record and Command and Control (CNC) programing of AIS instrumentation. Ensure the asset tag aligns with the CFG location in the MAXIMO record, and if a SUNA asset tag changes or sensor is swapped from HQ, update the MAXIMO record accordingly and provide NEON ENG with the new asset tag and EPROM ID.

6.3.1 Decontamination

If the SUNA is to be removed from the site for repair, replacement or laboratory calibrations, it must be thoroughly cleaned following the decontamination protocol in RD [05].

6.3.2 Storage

1. Attach a clean and lubricated dummy plug and a lock collar to the sensor.
2. Rinse the sensor with fresh clean water.
3. Flush the optical area with fresh clean water.
4. Dry the sensor with Kimwipes or blown air.
5. Place the clean dry sensor into the custom fitted Pelican case for storage.

6.3.3 Packaging and Shipping

1. Use the manufacturer-provided case for transport (Pelican case).
2. Label as FRAGILE and ship to the appropriate address.

For the SUNA 12V Merlot Grape, conduct the following steps:

1. Remove Ethernet cable to power down the Merlot Grape.
2. Remove Sensor connections.
3. Remove biologics and clean caps and connectors.
4. Cap all connectors.
5. Conduct decontamination.
6. Cap connections and place the device in an ESD bag and shipping container.
7. Update asset records via the NEON's project Asset Management and Logistic Tracking System (e.g., MAXIMO). NEON HQ, Logistics Warehouse (LOGWAR) receives the Grapes for refresh and distributes to CVAL.
8. Provide an electronic packing list to CVAL with the Box number and Asset Tag number (14-digit Property Tag ID ("Property of") number) of each item. CVAL uses this information to verify items via LOGWAR/general HQ distribution of shipments.
9. Prepare a Bill of Lading.

NOTE: For any Non-CVAL initiated sensor returns, please notify CVAL of the return.

Package sensor items via packaging from CVAL HQ or per guidance via the Issue Management System and return to the NEON project HQ using the following address:

Battelle Ecology, **ATTN: CVAL**

1685 38th Street, Suite 100

Boulder, CO 80301

Only include sensors/subsystems for refresh. Additional equipment must ship separately as they may require attention from other NEON HQ departments. Sensor refresh shipments go direct to CVAL. If sensors are shipping to HQ to address a trouble ticket, per guidance via the Issue Management System, return to the NEON project HQ using the following address:

Battelle Ecology, **ATTN: Repair Lab**

1685 38th Street, Suite 100

Boulder, CO 80301

6.4 Sensor Refresh and Record Management of Assets

In addition to the physical movement of devices, the sensor refresh process requires dedicated and accurate record management of asset movement and location.

6.4.1 NEON Asset Management and Logistic Tracking System Requirements

Technicians must update the instrumentation records via the NEON's project Asset Management and Logistic Tracking System (e.g., MAXIMO). NEON HQ must maintain accurate record keeping on the location, date, and time offline of an instrument to ensure NEON HQ, Computer Infrastructure, Data Products, and CVAL are aware to apply the correct algorithms, calibrations, and processing factors. Ensure the CFG location reflects the current site of the sensor.

6.4.2 Command and Control Program Information Requirements

Provide notification of the new sensor/subsystem NEON Asset Tag Number via the Asset Management and Logistic Tracking System (e.g., MAXIMO), which is the 14-digit Property Tag ID ("Property of") number on the sensor/subsystem and EPROM ID via the NEON project issue management and reporting system (e.g., JIRA). This ensures integration of the new sensors/subsystems into the NEON Command and Control program. Route and/or add NEON Engineering to the ticket to notify the appropriate points of contact.

6.4.1 Lamp Replacement

NEON sends the SUNA to the manufacturer annually for lamp replacement, service and full calibration. NEON also maintains the calibration coefficients, which are stored in the sensor. CVAL performs the quality assurance on manufacture calibration on new or post-serviced sensors from the manufacturer.

Field Operations performs the field calibration procedure in the field at the time of deployment and as part of routine maintenance to correct for drift due to biofouling, sensor drift and lamp degradation.

7 ISSUE REPORTING OUTPUTS

If any issues arise that may affect the integrity of the AIS or data quality, complete the metadata sheet in Appendix A1 and submit it with a trouble ticket.

For SUNA corrective actions, ensure proper tracking of the asset via the NEON issue management and tracking system (e.g., JIRA) to establish a chain of custody of the asset between Engineering Repair Laboratory and CVAL.

Conduct the following tasks to ensure the proper management of the asset between sites:

1. For each issue where NEON, HQ is replacing a defective instrument/subsystem at a AIS site, please create a sub-task in the NEON Issue Management and Reporting System for the defective asset from the reported issue. Resolution of an issue does not occur with the installation of a replacement, but with the root cause analysis of the issue deriving from the defective asset. FOPS may resolve the ticket upon installation of the replacement if a sub-task exists for the defective asset for NEON HQ to conduct root cause analysis.
2. Ship all defective equipment/assets with a red "Rejected" tag. Figure 33 displays the minimum information requirements for each tag.

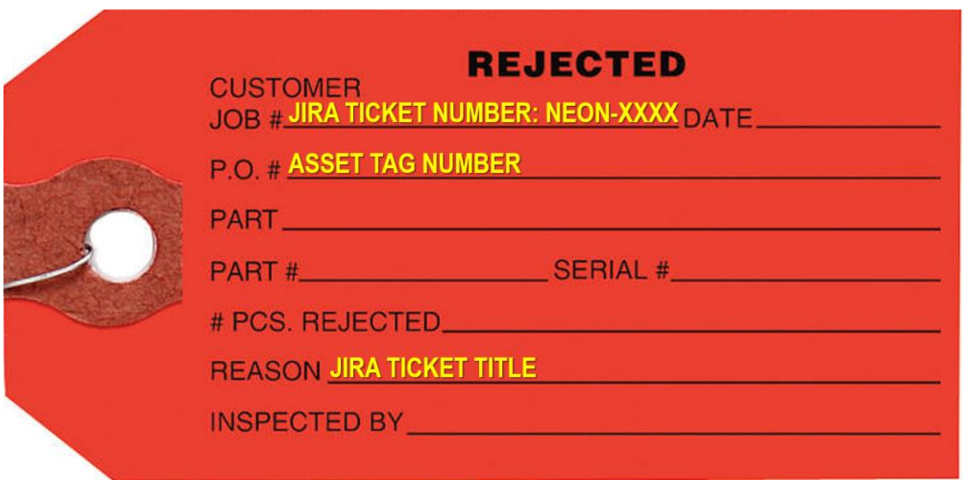


Figure 33. Red Rejected Tag for Defective Assets (MX104219)

8 APPENDIX

8.1 A1 – Issue Reporting Datasheet

Table 4. Metadata Output Checklist

Issue Reporting Datasheet		
Datasheet field	**Entry**	
NEON Domain and Aquatic Site Code		
Maintenance Time and Date		
Maintenance Technician		
Preventive Maintenance	**Issue Noted**	**Issue Summary**
Cables & Connectors - Condition Check	☐	
SUNA Grape – Condition Check	☐	
SUNA Mount – Condition Check	☐	
SUNA External Surface – Condition Check	☐	
SUNA Window – Condition Check	☐	
SUNA Optical Path – Condition Check	☐	
SUNA Calibration – Configuration Check	☐	
SUNA Available Lamp Time Check	☐	
Sensor - Other Specific Checks *(Cable ties are securing the sensor to its infrastructure, no corrosion is occurring on the captive discs, etc.)*	☐	
Environmental Information *(Any significant weather events occur that may correlate with the issue summary?)*	☐	
Sensor Removal *(due to seasonal conditions such as significant freezing, ice heaving and accumulations, etc.)*	☐	
Notes/Observations:		

8.2 A2 – Preventative Maintenance Quality Assurance Datasheet

Table 5. Data Output for Data Quality Assurance associated with preventative maintenance activities

Preventative Maintenance Quality Assurance Datasheet			
Datasheet field	**Entry**		
NEON Site Code			
Maintenance Date			
Maintenance Technician			
Quality Assurance Data	**Pre-Cleaning Value**	**Post-Cleaning/Pre-Calibration Value**	**Post-Calibration Value**
S2 - Nitrate			
Available Lamp Time (hours)			
Notes			

8.3 A3 – Field Calibration Data Transmission Instructions

When aquatic sensors are calibrated in the field, NEON is limited to using the manufacturers' programs (versions controlled by CVAL in the directory shown in Figure 34), and thus reliant on manual transmission of data via the files created by these programs.

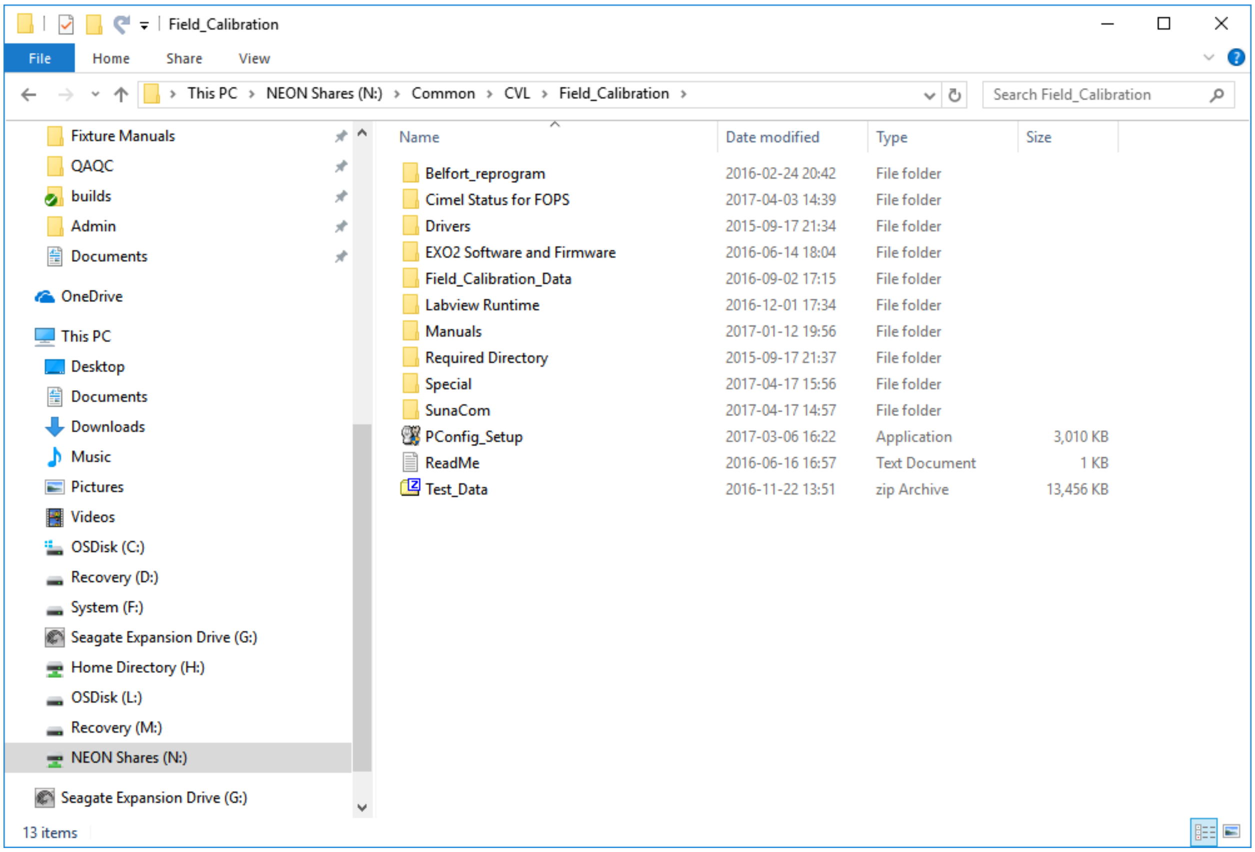


Figure 34. Location of version controlled calibration software for SunaCom (Suna Sensor) and EXO2 Software and Firmware (Sonde Sensors) at \\eco.neoninternal.org\neon\Common\CVL\Field_Calibration or N:\Common\CVL\Field_Calibration

The transfer of the files needs to happen on the device used for the calibrations and when network connectivity is available. It is prudent that these be transferred as soon as possible from the date of the maintenance for prompt transmission to the data portal.

For file transfers, use the common drive with the following directory (if N-drive is mapped properly, the lower directory is sufficient):

\\eco.neoninternal.org\neon\Common\CVL\Field_Calibration\Field_Calibration_Data\AIS

or

N:\Common\CVL\Field_Calibration\Field_Calibration_Data\AIS

Figure 35 shows an example folder for sensors calibrated with this protocol (Figure 35).

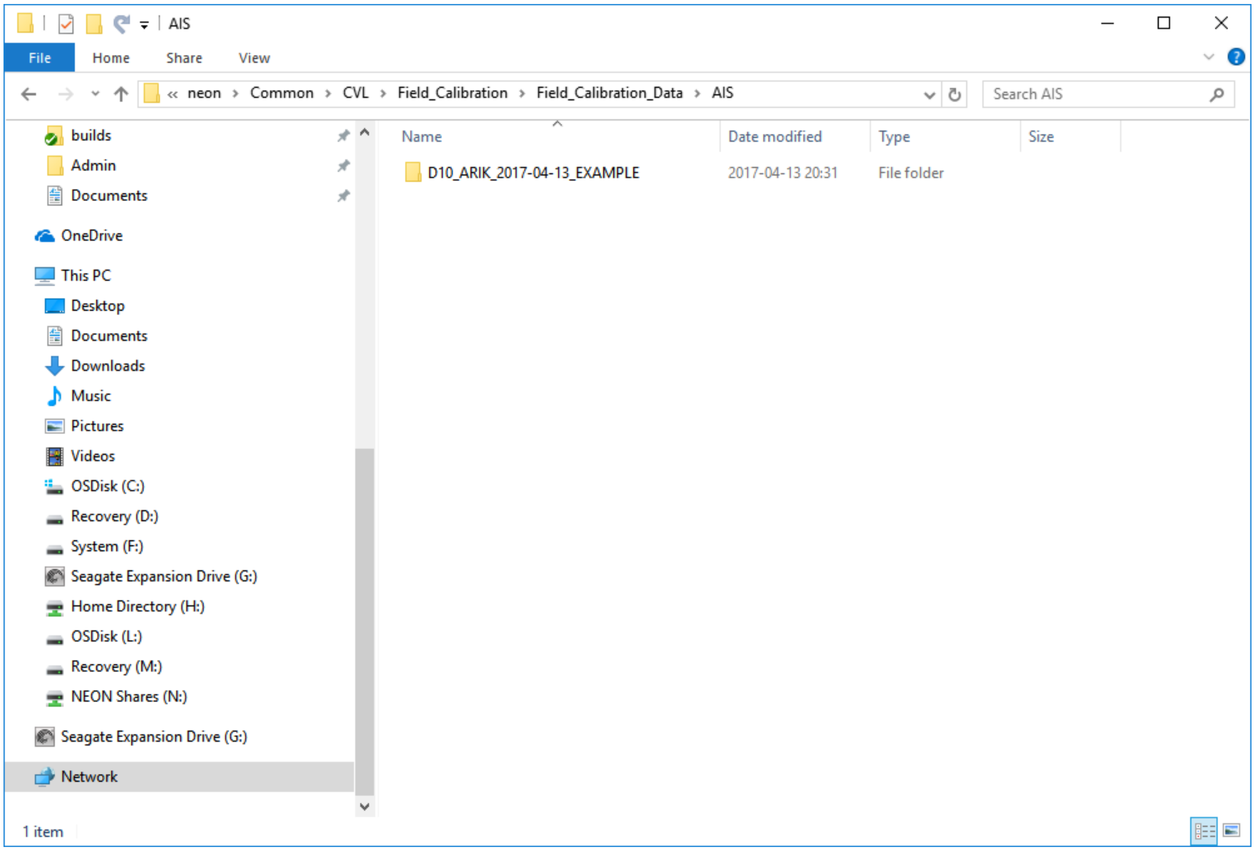


Figure 35. Example folder structure in data transmission directory

As shown in the example, folders should be named as follows: Domain#_Site_Date, e.g., D10_ARIK_2017-04-13. Use the date format YYYY-MM-DD for consistency. The date should correspond to the date of the file transfer. Figure 36 provides an example of the folder structure for each sensor, named as follows: Asset#_SensorID_operator.

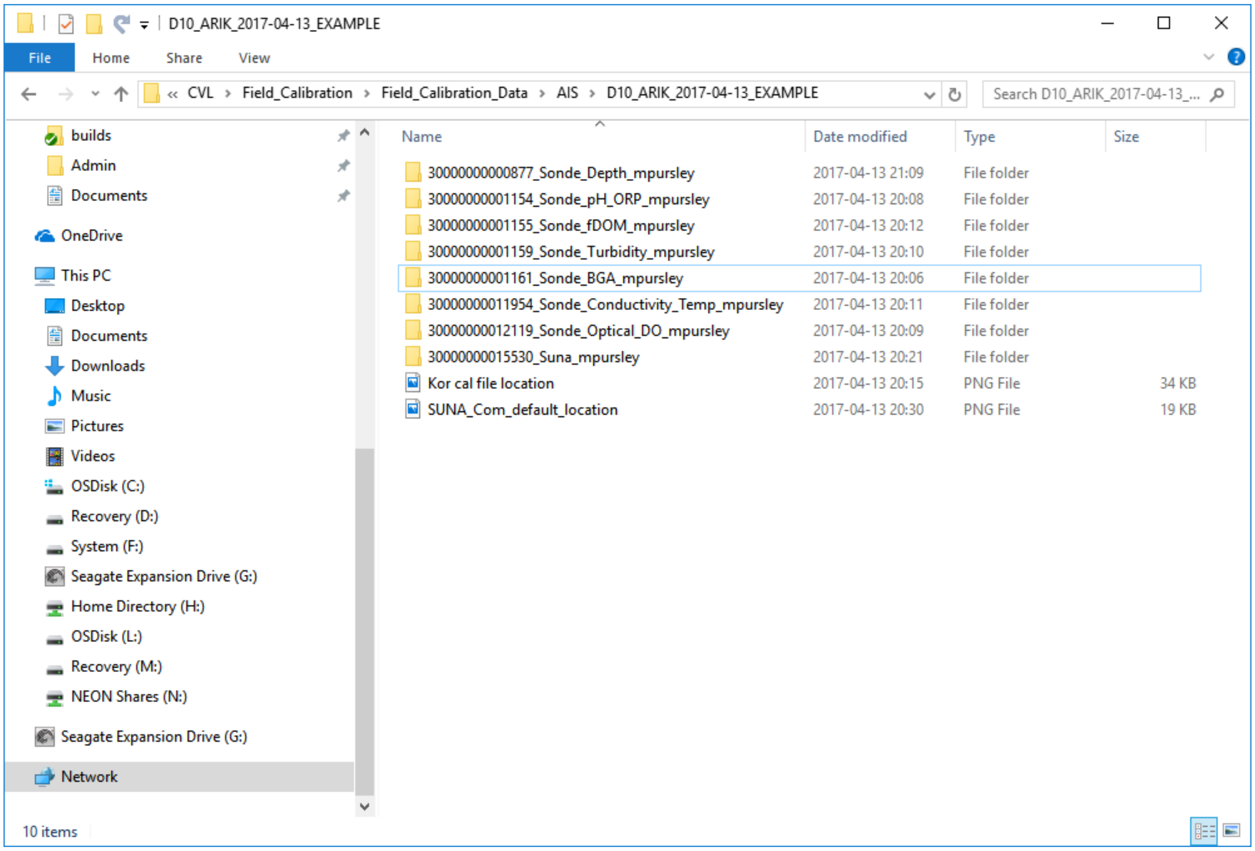


Figure 36. Sensor calibration folder structure with asset tag, sensor description, and operator provided.

Asset # must be the 14-digit identification (ID) on the asset scan-able tag and the operator should be first initial, last name. It is recommended that this folder structure be created annually upon sensor receipt, updated when sensors are changed out, and saved to a domain specific directory as these will need to be copied here whenever a calibration occurs. Entire folders will be transferred and deleted out of this directory once the automated program scans them for calibration transmission.

The SunaCOM software has a user input default location. A recommended folder structure is given in Figure 37, but the priority is that the domain staff can locate the files.

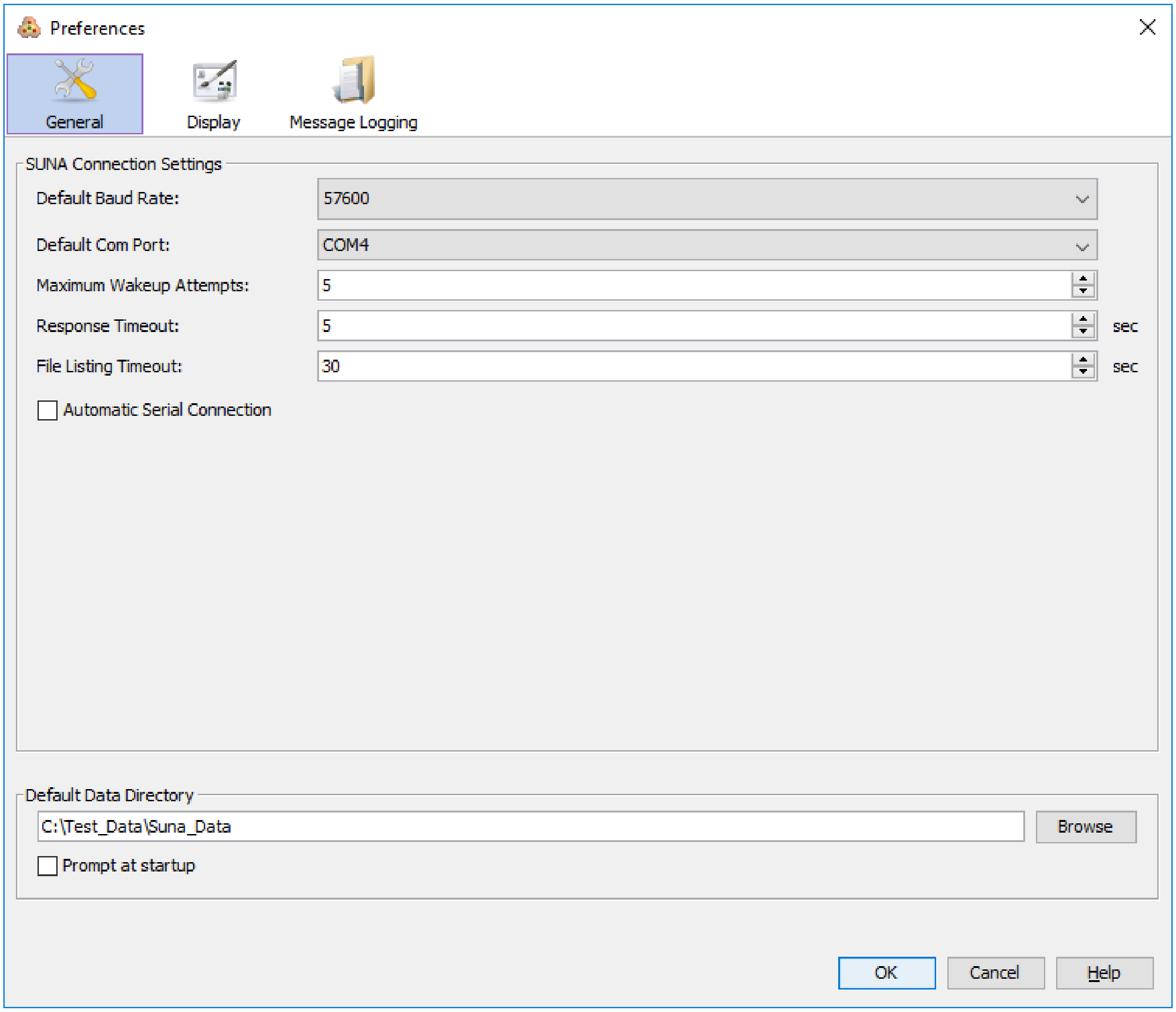


Figure 37. SUNA_COM program preferences menu with Default Data Directory provided at the bottom with a recommendation of C:\Test_Data\Suna_Data as the location for SUNA calibration files

The files in the local directories shown in Figure 37 should have all historic calibrations for the sensors. Initially, copy all files over to the transmission folder. You may continue to copy all files or the file most recently created. However, it is important to capture all calibrations that have occurred in the field, so if you are unsure if a file has been transferred, copy it to the directory and the automated program will determine if a new calibration event occurred.

Make sure all files copied over have the .cal extension as the PDF files cannot be used to transmit data from the calibration. Please contact Mike Pursley mpursley@battelleecology.org with questions.

8.4 A4 – Buoy Interconnect Mapping

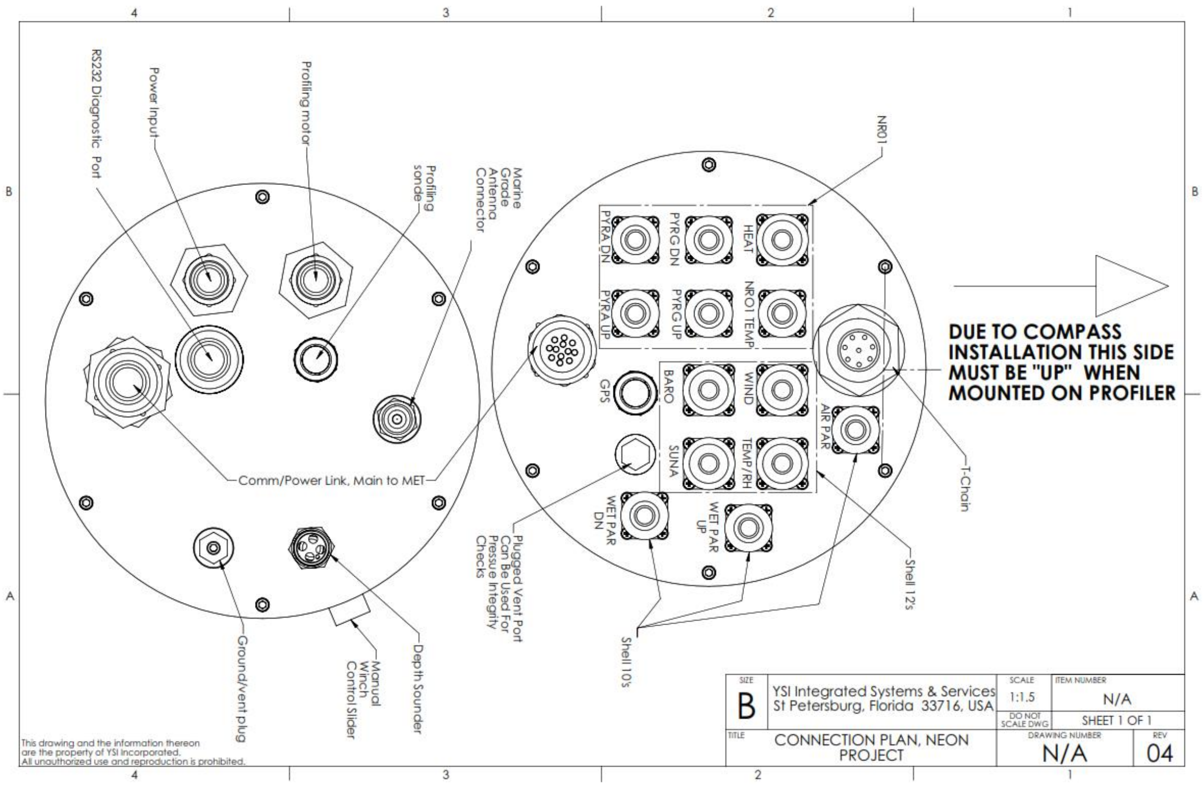


Figure 38. Buoy Interconnect Mapping