NEON PREVENTIVE MAINTENANCE PROCEDURE: SUBMERSIBLE ULTRAVIOLET NITRATE ANALYZER (SUNA)

PREPARED BY	ORGANIZATION	DATE
Bobby Hensley	AQU	03/11/2024
Jesse Vance	AQU	07/25/2017
Dylan Monahan	AQU	08/30/2018
Janae Csavina	CVAL	07/25/2017
Rachael Willingham	ENG	08/14/2018
Madeline Cavileer	ENG	02/19/2020

APPROVALS	ORGANIZATION	APPROVAL DATE
Keli Goodman	AQU	04/19/2022

RELEASED BY	ORGANIZATION	RELEASE DATE
Tanisha Waters	CM	04/19/2022

See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	09/14/2017	ECO-02640	Initial Release
B	01/03/2019	ECO-05799	Updates to graphics, formatting, grammar, and removed references to JIRA. Incorporated feedback from FOPS and HQ personnel. Incorporated updates to Section 2, Section 5, Section 6 and Appendices. Renamed Field Calibration Procedures to Field/Domain Calibration Validation Procedures. (The manufacturer for the SUNA calibrates the sensor. The field conducts validations on calibrated SUNA sensors.) Added adjusting the SUNA position to meet AIS science requirements during seasonal variability. Decreased Reference Spectrum updates from biweekly to monthly. The SUNA software SUNACom is now UCI; updated sections to reflect software GUI changes. Expanded on removal/reinstall instructions.
C	03/12/2020	ECO-06391	Updates include document template, changes in terminologies (NEON project to program and FOPS to Field Science), edits to sensor overview section, correction of Light:dark configuration in screenshots to 20:1 frames, and additional parameters to check in self-test. Incorporated two new appendices (Appendix D and E) for data monitoring and retrieving previous cal files per INC0031743. Removed references to the SAS report and replaced with PuTTy, DQ Blizzard, and IS Monitoring and Control Suite. Added NEON.DOC.005227 (AD [12]) as a reference in Section 2, updated DI water requirements in Section 5.4.1, and lastly, provided updated science guidance: Instead of automatically removing the sensor for a broken wiper or failed reference spectrum update, Field Science is to contact the AQU Science Team for further evaluation.

D	01/05/2022	ECO-06756	Updates to procedure for downloading .cal files following reference updates. Updated screenshots for UCI version 2.0.3.
E	03/22/2022	ECO-06793	Minor formatting updates
F	04/19/2022	ECO-06807	Updated cleaning procedure to allow for use of 2:1 vinegar solution if fouling remains after cleaning with isopropyl.
G	3/11/2024	ECO-07068	Updated validation and calibration procedure to use Y-cable powered by external battery pack. Clarified procedure for disconnecting SUNA from UCI software. Added instructions to begin performing quarterly log file downloads. Replaced remote monitoring in DQ Blizzard with Grafana.

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1 DESCRIPTION

1.1 Purpose

Routine preventive maintenance is imperative to ensure the proper functional and operational capability of National Ecological Observatory Network (NEON) systems, and the preservation of NEON infrastructure. This document establishes mandatory procedures and recommended practices for preventive maintenance of the **Submersible Ultraviolet Nitrate Analyzer (SUNA)** to meet the objectives of the NEON program, and its respective stakeholders and end users.

1.2 Scope

Preventive Maintenance is the planned maintenance of infrastructure and equipment with the goal of improving equipment life by preventing excess depreciation and impairment. This maintenance includes, but is not limited to, inspecting, adjusting, cleaning, clearing, lubricating, repairing, and replacing, as appropriate. The procedures in this document are strictly preventive and do **not** address corrective actions.

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.001570	NEON Sensor Command, Control and Configuration (C3) Document: SUNA Nitrate Analyzer, Wadeable Streams
AD [05]	NEON.DOC.003808	NEON Sensor Command, Control and Configuration (C3) Document: Buoy Meteorological Station and Submerged Sensor Assembly
AD [06]	NEON.DOC.001972	AIS Comm Interconnect Mapping
AD [07]	NEON.DOC.004613	NEON Preventive Maintenance Procedure: AIS Buoy
AD [08]	NEON.DOC.003880	NEON Preventive Maintenance Procedure: AIS Stream Infrastructure
AD [09]	NEON.DOC.004713	AIS Stream Nutrient Analyzer Formal Verification Procedures
AD [10]	NEON.DOC.004886	NEON Preventive Maintenance Procedure: Aquatic Portal & AIS Device Posts
AD [11]	NEON.DOC.005048	NEON INSTALLATION PROCEDURE: HB066000XX- SUBSYSTEM, SENSOR INFRASTRUCTURE, STREAM, [SAND, BEDROCK, COBBLE]
AD [12]	NEON.DOC.005227	NEON Standard Operating Procedure: SUNA V2 Nitrate Sensor Data Management 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.000769	Electrostatic Discharge Prevention Procedure
RD [04]	NEON. DOC.001570	NEON Sensor Command, Control and Configuration (C3) Document: AIS Nitrate Analyzer
RD [05]	NEON.DOC.004257	NEON Standard Operating Procedure (SOP): Decontamination of Sensors, Field Equipment and Field Vehicles
RD [06]	NEON.DOC.004638	AIS Verification Checklist
RD [07]	NEON.DOC.004608	AIS Buoy Verification Procedures
RD [08]	NEON.DOC.005038	NEON Standard Operating Procedure (SOP): Sensor Refresh
RD [09]	NEON.DOC.004472	PDS Array Device Post and Field Device Post Formal Verification Procedures
RD [10]	NEON.DOC.004651	Domain 18 (D18) AIS Oksrukuyik Creek (OKSR) Alternate Power Site Standard Operating Procedure (SOP)

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.

ER [01]	SUNA Manual, Rev. F https://www.seabird.com/asset-get.download.jsa?id=54627862534
ER [02]	Sea-bird Scientific, UCI User Manual, 02/2017, Edition 11 (UCI170209). http://www.seabird.com/sites/default/files/documents/UCI-1.2-User-Manual.pdf
ER [03]	UCI Software Download: N:\Common\CVL\Field_Calibration\UCI

2.4 Acronyms

Acronym	Explanation
AIS	Aquatic Instrument Systems
CVAL	Calibration, Validation and Audit Laboratory
DI	Deionized
EHSS	Environmental Health, Safety and Security
ESD	Electro-static Discharge
FOPS	Field Operations
GRAPE	Grouped Remote Analog Peripheral Equipment
GRSM	Great Smoky Mountain
HQ	Headquarters
MBARI	Monterey Bay Aquarium Research Institute
PAR	Photosynthetically Active Radiation
POE	Power Over Ethernet
PRT	Platinum Resistance Thermometer
PVC	Polyvinyl Chloride
S1	AIS Sensor Set 1 (upstream sensor set)
S2	AIS Sensor Set 2 (downstream sensor set)
SUNA	Submersible Ultraviolet Nitrate Analyzer
UV	Ultraviolet (light)

3 SAFETY AND TRAINING

Personnel working at a NEON site must be compliant with safe fieldwork practices in AD [01] and AD [02]. 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 work in unsafe conditions.

Technicians must complete safety training and procedure-specific training to ensure the safe implementation of this protocol per AD [03]. Refer to the site-specific EHSS plan via the NEON Safety document portal for electronic copies.

Preventive maintenance of AIS Infrastructure may require the use of a special equipment to access the sensor subsystem assemblies. Follow Domain site-specific EHS plans via the Network Drive and NEON safety training procedures when conducting maintenance activities. Conduct a Job safety Analysis (JSA) prior to accessing the sensor subsystems onsite. Reference the Safety Office SharePoint portal for JSA templates and additional hazard identification information.

Personal Protective Equipment (PPE) may be required in the decontamination procedures to maintain safe working conditions (e.g., use of equipment such as power washers, air compressors), and disinfectants. For this reason, personnel should be trained and familiar with the Safety Data Sheets (SDS) for the cleaning solutions, tools and equipment necessary for decontamination of the sensor sets herein.

Technicians must not enter the water without water safety training and a personal floatation device (PFD), and must display basic competency in boat operation, regardless of whether or not boat operation is a primary responsibility.

4 SENSOR OVERVIEW

4.1 Description

Nitrate (NO_3^-) is a naturally occurring nutrient that is vital for aquatic ecosystems, as it is a significant source of bioavailable nitrogen. Increasing concentrations of NO_3^- from anthropogenic inputs (i.e., fertilizers or sewage) often act as a stressor rather than a beneficial nutrient and can stimulate a bloom in algae populations, known as eutrophication. This is often followed by depletion of dissolved oxygen, a condition known as hypoxia, which can be harmful to fish and other aquatic organisms. This makes NO_3^- a measurable indicator of potential anthropogenic stressors in aquatic ecosystems. To measure NO_3^-, the NEON program uses a Sea-Bird Scientific Submersible Ultraviolet Nitrate Analyzer (SUNA) V2 (version 2) with integrated antifouling/hydro-wiper with titanium housing (**Figure 1**).

Figure 1. Sea-Bird Scientific SUNA V2 with Integrated Anti-Fouling Wiper.

Most NEON sites use a model with a 10 mm pathlength (0329950000), while SUGG uses a 5 mm pathlength (0329950005). Each site also contains the following subsystem components:

Wadeable Downstream Sites (AD [08])

- SUNA Power Cable, 75 Ft. (HB08820075) contains EEPROM
- Grape Merlot G4 12V, 2digi 6anlg (CB14023600) (data acquisition device) with sun shield Unistrut mount (CF00700000)
- Armored Power over Ethernet (PoE) cord, which connects from the SUNA Grape to the S2 Combination (Combo) Box onshore, which connects to the Aquatic Portal. A 75ft. cable is for high water installations where the Grape is nearby onshore (instead of the stream).

Lake and River Buoy Sites (AD [07)]

- SUNA Power Cable, 15 Ft. (HB08820015) contains EEPROM
- Subsystem, DAS, Buoy, Nutrient Analyzer Telemetry (HB12140000): SUNA Radio Box, Cable and Antenna on the Buoy.
- Subsystem, DAS, Portal, Telemetry, Buoy (HB16100000): Includes the Buoy Portal Radio with serial cable from the Aquatic Portal radio to Oz Grape inside the Portal and the Antenna and Mast outside the Portal.
- PoE cord (from Grape to Aquatic Portal PoE Switch)

Sensor Accessories

Y Validation/Calibration Cable with USB Connector and external battery pack (HB15920000) (**Figure 10**)

4.2 Handling Precautions

Aquatic Technicians must employ special care to avoid dropping solutions, hardware, or tools into the water while working to prevent contaminating an aquatic environment. In addition, per NEON.AIS.4.1735, all vehicles, trailers, boats, tools, protective outerwear, and any other items that encounter an aquatic or riparian environment, require decontamination prior to site access per RD [05]. When transporting a biofouled SUNA in its case, take care to keep the sensor isolated from the carrying case.

4.2.1 Sensor Handling Precautions

While removing, cleaning, or replacing the sensor, employ care to prevent scratches on the optical windows or path material, which may alter light refraction, and therefore alter NO3- measurements and permanently damage to the sensor.

The SUNA bulkhead connection, and the end of the cable are especially sensitive to bending. Tight bends may damage the internal wires. Never bend the cable, especially at the connector, tighter than a 6-inch radius. Leave slack in the sensor cable when dressing the cable(s) to prevent strain and/or sharp bends in the cable. Never lift the sensor by the cables. Damage to the sensor housing or cable assembly may result in electrical failure.

4.2.2 Subsystem Handling Precautions

Grapes and PoE devices contain electrostatic discharge sensitive parts (see RD [03]); 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 components, Technicians must ground themselves. Do not hot swap sensor connections! When power is ON, disconnect the RJF/Eth-To Comm Box cable BEFORE disconnecting a sensor cable. Connect a sensor cable BEFORE connecting the RJF/Eth-To Comm Box cable.

4.3 Operation

The SUNA is a high-resolution spectrometer that utilizes ultraviolet (UV) range wavelengths (190-370 nm). The sensor consists of a stable deuterium lamp, a detector, an on-board controller and an internal data storage device. The SUNA internally converts signals to digital readings and applies algorithms created by the Monterey Bay Aquarium Research Institute (MBARI) and Sea-Bird Scientific prior to output.

Water flows between two quartz windows that are 1-cm or 0.5 cm apart (the 0.5 cm window is designed for sites with optically dense water, SUGG is the only site in the NEON observatory with a 0.5 cm opening), continuously flushing the optical path. To collect a measurement, the SUNA applies an UV light source across the water sample in the optical path. Nitrate in the water absorbs light from the lamp in the 217-240nm range. The spectrometer measures how much light passed through the sample at each wavelength compared to a DI reference sample. For each measurement burst, the sensor records light frames (when the lamp is on) and dark frames (when the lamp is off) to account for any background light reaching the detector. The absorbance signal, due to NO_3^- in the water, is proportional to its concentration in the sample. Longer wavelengths outside the nitrate absorbance range are used to correct for interference from other UV absorbing substances present in the water. Between measurements, the analyzer uses sleep mode to conserve power and extend the life of the deuterium lamp. Configuration of this sensor is in accordance with RD [04] to collect a burst of measurements at 15-minute intervals.

4.4 Theory of Absorbance Measurements

A spectrometer splits light into various wavelengths, and then measures the absorbance at each of these wavelengths (**Figure 2**). Absorbance is the amount of light absorbed by a sample, which is calculated using the ratio of incident light received by the sample divided by the light transmitted by the sample (Equation 1). The incident light put out by the SUNA lamp across all wavelengths (a spectrum) is characterized by sampling a DI "blank", which is then stored as a file on the instrument.

$$A = \log_{10} \frac{F_e^i}{F_e^t}$$

Equation 1. Equation for Calculating Absorbance as the Log of the Ratio of Incident Light to Transmitted Light.

The absorbance is then used to calculate NO_3^- concentration using the Beer-Lambert Law which states that concentration in units of mol/L equals absorbance divided by the pathlength (1 or 0.5 cm) and an extinction coefficient ε in units L/mol/cm (Equation 2).

$$C = \frac{A}{l \times \varepsilon}$$

Equation 2. Equation Used to Calculate Concentration from Absorbance.

Since the output of the SUNA lamp decays over time, the reference spectrum (which characterizes the lamp output) requires periodic updating. Updating the reference file with anything other than pure DI water compromises the calculation of the absorbance values.

For SUNA data collection, any compound that also absorbs or scatters UV light affects the absorbance reading. For example, natural conditions, such as high dissolved organic matter (DOM) or turbidity alters the transmittance. The absorption range of DOM overlaps with that of NO_3^-, while turbidity scatters light, preventing it from reaching the SUNA's detector. The SUNA's algorithms that convert absorbance to NO_3^- concentration are sophisticated and account for these in many circumstances. However, if transmittance (Φ^t/Φ^i) at a given wavelength falls below 5% (equaling an absorbance value greater than 1.3), the SUNA omits that wavelength from its calculation. If less than 10 wavelengths within the NO_3^- absorbance range (217-240 nm) remain, the SUNA is unable to make an accurate prediction of concentration and reports an error ("-1"). Debris or biofilms on the SUNA windows can also absorb or scatter light, and the SUNA algorithm is unable to correct for this in the data.

PRO TIP: *The SUNA V2 uses "-1" to indicate low transmittance. If you notice sequences of -1 concentration (µM* ***and*** *mg-N/L) in your SUNA data, report it by creating an incident ticket.*

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Equipment

Table 1. Preventative Maintenance Equipment.

Part No.	Description	Quantity
Tools		
HB09780000	USB-Power-SUNA Cable (Y-Cable for SUNA Field Validations/Calibrations)	1
NEON	Tablet and/or Notebook and pen/pencil	1
NEON, IT	PC Laptop with latest UCI software installed	1
GENERIC	1 Liter Nalgene wash bottle	2
GENERIC	1 Liter Glass or Teflon DI water bottle	1-2
GENERIC	5 Gallon Bucket or Dairy Crate (for water temperature equilibration)	1
GENERIC	5/16th Allen Wrench	1
GENERIC	Flush cuts (for zip ties to remove sensor cables)	1
GENERIC	Scrub brush/dry brush (to clean off stream/lake/river infrastructure)	1
GENERIC	Waders	1
MX102344	[Optional] STANLEY Retractable Utility Knife, 3 Blades (to puncture Parafilm without compromising the film seal on the SUNA)	1
GENERIC	Plastic Pipette	1
GENERIC	Squirt bottle	1
Consumable items		
COMIN18JU007177	Dow Corning® 4 Electrical Insulating Compound	5.3 oz.
MX100642	Kimwipes/lint-free tissues (e.g., Opto-wipes) or microfiber cloths	4
MX100691	Wrapping Film, 4in. Wide Roll (Parafilm or Equivalent)	200 cm
GENERIC	Fresh MilliQ Deionized (DI) water per Section 5.3.4	1 L
GENERIC	> 90% isopropyl or ethyl alcohol (in a wash bottle)	100 mL
GENERIC	Zip ties	A/R
GENERIC	Powder-free nitrile gloves	A/R
GENERIC	Vinegar (Acetic Acid)	A/R
Resources		
SUNA V2 Manual https://www.seabird.com/asset-get.download.jsa?id=54627862534		1
UCI Software Manual https://www.seabird.com/asset-get.download.jsa?id=54712835755		1
Sea-bird Scientific UCI (for SUNA Validation and Calibration): N:\Common\CVL\Field_Calibration\UCI ***DO NOT REMOVE THE CABLE FROM THE SUNA WITHOUT DISCONNECTING FROM THE UCI SOFTWARE FIRST!***		1
FTDI Driver http://www.ftdichip.com/FTDrivers.htm (use with loaner laptops)		A/R
XCTU (SUNA Radio Config): https://www.digi.com/products/xbee-rf-solutions/xctu-software/xctu		A/R
Grafana: http://www. https://grafana.issites.gcp.neoninternal.org/		1
LC State of Health (SOH) App: http://soh.ci.neoninternal.org/		1
IS Monitoring Suite: N:\Common\CVL\Field_Calibration\Required Directory\Test_Data\Current Executables\IS Control and Monitoring Suite		1
SSL for AIS Sensors and Subsystem Components: https://neoninc.sharepoint.com/sites/fieldops/database/FOPs%20Database/SitePages/Sensors.aspx?Department=AIS		1
Document Warehouse: https://neoninc.sharepoint.com/sites/warehouse/Documents/Forms/AllItems.aspx		1

5.2 Subsystem Location and Access

5.2.1 Wadeable Stream Sites

At wadeable stream sites, the SUNA sensors are part of the downstream sensor set (S2) or single station sensor set at D11 BLUE. The SUNA is co-located with a YSI EXO2 Multisonde, which measures other water quality parameters (**Figure 2**). The SUNA should be located within 40 cm horizontally of the Multisonde and within 3 cm vertically, to associate the data of each sensor set. To ensure SUNA samples are representative of an entire water column, the SUNA and Multisonde must be set at 60% (+/- 20%) of the water depth as measured from the surface. In other words, if the site is 1m deep, the SUNA should be positioned at a depth between 0.4-0.8m measured from the surface (or conversely 0.2-0.6m measured from the streambed). The site should also be located in either the thalweg (deepest part of the active channel) or another well-mixed location.

At wadeable stream sites, the SUNA is connected via cable to a Merlot Grape which provides power and communications. At some sites the Grape is mounted to the same strut as the SUNA. At sites which experience higher water levels, the Grape is mounted to an arbor above the bank, as either a stand-alone installation, or on a device post with a Power and/or Comm/Combo box.

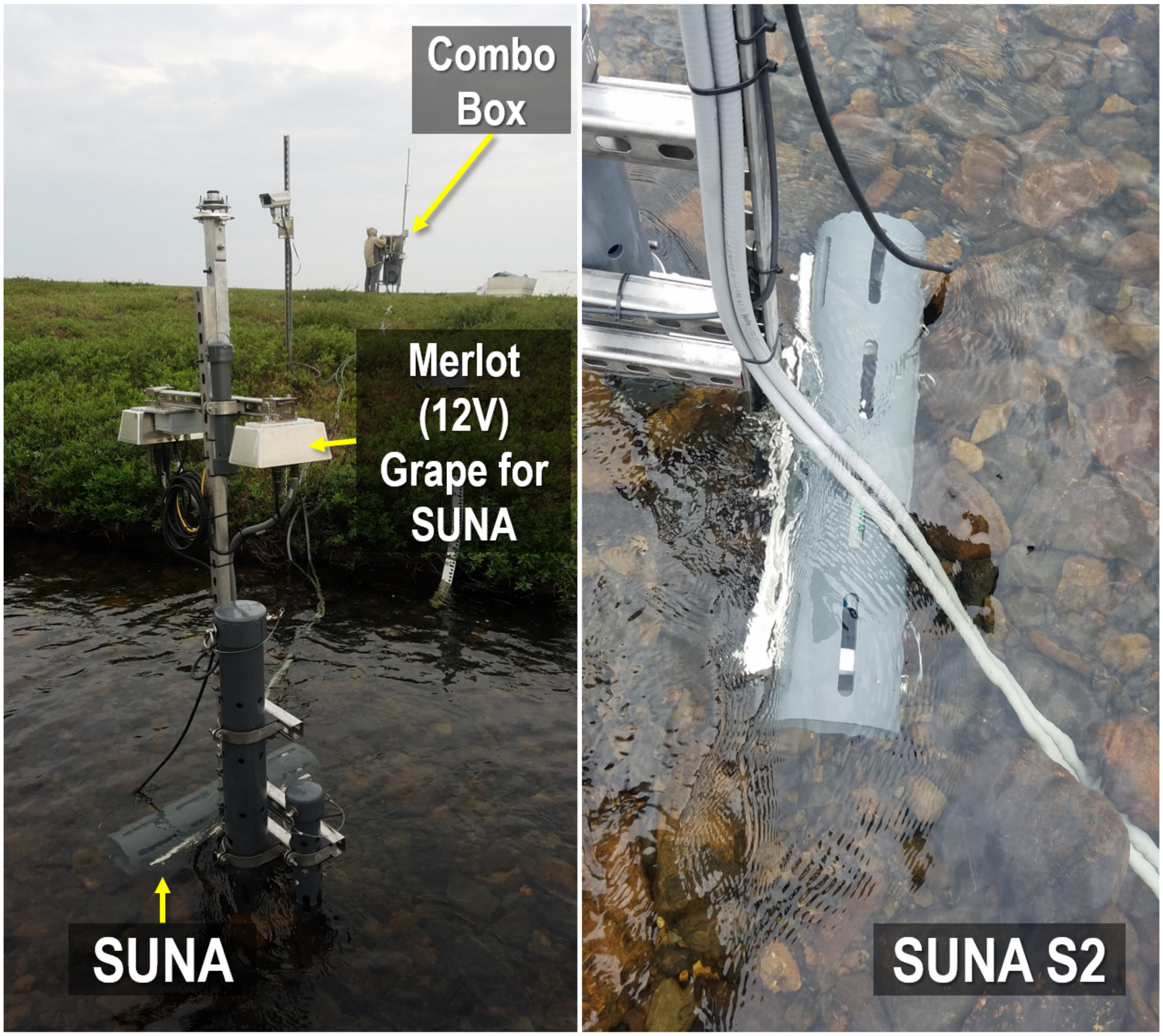


Figure 2. S2 Downstream Location: SUNA on an Anchor with Subsystem Components at a Low Water Site.

5.2.2 Lake and River Sites

At river and lake sites, the SUNA mounts from the AIS buoy in an enclosure 0.5 meters below the water surface. At most lake and river sites the SUNA is housed inside a protective cage attached to a folding arm that comes off the side of the buoy (Error! Reference source not found.). The uPAR sensors also mount to the folding arm. Be careful not to pinch any of the cable when raising or lowering the folding arm. Reference AD [07] for more information on AIS Buoy sensor removal/replacement.

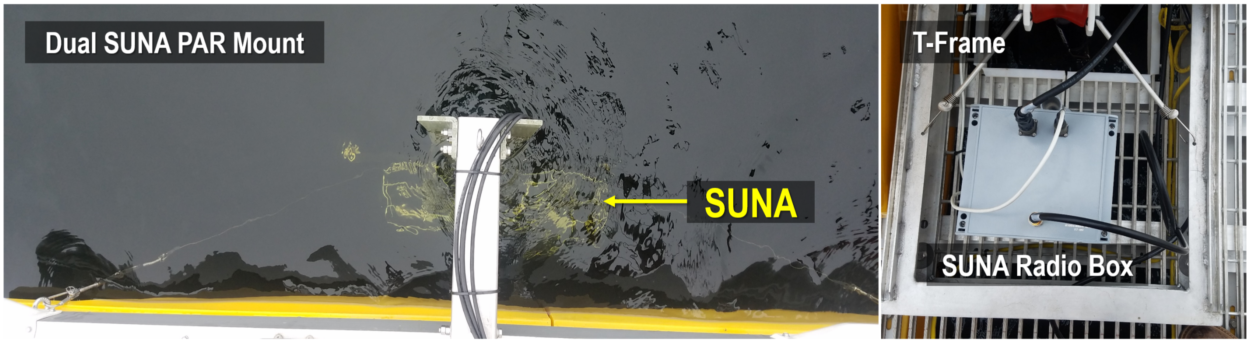


Figure 3. Folding arm with SUNA and uPAR mounts (left). SUNA radio comms box (right)

At D03 FLNT and D08 BLWA, the SUNA is housed in cylindrical tubes which pass through the body of the buoy (**Figure 3**).

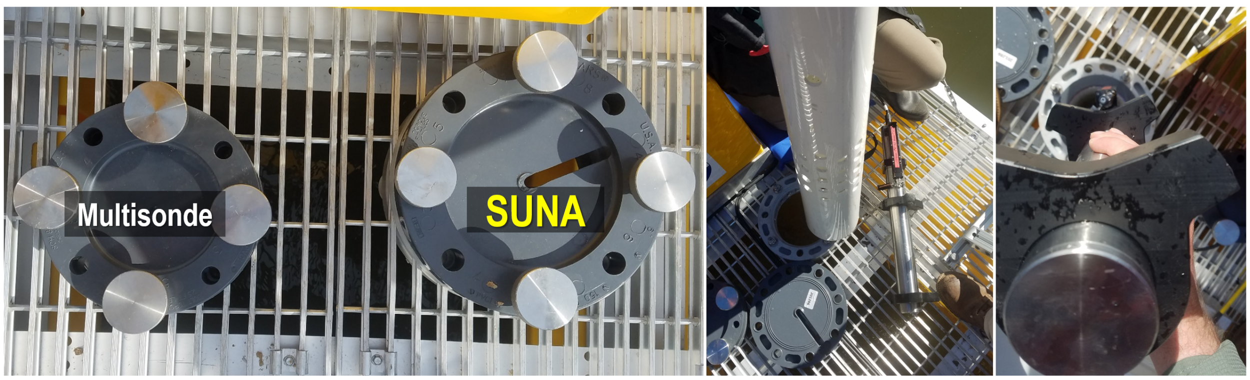


Figure 4. SUNA housing mounted under the buoy deck at FLNT.

At lake and river sites, the SUNA is connected to a radio comms box located in the front compartment of the buoy. The data from the SUNA transmits directly via radio, which exists specifically for the SUNA on the buoy due to CR1000 usage limits. The CR1000 is a Campbell Scientific data logger; the buoy does not use Grape data loggers for the sensors onboard. The SUNA radio (**Figure 3**) transmits to a radio in the Aquatic Portal, which connects to an Oz Grape to transmit SUNA data to the LC (**Figure 5**).

Note: The Oz Grape does not require annual calibration and validation (do not remove this Grape for Sensor Refresh).

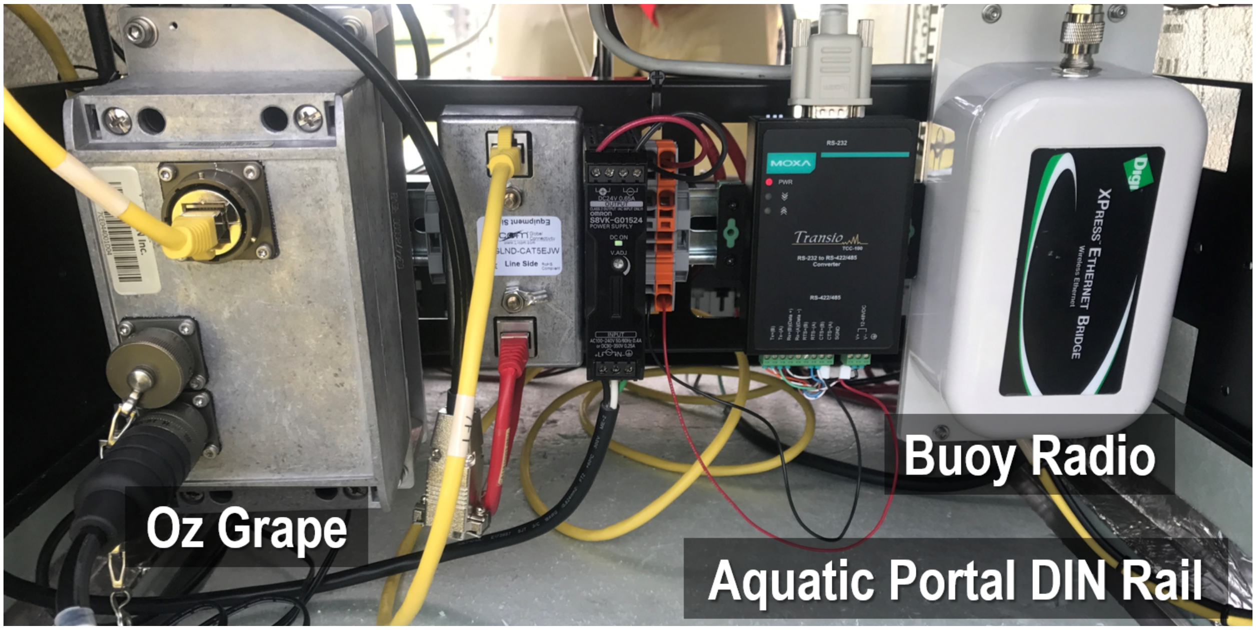


Figure 5. Aquatic Portal Precip DIN Rail: AIS Buoy Portal Radio/Oz Grape Subsystem.

Onboard solar panels and batteries power the buoy sensor sets. The SUNA radio box connects directly to the battery box for power. Reference AD [07] and AD [10] for more information on AIS Buoy mechanical and electrical infrastructure.

5.3 Maintenance Procedure

Error! Reference source not found. is an interval schedule of each component requiring preventive maintenance.

Table 2. SUNA Preventative Maintenance Tasks Interval Schedule.

Maintenance	Daily	Bi-Weekly	Monthly	Quarterly	Annual	As Needed	Maintenance Type
SUNA							
Verify data is streaming	X						P
Visual Inspection		X					P
Remove Debris from Enclosure/Cage		X				X	P
Clean Sensor		X					P
Field Validation (Drift Test)		X					P
Perform SelfTest		X					P
Verify Configuration		X					P
Check Lamp Hours		X					P
Synchronize Clock		X					P
Wiper Check		X					P
Reference Spectrum Calibration			X			X	P
Download Logged Data				X			
Lamp Replacement (Sensor Refresh)						X	P/R
Replace Wiper Brush						X	R
Seasonal Maintenance					X	X	P/R
Electrical & Communication Infrastructure (DAS and PDS)							
Visual Inspection		X					P
Replace Cable Ties						X	R
Clean Biofouling from Cables/Wires		X				X	P/R
MISCELLANEOUS EQUIPMENT							
Physical Infrastructure							
Visual Inspection		X					P

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 Overview

- **Daily**
  Review Domain Reports and remotely monitor SUNA data streams to verify the sensor is online, operational and data is reaching HQ. *See Section 5.3.2 for more information*.

- **Bi-weekly**

Visually inspect sensor, subsystems and infrastructure (*See Section 5.3.3 for more information*).
Perform field validation procedures (See Section 5.4 for more information). These include:

- Clean sensor body an optical window.
- Record pre- and post-cleaning measurement in DI.
- Perform sensor selfTest.
- Verify configuration settings are in accordance with RD[4].
- Check the remaining lamp hours.
- Synchronize the SUNA clock to prevent drift.
- ***Critical Note: Properly reconfigure the SUNA for deployment and correctly disconnect from laptop after any PM. Failure to do so will prevent the SUNA from properly collecting data. See section 5.5 for more information.***

- **Monthly**
  Perform field calibration procedure to update the Reference Spectrum. *See Section 0 for more information.*

- **Quarterly**
  Download logged data files from SUNA and upload to LogJam. *See AD[12] for more information.*

- **Annually**
  Conduct Sensor Refresh on the SUNA annually. *See Section 6 and RD[08] for more information*.

- **Seasonal/As-Needed**
  Adjust the SUNA mount at wadeable stream locations to ensure the sensor continues to meet the science requirement for its in situ location onsite (40-80% of water depth as measured from the surface) If the SUNA is too high it will come out of the water during decreasing flow. If the SUNA is too low, sediment stirred up from the bottom may potentially interfere with sensor operation. *See Section 0*

Seasonal Maintenance (Stream Sites) *on page 46 for more information.*

5.3.2 Remote Monitoring

Verify the SUNA is streaming data to HQ daily. Reference **Table 1** in the Resources section for links to the following remote monitoring software applications: the DQ Blizzard, IS Monitoring and Control Suite, PuTTy, and the LC SOH. Additionally, use remote monitoring to check the quality of the data streams.

Field Science is responsible for monitoring the quality of data from all sensors within their Domain to determine if the instrument requires corrective maintenance. *See Section 9 for instructions on connecting remotely to the SUNA and basic troubleshooting from a remote location to identify preventive or corrective actions onsite.*

For the SUNA, remote monitoring is the first step in quality control of the data. Currently, AQU SCI recommends using Grafana to monitor SUNA data and understand data ranges expected for your sites. The aim is to monitor for unexpected changes to the data to report it ASAP. In addition to concentration, AQU SCI recommends monitoring SUNA cumulative lamp time, relative humidity, and sensor temperature.

Note: Data streaming from sensors under the wrong CFGLOC in Maximo affects data product data quality and requires HQ to flag the data. Grape data loggers always remain at the SITE level.

5.3.3 Visual Inspections

The goal of all AIS instrumentation is to measure natural conditions. To that aim, NEON's Preventive Maintenance procedures should cause little to no disturbance to the natural conditions at the site. In general, the implementation of preventive maintenance procedures should not require removal of live rooted vegetation. However, if living vegetation is growing directly on the infrastructure or entangled in such a way that it prevents the removal and maintenance of the SUNA, remove as little vegetation as possible to access the sensor and/or its subsystems. Do not remove vegetation that does not directly interfere with the maintenance or safety of the sensor and personnel servicing the sensor.

Reference AD [08] for visual inspection of stream infrastructure, AD [07] for visual inspection of the AIS Buoy infrastructure, AD [10] for general AIS site electrical infrastructure. These reference documents include the stream anchors, buoy sensor mounts, Aquatic Portal and device posts, and subsystem components and their supporting infrastructures.

Specific visual inspections for the sensor and its infrastructure include inspecting the following components in **Table 3** for visible damage or debris (**Figure 6**). Capture pictures of each component displaying damage/issues and report incidents in the NEON Program's Issue Reporting and Management System.

Table 3. Components Requiring Visual Inspections.

STREAM SITES	LAKE/RIVER SITES
Sensor PVC Housing on Stream Anchor	Sensor Cage on Dual PAR SUNA Mount
Sensor power cable to Merlot Grape	Sensor power cable to SUNA Radio Box
12V Merlot Grape connections and connectors	SUNA Radio Box connections and connectors
Armored Ethernet cable to Combo box	Power cable to battery box
Combo box connections and connectors	Aquatic Portal Precip DIN Rail (Radio & Oz Grape)

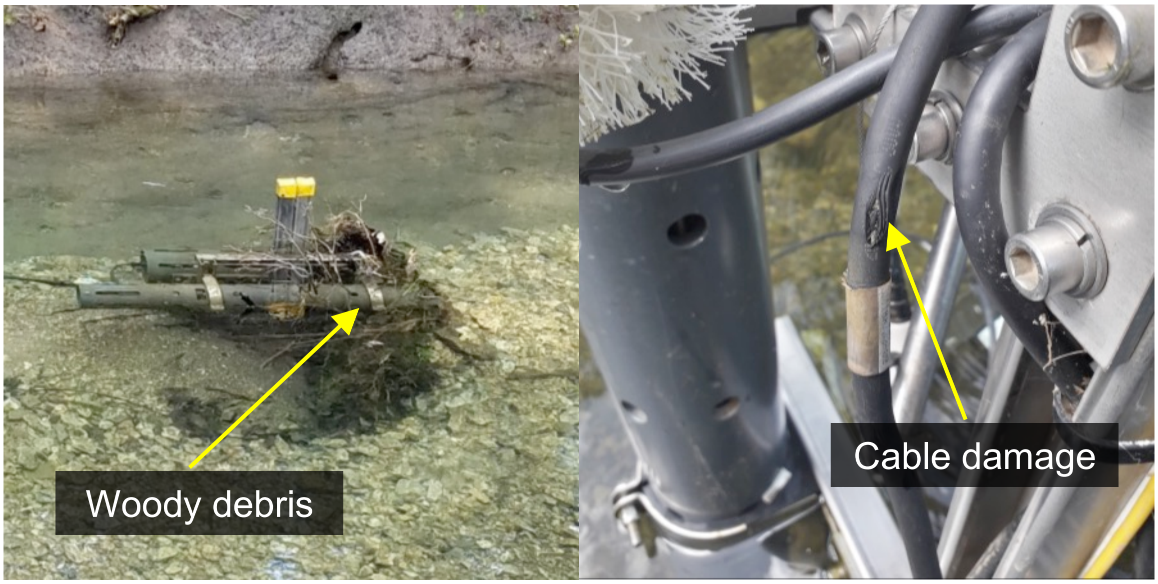


Figure 6. Examples of Damage to Report.

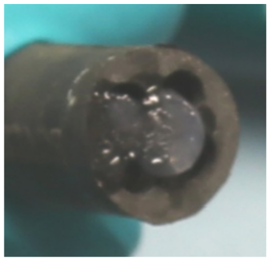
5.3.4 Bulkhead Connectors and Cable Maintenance

Connectors that have corrosion may cause irreparable damage to the sensor, a loss of data and increase the costs for service. Attach cleaned and lubricated dummy connectors to the sensor immediately after each deployment to prevent the bulkhead connector from damage with the following procedure.

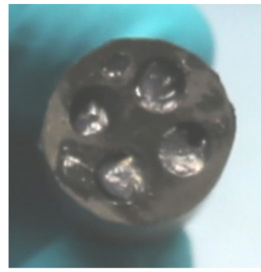
Critical Note: Do not use cleaners that contain petroleum or ketones. Do not use the cable to lift the sensor! This can damage the cable, cable splices, and bulkhead connectors. Do not connect or disconnect connectors under water.

1. Examine, clean, and lubricate bulkhead connectors each time they are connected. Connectors that are not lubricated cause wear and tear on the rubber that seals the connector contacts.
2. Clean the connector contacts with isopropyl alcohol. Apply as a spray or with a nylon brush or lint-free swabs or wipes.
3. Flush the contacts with de-ionized or distilled water. Use a wash bottle with a nozzle to flush inside the sockets over a bucket and dispose of the water using local Domain wastewater procedures.
4. Shake the socket ends and wipe the pins of the connectors to remove water.

5. Examine the sockets and the rubber on the pins to make sure there are no problems. Use a flashlight and magnifying glass. Look for cracks, frayed scores, and delamination of the rubber on the pins and inside the sockets
6. Use a finger to place a small quantity, approximately 1.5 cm in diameter of Dow Corning® 4 Electrical Insulating on the socket end of the connector.



Lubricant on socket end of the connector



Lubricant pushed into the sockets of the connector

Figure 7. Lubricated Sockets for SUNA Bulkhead Connector.

7. Use a finger to push as much of the lubricant as possible into the sockets.
8. Connect the connectors. There should be a small quantity of lubricant squeezed out the seam of where the two connectors meet.
9. Wipe the excess lubricant from the sides of the connectors to complete this procedure.

5.4 Field Validation Procedures (Drift Test)

5.4.1 Sensor Deionized (DI) Water Requirements

This procedure is first because it requires additional preparation time in the Domain Support Facility and onsite with the SUNA sensor. Poor quality, old, or improperly stored DI water can cause bad blank readings, resulting in incorrect measurement in the field. The intent here is to have sterile, nitrate and organic-free blank water which is the approximate temperature of the site water.

Critical Note: Using impure DI contaminated with UV absorbing substances for SUNA calibration or validation will result in inaccurate nitrate measurements.

5.4.1.1 DI Water: Domain Lab Preparation

DI water must meet the following minimum requirements:

	Type I	Type II	Type III	Type IV
Electrical conductivity, max, µS/cm at 298 K (25°C)	0.056	1.0	0.25	5.0
Electrical resistivity, min, Mcm at 298 K (25°C)	18	1.0	4.0	0.2
pH at 298 K (25°C)	A	A	A	5.0 to 8.0
Total organic carbon (TOC), max, µg/L	50	50	200	no limit
Sodium, max, µg/L	1	5	10	50
Chlorides, max, µg/L	1	5	10	50
Total silica, max, µg/L	3	3	500	no limit

Figure 8. DI Water Minimum Requirements: ATSM Type II[1].

Therefore, Field Science must conduct the following procedure before heading into the field to validate the SUNAs onsite.

1. Acquire fresh DI water from the domain support facility (DSF). The DI water is considered fresh if it was dispensed within 24 hours to meet the minimum standard specification of Type II water (**Figure 8**).
2. Use a calibrated handheld conductivity probe to validate that the DI water produced by the Domain's DI water system meets the required conductivity @25C (or use specific conductance setting) (**Figure 8**) prior to going out into the field. Ensure the probe does not contaminate the water you use for any maintenance activities.

[1] The measurement of pH in Type I, II, and III reagent waters has been eliminated from this specification because these grades of water do not contain constituents in sufficient quantity to significantly alter the pH. Source: https://www.astm.org/DATABASE.CART/HISTORICAL/D1193-99E1.htm

3. If the DI water fails to meet the conductivity requirement, conduct the following steps:
   a. Replace the DI water system cartridge and/or filter and test for conductivity again. If the filter replacement fixes the issue, then proceed with routine maintenance activities. If it does not, proceed to the next step.
   b. If replacing the cartridge and/or filter does not fix the problem, it may be caused by the quality of the Domain's tap water. If you think it is the quality of the tap water, install a Reverse Osmosis filter system, in addition to the DI water system cartridge.
   c. If you can fix the problem (DI water meets conductivity @25C) in ≤ 1 month, then wait until the problem is fixed before performing SUNA PM. If fixing the problem will take ≥ 1 month, borrow (e.g., from a local University) Type II water that meets the requirements or purchase HPLC (aka-type 1 water) water. If purchasing, only purchase Type I water in a glass bottle. Do not purchase Type II water; it will arrive in plastic bottles. Always store HPLC (type 1) in glass only. The goal is to let no more than 1 month of time pass beyond your scheduled maintenance bout.
4. Seal/store DI water in a combusted glass or clean Teflon container. DI water stored in plastic may have plastic molecules that have leached into the DI water that can absorb UV over the spectral range of the sensor, and will cause an incorrect DI blank reading.
5. Rinse bottles and caps with fresh DI water at least three (3) times before use.

5.4.1.2 DI Water: Field Equilibration Procedure

In order to accurately measure sensor drift from the pre- and post-cleaning reading of NO_3^- values, Field Science must equilibrate the DI water to ambient stream temperatures. Upon arrival to site or before beginning SUNA maintenance, choose one of the following options to equilibrate the DI water.

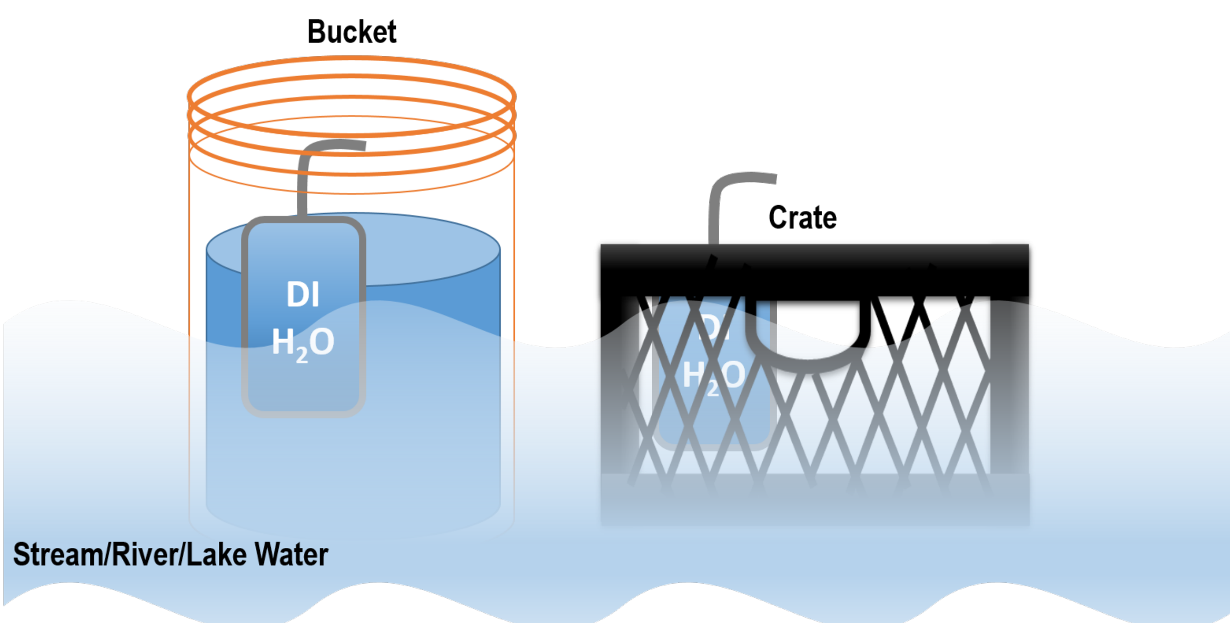


Figure 9. Alternate Setups for DI Water Temperature Equilibration.

A. Submerge a wash bottle full of DI water directly into the surrounding body of water. Be sure the wash bottle is secure and will remain in place, submerged without contamination for **10 minutes**. A dairy crate which allows water to flow through can be used to secure the bottle. The temperature of the DI water must reach the same temperature as the body of water of the SUNA location onsite.
B. Alternatively, use a five-gallon bucket to equilibrate DI water to site's ambient water temperature with the following procedure.
    1. Place approximately 50 cm of water from the site (e.g., stream, river, or lake) into a 5-gallon bucket and place the bucket or crate in the water. Ensure it is secure and will not float away. HQ recommends using a dairy crate since it allows the water flow through, while the bucket method requires a longer equilibration time because the bucket and the water inside it partially insulates the sample wash bottle from the site water.
    2. Place wash bottle full of DI water into water bath to equilibrate it to ambient water conditions.
    3. Let stand at least **30 minutes** for the temperature of the DI water to reach the same temperature as the environment.
    4. If it is hot out or the bucket is in direct sunlight, you may need to periodically exchange the water in the bucket for fresh water to speed the process along.
    5. If the DI water is freezing during the validation or calibration process, or Technicians are unable to access the SUNA due to ice/unsafe working conditions, do not continue validations/calibrations.

5.4.2 Connect to SUNA

Connect to the SUNA using a field laptop that has the UCI Software via N:\Common\CVL\Field_Calibration\UCI. UCI is a software application for setup and configuration, operation, and in-field/Domain laboratory reference checks of the SUNA. At the publication of this document, the current software version is UCI version 2.0.3. Follow the steps in **Table 4** to connect the SUNA to UCI software to initiate the field validation process.

Table 4. How-To: Connect SUNA for Field Validation Process.

STEP 1 | Acquire the necessary equipment to conduct field validations for the SUNAs onsite. This includes the HB15920000 SUNA Calibration Cable, which is a NEON custom Y-cable (**Figure 10**), to connect to the SUNA, the laptop with UCI, and an external battery pack. This cable is for both Lake/River Buoy and Stream site SUNA calibrations/validations.

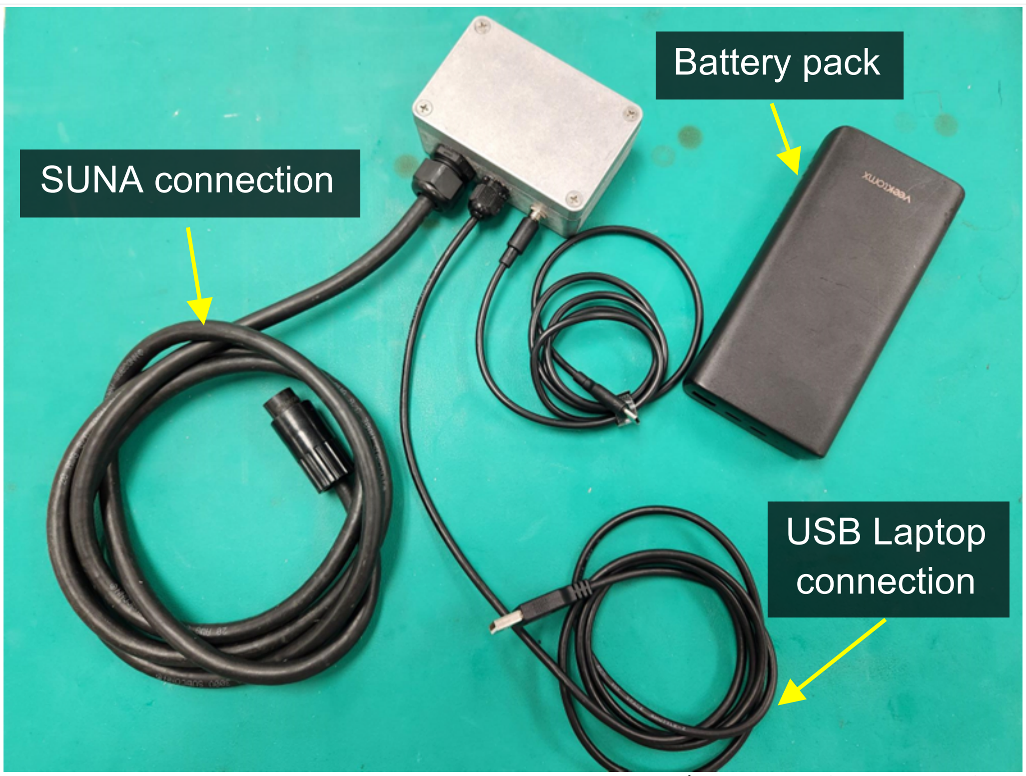


Figure 10. NEON Custom Y-Cable for SUNA Field Validations/Calibrations (HB15920000).

STEP 2 | Disconnect the SUNA power source to safely de-energize the instrument and subsystem to prevent hot swapping Grape connections.

- For wadeable stream sites, disconnect the SUNA 12V Merlot Grape from power by disconnecting the Ethernet cable (RJF) that connects to the Grape. Then disconnect the SUNA power cable from the 12-10 connector on the Grape.

CRITICAL NOTE: To avoid possible electrical shock, always disconnect the RJF cable from the GRAPE prior to disconnecting (or connecting) any sensor instruments. Reference AD [06] for the AIS Comm Interconnect Mapping for the SUNA Grape and AD [01] and [07] for procedures on isolating the energy source and electrostatic discharge.

- For lake and river sites, disconnect the cable from the SUNA radio box located under the front compartment. Reference AD [06] for the SUNA Radio Box interconnect map.

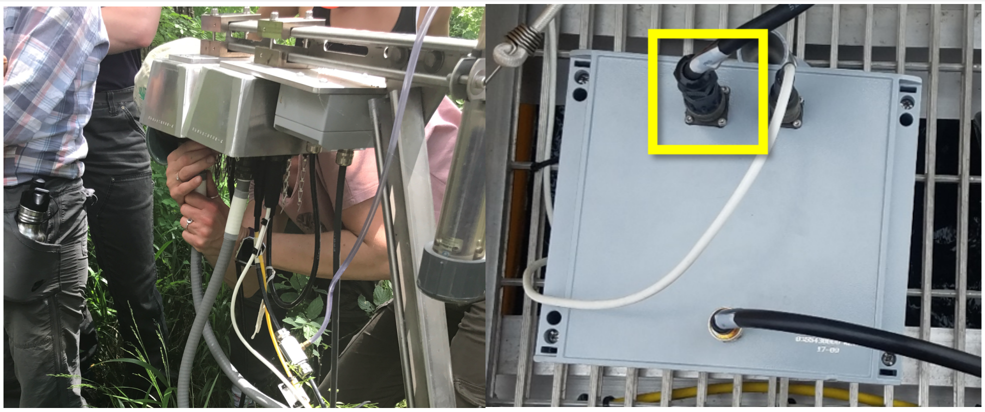


Figure 11. Disconnect the SUNA power source for wadeable streams (left) and buoys (right).

STEP 3 | Remove the SUNA from it housing. *See section 6.2 for further instructions.*

CRITICAL NOTE: Do not pull on the SUNA power cable to remove it from its housing. This may damage the power cable as well as the SUNA bulkhead connector.

STEP 4 | Disconnect the power cable from the SUNA bulkhead connector.

STEP 5 | Connect the calibration Y-cable. First, connect the 8-pin bulkhead connector to the SUNA. Next, connect the USB-C power end of the calibration Y-cable to the external battery pack cable (**Figure 10**). Finally, connect the USB-A end of the calibration Y-cable to the field laptop computer.

Figure 12. Connect the calibration Y-cable to an external battery back using the USB-C connection.

PRO TIP: *Just like the inside of a car, the titanium housing of the SUNA can quickly overheat on warm days, especially if left in direct sunlight. Temperature affects the performance of the SUNA lamp, and larger than normal differences in reference spectra may occur when calibrations are performed at vastly different temperatures. Additionally, to avoid permanent damage, the SUNA has a safety feature which overrides the configuration and shuts the lamp off when the temperature reaches 35°C. If the air temperature is above 30°C, consider keeping the SUNA in a shaded backpack or a bucket of water until you are ready to perform the validation/calibration procedure, or perform the procedure in the hut or an air conditioned vehicle.*

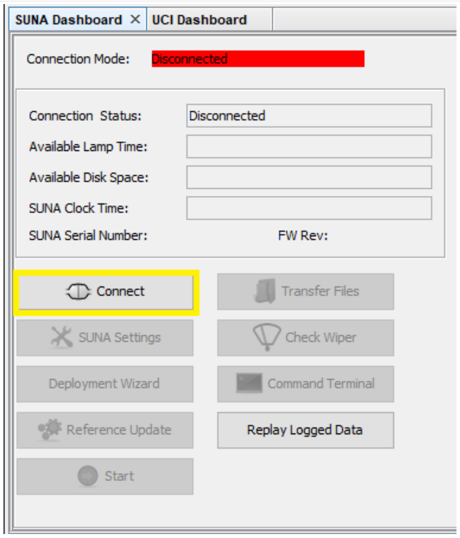


Figure 13. Select Connect.

STEP 6 | Launch UCI 2.0.3 on a laptop. Select the “Connect” button under the SUNA Dashboard (**Figure 13**).

Some laptops may require FTDI drivers to run the software. FTDI drivers allows the software to connect to the SUNA through the laptops COM port. Without the FTDI drivers, the software is attempting to talk to the COM Port, but cannot connect.

STEP 7 | Select the baud rate from the dropdown options in the Connect pop-up window. For wadeable stream sites select a baud rate of 57600 (**Figure 14**). For buoy sites select a baud rate of 115200 (**Figure 15**).

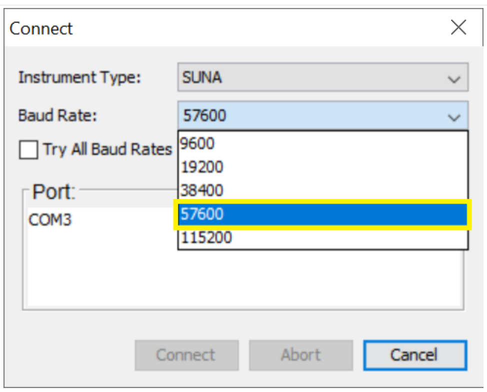


Figure 14. Select 57600 for Wadeable Stream sites.

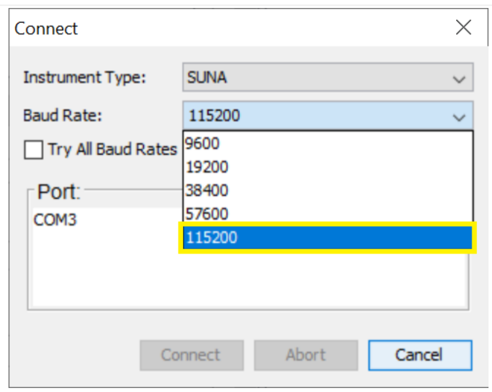


Figure 15. Select 115200 for Buoy sites.

STEP 8 | Select the appropriate laptop “**COM#**” port (**Figure 16**).

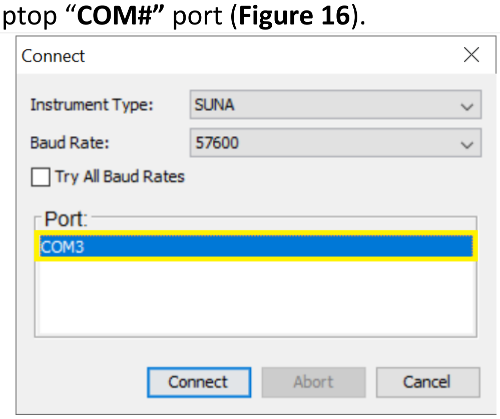


Figure 16. Select the appropriate com port.

*Note: If unable to determine which port to use, verify laptop ports under **Device Manager** (they may differ across laptops). The SUNA is the other COM# port offered as an option. COM3 is the default COM port for Lenovo ThinkPad Laptops.*

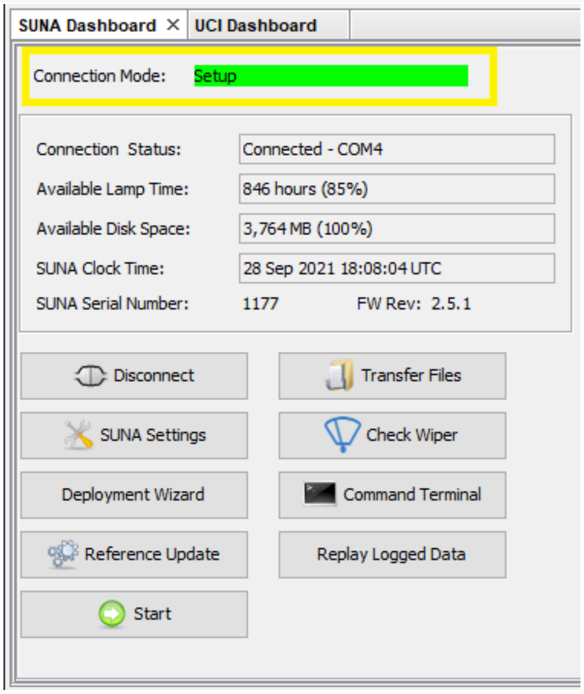


Figure 17. Successful Connection to SUNA.

STEP 9 | Select "Connect" button.

Indicators that the connection is successful are when the Connection Mode turns green and states "**Setup** (**Figure 17**).

Note: If the serial port connection fails on the SUNA, close the program and unplug the USB connection from the laptop. Plug it back in and start the process again. If still unsuccessful after a few attempts, power cycle the SUNA. Unplug the Y- cable from the SUNA bulkhead to disconnect the SUNA from power for 15-20 minutes. Re-attempt this procedure starting from Step 6. Further troubleshooting options are available in Section 9.

PRO TIP: *If the software freezes, the laptop Bluetooth may be the culprit. Close the software, disable Bluetooth and restart this procedure. If the problem persists, reinstall the FTDI drivers (see **Table 14**) and try again. If you are unsure if a driver is necessary, look under the Laptop **Device Manager** under **Com Ports**. Installed drivers display the SUNA cable with "**SUNA**" in the name. If the COM Port is showing "Serial USB Device", then the drivers are incorrect. If this occurs, download the FTDI drivers and restart this procedure.*

5.4.3 Configure & Prepare SUNA

After connecting the SUNA to the UCI software in Section 0, change the SUNA operating mode and disable the wiper to allow for the application of the Parafilm for the validation process. Reference **Table 5** to complete these tasks.

Table 5. Drift Check Preparation: Switch Operational Mode & Disable Wiper.

STEP 1 | Acquire the necessary equipment to complete this procedure onsite. This includes powder-free nitrile rubber gloves, Parafilm, materials to equilibrate DI water onsite and cleaning supplies.
STEP 2 | Equilibrate fresh DI water in accordance with Section 5.4.1.2 DI Water: Field Equilibration Procedure on page 20.

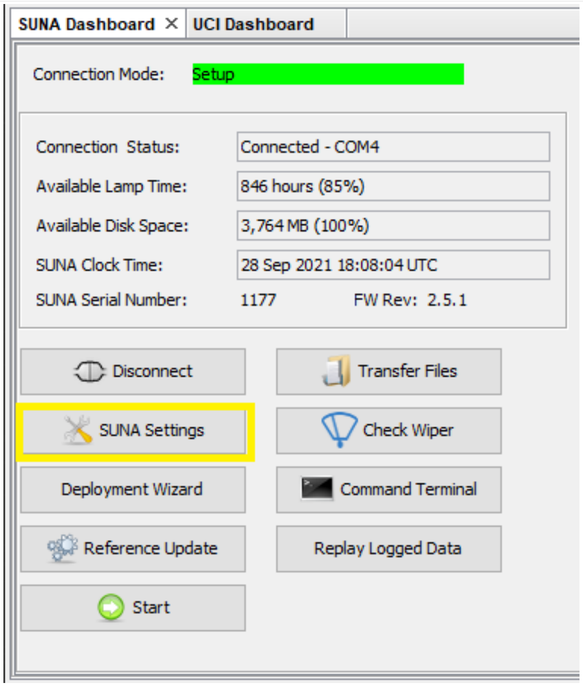


Figure 18. Select SUNA Settings.

STEP 3 | Click the "**SUNA Settings**" button in the **SUNA Dashboard** window. (**Figure 18**).

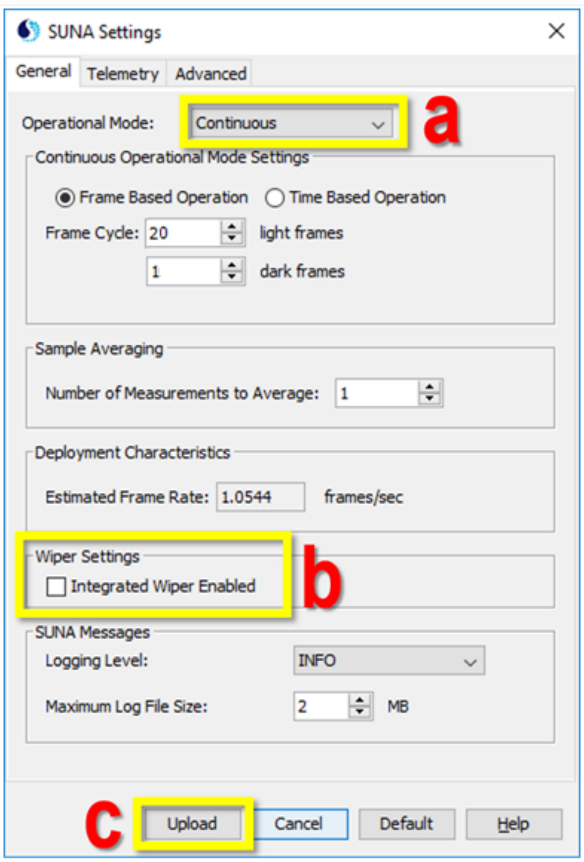


Figure 19. Configure SUNA for Validation Process.

STEP 4 | In the **SUNA Settings**, switch the **Operational Mode** from "**Periodic**" to "**Continuous**" ("a" in **Figure 19**).

STEP 5 | Under **Wiper Settings**, disable the wiper by unchecking the "**Integrated Wiper Enabled**" box ("b" in **Figure 19**).

STEP 6 | Verify that all options in the **SUNA Settings** are correct and click "**Upload**" to apply the changes made to the SUNA Settings ("c" in **Figure 19**).

STEP 7 | ***CRITICAL NOTE: Wear powder-free nitrile gloves to complete the next steps. Even though these gloves state they are "Powder-free", they may still contain some residue. Rinse the gloves in the stream until they are no longer slippery and then rinse with a little DI water.***

Figure 20. Physically Move Wiper on SUNA.

STEP 8 | Manually move the wiper away from the optical area (**Figure 20**). Gently push the wiper up and out of the area of the optical window to prevent it from puncturing the Parafilm wrap when collecting nitrate readings.

Note: This step is also required when Field Science ships the sensor to HQ, CVAL for annual Sensor Refresh.

STEP 9 | Create a DI reservoir in the optical window using Parafilm and equilibrated DI water.

Figure 21. Cut Parafilm to Size.

STEP 9.1 | Cut and pre-stretch a 40cm piece of parafilm and carefully dry the area around the optical bench to enable a watertight seal (**Figure 21**).

PRO TIP: *Pre-stretch the parafilm a little before wrapping it around the SUNA optical bench to enable a watertight seal on the first go. On cold days, place the parafilm in a pocket to keep warm before use.*

Figure 22. Wrap Parafilm around Optical Area of SUNA.

STEP 9.2 | Wrap the Parafilm around the optical area of the sensor (**Figure 22**).

Ensure the Parafilm completely overlaps and that no wrinkle or voids (bubbles) that may cause the DI water to leak out of the wrapped optical area chamber. **It must be watertight.**

PRO TIP: *It may be easier to wrap the Parafilm around the sensor when it is horizontal, as opposed to vertical in the graphic (**Figure 22**).*

STEP 9.3 | Puncture a small hole through the Parafilm in the top area of the optical bench. Use a sharp, clean, pointed object to puncture the Parafilm, such as a clean plastic pipette tip.

Figure 23. Fill Optical Area with Equilibrated DI Water.

STEP 9.4 | Gently fill the optical area with equilibrated DI water (**Figure 23**). Fill the area carefully to prevent water bubbles in the Parafilm.

Added pressure to puncture and fill the area may cause leaks and require you to restart this process. Employ caution when conducting this task.

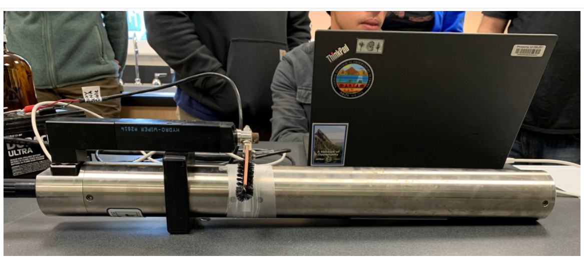


Figure 24. Validate SUNA Vertically to Prevent Bubbles on Optical Bench.

STEP 9.5 | Set the sensor horizontally to prevent air bubbles from accumulating on the optical bench (**Figure 24**).

5.4.4 Conduct SUNA Drift Test

Sensor drift is the slow change in sensor measurement independent of the actual concentration of nitrate in the water. Tracking sensor drift is critical for correcting data and determining sensor lifespan. In using a known DI blank (0 mg/L) to measure pre- and post-cleaning nitrate values, we are able to track sensor drift and assess measurement quality appropriately. Reference **Table 6** to conduct this procedure.

CRITICAL NOTE: Always remember to collect a pre-cleaning DI blank nitrate value before cleaning the optical area!

5.4.4.1 Collect Pre-Cleaning DI Blank Nitrate Reading

Table 6. Collect Pre-Cleaning DI Blank Nitrate Reading Procedure.

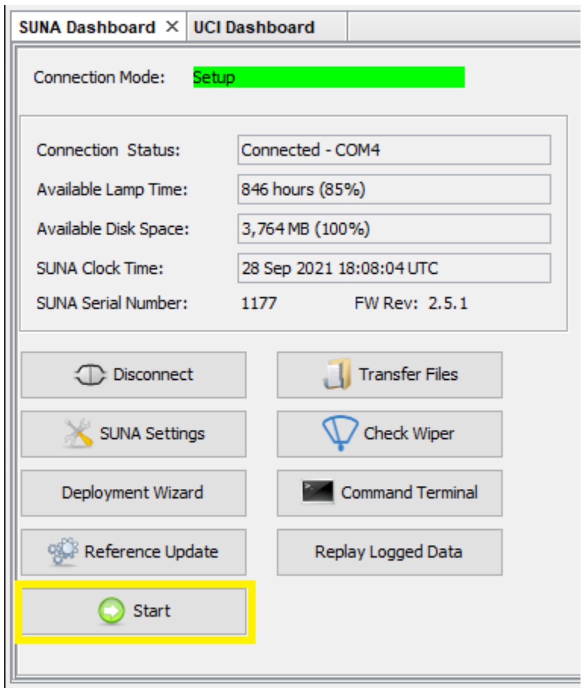


Figure 25. Press Start on the SUNA Dashboard.

STEP 1 | Press the "Start" button in the **SUNA Dashboard** to begin a real-time SUNA nitrate measurement (**Figure 25**).

The **Connection Mode** will show "Acquisition" and stay green.

The Spectra graph in the main UCI window will begin populating with data.

STEP 2 | Collect data for 1 minute by watching the time interval at the bottom of the graph until it reaches 60 seconds (**Figure 26**).

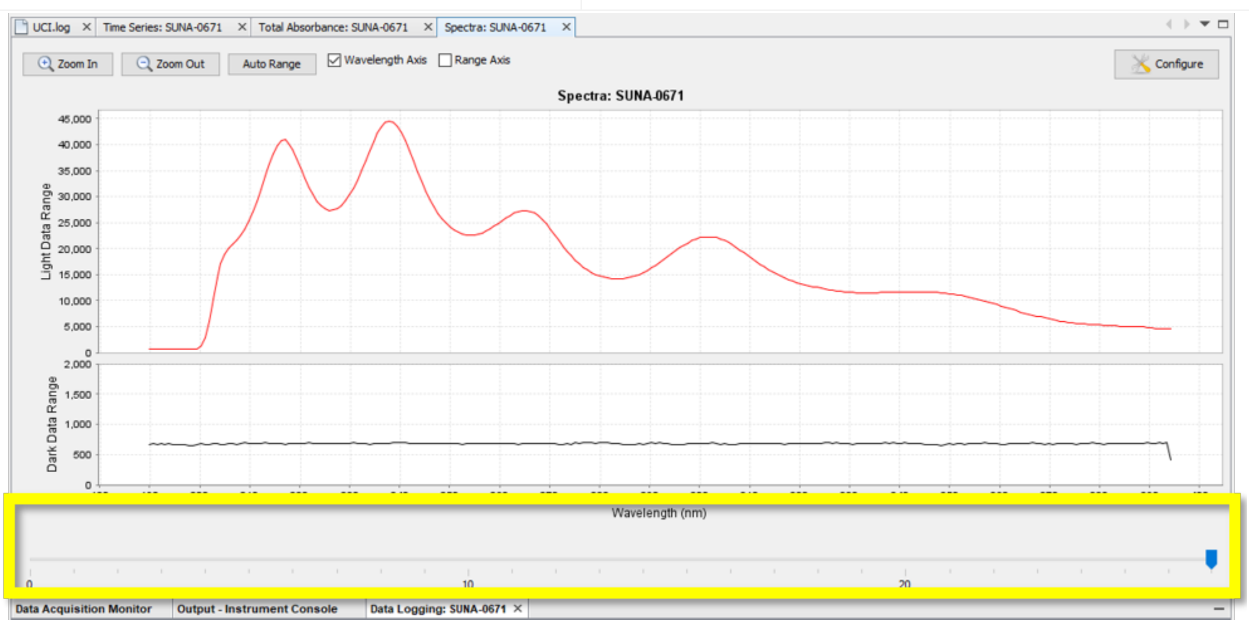


Figure 26. Collect Data for 1 Minute Monitoring the Wavelength Measurement.

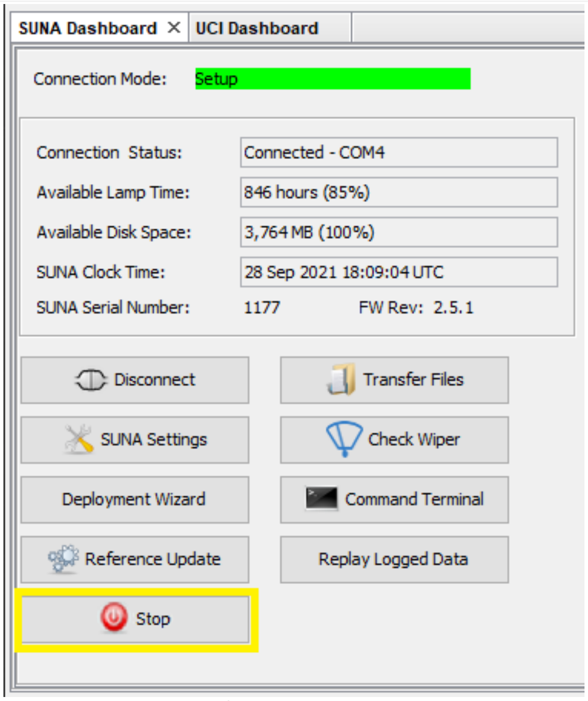


Figure 27. After 1 Minute, Click Stop.

STEP 3 | After 1 minute, click "**Stop**" (**Figure 27**).

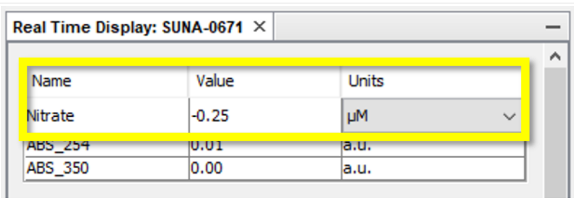


Figure 28. Record Real-Time Nitrate Measurement in Lower Left Corner.

STEP 4 | The nitrate measurement displays in the bottom left-hand corner in the Real Time Display section (**Figure 28**).

Record the nitrate measurement value.

STEP 5 | Remove the Parafilm and drain the DI water from the dirty optical area.

STEP 6 | Clean the sensor following the guidance in Section 5.4.4.2. Clean the sensor regardless of the dirty measurement value to capture a clean measurement value per Section 5.4.4.3.

5.4.4.2 Clean SUNA

After collecting the dirty nitrate reading, clean the SUNA body and optical area.

CRITICAL NOTE: Employ caution when cleaning the SUNA optical area; DO NOT SCRATCH THE LENSES!

1. With gloves still on, gently remove loose debris on the SUNA body by hand. Do not use your hands/fingers to remove any debris present in the SUNA's optical bench. NEVER insert your hands/fingers into the optical area.
2. If there is stubborn debris/bio-fouling buildup on the SUNA body, use a scrub brush with vinegar. Ensure the scrub brush does not touch the optical area.

3. Clean the optical bench by flushing it with DI water.
4. Use Kimwipes/micro-fiber or lint-free cloths to carefully clean the optical window with isopropyl.

5.4.4.3 Collect Post-Cleaning DI Blank Nitrate Reading

Repeat the procedure in **Table 6** after cleaning the SUNA to collect a post-cleaning DI blank nitrate value. If the post-cleaning reading is **> ± 2.00 µM**, re-clean the sensor and repeat. If the value is still > ± 2.00 µM after the second cleaning, perform a reference spectrum update (*see Section **Error! Reference source not found.** below*), and then collect a new DI blank value**.** This unplanned reference spectrum update should not affect or delay the scheduled monthly reference spectrum update. If the value is still > ± 2.00 µM, report the value to HQ via a Service Now INC ticket.

5.4.5 Revert SUNA Configuration

After conducting the validation procedure for drift, return the SUNA back to its deployment wiper and mode settings. Be aware, Technicians must manually move the wiper to its operational position (original position) and re-enable its settings in UCI. However, physically moving the wiper for drift tests every two weeks has the potential to affect the mechanical operation of the wiper over time. Small changes may compound and the sensor may require corrective action if the wiper is not manually moved correctly or carefully. Reference **Table 7** to revert the SUNA configuration for sampling.

Table 7. Test Wiper Function & Restore Original SUNA Settings for Measurement Collection.

STEP 1 | Manually return the SUNA wiper to its original position by carefully moving the wiper back to the edge of the optical window.

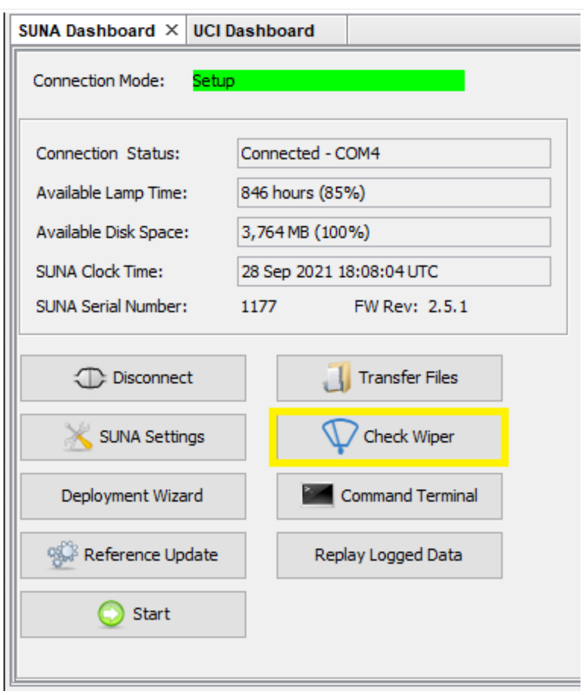


Figure 29. Select "Check Wiper".

STEP 2 | Verify wiper function by conducting wiper tests with the UCI software. Click on the "Check Wiper" button under the **SUNA Dashboard** (**Figure 29**).

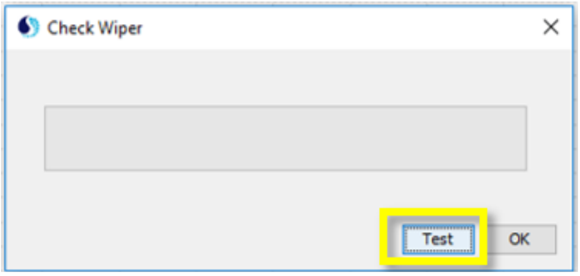


Figure 30. Select "Test" to Verify Wiper Function.

STEP 3 | Select "**Test**" and watch the wiper move through the optical window (**Figure 30**).

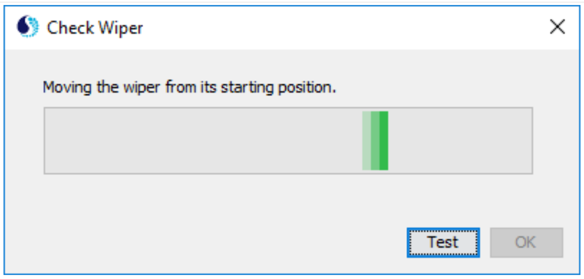


Figure 31. Monitor Wiper Movement.

STEP 4 | Monitor the wiper movement during the function test (**Figure 31**). Pay careful attention to verify if the wiper is sweeping through the entire window, stopping halfway through, or gets stuck on the edge of the window and does not complete a wipe.

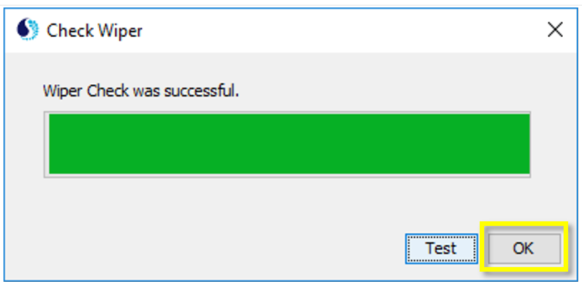


Figure 32. Select "OK" to Complete Wiper Test.

STEP 5 | Select "**OK**" when the wiper check is complete (**Figure 32**).

Physically (with your hands) adjust the wiper, if necessary, to allow the wiper to perform a normal, full sweep of the optical window.

STEP 6 | Repeat the wiper check until the wiper successfully passes 3 to 4 tests in a row. If the wiper fails this check, it is likely the coupler, submit an incident ticket in the NEON Program's Issue Reporting and Management System. **Do not remove a SUNA from the site for a broken wiper unless explicitly instructed by the AQU Science Team**. In most cases, bi-weekly manual cleaning should be sufficient to prevent impactful levels of biofouling until a replacement SUNA with working wiper is available.

STEP 7 | Open the "**SUNA Settings**" window as previously shown in **Figure 18**.

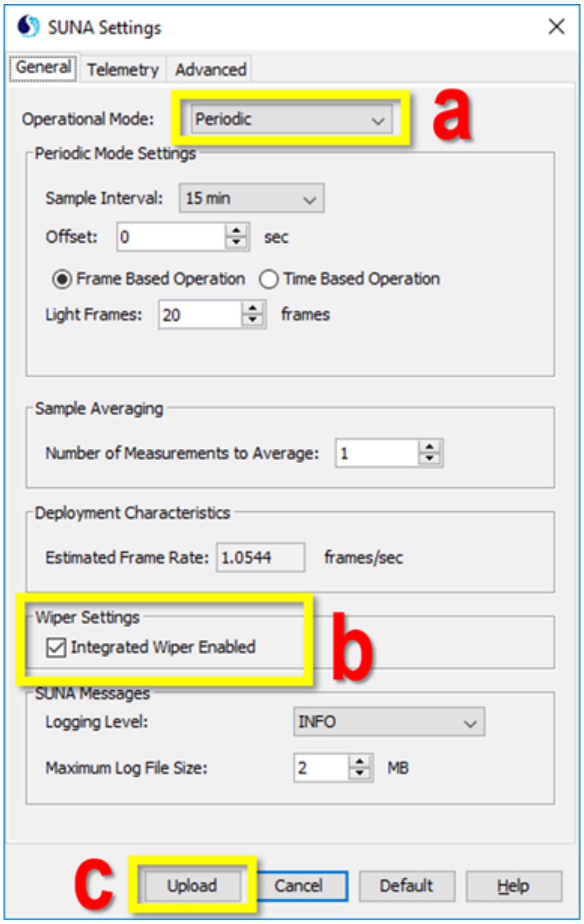


Figure 33. Return SUNA to Original Settings for Deployment.

STEP 8 | In the **SUNA Settings** window, switch the **Operational Mode** from "Continuous" to "**Periodic**" ("a" in **Figure 33**).

STEP 9 | Under **Wiper Settings**, enable the wiper by checking the "**Integrated Wiper Enabled**" ("b" in **Figure 33**).

STEP 10 | Verify **SUNA Settings** window align with **Figure 33**.

Select "**Upload**" to apply the changes made to the SUNA Settings ("c" in **Figure 33**).

CRITICAL NOTE: If the SUNA is left in Continuous mode it will continue collecting data continuously, instead of every 15 minutes. While the NEON Level 1 transition algorithm will ignore this extra data, it will prematurely age the SUNA lamp, requiring a sensor refresh. See Section 9 for further information on how to remotely change the configuration of a SUNA if you discover it has accidentally been left in Continuous mode.

5.4.6 Available Lamp Time Verification

Check the "**Available Lamp Time**" in the **SUNA Dashboard** and record the hours to monitor lamp lifespan overtime (**Figure 34**).

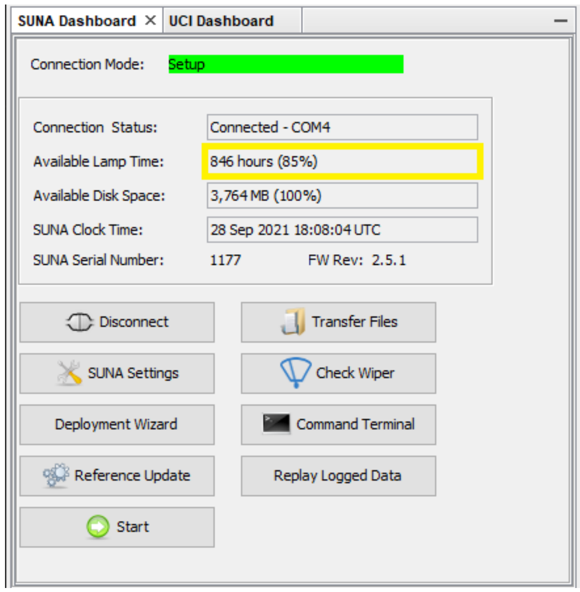


Figure 34. SUNA Dashboard: Available Lamp Time | Verify Lamp Time is > 50 Hours.

If the Available Lamp Time is ≤ 50 hours, initiate SUNA sensor refresh by reporting the hours to CVAL, HQ via an incident ticket in the NEON Program's Issue Reporting and Management System. Once a replacement sensor has arrived at the DSF, follow the instructions in Section 6 to replace the field sensor and return the SUNA with ≤ 50 hours of lamp life to CVAL for servicing.

5.4.7 Sensor Clock Synchronization

The SUNA internal clock drifts over time, especially the longer the instrument has been in the field. Use **Table 8** for instructions on synchronizing the SUNA internal clock. Synchronize the clock every time you connect to the SUNA for preventive maintenance.

CRITICAL NOTE: The SUNA clock must be within ±30 seconds Universal Time Coordinated (UTC) for the Location Controller (LC) to collect data from the SUNA.

Table 8. Synchronize SUNA Internal Clock to UTC.

STEP 1 | From the main software window, use the "Sensor" dropdown menu to select **SUNA** > **Advance** > **Set Clock** (**Figure 35**).	

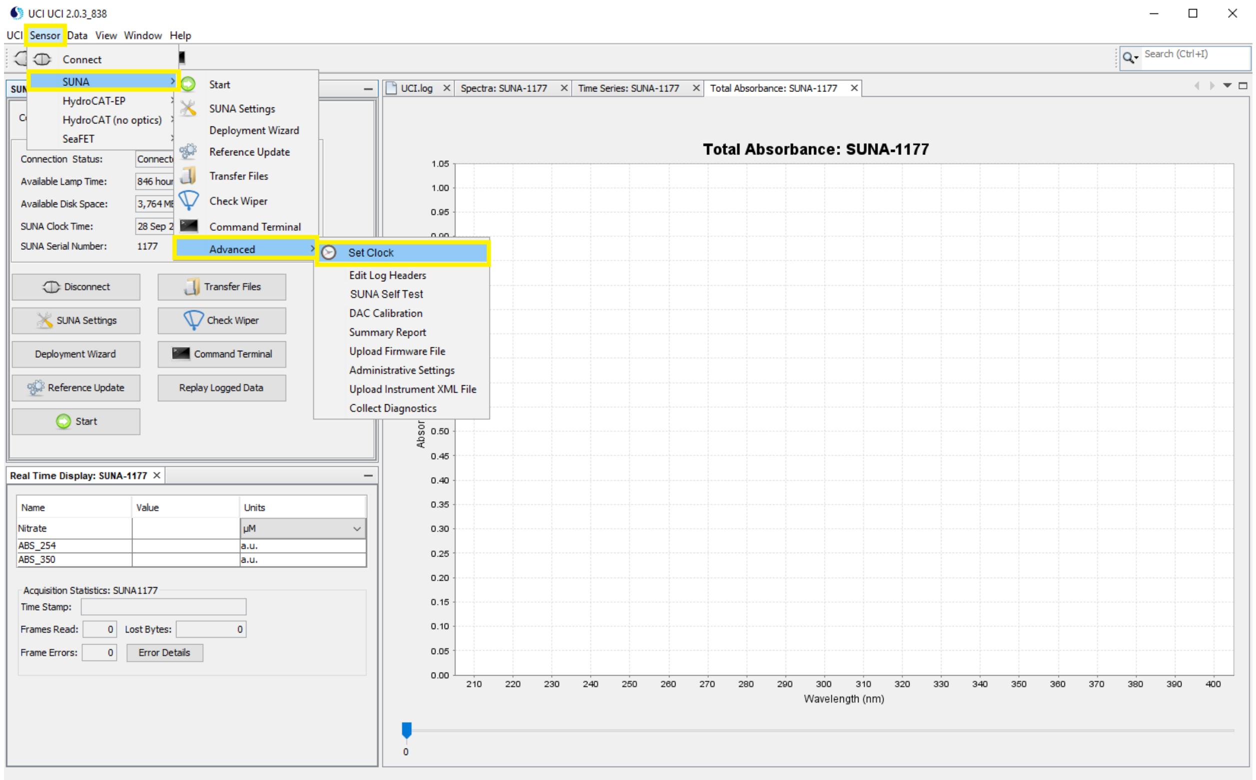


Figure 35. Use the "Sensor" Dropdown to Select "Set Clock".

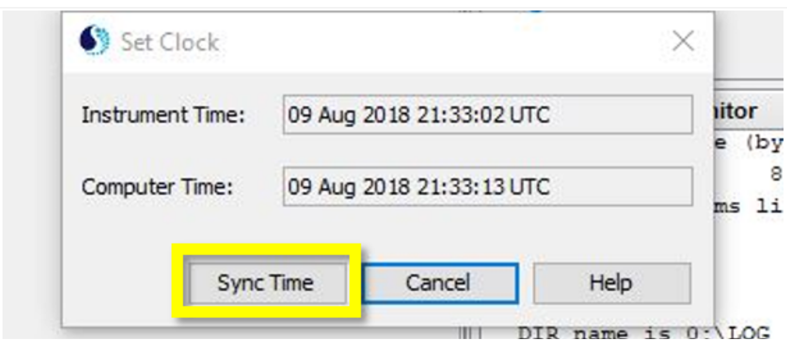


Figure 36. Select "Sync Time" to Automatically Update the SUNA Clock.

STEP 2 | A **Set Clock** window opens. Click on "**Sync Time**" (**Figure 36**).

Note: The software automatically converts your computer local time to UTC. Ensure the laptop connecting to the SUNA is displaying the accurate local time. If unsure if it is accurate, google current local or UTC time or check the LC if internet access is not available.

5.4.8 Sensor Configuration Verification

Table 9 provides instructions to confirm the SUNA configuration is correct for deployment.

Table 9. How to Verify Sensor Configuration.

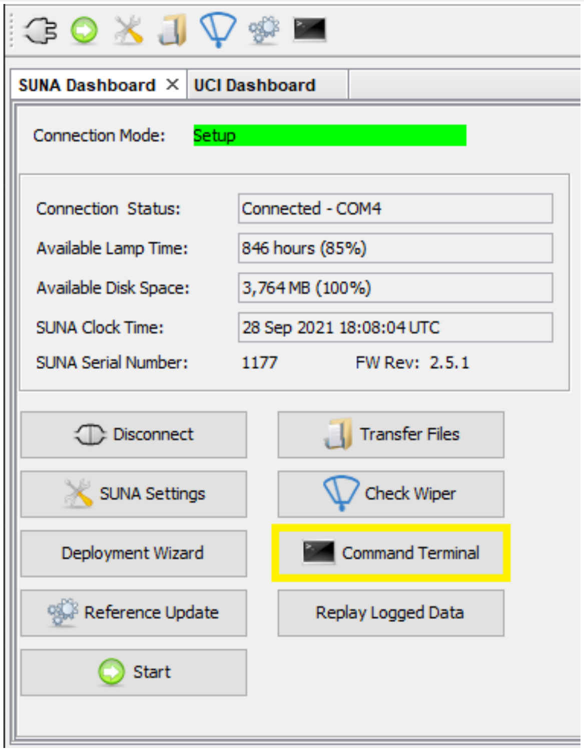


Figure 37. Open Command Terminal Window.

STEP 1 | To verify the SUNA settings, click the "**Command Terminal**" button on the **SUNA Dashboard** (**Figure 37**).

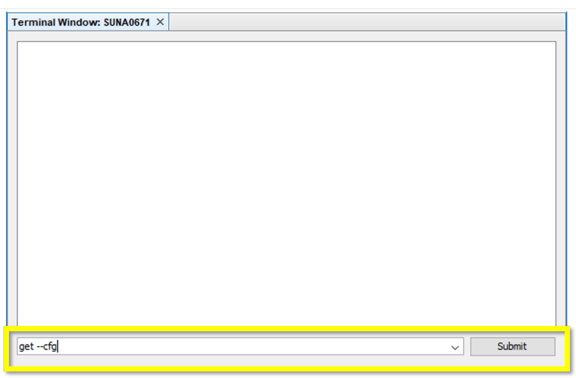


Figure 38. Select "get --cfg" from the Dropdown Command Prompt.

STEP 2 | In the terminal window, select "**get --cfg**" from the dropdown command prompt and click **Submit** (**Figure 38**).

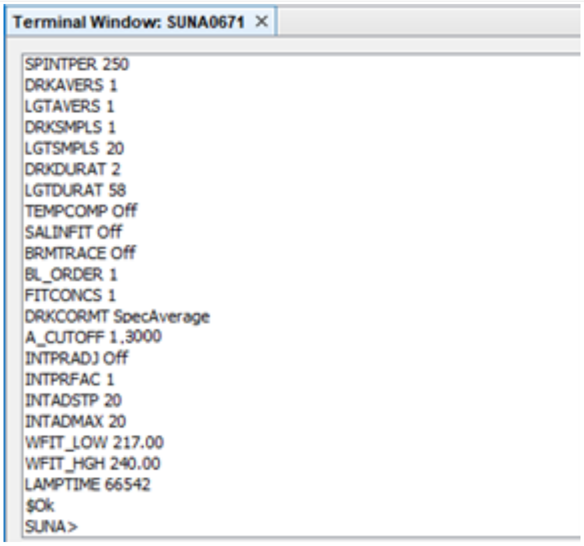


Figure 39. Configuration Output.

STEP 3 | This command lists the current configuration settings for the SUNA sensor (**Figure 39**).

These parameter values must match with the Parameter Values in the NEON Sensor Command, Control and Configuration (C3) Document: AIS Nitrate Analyzer via AD [04].

If the SUNA configuration settings do not match the configuration in AD [04], submit an incident ticket in Service Now.

CRITICAL NOTE: Changing specific parameters can throw the sensor out of calibration; review AD [04].

PRO TIP*: Good parameters to check are OPERMODE, OPERCTRL, PERDSMPLE, and DRKSMPLES.*

5.4.9 SUNA Self-Test

The selfTest can be used to identify any potential issues with the SUNA. Table 10 provides information on how to run a selfTest.

Table 10. How to Conduct a SUNA Self-Test.

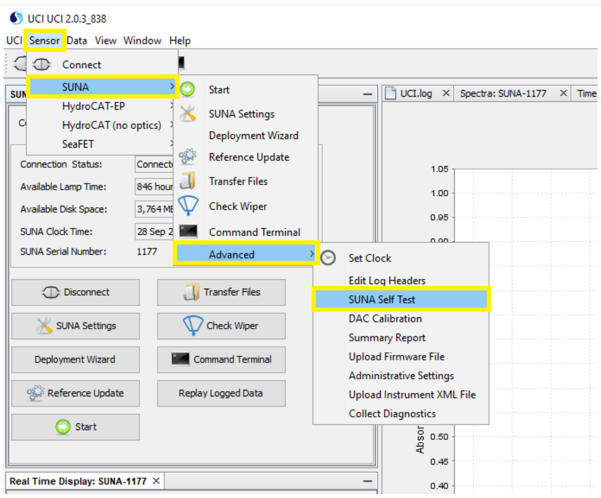


Figure 40. Open Command Terminal Window.

STEP 1 | From the main software window, use the "Sensor" dropdown menu to select **SUNA** > **Advance** > **SUNA Self Test**.

Figure 41. Select "SelfTest" in the Terminal Window.

PRO TIP: the SelfTest can also be run from theCommand Terminal as shown previously in Figure 37. In the terminal window, select "SelfTest" from the dropdown command prompt and click Submit.

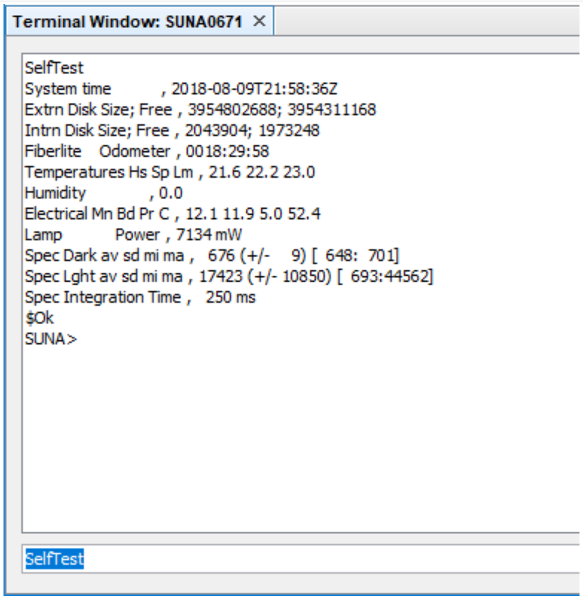


Figure 42. "SelfTest" Output Populates in the Terminal Window.

STEP 2 | The "**SelfTest**" output populates in the command terminal (**Figure 42**).

Check this output for any "**!**", which indicate that the SUNA has a problem.

<u>Humidity:</u> This reports the internal humidity of the SUNA housing. An increase in this value over time indicates that the SUNA body has a leak somewhere and requires corrective action. A "**!**" means the water level inside the SUNA is high enough to cause a malfunction and/or damage.

<u>Temperature:</u> This reports the internal temperature of the SUNA housing. A "!" means the internal temperature in the SUNA has been high enough to cause a malfunction and/or damage.

<u>Spec Light av:</u> When in DI, if the average (first number) is less than 10,000, it indicates low light reaching the detector. This may indicate an unclean window and/or DI contaminated with UV absorbing or scattering substances. Alternatively, it may indicate a degraded lamp. By tracking this value, we can determine if a lamp is degrading prematurely (i.e., faster than expected based on the cumulative lamp time). **This value will not always be flagged with "!" and should be verified manually.**

CRITICAL NOTE: Submit a ticket in the NEON Program's Issue Reporting and Management System if a "!" output is present on your SUNA. If the Spec Light av < 10,000, submit a ticket even if a "!" output is not present.

<u>PRO TIP</u>: *As an aid for future troubleshooting, and to analyze SUNA performance changes over time, copy and paste SUNA humidity and temperature information into a log to keep track of the SUNA "**SelfTest**" output. This makes spotting an abnormal reading easier for these indicators. If the temperature reports **-99.9!**, run the self-test again. This reading is likely an error.*

STEP 4 | Click the "**X**" in the upper right hand corner to close the Terminal Window when complete.

5.5 [CRITICAL PROCEDURE] Disconnect SUNA from Software and Hardware

Table 11. How to Properly Disconnect from a SUNA.

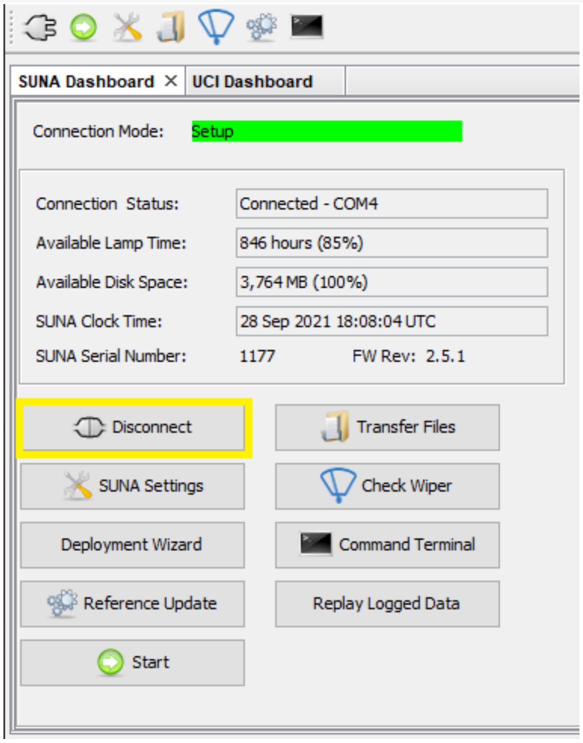


Figure 43. In SUNA Dashboard, select "Disconnect".

STEP 1 | In the **SUNA Dashboard,** select the "**Disconnect**" button ***BEFORE*** disconnecting the USB connection from the laptop and cable from the SUNA (**Figure 43**).

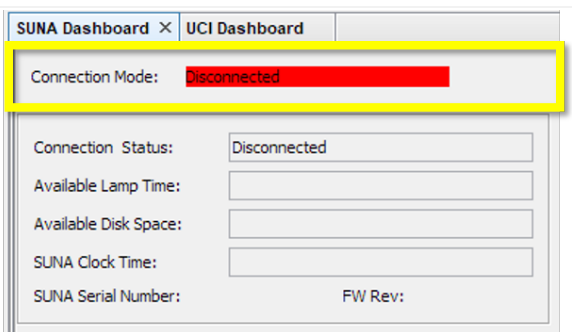


Figure 44. Confirm Connection Mode is Disconnected.

STEP 2 | You must wait for the software to successfully disconnect from the SUNA; it will show the **Connection Mode** as "Disconnected" in red (**Figure 44**).

CRITICAL NOTE: Disconnecting from the SUNA without this step leaves the SUNA in a state where it is unable to take measurements or transmit any data.

PRO TIP: *If the SUNA was not properly disconnected, leave the SUNA unpowered for 5 minutes. Then, reconnect to the SUNA, verify the SUNA configuration settings and correctly disconnect from the SUNA via the UCI software. If the software is not disconnecting properly, or the SUNA is not streaming after disconnecting correctly, see Section 9 for additional troubleshooting guidance.*

STEP 3 | Disconnect the SUNA calibration Y-cable following the steps from Section 5.4.2, but in the reverse order.

STEP 4 | Reinstall the SUNA following instructions in Section 6.2, Table 15.

STEP 5 | Reconnect the field SUNA power cable to its power source.

PRO TIP: *Failure of the Grape to require the SUNA is a common failure mode with this sensor, which results in a failure to correctly stream data to the LC. To verify, open Grafana in the terminal window and navigate to the "Brain". If a SUNA is not showing up as connected to the Grape, power cycle the Grape for 15 minutes and check again.*

STEP 6 | ***CRITICAL NOTE: Verify that data is streaming again before leaving the site. THIS IS THE MOST IMPORTANT STEP OF ANY PM!***

5.6 Monthly Validation/Calibration Procedure

Performing a calibration (a.k.a. reference spectrum update) at least once a month corrects for lamp degradation. Over one month of normal use, the expected change in the reference spectrum should be between +5% and -20%. Changes outside this range indicate an uncleaned optical window, a contaminated DI blank, or a potentially serious problem with the SUNA lamp (higher changes at wavelengths <215 nm where the SUNA lamp output is less are more common. These are also outside the nitrate absorbance range and do not substantially affect the measurement). Regardless, if you see any change outside +5% to -20%, submit an incident ticket in ServiceNow soliciting advice from the AQU Science team.

5.6.1 Monthly Calibration: Reference Spectrum Update Procedure

Conduct the procedure in Error! Reference source not found. to calibrate the SUNA.

Table 12. Monthly Calibration Validation: Reference Spectrum Update Procedure.

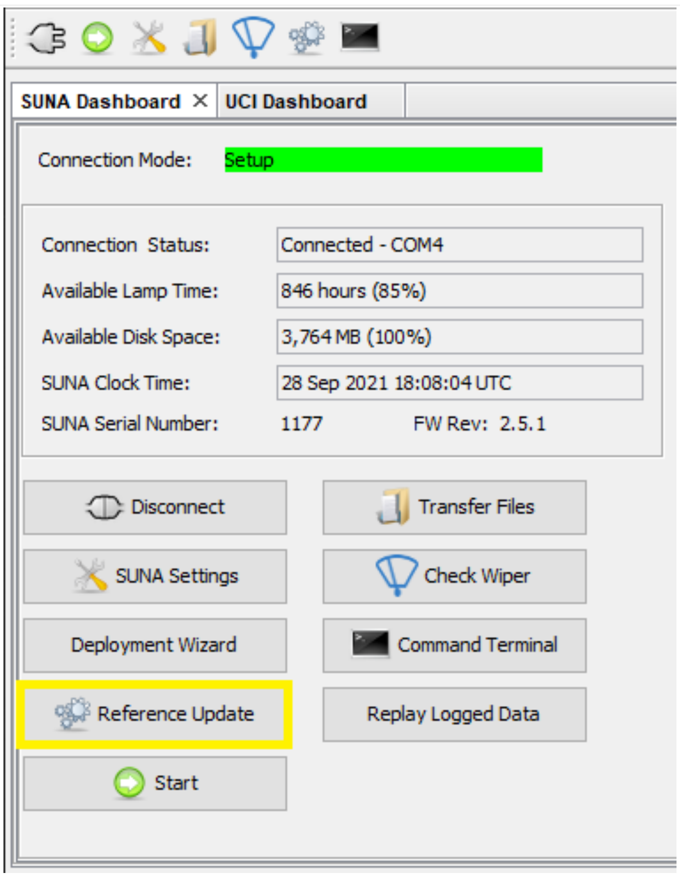


Figure 45. Click on the “Reference Update” on SUNA Dashboard.

STEP 1 | Begin every reference update with the routine maintenance in Section 5.5. After completing the cleaning and validation procedure, select “**Reference Update**” on the **SUNA Dashboard** (Error! Reference source not found.).

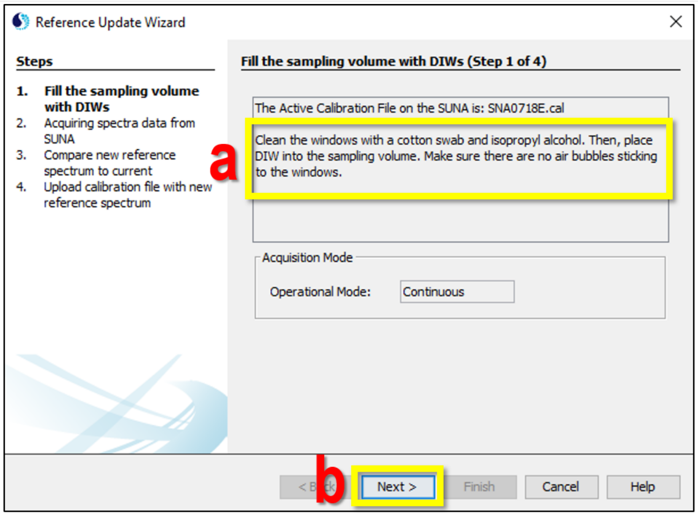


Figure 46. Fill the sampling volume with DI.

STEP 2 | Follow the prompts in Reference Update Wizard. After ensuring that the optical window is cleaned, the parafilm is filled with fresh DI water which meets the Type II Standards described in Section 5.4.1.1, and that there are no air bubbles sticking to the windows ("a" of Error! Reference source not found.), click "**Next >**" ("b" of Error! Reference source not found.).

CRITICAL NOTE: Calibrating a SUNA with an uncleaned optical window or using contaminated DI will cause it to fail calibration and/or collect bad data.

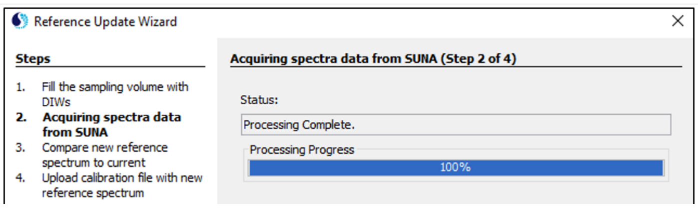


Figure 47. Acquiring spectra data from SUNA.

STEP 3 | For Step 2 of 4 in the Reference Update Wizard, the software acquisitions spectra data from the SUNA. This process does not require any actions except to wait until it is complete before clicking next (Error! Reference source not found.).

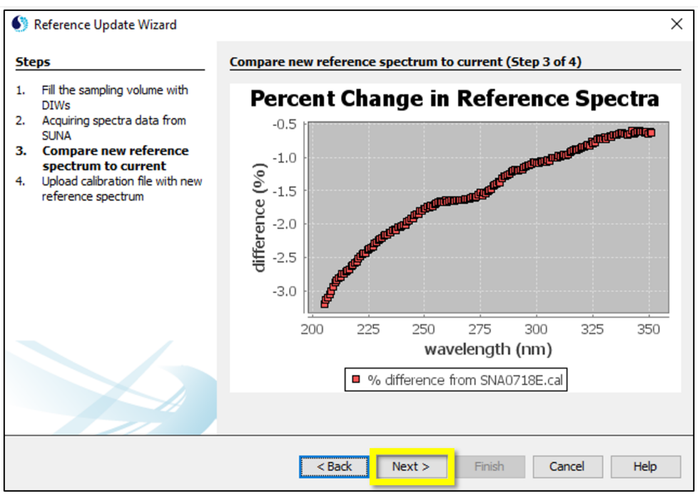


Figure 48. Compare reference spectra.

STEP 4 | For Step 3 of 4 in the Reference Update Wizard, if the percent change is between -20% and +5%, click "**NEXT>**" to accept the percent change (Error! Reference source not found.), and skip to **Step 6** below.

STEP 5 | If the percent change is outside -20% to +5%, click "**Cancel**" to reject the update. Re-clean the optical window and re-attempt the reference spectrum update. If your site has harder water or you notice precipitation on the lens that is not being removed by isopropyl alcohol, you may opt to clean using a 2:1 solution of water and white vinegar (5% acidity). Be sure to check the box in the Fulcrum app indicating vinegar solution was used for cleaning. If the SUNA fails for a second time after re-cleaning, accept the new reference spectrum anyway and complete the update (**Steps 6-11**). Create an incident in Service Now for the AIS science team to evaluate.

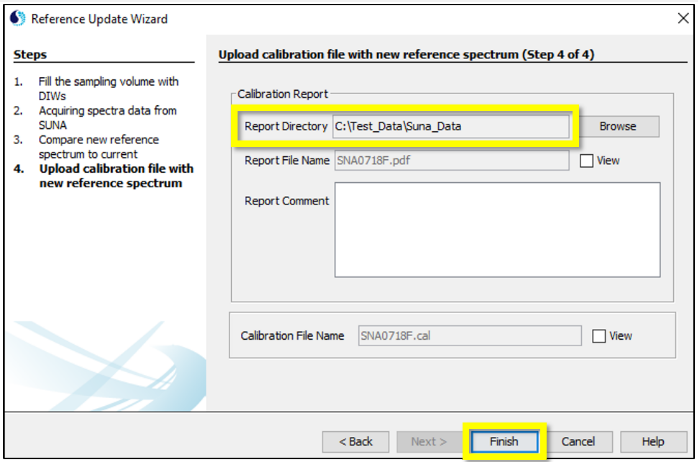


Figure 49. Save calibration file.

STEP 6 | Save the calibration report .pdf file locally on the PC laptop in **C:\Test_Data\Suna_Data**. If this folder is not present, create one. Click "**Finish**" to upload the new Reference Spectrum into the SUNA (Error! Reference source not found.).

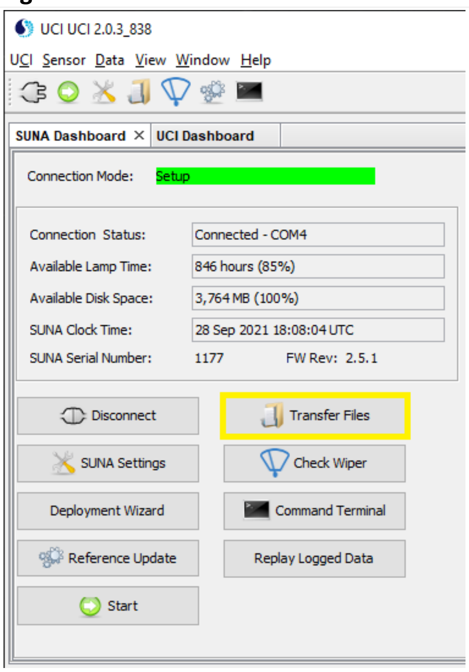


Figure 50. Click on the "Transfer Files" on SUNA Dashboard.

STEP 7 | Transfer the .cal calibration file from the SUNA to the laptop.

In the SUNA UCI software application, select "**Transfer Files**" on the **SUNA Dashboard (Figure 50)**.

Click on the "**Calibration Files**" tab. Use the "Browse" button to ensure the directory is set to **C:\Test_Data\Suna_Data** . Select the appropriate .CAL file in the window on the right. Click on the **<-** button to transfer the file (**Figure 51**).

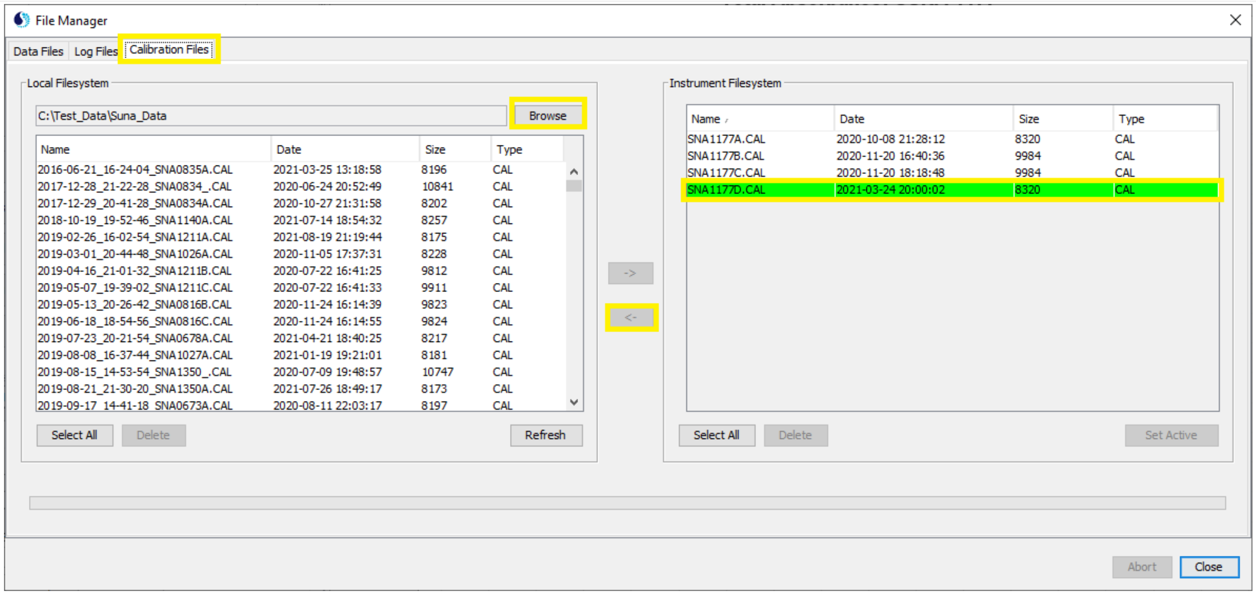


Figure 51. Transfer the .CAL file from the SUNA to the laptop.

***PRO TIP**: You can also access past calibrations in this way. You can also access and download logged data by clicking on the Data Files tab.*

CRITICAL NOTE: Be careful not to accidentally delete or alter any files.

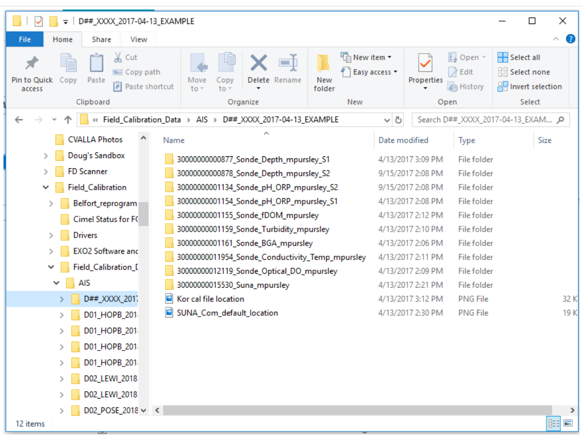


Figure 52. Create folder on N:\ drive.

STEP 8 | Move the calibration file to the project Network Drive folder for CVAL Field Calibration Data (Error! Reference source not found.).

After saving the SUNA calibration file locally on your laptop, move the **.cal** file to here:

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

Create a folder, if the current date does not exist for the SUNA.

Example Folder Naming Convention: **D01_HOPB_2018-07-03**

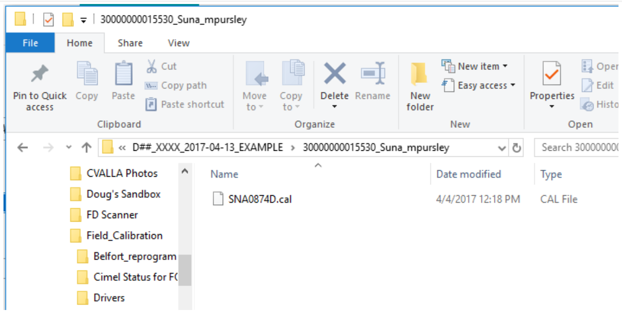


Figure 53. Save cal file.

STEP 9 | Once inside the correct **DOMAIN/SITE/DATE** folder, create a sub-folder for the calibration data. Use the following naming convention:

ASSETNUMBER_SUNA_yourname

For example, "**30000000015530_SUNA_mpursley**" in Error! Reference source not found.**.**

Save the calibration file inside your respective folder, leaving the default **.cal** file name (e.g., SNA0874D.cal).

CRITICAL NOTE: Make sure you are uploading the .cal file, which is different from the .pdf report (which is optional). If the SUNA calibration files are not uploaded, the SUNA data from the site will be flagged.

STEP 10 | After updating the reference spectrum graph, run a new DI blank following the procedures in Section 0. If the nitrate value is < ± 2 µM, the SUNA has passed calibration.

If the nitrate value is **> ± 2** µM**,** repeat the process for the monthly reference spectrum update starting from Step 1 in Error! Reference source not found.. If the SUNA fails to meet the threshold again, redeploy the sensor and immediately submit a Service Now ticket for further guidance.

STEP 11 | Disconnect the SUNA from the UCI software and redeploy following the correct procedure in Section 5.5.

STEP 12 | ***CRITICAL NOTE: Verify that data is streaming again <u>before</u> leaving the site.***

5.7 Seasonal Maintenance (Stream Sites)

This section addresses seasonal changes in streamflow that may affect the sensor function and data collection. Per Aquatic Science requirements, sensors and infrastructure shall be installed and adjusted seasonally, as directed by HQ and according to the preventative maintenance documentation, such that water quality, temperature and nutrient measurements shall be captured at 60% (±20%) of the total water depth at wadeable stream sites, excluding temporary changes in water depth which may be large and rapid due to storm events. Conduct the following actions to address the scenarios in **Table 13** to ensure sites maintain compliance with AIS Science requirements. Reference AD [07] for thresholds and seasonal guidance on the sensors that mount to the AIS Buoy.

Table 13. Seasonal Maintenance: Stream Flow Changes.

 **Figure 54.** Dry Stream Bed.	**SCENARIO 1** | As mentioned above, per aquatic science requirements, the SUNA must maintain a water depth of 60% (with ± 20% of flexibility). If the stream dries up (**Figure 54**), **do not remove the sensor**. Create an incident in the NEON Program's Issue Reporting and Management System to inform AIS Science that the site is dry. The data requires data quality flags during dry conditions. The brush may also be disabled remotely or onsite by HQ or at the direction of HQ. When water returns, report it in the same incident and resolve the incident.

Figure 55. SUNA Partially Submerged in Stream.

SCENARIO 2 | **Figure 55** is an example of a SUNA partially submerged. For this scenario, conduct the following assessment.

If the SUNA enclosure is breaching the water surface, move the mount further down the stream anchor to submerge the sensor in the stream flow. This will also affect the Multisonde depth, which will also require adjustments. The SUNA and Multisonde must be at the same depth.

If the streamflow is too low to allow adjustments, leave the sensor as-is and submit a ticket to notify AIS Science Staff to flag for data quality.

*Note: Only make this adjustment for the SUNA**. Do not move the Level TROLL**. The Level TROLL must remain in a consistent location per NEON.AIS.4.1758.*

Figure 56. Winter ice accumulation.

SCENARIO 3 | Per NEON.AIS.4.1314, aquatic-based sensor infrastructure shall be removed from select northern lake and wadeable stream sites prior to ice formation that could result in structural damage.

At lake sites, the SUNA should be removed along with the buoy. See AD [07] for further guidance.

OKSR is the only wadeable stream site where the SUNA is removed for winter. The SUNA at OKSR should be removed when the site is powered off. See RD [10] for mor information.

At other select wadeable stream sites (BLDE, COMO, WLOU, CARI), ice forms on the surface, but the SUNA remains in liquid water below (**Figure 56**). SUNAs at these sites should remain installed over the winter. Several other sites may freeze temporarily. Do not attempt to dig and/or chip out a SUNA frozen under ice to perform a PM, unless otherwise directed by HQ.

Figure 57. High flow events.

SCENARIO 4 | For imminent high-flow events, such as **Figure 57,** the site may not be safe to access. Consult with the NEON program safety office and AIS science staff for guidance.

6 REMOVAL AND REPLACEMENT (SUBSYSTEM ONLY)

6.1 Equipment

Table 14. Equipment for Sensor and Subsystem Removal and Replacement.

Maximo No.	Description	Quantity
Tools		
GENERIC	Open Ended Wrenches	Set
MX109759	Ratchet set	Set
MX109746	Allen Wrenches (5/16 Allen Wrench to remove SUNA enclosure)	Set
MX101649	Greenlee 0254-40 10 Pc T-Handle Hex Key Set	1
MX101639	Screwdriver set (flathead screwdriver to open Combo boxes)	1
MX102345	Measuring Tape	1
MX105024	Torque Wrench	1
NEON, Safety	Aquatic PPE	A/R
MX101632	PETZL Headlamp, Wide Beam, Gray	1
NEON, Safety	LOTO Equipment	A/R
MX102703	Digital Multi-Meter (DMM)	1
MX109755	Flush cut pliers or scissors (to remove zip ties)	1
MX102767	11-in-1 Screwdriver/Nut driver w/Interchangeable Blade	1
MX104238	SK Alum Edge Folding Utility Knife w/Belt Clip, Blue 3.5"	1
MX103120	Anti-static wristband	1
Consumable items		
	UV-resistant Zip ties	A/R
MX105865	3M Bag, ESD Shielded, 8 inch x 11 inch, Cushioned	1
MX105931	3M Bag, ESD, Static Shield, 6 x 8 Inches, Zip Closure, Non-Cushioned	1
MX105864	3M Bag, ESD Shield, 6 Inch X 7 Inch, Cushioned	1
MX105866	3M Bag, ESD Shielded, 14 Inch X 15 Inch Cushioned	1
MX105935	3M Bag, ESD, Static, 15 x 18 Inches, Zip-Closure Top	1
GENERIC	Masking tape	Roll
GENERIC	Sharpie/Paint pen	1
GENERIC	Boxes (to transport non-decontaminated sensors back to Domain)	A/R

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. **Reference RD [08] for the standard operating procedures for the annual Sensor Refresh process and delineation of sensor, administrative and logistical requirements.**

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.

6.2.1 Stream (S2) Sites

Conduct the following removal and replacement procedures for the SUNA at wadeable stream sites in **Table 15**. Reference *AD [08], NEON.DOC.003880 NEON Preventive Maintenance Procedure: AIS Stream Infrastructure* for additional information to support or compliment this procedure.

Table 15. SUNA Removal & Replacement Procedures for Stream Sites.

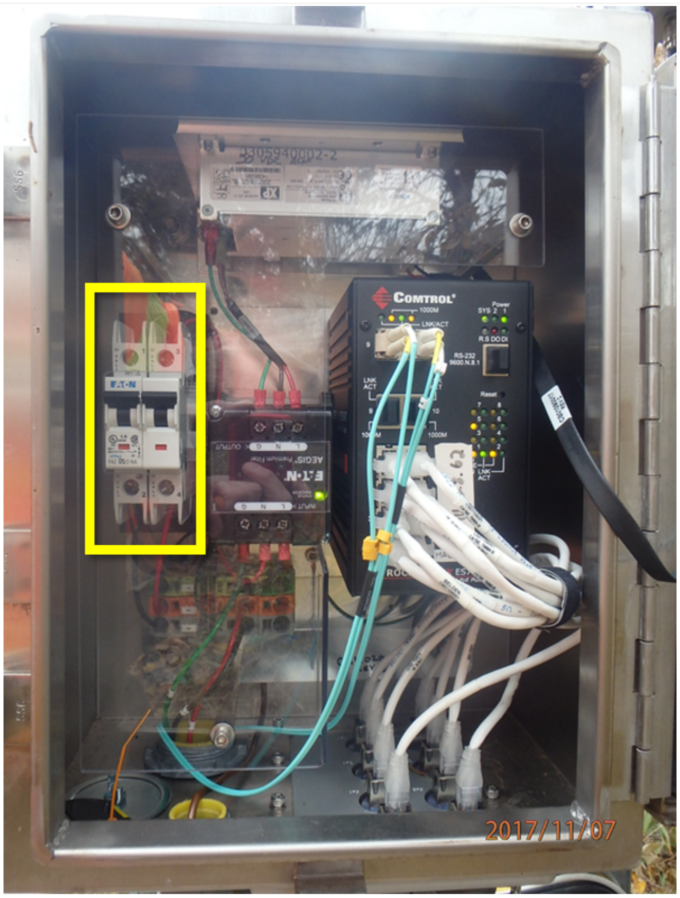
 **Figure 58**. AIS Combination Box - 5 Amp Breakers.	**STEP 1** | Power down S2 from the Combo Box. Use a flathead screwdriver to open the Combo box (**Figure 58**). *Reference AD [10] for additional guidance on the AIS power distribution system.*

Figure 59. SUNA 12V Merlot Grape subsystem.

STEP 2 | Disconnect the Ethernet Cable (RJF/Eth to Comm on AIS Interconnect Mapping) from the 12V Merlot Grape that powers and acquires data from the SUNA (**Figure 59**). Drape the cable over the anchor. Do not allow the cable connector to get wet or dirty.

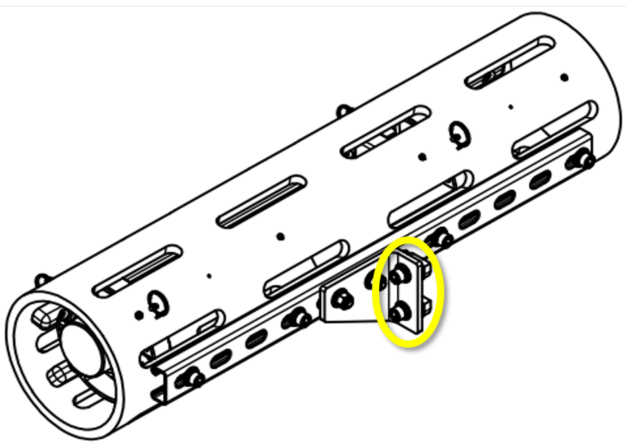
Reference AD [06] for AIS Grape Mapping.

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.

STEP 3 | Remove the 12V Merlot Grape for Sensor Refresh. Remove the four screws that affix the Grape to the Grape Shield using a hex wrench.

It may be easier to remove the Grape Shield(s) from the anchor Unistrut to prevent losing the four screws that secure the Grape to the shield. Use a 3/16" hex wrench to remove the entire assembly with the Grape. Store Grapes without caps in an ESD bag.

STEP 4 | Using a 5/16th Allen wrench, remove the SUNA PVC enclosure from the in-stream anchor (**Figure 60**). Remove the bolts connecting the L Bracket to the Unistrut. Be aware, you will need to catch the nut on the screw before it falls off and flows downstream. In the event you do lose a nut, order spares (0329850000Nut, Channel w/o spring retainer, 3/8-16 Stainless). It is also OK to pull out the locking pins and slide the sensor out from the enclosure, along with the captive discs; however, this method may make it harder to align the captive discs with the pinholes on the PVC enclosure underwater.



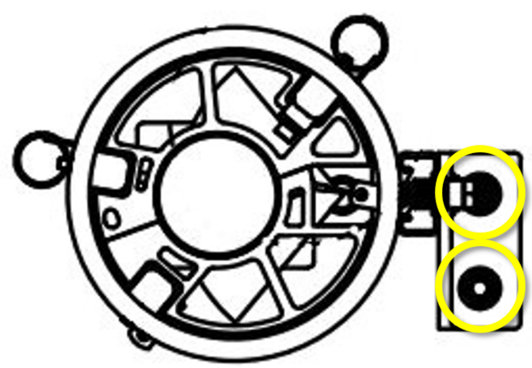


Figure 60. Remove the 2 bolts that attach the mount.

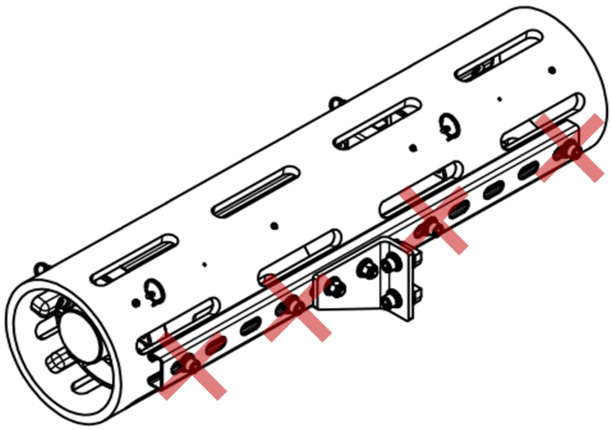


Figure 61. Do not remove these 4 bolts.

Do not remove the bolts connecting the bracket to the housing. (**Figure 61**). Doing so will make it very difficult to reinstall.

Figure 62. Remove SUNA PVC enclosure.

STEP 5 | Disconnect the sensor power cable that connects to the Grape (**Figure 62**).

Remove zip ties that are securing the sensor cable to the anchor, using snips, as appropriate to remove the cable, if necessary, otherwise drape the cable above water to prevent submerging the connectors.

Place a dummy plug over the sensor connector to protect it from getting wet.

STEP 6 | The SUNA enclosure uses two captive discs to hold the sensor in place (**Figure 62**). If the screws (0337670008) of the captive discs develop significant corrosion, replace the hardware and reassemble the discs following the installation instructions.

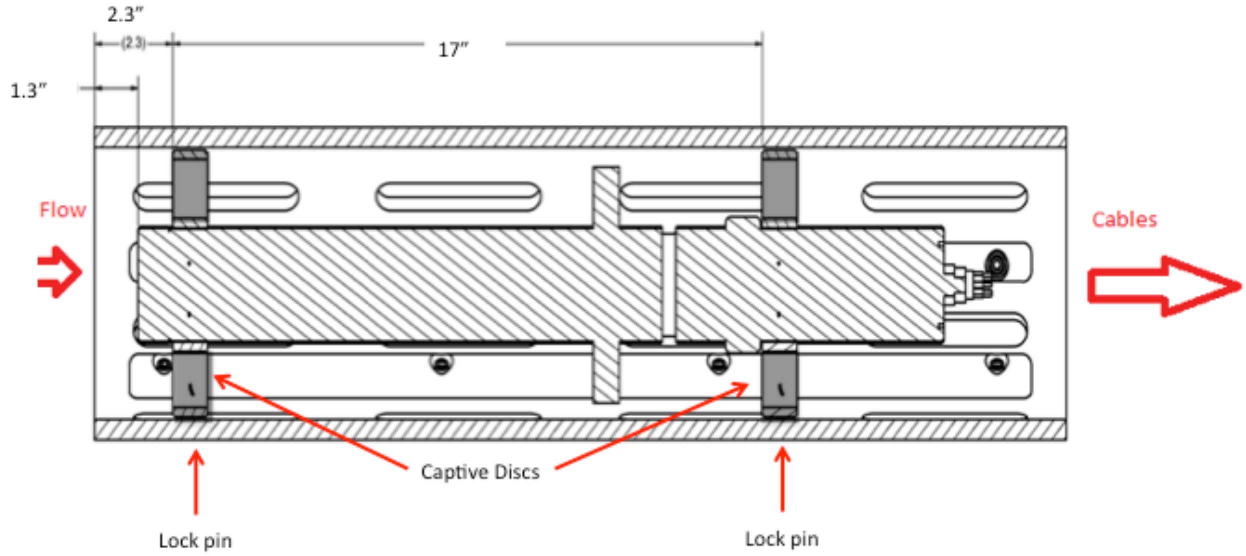


Figure 63. SUNA orientation and installation components.

Note: Bio-fouling may accumulate in the tracks, which may cause difficulty removing and reinstalling the SUNA into the PVC enclosure. Try to flush the PVC enclosure with water to dislodge any debris, if possible.

Figure 64. Pull 4 lock pins to remove captive discs.

STEP 7 | Pull the four lock pins from the enclosure to free the two captive discs (**Figure 64**).

Note: the pinholes must align with the captive discs. This is good to be aware of for reinstallation of the SUNA in the enclosure.

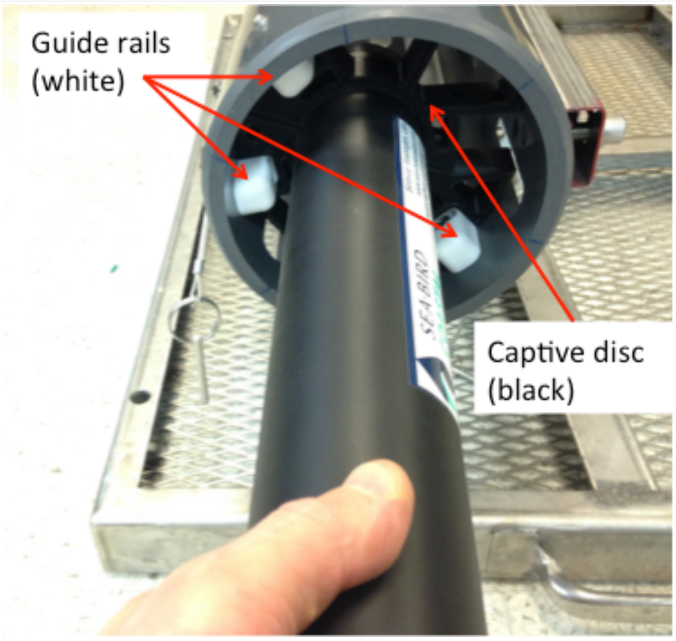


Figure 65. Remove sensor from PVC enclosure.

STEP 8 | Slide the sensor assembly out of the enclosure by grabbing onto the wiper housing at the top of the sensor (**Figure 65**). The color of the captive discs may vary, but the design and material are the same across stream sites.

STEP 9 |Install the captive discs on the SUNA, if applicable. These must align with the pinholes on the PVC enclosure. The most common issue that arises when removing/reinstalling the captive discs is when attempting to align the discs with the pinholes in the PVC enclosure. HQ recommends reinstalling the SUNA with captive discs into the enclosure, *out of the water*; it makes it a lot easier to align the discs with tiny pinholes on the PVC when they are not masked under blurry water. Skip this step if personnel did not remove the sensor with captive discs.

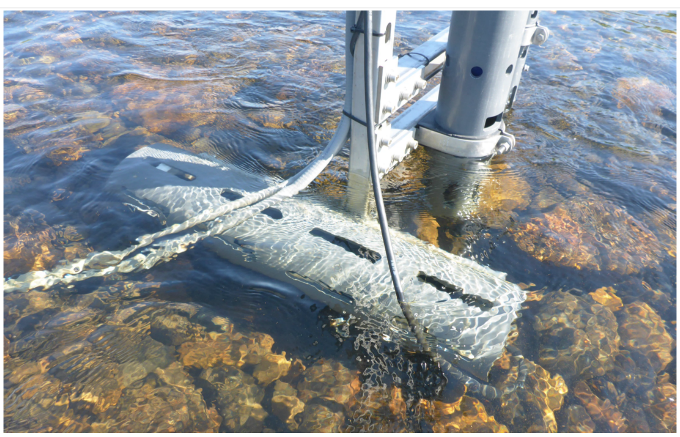


Figure 66. S2 SUNA enclosure at D18 OKSR.

Even in clear water (**Figure 66**), it is difficult to see the pins.

Use a scrub brush and stream water to remove biofouling that may make it difficult to align the pinholes with the captive discs.

STEP 10 | Install the SUNA enclosure on the main vertical support anchor so that it is ±5cm above or below the Multisonde probes. The SUNA power cable should exit the enclosure towards downstream. *Reference AD [11] and AD [09] to review stream installation and verification procedures.*

PRO TIP: *slightly thread the nut on the screw first before reinstalling the SUNA enclosure because it is difficult to reach under and place the nut on the screw after enclosure mounts to the anchor.*

STEP 11 | Reinstall a new 12V Merlot Grape into a Grape Shield by threading the four screws that affix the Grape to the Grape Shield using a hex wrench.

Figure 67. Reconnect sensor and ethernet cables to Grape.

STEP 12 | Remove dust caps on sensor connectors and Eth-To-Comm connector. Re-connect sensor and armored Ethernet cable in accordance with AD [06].

Use the dust caps from the new Merlot when shipping back the old Merlot for Sensor Refresh.

Figure 68. SUNA cable dressing

STEP 13 | Dress cables with zip ties to look as shown in **Figure 68.**

Use flush cuts to cut off the remaining zip tie to ensure the cut zip tie is flush. Do not litter the site with leftover zip ties. Ensure these are disposed of properly.

STEP 14 | Restore power to S2 from the Combo Box.

STEP 15 | Verify the SUNA data streams are present via the Location Controller (LC) and the sensor shows data streaming in one of our in-house remote monitoring tools. If the SUNA is not streaming data, ensure the SUNA CFGLOG is accurate in Maximo.

6.2.2 Lake and River AIS Buoy Sites

6.3 For lake and river sites reference Section 6 in *AD [07], NEON.DOC.004613 NEON Preventive Maintenance Procedure: AIS Buoy* for removal and replacement procedures. Cleaning & Packaging of Returned Sensor

Field Science staff decontaminate, package, and ship sensors back to the CVAL at the NEON Program HQ (Battelle) for annual Sensor Refresh (swap)/calibration requirements (Please note: if a sensor is defective, submit an incident in Service Now and affix a red tag with the incident number on it (**Figure 70**)).

Note: Asset tags for each sensor must return with the sensor shipment to HQ. Each sensor must reflect CFGLOC changes in the NEON Program Asset Management System. If an asset tag is missing for a sensor, contact the NEON HQ property management office for guidance and awareness for when the shipment arrives at HQ.

Important: DO NOT tamper with, change, or reassign asset tags from Data Generating Device (DGDs) without direct consent from HQ property management office. This prevents chain of custody and/or data issues that tie to asset tags.

6.3.1 Decontamination

Conduct decontamination procedures when shipping the sensor to HQ for annual Sensor Refresh, Winterization or Repair Lab. In addition, per NEON.AIS.4.1735, all vehicles, trailers, boats, tools, protective outerwear, and any other items that encounter an aquatic or riparian environment, require decontamination prior to site access. Reference *RD [05], NEON.DOC.004257 NEON Standard Operating Procedure (SOP): Decontamination of Sensors, Field Equipment and Field Vehicles* for instructions to prevent cross-contamination of invasive species and other biological matter from sites.

Note: Field Science must not transport non-decontaminated sensors in the same shipping and packing materials that are for shipping decontaminated sensors to CVAL. Use a plastic liner to protect the shipping materials from site biologics.

6.3.2 Storage

Follow the packing procedures in Section 6.3.3 for short-term storage of the sensor, as applicable.

6.3.3 Packaging

Post-decontamination, follow the procedure below to pack the SUNA to prepare it for shipping and handling.

1. Clean and lubricate the SUNA dummy plug per Section 5.3.4.
2. Attach the dummy plug and twist to secure to sensor.
3. Conduct sensor decontamination per Section 6.3.1.
4. Manually place the wiper in the upward position for shipping.
5. Place the clean, dry sensor into a Pelican case or equivalent for shipping (or storage). **Figure 69** displays the SUNA in a pelican case.

Figure 69. Example of SUNA for shipping/storage.

6. Use the manufacturer-provided case for transport (Pelican case). The Domain is responsible for replacing the case if damage or the case is missing. Contact Sea-bird Scientific for ordering information.
7. Label the package as FRAGILE and secure it on the shipping crate or ship separately if SUNA issues require shipment back to HQ other than during the site-specific annual Sensor Refresh.

Note: For any Non-CVAL initiated sensor returns, please notify CVAL of the return via the NEON program's issue management system. Reference KB0012946 Mandatory Information Requirements for Returning Instrument System (IS) Items to HQ via ServiceNow.

6.4 Sensor Refresh 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. ***Reference RD [08] for the standard operating procedures for the annual Sensor Refresh process and delineation of sensor, administrative and logistical requirements.***

6.4.1 NEON Asset Management and Logistic Tracking System Requirements

Field Science must update the instrumentation records via the NEON's project Asset Management and Logistic Tracking System (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. Reference RD [08] for additional information on Sensor Refresh administrative procedures. Ensure the CFG location reflects the current site of the sensor. All devices leaving a CFGLOC must move to SITE first, then TRANSIT/DxxSUPPORT.

Note: In general, to minimize errors for CI, all devices leaving a CFGLOC must move to SITE first, then TRANSIT/DxxSUPPORT.

Note: An important exception when assigning CFG locations are Grape data loggers. Grapes remain at the SITE level (a four-letter site code) or a more specific location within the hierarchy. Do not assign Grapes to a CFG location using the "CFGLOC" prefix. Grapes are data loggers and log data from sensors from specific CFG locations.

After installation of the sensors, verify sensor data state of health (Data Product) in PuTTy, DQ Blizzard and/or the IS Monitoring and Control Suite the next day. Validate sensor data stream(s) and L0 data is within an expected range for your site. Monitor the sensor frequently after maintenance activities to ensure it continues to function as expected through remote monitoring.

6.4.2 Remote Connection Program Information Requirements

For AIS Buoy sites, if there is a need to access LoggerNet™ (Profiler and MET Software) remotely (from the Domain or HQ), ENG must shut down the RTU program for the site (software that collects and transmits the data from the AIS Buoy to HQ). The RTU program uses the same port we would use to connect remotely to communicate with LoggerNet™. Generate a request via the NEON Issue Management/Reporting System to coordinate to contact the Software Engineers in the NEON HQ, Engineering Department. Otherwise, verify the Buoy sensor data from the Oz Grape using PuTTy (note the data streams are collected in bursts via radio transmission).

7 ISSUE REPORTING OUTPUTS

Use this metadata sheet in **Table 16.** SUNA Issue Reporting Datasheet to track and/or communicate maintenance tasks and findings by technician/site/date. Follow local paper-based and electronic record management procedures.

Table 16. SUNA Issue Reporting Datasheet.

Issue Reporting Datasheet		
Datasheet field	**Entry**	
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 Validation – Drift Test	☐	
SUNA Validation – Configuration Check	☐	
SUNA Available Lamp Time Check	☐	Available lamp time:
SUNA Self Test Check	☐	Spec Lght av:
SUNA Validation – Reference Check	☐	
SUNA Calibration – Reference Spectrum	☐	
Sensor - Other Specific Checks *(Sensor and cable ties are secure, 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		

For SUNA corrective actions, ensure proper tracking of the asset via the NEON Issue Management and Tracking System (i.e., ServiceNow) to establish a chain of custody of the asset between Engineering Manufacturing 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 an AIS site, create an incident and assign incident tasks to HQ personnel in the NEON Issue Management and Reporting System for the defective asset from the reported issue.
2. Ship all defective equipment/assets with a red "Rejected" tag. **Figure 70** displays the minimum information requirements for each tag.

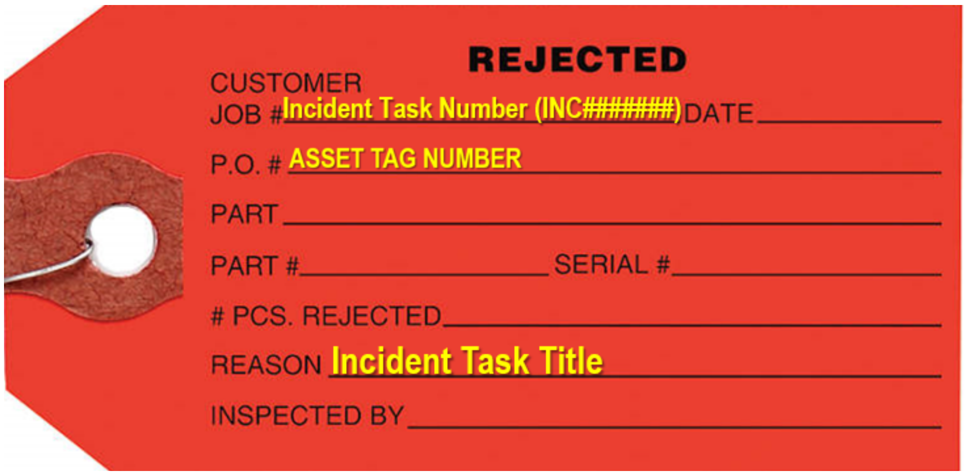


Figure 70. Red Rejected Tag for Defective Assets (MX104219).

8 APPENDIX A: PREVENTATIVE MAINTENANCE QUALITY ASSURANCE DATASHEET

Table 17 provides the minimum standard for information Field Science must capture either electronically or via paper-based methods when conducting preventive maintenance on this sensor. Follow local paper-based and electronic record management procedures.

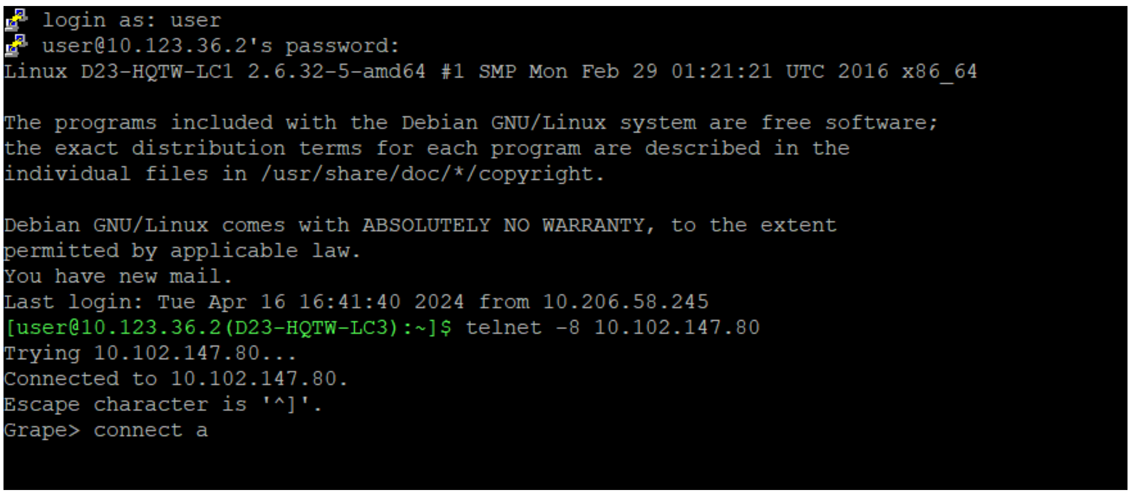
Table 17. Preventative Maintenance Quality Assurance Datasheet.

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

9 APPENDIX B: REMOTE CONNECTION & BASIC TROUBLESHOOTING

To check or reconfigure the SUNA settings remotely, use the procedures in Table 18 Note that this procedure is only applicable for SUNA's at wadeable stream sites that are connected to a GRAPE. Buoy SUNAs must be reconfigured on-site.

Table 18. How to Remotely Connect to the SUNA.

Step #	Instructions
1	Determine the IP address of the GRAPE the SUNA is connected to.
2	Connect with the LC and type "**telnet -8**" followed by the Grape IP address (e.x. **telnet –8 10.102.147.80**) and then press the "**Enter**" key.
3	Figure 71At the prompt "Grape>", type "connect a" then press the "Enter" key.  **Figure 71.** Connect to SUNA using telnet.
4	Output from the SUNA should appear. Either the prompt "**SUNA>**" or the following: **[2017/08/16 17:02:42] vMainNitrateTask()::INFO-Start SUNA SN:0838 V2, FW 2.5.1** **[2017/08/16 17:02:42] vMainNitrateTask()::INFO-Charge power loss protector.** **[2017/08/16 17:02:44] vMainNitrateTask()::INFO-Reset from power cycling, sv telemetry wakeup** Continue pressing combinations of "**$**" and "**<enter>**" until the "**SUNA>**" prompt appears.
5	Once the "**SUNA>**" prompt appears, type "**get cfg**" and press **enter**.
6	Compare this list of parameters in accordance with AD [04] to verify they are correct.
7	If a parameter is incorrect, use the command "**set**" followed by the parameter name, and then the new value (e.x. "**set OPERMODE Periodic**" or "**set LGTSMPLS 20")**" and press "E**nter**" key. If successful, "**$Ok**" is returned before the next "**SUNA>**" prompt. Ensure CVAL is aware of any changes to the configuration outside of field calibration/reference spectrum updates. Capture the "**get cfg**" before and after the changes and submit them to CVAL via ServiceNow.
8	Repeat Steps 6 and 7 until all SUNA configuration parameters are correct.
9	Type "**exit**" and press "**Enter**". The "**SUNA>**" prompt should disappear and the following output may also appear: **SUNA> exit**

Step #	Instructions
Critical Process Step!	**$Ok** **SUNA>** **[2017/08/16 17:05:34] mode_Periodic()::INFO-Down until 2017/08/16 17:15:00** **[2017/08/16 17:05:36] vPLSTask()::INFO-Power is off, shutting down.** ⚠ **Warning:** Without the proper "exit" command, the SUNA will be waiting at the "SUNA>" prompt and will never run or send data. If the SUNA was disconnected without exiting properly, reconnect and type "$" and <enter> combinations until the "SUNA>" prompt appears and then type exit. **If in doubt, repeat this procedure until you are confident the SUNA is properly disconnected.**
10	This should return you to the "telnet>" prompt. Type "quit" and hit "Enter" to disconnect from telnet.
11	After reconfiguring a SUNA, the GRAPE should be power cycled for 15 minutes. Then, verify the SUNA is streaming to the LC using Grafana.

10 APPENDIX C: SUNA POWER CABLE ASSEMBLY DRAWING

The SUNA power cable (**Figure 72**) and wiring (**Figure 73**) are for reference purposes.

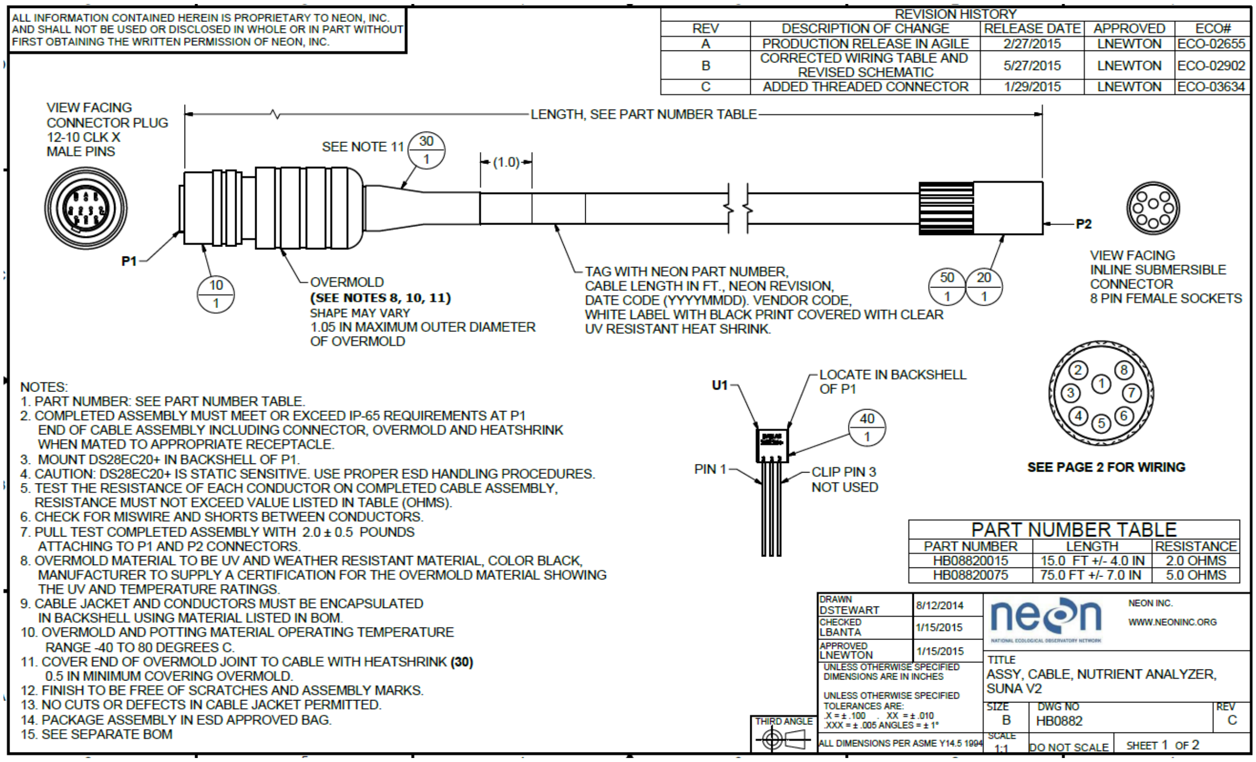


Figure 72. SUNA Power Cable Drawing.

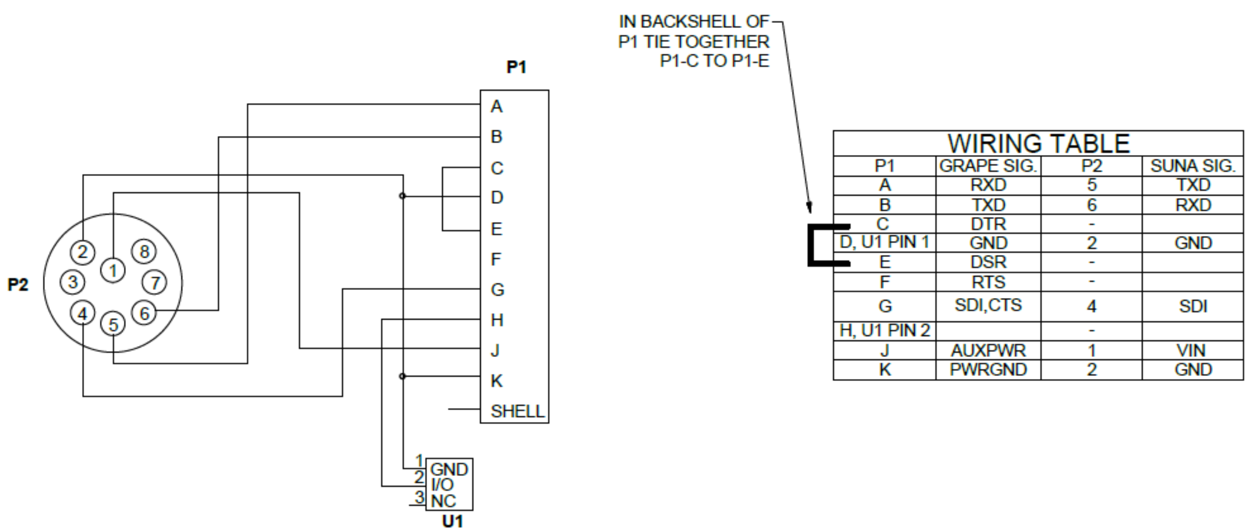


Figure 73. SUNA Power Cable Wiring.

11 APPENDIX D: MONITORING SUNA DATA FOR PROBLEMS

Use Grafana to monitor SUNA data in real-time. https://grafana.issites.gcp.neoninternal.org/.

The status should be "Up" and all the bars should be completely green. The top bar indicates that lamp is turning on and collecting light measurements. The middle block indicates whether the data block of 1 dark and 20 light bursts is complete. The bottom bar indicates that all 256 spectral channles are present and the data was not dropped mid-burst. If you see your SUNA is offline or streaming intermittently, create an INC in Service Now, tagging a member of the AIS Science Team.

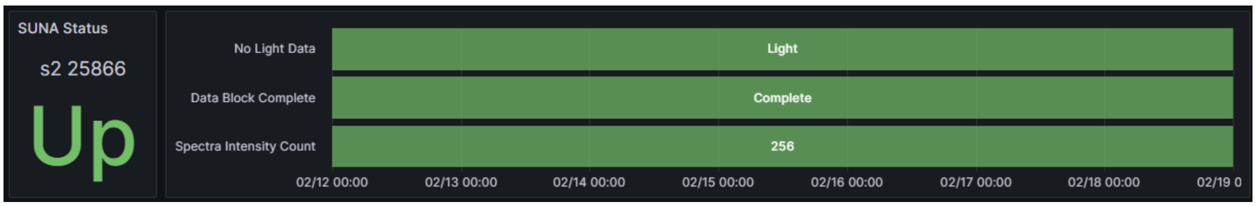


Figure 74. SUNA status bar in Grafana.

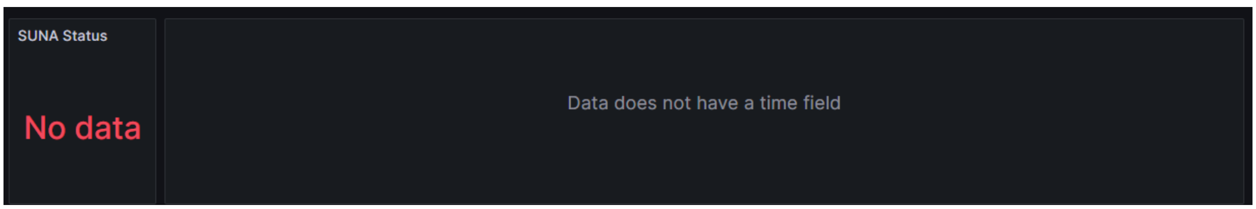


Figure 75. SUNA that is offline.

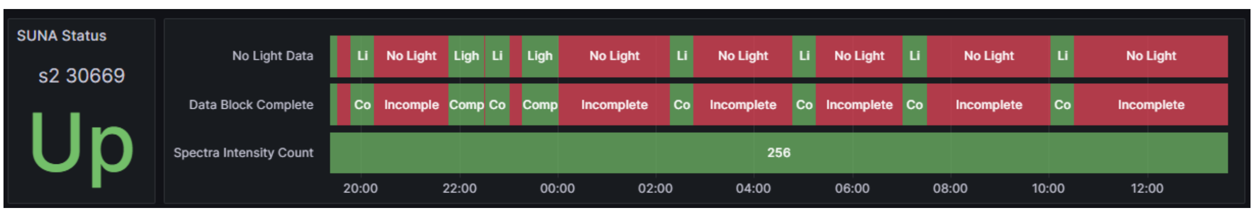


Figure 76. SUNA that is streaming intermittently.

This plot shows the nitrate concentration being measured by the SUNA. For nitrate, 1 µmol/L = 0.014 mg/L. Nitrate concentrations vary across NEON sites, and also within sites in response to season and discharge. You should get an idea of the range of expected values for your site.

Figure 77. SUNA nitrate concentration in Grafana.

Negative values indicate the measured nitrate measured is less than in the calibration blank (which is assumed to be 0). This can happen when water levels drop and the SUNA is reading in the air. It also can happen because of contaminated DI during calibration. If it happens consistantly, consider purchasing HPLC water for calibration. Values of exactly "-1" are the SUNA's error code for low transmittance. Normally this happens when the optical window is obstructed by biofouling, sediment, or a broken wiper, but can also happen when the water is especially turbid or tannic.

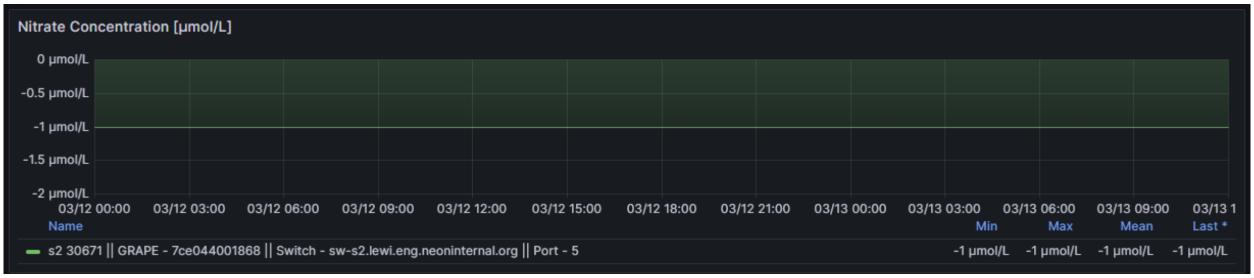


Figure 78. SUNA reading "-1" in Grafana.

This plot shows the SUNA voltage. The main voltage should be around 10V, the Internal voltage should be around 5V, and the lamp voltage should be around 12V.

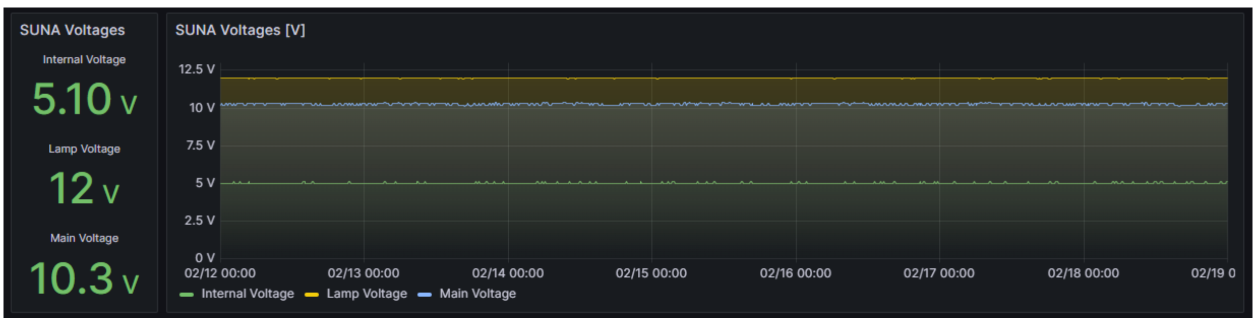


Figure 79. SUNA voltage in Grafana.

This plot shows the SUNA lamp temperature. The maximum operating temperature of the SUNA lamp is 35° C. Above this temperature the lamp will not turn on and collect light measuremnts to prevent damage from overheating. This most often happens when the SUNA is removed from the water for calibration.

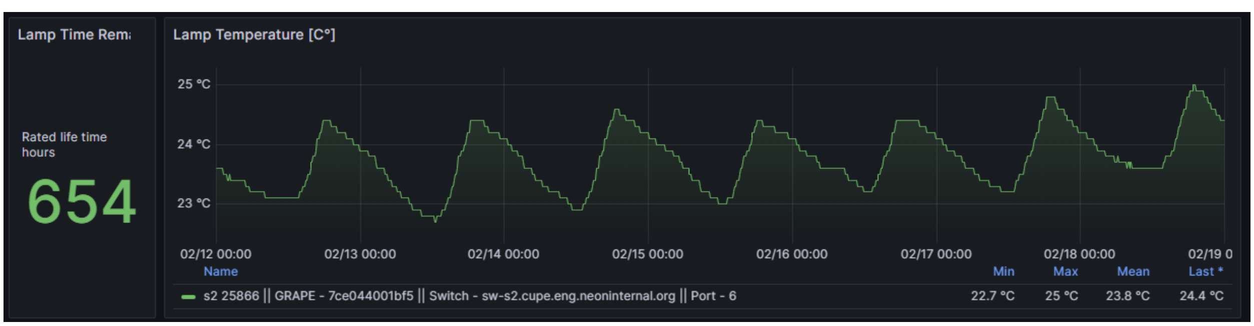


Figure 80. SUNA lamp temperature in Grafana.

This plot shows the SUNA internal humidity. High humidity indicates a potential leak in the body of the SUNA.

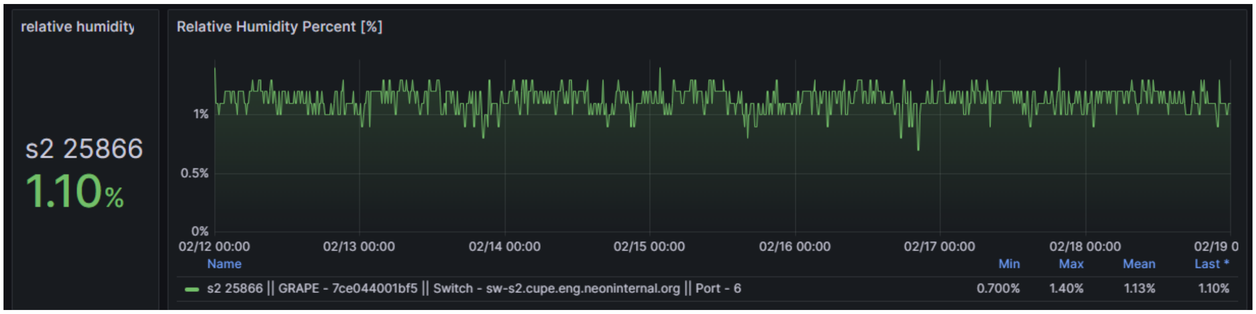


Figure 81. SUNA relative humidity in Grafana.