NEON PREVENTIVE MAINTENANCE PROCEDURE: AIS SURFACE WATER LEVEL

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	02/20/2018	ECO-05412	Initial release.
B	05/13/2019	ECO-06100	Updated Section 5 to cease quarterly removal and cleaning of the sensor per KB0011739. Removed references to JIRA, and changed NEON Project to NEON Program, Field Operations to Field Science, and Battelle Ecology, Inc. to Battelle. Updated PM Template to reflect new program logo. Made minor edits to fix typos/graphics for clarity.
C	03/16/2022	ECO-06785	• Update to reflect change in terminology from relocatable to gradient sites.
D	MM/DD/2023	ECO-07049	Updated Section 6.2.1.2 Step 7 and Figure. 16 and Section 6.2.2.2 Step 7 and Figure. 22. (KB0012709)

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1 DESCRIPTION

1.1 Purpose

NEON sites host sensors that take measurements from air, wind, water, soil, and sun. Regular maintenance of sensors and infrastructure is necessary for the continued operation of the observatory. It is important to identify small problems before they escalate.

This document establishes mandatory procedures and recommended practices for preventive maintenance of the **AIS Surface Water Level** sensor 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 sensors and infrastructure with the goal of ensuring that the instrument and/or infrastructure performs correctly to ensure the collection of the best available science, by preventing excess depreciation and impairment. This maintenance includes, but is not limited to, inspecting, calibrating, adjusting, cleaning, clearing, lubricating, repairing, and replacing, as appropriate. The procedures in this document are strictly preventive and do **not** address corrective actions.

This document addresses preventive maintenance procedures to maintain the In-Situ, Inc. Level TROLL 500 (***0317680000***) water level sensors at Aquatic Instrument System (AIS) sites. This procedure specifically addresses surface water level sensors for AIS inlet/outlet sites (***HB03570000*** *AQU Lake Inlet/Outlet, Sensor Set Enclosures, Level Troll*) and AIS stream sites (***HB03590000*** *AQU Mid Channel, Sensor Set, Enclosures, Level Troll*). This includes preventive maintenance procedures and requirements for the instrument, subsystem and supporting infrastructures.

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	Environmental, Health, Safety And Security (EHSS) Policy, Program and Management Plan
AD [02]	NEON.DOC.004301	EHSS Environmental Protection Manual
AD [03]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD [04]	NEON.DOC.001972	AIS Comm Interconnect Map
AD [05]	NEON.DOC.000620	AIS Verification Checklist
AD [06]	NEON.DOC.003880	NEON Preventive Maintenance Procedure: AIS Stream Infrastructure
AD [05]	NEON.DOC.003838	Assembly Instruction, HB03590000, AQU Mid Channel, Sensor Set Enclosures, Level Troll
AD [08]	NEON.DOC.001175	NEON Sensor Command, Control and Configuration (C3) Document: Level TROLL 500
AD [09]	NEON.DOC.004456	LAKE INLET / OUTLET DATA ACQUISITION SYSTEM (DAS) FORMAL VERIFICATION PROCEDURES
AD [10]	NEON.DOC.003162	AOS Protocol and Procedure: Wadeable Stream Morphology
AD [11]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure
AD [12]	NEON.DOC.003827	Assembly Instruction, HB03570000, AQU Lake Inlet/Outlet, Sensor Set Enclosures, Level Troll
AD [13]	NEON.DOC.004362	NEON Preventive Maintenance Procedure: AIS Groundwater Wells
AD [14]	NEON.DOC.002757	NEON Preventive Maintenance Procedure: Underwater Photosynthetically Active Radiation (uPAR)
AD [15]	NEON.DOC.005038	NEON Standard Operating Procedure (SOP): Sensor Refresh

2.2 Reference Documents

The reference documents (RD) listed below may provide complimentary information to support this procedure. Visit the NEON Document Warehouse for electronic copies of these documents.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles
RD [04]	NEON.DOC.001637	NEON Preventive Maintenance Procedure: Aquatic Meteorological (Met) Station
RD [05]	NEON.DOC.003299	STCDD - 0317680000 Sensor In-Situ Level TROLL 500 15 psig (gauged) Surface Water Level Sensor
RD [06]	NEON.DOC.004822	Domain 14 (D14) AIS Sycamore Creek (SYCA) Alternate Power Site Standard Operating Procedure (SOP)

RD [07]	NEON.DOC.002767	AIS Subsystem Architecture, Site Configuration and Subsystem Demand by Site – SCMB Baseline
RD [08]	NEON.DOC.004651	Domain 18 (D18) AIS Oksrukuyik Creek (OKSR) Alternate Power Site Standard Operating Procedure (SOP)
RD [09]	NEON.DOC.004752	NEON Installation, Operation & Maintenance Procedure: Mobile Deployment Platform (MDP) Aquatics Module
RD [10]	NEON.DOC.004418	River Sensor Infrastructure Formal Verification Procedure
RD [11]	NEON.DOC.002556	L1A300 Aquatic Pressure Calibration Fixture Manual
RD [12]	NEON.DOC.004685	RP Fuel Cell Standard Operating Procedure (SOP)
RD [13]	NEON.DOC.004977	ARP Fuel Cell Standard Operating Procedure (SOP)

2.3 External References

External references contain information pertinent to this document, but are not NEON configuration-controlled. Examples include manuals, brochures, technical notes, and external websites.

ER [01]	In-Situ, Inc. Level TROLL 400, **500**, & 700H Operators Manual. 0052210 | Rev. 009, 2013. *https://in-situ.com/wp-content/uploads/2014/11/Level-TROLL-400-500-700-700h_Manual.pdf*
ER [02]	In-Situ, Inc. Level TROLL 500 Data Logger. *https://in-situ.com/products/water-level-monitoring/level-troll-500-data-logger/*
ER [03]	In-Situ, Inc. Care and Maintenance of Aqua TROLL® and Level TROLL® Instruction Sheet. *https://in-situ.com/wp-content/uploads/2014/11/Aqua_Level_TROLL_Maintenance_Guide.pdf*
ER [04]	In-Situ, Inc. TROLL® Shield Nose Cone Information Sheet. *https://in-situ.com/wp-content/uploads/2014/11/Antifouling-TROLL-Shield-Nose_Instruction.pdf*
ER [05]	In-Situ, Inc. Antifouling System Extends Instrument Deployment by Up to Six Weeks. *https://in-situ.com/wp-content/uploads/2015/01/Antifouling-System-for-the-Aqua-TROLL-200-Instrument-Extends-Instrument-Deployment-by-Up-to-Six-Weeks.pdf*
ER [06]	W.A. Hammond Drierite Co., LTD, Drierite, Indicating Safety Data Sheet (SDS), *https://in-situ.com/wp-content/uploads/2014/11/blue_silica_gel_sds.pdf*
ER [07]	In-Situ, Inc. Extra Large Desiccant, Part Number 0090420, Instruction Sheet. *https://in-situ.com/wp-content/uploads/2014/11/Extra-Large-Desiccant_Instruction.pdf*
ER [08]	In-Situ, Inc. Level TROLL Maintenance Kit, Part Number 0052530. https://in-situ.com/products/accessories/level-troll-maintenance-kit/
ER [09]	In-Situ, Inc. Desiccant Refill Kit, Part Number 0029140, Instruction Sheet. *https://in-situ.com/wp-content/uploads/2014/11/Desiccant-Refill-Kit_Instruction.pdf*
ER [10]	In-Situ, Inc. TROLL O-Ring Replacement Kit Instructions. *https://in-situ.com/wp-content/uploads/2014/11/TROLL-O-ring-Replacement-Kit_Instruction.pdf*

2.4 Acronyms

AOS	Aquatic Observation System
AQU	Aquatic
ESD	Electrostatic Discharge
kPa	Kilopascal
P/N	Product Number or Part Number
PRPO	Prairie Pothole
PSI	Pounds per Square Inch

S-1	Upstream Sensor Set 1
S-2	Downstream Sensor Set 2
SUNA	Submersible Ultraviolet Nitrate Analyzer
TEP	Terminal Emulator Program
TOOK	Toolik Lake
V	Volt

2.5 Terminology

The use of common names for NEON instrumentation and subsystems vary across departments and domains. This section aims to clarify and associate the common names with the technical names herein. The aim of this section is to marry up terms under one name so Technicians are aware of the component referenced in the procedures herein, but also aware they may be called another term in a group discussion with headquarters or training staff.

SYNONYMOUS COMMON NAME(S)	NEON TECHNICAL REFERENCE NAME
Pressure Transducer, Water Level, Troll *Note: Ground Water Wells (GWW) use the Aqua Troll.*	**Surface Water Level Sensor, Level TROLL 500** (*0317680000, Sensor In-Situ Level TROLL 500 15 psig (gauged) Surface Water Level Sensor*)
Power Box, Comm Box, National Electrical Manufacturers Association (NEMA) Enclosure, Power/Comm Infrastructure	**AIS Device Post**
Power and Comm Box, NEMA Enclosure	**Combination (Combo) Box**
Aquatics Instrument System (AIS) power distribution system (PDS) and data acquisition system (DAS), Portal *Note: Equivalent to the Instrument Hut for Terrestrial Instrument System (TIS) sites*	**Aquatic Portal**

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 Science 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.

All 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.

In the event the current method to conduct the procedures herein are no longer safe for use due to unforeseen or unknown site dynamics, consult with the NEON Safety Office via the NEON Program's Issue Management and Reporting System (i.e., ServiceNow) for alternative methods to conduct AIS preventive/corrective maintenance and Sensor Refresh procedures.

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.

⚠ **WARNING!** The blue silica gel indicating desiccant (drying agent) from In-Situ, Inc. is effective for the sensor, but poses health hazards as a skin, eye or inhalation irritant (ER [06]). **DO NOT RECHARGE THIS INDICATING DESICCANT IN THE DOMAIN OFFICE.** The TOS Oven does not vent outside, it vents into the Domain Office. Review alternative desiccant ingredients to verify they are OK to recharge inside the Domain Support Facility.

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.

3.1.1 Electrical Safety Training

This procedure may require Technicians to work around systems with 240 Volts, which requires an Authorized Instrument System (IS) Technician to perform powering down/up the system from the power box circuit breakers in the Aquatic Portal, and Field Operations Manager approval. The sensor and

sensor Grape are below 50V and do not require this certification to perform basic field cleaning/inspection procedures.

4 SENSOR OVERVIEW (SENSORS ONLY)

4.1 Description

Figure 1. AIS Surface Water Sensor: In-Situ Level TROLL 500

The NEON Program uses the AIS Surface Water Level sensor, the In-Situ Level TROLL 500 (**Figure 1**), to measure surface water level in lakes and streams. The aim is to maintain the sensor underwater, as close to the stream/lake bed as possible, to prevent having to adjust the sensor during seasonal droughts and low flow events and maintain a consistent measurement location per site.

Figure 2 displays the location of the Level TROLL 500 for S-1 and lake outlet infrastructure. The instrumentation and subsystem location is the same for S-2 and lake inlet infrastructures. However, there are slight variations to installations of subsystems to accommodate location dynamics.

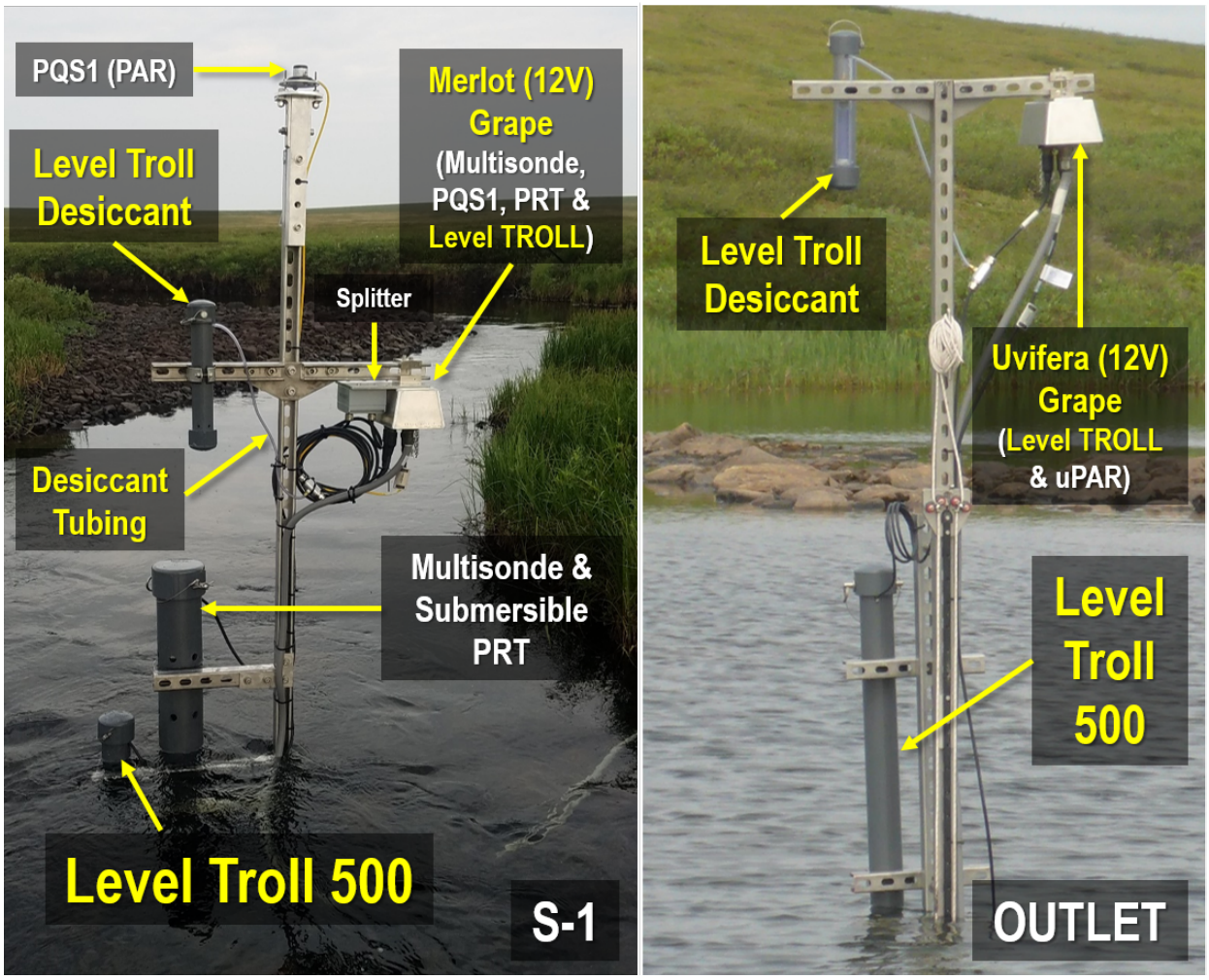


Figure 2. AIS Stream S-1 and Lake Outlet Subsystem Instrumentation and Infrastructure (D18 OKSR & D09 PRPO)

For stream locations, the Level TROLL 500 connects to a 12V Merlot Grape with the several other stream sensors (**Figure 2**), which connects to an AIS Device Post onshore to transmit data to the Aquatics Portal.

Note: Reference AD [06] for information on the stream instrumentation data and power subsystem infrastructure for various site substrates and high-water events.

For the lake inlet/outlet installations, the Level TROLL 500 shares a Uvifera[i] (12V) Grape with the uPAR, which connects to a Device Post onshore (**Figure 3**).

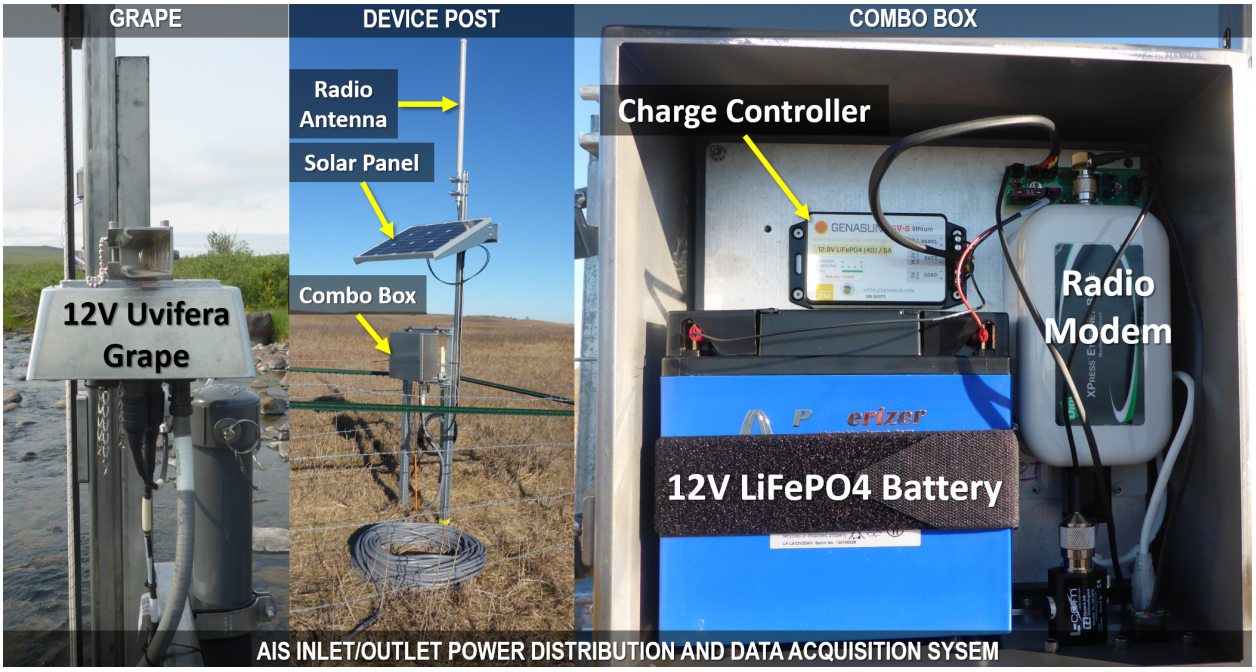


Figure 3. AIS Inlet/Outlet PDS and DAS Components (D09 PRPO & D18 TOOK)

The Inlet/Outlet device post and combo box design is almost identical to the GWW subsystem device post and power box. The radio transmits data from the inlet/outlet sensors to the Aquatics Portal.

4.2 Sensor Specific Handling Precautions

4.2.1 Instrument

The level TROLL 500 internal pressure membrane may crack if the sensor incurs damage from drops, falls or careless shipping and handling. Do not kink or bend the sensor cable when conducting maintenance/corrective action.

4.2.2 Subsystem

Grapes and PoE devices contain electrostatic discharge sensitive parts; therefore, all Grapes require ESD (antistatic) packaging and handling during inter- and intra-site transport, reception, and storage. As a rule, when handling (installing, removing, and servicing) these electrical components, all Technicians must ground themselves.

Note: When handling Grapes, follow ESD protocols (see AD [11]) and never hot swap sensor connections. When power is ON, disconnect the RJF/Eth-To Comm Box cable BEFORE disconnecting the sensor cable. Connect the sensor cable BEFORE connecting the RJF/Eth-To Comm Box cable.

The Aquatics Portal contains hazardous voltage (240V). Always wear PPE in accordance with AD [01]. Conduct a JSA to address electrostatic (ESD) and Lock-out/Tag-out (LOTO) procedures when handling/accessing or conducting maintenance on electrical and communication equipment.

4.3 Operation

The AIS surface measurement derives from the sensor measuring the surface water pressure of specific surface water bodies. This sensor provides data products for AIS and supports data products for Aquatic Observation Systems (AOS). AIS surface water depth and AOS wadeable stream and river discharge measurements create AOS continuous discharge measurement. Reference AD [08] for the command, control and configuration of this sensor. NEON HQ data quality personnel may flag the data with the help of Field Science Technicians reporting events using the NEON Program Issue Management and Reporting System using the "**AIS Data Quality**" component tag in the ticket, title and/or description.

Figure 4 displays the data acquisition system (DAS) and power distribution system (PDS) for the sensor in operation.

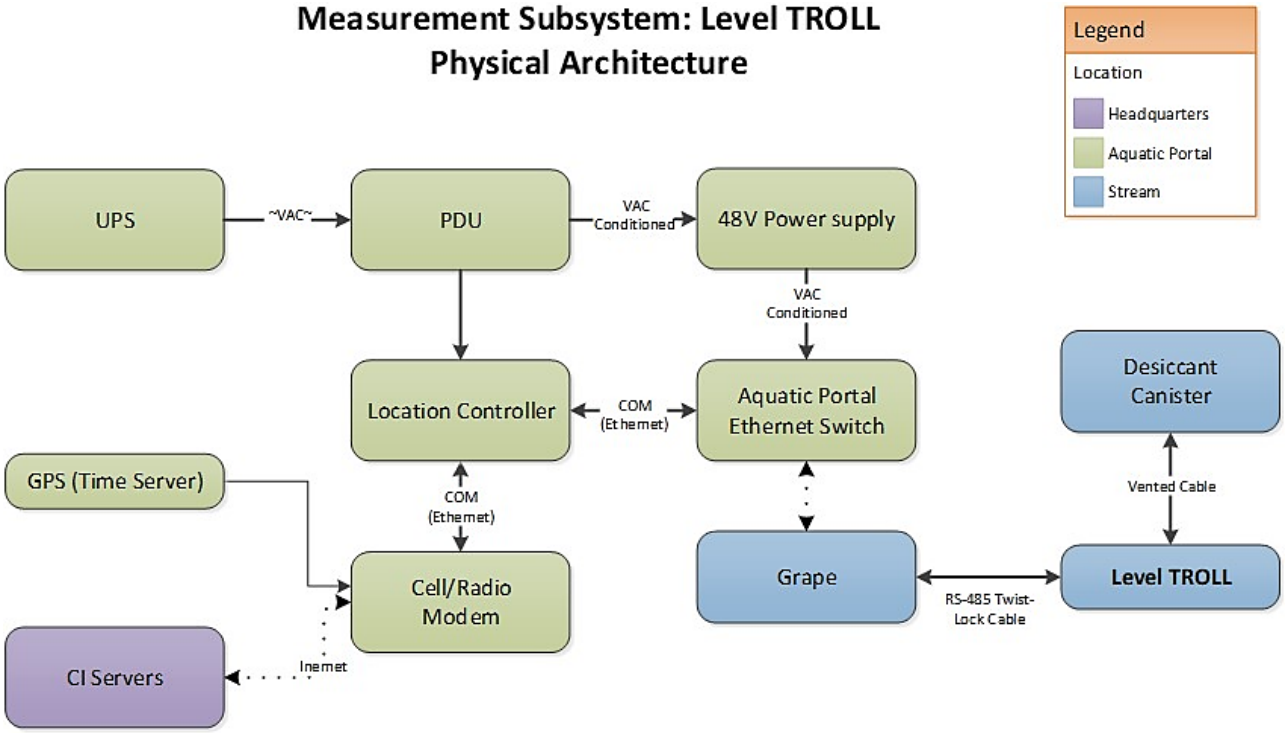


Figure 4. AIS Surface Water Level Sensor Physical Architecture in Operation

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Equipment

Note: When working on power systems, use tools with insulated handles.

Table 1. Maintenance Equipment List

P/N	NEON P/N	Description	Quantity
Tools			
GENERIC		Flush cutters/Scissors (to remove zip-ties)	1
GENERIC		Landscaping tools (to maintain vegetation around onshore subsystems)	A/R
NEON, IT		NEON Laptop (to connect to network in Aquatics Portal)	1
GENERIC		Ethernet Cable (to connect to network in Aquatics Portal)	1
GENERIC		Hex Wrench Set (for sensor swap/refresh)	1
GENERIC		Philipshead screwdriver (to access AIS device post combo boxes)	1
GENERIC		Aquatic PPE + Boat PPE	A/R
4620	MX103120	3M Antistatic Wristband (ESD Requirement)	1
GENERIC		Wash Bottle (for cleaning mixture or DI water)	1-2
GENERIC		5 Gallon Bucket (to catch cleaning materials/use to prevent contamination to aquatic sites)	1
GENERIC		Dry Brush (to remove biofouling/corrosion from infrastructure)	1-2
7187T23	0359490000	McMaster- Carr Supply Co. Hand Brush (to remove biofouling/corrosion from stainless steel/aluminum infrastructure)	1-2
GENERIC		Digital and/or Bubble Level (for verifying if infrastructure is level)	1
GENERIC		Funnel (to refill desiccant canisters with desiccant)	1-2
GENERIC		Bucket (to catch contaminants from PM procedures)	1-2
Consumable Items			
GENERIC		Paint pen/Sharpie Marker (to label infrastructure)	1
MS3181-10C MS3181-12C RJFC2G/SCP3181-18C-NE0N	CB08180000	Kit, Grape Dust Caps (Amphenol caps for Ethernet cables/Uvifera Grape)	A/R
GENERIC		Lint-free/microfiber cloths	A/R
34120	MX100642	Kimwipes/Cotton Swabs	1 Box
GENERIC		DI Water	A/R
GENERIC		5% acid white vinegar solution diluted by 50% water mixture	A/R
GENERIC		Clean tap water	1 Gallon
0719752		7” Zip-ties (to redress cables, as applicable)	A/R
0719793		14”Zip-ties (to redress cables, as applicable)	A/R
0090420	0320150001	In-Situ, Inc. Extra Large Desiccant Canister	A/R
0029140		In-Situ, Inc. Desiccant Refill Kit – See ER [06] SDS.	A/R
0052530		In-Situ, Inc. Level TROLL Maintenance Kit (contains O-Rings)	A/R
		High-Vacuum Grease (for O-Ring maintenance on connectors)	1
Resources			
PuTTY: http://www.putty.org/ or MobaXterm https://mobaxterm.mobatek.net/			
SAS: http://sas.ci.neoninternal.org/			
Location Controller (LC) State of Health (SOH) Application: http://soh.ci.neoninternal.org/			

P/N	NEON P/N	Description	Quantity
IS Control and Monitoring Suite: N:\Common\CVL\Field_Calibration\Required Directory\Test_Data\Current Executables\IS Control and Monitoring Suit			
Site Specific IP Addresses: N:\Common\SYS\Site Network Configurations			
Location Controller Username: user, password: resuresu			
Win-Situ 5 Software: https://in-situ.com/support/documents/win-situ-5-software/			
SSL for AIS Sensors and Subsystem Components: https://neoninc.sharepoint.com/sites/fieldops/database/FOPs%20Database/SitePages/Sensors.aspx?Department=AIS			

5.2 Subsystem Location and Access

Surface water level sensors reside at core and gradient AIS sites. These are upstream (S-1) and downstream (S-2) sites near the Aquatic Met Station subsystems and at inlet/outlet lake sites near AIS Lake Buoy sites. Subsystem components reside with the sensor on the infrastructure and/or onshore nearby. Access to these sites require a boat and Aquatic PPE prescribed by references in *Section 3 Safety and Training*. Access to sensor subsystem combo/power boxes may require the NEON combination code.

Note: Refer to site-specific As-Built documentation in the NEON SharePoint Document Warehouse to verify site-specific AIS Infrastructure and Sensor subsystems.

Note: Actions at S-1 may affect S-2. Be aware and execute preventive maintenance at S-1 with caution to prevent affecting the sensor measurements at S-2.

5.3 Maintenance Procedure

Table 2. AIS Level TROLL 500 Maintenance Schedule

Maintenance		Bi-weekly	Quarterly	Annual	As Needed	Type
AIS SURFACE WATER LEVEL SENSOR						
	Remote Monitoring	*Verify Data is Streaming Daily!*				P
	Visual Inspection of Sensor Infrastructure (do not move sensor)	X				P
	Visual Inspection of Sensor				X	P/R
	Check/Replace Desiccant	*X*			X	P
	Sensor Cleaning				X	P/R
	Replace O-Ring			X		P
	Winter Preparation for AK			X	X	P
Electrical & Communications Infrastructure						
	Remote Monitoring	X				P
	Visual Inspection	X				P
	Replace Cable Ties				X	R
	Clean Biofouling from Cables/Wires				X	P/R
	Clean Solar Panels		X		X	P/R
	Winter Preparation for AK			X		P

Maintenance		Bi-weekly	Quarterly	Annual	As Needed	Type
	Winter PM for Operational Sites				X	P
Inlet/Outlet Pulley System Infrastructure						
	Visual Inspection	X				P
	Clean Biofouling from PVC	*X*			X	P
P = Preventive, R = Repair, X = Indicates preventive maintenance task time interval may increase due to environmental (season/weather) or unforeseen/unanticipated site factors.						

5.3.1 Remote Monitoring

Conduct remote monitoring daily using the SAS report. To access static smart devices onsite, reference site-specific IP Addresses/Network Configurations via the NEON Network Drive (N:\Common\SYS\Site Network Configurations). Prior to traveling to the site, conduct a state of health check at the Domain on the sensors via their data streams using the SAS report for a daily snapshot, the LC SOH application for subsystem equipment, and/or IS Control and Monitoring suite to view sensor data streams. Field Science Technicians may also use terminal emulator program (TEP), such as PuTTy or MobaXterm, for real-time review of data streams. This action enables Technicians to prepare and prioritize any root cause analysis/corrective action to sensors onsite with missing or abnormal data streams on the level TROLL 500 sensors.

PRO TIP: *To perform these functions, Technicians must acquire the Grape MAC address and/or the EEPROM ID (from Maximo) of the sensor. This is available via the LC SOH or IS Control and Monitoring Suite. Use this to verify function of Grapes and Sensors post-Sensor Refresh, too.*

Note: For AIS sites using an Alternate Power System with no network connection, login to the LC onsite to view which sensors and subsystems are streaming. Remote monitoring from the Domain is unavailable for sites with no network connection.

5.3.2 Visual Inspection

An objective of AIS is to measure natural conditions. Maintenance of the infrastructure must result in little to no disturbance to the natural conditions of the AIS site. Employ care and use judgement when conducting maintenance on the site to mitigate or reduce our impacts to the site.

Conduct a visual inspection of components onsite to maintain structural integrity, science and engineering requirements. If the following tasks require corrective action, submit a ticket in the NEON Program Issue Management and Reporting System. **During visual inspections, do not move or disrupt the sensor placement/position.**

1. Inspect the infrastructure for fallen debris/trash, vandalism, or if any components seem out of place or display evidence of tampering (if sensors are not in their configured location, etc.).

2. After severe weather and/or high-flow events, inspect components for damage and/or if their installation location is no longer meeting science requirements due to seasonal changes or inclement weather events.

    a. The lake or stream substrate may bury the level TROLL 500 and even penetrate the sensor housing after a severe or high flow event. Depending on the composition of the substrate and amount of damage, the quality of the data may deteriorate. (Substrate compositions may or may not affect Level TROLL 500 sensor measurement collection. It depends on the amount and if the substrate does not enter the sensor housing.) Submit a ticket if emerging sensor data displays erratic measurements/measurement collection post-weather/high-flow event to determine corrective actions.

    b. Verify instruments are in accordance with site-specific science requirements. *Refer to site-specific As-Built documentation in the NEON SharePoint Document Warehouse to verify site-specific AIS sensors and subsystems.*

3. Inspect sensor mounts to ensure structural integrity/no evidence of tampering is present. Be careful to watch for snakes/biologics in sensor PVC housing. *Reference N:\Common\EHS to review Domain EHS plans to identify local potential hazards.*

4. Inspect vegetation growth around sensor infrastructure and device posts. Seasonal and environmental conditions may enable the growth of aquatic plant life. Trim vegetation around the onshore device posts to enable safe access to components requiring maintenance and/or troubleshooting.

5. Inspect the cables and connectors connecting to the sensor and device posts.

    a. Redress cables/replace cable ties, as appropriate.

    b. Verify connectors that are not in use have properly installed covers/dust caps.

    c. Check for evidence of corrosion, tampering, fraying, kinks or loose connections.

6. Inspect infrastructure mechanical components and associated AIS Device Post(s). Check structural integrity of Unistrut post, enclosures, cables, mounts, bolts, nuts, washers, and screws, etc. High-water stream installations and lake inlet/outlet subsystems are onshore.

    a. Ensure there are no insects/insect nests/rodents and/or rodent damage in the enclosures or to any of the other components (such as rodent damage to conduit, pull boxes, etc.). Employ caution and remove insect nests. Consult with the Domain Manager and NEON Safety Office in the event additional guidance is necessary to remove biologics, particularly bird nests.

b. If a site has cattle, verify structural components are intact from cattle grazing nearby infrastructure.

c. Inspect component hardware for deterioration (rust, corrosion, oxidation, etc.).

   i. If corrosion is present, attempt to clean/remove it with a wire hand brush (see **Table 1** for specific equipment information). Replace hardware, as applicable.

d. Inspect the Combo box door gaskets and ground strap to ensure they are not enabling water intrusions or biologics into the enclosure. Add washers to shim the enclosure to slightly non-level if water/condensation is accumulating in the device post box/boxes.

e. Inspect solar panels for debris, snow, or ice. Clean solar panels. If snow and/or ice are present on the panels, conduct the preventive maintenance procedures in *Section 8.4 Winter Maintenance for Operational Sites on page 41.*

7. Verify the infrastructure is level using a digital level. If the infrastructure is more than ±5° out of alignment, submit a ticket for AIS Science Staff to review and determine if corrective actions are necessary.

8. Inspect the Level TROLL desiccant housing/tubing and desiccant. Desiccant absorbs moisture from the top down. The black cap indicates the top.

   a. Replace desiccant before the entire volume turns pink or the alternative color change to indicate desiccant expiration. Desiccant requirements may vary across sites depending on relative humidity of each site. Expired desiccant (changes color when desiccant expires) may allow water build up in the vent tube, causing blockages that affect the sensor measurements. *Reference Section 5.3.3.5 to remove/replace and recharge expired desiccant.*

   b. Ensure there are no obstructions, bends or kinks in the vented cable/tube to the sensor. The minimum bend radius for the vented cable is 13.5 mm (0.54 in).

5.3.3 Level TROLL 500 Sensor Maintenance

5.3.3.1 Sensor Cleaning Procedure

The body of the level TROLL 500 sensor may require maintenance on an as needed basis to remove significant biofouling from the sensor. Do not remove the sensor without consulting with AIS Science. In order to use level troll data to develop rating curves, the level troll must be set at a constant depth. The level TROLL data requires that depth measurements be recorded at an uncertainty of 0.01m. Resetting the troll with even the smallest change in location creates a change in depth when one did not occur. The sensor itself is not particularly effected by biofouling; therefore, this procedure requires AIS Science approval before conducting in the field.

Removing biofouling enables the sensor to better capture accurate data. An example of significant biofouling is discovering biofouling on the sensor's black cap during Sensor Refresh. Field Science may clean the antifouling components under two conditions outside of the purview of AIS Science: (1) when removing the sensor for Sensor Refresh (sensor swap); or, (2) when removing the sensor for corrective maintenance (AIS Science is already notified of the sensor issue and to flag for data quality, so consulting for removal to clean is redundant/not necessary).

1. Power down the S-1/S-2 or inlet/outlet site. *Reference Section 6.2.2 or Section 9 for instructions on powering down a stream site from the Combo Box. Reference Section 6.2.1 instructions on powering down a lake inlet/outlet site from the onshore Combo Box (solar & battery combo).*
2. Remove the Level TROLL 500 from the stream or lake inlet/outlet infrastructure. *Reference* AD [06] *and Section 6.2.2 stream site removal instructions and Section 6.2.1 for inlet/outlet site removal instructions.*
3. Wear powder-free plastic gloves to handle and clean the sensor.
4. Clean the components with distilled water or with distilled water and mild detergent mixture to remove excessive biofouling/dirt build up. Use a soft brush or plastic scouring pad to clean.

***NEVER* submerge the connector portion of the instrument when it is not connected to a cable!**

5. Dry using a microfiber or lint-free cloth.
6. If unable to remove biofouling from these components using DI water/mild detergent, soak the components overnight in a mild acidic solution, such as household vinegar. Conduct this step in the domain laboratory.
7. Allow components to air dry or dry with a lint-free/microfiber cloth. If using a cloth, refrain from applying any pressure to the sensor diaphragm.

Under some circumstances, Field Science may encounter ice when servicing the sensor. Document ice presence/absence when conducting routine maintenance on the site. **DO NOT POUR ANY WARM WATER INTO THE INFRASTRUCTURE TO REMOVE SENSORS FROM ICE.** Leave the sensor installed onsite until the ice thaws. Monitor local weather forecasts, sensor temperature readings and monitor onsite ice development, where and when possible. Use previous winter ice on/off site data to determine general ice on/off monitoring timeframes for the site. In addition, for the level TROLL 500, protect the instrument from temperature extremes using the following guidelines: store within the temperature range -40° C to +80° C (-40° F to+176° F).[ii]

5.3.3.2 Pressure Port Cleaning Procedure

If the pressure ports in the front end of the sensor (**Figure 5**) contain silt or mud, try one or more of the following to remove the fouling. Do not remove the sensor without consulting with AIS Science in order to conduct this procedure.

Figure 5. Ports for Pressure Sensor

1. Agitate the instrument vigorously in a bucket of clean water.
2. Apply a gentle stream of water from a wash bottle.
3. Clear the front end with a cotton swab.
4. In severe cases, remove the nose cone and clean out the holes with a soft brush or pipe cleaner.
5. Allow components to air-dry. Wet reassembly is OK, too.

Note: The nose cone protects a sensitive pressure sensor diaphragm within the body of the sensor. Removing the nose cone completely exposes this sensitive component. Do not insert any object into the sensor opening or attempt to dig out dirt or other materials. Replace the nose cone as soon as possible!

The manufacturer recommends replacing the antifouling nose cone (*P/N 0081480 In-Situ, Inc. TROLL Shield Nose Cone*) every 12 months or sooner if site conditions are extremely harsh. Evaluate the longevity of the antifouling nose cone per site to determine future replacement schedules (NEON HQ expects these to last longer than 12 months at most sites.) Sites with visibly turbid water may require nose cone replacement more often. Use the condition of the nose cone to make a determination.

Figure 6. Sensitive Pressure Sensor Diaphragm (Level TROLL 500 without Nose Cone) ER [03]

5.3.3.3 Pressure Sensor Diaphragm Cleaning Procedure

If Field Science observes significant contamination, it may result in needing to conduct a deep cleaning of the sensor. This includes cleaning the sensor's pressure sensor diaphragm. This situation is rare. **Use the following cleaning procedure at the explicit consent/oversight of AIS staff.**

Note: Removing the protective guard from the Level TROLL 500 exposes the electrodes. While they are not extremely delicate, treat these with care and gently clean the components following the cleaning procedures in this section.

1. Soak the diaphragm for several hours using household vinegar.

2. Apply a gentle stream of undiluted vinegar using a wash bottle. Do not spray the pressure sensor directly. Use the wash bottle to spray the sidewalls and swirl the vinegar vigorously down around the sensor by gently rotating/swaying the sensor while spraying.
3. If necessary, use a cotton swab to **gently** clean the sensor. **DO NOT SHOVE OR PUSH CLEANING UTENSILS OR MATERIALS INTO THE SENSOR (Figure 6). The Pressure sensor is delicate and easily susceptible to damages from cleanings.**
4. Allow components to air dry or reassemble wet.

Note: Too much pressure may easily damage or scratch the sensor. If the above steps do not adequately clean the sensor, replace the sensor. Contact AIS Science Staff at NEON HQ to determine next steps.

5.3.3.4 Sensor Cables and Connector Maintenance

The cable connects to the sensor using a twist-lock connector. The desiccant canister uses the same connector. The sensor and cable are designed for frequent connection/disconnection during routine maintenance. Inspect these cables and connectors at each location to ensure they are intact without any breaks, cracks, or bends and securely connects to the level TROLL 500. If the cable contains bends/cracks, it changes the pressure reading of the sensor and affects data quality. Keep the pins on all connectors free of dirt and moisture by installing the soft protective dust caps when cable is not attached.

Inspect the cables and connectors for visible foreign material or wear and tear.

If Field Science observes a buildup of dirt, clean the cable or connectors with a clean, dry microfiber/lint-free cloth. *For more detail, refer to the In-Situ Inc. Level TROLL Owner's Manual (ER [01]) and/or AD [13].*

5.3.3.5 Desiccant Inspection and Maintenance

The level TROLL 500 uses a vented cable, which requires a desiccant canister (***0320150001*** *Desiccant Canister*) to prevent moisture/condensation accumulation in the vent tube. Excess moisture in the vent tube may cause blockages and is capable of causing irreparable damage and loss of data. It is important to inspect and manage desiccant swaps at a frequency to address site-specific characteristics to maintain the sensor state of health. Replace desiccant before it expires in order to prevent damage to the sensor's internal components. The in-situ, Inc. desiccant is estimated to last approximately nine months at 35°C with 90% relative humidity; however, use site conditions to establish an accurate expectation for desiccant exchanges. ER [07] provides additional information on this component.

The desiccant canister is a clear acrylic tube filled with 52 grams of replaceable indicating desiccant. It resides either on the stream and/or lake inlet/outlet infrastructure or nearby onshore (**Figure 7**). The vent tube attaches to the canister with the same style pin-lock connector as the level TROLL 500.

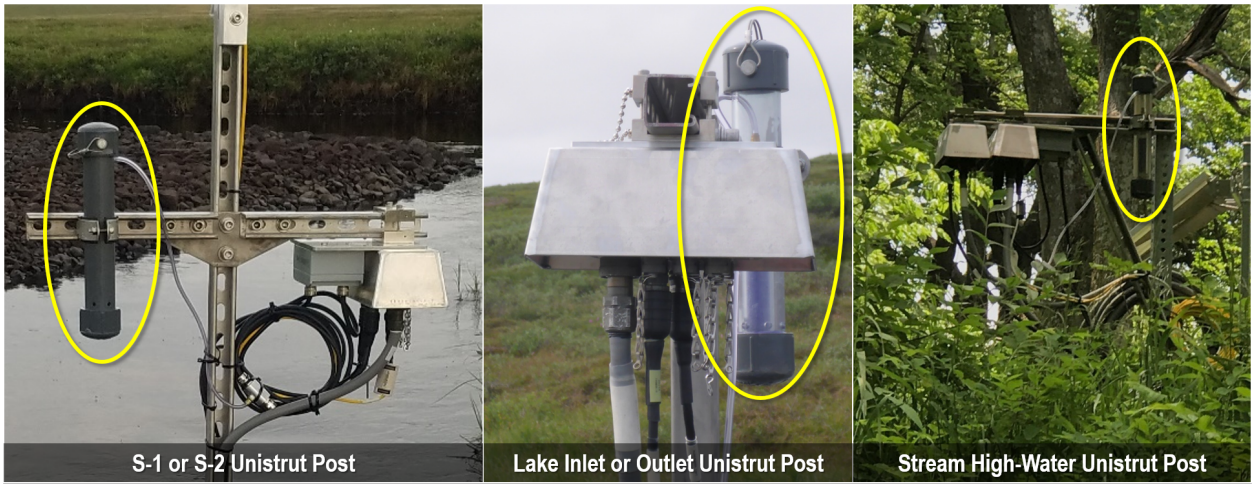


Figure 7. Level TROLL 500 Desiccant Canister Locations (Left to Right: D18 TOOK, D09 PRLA, D06 KING)

Inspect the desiccant housing, vent tube and connection points. Remove any foreign matter and clean the connectors with a clean, dry microfiber/lint-free cloth. Do not use abrasive cleaning devices, as a protective oxide layer will form on the metal components. The O-ring is part of the replaceable desiccator and does not require maintenance cleaning. Do not lubricate the O-ring.

Note: The pin-lock connection at the desiccant canister does not have a spring that gives a positive lock feel, an O-ring serves this purpose. Ensure the O-ring is not displaced, torn, or lost. FOPS must visually check that the connector ring is turned completely clockwise.

5.3.3.6 Desiccant Replacement Procedure

If more than 50% of the desiccant is pink or light purple, replace the desiccant. Conduct the following procedure to replace the desiccant canister:

1. Remove the cotter pin to remove the cap from the desiccant canister PVC housing.
2. Pull the desiccant canister out and remove the twist lock connector connecting the vented cable by rotating counterclockwise ¼ turn.
    - If the Domain has extra desiccant canisters, then swap a fresh desiccant canister with an old desiccant canister onsite. This is best practice, if possible.
    - If not, refill desiccant canisters over a bucket using a funnel. Remove the black nylon vent cap from the top of the desiccant to refill. The blue silica indicating desiccant from In-Situ, Inc. is toxic to aquatic life. Carefully refill canisters and NEVER spill any onsite. Move to a better location to refill desiccant if unable to complete this task without spilling/contaminating the site. ***Do not inhale the silica dust when pouring desiccant from one container to another!***
3. Install a new desiccant canister or refill with freshly recharged or new desiccant. Line up the flat side of the connectors, push, twist, and click to lock the desiccant canister to the cable.
    - Visually ensure the pins engage in the connector, twist clockwise ¼ turn to the stop.

- *Reference Section 5.3.3.6.1 to recycle expired desiccant.*
- Remove the red dust cap from the desiccant canister vent, if present.

4. Ensure there are no kinks or sharp bends in the tubing connecting to the desiccant canister and leading outside of the PVC housing/infrastructure.

5.3.3.6.1 Desiccant Recharge Procedure

⚠ **WARNING!** The blue silica gel indicating desiccant (drying agent) from In-Situ, Inc. is effective for the sensor, but poses health hazards as a skin, eye or inhalation irritant (ER [06]). **DO NOT RECHARGE THIS BLUE INDICATING DESICCANT IN THE DOMAIN OFFICE!** The TOS Oven does not vent outside, it vents into the Domain Office. Review alternative desiccant ingredients to verify they are OK to recharge inside the Domain Support Facility.

Recycle non-toxic desiccant by recharging it at the Domain Support Facility (DSF). Technicians may recharge the desiccant until it no longer returns to its original color. Please increase ventilation during this process by opening doors and windows to the facility.

1. Pour the expired desiccant into a separate plastic container.
2. In the Domain Office, evenly spread the expired desiccant beads on a non-stick oven tray.
3. Set the oven for 275°F. Bake in the TOS oven for 1½-2 hours.

PRO TIP: This is a good timeframe to clean dirty desiccant canisters, too!

4. Allow the desiccant to cool.
5. Refill desiccant canister(s) and reuse or store in an airtight container for reuse later. Cover the storage container opening with electrical tape.

5.3.3.7 O-Ring Inspection and Maintenance

The O-rings insure a watertight seal between the sensor connector (**Figure 8**). Per ER [03] and ER [10], examine O-rings for wear, dryness, discoloration, stretching, cracks, nicks, and brittleness during sensor refresh and after long durations of sensor deployment and after seasonal weather/ environmental changes/significant temperature fluctuations. Replace O-rings when any of these conditions are present. Replacing O-Rings on an annual basis, regardless their condition is the best way to protect against moisture damage. Perform the following steps to replace an O-ring.

Figure 8. O-Ring Location on Level TROLL Sensor

1. Remove and discard the damaged O-ring. The best method is to squeeze opposing sides between thumb and forefinger, then push sideways. This will slightly stretch the O-ring and force it out of the groove slightly on one side. Then roll it out of the groove with finger of other hand.
2. Use a clean, dry, soft cloth to clean the O-ring groove on the sensor to remove dirt or residue.
3. Lubricate the new O-ring sparingly using high-vacuum grease.
    a. Wash hands thoroughly.
    b. Apply a small amount of grease to the pad of index finger, and rub index finger and thumb together to spread the grease evenly.
    c. Inspect the new O-ring and remove any debris stuck to it.
    d. Rub fingers around the O-ring until there is a thin layer of grease on the entire O-ring.
4. Install the O-ring in the groove and remove any excess lubricant with a clean cloth.

Note: Do not allow water or lubricant to enter the connector!

6 REMOVAL AND REPLACEMENT (SUBSYSTEM ONLY)

6.1 Equipment

Table 3. Removal and Replacement Equipment List

P/N	MX/NEON P/N	Description	Quantity
Tools			
GENERIC		Flush cutters/Scissors (to remove zip-ties)	1
NEON, IT		NEON Laptop w PuTTy or MobaXterm	1
GENERIC		Extra Ethernet cable (to verify sensor function via portal onsite)	
GENERIC		Hex Key/Wrench Set	1
GENERIC		Wrench Set	1
GENERIC		Digital Level (for reinstallation of sensor, as appropriate)	1
GENERIC		Aquatic + Boat PPE	A/R
4620	MX103120	ESD Wrist Strap (to follow ESD protocols)	1
GENERIC		#2 Philips head screwdriver (to open power boxes)	1
GENERIC		Flathead screwdriver (to open combo boxes)	1
GENERIC		7/16” Open End / Box Wrench	2
GENERIC		3/16” Allen Driver	1
GENERIC		Dry Brush	1
Consumable Items			
3M		ESD Bags (for level TROLL and Grape swaps)	3
		Amphenol caps (for Ethernet cables/Grapes)	2-4
0719752		7” Zip-ties (to redress cables, as applicable)	A/R
0719793		14”Zip-ties (to redress cables, as applicable)	A/R
GENERIC		Contractor Trash Bags	A/R
0051130		In-Situ, Inc. Level TROLL 500 Replacement Black Nose Cone	A/R
0029810		Alconox Powder Detergent (biodegradable)[iii] for decontamination procedures	4 lbs. box
80337	0355220000	SAF-T-LOK SAFTEZE Food/Drug Grade Anti-Seize *Temperature Range: Lubricant -65 to 450°F | Anti-Seize -65°F to 2600°F*[iv]	1
Resources			
	PuTTY: http://www.putty.org/ or MobaXterm https://mobaxterm.mobatek.net/		1
	Location Controller Username: user, password: resuresu		1

Note: When working on power systems, use tools with insulated handles. Always shutdown the power prior to removing or replacing any components. Do not hot-swap (Power is ON) any component or sensor connections at AIS sites.

6.2 Removal and Replacement Procedure

The Field Science Domain Manager is responsible for managing the removal and replacement of the sensors onsite for preventive maintenance and/or sensor swaps and manages field calibration and validation of sensors, as appropriate. The NEON Program Calibration, Validation and Audit Laboratory (CVAL) is responsible for the calibration and validation of select sensors and manages Domain sensor

refresh (swap) schedules. ***Reference AD [15] 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. See **Table 4** for sensor refresh requirements for the subsystem infrastructure on the Level TROLL 500 Sensor.

Table 4. AIS Level TROLL 500 Sensor Refresh Requirements

	LOCATION		TIMEFRAME			
	CVAL	*FIELD*	*BIWEEKLY*	*ANNUAL*	*NA*	COMMENTS
Level TROLL 500 Sensor	X			X		Sensor cable and anti-fouling nose cone remains in the Domain. Return sensor with black nose cone and protective cap on cable end to CVAL. Follow ESD protocol.
Uvifera (12V) Grape	X			X		Follow ESD protocol
Merlot (12V) Grape	X			X		Follow ESD protocol

6.2.1 Lake Inlet/Outlet Subsystem Removal/Replacement Procedures

6.2.1.1 Uvifera Grape Removal/Replacement Procedure (Inlet/Outlet)

1. Employ ESD protocols when handling Grapes. Reference AD [11].
2. Power down the site at the AIS Device Post Combo Box. Disconnect the armored Ethernet cable connecting to the Combo Box (**Figure 9**).

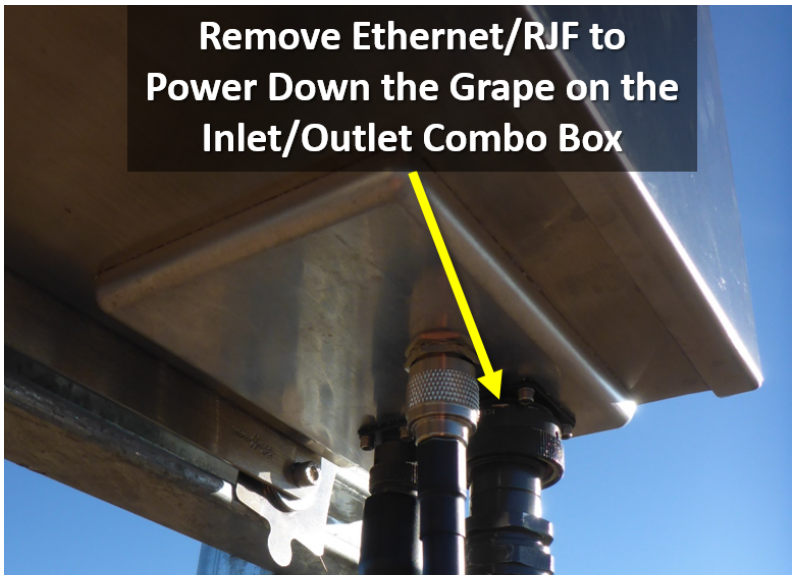


Figure 9. Power Down the Grape on the Inlet/Outlet Infrastructure

3. Disconnect the armored Ethernet cable connecting to the RJF/Eth to Comm connection.

4. Disconnect sensor connection(s).

5. Remove Uvifera (12V) Grape from Grape Shield (**Figure 10**). Remove the four screws that affix the Grape to the Grape Shield using a hex wrench.

Figure 10. Remove Grape from Grape Shields (D06 KING)

6. If there is a need to remove the Grape Shield from the Inlet/Outlet Infrastructure, remove the Grape Shield mount/clamp using a 3/16” hex wrench (**Figure 11**).

Figure 11. Remove Grape Shield with 3/16" Hex Wrench

PRO TIP: It is easier to reinstall the Grape in the Grape Sheild when the mount is removed from the infrastructure.

7. Install dust caps on Amphenol connectors of old Grape.
8. Reinstall new Grape to the Grape Shield by threading the four screws that affix the Grape to the Grape Shield using a hex wrench.
9. Remove dust caps on sensor connectors and Eth-To-Comm connector. Re-connect sensor and armored Ethernet cable in accordance with AD [04].
10. Re-energize the site and verify Grape and Level TROLL 500 Sensor function. Connect locally to the Aquatics Portal or from the Domain using a TEP and **Table 3**.

6.2.1.2 Sensor Removal/Replacement Procedure (Inlet/Outlet)

Table 5 addresses removing and replacing the Level TROLL 500 from Lake inlet/outlet locations.

Table 5. Inlet/Outlet Level TROLL 500 Sensor Removal/Replacement Procedure

 Figure 12. Power Down Site from Combo Box	**STEP 1** | Power down the site. Remove the cable connecting to the Ethernet/RJF and Grape on the bottom of the lake inlet/outlet combo box (solar/battery combo) (see Figure 12).

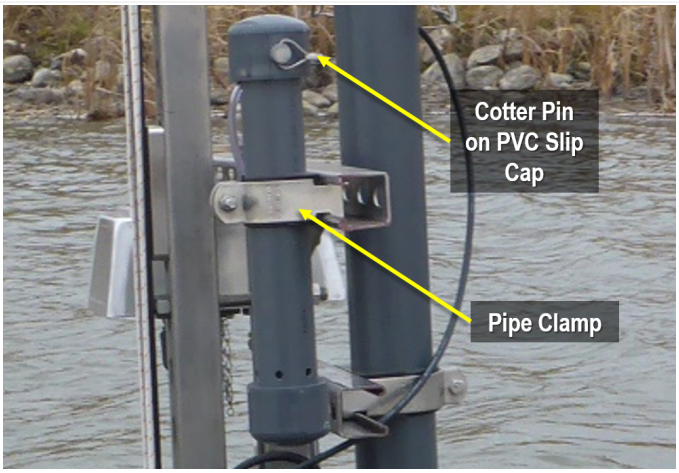


Figure 13. Remove Desiccant PVC Housing via Slip Cap

STEP 2 | Remove zip-ties from cables, as appropriate and disconnect sensor from desiccant.
Open the desiccant housing by removing the cotter pin from the PVC slip-on cap (Figure 13).
[OPTIONAL] If there is a need due to unforeseen issues, remove the PVC housing from the Unistrut via its pipe clamp (Figure 13).

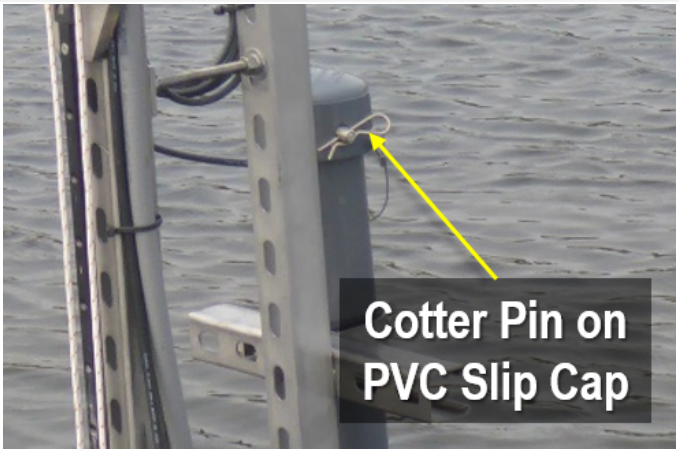


Figure 14. Remove Cotter Pin from PVC Slip Cap to Access Sensor

STEP 4 | Remove the cotter pin from the PVC slip-on cap (Figure 14). Inside the tube, remove the sensor from the white delrin sensor mounting disc.

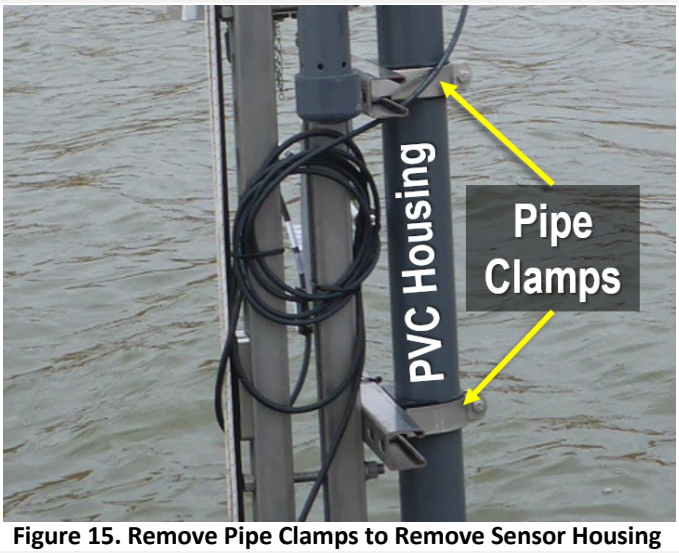


Figure 15. Remove Pipe Clamps to Remove Sensor Housing

STEP 4 | **[OPTIONAL]** Remove the sensor PVC housing from the stream infrastructure from the pipe clamp (Figure 15).

Technicians may find it easier to remove/reinstall the sensor into the PVC housing onshore depending on current flow dynamics and biologics onsite.

STEP 5 | Remove the sensor from the delrin acetal resin clamp-on collar (reference Figure 16). Remove biofouling/animal excrement from the clamp on-collar with a dry brush and lake water.

STEP 6 | Conduct decontamination on the old sensor in accordance with RD [03] or in accordance with manufacturer recommendations per ER [03]. Remove biofouling/animal excrement from sensor PVC housing remaining infrastructure components with a dry brush and lake water.

STEP 7 | Install the clamp-on collar to the "refreshed" Level TROLL 500. Set the Level Troll collar at 1.216" +/- 0.040 (approximately 1 and 1/4") from the largest top shoulder (the highest point when vertically situated, i.e., near the cable end; same diameter as the troll body) of the Level TROLL (Figure 16). The Level TROLL 500 does not require configuration like the Aqua TROLL 200. It should "plug-and-play" upon reinstallation.

Note: Collar placement impacts surface water elevation data. It must be standard across sites for consistent data collection and quality.

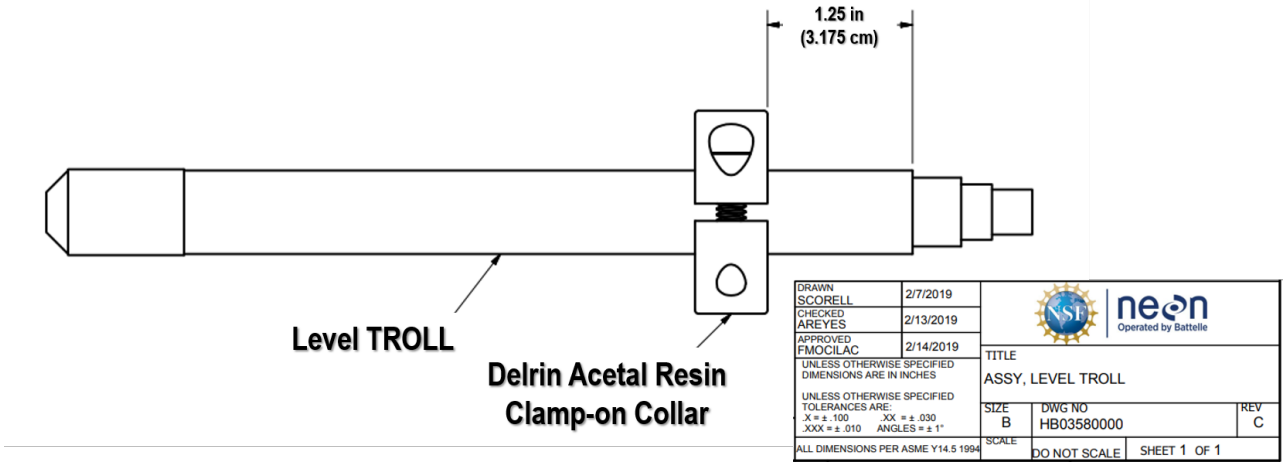


Figure 16. HB03580000 Assembly, Level TROLL | Clamp-on Collar Location on Sensor

STEP 8 | Reinstall the sensor and desiccant canister in the PVC housing. Reinstall PVC housing, if applicable (if removed). Secure the housing via the pipe clamp on the L-bracket at S-1 or S-2. Ensure reinstallation of the sensor meets site-specific requirements. **DO NOT KINK OR BEND THE VENTED CABLE.**

PRO TIP: To prevent stainless steel parts from seizing in the field, use SAFTLOK food grade anti-seize per NEON-1433 and ECO-04016. Reference AD [12] for areas to apply anti-seize on the assembly. Wipe off excess anti seize from the threads after tightening.

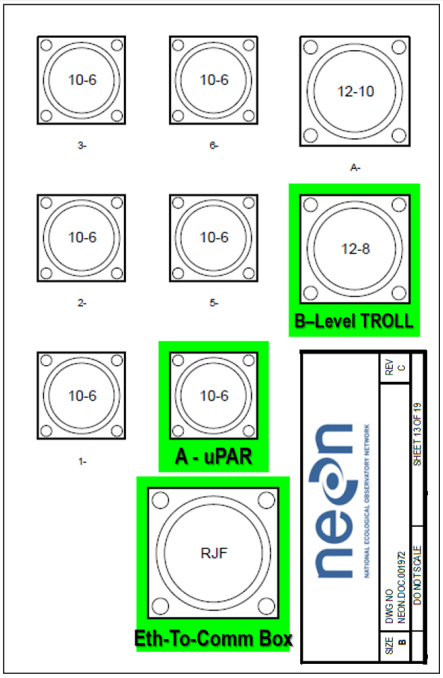


Figure 17. Uvifera (12V) Grape (AD [04])

STEP 7 | Connect sensor to Uvifera (12V) Grape per AD [04] in Figure 17.

Employ ESD protocols per AD [11].

Note: Maintain AIS sensor set asset tags in the closest onshore device post (e.g., the Combo Box or Aquatics Portal). Use option one or option two, do not split of up tags between the two options. ***Do not send a sensor to CVAL without its asset tag.***

Figure 18. Secure Cables using Zip Ties

STEP 9 | use zip-ties and redress sensor cables. Add drop loops, where applicable.

Figure 18 displays an example of how to dress cables on inlet/ outlet infrastructure.

DO NOT SECURE THE VENTED CABLE TOO TIGHTLY OR INDENT THE CABLES FROM WITH ZIP TIES. Blocks or kinks in the cable affect the pressure readings on the sensor.

STEP 6 | Reconnect the armored Ethernet cable to the Combo box to return power to the site (reference Figure 12).

STEP 6 | Verify sensor function post reinstallation. *Reference Section 5.3.1 Remote Monitoring*.

6.2.2 Stream Subsystem Removal/Replacement Procedures

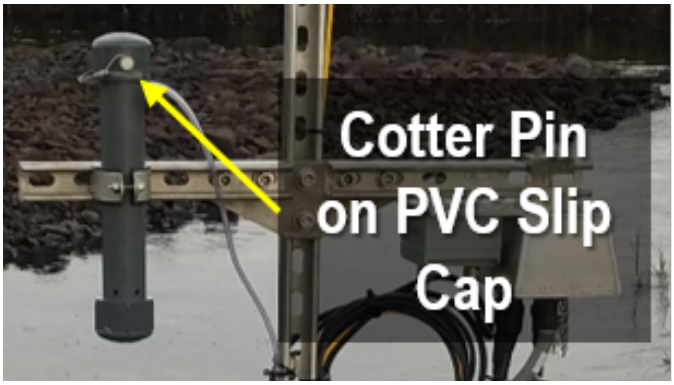
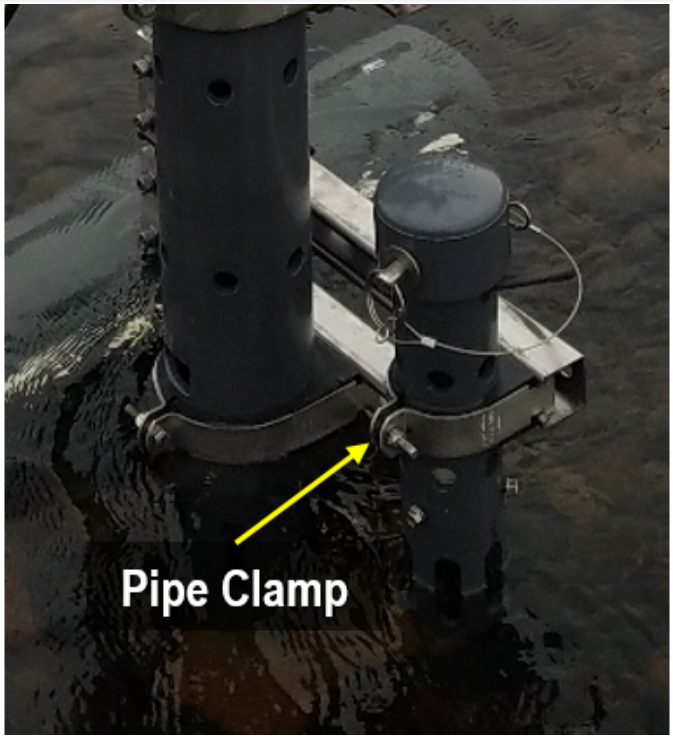
6.2.2.1 Merlot Grape Removal/Replacement Procedure (S-1/S-2)

1. Power down S-1 or S-2. *Reference Section 9 Appendix B – HOW TO POWER DOWN AN AIS Stream Combination (*Combo) Box*.*
2. *Reference AD [06] for removal/replacement information to conduct AIS stream infrastructure preventive maintenance.*

6.2.2.2 Sensor Removal/Replacement Procedure (S-1/S-2)

Table 6 provides a guideline to remove and reinstall the level TROLL 500 sensors at S-1 and S-2. *Reference AD [06] for comprehensive information to conduct AIS stream infrastructure preventive maintenance.*

Table 6. Level TROLL 500 Stream Removal/Reinstallation Procedure

STEP 1 | Power down S-1 or S-2. *Reference Section 9 Appendix B – HOW TO POWER DOWN AN AIS Stream Combination (*Combo) Box*.*	
 **Figure 19. A Slip Cap with Cotter Pin Secures Desiccant PVC Housing**	**STEP 2** | Remove zip-ties from cables, as appropriate and disconnect sensor from desiccant. Open the desiccant housing by removing the cotter pin from the PVC slip-on cap (Figure 19).
 **Figure 20. Remove Sensor PVC Housing from Stream via Pipe Clamp**	**STEP 3** | **[OPTIONAL]** Remove the sensor PVC housing from the stream infrastructure from the pipe clamp (Figure 20). Technicians may find it easier to remove/reinstall the sensor into the PVC housing outside of the stream/onshore depending on current flow dynamics and biologics onsite.

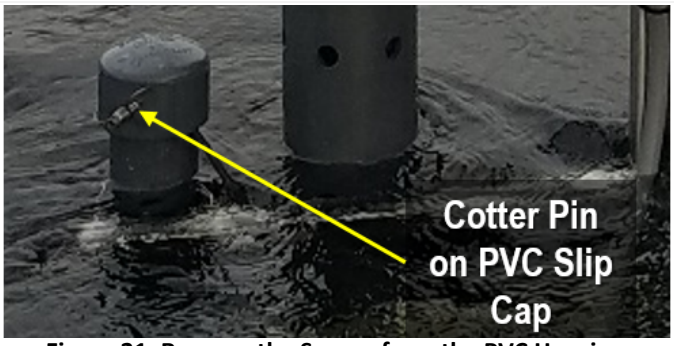


Figure 21. Remove the Sensor from the PVC Housing

STEP 4 | Remove the sensor from the PVC housing by removing the cotter pin from the PVC slip-on cap (Figure 21).

STEP 5 | Remove the sensor from the delrin acetal resin (i.e., crystalline plastic)[v] clamp-on collar (use Figure 22 as an example). Remove biofouling/animal excrement from the clamp on-collar with a dry brush and stream water.

STEP 6 | Conduct decontamination on the old sensor in accordance with RD [03] or in accordance with manufacturer recommendations per ER [03]. Remove biofouling/animal excrement from sensor PVC housing remaining infrastructure components with a dry brush and stream water.

STEP 7 | Install the clamp-on collar to the "refreshed" Level TROLL 500. Set the Level Troll collar at 1.216" +/- 0.040 (approximately 1 and 1/4") from the largest top shoulder (the highest point when vertically situated, i.e., near the cable end; same diameter as the troll body) of the Level TROLL (Figure 22). The Level TROLL 500 does not require configuration like the Aqua TROLL 200. It should "plug-and-play" upon reinstallation.

Note: Collar placement impacts surface water elevation data. It must be standard across sites for consistent data collection and quality.

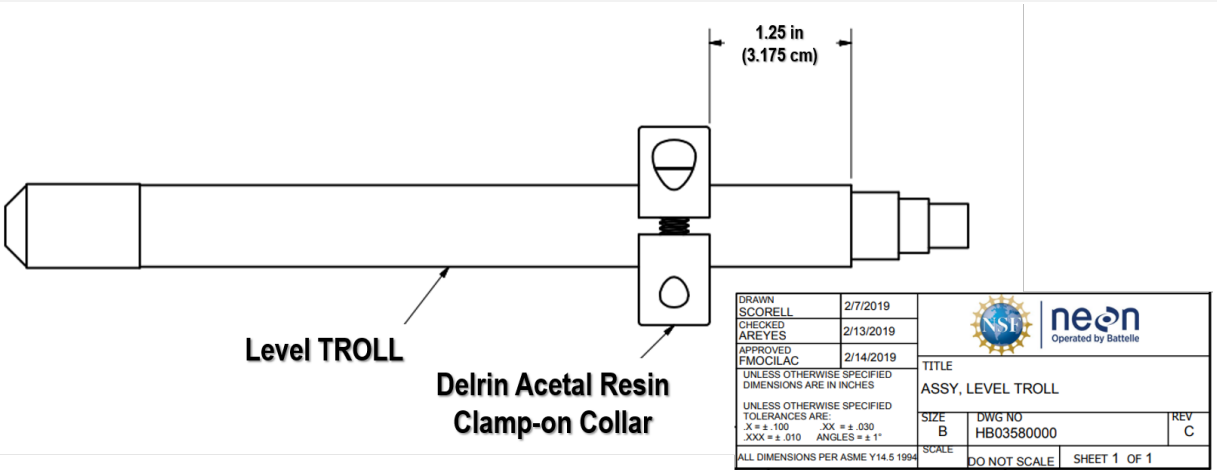


Figure 22. HB03580000 Assembly, Level TROLL | Clamp-on Collar Location on Sensor

STEP 8 | Reinstall the sensor and desiccant canister in the PVC housing. Reinstall PVC housing, if applicable (if removed). Secure the housing via the pipe clamp on the L-bracket at S-1 or S-2. Ensure reinstallation of the sensor meets site-specific requirements. **DO NOT KINK OR BEND THE VENTED CABLE.**

PRO TIP: To prevent stainless steel parts from seizing in the field, use SAFTLOK food grade anti-seize per NEON-1433 and ECO-04016. Reference AD [05] for areas to apply anti-seize on the assembly. Wipe off excess anti seize from the threads after tightening.

STEP 9 | Connect sensor to Merlot (12V) Grape per AD [04]. Employ ESD protocols per AD [11].

Figure 23. Secure Cables using Zip Ties (D18 OKSR)

STEP 10 | use zip-ties and redress sensor cables. Add drop loops, where applicable.

Figure 23 displays an example of how to dress cables on stream infrastructure.

DO NOT SECURE THE VENTED CABLE TOO TIGHTLY OR INDENT THE CABLES FROM WITH ZIP TIES. Blocks or kinks in the cable affect the pressure readings on the sensor.

Note: Maintain AIS sensor set asset tags in the closest onshore device post (e.g., the Combo Box or Aquatics Portal). Use option one or option two, do not split of up tags between the two options. ***Do not send a sensor to CVAL without its asset tag.***

STEP 11 | Verify sensor function on post reinstallation. After installation of the sensors, verify sensor data state of health (Data Product) in the SAS report (this report updates every 24 hours) and the IS Monitoring Suite (optional) the next day. Validate sensor data stream(s) and L0 data are Active (in green). *Reference Section 5.3.1 Remote Monitoring*.

6.3 Sensor Storage Requirements

Store the Level TROLL 500 Instrument in an environmentally controlled, clean and dry place. Place the protective red plastic nipple cap on the cable end, or store the sensor with cable attached to protect the connector pins and O-ring. Wrap the open end of the cable with a plastic baggy and electrical tape for temporary protection or use a red plastic nipple cap. Store the instrument in secure packaging to prevent crushing or dropping the sensor. The Level TROLL 500 storage temperature range is -40°C to 80°C.

6.4 Cleaning & Packaging of Returned Sensor

Field Science staff clean, package, and ship the sensors back to the CVAL at the NEON Program HQ (Battelle) for annual sensor swap/calibration requirements. (Please note: if a sensor is defective, submit a trouble ticket and affix a red tag with the trouble ticket number on it.)

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 (Logistics) 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.

6.4.1 Decontamination Requirements

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 [03], 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.

Please remove all arachnids and/or insects from AIS instruments prior to packing and shipping. Reference RD [03].

6.4.2 Packaging Requirements

Pack the devices for shipping/handling.

1. Place Uvifera/Merlot Grape in an ESD bag and shipping container.
2. Verify Level TROLL 500 sensor is decontaminated and has its protective caps.
3. Place level TROLL 500 sensor in an ESD bag. Ship the sensor back to HQ in the same shipping package CVAL provided for the “refreshed” level TROLL 500 sensor.
4. Update asset records via the NEON’s project Asset Management and Logistic Tracking System (e.g., All devices in transit to HQ shall be moved to TRANSIT in Maximo). NEON HQ, Logistics Warehouse (LOGWAR) receives the Grapes for refresh and distributes to CVAL.

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

5. Provide an electronic packing list to CVAL with the Box number and Asset Tag number (14-digit Property Tag ID (“Property of”) number) of each item. CVAL uses this information to verify items via LOGWAR/general HQ distribution of shipments.
6. Prepare a Bill of Lading.

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

For Sensor Refresh, package sensor items via packaging from CVAL HQ with packing list or per guidance via the Issue Management System and return to the NEON Program HQ using the following address:

BATTELLE, **ATTN: CVAL**
1685 38TH STREET, SUITE 100
BOULDER, CO 80301

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

BATTELLE, **ATTN: REPAIR LAB**
1685 38TH STREET, SUITE 100
BOULDER, CO 80301

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

6.5.1 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 DxxSUPPORT, and then TRANSIT.

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.

7 ISSUE REPORTING OUTPUTS

Field Science must report issues encountered while conducting preventive maintenance in the NEON Program Issue Management/Reporting System. Field Science must report streaming problems encountered during preventive maintenance. To ensure a quick response and remedy to an issue, please include as much information and detail, as possible. This includes, but is not limited, to the following:

- Domain and Site name
- Date and Time
- Technician Full Name
- Issue Narrative (detailed narrative of the issue, specific location of issue on tower infrastructure, relevant 2nd/3rd order effects to infrastructure, possible cause [e.g., weather event, obstruction, human activity])
- Multiple Photographs (to capture vantage points/perspectives for remote diagnostic)
- Provide Part Number/Manufacturer Information, EPROM ID, Asset Tags, IP/MAC Address, etc.
- Provide Diagnostic Information (from firmware, if applicable), such as error codes, values, etc. Provide screenshots.

Table 7. Surface Water Level (Level TROLL 500) Sensor Metadata Output Checklist

Issue Reporting Datasheet		
Datasheet field	**Entry**	
NEON Site Code		
Maintenance Date		
Maintenance Technician		
Preventive Maintenance	**Issue Noted**	**Issue Summary**
Sensor - Configuration Check – Data streams on Network/SAS	☐	
Site – Condition Check	☐	
Desiccant – Saturation Check	☐	
Infrastructure – Condition Check	☐	
Infrastructure – Level (±5)	☐	
Sensor Vented Cable – Condition Check	☐	
Sensor – Condition Check	☐	
Sensor Connectors & O-Rings – Condition Check	☐	
Environmental Information	☐	
Notes		

Ship all defective equipment/assets with a red “Rejected” tag. **Figure 24** displays the minimum information requirements for each tag.

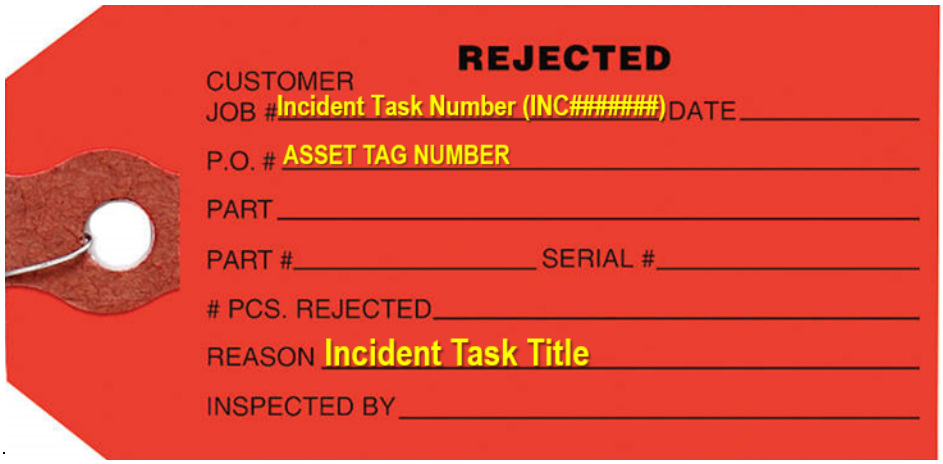


Figure 24. Red Rejected Tag for Defective Assets (MX104219)

8 APPENDIX A - INLET/OUTLET WINTERIZATION REQUIREMENTS

This procedure specifically applies to sites that incur winter temperatures that fall below infrastructure environmental thresholds, as applicable (D05, D09, D12, D18, and D19 per NEON.AIS.4.1314). **This is mandatory for sites in Alaska (D18 and D19).** AIS Science is addressing the remaining sites on a case-by-case basis to monitor weather patterns to determine best-case scenario or determine if there is a need to remove the instrument and battery from each inlet/outlet (D05, D09, D13 and D12).

The Domain Manager must use their discretion to determine the most appropriate time to shut down the site as October arrives, and when to start-up in May (per TIS Science guidance for snowpack at D18 TOOL). Follow the AIS Science ice-on/ice-off rule of thumb – remove/shutdown when ice accumulates and reinstall/startup when ice melts. See **Table 8** for specific guidance on infrastructure equipment operating parameters to determine equipment removal per site.

Note: Dates for removal/reinstallation are subject to change as Domains experience and gain additional insight on weather patterns. Track dates using the NEON Program Issue Management and Reporting System.

Table 8. Inlet/Outlet Sensor and Subsystem Winterization Requirements

Equipment	Environmental Specifications
Solar Charge Controller, 12.8V LiPO4, 65W	Operating Temp: -40°C - 85°C 10 Year Warranty Trickle charge to recover dead battery
Radio Modem, 900 MHz, RS485	Operating Temp: -40°C to 85°C
Battery, LiFePO4, 12.8V 25AH	No need for a trickle charger. Requires charging prior to re-installation. Charge battery pack with specific charger, 0.2 C20A constant Current/constant voltage to 15.2V. Storage Temperature: -10~40℃ Best storage temperature for long durations: 20±5℃
Antenna, Omnidirectional	Operating Temp: -40°C to 60°C
Molex Connectors	Non-operating/Operating: - 40°C to + 105°C
Cables	Ice may form on cables that remain onsite. Remove ice from cables when able to access equipment onsite.
Uvifera (12) Grape	The standard Grape operating range is −29°C to 50°C. Testing found Grapes are capable of operating safely from −40°C to 60°C.[vi]
uPAR	Operating Temp: −40°C to 65°C
Level TROLL 500	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F) Do not deploy instruments in such a way that ice may form on or near the sensors or cable connections. Ice formation is a powerful expansive force that can over-pressurize the sensor or otherwise cause damage that is not covered by the warranty.[vii]

8.1 Equipment

Table 9 provides a list of equipment to removal/reinstall the Inlet/Outlet Combo box 12V battery and winterization considerations/maintenance for the Level TROLL 500 sensor and subsystem.

Table 9. Winterization Equipment Removal Procedure Equipment List

P/N	NEON P/N	Description	Quantity
Tools			
GENERIC		Philipheads Screwdriver (to open Power/Comm boxes)	1
CH-LF12810A	0354920000	AA Portable Power Corp, Smart Charger (designed to charge Lake Inlet/Outlet LiFePO4 batteries)	1
Various		Winter Weather Equipment	A/R
Consumable Items			
GENERIC		Packaging (to protect batteries in transit to the Domain)	A/R
In-Situ, Inc.		Red Plastic Nipple Caps (in-situ caps that come with assembly)	A/R
GENERIC		Plastic Baggy	A/R
GENERIC		Electrical Tape (rated for -70°C and Rain for covering connectors on the power box & regular tape to cover cables temporarily in storage at DSF)	1-2 Rolls
3M		ESD Bags	2-4

8.2 Inlet/Outlet Combo Box Battery Removal/Reinstallation Procedure

8.2.1 Remove Inlet/Outlet Combo Box Battery

1. The Ethernet cable from the Inlet/Outlet Combo box to power down the Uvifera (12V) Grape (**Figure 25**).

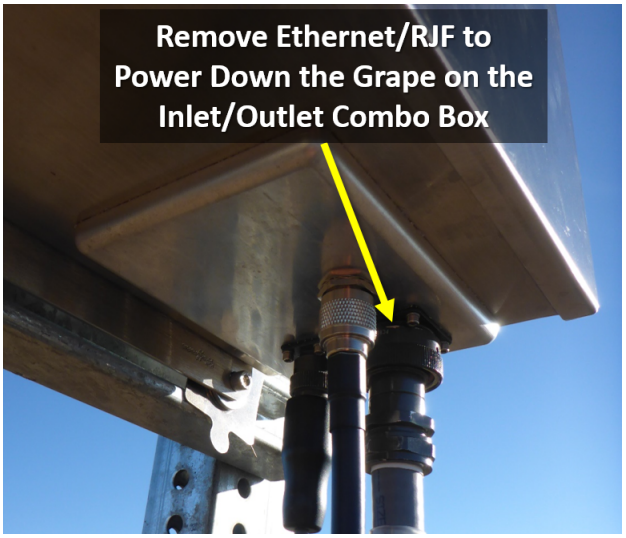


Figure 25. Inlet/Outlet Combo Box

2. Cap the power cable connectors. Use the red nipple caps provided with the assembly or leave the cable connected and hang the cable connector facing using a small plastic bag with electrical tape to act as a rain shield/cap.

3. Open the Inlet/Outlet Comb Box using a Phillips head screwdriver.

4. Unplug the solar panel and battery connector from the junction board (*CB14140000*) using **Figure 26**. ***Squeeze the locking tab prior to pulling the cable from the board. Be gentle to prevent un-seating any of the pins in the connectors.***

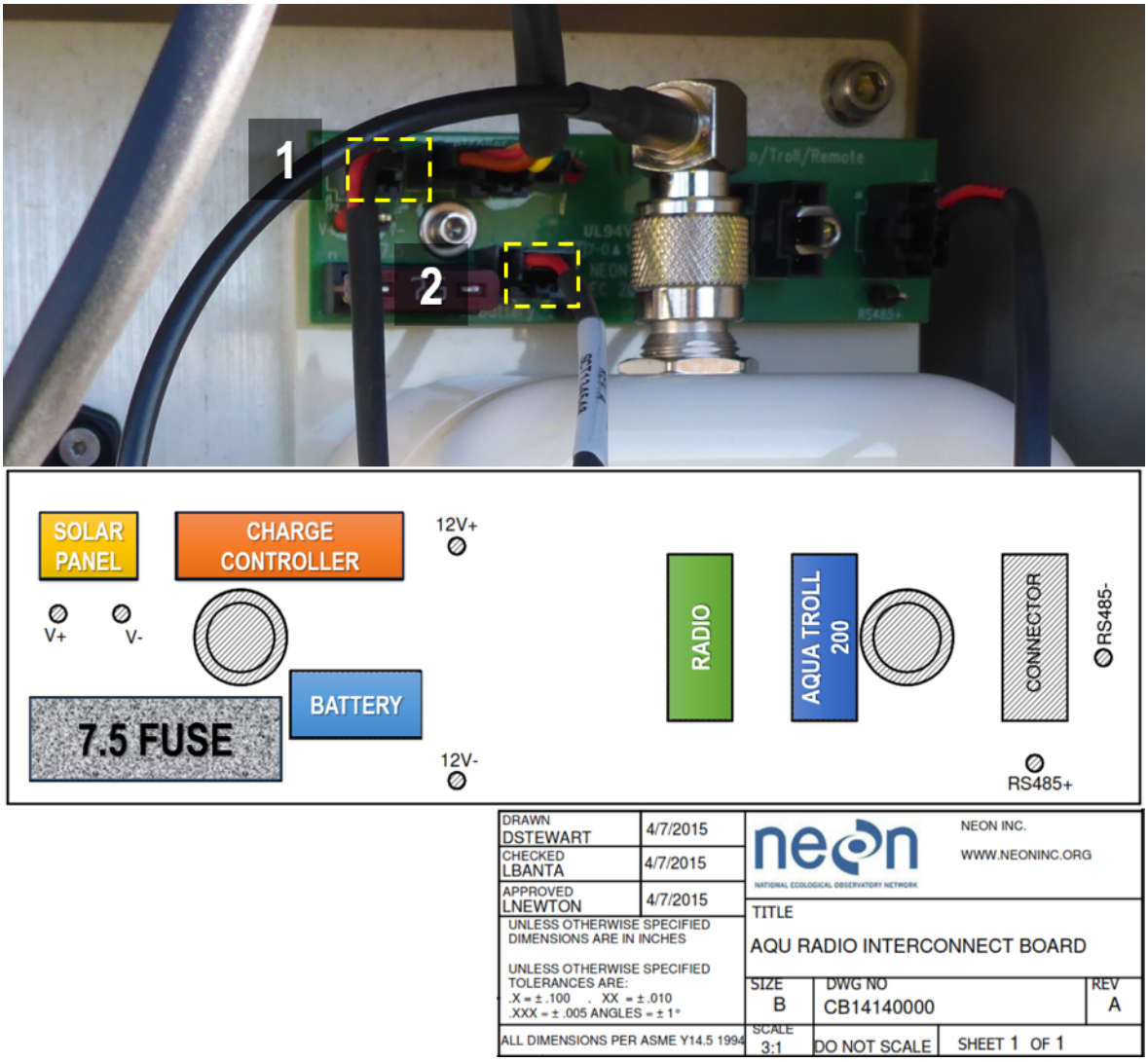


Figure 26. Solar Panel and Battery Connector from the Junction Board (CB14140000)

5. Release battery from Velcro strap and place in packaging/bag/box.

6. Disconnect radio connector (**Figure 27**). ***Squeeze the locking tab prior to pulling the cable from the board. Be gentle to prevent un-seating any of the pins in the connectors.***

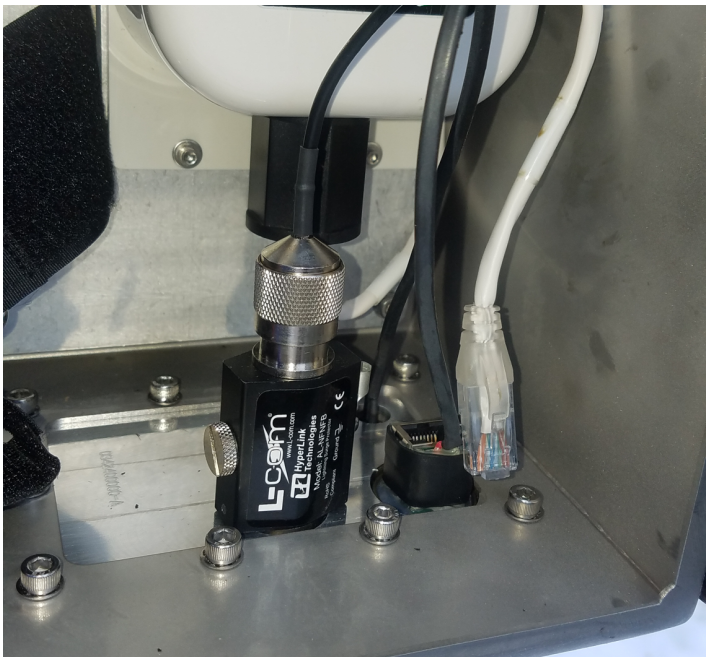


Figure 27. Disconnect Radio Connector (Bottom Right Corner of Combo Box, D18 TOOK)

Note: Since the NEON Program does not presently have specifications for sturdy caps (or as part of the assembly) for the Combo Box, HQ recommends disconnecting components internally, while leaving the cables connected, but capped, to protect the connectors and capping from water intrusion, etc.

7. Close the Inlet/Outlet Comb Box using a Phillips head screwdriver.
8. Store the batteries in an environmentally controlled storage space/Domain Office.
9. See **Table 9** for battery charger information.

8.2.2 Reinstall the Inlet/Outlet Combo Box Battery

1. Verify batteries have a full charge prior to heading to the site. Use the charger or equivalent listed in **Table 9** for this step.
2. Open the Inlet/Outlet Comb Box using a Phillips head screwdriver.
3. Reattach battery in Velcro strap. **WAIT to plug in the battery.**
4. Reinstall Inlet/Outlet instrumentation, disregard if not applicable.
5. Plug in the battery in the upper right hand corner of the NEMA enclosure (see **Figure 26** for location). ***Only connect the battery when the Lake Inlet/Outlet instruments are in place and connected to the Radio/Power box components.*** The solar power system does not have switches to control for power like the alternate power system.

6. Plug in Solar Panel connector to the junction board (CB14140000) using **Figure 26**.
7. Plug in the radio connector.
8. Remove plastic caps/bags and reconnect power cables to combo box.
9. Close the Inlet/Outlet Comb Box using a phillipshead screwdriver.

8.3 Level TROLL 500 Sensor Removal/Reinstallation Procedure

1. Follow the procedure to remove/reinstall the Level TROLL 500 sensor(s) in *Section 6.2.1 Lake Inlet/Outlet Subsystem Removal/Replacement Procedures.*

8.4 Winter Maintenance for Operational Sites

For procedures involving ice removal, conduct a JSA to determine if the site is safe to visit and/or conduct the procedures below. Field Science must coordinate with the NEON Safety Office to determine site safety criteria/hazard identification to determine when it is safe to conduct AIS winter maintenance.

8.4.1 Equipment

P/N	NEON P/N	Description	Quantity
Tools			
GENERIC		Wooden Dowel (.50 dia x 36” Lg.)	1
GENERIC		Snow Removal Tool/Telescoping Squeegee	1
GENERIC		Winter Weather Equipment, PPE + Gloves	A/R
GENERIC		Hand Warmers (Self-Heating)/Thermos	A/R

8.4.2 Remove Ice from Combo/Key Locks

To remove ice, use self-heating hand warmers or thermos of hot water.

8.4.3 Remove Ice from Cables

Use gloved hands or a wooden dowel (.50 dia x 36” Lg.) to move the cables to break off ice**. DO NOT HIT THE CABLES**. Brush the snow away from the connectors as much as possible. Break off any hanging icicles, as appropriate (consult with the NEON Safety Office to establish criteria for winter hazard identification or conduct a JSA to determine if the site/icicle is safe to approach). **Do not remove icicles when staff or specific equipment are present below.** A gentle tap with a wooden rod on the icicle base should suffice.

8.4.4 Remove Snow and/or Ice from Solar Panels

For solar panel winter preventive maintenance, use equipment similar to removing ice from a car windshield (solar panel exterior is tempered glass) or use a specific snow removal tool/telescoping squeegee. Do not use ethanol; it increases the risk of spills/site contamination. Do not use special window/car treatments for ice - no RainX, rock salt or car wax.

9 APPENDIX B – HOW TO POWER DOWN AN AIS STREAM COMBINATION (COMBO) BOX

Powering down the site enables Technicians to perform work with less hazards to themselves and to the equipment. It also mitigates requiring NEON Headquarters to conduct data quality analysis when Technicians are onsite close enough to the sensors to influence data collection. Power down the Aquatic Site S-1/S-2 Device Post/Comm box providing power to the stream sensors requiring removal/replacement using **Figure 28** for guidance.

1. Use a flathead screwdriver to open the Device Post/Comm box.

2. Flip the 5-Amp breaker(s) (from RED to GREEN) to de-energize the sensors and Grapes.

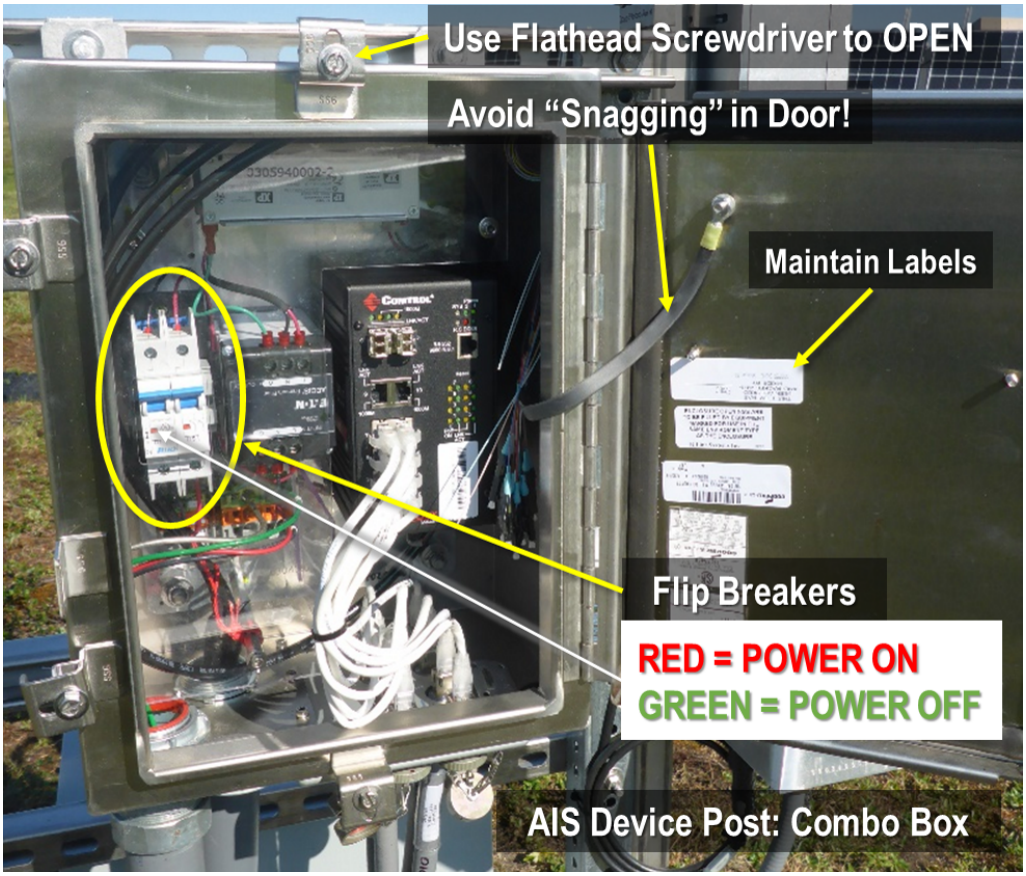


Figure 28. AIS Device Post: Combo Box for S-1/S-2 (D18 OKSR)

1. Conduct LOTO procedures and proceed with Aquatic Met Station Preventive Maintenance, Sensor Refresh and/or Corrective Maintenance.

If there is a need to remove a single sensor assembly onsite, then power down the sensor assembly from its Grape. Remove the armored Ethernet cable from the Merlot Grape RJF/Eth-To-Comm connector before disconnecting or connecting sensor connections. Removing sensor connections with

the RJF/Eth-To-Comm cable disconnected is best practice to avoid accidental hot swapping when the power is ON. *Reference AD [04] for AIS Grape mapping.* Follow ESD procedures in AD [11].

10 SOURCES

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[i] Also known as a "Sea Grape". Source: https://plants.usda.gov/core/profile?symbol=COUV

[ii] In Situ, Inc. Care and Maintenance of Aqua TROLL® and Level TROLL® Instruction Sheet. https://in-situ.com/wp-content/uploads/2014/11/Aqua_Level_TROLL_Maintenance_Guide.pdf page 2.

[iii] Use to decontaminate glassware, metals, plastics, ceramic, porcelain, rubber and fiberglass without harsh chemicals or corrosives and is biodegradable and recommended by In-Situ, Inc.

[iv] SAF-T-LOK International Corporation, SAF-T-EZE FOOD/ DRUG GRADE ANTI-SEIZE Technical Data Sheet, 0355220000 Hardware in Agile accessed January 01, 2018.

[v] Ensigner, DELRIN® acetal homopolymer https://www.ensinger-inc.com/products.cfm?page=product&product=delrinandreg;*+acetal+homopolymer

[vi] John Staarmann, RE: Operating/Storage Temps for Uvifera Grape Email, January 10, 2018

[vii] In-Situ, Inc. "*Cleaning and Maintenance*", Level TROLL 400, 500, 700, 700H Model Operators Manual, pg. 72 https://in-situ.com/wp-content/uploads/2014/11/Level-TROLL-400-500-700-700h_Manual.pdf