NEON PREVENTIVE MAINTENANCE PROCEDURE: TIS & AIS SECONDARY PRECIPITATION GAUGE

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	01/10/2018	ECO-05294	Initial release
B	12/01/2022	ECO-06920	Updated NEON logo and minor formatting fixes

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

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 **Secondary Precipitation Gauge** to meet the objectives of the NEON project, and its respective stakeholder 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 Met One Tipping Bucket (370 Series), Secondary Precipitation Gauge for applicable NEON Terrestrial Instrument System (TIS) and Aquatic Instrument System (AIS) sites. This includes preventive maintenance procedures and requirements for the Secondary Precipitation Gauge instrument, subsystem and supporting infrastructures. These procedures do not apply to the Primary Precipitation Gauge. Reference RD [07] for preventive maintenance procedures on the Belfort AEPG MKIII Precipitation Gauge and Double Fence Intercomparison Reference (DFIR) for TIS and AIS sites.

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.001436	TIS Comm Interconnect Map
AD [05]	NEON.DOC.001972	AIS Comm Interconnect Map
AD [06]	NEON.DOC.000367	NEON Sensor Command, Control and Configuration – Secondary Precipitation – Tipping Bucket
AD [07]	NEON.DOC.002490	Assembly, Secondary Precipitation Non-Heated
AD [08]	NEON.DOC.000724	Chemical Hygiene Plan and Biosafety Manual
AD [09]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure
AD [10]	NEON.DOC.000531	NEON Installation Procedure: Secondary Precipitation
AD [11]	NEON.DOC.000816	NEON Algorithm Theoretical Basis Document (ATBD) – Secondary Precipitation
AD [12]	NEON.DOC.003484	NEON Installation Procedure: Primary Precipitation Gauge

2.2 Reference Documents

Reference documents 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.004257	NEON Standard Operating Procedure (SOP): Decontamination of Sensors, Field Equipment, and Field Vehicles
RD [04]	NEON.DOC.003342	NEON Preventive Maintenance Procedure: Primary Precipitation Gauge and Double Fence Intercomparison Reference (DFIR)
RD [05]	NEON.DOC.002768	TIS Subsystem Architecture, Site Configuration and Subsystem Demand by Site - SCMB Baseline
RD [06]	NEON.DOC.000620	AIS Verification Checklist
RD [07]	NEON.DOC.004637	TIS Verification Checklist
RD [08]	NEON.DOC.004822	Domain 14 (D14) AIS Sycamore Creek (SYCA) Alternate Power Site 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]	Met One Instruments, Inc. Rain. 370-380 Precipitation Gauges. *http://metone.com/meteorological-sensors-systems/rain/370-380/*
ER [02]	Belfort Instrument, Alter Shield Installation Assembly Instructions, Rev D. Sept. 13, 2012 Filename: Belfort Alter Shield Installation Assembly Instructions Rev D 09132012.pdf SHA1 Checksum: 35fda70e1da392a9169bb5b000a05db4dda42330

2.4 Acronyms

Acronym	Description
A/R	As Required
AC	Alternating Current
AQU	Aquatic
Comm	Communication
NA	Not Applicable
JSA	Job Safety Analysis
NOAA	National Oceanic and Atmospheric Administration
OCS	Office of Coast Survey
P/N	Product Number
PoE	Power over Ethernet
SHA1	Secure Hash Algorithm 1
V	Volts

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
Power Box, Comm Box, National Electrical Manufacturers Association (NEMA) Enclosure, Power/Comm Infrastructure	**Device Post**
Tipping Bucket, Rain Gauge, Precipitation Collector	**Secondary Precipitation Gauge**
Tipping Bucket on the Tower	**TIS Secondary Precipitation Gauge**
Tipping Bucket with the Alter Shield	**AIS Secondary Precipitation Gauge**

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.

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 and TIS 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 Project's Issue Management and Reporting System (i.e., JIRA or ServiceNow) for alternative methods to conduct TIS and AIS preventive/corrective maintenance and Sensor Refresh procedures.

4 SENSOR OVERVIEW (SENSORS ONLY)

4.1 Description

The NEON project utilizes a modified Met One 372 as a secondary sensor for measuring precipitation events at TIS & AIS sites. There is a non-heated (***0321340000*** *Sensor, Rain Gauge Tipping Bucket 8 inches Non-Heated Model 10491*) and heated (***0321330000*** *Sensor, Rain Gauge Tipping Bucket 8 inches Heated Model 10490, 240 Volts AC*) version for TIS and non-heated (***HA06800000*** *Assembly, AQU Secondary Precipitation, Non-heated*) version for AIS within the NEON network. Installations using heater mechanisms aim to sustain the gauge above-freezing temperatures to melt snow and ice that may accumulate in the collector through winter seasons. AIS sites employ an Alter Shield with the sensor to minimize the effects of wind-induced flow distortion around the sensor body.

4.1.1 TIS Secondary Precipitation Gauge

At TIS sites, the Secondary Precipitation Gauge mounts from a short boom on the tower top level (see **Figure 1**).

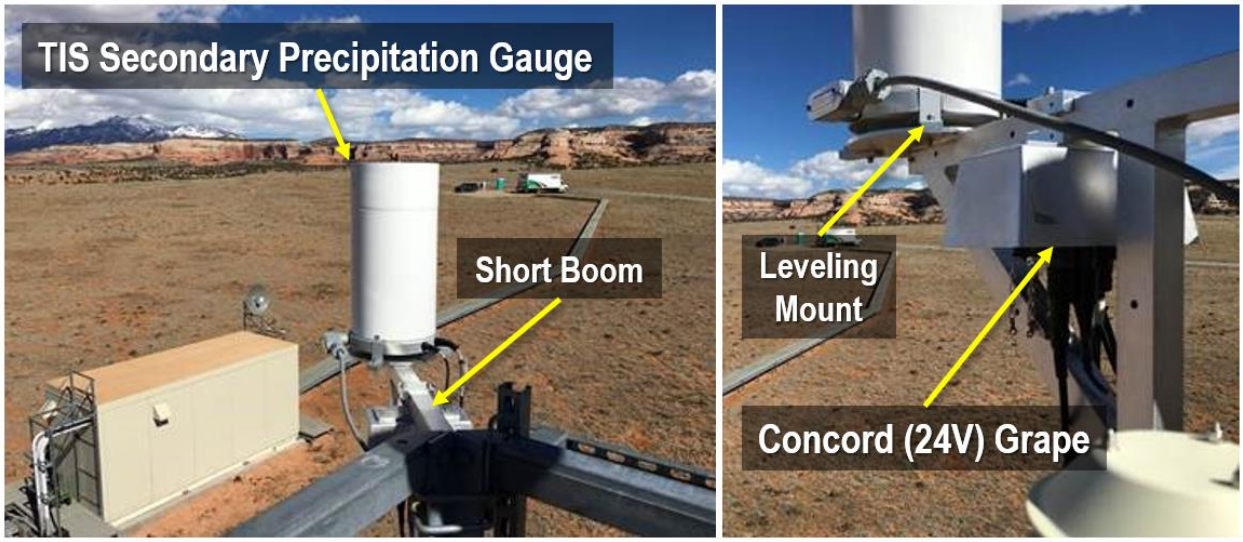


Figure 1. TIS Secondary Precipitation Gauge on a Short Boom from the Tower Top Level (Domain 13, MOAB).

The TIS Secondary Precipitation Gauge subsystem consists of the following components:

- Secondary Precipitation Gauge (Heated or Un-heated Assembly)
- [Heated Assembly Only] 35’ AC Heater Cable using 12-3 Connectors
- Short Boom, Tipping Bucket Assembly
- 33’ Power over Ethernet (PoE) Cable
- Leveling Mount & Screws
- Concord Grape (24V Grape)

Figure 2 displays the components of the Secondary Precipitation Gauge. These are the same components for both TIS and AIS sites.

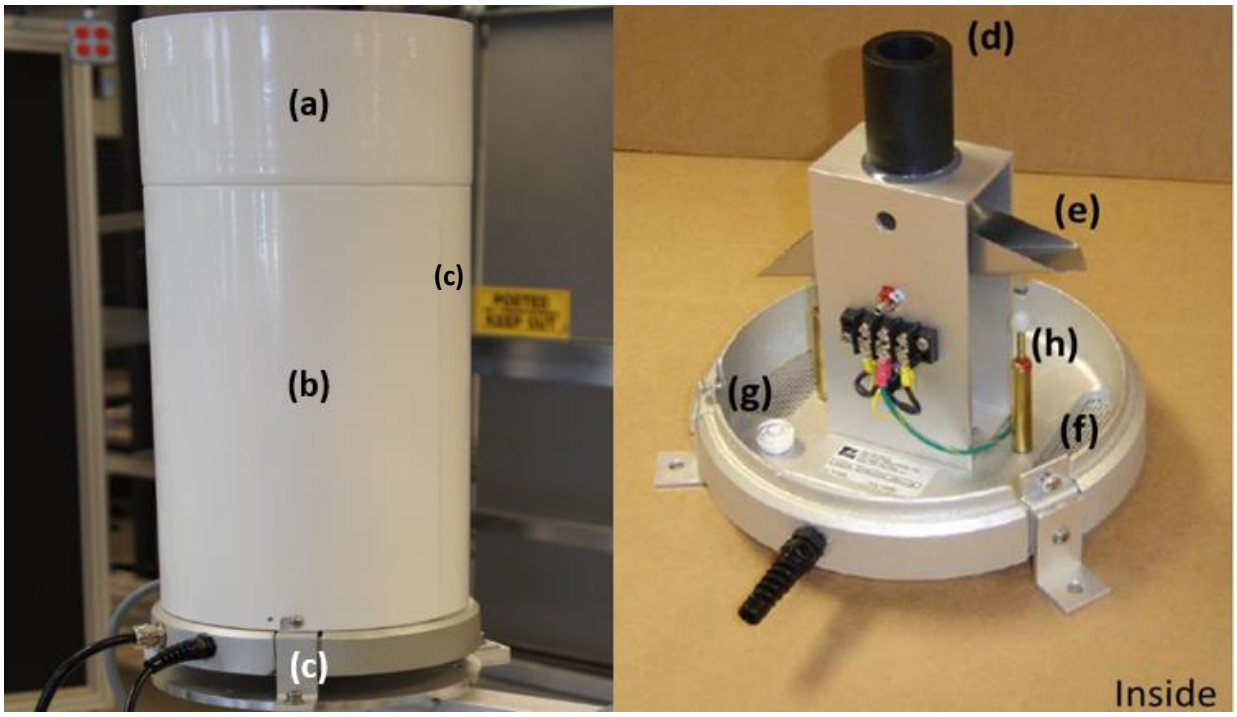


Figure 2. The tipping bucket consists of an (a) 8" white cylindrical body, (b) 8" top opening, and (c) mounting base that holds the tipping bucket mechanism. Inside the instrument is the (d) precipitation inlet, the (e) dual chambered tipping bucket mechanism, (f) drainage holes, (g) bubble level, and (h) tipping bucket adjustment stops.

4.1.2 AIS Secondary Precipitation Gauge

At AIS sites, the Secondary Precipitation Gauge is at ground level. It sits on an in-ground post using a slightly different mounting plate than the TIS version. An Alter Shield surrounds the sensor to minimize the effects of wind-induced flow distortion on measurement accuracy (the shield is not spatially feasible on a TIS tower). **Figure 3** displays the components of an AIS Secondary Precipitation Gauge.

Figure 3. AIS Secondary Precipitation Gauge with Alter Shield at Aquatic Sites

The AIS Secondary Precipitation Gauge subsystem consists of the same components as the TIS subsystem with exception of the short boom assembly. The AIS subsystem contains the following infrastructure components:

- Alter Shield
- Grounding Rod
- Rain Gauge Pole Mount with Leveling Base

4.2 Sensor Specific Handling Precautions

4.2.1 Instrument

The tipping bucket mechanism within the gauge is sensitive to abrupt shocks. Shocks or damage to the tipping mechanism may result in inaccurate measurements. Take care to secure the buckets from tipping during transport to and from the site.

The tipping bucket must maintain vertical orientation during shipping and handling. If a sensor is found on its side or falls on its side the sensor bearing needs to be evaluated for proper bearing operation (the bearing should tip freely and the tipper should have a slight amount of play without misalignment in the sensor housing).

Do not remove the funnel portion of the tipping bucket during a precipitation event, unless the sensor is protected from precipitation, in order to avoid exposing the sensor electrical contacts to water.

4.2.2 Subsystem

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

Reference AD [09]. Conduct Lockout/Tagout (LOTO) procedures to disable machinery or equipment to prevent the release of hazardous energy while performing service and maintenance activities.

4.3 Operation

This sensor assembly collects any precipitation that falls through a fixed horizontal plane (the top of the white collector). The collector then funnels liquid water into the sensor. The sensor utilizes a two-sided "bucket" that will alternate tips between sides (both of similar volume). As one side of the bucket has accumulated the prescribed amount (typically about 0.5mm of liquid precipitation accumulation), the bucket tips to the other side, immediately beginning new precipitation accumulation into the opposite bucket while the previous side tips to drain. This tipping design allows for continuous measurement of the rainfall amount and rate. The tipping mechanism is fitted with a magnet that passes by a reed switch, closing the sensing circuit with each bucket tip in either direction. The limitation of this form of collection are small precipitation events that fail to trigger the tipping mechanism, and thus, fail to collect a measurement. Capturing low-volume precipitation events may occur within a later event, or become lost due to evaporation before allowing the gauge to measure any collection. CVAL calibrates the volume of the collection buckets annually.

Heated units are fitted with a heater on both the sensor body and the precipitation collector. This ensures that frozen water precipitation events (e.g. snow, hail, sleet) are melted and recorded as liquid water (ideally prior to sublimation or evaporation). Additionally, the heaters keep the internal tipping mechanism and bearing operating freely and consistently throughout the year. Per AD [06], the heater control thermostat set point is 4.4^{o}C. Once the temperature falls to the 4.4^{o}C set point, the heater automatically turns on. Once it rises to the set point, the heater turns off.

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Equipment

Table 1. Preventative Maintenance Equipment List.

P/N	MX/NEON P/N	Description	Quantity
Tools			
		Common landscaping tools (to maintain vegetation)	A/R
NEON, IT		NEON Laptop	1
		Ethernet Cable (to connect to network in Aquatics Portal or Instrument Hut to verify function of sensors/Grapes)	1
GENERIC		Hex Wrench Set (to remove Grapes/Grape Shields, as appropriate for sensor swap/refresh)	1
		#2 Philips head screwdriver (to open power boxes)	1
		7/16” Open End / Box Wrench	2
		3/16” Allen Driver	1
GENERIC		Aquatic PPE or Tower Climbing PPE	1 per Technician
GENERIC		Digital and/or Bubble Level (to verify alignment)	1
NEON		Boomtron/Boat Hook (custom tool to reach sensors safely)	1
4620	MX103120	3M Antistatic Wristband (ESD Requirement)	1
Consumable Items			
		Lint-free/Microfiber Cloth (to clean sensors)	20
		Cotton Balls/Swabs	20
		Amphenol caps (for Ethernet cables/Grapes)	A/R
0719752		7” Zip-ties (to redress cables, as applicable)	A/R
0719793		14”Zip-ties (to redress cables, as applicable)	A/R
Resources			
	PuTTy: http://www.putty.org/ or MobaXterm https://mobaxterm.mobatek.net/		1
	SAS: http://sas.ci.neoninternal.org/		1
	Site Specific IP Addresses: N:\Common\SYS\Site Network Configurations		
	Location Controller Username: user, password: resuresu		

5.2 Subsystem Location and Access

At TIS sites, the Secondary Precipitation Gauge mounts from a short boom off the top measurement level (ML) of a Tower. At AIS sites, the sensor is ground mounted surrounded by an Alter Shield. AIS installations are near the AIS Aquatic Meteorological (Met) Station. **Figure 4** displays an example of a Secondary Precipitation Gauge at a TIS site (left) and AIS site (right).

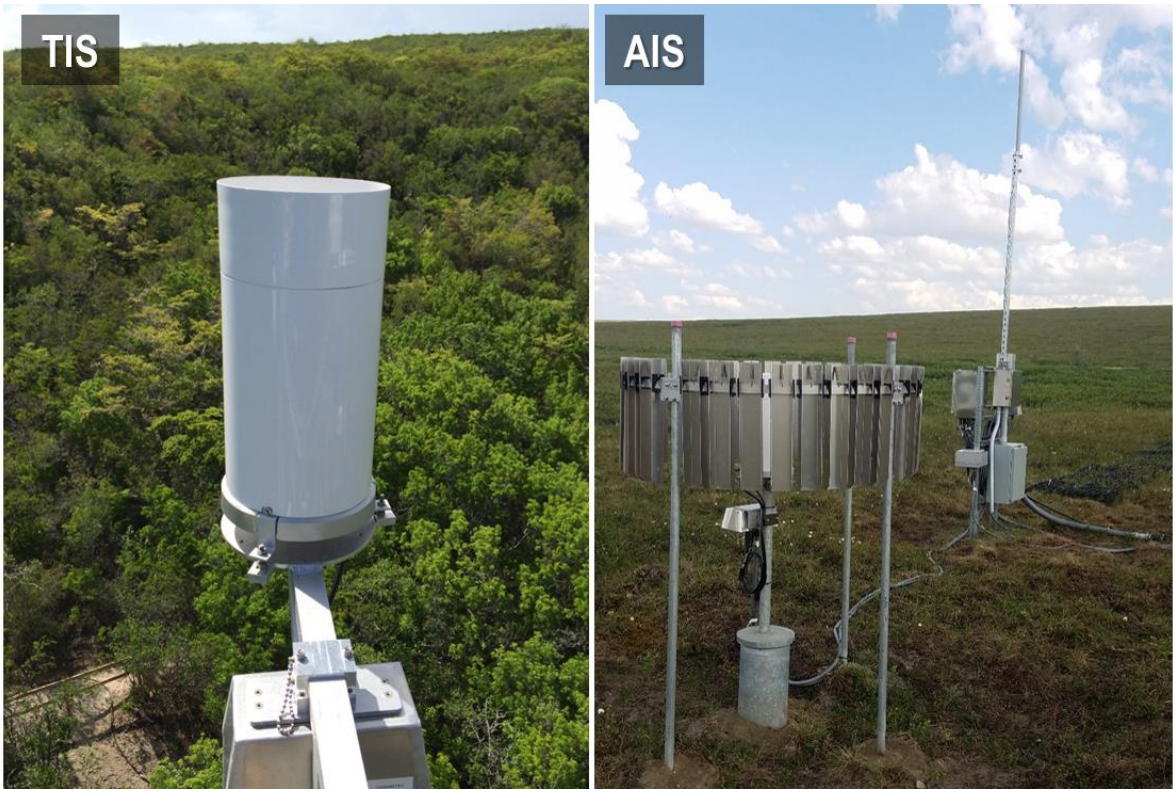


Figure 4. Secondary Precipitation Gauge: TIS Site (Left) Domain 04, GUAN, AIS Site (Right) Domain 18, TOOK.

The Secondary Precipitation Sensor transmits data to the NEON network via a Concord Grape. The TIS Secondary Precipitation Gauge Grape connects to the tower top ML power box. AIS Secondary Precipitation Gauge may share a power box with an Aquatic Met Station or connect to their own power box via a Concord Grape. At extreme sites, a power transformer box to energize heaters are included as part of the Secondary Precipitation sensor PDS.

5.3 Maintenance Procedure

Table 2. Secondary Precipitation Maintenance Intervals.

Maintenance		Bi-weekly	Quarterly	Annual	As Needed	Type
Secondary Precipitation						
	Remote Monitoring	X			X	P
	Visual Inspection of Sensor	X			X	P
	Collector Cleaning	X			X	P/R
	Sensor Leveling and Cleaning	*X*	X		X	P
	Large (Coarse) Screen Winter Req.				X*	P

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

Maintenance	Bi-weekly	Quarterly	Annual	As Needed	Type
** See Section 5.3.2 for installation and removal dates of the coarse mesh screen located within the funnel.*					

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 or use terminal emulator program (TEP), such as PuTTy or MobaXterm, for real-time review of data streams. For the Secondary Precipitation Gauge, data streams are present when the tipping mechanism is collecting live samples (data streams do not show up unless it is active during a weather event – only as it "tips"). Otherwise, look up to view if the subsystem components have power. This action enables Technicians to prepare and prioritize any root cause analysis/corrective action to sensors onsite with missing or abnormal data streams or no power on the Secondary Precipitation Sensor subsystems. Verify data streams using **Table 3**.

PRO TIP: *To perform these functions, Technicians must acquire the Grape MAC address and/or the EEPROM ID (from Maximo) of the sensor. 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, skip to the next section.

Table 3. View Grape and Sensor Data Streams.

PuTTy Commands	Description
`vd | grep [MAC address]`	This displays the data from the grape with the MAC Address entered (e.g., using "7CE0440015FD"). Enter either in decimal or hexadecimal format. Use "**grep –i**" to ignore case.
`vd –s [sensor eeprom id]`	To view data from a sensor. For example "root@D23-HQTW-LC1:~# vd -s 3171982"
`vd –s [sensor eeprom id] –r [stream number]`	To view data from a sensor and specific data stream.

Note: Reference AD [06] for the Secondary Precipitation Gauge command, control and configuration requirements.

5.3.2 Coarse Mesh Screen Installation and Removal

The rain gauges come with a large coarse mesh screen to prevent debris from getting into the gauge mechanism. During the winter months, the coarse mesh screen accumulates snow above the heated

section of the funnel. This prevents the heater mechanism from melting snow accumulation and influences precipitation collection measurements. To prevent this, FOPS Technicians must remove the large coarse mesh screen during the winter months at sites with snow.

Figure 5. Large Coarse Mesh Screen.

Table 4 and **Table 5** contain dates to remove and re-install the screen based on the National Oceanic and Atmospheric Administration (NOAA) Office of Coast Survey (OCS) median date of first and last measurable snowfall.

Table 4. TIS Secondary Precipitation Winter Requirements for Large Coarse Screen.

Domain	Site	Removal Date	Reinstallation Date
1	BART	8-Nov	8-Apr
1	HARV	8-Dec	23-Mar
2	SCBI	8-Dec	8-Mar
2	SERC	23-Dec	14-Feb
2	BLAN	8-Dec	8-Mar
3	OSBS	NA	NA
3	DSNY	NA	NA
3	JERC	NA	NA
4	GUAN	NA	NA
4	LAJA	NA	NA
5	UNDE	8-Nov	8-Apr
5	TREE	8-Nov	8-Apr
5	STEI	8-Nov	8-Apr
6	KONZ	8-Dec	8-Mar
6	KONA	8-Dec	8-Mar
6	UKFS	8-Dec	8-Mar
7	ORNL	31-Dec	14-Feb
7	GSNP	23-Dec	14-Feb
7	MLBS	8-Dec	8-Mar

Domain	Site	Removal Date	Reinstallation Date
8	TALL	NA	NA
8	DELA	NA	NA
8	LENO	NA	NA
9	WOOD	1-Nov	8-Apr
9	DCFS	1-Nov	8-Apr
9	NOGP	1-Nov	8-Apr
10	CPER	15-Oct	23-Apr
10	STER	8-Nov	8-Apr
10	RMNP	15-Oct	23-Apr
11	CLBJ	31-Dec	14-Feb
11	OAES	23-Dec	14-Feb
12	YELL	8-Nov	8-Apr
13	NIWO	15-Oct	23-Apr
13	MOAB	23-Nov	8-Apr
14	SRER	NA	NA
14	JORN	23-Dec	14-Feb
15	ONAQ	23-Nov	8-Apr
16	WREF	8-Dec	14-Feb
16	ABBY	8-Dec	14-Feb
17	SJER	NA	NA
17	SOAP	23-Nov	8-Apr
17	TEAK	8-Nov	23-Apr
18	TOOL	8-Sep	15-Jun
18	BARR	23-Sep	15-Jun
19	HEAL	5-Oct	25-Apr
19	DEJU	5-Oct	25-Apr
19	BONA	5-Oct	25-Apr
20	PUUM	NA	NA

Table 5. AIS Secondary Precipitation Winter Requirements for Large Coarse Screen.

Domain	Site	Removal Date	Reinstallation Date
4	CUPE	NA	NA
4	GUIL	NA	NA
6	MCDI	8-Dec	8-Mar
13	WLOU	15-Oct	23-Apr
14	SYCA	NA	NA
17	BIGC	8-Nov	23-Apr
18	TOOK	8-Sep	15-Jun

Note: Dates are subject to change as additional insight on weather patterns are experienced.

PRO TIP: *For TIS sites, remove the Throughfall screen in the soil plots at the same time.*

5.3.3 Visual Inspection

Conduct a visual inspection on components onsite to maintain structural integrity, science and engineering requirements. If the following tasks require corrective action, submit a ticket in the NEON project Issue Management and Reporting System.

5.3.3.1 Alter Shield

The Alter shield consists of 32 aluminum deflectors mounted on a circumferential stainless steel hoop surrounding the sensor. The deflectors move depending on the wind speed and direction, up to 30° from vertical (rubber grommets restrain the movement to 30°). These deflectors are spring loaded to return to vertical in low-to-no wind conditions. A Parts List for the Alter shield is in ER [2].

For sites with an Alter Shield (AIS), conduct the following preventive maintenance actions.

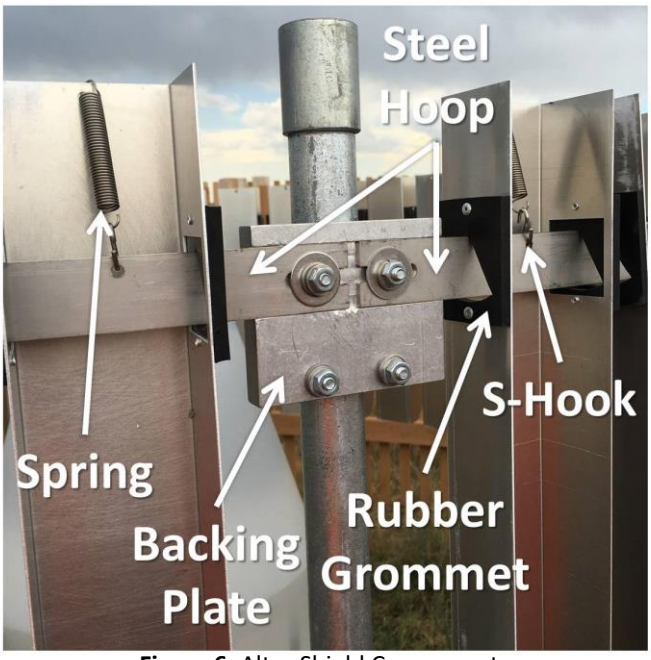


Figure 6. Alter Shield Components.

1. Visually inspect each aluminum deflector (also referred to as a fin) of the Alter shield.
    a. Remove any debris caught within the Alter shield fins or supporting infrastructure.
    b. Check the vertical orientation of each fin during low-to-no wind conditions. Ensure each fin is able to swing freely (up to 30° from vertical).
    c. Verify the presence of all centering springs on each fin.
    d. Inspect the condition of the rubber grommets, springs, S-hook connectors, backing plates, and the condition of the steel hoop (see **Figure 6**).

5.3.3.2 Tipping Bucket Gauge

1. Visually inspect the exterior of the assembly and mounting hardware every 2 weeks to determine if it is free from large debris and plants. Plants, including standing dead plants, that are simply touching part of the assembly, do not require any action; however, plants that appear to be at least partly dependent on the assembly for support (i.e., if the assembly was absent the plant would not be in its current position), should be gently moved or removed and left in place on the ground.

a. If no debris or plants are present, do nothing.

b. If debris or plants are present, are they directly above the collector (i.e., likely affecting precipitation collection)?

i. If no, remove the debris and place it as close as possible to the location where it would have fallen had the assembly not been present, as long as this location does not cause the debris to partially block the collector. For climbing plants that have attached to any parts of the assembly, detach and/or unwind them from the assembly as gently as possible (i.e., minimizing damage to the plant) so that they are no longer supported by the assembly. No ticket is necessary for this scenario.

ii. If yes, take a photo showing the debris and partially covered collector. If possible, the photo should be taken from directly above the sensor. Then remove the debris and place it as close as possible to the location where it would have fallen had the assembly not been present. Submit a ticket including a description and photo of the affected area.

2. Ensure there are no obstructions in the drain holes.

5.3.4 Collector Housing Cleaning

1. De-energize the entire measurement level (for TIS tower sites) per Appendix A – Power Down a TIS Tower Measurement Level or Appendix B – Power Down an AIS Aquatic Device Post.

a. Disconnect the RJF cable going into the Concord Grape associated with the secondary precipitation sensors before proceeding.

2. Check for any debris (foliage, bugs, etc.) that may have accumulated in the screens or collector (**Figure 7**).

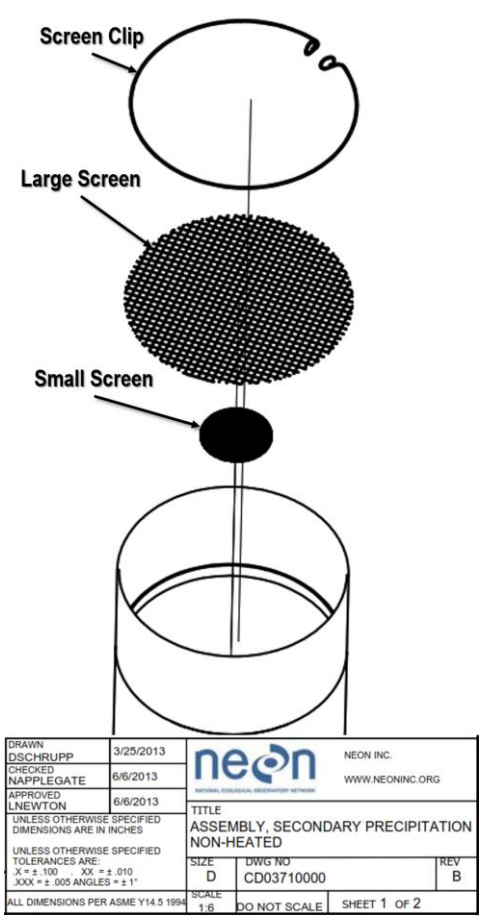


Figure 7. CD03710000 Assembly, Secondary Precipitation Non-Heated.

a. If no debris is present, make sure screens are secure (including screen clip) & properly positioned.

b. If any debris is present, remove screen clip and screens to clean (**Figure 5** and **Figure 7**).

c. Remove all visible debris. Carefully clean the screens separately with distilled or DI water and a lint-free cloth. Wipe any debris residue out of the collector with a damp lint-free cloth. Dry all screens and collector with a dry lint-free cloth.

Note: Do not use any abrasive material on the white powder coated surface of the collector. ***Do not let any soiled water drain through collector onto sensor while cleaning.***

3. Carefully reinstall screens. Ensure both screens are sitting flat before re-inserting the retaining clip. Reference **Figure 7** for screen re-installation order.

4. Reconnect the RJF cable to Grape associated with this sensor.

5. Re-energize the entire measurement level (for TIS tower sites) per Appendix A – Power Down a TIS Tower Measurement Level or Appendix B – Power Down an AIS Aquatic Device Post.

5.3.5 Sensor Leveling

1. Check level of sensor using a digital level in orthogonal directions across the top of the collector. If sensor is more than 2° out of level, in either dimension:

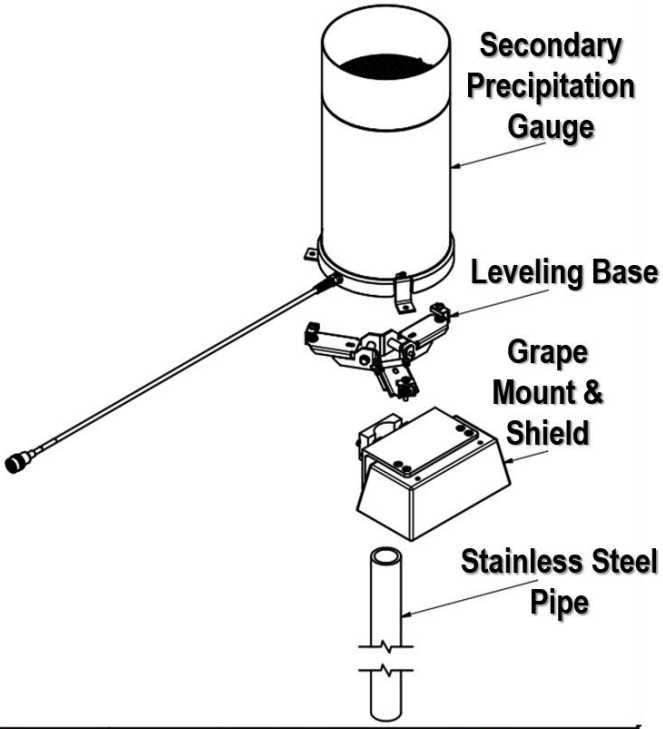
    a. Less than ±2° out of level: proceed to the next step.

b. More than ±2° from level: photo-document the measured angles in both dimensions.

c. Use a 7/16" box wrench to loosen the lock nuts then use 3/16" Allen driver to adjust the height of the 3 sensor feet on the leveling base, as-needed until the collector orifice is back under ±2° (target is: < ±0.5°).

d. See **Figure 8** for reference on sensor leveling base – this is a very similar component for TIS, which mounts on a short boom versus a pipe.

e. Secure the sensor to the leveling base by torqueing 1/8 of a full rotation past finger-tight.



DRAWN RMONTGOMERY	3/11/2014	NEON INC. WWW.NEONINC.ORG	
CHECKED STOWER	10/7/2014		
APPROVED LNEWTON	10/13/2014	TITLE: ASSY, AQU SECONDARY PRECIP, NONHEATED	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: .X = ± .100 . XX = ± .010 .XXX = ± .005 ANGLES = ± 1°		SIZE B	DWG NO HA06800000 REV A
ALL DIMENSIONS PER ASME Y14.5 1994		SCALE 1:6	DO NOT SCALE SHEET 1 OF 1

Figure 8. AIS Secondary Precipitation.

5.3.6 Tipping Mechanism Cleaning

1. Remove Collector from Sensor.

   a. Using a #2 Philips driver, loosen the three screws that fasten the collector to sensor base two full turns (do **not** completely remove). Rotate collector counter-clockwise and lift collector straight up – keeping collector vertical so as not to jostle the screens in the collector (see **Figure 10**).

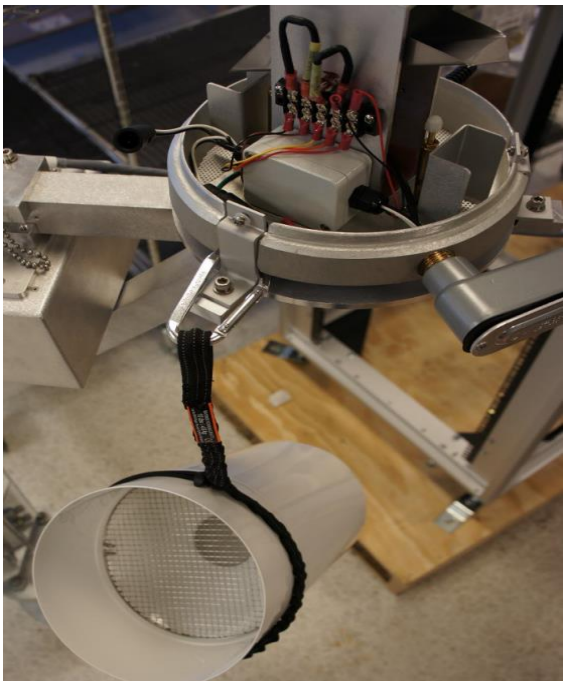


Figure 9. Loosen Screw to Twist and Lift Housing.

Figure 10. Lanyard to Constrain Secondary Precipitation Collector when Cleaning. Tipping Mechanism at TIS Sites.

Important: Only perform this step if Technicians are able to shield the tipping mechanism from ambient precipitation. If this is not possible, delay this cleaning step until conditions improve.

For TIS sites, consider attaching a lanyard to the collector to avoid a damaging drop from the tower top (**Figure 9**).

b. After removing the collector from the base, clean the collector, screens and retainer spring separately (so as not to introduce additional debris to the sensor). *See 5.3.4 for additional information on cleaning the collector.*

    i. If dust or debris is present in the collector or screens, visually inspect and photograph the tipping mechanism for any material that may have accrued in the bucket or obstructed the movement of the tipping mechanism.

c. Remove any loose debris from the tipping mechanism and from the inside of the sensor. If any material is stuck to the tipping mechanism, conduct the following cleaning steps:

    i. Spray a small amount of distilled or deionized water inside one of the tipping buckets allowing it to “soak in” and loosen the debris. Be careful not to over-spray onto electrical terminal strip on sensor body.

    ii. Use a cotton swab to aid in loosening and removing the debris. Use only gentle pressure and continue spraying with water.

iii. Dry with a lint-free cloth after the removal of all debris/dirt.

iv. Repeat for the second bucket.

d. Check on mechanical operation of tipper (bearing integrity) and inspect for corrosion. See **Figure 11**.

e. Verify that all electrical connections are snug (using a #2 Philips head on all the terminals), and visually inspect for corrosion on any of the terminals. If any corrosion exists, record what terminals are affected and if possible, document with a camera. See **Figure 12**.

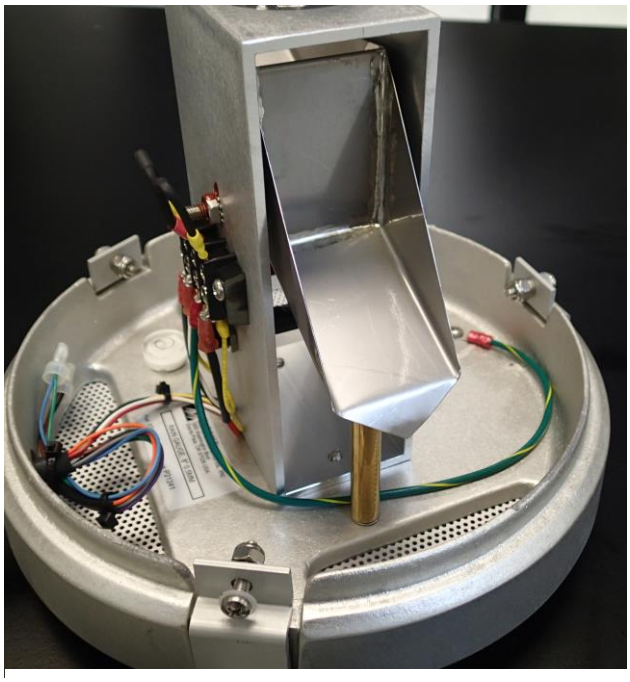


Figure 11. Tipping Mechanism.

2. Reassemble the collector using the reverse order of this procedure.

   a. Ensure nylon washers (reference in **Figure 10** retained on mounting screws are on the outside of the collector (between the screw head and white collector surface, see prior to tightening the three Philips head screws that secure collector to base.

   b. Torque ¼ turn past finger-tight.

3. Reconnect all cables including RJF cable to Grape associated with this sensor.

4. Re-energize site power.

Figure 12. Inspect Terminal Strip(s).

6 REMOVAL AND REPLACEMENT (SUBSYSTEM ONLY)

6.1 Equipment

Table 6. Removal and Replacement Equipment List.

P/N	MX/NEON P/N	Description	Quantity
Tools			
GENERIC		Flush cutters/Scissors (to remove zip-ties)	1
		NEON Laptop w PuTTy or MobaXterm	1
		Extra Ethernet cable (to verify sensor function via portal onsite)	
GENERIC		Hex Key/Wrench Set (to remove Grapes/Grape Shields, as appropriate for sensor swap/refresh; use a 3/16” hex wrench to remove sensor mounts from booms).	1
GENERIC		Wrench Set	1
		Digital Level	1
GENERIC		Aquatic or Tower Site PPE	1 per Technician
4620	MX103120	ESD Wrist Strap (to follow ESD protocols)	1
GENERIC		#2 Philips head screwdriver (to open power boxes)	1
GENERIC		7/16” Nut Driver	1
GENERIC		7/16” Open End / Box Wrench	2
GENERIC		3/16” Allen Driver	1
Consumable Items			
		ESD Bags (for 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
	0366370007	Replacement Slat springs (AIS only)	4
	0366370001	Replacement Slats (AIS only)	4
GENERIC		Cotton Swabs	10
GENERIC		Lint-free/Microfiber Cloths	10
	MX112377	Size #33 Rubber bands (for securing tipper)	10

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 Operations 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 project Calibration, Validation and Audit Laboratory

(CVAL) is responsible for the calibration and validation of select sensors and manages Domain sensor refresh (swap) schedules.

To minimize data downtime and optimize the availability of sound data, coordinate instrumentation and subsystem annual calibration, validation and preventive maintenance requirements to occur within the same timeframe. See **Table 7** for sensor refresh requirements for the subsystem infrastructure on the Secondary Precipitation Sensor.

Table 7. Secondary Precipitation Sensor Refresh Requirements.

	LOCATION		TIMEFRAME			
	CVAL	*FIELD*	*BIWEEKLY*	*ANNUAL*	*NA*	COMMENTS
Secondary Precipitation	X			X		
Concord (24V) Grape	X			X		Follow ESD protocol

6.2.1 Assembly Field Inspection

Prior to field deployment, verify the structural integrity of the Secondary Precipitation Gauge. Ensure the tipping mechanism has **not** been damaged during shipment to the domain office.

1. Remove the collector tipping mechanism from the sensor housing.
    a. Using a #2 Philips driver, loosen the three screws that fasten the collector to the sensor base two full turns (do **not** completely remove).
    b. Rotate collector counter-clockwise and lift collector straight up.
2. Examine the tipping mechanism for any interference between the tipping bucket and sensor body, and check for interference or excessive play in the bearings. Excessive play is defined as the tipper cone that sets in the bearing (in sensor body) being able to move more than ±1mm from the tipping axis.
    a. If either are apparent, document with photos, attach a red tag (see **Figure 15**) and return to HQ for repair.
    b. If no interference or excessive play are evident, proceed with sensor swap per the annual refresh schedule.

6.2.2 Secondary Precipitation Removal/Replacement Procedure

1. Remove Secondary Precipitation Gauge from the TIS or AIS site.
    a. De-energize the TIS tower top measurement level per Appendix A – Power Down a TIS Tower Measurement Level or AIS device post per Appendix B – Power Down an AIS Aquatic Device Post.

b. Disconnect the RJF cable going from the Secondary Precipitation Gauge to the Concord (24V) Grape.

c. Disconnect remaining power and communications cables connecting sensor to NEON project infrastructure (i.e., 12-3 power cable).

d. Remove the Secondary Precipitation gauge from the mounting feet using a 7/16” box wrenches and a 3/16” Allen wrench.

2. Remove Collector from Sensor to conduct decontamination.

Note: Do not perform this procedure unless Technicians are able to shield the tipping mechanism from ambient precipitation. If this is not possible, delay this step until conditions improve.

a. Using a #2 Philips driver, loosen the 3 screws that fasten the collector to sensor base 2 full turns (do **not** completely remove).

b. Rotate collector counter-clockwise and lift collector straight up – keeping collector vertical so as not to jostle the screens in the collector.

c. Once collector is removed from base, conduct decontamination on the collector, screens and retainer spring separately (so as not to introduce additional debris to the sensor). *Reference 5.3.4 for more information.*

d. Use a rubber band to secure the tipping mechanism for shipping (**Figure 13**)**.**

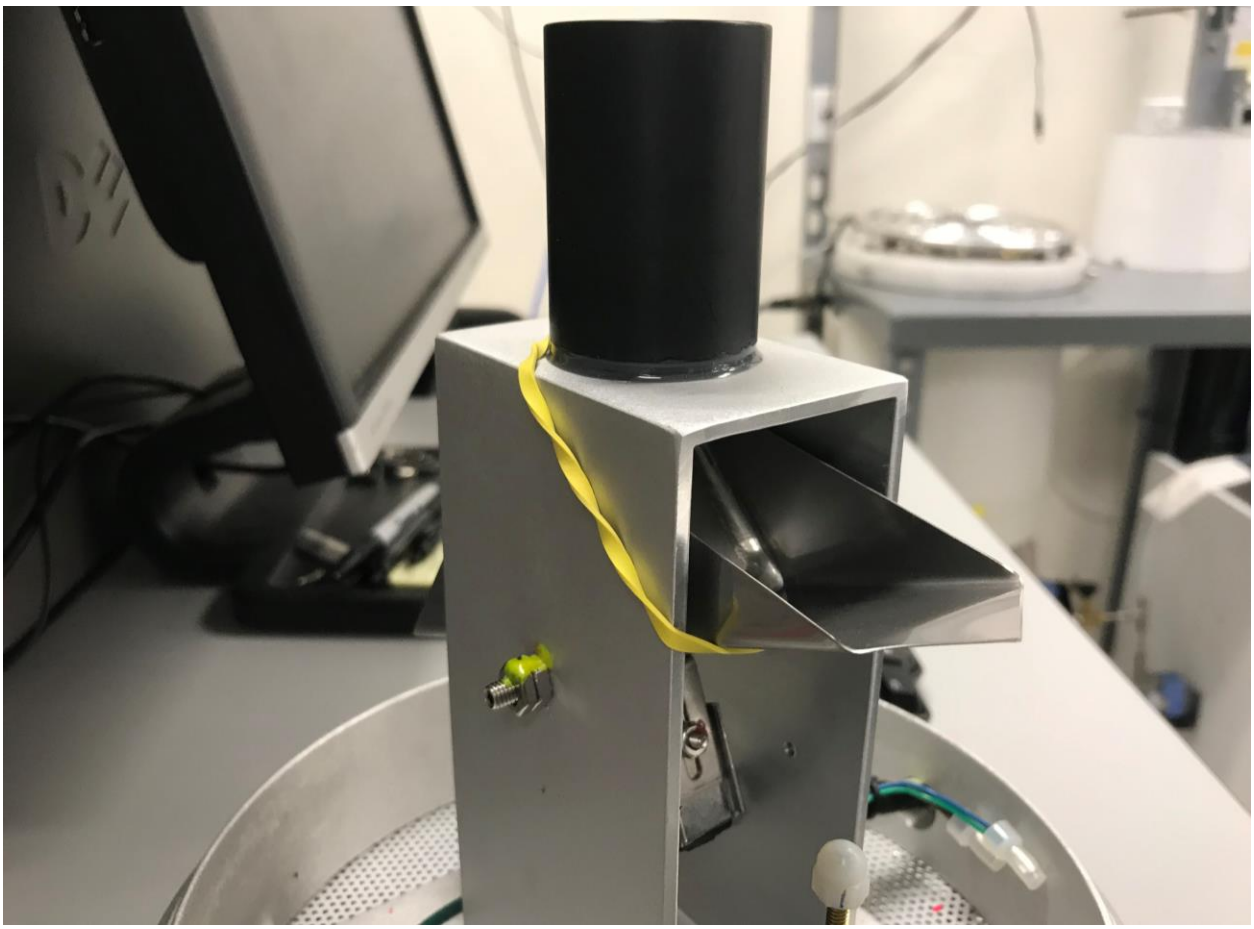


Figure 13. Rubber Band to Constrain Tipping Mechanism for Transport/Shipping.

e. Conduct decontamination on the sensor housing.

f. Reinstall the Collector in the sensor housing using the reverse order of the above steps. Make sure nylon washers retained on mounting screws are on the outside of the collector (between the screw head and white collector surface: see **Figure 10**) prior to tightening the three Philips head screws that secure collector to base. Torque ¼ turn past finger-tight. Then stage for return shipment to NEON HQ.

3. Install new (refresh) Secondary Precipitation sensor in the place of the old sensor (swap sensor).

   a. Remove the collector from the new sensor using a #2 Philips driver: loosen the 3 screws that fasten the collector to sensor base 2 full turns (but do **not** completely remove). Rotate collector counter-clockwise and lift collector straight up.

   b. Insert the ¼-20 Cap Screws through the holes in the sensor feet. Then thread on both the leveling and locking nuts.

c. Once all three sets of hardware are installed on the sensor base, align to mounting plate and thread in all three screws. Level the sensor by simultaneously adjusting the screws and nuts by hand and once level to within ±0.5°. Then torque nuts 1 flat (1/6th of a full turn) while holding the Allen key stationary. Repeat for all three feet.

d. Remove any materials used to restrain the tipping mechanism during shipment and handling (i.e., the rubber band or rubber cord).

Important: Do not pull or yank the band/cord from mechanism.

e. Position the (new) collector above the three mounting holes and rotate clockwise to fully-seat the collector.

   i. Ensure the nylon washers are on the *OUTSIDE* of collector (between white collector surface and screw head).

f. Torque the three Phillips screws 1/4 of a turn past finger tight.

g. For Heated units only: Reconnect the 12-3 power cable.

h. Re-connect RJF cable to Grape

i. Re-energize measurement level if de-energized per Appendix A – Power Down a TIS Tower Measurement Level

6.2.3 Alter Shield Section Removal/Replacement – AIS Only

Access to the precipitation gauge is through the Alter Shield, and requires removal of at least one of the four sections of the shield. Each shield section affixes to support poles by an aluminum backing plate and a 1/4 in. stainless steel hoop (**Figure 14**). Removal of a section is relatively easy, as each end of the stainless steel hoop has a slit at the securing bolts that allow it to slide off the support structure. Reference **Table 8** for systematic guidance on removing an alter shield section.

Note: The Alter shield sections are cumbersome and may have sharp edges. NEON recommends employing two Technicians to perform the removal/re-installation of an Alter shield section.

Figure 14. Alter Shield Area to Initiate Removal.

Table 8. Alter Shield Section Removal.

	**Step 1.** Loosen one of the bolts securing one section of the Alter shield with a 7/16 in. nut driver or standard wrench. Loosen the bolts enough to slide the metal hoop out from underneath the bolt.
	**Step 2.** Loosen the other side of the Alter shield section to for removal, and slide out the metal hoop out from underneath the bolt.
	**Step 3.** While holding up the Alter shield section, slide the other side of the metal hoop out from underneath the bolt.

Step 4. Place the Alter shield section in a safe location.

NOTE: You may remove more than one Alter Shield section if more room around the sensor is necessary.

6.2.4 Grape Removal/Replacement Procedure

1. Wear an anti-static wristband. Employ ESD protocols when handling Grapes. Reference AD [09].
2. Power down the site at the TIS Measurement Level Power Box or AIS Device Post.
    a. Reference Appendix A – Power Down a TIS Tower Measurement Level
    b. Reference Appendix B – Power Down an AIS Aquatic Device Post.
3. Disconnect the armored Ethernet cable connecting to the RJF/Eth to Comm connection.
4. Disconnect sensor connections.
5. Remove Concord Grape from Grape Shield by removing the four screws that affix the Grape to the Grape Shield using a hex wrench. If there is a need to remove the Grape Shield from the pipe, remove the Grape Shield mount/clamp using a 3/16” hex wrench.

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

6. Place dust caps on Amphenol connectors of old Grape.
7. Reinstall new Grape to the Grape Shield with the four screws using a hex wrench.
8. Remove dust caps on sensor connectors and Eth-To-Comm connector. Re-connect sensor and armored Ethernet cable in accordance with AD [04] or AD [05].
9. Re-energize the site and verify Grape and Secondary Precipitation Sensor function. Connect locally to the Aquatics Portal or from the Domain using a TEP and **Table 3**.

6.3 Cleaning & Packaging of Returned Sensor

Field Operations staff must clean, package, and ship the sensors back to the CVAL at the NEON project HQ (Battelle Ecology) for annual sensor swap/calibration requirements. (Please note: if a sensor is defective, submit a trouble ticket and affix a red tag (**Figure 15**) with the trouble ticket number on it.) Clean the Grape (also known as decontamination; *Reference RD [03])* by removing all biologics from the device prior to capping the connections and placing in ESD packaging.

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

For the cleaning and packaging of Secondary Precipitation Sensors and the associated Concord Grape post-removal, conduct the following steps:

1. Check mounting holes for spiders and spider webs. Remove biologics and clean connectors.
2. Cap all connectors.
3. Conduct decontamination (RD [03]) and remove any additional biologics/invasive species from device(s).
4. Pack sensor assembly in original box and packaging from the sensor manufacturer or what was provided via CVAL (e.g., pelican case or other packaging). Pack 24V grape in an ESD bag.
5. 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 TRANSIT/DxxSUPPORT.

6. 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.
7. 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 project HQ using the following address:

BATTELLE ECOLOGY, **ATTN: CVAL**
1685 38TH STREET, SUITE 100

BOULDER, CO 80301

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

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

6.4 Sensor Refresh Record Management of Assets

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

6.4.1 NEON Asset Management and Logistic Tracking System Requirements

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

7 ISSUE REPORTING OUTPUTS

FOPS must report issues encountered while conducting preventive maintenance in the NEON project Issue Management/Reporting System. 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 Address, MAC Address, etc.
- Provide Diagnostic Information (from firmware, if applicable), such as error codes, values, etc. Provide screenshots.

Table 9. Secondary Precipitation Metadata Output Checklist.

Issue Reporting Datasheet		
Datasheet field	**Entry**	
NEON Site Code		
Maintenance Date		
Maintenance Technician		
Preventive Maintenance	**Issue Noted**	**Issue Summary**
Cables/Connectors - Condition Check	☐	
Sensor - Condition Check	☐	
Sensor - Configuration Check	☐	
Sensor – Clean	☐	
Sensor – Other Specific Checks	☐	
Mesh screens removed?	☐	Yes: ☐ Date:
Mesh screens re-installed?	☐	Yes: ☐ Date:
Environmental Information	☐	
Notes		

Ship all defective equipment/assets with a red "Rejected" tag. **Figure 15** displays the minimum information requirements for each tag.

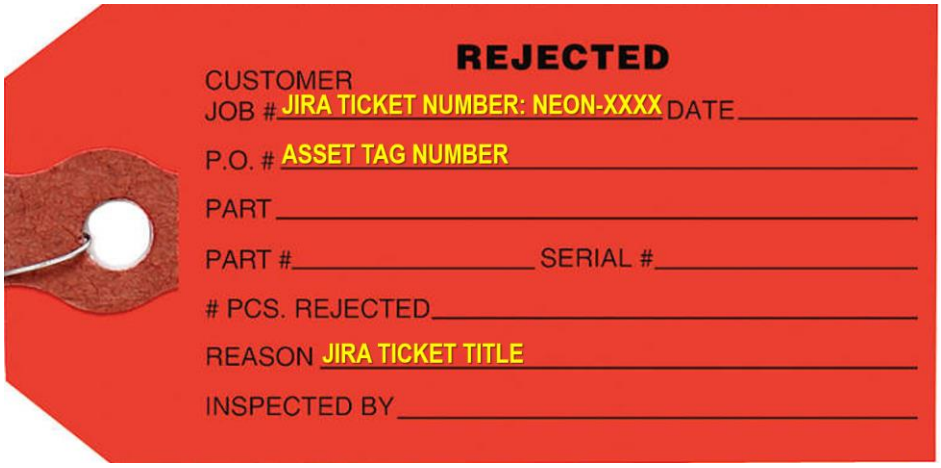


Figure 15. Red Rejected Tag for Defective Assets (MX104219).

8 APPENDIX A – POWER DOWN A TIS TOWER MEASUREMENT LEVEL

Power down the Measurement Level (ML) power box via the adjacent Communications (Comm) box providing power to tower ML.

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

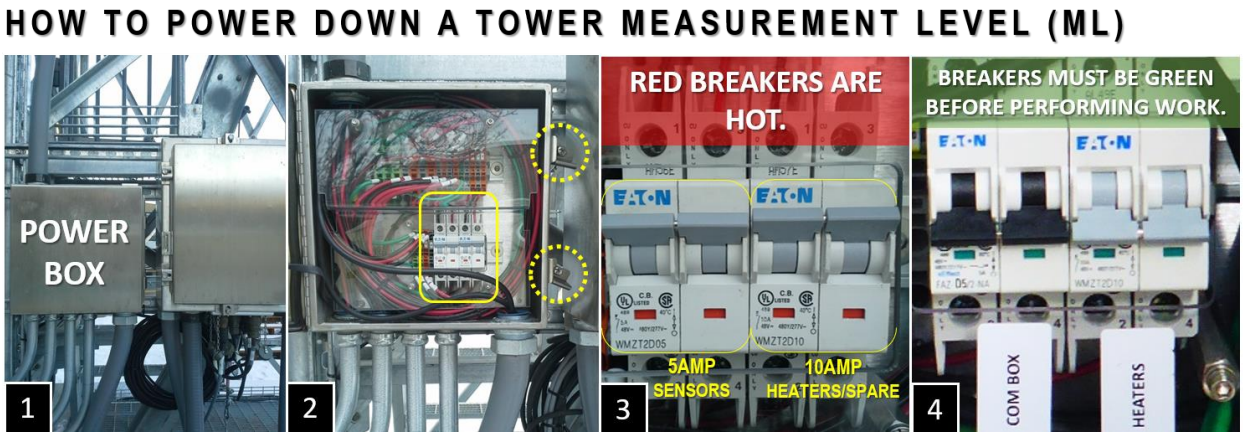


Figure 16. How to Power Down a Tower ML.

To power down a Tower ML to conduct preventive maintenance and/or to swap sensors and subsystems, conduct the following steps in accordance with **Figure 16**.

1. Locate the ML power box.
    a. ***Connections may reside on multiple levels if ports are unavailable. Please ensure this procedure occurs for all applicable power boxes for the ML.***
2. Open the power box using a Phillips-head screwdriver on the two clasps on the right. **Figure 16** identifies the location of the two clasps and the location of the breakers in image number 2.
3. Locate the breakers. A 5 Amp breaker is on the left and A 10 Amp breaker is on the right.
    a. The 5 Amp breaker turns the power on/off to the sensors (via their Comm box).
    b. The 10 Amp breaker turns the power on/off for sites employing heaters. If a site does not employ a heater, then it is a spare breaker.
    c. Red breakers indicate the power is ON – live voltage.
4. Flip the breakers down on the 5 Amp and the 10 Amp breakers to de-energize the ML.
    a. <u>The color on the breaker is green, signifying the power is OFF – ***go ahead and proceed***</u>**.**

9 APPENDIX B – POWER DOWN AN AIS AQUATIC DEVICE POST

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.

1. Power down the site from the AIS Device Post power box. Use **Figure 17** for this procedure.
    a. Power down the Device Post providing power to the Secondary Precipitation Sensor via the power box breakers.
    b. Open the Power Box using a Philips head screwdriver.
    c. Flip both breakers from RED to GREEN.
    d. Conduct LOTO procedures and proceed with the Preventive Maintenance, Sensor Refresh and/or Corrective Maintenance.

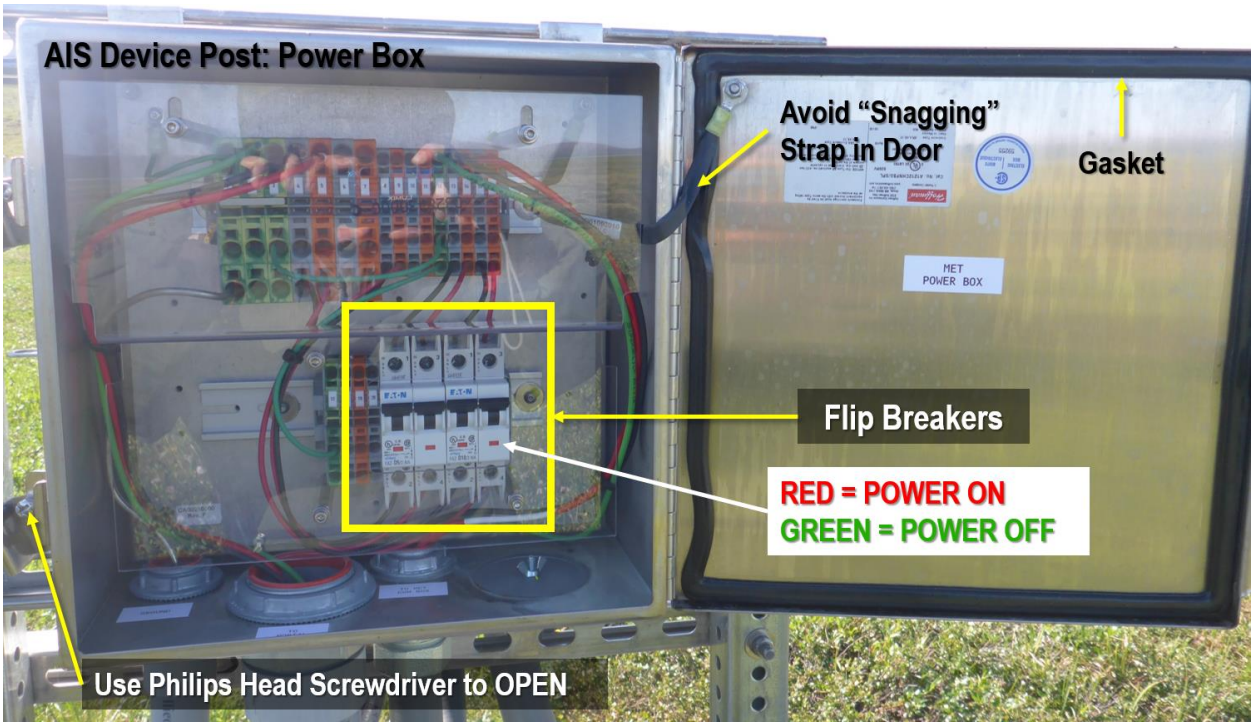


Figure 17. AIS Device Post: Power Box Components (Domain 18 OKSR AIS Aquatic Met Station).

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

10 SOURCES

Keller, Andrew. Secondary Precipitation Pictures, D13 MOAB Tower. November 27, 2017.

Ploeger, Torey. Secondary Precipitation Pictures, TIS Post-Deployment I&V Impact Report D04C GUAN Tower. January 19, 2017.

Simonds, Geoff. Verification Photos of TOOL AIS Secondary Precipitation. Accessed November 28, 2017. N:\Common\SYS\Install Docs Work in Progress 20170619\`AIS_Install_Docs\`Incoming_Drafts\D18-TOOK_Met

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Models: Robert Lee