NEON PREVENTIVE MAINTENANCE PROCEDURE: SOIL WATER CONTENT AND SALINITY PROFILE

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/12/2016	ECO-03681	Initial Release
B	04/04/2017	ECO-04604	Added procedure to check that cables and other infrastructure are at least 30 cm from the sensors
C	02/06/2018	ECO-05367	Added Section 6 removal/replacement procedures and Section 8 power-down procedures. Updated sensor information in all sections, added and consolidated graphics, and formatted. Incorporated specific sensor handling instructions following ESD protocols.
D	12/01/2022	ECO-06923	Updated NEON logo and minor formatting fixes

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1 DESCRIPTION

1.1 Purpose

NEON sites host sensors that take measurements from air, water, wind, 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 **Soil Water Content and Salinity Profile** 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 Sentek TriSCAN sensor based profiles at applicable NEON Terrestrial Instrument System (TIS) sites. This includes preventive maintenance procedures and requirements for the following soil water content and salinity profile instrument, subsystem and supporting infrastructures.

- ***CF00810000*** *Assembly, Soil Water Content Profile, Population, 2 Meter*
- ***CF00810010*** *Assembly, Soil Water Content Profile, Population, 2 Meter, 1 Sensor*
- ***CF00810020*** *Assembly, Soil Water Content Profile, Population, 2 Meter, 2 Sensors*
- ***CF00810030*** *Assembly, Soil Water Content Profile, Population, 2 Meter, 3 Sensors*
- ***CF00810040*** *Assembly, Soil Water Content Profile, Population, 2 Meter, 4 Sensors*
- ***CF00810060*** *Assembly, Soil Water Content Profile, Population, 2 Meter, 6 Sensors*
- ***CF00813000*** *Assembly, Soil Water Content Profile, Population, 3 Meter*

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.000804	Site Flora and Fauna Maintenance Plan
AD [06]	NEON.DOC.00XXXX	Site-specific Flora and Fauna Maintenance Plan
AD [07]	NEON.DOC.002030	Instruction, Assembly, Soil Water/Ion Content Sensor Profile Rod
AD [08]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure
AD [09]	NEON.DOC.000007	NEON Algorithm Theoretical Basis Document (ATBD): TIS Soil Water Content and Water Salinity
AD [10]	NEON.DOC.004313	Soil Water Content Formal Verification Procedure
AD [11]	NEON.DOC.000779	TIS Soil Plot Layout
AD [12]	NEON.DOC.003146	Soil Sensor Depth Selection
AD [13]	NEON.DOC.001084	L1W300 Soil Moisture Profile Normalization Fixture Manual
AD [14]	NEON.DOC.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles
AD [15]	NEON.DOC.001217	Schematic, Soil Moisture Assembly

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.002768	TIS Subsystem Architecture, Site Configuration and Subsystem Demand by Site - SCMB Baseline
RD [04]	NEON.DOC.004637	TIS Verification Checklist
RD [05]	NEON.DOC.003656	NEON Preventive Maintenance Procedure: Soil Throughfall Collector

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]	Sentek. 2003. TriSCAN Agronomic User Manual, Version 1.2a. Sentek, Stepney, South Australia. https://s.campbellsci.com/documents/sp/manuals/sentek_triscan.pdf

ER [02]	Buss, P., M. Dalton, S. Green, R. Guy, C. Roberts, R. Gatto, and G. Levy. 2004. Use of TriSCAN for measurement of water and salinity in the soil profile.in 1st National Salinity Engineering Conference, Perth, Western Australia. http://search.informit.com.au/documentSummary;dn=923443776113761;res=IELENG

2.4 Acronyms

Acronym	Description
A/R	As Required
AC	Alternating Current
ADC	Analog to Digital Converter
CPER	Central Plains Experimental Range (Domain 10)
Comm	Communication
DELA	Dead Lake (Domain 08)
LC	Location Controller
NA	Not Applicable
NaN	Not a Number
JSA	Job Safety Analysis
P/N	Product Number or Part Number
PoE	Power over Ethernet
QLS	Quantum Line Sensor
SP	Soil Plot
SWC	Soil Water Content
TALL	Talladega National Forest (Domain 08)
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, Combo Box, Arbor	**Device Post**
Soil Moisture Sensor, Sentek TriSCAN sensor, soil water content (SWC) sensor	**Soil Water Content and Salinity Profile**

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 TIS Soil Arrays 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 preventive/corrective maintenance and Sensor Refresh procedures.

4 SENSOR OVERVIEW (SENSORS ONLY)

4.1 Description

Soil water content and, to a lesser extent, salinity influence the rate of most soil processes, as well as the occurrence and activity of soil organisms and plant roots. This makes them important soil properties to monitor. At most NEON TIS soil plot sites, the Soil Water Content and Salinity Profile consists of up to eight sensors in a vertical profile on a rod within each soil plot (a total of five instruments with up to eight sensors per instrument). The vertical spacing between measurements is smaller near the top of the profile, since this area is the most dynamic, and the characterization of each sensor depth is partially from the thickness of soil horizons at a nearby location with similar soils (*reference AD [12] for more information*). The Soil Water Content and Salinity Profile extends to 2 meters (m) deep at most TIS sites, assuming this depth does not consist of bedrock or other environmental constraints, and to 3 m at most Alaskan sites in order to capture permafrost dynamics. (*Reference site-specific As-Built documentation to verify Soil Water Content and Salinity Profile assemblies at your site via the NEON Document Warehouse.)*

The Soil Water Content and Salinity Profile assemblies consists of a PVC outer tube in a borehole in each soil plot. The outer tube stays in the borehole as a permanent installation to prevent sensor removal/replacement tasks from disturbing the surrounding soil. The Soil Water Content and Salinity Profile instrument consists of several sensors, which mount to a single rod and resides inside the PVC outer tube (reference **Figure 1**).

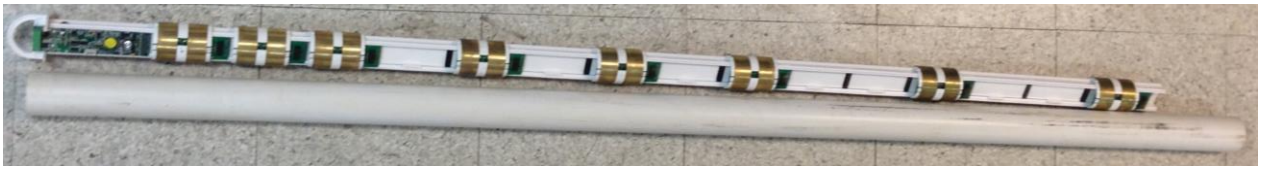

Figure 1. Soil Water Content and Salinity Profile Instrument with PVC Outer Tube (Below Instrument).

The Soil Water Content and Salinity Profile sensors are positioned against the interior wall of PVC outer tube and measure the soil water content and salinity in the surrounding soil. One or more rubber gaskets at the bottom of the PVC outer tube prevent water intrusion. The instrument sits in each soil plot under a protective cap (see **Figure 2**) and draws power from a nearby Merlot (12V) Grape.

Figure 2. Soil Water Content and Salinity Profile Installation with Cap in TIS Soil Plot (D08 DELA & TALL).

The Soil Water Content and Salinity Profile primary subsystem/accessories consists of the following components:

- PVC Outer Housing (permanent access tube in borehole)
- Top Cap Assembly (***0319390010***, *Sensor Accessory EnviroSCAN Top Cap Assembly*)
- Merlot Grape (12V) Data Logger, which mounts to the Soil Plot Short Arbor
- Back UV Polyurethane Power Cable (***0316970000***, *Cable 22 AWG 6 Conductor Shielded Black*)
- Desiccant (***0319390015***, *Sensor Accessory EnviroSCAN Installation Silica Gel, 25g Bag*)

4.2 Sensor Specific Handling Precautions

4.2.1 Instrument

FOPS Technicians must employ ESD protocols per AD [08] when handling Soil Water Conant and Salinity Profile for Sensor Refresh and/or while conducting other maintenance activities. When directly handling the Soil Water Conant and Salinity Profile, use a grounding cable to avoid ESD damage to the sensor. The grounding cable connects to Pin 4 on the main circuit board of the sensor in place of the multi-pin phoenix connector and clamps to the nearest soil arbor (**Figure 3**). Attach an ESD wrist strap to the screw in **Figure 4**. Another form of equipment FOPS may use is a ground wrist strap with alligator clip provided via CVAL. Verify grounding cables and straps by measuring for resistance using a Digital Multi-Meter (DMM).

WIRING TABLE			
P1	WIRE COLOR	RS232 POSITION	SENTEK VALUE
A	BLACK	5	TX
B	BROWN	6	RX
C	RED	4	GND
D	N/C	N/C	RTS
E	N/C	N/C	CTS
F	ORANGE	2	ID
G	YELLOW	1	+12V
H	GREEN	4	GND

neon
NATIONAL ECOLOGICAL OBSERVATORY NETWORK

TITLE
ASSY, SOIL WATER CONTENT PROFILE, INSTALLATION CAP

SIZE	DWG NO	REV
B	CF02200000	B
SCALE	DO NOT SCALE	SHEET 1 OF 1

Figure 3. Wiring Table for Phoenix Connector (CF02200000).

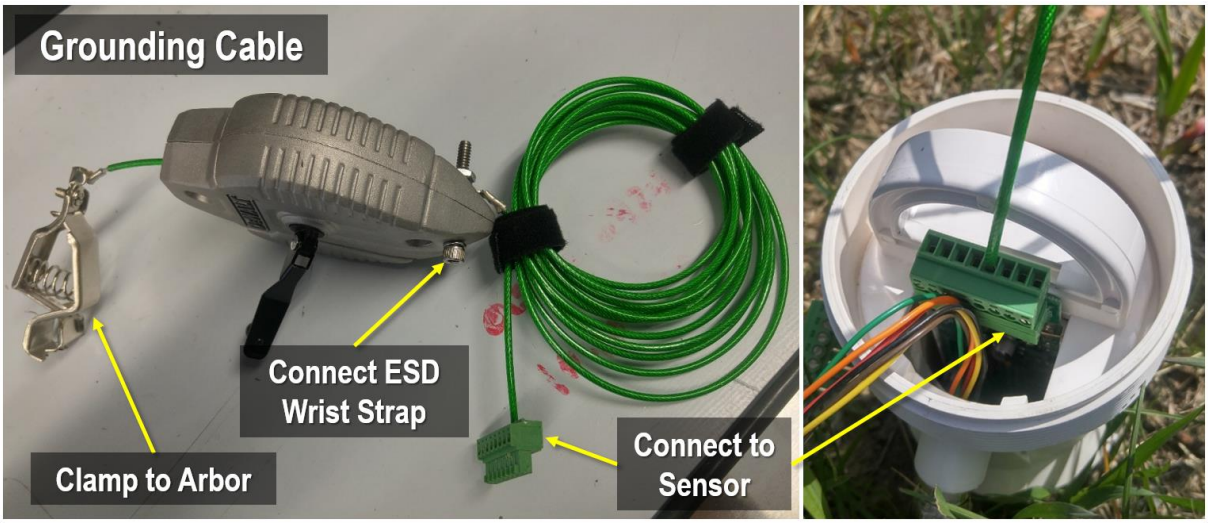

Figure 4. Grounding Cable for SWC & Salinity Profile Instrument.

Removing the cap exposes the instrument circuit board to the surrounding environment and elements. Maintain awareness of the weather when exposing the instrument circuit board. ***Do not allow water or other debris to enter the PVC outer tube when removing the assembly cap.***

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 [08]). 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

The Soil Water Content and Salinity Profile is a Sentek TriSCAN sensor, which is a capacitance-type sensor that measures the dielectric constant of the soil (including air and water) matrix surrounding the access tube. The dielectric constant correlates with volumetric soil water content with regard to the surrounding soil texture, salts, and organic matter content; however, application of site- and depth-specific calibration coefficients aim to mitigate the influence of soil physical and chemical properties on the sensor measurements. (Reference ER [01], ER [02], and AD [13] for additional information on sensor calibration.) The Sentek TriSCAN sensors performs measurements using two different frequencies, one of which estimates volumetric water content. Both measurement frequencies use a proprietary algorithm to produce the volumetric ion content, which correlates with soil salinity. **Figure 5** provides the physical architecture for data acquisition/transmission and power distribution systems in operation.

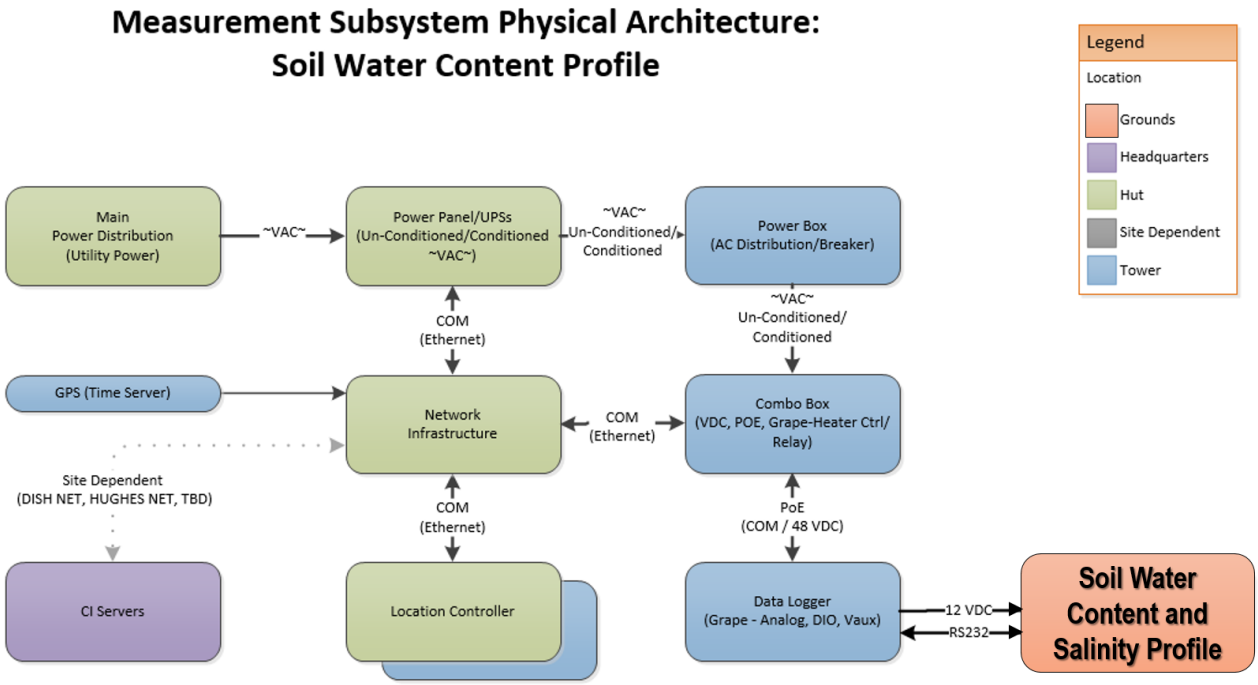

Figure 5. Soil Water Content and Salinity Profile Physical Architecture.

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Equipment

Table 1. Preventative Maintenance Equipment List.

Item No.	Description	Quantity
Tools		
NEON, IT	NEON Laptop	1
GENERIC	Ethernet Cable	1
GENERIC	#2 Philips head screwdriver	1
GENERIC	Camera	1
GENERIC	Compass	1
GENERIC	Wood plank, rubber mat, or similar (~60 x 40 cm) for standing on in soil plot	1
	Fluke Digital Multi-Meter (DMM)	1
Consumable Items		
0319390015	Sensor Accessory EnviroSCAN Installation Silica Gel, 25g Bag (Desiccant)	5
0338570000	Bag, Disposable Desiccant, Indicating Silica Gel, for 60 Cubic Inches	A/R
Resources		
	Terminal Emulator Program (TEP) (i.e., PuTTy, MobaXterm, other SSH/Telnet client)	

5.2 Subsystem Location and Access

All the sensors within the soil plots are making measurements of the environment immediately surrounding them. **Figure 6** provides an example of a soil plot in Domain 10 at the Central Plains Experimental Range (CPER) TIS site. (This site does not have a canopy and no longer uses a Throughfall Collector; however, this provides graphical overview of all soil plot sensors that reside at TIS sites.)

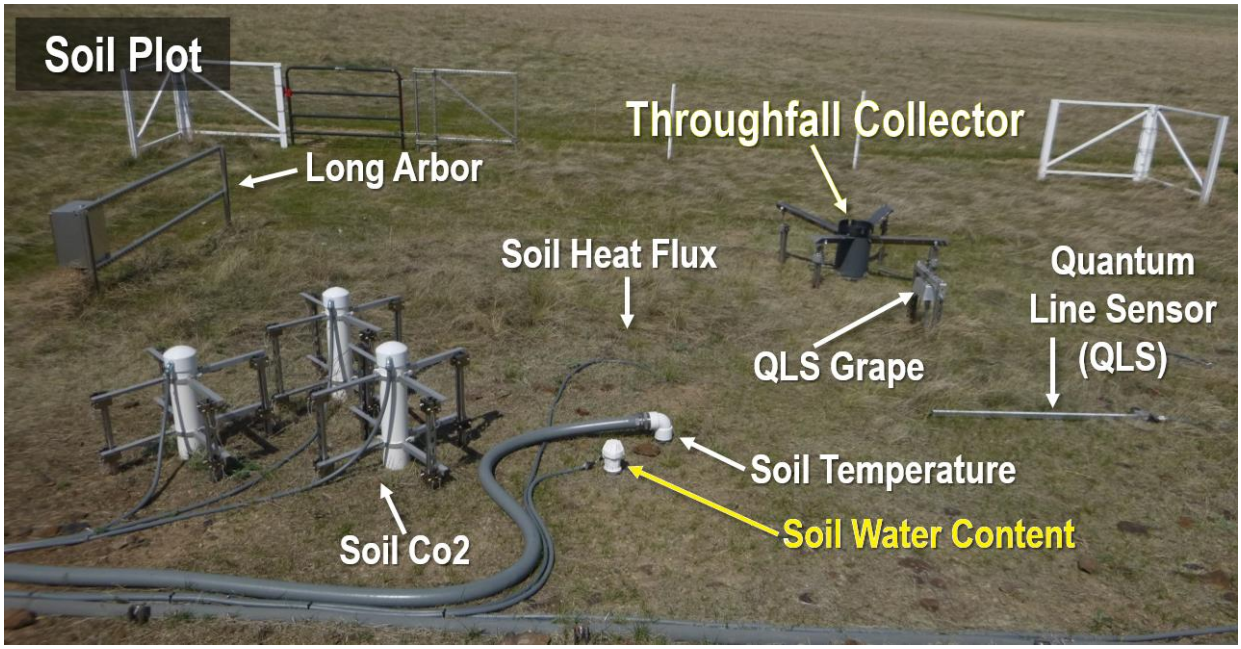

Figure 6. Soil Plot 1 (Domain 10, CPER) with Cattle Fencing (Not Shown: Device Post, Short Arbor, HMP and NR01).

It is important that FOPS does not disturb the soil plot and surrounding area while conducting maintenance activities. The NEON project headquarters (HQ) recommends grouping sensor maintenance activities together to minimize influencing the surrounding area and reduce FOPS ecological footprint in each plot. Minimize the amount and frequency of trips in and out of each plot and surrounding area as much as possible.

Access to the soil plots shall follow the designated route that was established during site construction. Typically, this route starts at the staging area and follows a clearly marked path that passes the instrument hut before reaching the soil array path. The NEON project only permits foot traffic between the soil array path and each soil plot (i.e., no wheeled carts or other machinery), with the exception of equipment to perform maintenance to meet the conditions specified in the Flora and Fauna plans in AD [05] and AD [06]. For example, a rototiller to mimic plowing at an arable site.

Important: Once Technicians reach the device post at the relevant soil plot, they must walk towards the soil plot following the route of the conduit from the device post to the soil plot arbor remaining at least 1m (~3.3') outside of the soil plot at all times (see **Figure 7).** Always travel the shortest route towards the assembly that remains at least 1m outside of the soil plot.

Remain at least 1m outside of the plot unless maintenance activities require close contact with a sensor. When approaching a soil plot, do not step or place tools on the ground within 30cm (~1') of any sensors within the soil plot to minimize disturbance to the soil and vegetation surrounding the sensor.

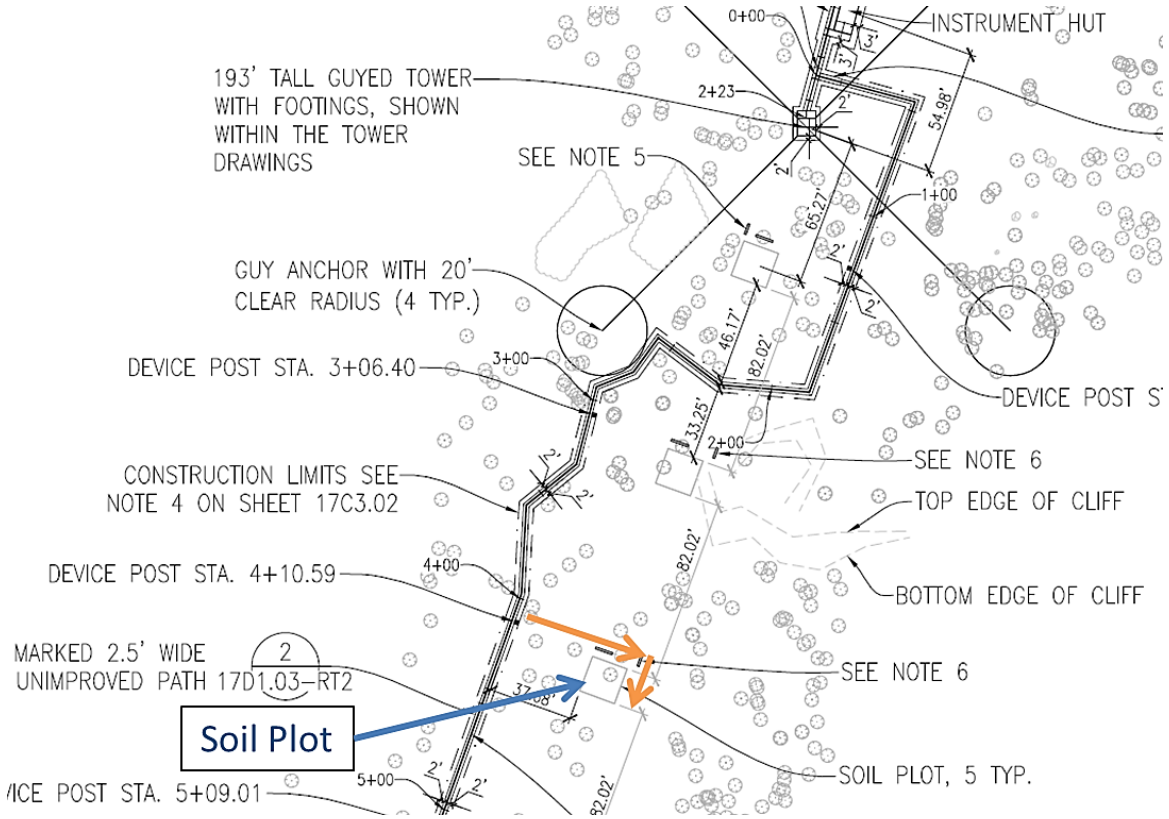

Figure 7. Walking Route Example Orange Arrows) From the Soil Array Path to A Soil Plot (D17 SOAP Civil Construction).

A Soil Water Content and Salinity Profile instrument resides in each TIS soil plot (AD [11]) in a vertical borehole directly beneath a top cap assembly. The top cap assembly, power cord (**Figure 2**) and Grape are the visible (aboveground) exterior components of this sensor and subsystem. The circuit board is visible (interior) beneath the cap (see **Figure 2**). The remaining belowground components (i.e., outer housing, rod area with sensors) are not visible without complete removal of the instrument from its access tube.

5.3 Maintenance Procedure

Table 2. Soil Water Content and Salinity Profile Maintenance Intervals.

Maintenance	Bi-weekly	Eight Weeks	Quarterly	Bi-Annual	Annual	As Needed	Type
Soil Water Content and Salinity Profile							
Remote Monitoring	X					X	P
Visual Inspection	X					X	P
Check Desiccant	X	X				X	P
Apply Anti-Seize			X				P

Maintenance	Bi-weekly	Eight Weeks	Quarterly	Bi-Annual	Annual	As Needed	Type
	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.						

5.3.1 Remote Monitoring

Verify TIS soil sensors are sending data to HQ via the SAS Report. For Soil Water Content and Salinity Profile data streams that are missing/red via SAS, conduct a real time verification of each missing/failed data stream to double check if the data streams are online, but failing to transmit data streams to HQ. Otherwise, look up to view if the subsystem components have power. Conduct this check using a Terminal Emulator Program (TEP), such as PuTTy or MobaXterm, to connect to each Merlot Grape in the soil array. The data state of health presents indicators to focus preventive maintenance efforts; anomalies in the data or if the Soil Water Content and Salinity Profile is off the network, it may dictate preventive maintenance tasks for investigation to determine if onsite corrective action is necessary. Use the Grape MAC address/Sensor EPROM ID with the command prompts in **Table 3**.

PRO TIP: *To perform these functions, Technicians must acquire the Grape MAC address (see **Figure 10**) and/or the EEPROM ID (from Maximo) of the sensor. Use this to verify function of Grapes and Sensors post-Sensor Refresh, too. Reference these from site sensor mapping documents and update these documents accordingly to have relevant information on hand.*

PuTTy Login Username: **user** | Password: **resuresu**

Table 3. View Grape and Sensor Data Streams (MAC and EPROM ID are Examples for this Command).

Remote Monitoring 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.

5.3.2 Visual Inspection

Conduct a bi-weekly visual inspection on the Soil Water Content assembly and subsystem. Conduct the following maintenance inspections.

Note: Do not stand or place tools on the ground closer than 30 cm (~1 foot) from the edge of the sensor location or any other sensor within the soil plot. Stand outside of the soil plot to inspect the Soil Water Content and Salinity Profile assembly unless preventive and/or corrective actions are necessary.

1. If no snow or standing water exists around the sensor, check for noticeable soil erosion, deposition, and burrowing around the assembly location and within 30 cm radius of the sensor location every 2 weeks.

    a. Inspect any gaps between the edge of the assembly tube and the wall of the borehole (the assembly tube should be flush with the surrounding soil).

*Note: If snow or standing water is present, **DO NOT** perform this check.*

    b. If there is no evidence of disturbance, do nothing.

    a. If soil disturbance is noticeable or if a gap between the assembly and the borehole is present, submit a ticket in the NEON project Issue Management System for science evaluation to determine corrective actions, if necessary. Photograph the erosion for the trouble ticket to enable a quicker evaluation response.

2. If no snow or standing water is present around the assembly, ensure there are no cables or other NEON project/BEI infrastructure within 30 cm of the assembly (exclude the black power cable that connects to the assembly).

    a. If a cable that is not part of the assembly is within 30 cm of the assembly, attempt to move the cable so that it is at least 30 cm away from the assembly. (When moving the cable, ensure it does not violate any other surrounding soil sensor requirements, as well.)

    b. If unable to move the cable or other NEON infrastructure 30 cm away from the assembly, document and submit a ticket in the NEON project Issue Management System for science evaluation to determine corrective actions are necessary.

Note: If Technicians use a magnetic compass for this step, please remember to account for magnetic declination at the site.

5.3.3 Instrument Desiccant Inspection

Note: Do not stand or place tools on the ground closer than 30 cm (~1 foot) from the edge of the sensor location or any other sensor within the soil plot

If snow or standing water is < 4 cm deep immediately around the sensor location (i.e., not covering the gray part of the collar on the cap assembly), check the desiccant in the soil water content assembly every 8 weeks (±1 week). If snow or standing water depth is ≥4 cm, do not check the desiccant until the level decreases. For sites with high humidity, please check at a higher frequency to determine if the desiccant is able to last eight weeks. Start at 2-4 week desiccant checks and decrease as applicable. If

desiccant within assemblies are expiring in higher or varying frequencies than normal, submit a ticket to determine if there is a leak in the access tube.

Employ judgement when navigating the soil plot to minimize disturbance to the area when standing and kneeling to perform this task. In many cases, particularly locations with sparse ground-level vegetation and/or when the soil is wet, this can be best achieved using the wood plank or rubber mat positioned ≥30 cm (~1 foot) from all sensors to distribute your weight over a wider area within the soil plot. However, if vegetation is particularly dense around the sensor the disturbance caused by using the plank or mat may be greater than simply standing or kneeling directly on the ground.

1. To remove the Top Cap assembly, brace the collar of the top cap with one hand and then unscrew the top cap using the other hand (**Figure 8**). Be careful to minimize movement or rotation of the access tube during this process by holding the collar firmly.

Figure 8. Brace Collar (right hand in picture on right) when Removing the Top Cap to Prevent Assembly Movement.

Note: Do not allow soil, leaves, or other material to fall into the tube. If it is raining, use a shield (e.g., poncho/small tarp) to prevent moisture or other debris from entering the access tube. If the rain is too heavy to prevent water from entering the access tube when using a shield, postpone this check until conditions improve (I.e., conduct during the next biweekly visit, if possible).

2. Inspect the color of the silica desiccant packet (**Figure 9**). The desiccant pack resides under the Top Cap assembly, opposite side of the circuit board. The sensor may remain in the access tube as-is; there is no need to remove the instrument from the tube to check the desiccant.

    a. If the desiccant is white, leave it in the tube.

b. If the desiccant is pink, replace the desiccant with a new desiccant packet.

Figure 9. The Desiccant Pack Resides Directly Under the Top Cap Assembly.

PRO TIP: In the event the Sentek TriSCAN 25g desiccant packets are unavailable, please substitute with three soil CO_2 sensor 10g desiccant packets.

3. Reassemble the Top Cap assembly while bracing the collar to prevent unnecessary movement of the assembly or creation of gaps between the assembly and borehole.

If the desiccant requires three or more sequential inspections due to discovering faster expiration of the desiccant pack, submit a trouble ticket stating the sensor assembly and soil plot number (see site-specific requirements for plot number), as this may indicate that the desiccant either requires more frequent inspections or that a leak is present in the assembly.

6 REMOVAL AND REPLACEMENT (SUBSYSTEM ONLY)

6.1 Equipment

Table 4. Removal and Replacement Equipment List.

Item No.	Description	Quantity
	Tools	
GENERIC	#2 Philips head screwdriver	1
GENERIC	Hex Wrench Set	1
GENERIC	3/16" Allen Driver	1
MX103120	3M Antistatic Wristband (ESD Requirement)	1
	Sensor Green Ground Cable	1
	Wood plank, rubber mat, or similar (~60 x 40 cm) for standing on in soil plot	1
GENERIC	Landscaping/mechanics gloves for traction removing cap/handling objects	1 Pair
	Consumable Items	
0319390015	Sensor Accessory EnviroSCAN Installation Silica Gel, 25g Bag (Desiccant)	A/R
See below	ESD Packaging for Grape(s)	5
MX105865	3M Bag, ESD Shielded, 8 inch x 11 inch, Cushioned	A/R
MX105931	3M Bag, ESD, Static Shield, 6 x 8 Inches, Zip Closure, Non-Cushioned	A/R
MX105864	3M Bag, ESD Shield, 6 Inch X 7 Inch, Cushioned	A/R
MX105866	3M Bag, ESD Shielded, 14 Inch X 15 Inch Cushioned	A/R
MX105935	3M Bag, ESD, Static, 15 x 18 Inches, Zip-Closure Top	A/R
MX104219	Grainger Red Inspection Tag, Paper, Rejected, PK1000	A/R
	Plastic Grape Dust Caps	2-6
	Resources	
CVAL	Soil Water Content and Salinity Profile Shipping Container	5

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 TIS 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 5** for sensor refresh requirements for the subsystem infrastructure on the Soil Water Content and Salinity Profile.

Table 5. TIS Soil Water Content and Salinity Profile Sensor Refresh Requirements.

	LOCATION		TIMEFRAME			
	CVAL	*FIELD*	*BIWEEKLY*	*ANNUAL*	*NA*	COMMENTS
Soil Water Content and Salinity Profile	**X**			**X**		Follow ESD protocols when directly handling this instrument.
Merlot (12V) Grape	**X**			**X**		Follow ESD protocols.

6.2.1 Soil Water Content and Salinity Profile Removal/Replacement Procedure

6.2.1.1 Soil Water Content and Salinity Profile Removal Procedure

Remove the Soil Water Content Profile from the Soil Plot using the following procedure. If snow or standing water depth is ≥4 cm, do not remove the sensor until the level decreases. If it is unlikely that the water or snow level will decrease in a reasonable timeframe, submit a ticket in the NEON project Issue Management System for HQ guidance. **Do not allow water into the access tube.**

1. De-energize the entire soil plot per *Section 8 Appendix A – Power Down A Soil Plot Power Box.*
2. Disconnect the RJF cable on the Soil Water Content and Salinity Profile Merlot Grape (**Figure 10**).
3. Technicians must employ their judgement onsite to minimize soil disturbance to the area where standing and kneeling are necessary to perform this task. In many cases, particularly locations with sparse ground-level vegetation and/or when the soil is wet, this can be best achieved using the wood plank or rubber mat positioned ≥30 cm (~1 foot) from all sensors to distribute your weight over a wider area within the soil plot. However, if vegetation is particularly dense around the sensor, the disturbance caused by using the plank or mat may be greater than simply standing or kneeling directly on the ground.
4. Brace the collar of the top cap with one hand and then unscrew the top cap using your other hand. Be careful to minimize movement or rotation of the access tube during this process by holding the collar firmly (**Figure 8**).

Note: Do not allow soil, leaves, or other material to fall into the tube. If it is raining, use a shield (e.g., poncho) to prevent moisture or other debris entering the tube. If the rain is too heavy to prevent water entering the tube even when using a shield, postpone this check until conditions improve.

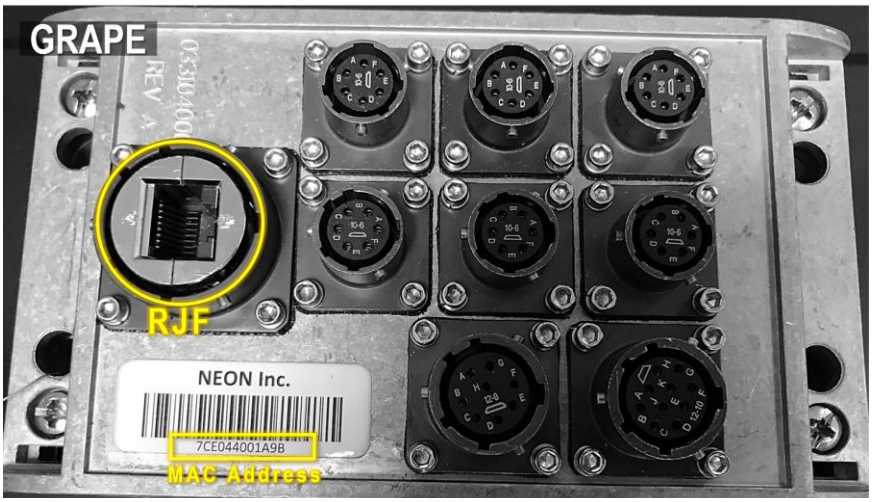

Figure 10. Grape RJF Connector and MAC Address Location.

5. Remove the desiccant pack that resides under the Top Cap assembly. Check the color of the packet of indicating silica desiccant. Reference **Figure 9**.
    a. If the desiccant is white, it may remain with the sensor.
    b. If the desiccant is pink, replace the desiccant pack with a new desiccant pack.
6. Attach ESD wrist strap and sensor grounding cable to the nearest soil plot arbor. *See Section 4.2.1 in Section 4.2 Sensor Specific Handling Precautions.*
7. Unplug the green cable connector from the Soil instrument (**Figure 11**).

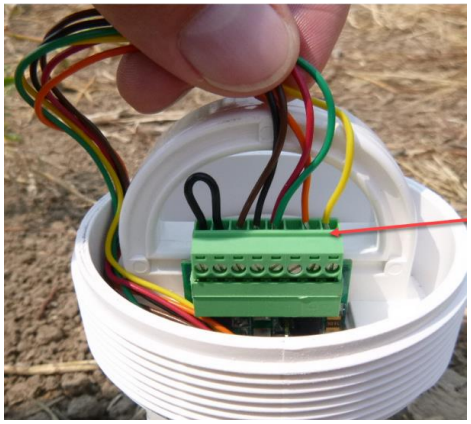

Figure 11. Green Cable Connector.

8. Attach the grounding cable to the sensor. *Reference **Figure 4**.*
9. Pull rod with sensor heads straight up out of the tube using the handle (**Figure 12**).

Figure 12. Remove Sensor from Access Tube.

10. If the sensor reinstallation is not immediately after removal, place the sensor in its protective shipping tube before disconnecting grounding cable. **Figure 13** displays an example of the instruments protective tubing.

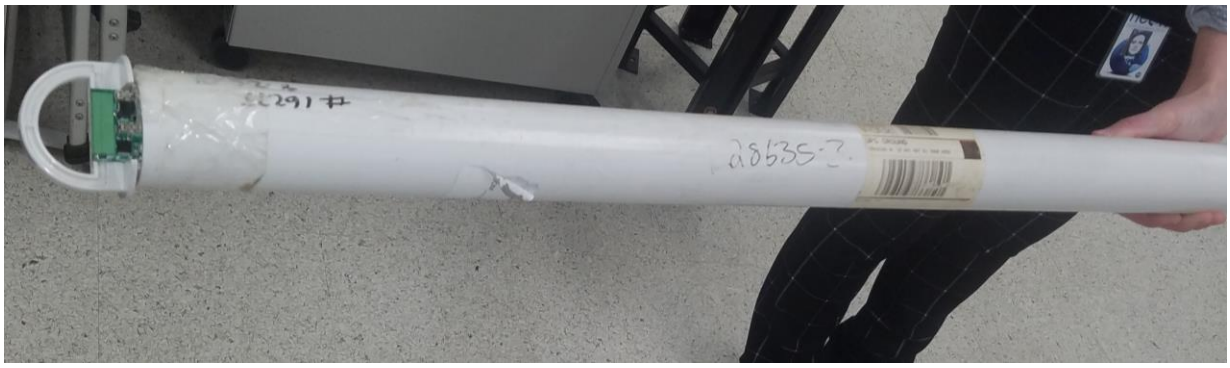

Figure 13. SWC Sensor in Shipping Tube.

11. Inspect the tube for water ingress. If water is found in the tube, submit a ticket including an estimate of the water level. Note/photograph signs of leaks/water intrusions.

12. If the sensor reinstallation is not immediately after removal, reinstall PVC Top Cap assembly. Brace the collar of the top cap with one hand and then reattach the top cap using your other hand. Be careful to minimize movement or rotation of the access tube during this process by holding the collar firmly. *Reference Section 5.3.3 Instrument Desiccant Inspection for additional instructions on removing the Top Cap assembly.* Make sure the Top Cap assembly bottoms out on the gray collar to a hard stop.

6.2.1.2 Soil Water Content and Salinity Profile Replacement Procedure

Replace the Soil Water Content and Salinity Profile in the Soil Plot using the following procedure. If snow or standing water depth is ≥4 cm, do not remove the sensor until the level decreases. If it is unlikely that the water or snow level will decrease in a reasonable timeframe, submit a ticket. Do not allow water into the access tube.

1. De-energize the entire soil plot per *Section 8 Appendix A – Power Down A Soil Plot Power Box.*

2. Disconnect the RJF cable on the Soil Water Content and Salinity Profile Merlot Grape (**Figure 10**).

3. Brace the collar of the top cap with one hand and then unscrew the top cap using your other hand. Be careful to minimize movement or rotation of the access tube during this process by holding the collar firmly (**Figure 8**). Protect the access tube if it is raining/windy with a cover until the sensor is ready for reinstallation.

Note: Do not allow soil, leaves, or other material to fall into the tube. If it is raining, use a shield (e.g., poncho) to prevent moisture or other debris entering the tube. If the rain is too heavy to prevent water entering the tube even when using a shield, postpone re-installation until conditions improve.

4. Attach ESD wrist strap and sensor grounding cable to the nearest soil plot arbor. *See Section 4.2.1 in Section 4.2 Sensor Specific Handling Precautions.*

5. Attach the grounding cable to the sensor in the protective shipping tube. *Reference **Figure 4**.*

6. Remove sensor from its protective shipping tube.

7. Inspect the jumpers on the pin strip connectors to verify they are secure for each individual sensor along the rod. If this jumper pulls off easily, replace with new jumper (see **Figure 14**).

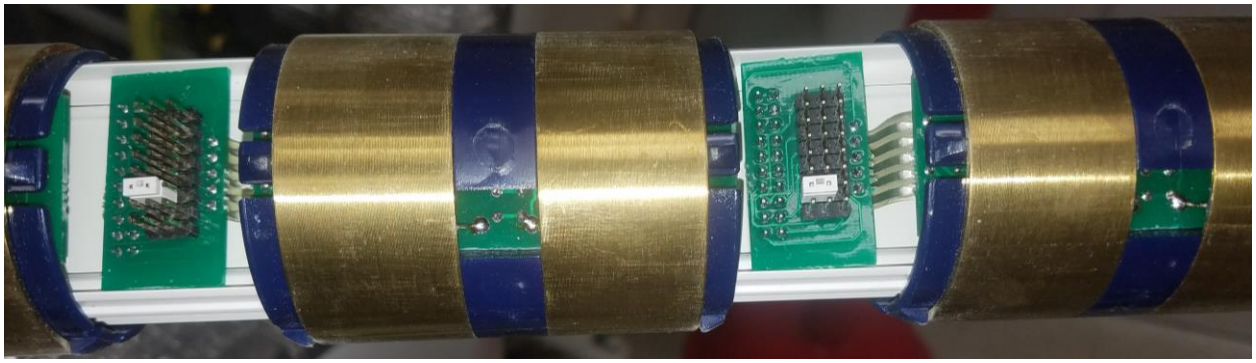

Figure 14. Jumper Boards.

8. Inspect the circuit board at the top of the rod to ensure it is seated in the ribbon cable. If it is not seated, it may result in NaN (not a number) readings for all sensors on the probe.

9. Slide the instrument rod vertically into the access tube. ***Ensure the jumper boards do not catch on the edge of the tube.***

10. Disconnect the grounding cable from the sensor.

11. Attach the sensor cable to the sensor.

12. Install white desiccant pack.

13. Reinstall PVC Top Cap assembly. Brace the collar of the top cap with one hand and then reattach the top cap using your other hand. Be careful to minimize movement or rotation of the access tube during this process by holding the collar firmly. *Reference Section 5.3.3 Instrument Desiccant Inspection for additional instructions on removing the Top Cap assembly.* Make sure the Top Cap assembly bottoms out on the gray collar to a hard stop.

14. Plug the sensor cable into the Grape according to **Figure 15**.

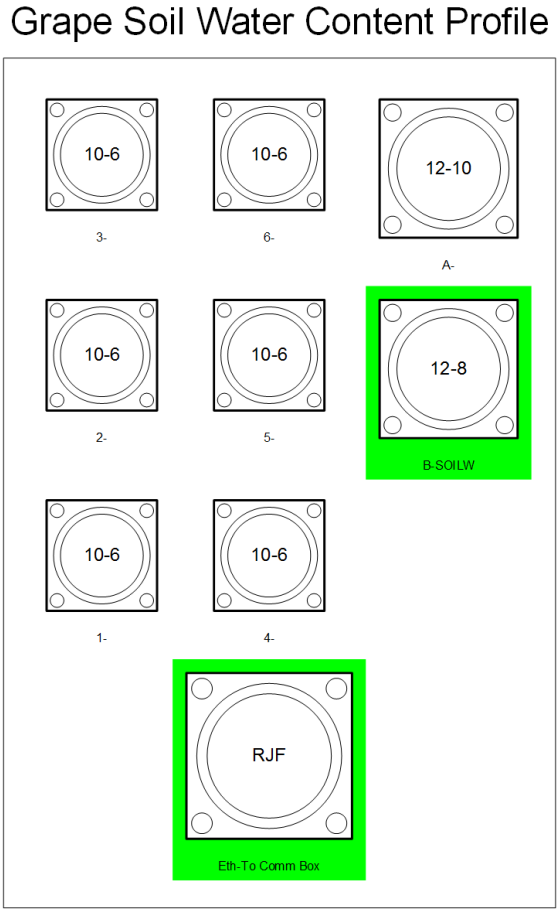

Figure 15. Grape Sensor Mapping.

6.2.2 Grape Removal/Replacement Procedure

1. Record EPROM ID/MAC Address, “Property of” Asset Tag number, Removal/Replacement date and time. The following template is an example for capturing Sensor Refresh information to update logistic records and monitor the Grape state of health via the LC pre- and post-swap.

AIS / TIS (Circle One) | Site Name: _____
Merlot / Concord / Catawba (Circle One) Grape | Location: S - ___ / ML - ___ / Other _____

	Old Grape	New Grape
EPROM ID/ MAC Address		
14-digit Asset Tag (Property of)		
Uninstall / Install Date and Time		
Moved in Maximo?		

2. Employ ESD protocols when handling Grapes. Reference AD [08].

3. Power down the site at the Soil Plot Device Post.

    a. *Reference Appendix A – Power Down A Soil Plot Power Box.*

4. Disconnect the armored Ethernet cable connecting to the RJF/Eth to Comm connection. Reference **Figure 15**.

5. Disconnect sensor connection(s).

6. Remove Merlot Grape from Grape Shield. Remove 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.

7. Place dust caps on the Amphenol connectors of the 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 Soil Water Content and Salinity Profile function. Connect locally to the Soil Plot Arbor/Instrument Hut or from the Domain using a TEP and **Table 3**.

PuTTy Login Username: **user** | Password: **resuresu**

6.3 Cleaning & Packaging of Returned Sensor

Field Operations staff 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 in Figure 16 with the trouble ticket number on it.) Clean the Grape (also known as decontamination; *Reference* AD [14]*)* 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 AD [14].

For the cleaning and packaging of the Soil Water Content sensors and the associated Merlot Grape post-removal, conduct the following steps:

1. Check mounting holes for spiders and spider webs.
2. Remove biologics and clean connectors with a lint-free cloth.
3. Cap all connectors on Grapes and Cables.
4. Conduct decontamination and remove any additional biologics from the devices. For grapes, use a Clorox bleach mixture (9 parts water/1 part bleach) mixture to rinse the Grape for five minutes to decontaminate the exterior. Rinse with tap water. Repeat as necessary. Since the sensors are within a sealed PVC tube during deployment, they do not require decontamination unless the outer PVC tube developed a leak that allowed soil and/or water to enter. If a leak occurred, and the sensors became contaminated, submit a trouble ticket to determine a decontamination procedure. Sensors are not waterproof.
5. Pack sensor assembly in original box and packaging from the sensor manufacturer or packing CVAL provides (e.g., **Figure 13**). Pack 12V grape in an ESD bag before packaging in a shipping container/box.
6. 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.

7. 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.
8. 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/screenshots (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.

Table 6. Soil Water Content and Salinity Profile 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 – Borehole/Access Tube Inspection for Erosion, Gaps, etc.	☐	
Sensor – Desiccant Check/Replacement	☐	
Environmental Information	☐	
Notes		

Ship all defective equipment/assets with a red "Rejected" tag. **Figure 16** displays the minimum information requirements for each tag.

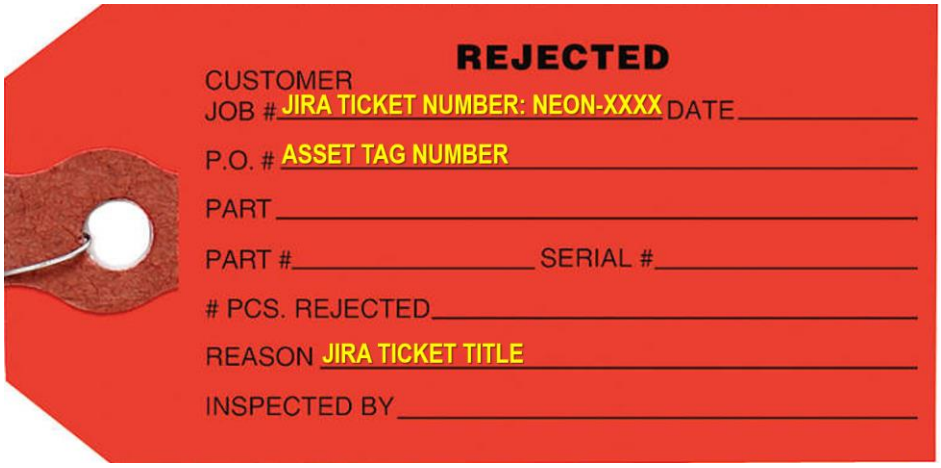

Figure 16. Red Rejected Tag for Defective Assets (MX104219).

8 APPENDIX A – POWER DOWN A SOIL PLOT POWER BOX

Powering down the soil plot 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 plot from the Soil Plot Device Post Power Box.

    a. Open the Power Box using a Philips head screwdriver (**Figure 17**).

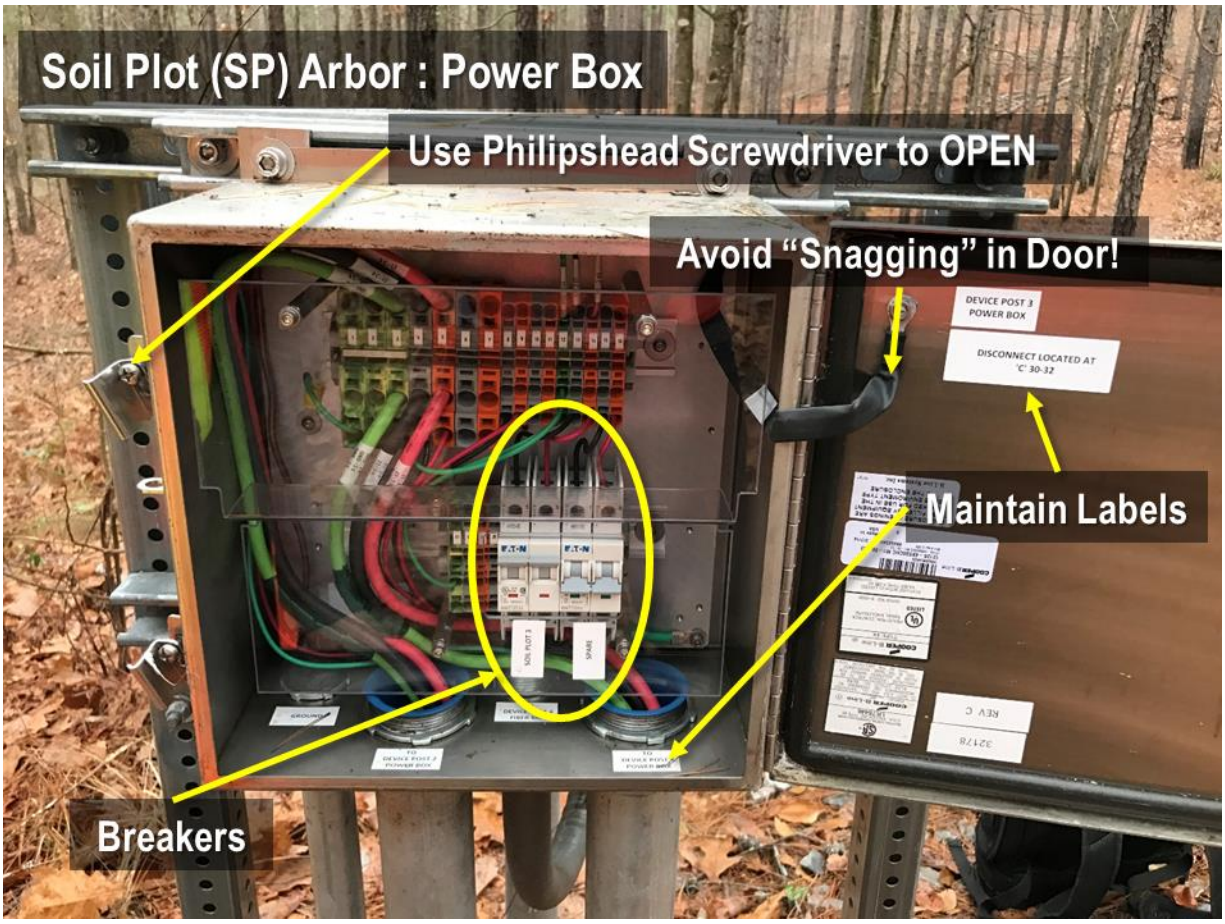

Figure 17. Open Soil Plot Device Post Power Box.

    b. Flip both breakers from RED to GREEN to de-energize the sensors (**Figure 18**).

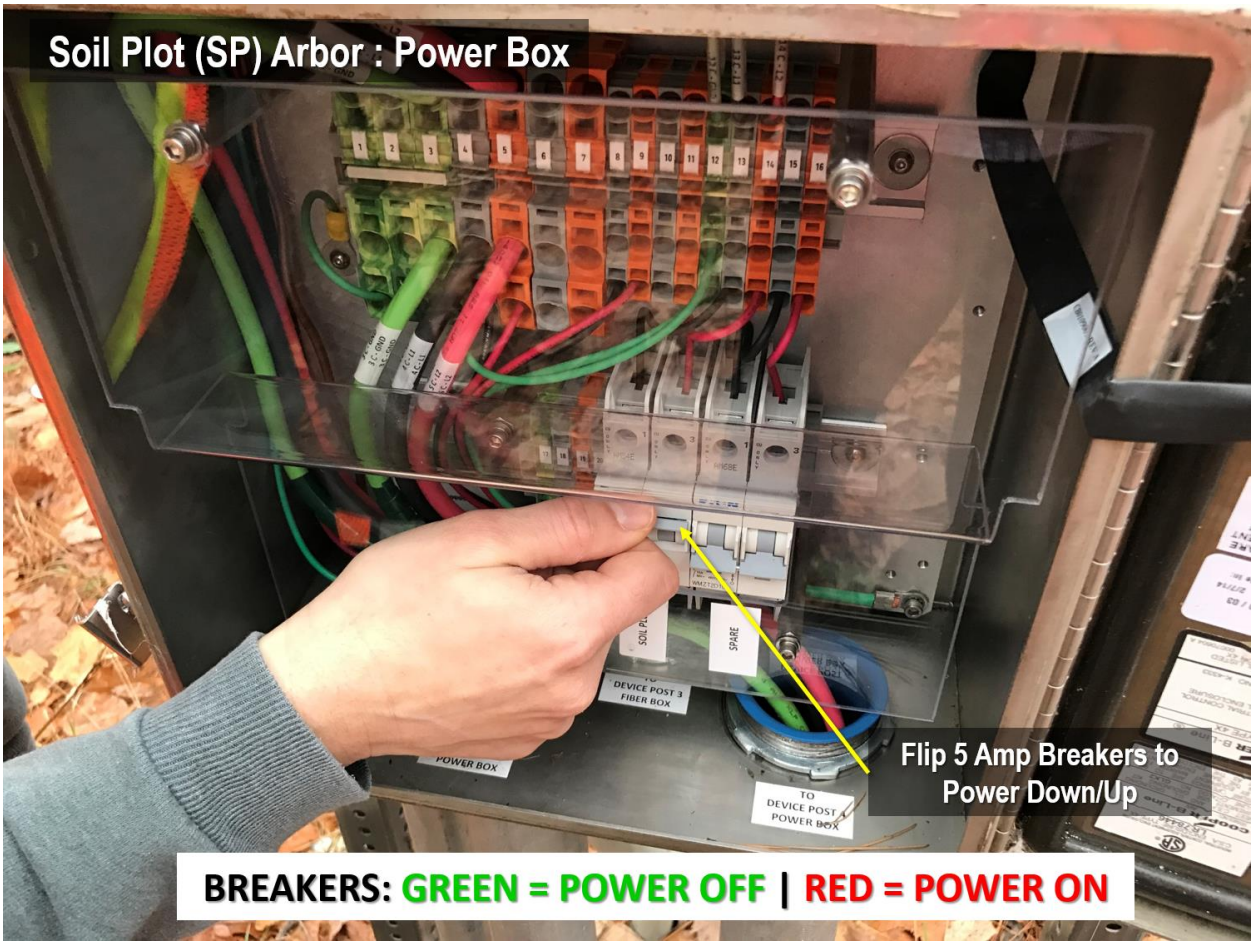

Figure 18. Flip 5Amp Breakers.

c. Conduct LOTO procedures and proceed with the Preventive Maintenance, Sensor Refresh and/or Corrective Maintenance.

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

9 SOURCES

Cain, Gregory. Soil Plot Verification Checklist, V 1.0. May 22, 2017.

Encyclopedia Britannica, Inc. “Dielectric Constant”. https://www.britannica.com/science/dielectric-constant accessed January 2, 2018.

Hand Model(s): Genevieve Faria, Madeline Cavileer