Opti Monitoring Hardware Operations & Maintenance Manual

Prepared by

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NFPA National Fire Protection Agency
OSHA Occupational Safety and Health Administration
TSS Total Suspended Solids

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Safety Information

- Power must be turned off before servicing, modifying, or maintaining any equipment. Refer to the De-Energizing Procedure for instructions to turn power off.
- OptiRTC does not warranty hardware beyond that of the vendor or manufacturer, and it is the Owner's responsibility to verify hardware integrity prior to any on-site work.
- Only Qualified Personnel (according to OSHA 1910.332) should conduct electrical work on-site, and all work should conform to national and local electric codes (e.g. NFPA 70).
- Proper confined space entry procedures should be followed at all times when entering confined space outlet structures.

Contact Information

Contact Opti for online dashboard operation, site management, system operation questions, Opti services, and other support questions.

Email: support@optirtc.com
Phone: (844) 678-4782, Ext. 2

Necessary Tools

Below is a list of tools routinely used for maintenance on Opti hardware.

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Field Service Kit for Inspections

Tools:

Item:	Description / Notes:
Multi Functional Wire Strippers	Cut / clean / strip wire ends
Screwdrivers - Phillips and Flat	Very small flat head required for terminal blocks (eg. 3/32”)
Multimeter (CAT III or IV)	**Must have current loop and continuity testing capabilities; must read DC voltage and amperage**
Adjustable wrench or SAE and metric deep well sockets / ratchet	Tighten any components that may be loose
Measuring tape / level rod	For measuring water depth, etc.
Ladder	For cleaning solar panels, rain gauge
Additional basic misc. tools	Hammer, needle nose pliers, utility knife, pry bar, etc. for general tasks
5 gallon bucket or similar	May be used for pressure sensor testing if pond is dry; will also need 1-3 gallons of water to test senor at two different water depths
Pruning tool(s) (not required at all sites)	Tool to trim branches, etc. that may be growing over rain gauge or solar panel

Consumables:

Item:	Description / Notes:
Coin Cell Battery	CR1220 battery for Thunder Panel
Towels / rags	For cleaning solar panel, rain gauge
Typical Misc. Supplies	Electrical tape, cable ties, wire nuts, etc.

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Introduction

This manual provides guidance for operating and maintaining the hardware for your Opti monitoring installation. Environmental sensors associated with the Opti monitoring installation may include: water level sensors, soil moisture sensors, rain gauges and weather stations, total suspended solids (TSS) sensors, and other multiparameter water quality sensors in custom configurations based on site needs.

Each Opti monitoring installation is unique and may include hardware not described in this manual. Contact Opti Support for questions about custom hardware maintenance.

Figure 1: Opti Monitoring Installation

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Hardware Information

The basic Opti monitoring configuration includes a monitoring panel, a solar panel, and up to seven sensors in its digital, analog, and pulse sensor wiring terminals. Refer to site drawings for information on your hardware installation and component locations.

Opti Monitoring Panel

The Opti Monitoring Panel is shown in Figure 2 with major components shown in Figure 3. The serial number is located on the blue cover plate near the top. The OptiThunder cellular gateway is behind the blue cover plate. All electrical components in the monitoring panel are controlled by OptiThunder.

Figure 2: Opti Monitoring Panel cover, interior, and the OptiThunder cellular gateway and Genasun Charge Controller (left to right).

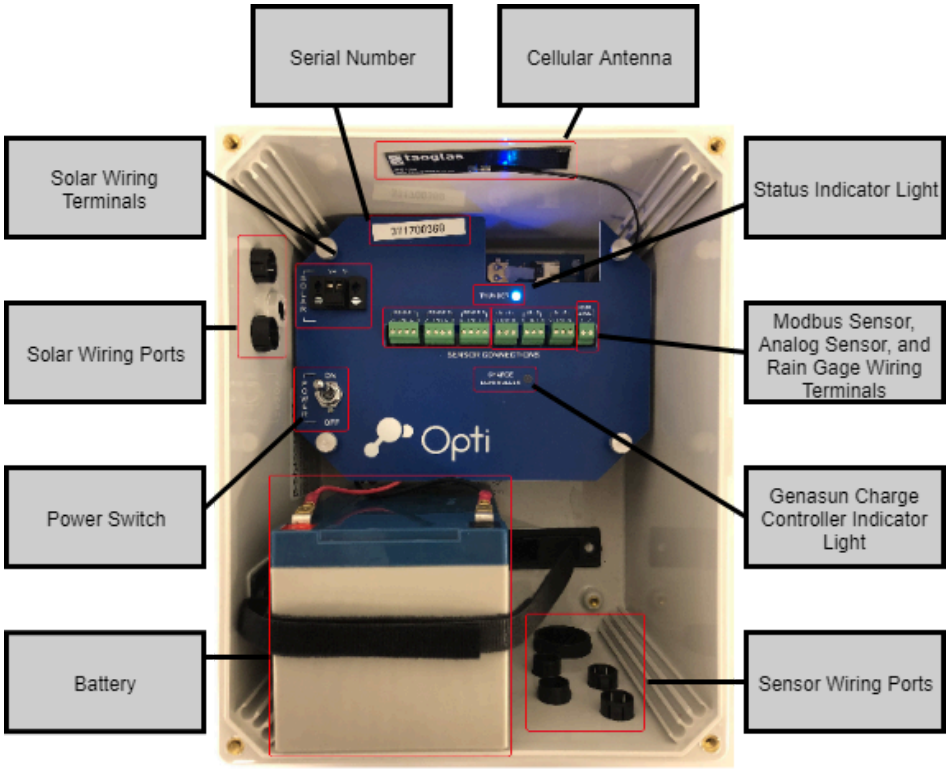

Figure 3: Opti Monitoring Panel annotated with major components

OptiThunder Cellular Gateway

OptiThunder is Opti's proprietary cellular gateway, which connects the panel to the Opti cloud platform. The OptiThunder cellular gateway receives, processes, and sends commands to and from all sources. It also manages power consumption to its sensors from a 12V lead-acid battery, which is charged with a Genasun GV-5 charge controller and an external solar panel.

OptiThunder Status Indicator Light

The OptiThunder cellular gateway processes all incoming sensor and battery information and connects the panel to the Opti cloud platform. When on site, the status indicator lights will provide the best indication of its behavior. During normal operation, the status indicator light periodically "breathes" cyan by fading in and out softly when it is logging sensor data and sending network data and remains off between these modes, when it is in sleep mode. Cycling power to the control panel will turn the OptiThunder cellular gateway off and on, and its indicator lights will provide information about its status as it changes (Table 1). There may also be a second, smaller LED that blinks red, which can be ignored.

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If the OptiThunder cellular gateway is unable to establish a cloud connection after 5 minutes, power cycle the monitoring panel using its circuit breaker to force OptiThunder to reconnect. If the issue persists contact Opti support staff for further assistance.

Table 1: Common status indicator light signals

Flashing Green	Connecting to cellular network
Flashing Cyan	Connecting to cloud
Breathing Cyan	Successfully connected to cloud
Blinking Blue	Check SIM card connection

Genasun Charge Controller Indicator Light

The Genasun GV-5 charge controller maintains battery voltage from the solar panel. Its indicator light will blink various patterns in either green or red depending on its charge state. Any pattern of red blinking indicates that maintenance is required.

Wiring Ports and Terminals (Solar and Sensor)

The solar panel is connected to the Genasun charge controller through the wiring ports and terminals. The sensors will connect directly to the OptiThunder cellular gateway wiring terminals. All wires come through the wiring ports with cord grips which allow for a waterproof seal.

Battery and Power Switch

The 12V absorbed glass mat lead-acid battery is rated for 10 days of autonomous operation if disconnected from solar panels. Be sure to keep the battery connected to the solar panels and charge controller to avoid over-discharging the battery. The power switch will safely disconnect the OptiThunder cellular gateway from the battery, while keeping the battery and charge controller on.

Cellular Antenna

Depending on cellular connection strength, the cellular antenna will either be an internal antenna as shown, or a puck antenna outside the panel with a waterproof seal.

Serial Number

When contacting Opti Support, make sure to know the panel's serial number.

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Maintenance Procedures

This section describes hardware operation and maintenance procedures. In addition to corrective maintenance, all components should be inspected for signs of wear or damage during regular site visits or as needed based on site specific conditions. Refer to Appendix A for an inspection and maintenance log with suggested maintenance procedures.

Routine Maintenance

Routine maintenance procedures for the Opti Monitoring Panel and its supported sensors are described in Table 2. Refer to each sensor's user manual for a more complete description of maintenance and calibration procedures.

Table 2: Sensor components and common maintenance procedures

Monitoring and Solar Panels	Clean solar panels with a soft cloth. Winterize and de-winterize if needed. Clear any tree/plant growth casting shadows on the solar panel.	Annually
Water Level Sensor	Visually inspect for obstructions and fouling. Replace desiccant cartridge if crystals have turned from blue to pink. Calibrate any time the sensor moves.	Annually and during every site visit
Rain Gauge	Inspect for debris, obstructions, and corrosion. Clean as needed.	Annually and during every site visit
Soil Moisture Sensor	Check wiring and supply voltage; ensure proper soil contact.	Annually
Water Quality TSS Sensor	Clean obstructions and fouling with cotton cloth.	Annually
Multiparameter Sensor	Clean obstructions and fouling with cotton cloth.	Clean and inspect every 6 months, and send for factory calibration every 6 to 18 months as needed.

Monitoring Panel De-Energizing Procedure

Whenever maintenance is required, the Opti Monitoring Panel must first be de-energized. To de-energize, look for the power switch (Figure 3) and position it to the off position. Note that the solar panel, charge controller, and battery remain powered. If desired, the battery

leads can be disconnected entirely; however, the battery will lose charging capacity over time if not connected to a power source. If the Opti Monitoring Panel is off for extended periods of time, make sure that the battery leads are still connected to the charge controller.

Water Level Sensor Calibration

Water level sensors may need to be calibrated after: installation, de-winterization, re-location of sensors, or when data shown on the dashboard does not match observed values. All calibration is done through Opti software and requires no hardware changes. To take calibration measurements, follow this procedure:

1. Place the water level sensor in a bucket of water.
2. De-energize the Opti Monitoring Panel using the power switch.
3. Measure the depth of the sensing element at the end of the water level sensor.
4. Turn the Opti Monitoring Panel back on and wait until the status indicator light breathes cyan. This indicates that a pressure is being recorded and sent to Opti. Record both the time of the measurement and the depth of water.
5. Place the water level sensor in its final position in the body of water, and repeat steps 2-4 to record the sensor depth and time. Do not move the sensor afterwards.
6. Measure the distance between the water surface elevation and a known elevation such as a valve elevation, and record the time.
7. Contact Opti Support and send the three pairs of time and elevation measurements.

Winterization and De-winterization

Winterization may be necessary if a site encounters freezing temperatures during winter months. Winterization is done to avoid damage to sensors caused by expansion of freezing water. Sites may not need winterization if sensors are installed deep enough where water does not freeze. A typical winterization and de-winterization process follows the steps below.

Winterization

1. Remove the sensor from the water and store it at an elevation where it will not be submerged. The sensor(s) may be attached with zip ties, with any extra cable looped neatly. This is recommended for pressure transducers, TSS sensors, and multiparameter sensors, which may be damaged by freezing water.
2. Once you have locked the site again, notify Opti support via email or phone that the site has been winterized.

De-winterization

1. Replace all sensors in their original location in the water.
2. Follow the procedure described in Water Level Sensor Calibration by recording level sensor depth and time at two different water heights.
3. Notify Opti Support that the site is now de-winterized. Include water level sensor calibration measurements.

Troubleshooting

Troubleshooting involves identifying an issue and performing corrective maintenance on an unknown problem. Troubleshooting becomes much easier with a good understanding of dependencies within the Opti monitoring installation and the correct tools to detect where failures may be occurring.

Dependency Flow Diagram

The diagram in Figure 4 is a simplified view of the flow of information and power through various components. An arrow indicates a direct dependency, in which information or power may flow between components. This diagram can be used to help find, diagnose, and repair problems either remotely or on site.

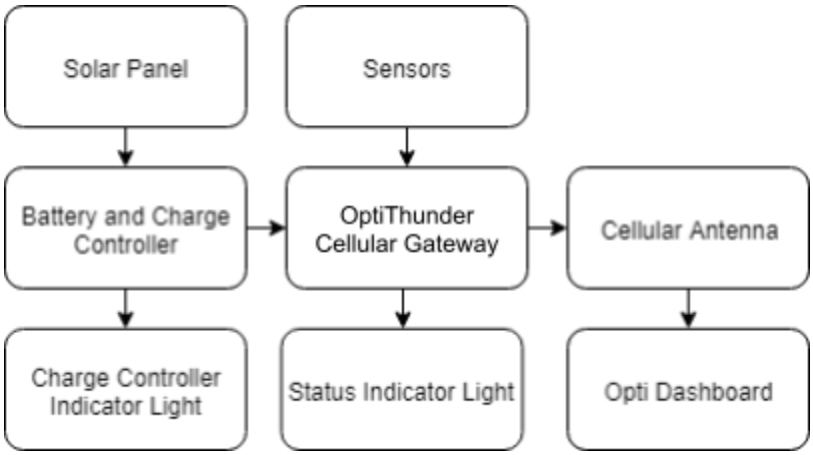

Figure 4: Dependency flow diagram

If a problem is identified using the Opti dashboard, individual components can be tested according to this guide or the equipment's user manual. A general procedure for troubleshooting involves inspecting each part in a dependency line. Start from where the problem is first observed and work back along the arrows, until the source of the problem is found. Table 3 indicates ways to be sure that a part is working properly.

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Table 3: Hardware tests for panel components

Solar Power and Charge Controller	Check that the power switch is flipped up, to the on position. Use a multimeter to check that voltages are the same across the charge controller.
Battery	Use a multimeter to check that the battery voltage is above 11.4 V.
Sensors	Gently tug wires and terminals to ensure none are loose. Follow common maintenance procedures for sensors (Table 2).
OptiThunder cellular gateway	Make sure status indicator light is breathing cyan. Power cycle the OptiThunder cellular gateway using the power switch.
Cellular Connection	Check the Opti dashboard for cellular connectivity.

Triggers for Maintenance

By providing real-time data online on the Opti dashboard, indicators of maintenance needs can be observed remotely. Please see below for some examples of unusual data patterns that indicate when maintenance is required.

Opti Dashboard Troubleshooting Examples

Water Level Sensor Electrical Failure

In this example, the water level sensor PT3 (orange) frequently spikes to the high end of its range (Figure 5). Since the sensor outputs an electrical signal, it appears that electrical components may be short-circuited. This sensor shows this behavior intermittently and may be irreparably damaged. To troubleshoot water level sensor issues, follow routine maintenance procedures by checking all connections to the sensor, cleaning dirt and debris, and checking the desiccant. If the problem continues, replace the sensor.

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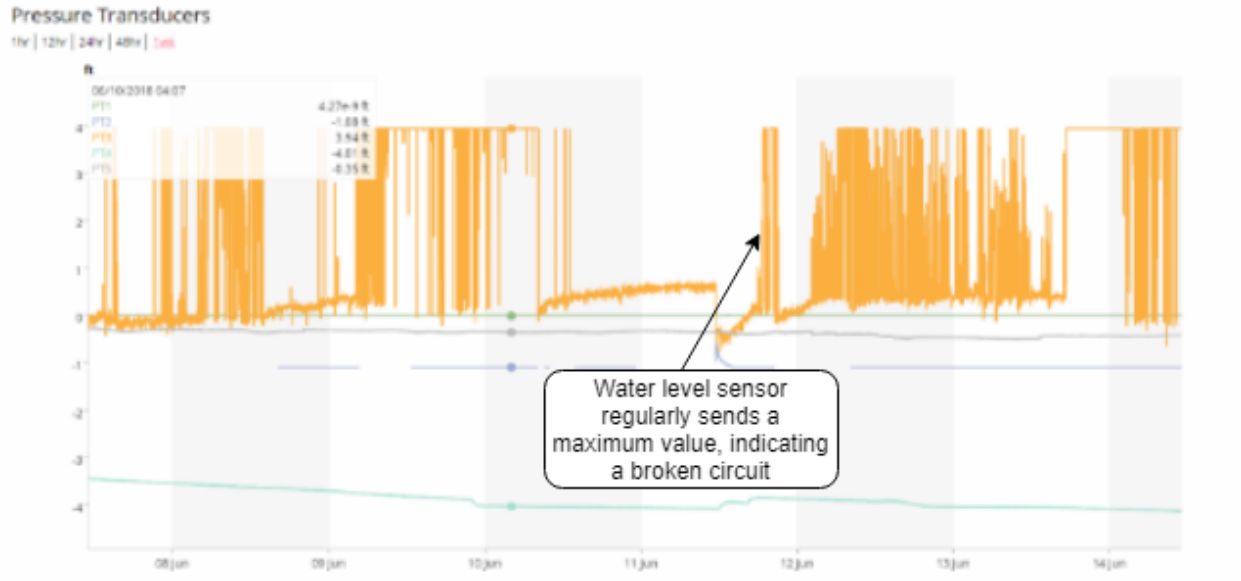

Figure 5: Faulty water level sensor readings

Water Quality Sensor Biofouling

In this example, a conductivity sensor exhibits large periodic fluctuations (Figure 6). After routine maintenance, biofouling was found to disturb site measurements. Biofouling was removed and the sensor behavior returned to normal. Be sure to perform routine maintenance as a first step to troubleshoot sensor failure.

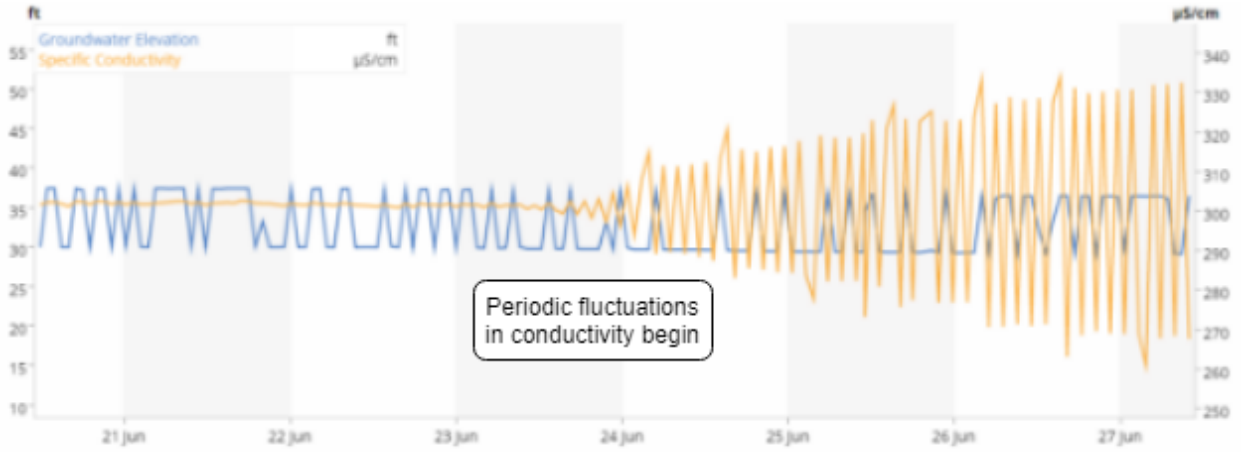

Figure 6: Biofouled conductivity readings

Soil Moisture Sensor Placement

In this example, soil moisture sensor SM1 (green) exhibits large periodic daily fluctuations which indicate a confounding factor, such as a daily timed sprinkler (Figure 7). The sensor appears to have readings within a normal range for the site and reads storm events appropriately. Be sure to check sensor user manuals, provided separately, for information

on sensor placement. Soil moisture and TSS sensors are among the most susceptible to large errors if placed incorrectly.

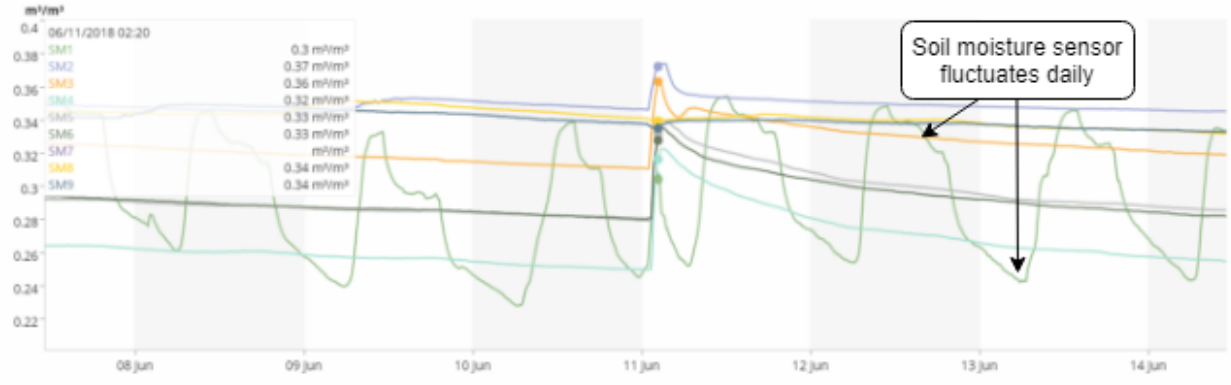

Figure 7: Periodic soil moisture sensor readings

Soil Moisture Sensor Failure

In this example, soil moisture sensor SM9 (dark green) spikes erratically (Figure 8). Soil moisture sensor failures are typically caused either by poor soil contact, low voltage, or electrical damage. Check the sensor placement and electrical connection, and replace the sensor if it is damaged.

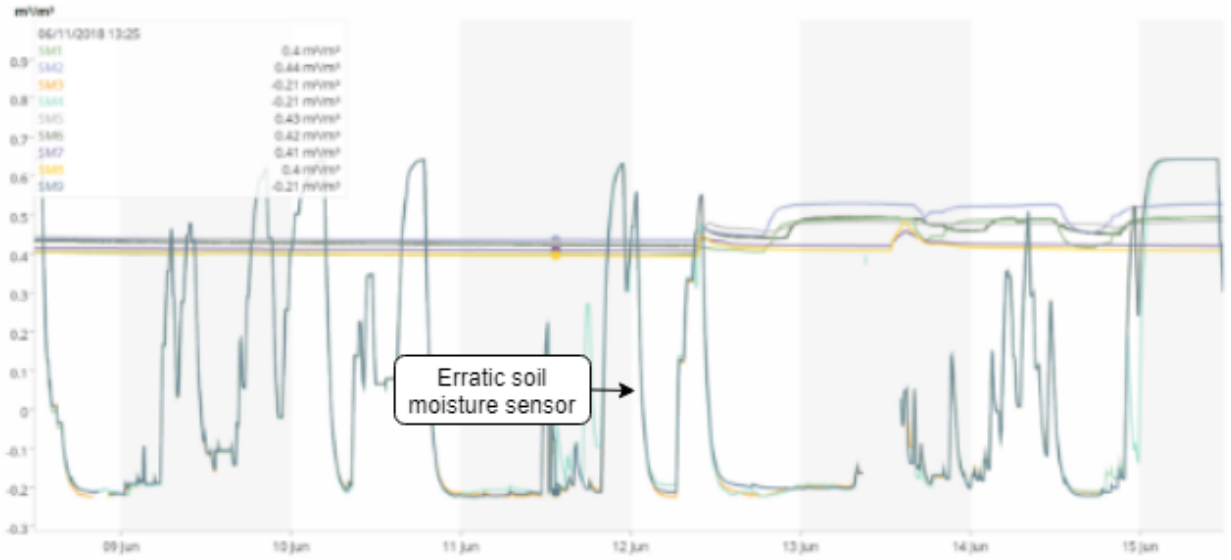

Figure 8: Soil moisture sensor failure readings

Connectivity Failure

In this example, the connectivity chart shows that the antenna needs to be moved or replaced (Figure 9). A site with more than 10% offline behavior indicates a poor connection. After a new antenna was installed, the site's connectivity improved to nearly 100% online.

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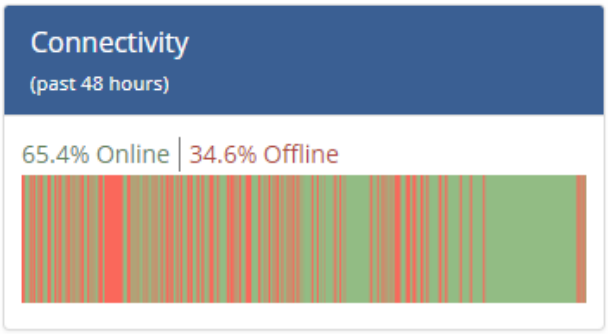

Figure 9: Faulty connectivity readings

Rain Gauge Obstruction

In this example, the rain gauge shows a 0.01" increase every 12-14 hours, even during a dry weather period with no rainfall (Figure 10). This indicates an obstruction within the rain gauge, where a small amount of debris inside the tipping bucket was causing rainfall readings. After on-site inspection, cleaning, maintenance, and recalibration, the obstruction was removed and readings returned to normal.

Figure 10: Rain gauge obstruction readings

TSS Sensor Obstruction

In this example, the TSS sensor continuously displays erroneously high values of 1,000,000 mg/L (Figure 11). The triangular orange warning indicates that there are data with values outside of the graph's scale. Because the TSS sensor emits noise and detects the echo, it will report high values when there is an obstruction in front of the sensor. In this case, the TSS sensor had been buried in sediment following a large storm event. After cleaning and moving the sensor up in the water column, the sensor returned to reading normal particle concentrations.

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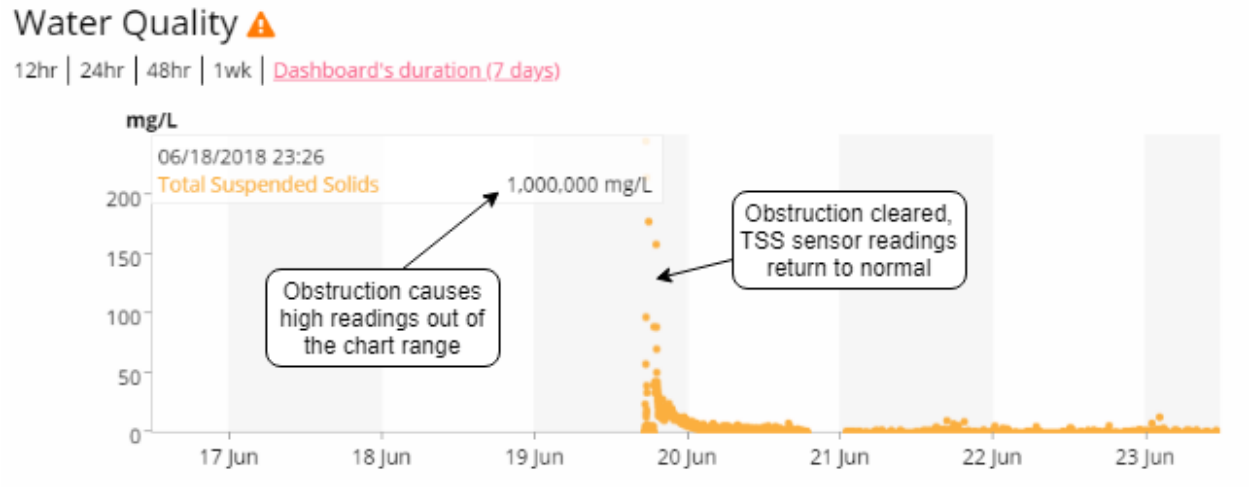

Figure 11: TSS sensor obstruction readings

Recurring Overnight Offline Periods

Batteries will degrade over time and eventually require replacement. In this example, a site experiences recurring offline periods overnight. During daytime hours the solar panel generates enough energy to operate the Opti system; as the sun sets the batteries rapidly lose charge and the site goes offline (Figure 11). The battery will be disconnected when it's voltage drops below 11.5V and will reconnect once it has been charged such that the voltage exceeds 12.5V. Contact Opti Support for battery specifications or battery replacement support..

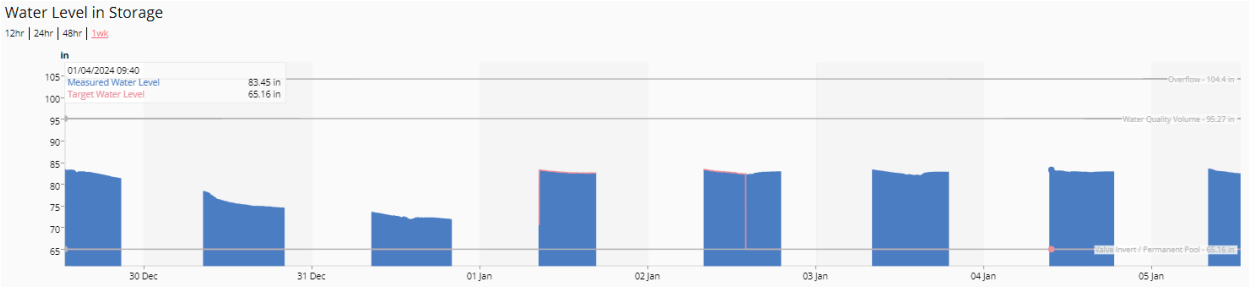

Figure 11: Recurring offline periods during overnight hours

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Appendix A: Inspection/Maintenance Log

Opti Facility	
Inspected By:	
Date and Time:	
Weather:	

Recommended: bring the list of tools found in Inspections_Tool_Kit.pdf to perform maintenance and repairs as needed. Contact Opti Support (support@optirtc.com or 1-844-678-4782 ext. 02) if major repairs are necessary.

Monitoring Panel:

Checklist Item	Result
Inspect interior of Opti Monitoring Panel for water intrusion or pest infestation	
Inspect all exposed conduit for damage or loose connections. Repair if necessary.	
Replace Thunder coin cell battery - **plus side out**. Battery type: CR1220s (found at Home Depot). Example: 	

Comments / Notes:

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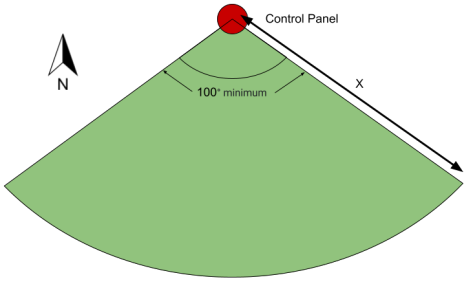
Solar Kit:

Checklist Item	Result
Wipe solar panels with cotton cloth	
Check 12V battery charge with multimeter	Battery Voltage:
Remove any vegetation directly blocking the solar panel. Note tree canopy coverage and inform Opti/Site if significant blockage shading solar.	
Panels ideally have at least 100’ of open horizontal space and 75’ vertical space as shown below 	Estimated open horizontal space (ft): Estimated open vertical space (ft): *photo document if space requirements not met
Direction solar panel is facing	
Approx. angle of solar panel	

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Weather Station / Rain Gauge (if applicable)**:**

Contact Opti Support (support@optirtc.com or 1-844-678-4782) during inspection

Inspect rain gauge for debris, obstructions, and corrosion. Clear debris and obstructions as needed.	
Inspect the wire that runs from rain gauge to monitoring panel	
Ensure rain gauge wires are connected to the right terminals in the monitoring panel MKIII Weather Station (RS435 ports): Davis / Texas Electronics Rain Gauge (Rain Gauge ports):	
Call Opti Support and test if the rain gauge is working as expected by simulating a precipitation event by pouring small amounts of water into the rain gauge to see if this is reflected on the dashboard.	
Davis Rain Gauge : Open funnel by twisting anticlockwise and ensure there is no algae build up on the exit at the bottom of the rain gauge	

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Comments/ Notes:

Water Level Sensor:

Note: if the site is dry during the maintenance visit, you will need a bucket of water to conduct the Pressure test

Checklist Item	Result
Winterization / de-winterization?	Yes / No
Clean sensor and stilling well	
Water level measurement (**if water is present)**	Survey point (e.g. top of OCS or weir wall): Distance to water (in): Time of measurement:
Sensor test **(if site is dry - Use "bucket test" for sensor calibration)**	Make sure the bucket is level. Measure the depth of water in the bucket. Place the sensor in a bucket for 10 minutes. Measurement 1 - Depth: Measurement 1 Start - Date / Time: Measurement 1 Finish - Date / Time: **After returning sensor to stilling well:** Survey point (e.g. top of OCS or weir wall): Distance from survey point to sensor location (in):
Junction box watertight / dry?	Y / N

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Bellows dry?	Y / N

Comments / Notes:

Inspection Completion Checklist:

The following procedures should be completed prior to leaving the site. Where they are not completed, please explain what conditions were preventing them from being accomplished.

Checklist Item	Result
Close panel door, double checking seals where necessary.	
Submit photo documentation of hardware and general field conditions	

Completed By: _____ Signature:_____Date:_____

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Appendix B: Sensor Wiring Guide

Modbus Sensors			
In-Situ Sensors		**APG Sensors**	
V+		V+	
GND		GND	
A		A	
B		B	
Rainwise MK-III-MB		**INW Sensors**	
Opti Monitoring Panel	**Rainwise Weather Station**		
V+	V+DC	V+	
GND	GND	GND	
A	B (+)	A	
B	A (-)	B	
Analog Sensors			
Decagon 10HS		**Sequoia LISST-ABS**	
V+		V+	
GND	Bare wire	GND	
SIG		IN	
Pulse Sensors			
Texas Electronics Tipping Bucket		**Davis Rain Collector II**	
1		1	
2		2	