CAMPBELL® SCIENTIFIC
WHEN MEASUREMENTS MATTER

Water Solutions

Complex Needs, Simple Solutions

Welcome to Campbell Scientific, world leader in robust and resilient water-measurement solutions

Campbell Scientific continues to provide a full line of instruments for water-quality and water-level measurement and data collection.

We are excited to promote two newer products. We have updated our popular CS475 **radar water-level sensor** with the CS475A, a higher accuracy model (+/- 2 mm) that will support SDI-12 version 1.4 communications.

We are also excited to announce that **Hydro-Link,** a new, free **user interface**, is now available. The software can configure the newer CR300-series Campbell Scientific dataloggers, with support for multiple types of communication (initially GOES, Iridium, and cell modem) and multiple measurement types, all from a web page. The web page can be accessed via a computer, cell phone, or tablet without physically connecting to the datalogger (depends on the choice of logger).

Recently we introduced the OBS501 dual (back and sidescatter) **turbidity probe** with patented ClearSense® antifouling. The OBS501 is perfectly suited for high-sediment-load conditions, with a measurement range of 0 to 4,000 FNU. The ClearSense antifouling feature ensures continued quality data in the most bioactive environments.

Collection of **water-level data** has never been easier. Our CS451 pressure transducer integrates perfectly with any of our dataloggers, while the CRS451 and CRS451V recording sensors have the datalogger imbedded into the housing of the sensor itself. For non-contact applications, we provide sonic, radar, or bubbler systems.

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Water Level Sensors

Pressure Transducers, Recording Sensors, and Ranging Sensors

Rugged, reliable, and ready for any application

RELIABLE SINCE 1974 MONITORING

Water Level Sensors are used in a wide array of applications, in many natural and industrial environments, including streams, watersheds, wells, caves, water/wastewater treatment plants, aquaculture operations, landfills, and processing plants. Each sensor provides research-grade accuracy and reliability.

MAJOR SPECIFICATIONS

	Output	Measurement Range	Accuracy	Current Drain
CS451 | Pressure Transducer/ Temperature Probe In stainless-steel case for water level measurements 	SDI-12, RS-232	0 to 2.9 psig[a], 0 to 7.25 psig, 0 to 14.5 psig, 0 to 29.0 psig, 0 to 72.5 psig, 0 to 145 psig	±0.1%, ±0.05%[a]	Quiescent: <50 µA Measurement/ Communication: 8 mA (1 s measurement) Maximum: 40 mA
CS456 | Pressure Transducer/ Temperature Probe In titanium case for water level measurements in salt-water or harsh environments 	SDI-12, RS-232	0 to 2.9 psig[a], 0 to 7.25 psig, 0 to 14.5 psig, 0 to 29.0 psig, 0 to 72.5 psig, 0 to 145 psig	±0.1%, ±0.05%[a]	Quiescent: <50 µA Measurement/ Communication: 8 mA (1 s measurement) Maximum: 40 mA
CRS451 | Water-Level Recording Sensor In stainless-steel case for water level measurements 	micro USB	0 to 7.25 psig, 0 to 14.5 psig, 0 to 29.0 psig, 0 to 72.5 psig, 0 to 145 psig	±0.1%	Quiescent: < 80 µA Measurement/ Communication: 4 mA (1 s measurement)
CRS456 | Water-Level Recording Sensor In titanium case for water level measurements in salt-water or harsh environments 	micro USB	0 to 7.25 psig, 0 to 14.5 psig, 0 to 29.0 psig, 0 to 72.5 psig, 0 to 145 psig	±0.1%	Quiescent: < 80 µA Measurement/ Communication: 4 mA (1 s measurement)
CRS451V | Water-Level Recording Sensor In stainless-steel case for water level measurements 	RS-232	0 to 7.25 psig, 0 to 14.5 psig, 0 to 29.0 psig, 0 to 72.5 psig, 0 to 145 psig	±0.1%	Quiescent: < 80 µA Measurement/ Communication: 4 mA (1 s measurement)
CRS456V | Water-Level Recording Sensor In titanium case for water level measurements in salt-water or harsh environments 	RS-232	0 to 7.25 psig, 0 to 14.5 psig, 0 to 29.0 psig, 0 to 72.5 psig, 0 to 145 psig	±0.1%	Quiescent: < 80 µA Measurement/ Communication: 4 mA (1 s measurement)
CS475A | Radar-Ranging Sensor For water level measurements 	SDI-12	0.5 to 35 m (1.64 to 114.8 ft)	±2 mm (±0.0065 ft)	< 500 µA (sleep, low power mode) < 5 mA (sleep, normal power mode) < 7 mA (measurement state)

[a] The 0 to 2.9 psig range is not available for the high-accuracy option for the CS451 and CS456 pressure transducers.

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CS451 and CS456

Submersible Pressure Transducers

Rugged and Accurate

Ideal for long-term deployment in harsh conditions

standard nose cone

weighted nose cone

¼ inch NPT nose cone

Overview

Campbell Scientific's CS451 and CS456 submersible pressure transducers provide reliable, accurate pressure and temperature measurements. Their rugged construction makes them suitable for water level measurements in canals, wells, ponds, harbors, lakes, streams and tanks.

These transducers consist of a piezoresistive sensor and a temperature sensor housed in a metal case. The CS451 has a 316L stainless-steel case that can be submerged in most canals, wells, ponds, lakes, and streams. The CS456 has a rugged titanium case that allows it to be used in saltwater or other harsh environments.

Benefits and Features

- Output acceptable for recording devices with SDI-12 or RS-232 capability including Campbell Scientific dataloggers.
- Static accuracies of ±0.1% full-scale range and ±0.05% full-scale range[1] available. Accuracies are over 0° to 60°C range.
- Quality construction that ensures product reliability.
- Rugged stainless steel or titanium case that protects piezoresistive sensor.
- Fully temperature compensated.
- Simultaneous 50/60 Hz rejection.
- Low power sleep state between measurements that reduces power consumption.
- Weighted nose cone option available for easier submersion. Adds 0.211 kg (0.465 lb) to the transducer's weight.
- NPT nose cone option available for closed-pipe applications.

Technical Details

Both transducers output either a digital SDI-12 or RS-232 signal to indicate observed pressure and temperature. This output is acceptable for recording devices with SDI-12 or RS-232 capability including Campbell Scientific dataloggers.

The CS451 and CS456 are fitted with a rugged Hytrel cable that remains flexible, even under harsh environmental conditions. The cable incorporates a vent tube to compensate for atmospheric pressure fluctuations. The vent tube terminates inside a desiccant tube, which prevents water vapor from entering the inner cavity of the transducer.

Options[a]

- Cable length: 15 ft, 17 ft, 30 ft, 33 ft, 50 ft, 75 ft, 100 ft, 200 ft, or user-specified
- Accuracy: standard 0.1% full-scale range TEB[b] or high 0.05% full-scale range TEB[b]
- Pressure ranges[c]: up to 2.9 psig, 7.25 psig, 14.5 psig, 29 psig, 72.5 psig, or 145 psig
- Nose cone: standard, weighted (for easier submersion), or ¼ inch NPT (for closed-pipe applications)

Accessories[a]

- Split Mesh Cable Grip (pn 25431)
- Replacement Desiccant Tube (pn 25366)
- A200 Sensor to PC Interface (for configuring sensor)
- A150-L Single Sensor Terminal Case, Vented with Desiccant
- Heyco Cable Grip (pn 31648) for mating with a 1 in. PVC pipe

Specifications

- Power Requirements: 6 to 18 Vdc
- Measurement Time: < 1.5 s
- Outputs: SDI-12 (version 1.3) 1200 bps; RS-232 9600 bps
- Measurement Ranges:

Pressure (psig)	Pressure (kPa)	Depth of fresh water
0 to 2.9[c]	0 to 20[c]	0 to 2.0 m (6.7 ft)[c]
0 to 7.25	0 to 50	0 to 5.1 m (16.7 ft)
0 to 14.5	0 to 100	0 to 10.2 m (33.4 ft)
0 to 29	0 to 200	0 to 20.4 m (67 ft)
0 to 72.5	0 to 500	0 to 50.9 m (167 ft)
0 to 145	0 to 1000	0 to 102 m (334.5 ft)

- Water-Level Resolution: 0.0035% full-scale range
- Worst-Case Temperature Resolution: 0.006°C
- Overpressure: 2 x pressure range
- Dry Storage Temperature[d]: -10° to 80°C
- Operating Temperature[d]: 0° to 60°C
- Temperature Accuracy: ±0.2°C
- Cable Type: 5 Conductor, 26 AWG, Hytrel Jacket
- Top Cone Material: Delrin
- Diameter: 21.34 mm (0.84 in)
- Length: 213.36 mm (6.875 in)
- View EU Declaration of Conformity at:
  www.campbellsci.com/cs451
  www.campbellsci.com/cs456
- Cable Weight: 0.0421 kg/m (0.0283 lb/ft)

Accuracy

- Standard Option: ±0.1% full-scale range TEB[b]
- High Option: ±0.05% full-scale range TEB[b]

Power Consumption

- Quiescent Current: < 50 µA
- Measurement/Communication Current: 8 mA for 1 s measurement
- Maximum Peak Current: 40 mA

Maximum Cable Length

- SDI-12 (one transducer connected to a single port): ~457 m (1500 ft)
- SDI-12 (10 transducers connected to a single port): 60 m (200 ft)
- RS-232: 60 m (200 ft)

Distance from pressure sensor interface (black line etched on housing) to:

- End of Standard Nose Cone: 2.3 cm (0.9 in)
- End of NPT Nose Cone: 2.54 cm (1 in)
- End of Weighted Nose Cone: 9.9 cm (3.9 in)

Air Gap

- Standard and weighted nose cone: 0.653 cm (0.257 in)
- NPT Nose Cone: 2.72 cm (1.07 in)

Material and Weight

Sensor	Material	Weight
CS451	316L stainless steel (body and element)	0.17 kg (0.37 lb)
CS456	Titanium (body), Hastelloy (element)	0.10 kg (0.23 lb)

[a]For more information about the options and accessories, refer to: www.campbellsci.com/order/cs451 or www.campbellsci.com/order/cs456

[b]Total Error Band (TEB) includes the combined errors due to nonlinearity, hysteresis, nonrepeatability, and thermal effects over the compensated temperature range, per ISA S51.1.

[c]The high accuracy (±0.05% FS) option is not available for some pressure range options. For more information, refer to www.campbellsci.com/order/cs451 or www.campbellsci.com/order/cs456.

[d] WARNING: Sensor could be damaged if encased in frozen liquid.

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CS475A-L

Radar Water-Level Sensor, 114.8 ft Maximum Distance

Non-Contact Water Level Monitoring

FCC approved for outdoor use

Overview

The CS475A radar sensor monitors the water level of rivers, lakes, tidal seas, and reservoirs. The sensor is ideal for areas where submersed sensors can be damaged due to corrosion, contamination, flood-related debris, lightning, or vandalism. It emits short microwave pulses and then measures the elapsed time between the emission and return of the pulses. The elapsed time measurement is used to calculate the distance between the sensor and the target (for example, water, grain, slurry). The distance value can then be used to determine depth of the medium.

The CS475A outputs a digital SDI-12 signal to indicate distance and stage. This output is acceptable for recording devices with SDI-12 capability, including Campbell Scientific dataloggers.

Benefits and Features

- Meets OSW requirements for accuracy (0.01%)
- SDI-12 version 1.4 functionality
- Makes 1 Hz measurements
- Monitors tides for NOAA physical oceanographic real-time systems (PORTS)
- Easy to set up and configure over USB or SDI-12
- FCC compliant (FCC IC# MOIPULS 616263); individual FCC license not required
- Low maintenance—no moving parts significantly reduces maintenance cost and time
- Low power mode available
- Rugged enough for harsh environments—IP68 rating
- Optional display available

Detailed Description

Features of the SDI-12 version 1.4 functionality:

- M! commands return stage, distance, voltage, and error codes
- SHEF coded meta data

Specifications

Measurement Distance (d)	0.5 to 35 m (1.6 to 114.8 ft)
Accuracy	±2 mm (±0.0065 ft)
Resolution	1 mm (0.0033 ft)
Communications Output	SDI-12 version 1.4
Radar Frequency	K band (~26 GHz)
Pulse Energy	1 mW (maximum)
Beam Angle	10°
Input Voltage	9.6 to 32 Vdc
Surge Protection	1.5 KVA
Operating Temperature Range	-40° to +80°C
Vibration Resistance	Mechanical vibrations with 4 g and 5 to 100 Hz
Mechanical Rating	IP66/68
Housing Material	Aluminum
Horn Material	PVDF plastic
Housing Height	129 mm (5.1 in.)
Horn Width	115 mm (4.5 in.)
Horn Height	122 mm (4.8 in.)
Weight	2 kg (4 lb)

Nominal Current Drain

Normal Power Mode	< 5 mA (sleep state) < 7 mA (measurement state)
Low Power Mode	< 550 µA (sleep state) < 7 mA (measurement state)

Measurement Response Time

Normal Power Mode	< 1 s
Low Power Mode	60 s + (5 • Integration Time) + (Measurement Time)

For comprehensive details, visit: www.campbellsci.com/cs475a-l

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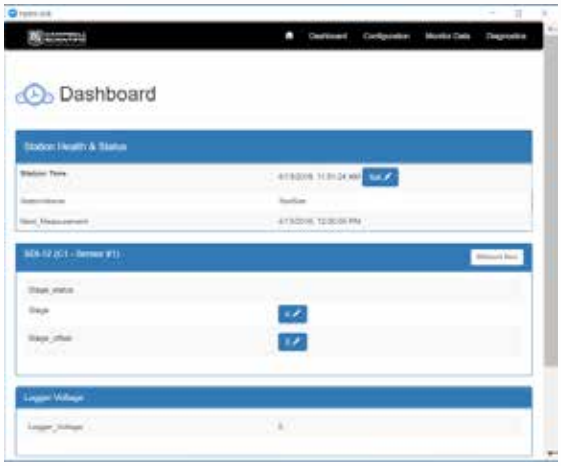
Hydro-Link

Hydro-Met Datalogger Interface Tool



Menu-Based Interface

Offers point-and-click simplicity

Overview

Hydro-Link is a free, simple-to-use interface for system configuration and performing site service activities on your Campbell Scientific CR300 or CR310 datalogger.

The Hydro-Link interface provides a straightforward way to configure the datalogger using simple and familiar menu selections. After the configuration options are complete, applying them to the datalogger automatically creates the CRBASIC program to run the defined application. Also, based on the menu selections, a custom dashboard for the application is generated to aid the user in site service activities.

This tool has been developed to meet the needs of the water market, yet it is easily used in many other applications. The interface allows easy setup of the various components of the station, including the datalogger, sensors, and communication devices. In addition, Hydro-Link is used to set alarm conditions and specify the action to take when an alarm occurs.

To download Hydro-Link, refer to the Downloads section.

Benefits and Features

- Dashboard shows live readings from the sensors for real-time data
- Easily change measurement offsets, etc., without changing the program
- Automatic offset generation tools
- Added tools for in-service rain gage testing and verification
- Flexible data presentation tools—from data tables to graphs
- Simple and familiar data download options
- Direct connect using the USB port to a CR300-series datalogger
- Direct connect using the Ethernet port on the CR310 datalogger
- Connect remotely to a CR310 datalogger that is connected to the Ethernet
- Wirelessly connect to a Wi-Fi-enabled CR300-series datalogger

Detailed Description

Connectivity

Hydro-Link is easily used with a PC directly connected to a datalogger. The Hydro-Link interface can also connect wirelessly with dataloggers equipped with the Wi-Fi option. When using Wi-Fi connectivity, smartphones and tablets can also be used to run the interface. Dataloggers with IP connectivity (such as the CR310) can also host the interface directly.

Sensor Options

The sensor library has been reduced when compared to other related products to limit the chance of selecting the wrong sensor. Yet, with the generic sensor options, virtually all sensor types can be used with Hydro-Link. This includes analog sensors, digital sensors, and smart SDI-12 sensors.

Communications

Currently the interface supports GOES scheduled transmissions and cell modem operations for sending email notifications. Other communication options will be available in later releases.

Specifications

Current Version	1.1
Operating System	Windows 10, 8, and 7 (Only 64-bit operating systems are supported.)

For comprehensive details, visit: www.campbellsci.com/hydro-link

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CR300

Measurement and Control Datalogger

Best of Both Worlds

Low-cost and high-flexibility

DESIGNED FOR WATER APPLICATIONS

Overview

The new CR300 series is the datalogger of choice for water level monitoring and water quality applications. Two independent SDI-12 channels and support for a variety of serial communication protocols means that CR300 dataloggers can interface with virtually any water quality or 'smart sensor' available. With its integrated charging capabilities and communications options, the CR300 series is a cost effective way to monitor, record, and telemeter remote data.

Benefits and Features

- Low cost
- Support for multiple communication devices: GOES, cellular, radio, ALERT
- Integrated communications (available soon)
- Independent SDI-12 inputs
- Full serial input/output functionality
- Fast USB interface
- Simplified user interface
- Charge on-site battery (solar or ac-dc power converter) with in-built power regulator
- Operate on a very modest power budget
- Send encrypted/secure email messages and alarms
- Campbell quality surge and ESD protection

General Specifications

- **CPU:** ARM Cortex M4, running at 144 MHz
- **Internal Memory[a]:** 30 MB flash for data storage, 80 MB flash for CPU drive / programs, 2 MB flash for operating system
- **Clock Accuracy:** ±1 min per month
- **USB micro B** for direct connection to PC (limited power source during configuration), 2.0 full speed, 12 Mbps
- **RS-232** for connecting RS-232 modems or serial sensors
- **Battery Terminal Pair (-BAT+)** for regulated 12 V power input or rechargeable 12 V VRLA for UPS mode
- **Charge Terminal Pair (-CHG+)** for 16 to 32 V from dc power converter or 12 or 24 V solar panel (10 W)
- **Power Consumption @ 12 Vdc:** 1.5 mA (sleep), 5 mA (1 Hz scan with one analog measurement), 23 mA (active processor always on)

[a]*Internal memory is for dataloggers with serial numbers ≥ 2813*

General Specifications Continued

- **One Switched 12 V Terminal (SW12V)** for powering sensors or communication devices, 1100 mA @ 20°C[b]
- **Two Sensor Excitation or Continuous 0.15 to 5 V Terminal (VX1, VX2)** for sensor excitation or output control
- **Six Multipurpose Analog Input Terminals (SE1 - SE6)**
  - Analog functions (SE1 - SE6)
    - Analog inputs: 6 single-ended or 3 differential inputs with -100 to +2500 mV and ±34 mV ranges 24 bit ADC
    - 4 to 20 mA or 0 to 20 mA inputs (SE1, SE2 only)
  - Digital I/O functions (SE1 - SE4) consist of 3.3 V logic levels for:
    - High frequency counter (35 kHz)
    - Pulse width modulation
    - Interrupts and timer input
    - Period average (200 kHz, amplitude dependent)
- **Two Pulse Counting Terminals (P_SW, P_LL)**
  - P_SW
    - Switch closure (150 Hz)
    - High frequency counter (35 kHz)
  - P_LL
    - Low level ac (20 kHz)
    - High frequency counter (20 kHz)

[b] *The 1100 mA voltage output is for dataloggers with serial numbers ≥ 2813*

- **Two Control Terminals (C1, C2):** C terminals are software configurable for digital functions
  - Digital I/O functions consist of 5 V output and 3.3 V input logic levels for:
    - SDI-12
    - High frequency counter (3 kHz)
    - Switch closure (150 Hz)
    - General status/control
    - Voltage source 5 V: 10 mA @ 3.5 V
    - Interrupts
    - Serial asynchronous communication Tx/Rx pair
- **Best Analog Accuracy:** ±(0.04% of reading ±6 µV), 0° to 40°C
- **Best Effective Resolution:** 0.23 µV (±34 mV range, differential measurement, input reversal, 50/60 Hz f_{N1})
- **Operating Temperature Range:** -40° to +70°C
- **Weight**
  CR300: 242 g (0.53 lb)
  CR300-WIFI/RF407/RF412/RF422: 249.5 g (0.55 lb)
- **Dimensions:** 14.0 x 7.6 x 5.1 cm (5.5 x 3.0 x 2.0 in)
- **Compliance Information:** View the CR300 EU Declaration of Conformity at: www.campbellsci.com/cr300

Terminal Functions

Each terminal may only take on one function.

Analog Input Function	C1	C2	P_SW	P_LL	VX1	VX2	SE1	SE2	SE3	SE4	SE5	SE6	RS-232	SW12	Max
Single Ended Voltage							✓	✓	✓	✓	✓	✓			6
Differential Voltage							H	L	H	L	H	L			3
4 to 20 or 0 to 20 mA							✓	✓							2
Analog Output Function	**C1**	**C2**	**P_SW**	**P_LL**	**VX1**	**VX2**	**SE1**	**SE2**	**SE3**	**SE4**	**SE5**	**SE6**	**RS-232**	**SW12**	**Max**
Switched-Voltage Excitation					✓	✓									2
5 V Source	✓	✓			✓	✓									4
12 V Source														✓	1
Digital I/O Function	**C1**	**C2**	**P_SW**	**P_LL**	**VX1**	**VX2**	**SE1**	**SE2**	**SE3**	**SE4**	**SE5**	**SE6**	**RS-232**	**SW12**	**Max**
RS-232 ± 6 V out													✓		1
RS-232 0-5 V out	Tx	Rx													1
SDI-12	✓	✓													2
Pulse-Width Modulation							✓	✓	✓	✓					4
Timer Input							✓	✓	✓	✓					4
Period Average							✓	✓	✓	✓					4
Interrupt	✓	✓					✓	✓	✓	✓					6
General I/O	✓	✓	✓				✓	✓	✓	✓					7
Pulse Counting Function	**C1**	**C2**	**P_SW**	**P_LL**	**VX1**	**VX2**	**SE1**	**SE2**	**SE3**	**SE4**	**SE5**	**SE6**	**RS-232**	**SW12**	**Max**
Switch Closure	✓	✓	✓												3
High Frequency	✓	✓	✓	✓			✓	✓	✓	✓					8
Low Level AC				✓											1

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Dataloggers

Also known as Data Loggers, Data Recorders, and RTUs

Dataloggers are the heart of a data acquisition system. They measure sensors at a specific scan rate, process data, store the data, and initiate telecommunications. Our dataloggers also have control capabilities allowing them to respond to specific site conditions by opening flood gates, turning fans off/on, etc. All our dataloggers share similar measurement and programming capabilities. Selection of the appropriate datalogger depends mainly on the type, number, precision, and speed of measurements required.

MAJOR SPECIFICATIONS

	Channels	Input Voltage Range	Analog Voltage Resolution	A/D Bits
CR300 & CR310 | Capable, compact, low cost, high performing Small applications requiring long-term, monitoring and control 	Analog Voltage: 6 SE or 3 DF Analog Current 4 - 20 mA: 2 Pulse: 2 Switched Excitation: 2 voltage Digital: 2 I/O	-100 to 2500 mV	to 0.23 µV	24
CR6* | Innovative Vibrating Wire Powerfully versatile multi-tool for data acquisition; onboard vibrating-wire measurement  **The number of measurements listed in the Channels column assumes all of the U and/or C channels are configured for that type of measurement.*	12 universal (U) and 4 control (C) terminals are programmable to measure up to: • 12 SE analog inputs • 6 DF analog inputs • 16 pulses • 12 voltage switched excitation • 12 current switched excitation • 2 RS-232 • 2 RS-485 • 16 I/Os, • 8 SDI-12	±5000 mV	to 0.08 µV	24
CR800 & CR850 | Smaller, Simpler Research-grade power for smaller installations 	Analog: 6 SE or 3 DF Pulse: 2 Switched Excitation: 2 voltage Digital: 4 I/O or 2 RS-232	±5000 mV	to 0.33 µV	13
CR1000X | Rugged Versatility Multipurpose Monitoring and Control 	Analog Voltage: 16 SE or 8 DF Analog Current 4 - 20 mA: 2 Pulse: 2 Switched Excitation: 4 voltage Digital: 8 I/O or 4 RS-232	±5000 mV	to 0.02 µV	24

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Telemetry Peripherals

Wireless, remote, hard-wired, or two-way communication

Campbell Scientific offers a full line of telemetry peripherals that support remote communications between dataloggers and PCs. These peripherals have wide operating temperature ranges allowing their use in extreme, remote environments. They facilitate the accessibility, analysis, sharing, and reporting of data.

MAJOR SPECIFICATIONS

	Transmission Distance or Area	*Current Drain @ 12 Vdc*	*Service Requirements*
NL121 | Ethernet Interface Connects CR1000 or CR3000 to LAN or Internet	Worldwide	58 mA typical, 3 mA Ethernet off	Ethernet access
NL116 | Ethernet Interface and CompactFlash Module Connects CR1000 or CR3000 to LAN or Internet and stores data on a CompactFlash card	Worldwide	58 mA typical, 3 mA Ethernet off	Ethernet access
NL201 | Ethernet Interface Connects dataloggers to LAN or Internet via Ethernet	Worldwide	50 mA active 2 mA forced standby	Ethernet access
NL241 | Wi-Fi Network Link Wireless Network Link	Worldwide	< 1.5 mA (standby) 7.5 to 8 mA (client, idle) 65 to 75 mA (client, communicating) 67 mA (access point, idle) 70 mA (access point, communicating)	Wi-Fi hotspot (access to standard 802.11b/g/n networks)
CELL205 and CELL210 | Campbell Scientific 4G LTE CAT1 Cellular Modules	Dependent on antenna used and LTE, WCDMA, GSM EDGE, and GSM GPRS coverage	2 mA completely powered off via **IPNetPower()** Instruction 11 mA idle 50 mA busy	Network coverage at the datalogger site and cellular data service plan.
RV50 | Sierra Wireless 4G LTE Cellular Gateway	Dependent on antenna used and LTE, CDMA/EV-DO, and GSM/GPRS/EDGE/WCDMA coverage	1 mA typical enable/ignition sense low 65 to 95 mA typical idle 250 to 300 mA typical active	Network coverage at the datalogger site and cellular data service plan.
COM220 | Phone Modem Ideal for sites with telephone access	Worldwide	12 µA quiescent 30 mA active	If not available at the site, phone lines must be installed.
COM320 | Voice Phone Modem Make your datalogger speech capable	Worldwide	100 µA quiescent 35 mA active	If not available at the site, phone lines must be installed.

MAJOR SPECIFICATIONS

	Transmission Distance or Area	Current Drain @ 12 Vdc	Service Requirements
MD485 | RS-485 Multidrop Interface Connect many dataloggers with a single cable 	1219 m (4000 ft) Can increase distance by using more MD485s or combining with spread spectrum radios, Ethernet, or phone	1.2 mA standby 2 to 7 mA communicating	CABLE2TP two-twisted pair cable must be installed between networked dataloggers and base.
SRM-5A | Short Haul Modem 	Up to 12.2 km (7.6 miles) depending on data rate and wire gage	2.2 mA quiescent; 10 to 15 mA active	Dedicated two-twisted pair cable connects one field station with base.
RF320 Series with RF500M | Narrowband VHF/UHF Radios with Radio Modem Long-distance option for communication 	Up to 40.2 km (25 miles) between stations (line-of-sight and interference affects transmission length). Repeaters can be used to increase line-of-sight.	RF320-series radio: 25 mA receive standby <900 mA (transmit 2 W RF power) <1200 mA (transmit 5 W RF power) RF500M radio modem: < 15 mA (active)	FCC-assigned frequency and license. Requires line-of-sight
RF401A and RF411A | 900 MHz Spread Spectrum Radios 	Up to 16 km (10 miles) with Yagi antennas at ideal conditions; up to one mile with inexpensive omnidirectional antennas (line-of-sight obstructions and interference affects transmission length)	<0.5 mA stand-by 15 mA receiving < 80 mA transmitting	Shares frequency with other devices. Must not cause harmful interference to licensed radios. Requires line-of-sight
RF407 and RF412 | 900 MHz Spread Spectrum Radios 	Up to 16 km (10 miles) with Yagi antennas at ideal conditions; up to one mile with inexpensive omnidirectional antennas (line-of-sight obstructions and interference affects transmission length)	Transmit: < 80 mA (250 mW TX Power) Receive: 15 mA Stand-by: < 0.5 mA (depending on power saving mode)	Shares frequency with other devices. Must not cause harmful interference to licensed radios. Requires line-of-sight
RF422 | 868 MHz SRD860 Radio 	Up to 5 km, depending on antenna (line-of-sight obstructions and interference affects transmission length)	Transmit: < 25 mA (25 mW TX Power) Receive: 15 mA Stand-by: < 0.5 mA (depending on power saving mode)	Shares frequency with other devices. Must not cause harmful interference to licensed radios. Requires line-of-sight
RF451 | 900 MHz Spread Spectrum Radio 1 W power supports longer distances 	20 to 25 miles with Yagi antenna at ideal conditions; up to one mile with inexpensive omnidirectional antenna (line-of-sight obstructions and interference affect transmission length)	6 mA sleep mode 15 mA idle 40 mA receiving 650 mA transmitting	Shares frequency with other devices. Must not cause harmful interference to licensed radios. Requires line-of-sight
ST-21 | Argos Satellite Transmitter 	Worldwide	1.1 mA quiescent 375 mA transmitting	Must receive formal permission from Service Argos and pay a fee. Must use data for environmental purposes.
IRIDIUM9522B | Satellite Modem and Interface Kit 	Worldwide (including poles, oceans and airways)	Operating: 333 mA Standby: 125 mA	Needs a SIM card. Must pick a service provider and pay a fee.
HUGHES9502 | Inmarsat BGAN Satellite IP Terminal 	Worldwide between +70° and -70° latitude	Transmit: < 1.7 A peak Narrowbeam w/o transmit: 333 mA Idle (regional beam): < 84 mA Sleep (wake on Ethernet packet): < 0.8 mA Off, GPIO sleep pin control: < 0.3 mA	Needs a SIM card. Must pick a service provider and pay a fee.
TX321 | GOES or Meteosat Transceiver 	GOES: North America Meteosat: Europe	<5 mA, idle <100 mA, during GPS fix <2.6, transmit	GOES Must be U. S. government agency or sponsored by such an agency. Apply at: http://noaasis.noaa.gov/DCS. Meteosat Apply at: www.eumetsat.int

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Tailored GOES Telemetry

For Water Systems

Campbell Scientific provides GOES telemetry solutions to all of the premier U. S. networks including the U. S. Climate Reference Network and multiple Mesonets. We have a long history of providing data collection platforms (DCPs) to USGS, BOR, BLM, and many other government agencies.

Key Benefits

- Campbell Scientific is a trusted supplier of hardware for remote monitoring with over a million stations installed
- We are experienced at designing and supporting DCPs
- Hardware can be tailored to your exact needs for each monitoring site
- GOES DCP with Campbell hardware is easier than ever to configure with a new, free user interface available in early 2018.
- We are industry leaders in quick repairs, maintenance, and calibration

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Campbell Scientific, Inc. | 815 W 1800 N | Logan, UT 84321-1784 | (435) 227-9120 | www.campbellsci.com
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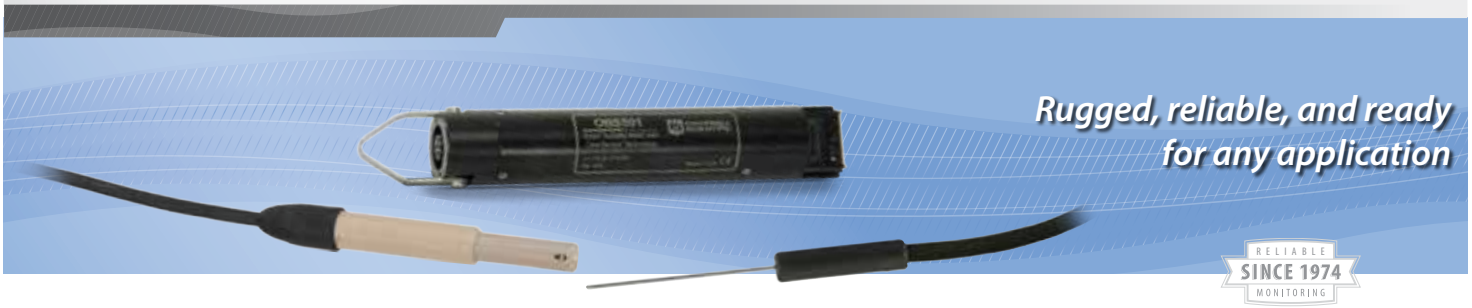
CAMPBELL SCIENTIFIC®
WHEN MEASUREMENTS MATTER

Water Quality Sensors

Turbidity, pH, ORP, DO, Conductivity, and Temperature Sensors



Water quality sensors are used in a wide array of applications, in many natural and industrial environments, including streams, watersheds, wells, caves, water/wastewater treatment plants, aquaculture operations, landfills, and processing plants. Each sensor provides research-grade accuracy and reliability.

MAJOR SPECIFICATIONS

	Output	Range	Accuracy	Operating Temperature	Major Features
OBS501 | Smart Turbidity Meter with Antifouling Features 	Analog 0 to 5 V RS-232 SDI-12	0 to 4000 NTU	2% of reading or 0.5 NTU	0° to +40°C	» Designed for heavy sediment loads. » Dual backscatter and side-scatter sensor » ClearSensor anitfouling method. » Optional plastic sleeve for faster cleanup » Optional copper sleeve for additional protection
OBS-3+ | Turbidity Sensor with side-ways-facing optics 	Analog 0 to 2.5 V 0 to 5 V or 4 to 20 mA	0 to 250 NTU 0 to 500 NTU 0 to 1000 NTU 0 to 3000 NTU 0 to 4000 NTU	2% of reading or 0.5 NTU	0° to +40°C	» OBS® technology used to measure suspended solids and turbidity » Stainless-steel body allows ≤500 m submersion in fresh water » Titanium body allows ≤1500 m submersion in fresh or salt water
OBS300 | Turbidity Sensor with down-ward-facing optics 	Analog 0 to 2.5 V 0 to 5 V or 4 to 20 mA	0 to 250 NTU 0 to 500 NTU 0 to 1000 NTU 0 to 3000 NTU 0 to 4000 NTU	2% of reading or 0.5 NTU	0° to +40°C	» OBS® technology used to measure suspended solids and turbidity » Stainless-steel body allows ≤500 m submersion in fresh water » Titanium body allows ≤1500 m submersion in fresh or salt water
OBS-3A | Turbidity and Temperature Monitoring System 	RS-232 RS-485	Turbidity: 0.4 to 4,000 NTU Temperature: 0° to 35°C Conductivity: 0 to 65 mS/cm (40 PSU, o/oo) <u>Concentration</u> Mud: 0.4 to 5,000 mg/l Sand: 2 to 100,000 mg/l Pressure: 0 to 10, 20, 50, 100, or 200 m	2% of reading or 0.5 NTU	0° to +40°C	» Measures turbidity with patented, field-proven OBS technology » Logs depth, wave height, wave period, temperature, and salinity » Runs up to 8,000 hours on three D-cell batteries

	Output	Range	Accuracy	Operating Temperature	Major Features
CS526 | Digital ISFET pH Probe 	Serial TTL Logic	1 to 14	±0.2 pH	10° to +40°C	» Uses state-of-the-art ISFET technology » No glass bulb to break, making the probe safer and more rugged
CSIM11 | pH Probe 	Analog ±59 mV/pH	0 to 14	±0.1% over full range	0° to +80°C	» Plunger-style pH glass electrode allowing the probe to be mounted at any angle » Internal amplifier boosts signal for less interference
CSIM11-ORP | Oxidation Reduction Potential (ORP) Probe 	Analog	-700 to +1100 mV	±0.1% over full range	0° to +80°C	» Plunger-style pH glass electrode allowing the probe to be mounted at any angle » Internal amplifier boosts signal for less interference
CS511 | Dissolved Oxygen (DO) Sensor 	Analog, 0 to 33 mV ±9 mV	0.5 to 50 ppm	±2%	0° to +50°C	» Submersible, rugged, low-maintenance sensor » In-line thermistor provides automatic temperature compensation
CS547A | Water Conductivity and Temperature Probe 	Analog (requires A547 interface)	-0.005 to 7.0 mS/cm	±5% of reading	0° to +50°C	» Corrosion Resistant » Epoxy housing is durable and easy to clean
109 | Temperature Probe 	Analog	-50° to +70°C	±0.2°C over 0° to +70°C tolerance	-50° to +70°C	» Rugged, Accurate, Versatile » Compatible with all of our dataloggers
109SS | Stainless-Steel Temperature Probe for Harsh Environments. 	Analog	-40° to +70°C	-40°C: ±0.6°C tolerance 0°C: ±0.38°C tolerance 25°C: ±0.1°C tolerance 50°C: ±0.3°C tolerance 70°C: ±0.4°C tolerance	-40° to +70°C	» Rugged, Accurate, Versatile » Designed for harsh, corrosive environments » Compatible with all of our dataloggers

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

OBS501

Smart Turbidity Meter with Antifouling Features

Ideal for Fouling Environments

ClearSensor antifouling features, dual backscatter sensors

Overview

The OBS501 is a submersible turbidity probe with active antifouling capabilities for better measurements in biologically active water with both high and low turbidity. It outputs an SDI-12, digitally processed signal that many of our dataloggers can measure. The OBS501 is similar to the OBS500, but the OBS501 has better mechanical performance in heavy sediment/sand conditions.

Benefits and Features

- Dual backscatter and sidescatter sensors used to measure turbidity
- ClearSensor antifouling method for better measurements in biologically active water
- Shutter/wiper mechanism keeps lenses clean
- Refillable biocide chamber prevents fouling
- Disposable plastic sleeve facilitates cleanup
- Optional copper sleeve for additional protection (especially for sea water) or disposable plastic sleeve facilitates easy cleanup

Detailed Description

Design features of the OBS501 include the combination of a backscatter sensor (better at measuring higher turbidity) with a second sidescatter sensor (better at measuring lower turbidity). It has a shutter that is opened only during measurements, which reduces the time that algae or other organisms can cling to its optics.

The OBS501 is constructed to prevent sand grains or packed sediment from getting wedged between the shutter and sensor body, which inhibits the shutter's movement. To do this, the OBS501's shutter and body were designed to eliminate parallel surfaces between moving parts wherever possible. The probe also uses a flushing action that moves the sediment down and out of the cavity behind the shutter.

To prevent biofouling and ensure better measurements, the OBS501 incorporates the ClearSensor Method (U.S. Patent No. 8,429,952. This method uses a shutter/wiper mechanism to protect and clean the optics. With the ClearSensor method, a chamber is also filled with a biocide that continuously leaches out over the optics while the probe shutter is in the closed position. *ClearSensor® and OBS® are registered trademarks of Campbell Scientific.*

For comprehensive details, visit: www.campbellsci.com/obs501

The OBS501 can sense if the shutter's motor is working harder than normal. If it is, the shutter moves slightly back and forth to dislodge sand grains before fully opening or closing.

Campbell Scientific offers a disposable, plastic sleeve that can make cleanup a snap, as well as a copper sleeve that can provide additional protection, especially in sea water.

Specifications

Dual Probe	90° sidescatter and backscatter
Range	0 to 4000 NTU
Active and Passive Antifouling	Shutter, wiper, biocide, copper, optional removable sleeve
Concentration Accuracy	±2% of reading or 0.5 NTU (whichever is greater)
Operating Temperature Range	0° to 40°C
Storage Temperature Range	0° to 40°C
Temperature Accuracy	±0.3°C
Emitter Wavelength	850 nm
Power Requirements	9.6 to 18 Vdc
Measurement Time	< 10 s
Maximum Submersion Depth	100 m (330 ft)
Diameter	4.8 cm (1.88 in.)
Maximum Cable Length	› 116 m (380 ft) for 1 channel SDI-12 or analog › 15 m (50 ft) for RS-232
Length	27 cm (10.63 in.)
Weight	0.59 kg (1.30 lb)

Power Consumption

Quiescent	< 200 µA
Measurement	< 40 mA
Communication	< 40 mA
Active Shutter Motor	< 380 mA

Outputs

SDI-12	Version 1.3, 1200 bps
RS-232	9600 bps, 8 data bits, 1 stop bit, no parity, no flow control
Analog	0 to 5 Vdc

For comprehensive details, visit: www.campbellsci.com/obs501

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Pennsylvania: Flood Warning

Campbell gear used to detect flood conditions and communicate warnings via Twitter

Case Study Summary

Application:
Measuring flood conditions and communicating warnings via social media

Location:
Upper Providence Township, Montgomery County, Pennsylvania

Sponsoring Organization:
Upper Providence Township

Integrators:
Distinctive AFWS Designs, Inc.

Products Used:
CR6, CS451, RavenXT

Measured Parameters:
Water level

Flooding is the number one natural cause of fatalities worldwide and was responsible for 6.8 million deaths in the twentieth century.* Today, humans are more vulnerable to flooding due to accelerations in population growth and changes in land-use patterns.* The good news is that our capability to measure water level and communicate those values in real time has never been better. This case study discusses a Campbell Scientific system that monitors river level and send alerts to decision makers via emails, Twitter, and a web page.

The Schuylkill River is roughly 130 miles long and has a drainage area of 2,000 square miles in Central and Eastern Pennsylvania. About 25 miles upstream of where it joins the Delaware River in Philadelphia is the Upper Providence Township in Montgomery County. In addition to the award-winning multi-use trails along the river, there are, as in most communities, properties (residential and commercial) subject to flooding during significant storm events. Prior to the time this system was designed, the Schuylkill River automated gaging stations nearest to Upper Providence were upstream in Pottstown (about 15 miles) and downstream in Norristown (about 10 miles). Between these two gages are more than 600 square miles of drainage basin.

Knowing the flooding history along this stretch of the river, the township officials identified the need for a local, automated gaging station that would provide real-time information and updates about the current water levels in the river. When funding was made available, the fire department and emergency management office worked with Distinctive AFWS Designs to design and build a station that met their needs. After many conversations about system design options, it was concluded that the most effective design would be a gaging station with a built-in web page and notification system.

*Doocy S, Daniels A, Murray S, Kirsch TD. The Human Impact of Floods: A Historical Review of Events 1980-2009 and Systematic Literature Review. PLOS Currents Disasters. 2013 Apr 16. Edition 1. doi: 10.1371/currents.dis.f4deb457904936b07c09daa98ee8171a.

The gaging station consists of a Campbell Scientific CR6 datalogger, a CS451 submersible pressure transducer, a 35 Ah 12 Vdc battery and 20 W solar charging system, and a RavenXT cellular digital modem (Figure 1). Water level is measured every 10 seconds and the datalogger records 1-minute and 5-minute interval averages of the measurements (to dampen out surface turbulence). The logged data is used to populate the station's internal web page (Figure 2). The web page returns current readings, long-term trends, and alarm states to aid in decision making.

The hydrographs use the 5-minute average and the River Last Reading value returns the latest 1-minute average. The river state (rising, falling, or steady) is determined by comparing the last three 5-minute averages for changes.

Anytime the water level reaches a defined alarm threshold, the datalogger sends out level-specific email and text notifications to emergency responders and public officials. The email/text group list is maintained by the emergency management staff on their email server (not in the gaging station). As a means of ensuring proper operations, at noon daily a heart-beat email is sent out to selected individuals. There are also maintenance-related notifications that can be sent out such as low battery or intrusion.

The second page of the station's web page includes impact statements related to the measured and reported water levels (Figure 3). The elevations for impact were determined after a professional survey was conducted of key hazard points along the river and related back to the water levels that would be measured at the gage.

Both of these web pages were intended for emergency responders and public officials. However, recent extreme flooding events has shown that social media is an important medium for informing the general public about hazardous conditions. Therefore, a Twitter account (www.twitter.com/fwg_Schuylkill) was created for the gaging station and it was configured to send out hourly tweets of the current river level as well as tweeting out whenever an alarm threshold is reached (Figure 4).

Just last month the Twitter page was opened up so that anyone can follow it. In the future, the use of hashtags will be imbedded in appropriate Tweets to better

Figure 1. Campbell Scientific datalogger, pressure transducer, battery, solar charging system, cellular digital modem

enable followers to stay informed. We are still working with a Twitter developer advocate to improve the automated tweeting experience and the information presentation through the use of IoT platforms (Internet of Things).

There are other potential uses and applications for getting gaging station information directly to the general public via social media. One of the driving forces in this particular case (and for potentially many others around the world) was the additional cost related to building a network or

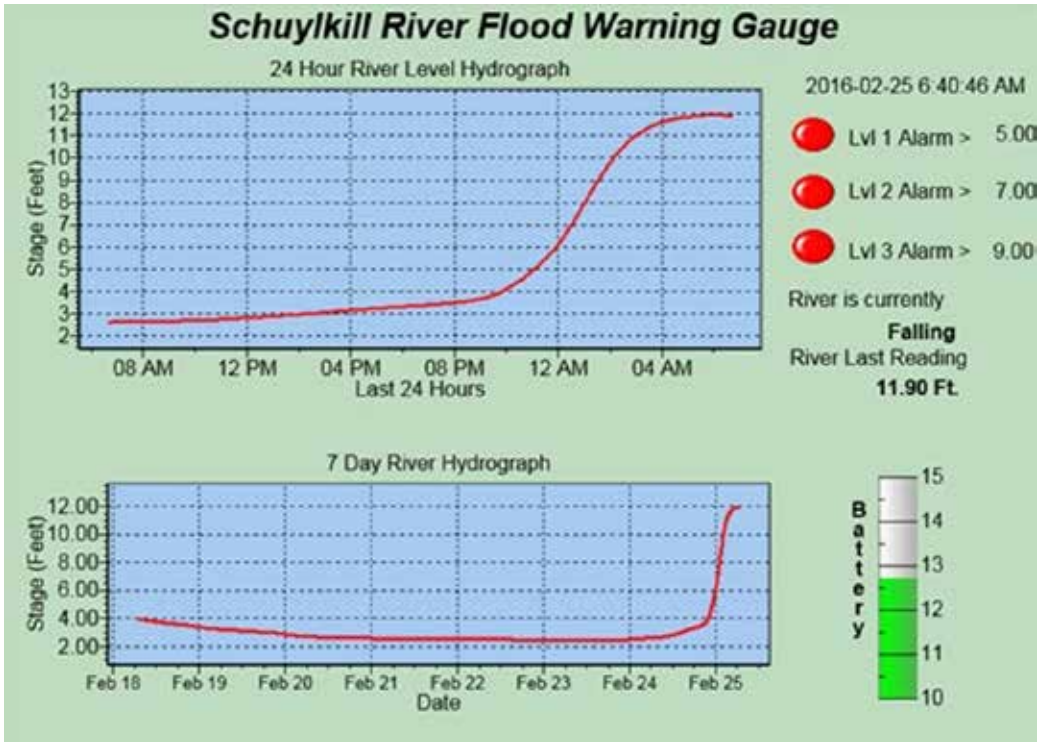


Figure 2. Schuylkill River gage internal website. The website displays the 24 hour and 7 day hydrographs. On the right are the stage alarms that have been identified. For demonstration purposes the Lvl X alarm levels on upper right side were lower than actual to show the active state.

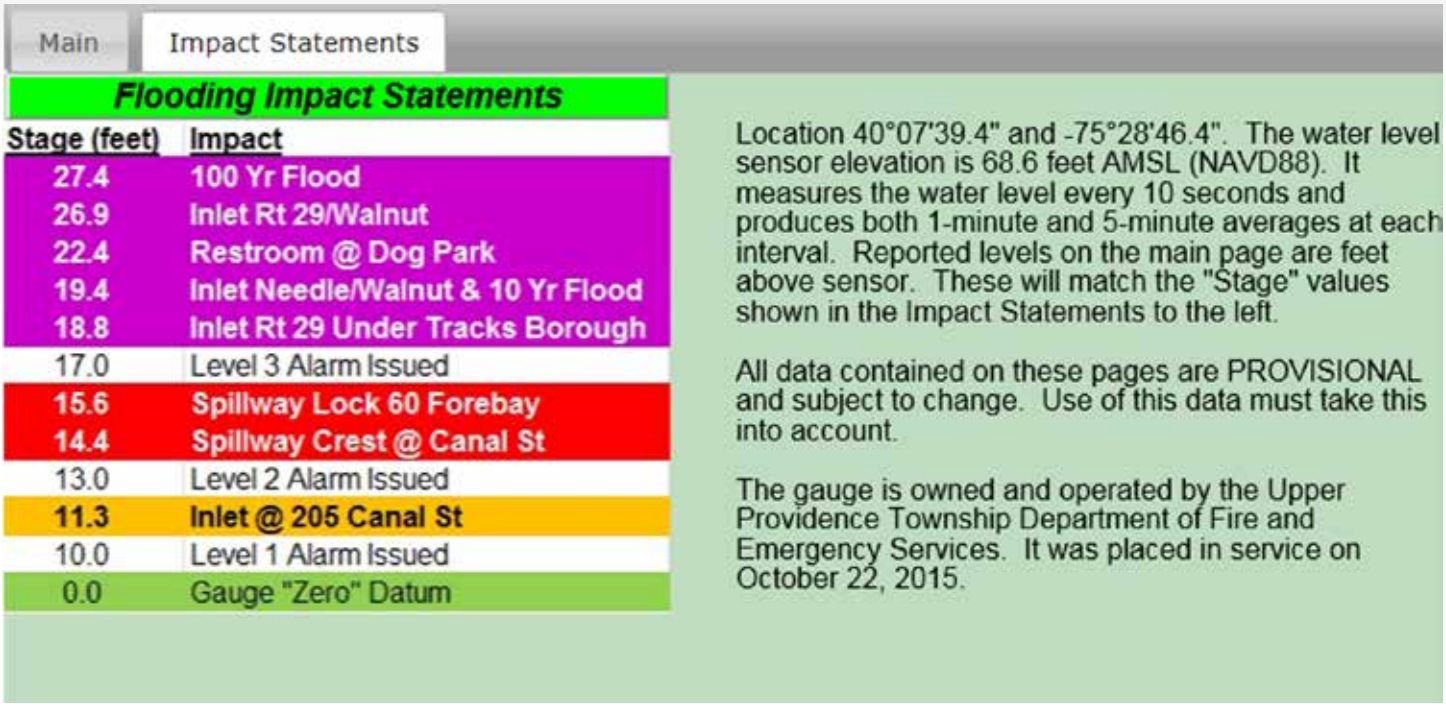


Figure 3. Shown are impact statements located on the station's second web page to explain alarm levels within the context of previous flood events and infrastructure at the site. This serves as an aide to emergency responders and decision makers.

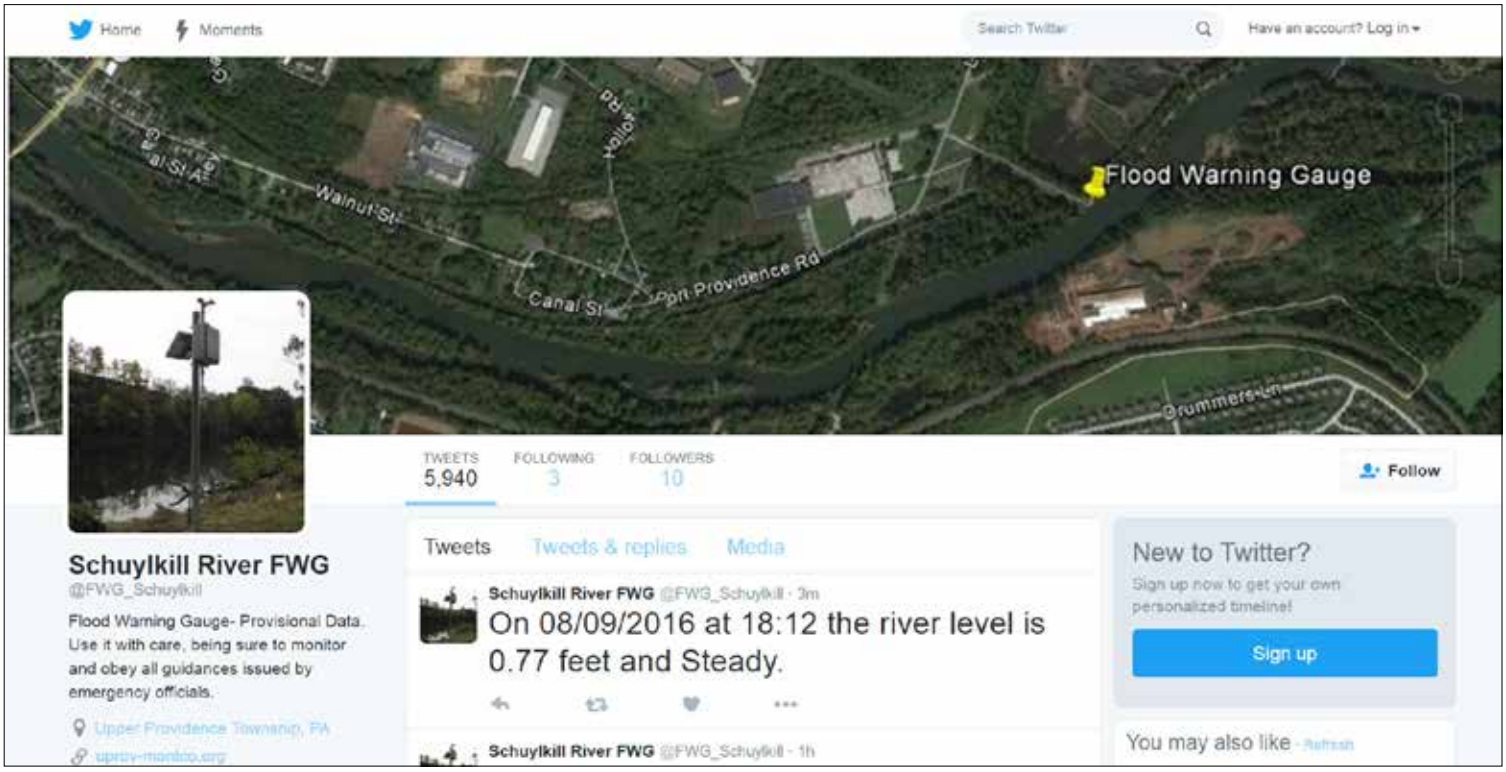


Figure 4. Example screenshot of the Schuylkill River Twitter site (Please follow us.)

infrastructure to get data from the gaging station to a traditional flood-warning base station computer system and the ongoing maintenance efforts and costs for those networks and systems. The designers of this system believe this general approach can be a great option for small municipalities or communities with reliable cell phone coverage. However, this solution could also be adapted for satellite or spread-spectrum license-free radios.

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Panama: Rain Forest Turbidity

Monitoring sediment loading from a copper mine with Campbell Scientific turbidity sensors

Figure 1. Location of the mine

Case Study Summary

Application:
Measuring turbidity in mine runoff with a network of monitoring stations

Location:
District of Donoso, Colón Province, Panamá

Integrators:
Water and Earth Technologies (WET)

Products Used:
CR800, OBS501, CS475

Measured Parameters:
Turbidity, water conductivity, water level, rainfall

Water and Earth Technologies (WET), a Campbell Scientific integrator, is a water resources and environmental engineering firm. WET provides engineering services in the areas of surface-water and groundwater hydrology, flood warning, data acquisition, hydraulic structure design, geomorphic design, erosion and sediment control, wetland hydrology, and data management. WET was hired by a Panamanian mining company to design and install water quality and sediment monitoring stations throughout a copper mine. The mine is located in the District of Donoso, Colón Province, Panamá.

The mine is approximately 5,900 hectares in 2016 and over the life of the mine will grow to the permitted 13,600 hectares. On average, the mine will produce roughly 320,000 tons of copper annually for the life of the mine. Based on the environmental impact statement, the mine must monitor sediment loads and turbidity in the water leaving the mine. WET was able to collect almost five years of pre-disturbance conditions before construction began on the property.

WET chose the OBS501 to measure turbidity at four monitoring stations at the mine after other turbidity probes could not survive the heavy sediment loads of the watershed. The OBS501 is perfectly suited for the lotic environments of the rainforest: high sediment loads and high opportunity for biofouling. The monitoring stations are located on the Rio Del Medio, Rio Botija, Rio Petaquilla, and the Rio Molejon.

Each monitoring station has a CR800 datalogger and communicates the data back to a base station running Novastar5 (Trilynx Systems) via an Orbcomm satellite radio (Quake Q1000). Figure 2 shows a typical monitoring station. Conductivity and water temperature (AquiStar CT2X conductivity/temperature), water level (CS475 radar level sensor), rainfall (Hydrolynx 1 mm buckets), and turbidity (OBS501) are monitored at each station. The radar level sensor is also used to trigger an automated sampler to collect water samples.

Each monitoring site (Figure 3) has two OBS501 sensors: an upper sensor and a lower sensor to allow for monitoring turbidity at both base flow and storm flow conditions. The conduit is required to protect the sensors during flood events that can completely cover the sensors in sediment. After flood events, significant maintenance is often

required to remove the sensors from the bed material. Figure 4 shows data collected at Rio del Medio from 24 July 2016 to 2 August 2016. The data includes the low-flow side-scatter turbidity record, 15-minute rainfall, and water-surface elevation as measured by the radar level sensor.

WET deployed their first four OBS501 sensors in February of 2016. They have been back for field maintenance once over the summer of 2016. They were pleased to find the optical windows clean and the shutters working perfectly in one of their most challenging monitoring environments. (Figure 3B) WET has purchased two more OBS501 sensors to be installed at the third monitoring station, and plans to purchase the last two in the near future.

Figure 2A. Typical stream monitoring station

Figure 2B. Campbell Scientific custom datalogger enclosure designed to meet WET specifications

Figure 3A. Conduit for the turbidity and conductivity and temperature sensors as well as the sampler hose

Figure 3B. OBS501 with shutter open during a maintenance visit

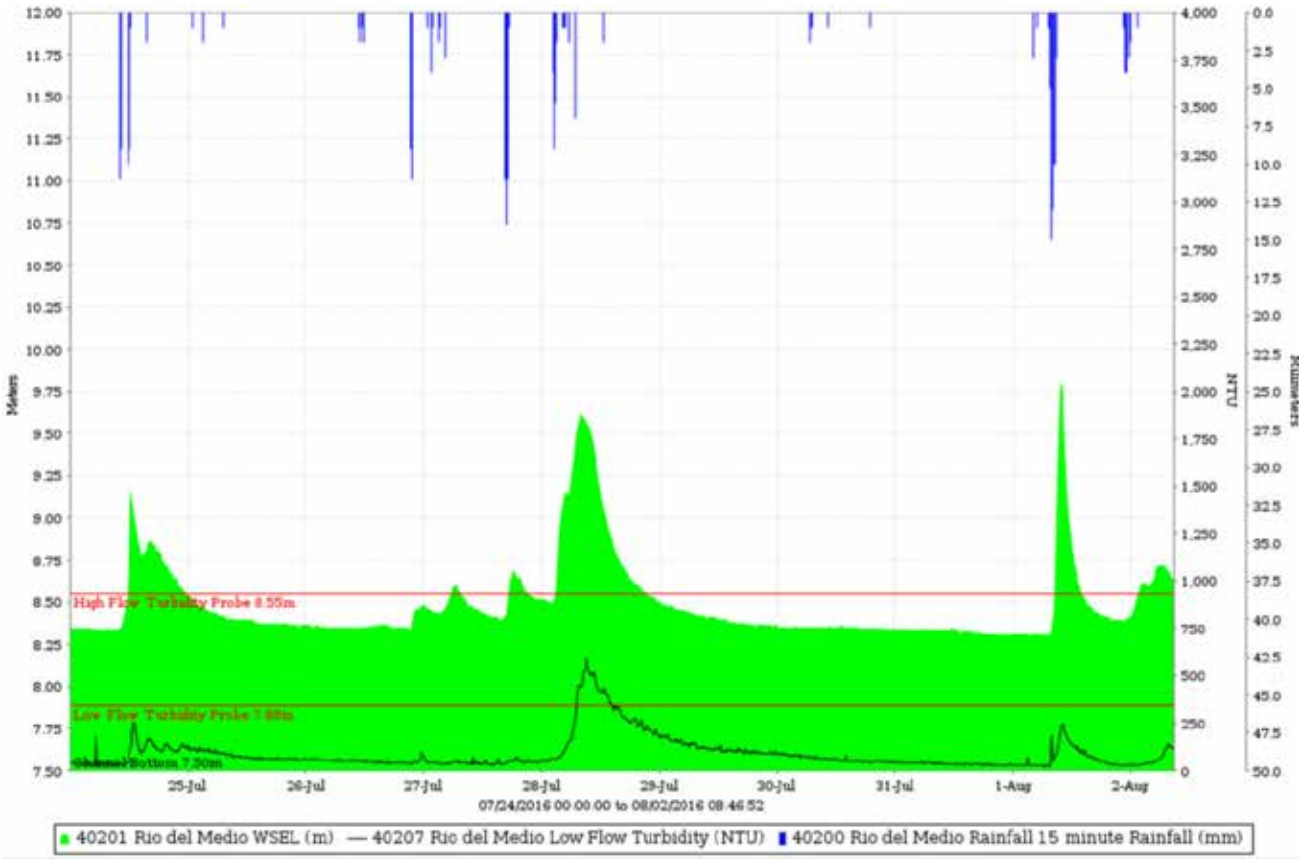


Figure 4. Turbidity, water-surface elevation, rainfall at the Rio del Medio monitoring station from 24 July to 2 August 2016.