# EC1500

VERSION 1.5

EC1500 ELECTRICAL CONDUCTIVITY SENSOR

**1500** 4-20MA INTERFACE | **1500S** SDI-12 INTERFACE

environmental systems & services

# PRODUCT USER MANUAL


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# Contents

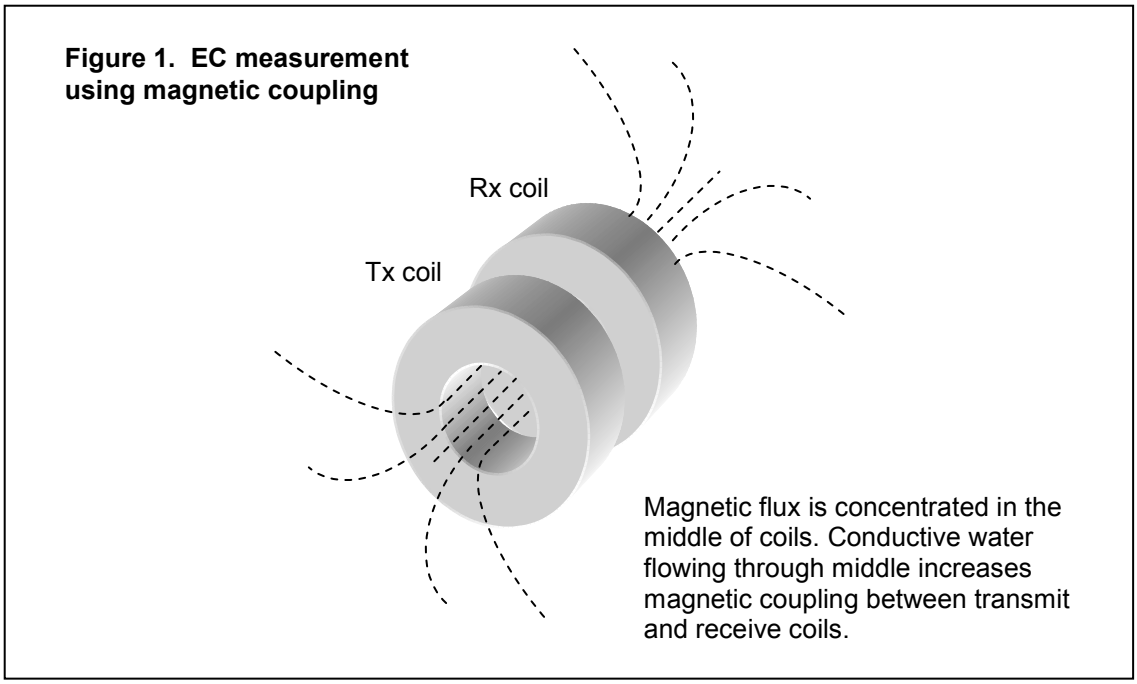



**Figure 1. 1500 Sensor measurement principle**

The above diagram shows how the sensor works. Transmit (Tx) coil forms a magnetic flux inside the coil pair. Conductive water increases the magnetic coupling which is seen as a transfer of oscillating current in receiver (Rx) coil. The degree of transfer is an indication of water conductivity.

## *What is temperature compensation?*

Like resistance, conductivity changes with temperature. The lower the temperature, the less the conductivity and this is because electrons find it harder to flow through dissociated salt molecules at lower temperature. This makes measurement confusing when actually trying to determine the water conductivity over a temperature range. To overcome this effect, conductivity measurements at any temperature are output as if the temperature is 25°C and is called *temperature compensated output.*

The relationship between compensated and non compensated (raw) output is linear and simply put, a percentage is added or subtracted from the raw measurement to determine compensated output. For the 1500 EC sensor, the compensation is set at approximately 2% per °C. For temperatures below 25 °C the proportion is subtracted and is added for temperatures above 25°C. Of course the temperature needs to be measured for compensation and therefore the 1500 EC sensor has an internal temperature sensor. As an additional feature, the 1500 EC sensor also has a separate temperature output available to loggers and controllers as a 4-20mA signal. Temperature compensation operates between 0 and 50°C, the typical expected water temperature for most environmental conditions.

$$\text{Corrected EC @ 25°C in uS/cm} = \frac{\text{Raw E.C. Reading in uS/cm}}{1 + 0.02\,(\text{Sample Temperature} - 25°\text{C})}$$

# Installation

## Site Selection

Before installing a 1500 EC sensor it is recommended a suitable site be selected first. The installation and maintenance complexity as well as the reliability of the instrument in critical applications depends on the site chosen and the length of cable required can then be determined.

Well chosen sites:

- slow flowing water (no stratification)
- minimal or no accumulation of debris around sensor
- easy and safe access, away from waterway traffic
- sensor head is always submerged in at least 200mm of water
- sensor head is at least 100mm from bottom and at least 50mm from any metal
- sensor cannot be dislodged during high flows

Avoid sites with:

- very low or stagnant water flows
- where debris can accumulate inside sensor head
- excessive air bubbles in water
- difficult or unsafe access
- high siltation rates
- where sensor will be exposed in air during low flows

The following is also recommended for EC sensor installation

- install the sensor out of direct sunlight, especially when in shallow water. Sunlight will heat the sensor head to produce a false temperature and compensated EC reading.
- Algae will tend to grow within the sensor hole. This can be minimized by covering the sensor with a shield to make the head as dark as possible. No sunlight means no algae
- Silt can accumulate in the sensor hole. Install the sensor so water can flow through the hole.

Typically, most sites that are already equipped with hydrographic instrumentation can be used for installation of the 1500 EC sensor.

### *Sensor installation*

For correct installation the following installation restrictions apply

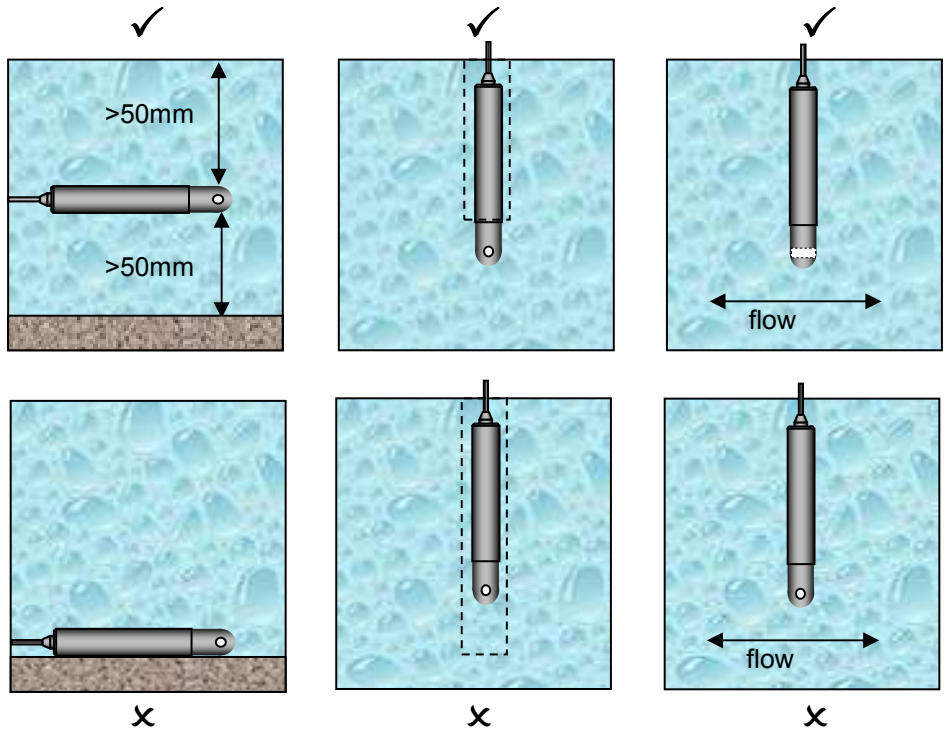



**Figure 3. Sensor orientation**

Sensor clearance

Correct orientation of the sensor will help to reduces the build up of silt and debris within the hole in the center of the EC head. Where algal blooms are likely it is recommended the sensor is covered with a sun shield, keeping the sensor in the shade, thereby reducing algae buildup. When installing a shield, ensure the shield clears the sensor head by at least 50mm. The shield should ideally be installed 100mm from the sensor, and cover the sensor sufficiently from direct sunlight. A shield will also prevent excessive temperature variations.

With the exception of the head (with hole trough it), the rest of the sensor can be completely covered. If 50mm ID poly tube is used for installation, a suitable compression gland is available from irrigation hardware suppliers. The sensor outside diameter is smaller than the compression gland internal diameter and can be clamped easily and securely using this method. When this system is used, the sensor head must protrude from the gland by as least 60mm.

### *Site preparation*

Before the sensor can  be installed, the site must be prepared to ensure the sensor will be secured, protected and serviceable.

The following recommendation is based on typical installation methods practiced by today's hydrographers. Several variations of this method are used to suit particular applications.

Please study the diagram below. Site preparation involves the installation of a larger plastic tube along the waterway bank as shown. The tube should ideally be continuous but may also be made from sections. One end of the tube must be installed into the water ensuring the sensor optical path will not be obstructed according to the previous section *Sensor Clearance*. The other end can be terminated in a junction pit that is large enough so that the sensor can be inserted from the pit. Typically, an underground electrical pit is used as this also allows a sensor carrier assembly to be inserted easily. The pit must be installed on a stable part of the bank that cannot erode.

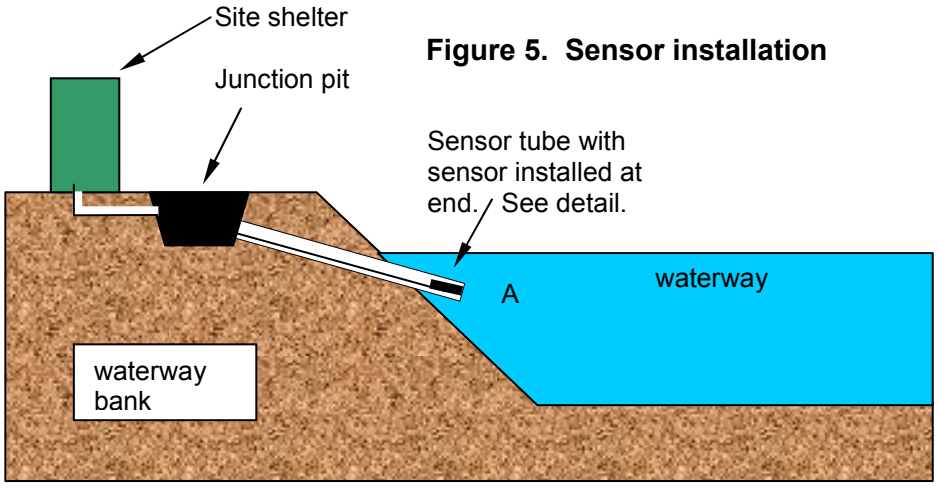



**Figure 5. Sensor installation**

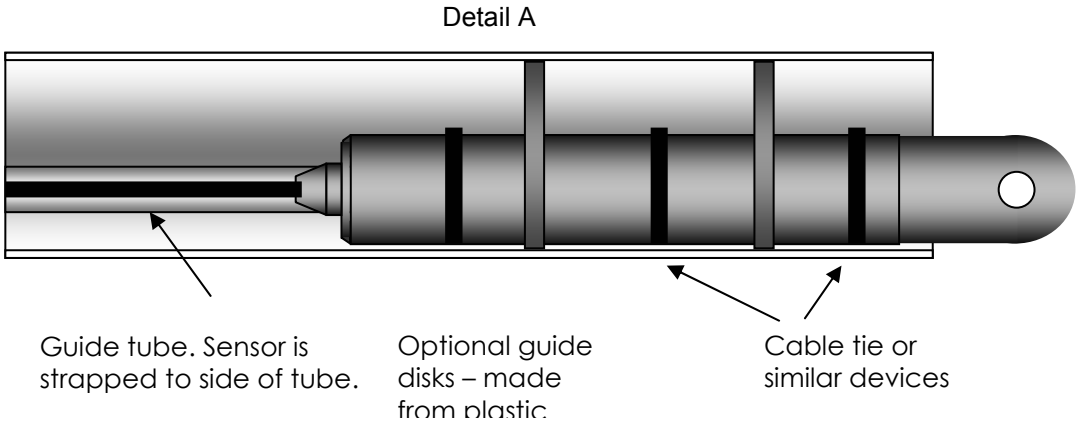
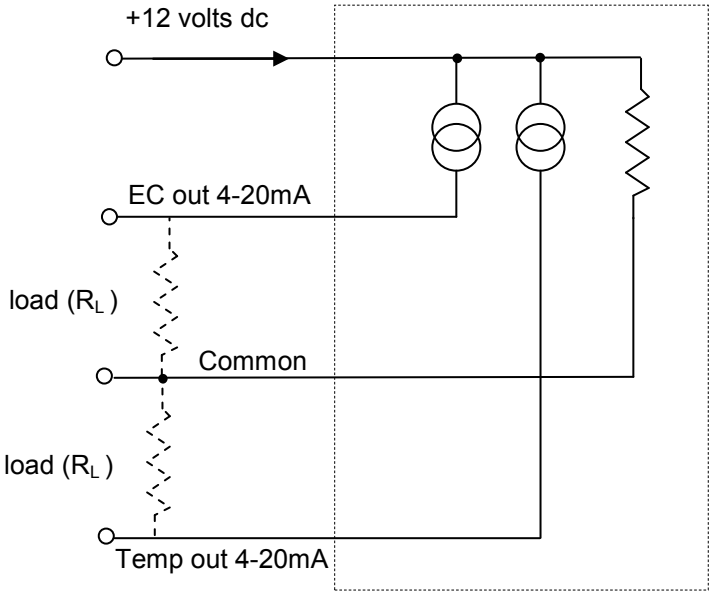



**Figure 6. Sensor installation**

### *1500 4-20mA sensor electrical connection*

The diagram below shows the electrical circuit equivalent of the 1500 EC sensor.




The 1500 EC sensor is a 3 wire current loop device

**Figure 7. Electrical equivalent circuit**

A single cable is hardwired to the 1500 sensor. The diagram below shows the configuration and typical connection of the sensor to power and controlling equipment.

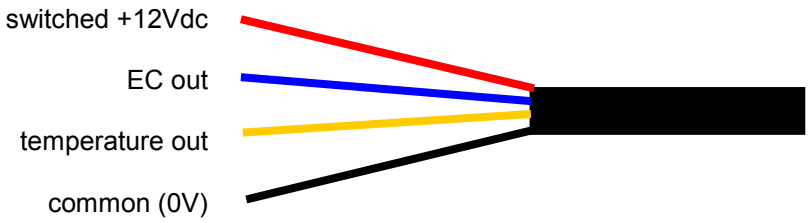



**Figure 8. 1500 4-20mA cable conductor designation**

| Conductor Colour | Conductor designation | Requirements | ES&S 3 pin plug x 2 | ES&S 5 pin plug |
|---|---|---|---|---|
| red | switched +12vdc input | 80mA min | A | A |
| blue | 4-20mA output, EC | source, max 450Ω load | B | B |
| yellow | 4-20mA output, Temp | source, max 450Ω load | B (plug 2) | D |
| black | common | 0V dc | C | C |
| | | | | E |

## *1500 Operation (4-20mA output)*

To obtain a measurement from the 1500 sensor:

- Install the sensor according to recommendations in Section *Installation*.
- Apply power to the sensor (figure 8.)
- 1500: 2 x 4-20mA current output will be produced at the respective outputs.
- 1500S: Conductivity data is available on the SDI-12 bus

A current output signal will be available for measurement after 1 second. For power conserving applications, the sensor can be switched off immediately after the reading is attained. The sensor can also be left on continuously if required.

The 4-20mA current output will be available for reading 1 second after switched power is applied.

With proper care and routine maintenance, the sensor can be left operating unattended for several months. Of course, as each application will be different, it is recommended that the total time between services is determined experimentally.

## *1500S Operation (SDI-12 Interface)*

The SDI-12 interface of the 1500S handles all of the communication, and power down features of the SDI-12 protocol.

All standard SDI-12 commands are supported. In addition, it has extended commands which can be used to calibrate sensor outputs. Each of the measurements can be scaled and offset with user supplied calibration coefficients. The SDI-12 Interface also has an on board temperature sensor.

The interface has been fully tested with the NR Systems SDI-12 Verifier.

Note that the 1500S is 11 cm longer than the 4-20mA 1500.

## SDI-12 Commands

The commands assume that the sensor address is 0, but any address could be substituted into the commands below. "\r\n" is carriage return and line feed characters.

Calibration coefficients are modified by extended "X" commands, and are indexed by a 2 dimensional array, where the first zero based index is the measurement index, and the second is the parameter.

| Measurement | Index |
|---|---|
| Sensor 1 | 0 |
| Sensor 2 | 1 |
| Sensor 3 | 2 |
| Temperature | 3 |

Each measurement has 3 parameters:

| Parameter | Index | Default Value |
|---|---|---|
| Offset | 0 | 0.0 |
| scalar | 1 | 1.0 |
| resistor gain | 2 | (Rs+Rp)/Rp |

**Example:**

To calibrate the output of the second sensor such that it's voltage is multiplied by 2 and an offset of 3 is added to the result using the following transfer function:

out= 2*x+3,

the following two extended commands would be used:

0XSET VAR[1,0]=3!

0XSET VAR[1,1]=2!

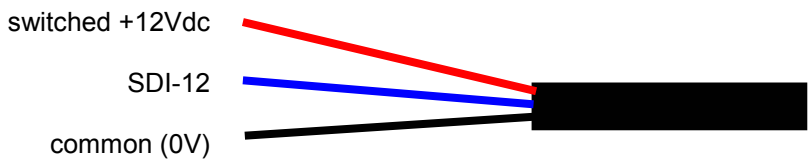



**Figure 9. 1500S SDI-12 cable conductor designation**

## DI-12 Command Table

| Command | Description | Typical Response |
|---|---|---|
| ?! | Returns address of a single sensor on the SDI-12 bus | "0\r\n" |
| 0! | Ping, returns same address | "0\r\n" |
| 0V! | Verify command. Subsequent 0D0! command will return the version of the Interface | "00001\r\n" |
| 0M! | Begin a measurement. Subsequent 0D0! command will return the 3 measurements and the temperature. | "00034\r\n" |
| 0MC! | Begin a measurement and respond with CRC on subsequent 0D0! command. | "00034\r\n" |
| 0C! | Begin a concurrent measurement. (Same as 0M! command but no service request is issued.) | "00034\r\n" |
| 0CC! | Begin a concurrent measurement and respond with CRC on subsequent 0D0! command. | "00034\r\n" |
| 0D0! | Get data is called after a 0M!, 0MC!, 0C!, 0CC!, and 0V! commands. If called after the 0V command then the single result is the version number, otherwise it returns 4 results, namely the 3 sensor voltages, and the internal temperature of the interface. | Response to 0V!<br>"0+2.0\r\n" ,<br>Otherwise:<br>"0+1.1+2.2+3.3+25.0\r\n" |
| 0XSET VAR[m,p]=VAL! | Set and store one of the calibration coefficients indexed by m,p, where m is the measurement, and n is the parameter | "0XACK\r\n" |
| 0XLOAD VAR[M,N]! | Retrieve and store the calibration coefficients indexed by m,p, where m is the measurement, and n is the parameter, to a string buffer ready to be retrieved by the 0XGET command. | "0XACK\r\n" |
| 0XGET! | Retrieve the string buffer that was filled from the previous 0XLOAD command | "0X +1.1\r\n" |
| 0XER! | Retrieve a string for the last error generated by the use of an X command. | If no error:<br>"0XOK\r\n"<br>Possible errors:<br>"0XER BAD COMMAND\r\n"<br>"0XER BAD MEASUREMENT INDEX\r\n"<br>"0XER BAD COEF INDEX\r\n" |

## Internal Temperature Sensor

The SDI Interface has an internal temperature sensor, however for higher accuracy it must be calibrated by the end user

# Example program to read SDI-12 Engine

```
'Program name: CR1000 sample display reading.CR1
'Date written: 3/06/2009 using the CRBasic programming tool from
' Campbell Scientific LoggerNet 3.4.1

'This program is used to test the SDI-12 Interface using a
'Campbells CR1000 logger.
'
'Sensor powered from 12V terminal and a G terminal, and with SDI-12
on C1 terminal.
' Logger   C1----blue-------Sensor SDI-12
'          12V --red--------Sensor Power +ve
'          G ----black------Sensor Ground

'The program below will collect data each second from the four SDI-12
Interface channels.

'Use one of the Data Displays from the loggerNet Connect Screen.
'Set the table cells to sdidata(1) to sdidata(4).
'The information from each of the four channels of the SDI-12 Sensor
'Engine will be displayed and updated every second.
'\\\\\\\\\\\\\\\\\\\\\\\\\ DECLARATIONS /////////////////////////

Public sdidata(4)  'sdidata(1) conductivity
                   'sdidata(2) temperature
                   'sdidata(3) not used
                   'sdidata(4) temperature of SDI IF uprocessor

'\\\\\\\\\\\\\\\\\\\\\\\\ OUTPUT SECTION ////////////////////////
'\\\\\\\\\\\\\\\\\\\\\\\\ SUBROUTINES ////////////////////////////
'\\\\\\\\\\\\\\\\\\\\\\\\\\ PROGRAM //////////////////////////////

BeginProg

  Scan(1,Sec, 3, 0)
    SDI12Recorder(sdidata, 1, "0", "M!", 1.000, 0)
  NextScan
EndProg
```

# *Maintenance*

The 1500 sensor will require little periodic maintenance to ensure that measurements remain accurate. While all wetted components are no metallic and cannot corrode in high salt or acidity liquids. Debris, silt and algae lodged in the hole can cause inaccurate readings. It is recommended the sensor is checked during every visit, or at least every 3-6 months. You may find the sensor will not require any maintenance for even longer periods however, warmer climates or high silt laded rivers and streams can accelerate these effects..

### General

- Ensure the sensor is not affected by debris, silt or algae (or marine growth). The sensor should be removed from its installed location for a thorough inspection. Using the recommended installation method outlined in the section Installation, removal should be easy and maintenance staff do not need to enter the waterway
- Ensure the installation is sound and the sensor is still secure from moving and there are no obvious signs of erosion or damage.

### Calibration check

The sensor output can be checked against a reference instrument if it is available. Ideally, the measurement should be taken in the same solution as the sensor while the sensor is installed. If there is a large difference, an installation problem may be highlighted. All sensor measurements should be within the specified accuracy.

- compare the sensor measurement to that of the reference instrument.
- ensure the reference instrument calibration error is also known.

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## Internal Temperature Sensor

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## *Ordering information*

| Item description | code |
|---|---|
| Electrical conductivity sensor | 1500 |
| Cable, hardwired to sensor, 10 meters std<br>(other cable length available on request) | 1510 |
| Connector, 2 x 3 pin male plugs fitted to 1510 cable<br>with "V" splice to sensor cable | 1520 |
| Connector, 5 pin male plug fitted to 1510 cable | 1530 |
| Extension cable with 5 pin male plug and 5 pin female jack, metres | 1540 |

Note: For EC with SDI-12 output, add "S" to the above ordering codes.
Example: SDI-12 Electrical conductivity sensor: 1500S

## *Contact Details*


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**Revision History:**

| REV | BY/DATE | DESCRIPTION | AUTHOR |
|---|---|---|---|
| 1.00 | 2/11/2005 | release | TG |
| 1.10 | 20/6/2009 | Add SDI-12 | GQ |
| | | | |

# 1500

## Electrical Conductivity Sensor

1500 (4-20mA interface)
1500S (SDI-12 Interface)

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# 1500

## Electrical Conductivity Sensor

1500 (4-20mA interface)
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# 1500

## Electrical Conductivity Sensor

1500 (4-20mA interface)
1500S (SDI-12 Interface)

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*version 1.5*

# DELIVERING WATER MONITORING SOLUTIONS

## 2600 Turbidity Sensor

The ES&S Turbidity sensor is a miniature backscatter nephelometer that detects turbidity and suspended solids in water. Applications include rivers / streams / irrigation runoff water quality, sediment transportation, aquaculture, waste water quality, EPA compliance monitoring. The 2600 is NOW AVAILABLE with SDI-12

## LevelPro 6100

The LevelPro 6100 advanced liquid level sensor is used to measure water level determination 0-70 metres. Applications include river / irrigation water level, tidal monitoring, groundwater level & landfill monitoring, dam, tank, reservoir levels, waste water monitoring, food warning systems, process industry liquid level.

## PumpPro 6150

The PumpPro 6150 combines an integrated air compressor module and levelpro 6100 advanced liquid level sensor to form a fully self contained hydrostatic pressure sensor designed to measure water and liquid levels reliably and accurately.

## Dipmeter

The Water Level Indicators Dipmeters are typically used to measure the depth of water levels in boreholes, standpipes or observation wells.

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