USER'S GUIDE
MODEL 4100/4110 SERIES
AQUATRAK®

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Aquatrak Corporation

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AQUATRAK® Model 4100/4110 SERIES USER GUIDE

TABLE OF CONTENTS

APPENDIX

LIST OF FIGURES

LIST OF TABLES

USER'S GUIDE APPLICABILITY

This User's Guide covers two versions of the Aquatrak Level Measuring System, namely Models 4100 and 4110. They are physically and functionally the same, the difference being that the 4110 firmware has been upgraded from a polled architecture to an interrupt driven design. The Model 4100 firmware is version 1.17; the Model 4110 firmware is version 4.XX. Version 4.XX incorporates all of the SDI-12 version 1.3 requirements including Cyclic Redundancy Check (CRC) and Parity Check on incoming commands.

In this Users Guide the differences in Models 4100 and 4110 for the RS-232 and SDI-12 menus and command are noted is Section 3 (PROTOCOLS AND COMMUNICATIONS).

Warranty

Aquatrak Corporation warrants its products to be free of defects in workmanship and material for a period of 12 months from date of shipment. During the warranty period, Aquatrak will repair or replace defective products at its own expense, subject to the following conditions:

1. The buyer must prepay all shipping, insurance, and associated costs to return the defective item to Aquatrak. Aquatrak pays return shipping and insurance.

2. The product must not have experienced misuse, neglect, and accidental damage or have been altered or repaired by the buyer during the warranty period.

3. This warranty and Aquatrak's obligation are in lieu of all other warranties.

4. Aquatrak is not liable for consequential or incidental damages, labor performed in conjunction with removal and replacement, loss of production, or any other loss incurred because of interruption of service or production of incorrect or incomplete data.

CAUTIONARY NOTES

Note:

Used to call attention to a special feature or procedure, which must be followed for correct operation of the equipment.

Caution:

Used to call attention to a concern where damage to the equipment or injury to personnel may occur unless certain steps are followed.

TYPICAL PARTS & MATERIALS REQUIRED

	Section	✓
Aquatrak Installation Kit	2.1, 2.2, 2.3	____
Protective Well	2.1, 2.3	____
S.S. Straps for PVC Pipe (5)	2.1, 2.3	____
Spacer Blocks for Well (5)	2.1, 2.3	____
CPVC Primer	2.2	____
CPVC Cement	2.2	____
Hacksaw, Fine Tooth	2.2	____
Trimming Knife	2.2	____
Fine Grit Sandpaper	2.2	____
S.S. Hose Clamp, 4 inch	2.3	____
Silicone Grease	2.4	____

METRIC /ENGLISH CONVERSION FACTORS

25.4 mm	=	1 inch	1 mm	=	0.0394 in
0.3048 meter	=	1 foot	1 meter	=	3.2808 ft.
0.454 kg	=	1 pound	1 kilogram	=	2.2 lb.

$$^{o}F = \frac{9(^{o}C)}{5} + 32 \qquad ^{o}C = \frac{5(^{o}F - 32)}{9}$$

1. INTRODUCTION TO THE AQUATRAK LIQUID LEVEL MEASURING SYSTEM

1.1 Improved Ability for Measuring Absolute Liquid Level

Aquatrak is superior to traditional liquid level sensors and provides unsurpassed reliability and proven performance. Using a patented acoustic ratiometric technique, the Model 41XX Series can be used to measure water level in rivers, lakes, and groundwater, tidal and sea level changes, wave height and sea state and industrial tank ullage.

The AQUATRAK sensor provides accurate measurement of absolute liquid level in all weather conditions. Designed for rugged, unattended operation, the sensor has been field proven for over twenty years in adverse environments around the world for hydrology, oceanography, and hostile environment chemical and nuclear tank control systems.

Acoustic Ratiometric Measurement Benefits

The AQUATRAK sensor is "non-contacting" and is therefore not affected by many of the factors, that cause significant errors and maintenance problems with traditional stilling wells using float or pressure transducers. Traditional gauging stations can all be replaced with the AQUATRAK. The technology is immune to atmospheric effects such as temperature, humidity, and atmospheric pressure changes. Some of the many advantages include:

- ✓ Easy Installation
- ✓ mm Resolution
- ✓ Low Maintenance
- ✓ No Moving Parts
- ✓ Wide Dynamic Range
- ✓ Long Term Stability w/o Calibration
- ✓ Sea State Measurement
- ✓ Interface to RS-232 and SDI-12

Reliability

The AQUATRAK provides reliability unmatched by conventional technologies. Because there are no moving parts such as gears, bearings, or floats to wear out, the reliability is a function of the carefully selected electronic components. Reliability is further enhanced because all electronic components are out of the liquid - in fact, there is no conductive path to the liquid at all. This all but eliminates damage from lightning. Aquatrak has obtained a field proven reliability record of better than 1,000,000 hours mean time between failures (MTBF).

Transducer Configurations.

Figures 1-1, 1-2, and 1-3 below show examples of transducers that are available. They are identical in function and performance; the differences are only in the method of cable entry.

Figure 1-1. 3000-XCR-4 Transducer, Side Mount Pigtail

Figure 1-2. 3001-XCR-4 Transducer, Top Mount Pigtail

Figure 1-3. 3003-XCR-4 Transducer, Top Bulkhead Connector

Proven Technology

The AQUATRAK sensors are based on technology developed and patented by Bartex and acquired by Aquatrak Corporation. The U.S. National Ocean Services (NOS) and the Australian National Tidal Centre have selected the Aquatrak Model 41XX gauge to be their primary standard instrument for tidal programs.

AQUATRAK Components

The Model 41XX AQUATRAK comes complete with the following items:

Qty.		Qty.	
1	Transducer	1	Controller
1	Transducer Cable, (3 meters)	1	RS-232 Cable (3 feet)
1	SDI-12/Power Cable (3 feet)	1	Calibration Tube

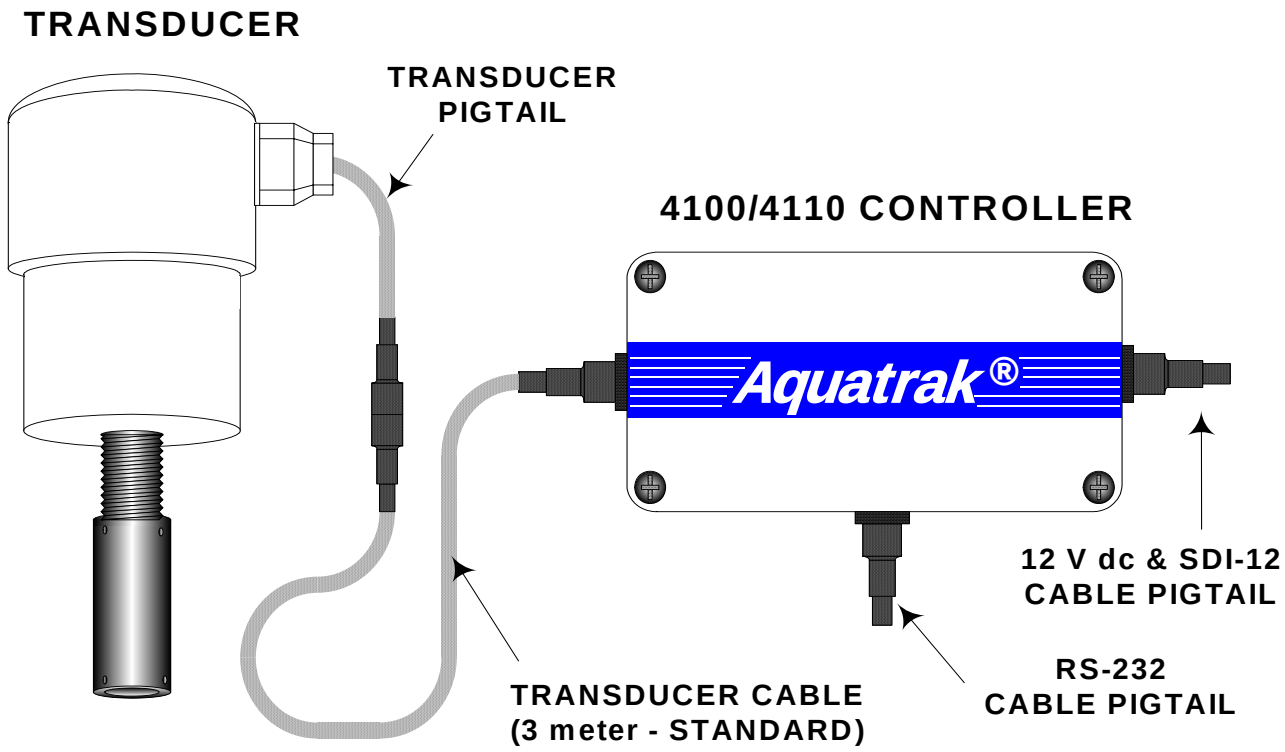


Figure 1-4 AQUATRAK Model 41XX Series Sensor

1.2 Performance Specifications for the Model 41XX Series

The Model 41XX Series AQUATRAK measures absolute liquid level in all indoor and outdoor conditions. Measurement is possible in open waters, stilling wells, ground wells, as well as in enclosed tanks.

Table 1-1 Specifications of the Model 41XX Series

Performance Specifications	
Dynamic Range	10 meters (35 ft) Standard
	15 meters (50 ft) Optional
	23 meters (75 ft) Special Order
Rate of Change	± 3 m/sec (10 ft/sec) max
Resolution	1 mm or 0.001 ft
Range Proportionate	1.2 – 2.4 / sec
Averaged over 2 – 255 Samples	1.0 / sec.
Calibration Accuracy	± 0.025 % Standard
	± 0.01 % Optional
Nonlinearity	± 0.02 %
Repeatability	± 0.01 %
Long Term Drift	None over 1 year period
Temperature Drift	< 1 PPM / °C
Data Update Rate	User Selectable (Section 3.2.1)

Electrical Specification	
Supply Voltage	+10.5 to +14.5 Vdc
Operating Current	< 30 ma with RS232 < 30 ma with SDI-12
Quiescent Current	< 1 ma
Fusing	500 ma fast action fuse supplied (LITTELFUSE 216.500 or equivalent)
Transient Protection	All power and signal lines are protected by MOV
Interface	RS-232 ASCII and SDI-12 standard

Environmental Specification	
Operating Temperature	- 40 to + 55 °C (- 40 to + 130 °F)
Storage Temperature	- 55 to + 60 °C (- 67 to + 140 °F)
Humidity	0 – 100%
Precipitation/Dust	NEMA-4X Corrosion Resistant

Table 1-1 Specifications of the Model 41XX Series (Continued)

Physical Specification	
Model 41XX Controller Box	175 mm L X 60 mm H X 80 mm W, @ 0.7 kg (7 in L X 2.5 in H, @ 1.5 lb.)
Transducer	90 mm diameter X 210 mm high, 1.2 kg (4 in diameter X 8 in high, 2.5 lbs.)
Cable Length, Transducer-to-Controller	3 m (10 ft) supplied, up to 300 m available
Shipping Carton	1 Box – 0.01 m^3 (0.3 ft^3), 2.3 kg (5 lbs.) for transducer and controller 1 tube – 1.4 m^3 (4.5 ft^3), 0.9 kg (3 lbs.) for calibration tube

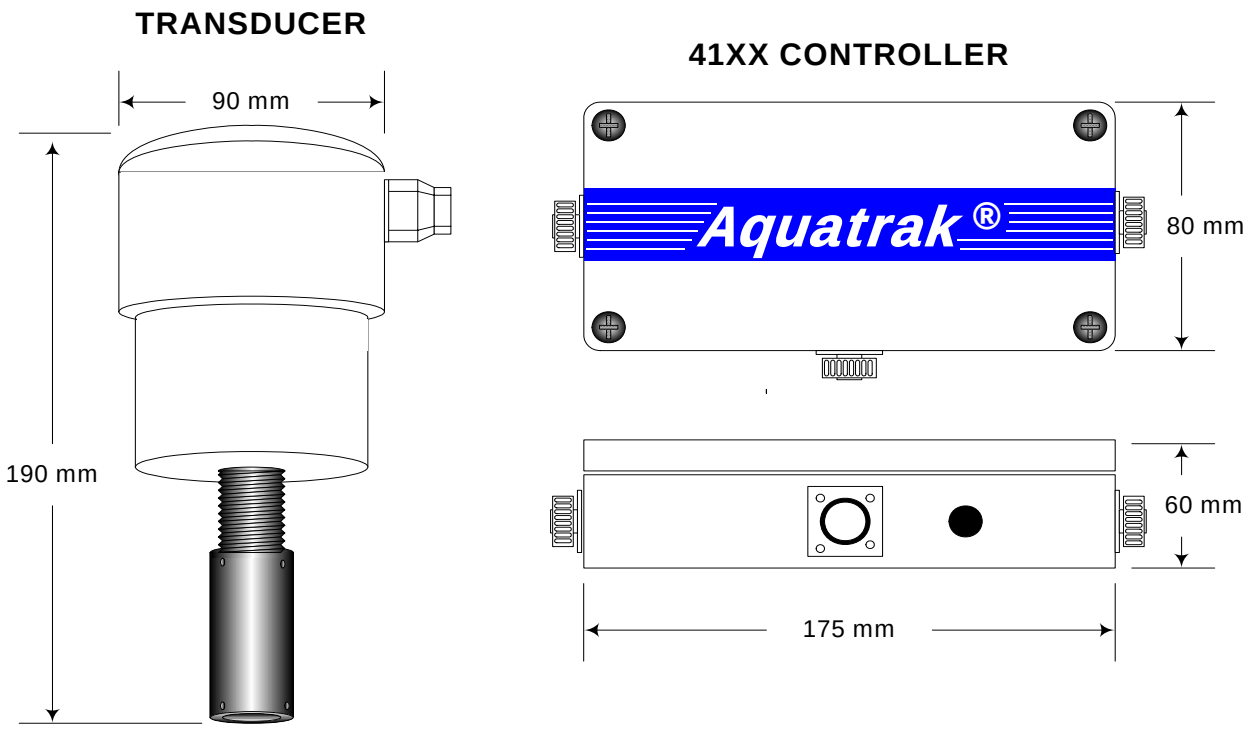


Figure 1-5 Dimensions of the Model 41XX Series Controller and Transducer

1.3 How the AQUATRAK Measures Liquid Level

> The Aquatrak patented ratiometric technique is based on fixed points, and is critical to high levels of accuracy, resolution, and long term stability.

The AQUATRAK sensor uses a very simple but accurate technology to measure liquid level. Driven by a microprocessor, a series of electrical pulses are transmitted from the Model 41XX Controller to the transducer. The transducer converts the electrical pulses into acoustic pulses and sends them to the liquid surface via a sounding tube.

As shown in figure1.3-1, the pulses pass through a calibration tube (Cal Tube), one or more ranging tubes, a trim tube, and a "red brass" tube. The tube protects the acoustic energy from such adverse environmental effects as wind, rain, and snow. The functions of the various tubes (collectively known as the "sounding tube") are as follows:

- ✓ The Cal Tube provides a return echo from a known distance
- ✓ The range tube(s) channel the acoustic pulses to and from the surface
- ✓ The trim tube allows minor corrections to the tube so that the overall tube length is 0.2 meters (0.5 ft) shorter than the protective well orifice.
- ✓ The "red brass" tube provides a measure of antifouling to keep the end of the tube free of marine growth and algae.

As the acoustic signal passes down through the Cal tube an echo is produced that is returned to the Model 41XX Controller receiver. When the pulse strikes the liquid surface another echo is produced which is also returned to the Model 41XX receiver. The patented ratiometric technique is based upon a pulse time of travel comparison within the known (through the cal tube) to an unknown distance to the liquid level (through the sounding tube).

Under host control, the Model 41XX Controller initiates the drive pulse to the transducer, times and stores the calibration return echo, and times and stores the liquid level return echo. The on-board microprocessor calculates the ratio, applies any programmed offsets, performs engineering conversions, and stores the data awaiting a data request from the host data logger or PC. The host computer does not have to perform any calculations to determine the water level because the Model 41XX provides this information in directly readable ASCII engineering units.

The sea state (wave height) may be approximated by multiplying the standard deviation from each measurement by a constant whose value is site and installation dependent. For a damped orifice, protected well, the multiple is approximately 5 (depends on dampening). For a fully open, unprotected well (no damping), the multiple is 3.8.

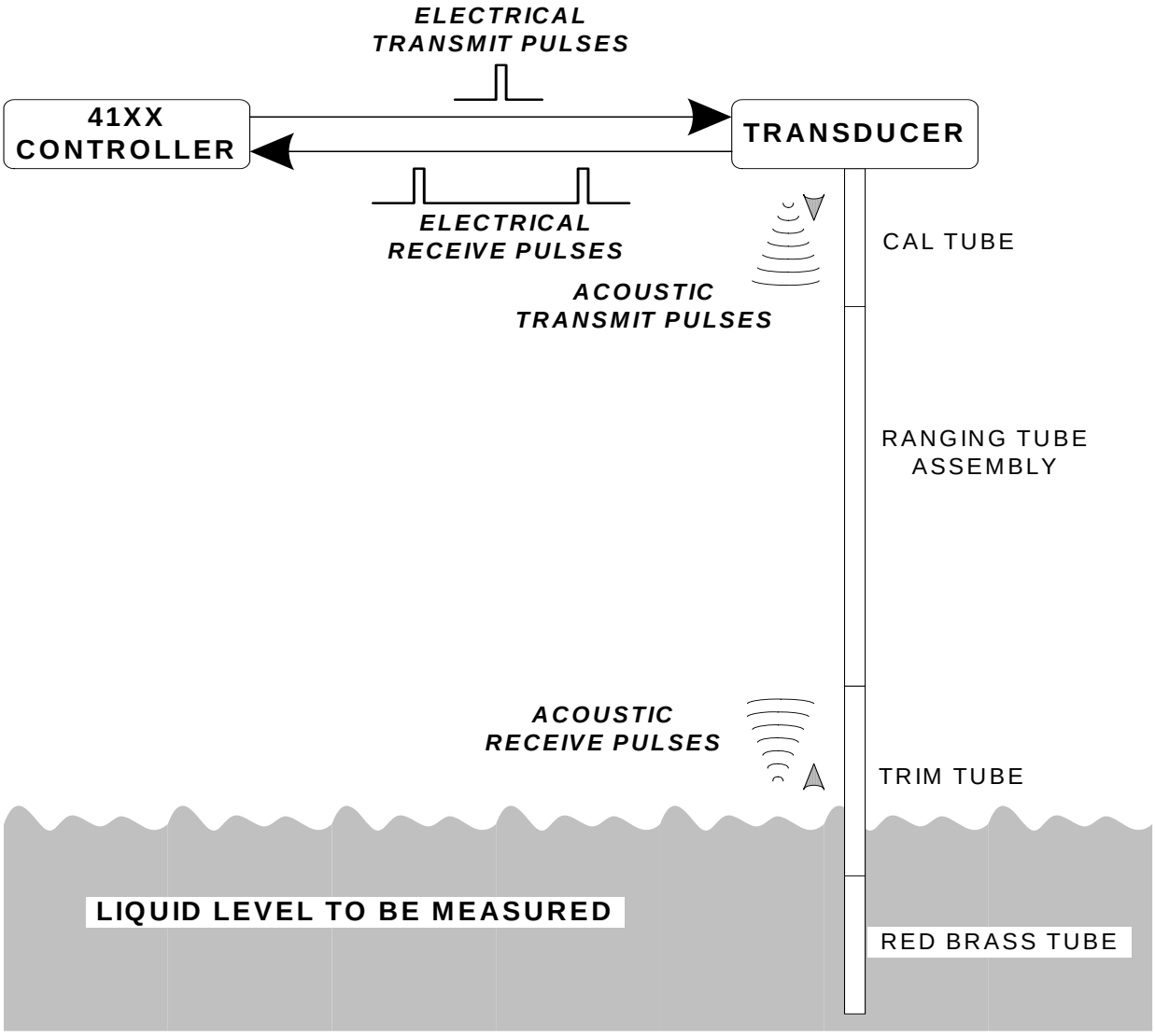


Figure 1-6 AQUATRAK Measurement Diagram

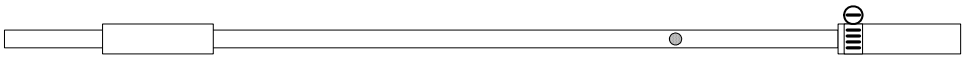
1.4 Accessories for the AQUATRAK Model 41XX Series

Note:

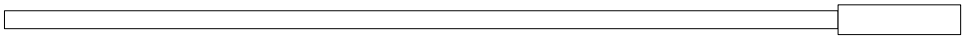
Several accessories are available from Aquatrak for the AQUATRAK Model 41XX Series. Contact the Sales Office for more information.

AQUATRAK Installation Kit - P/N 28-3000-NG (x)

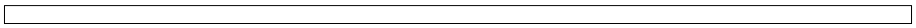
Every installation requires the use on an installation kit to properly install the sensor. The "(x)" in the part number refers to the inside diameter of the protective well supplied by the Aquatrak or the user. The inside dimension of the protective well is needed so that the correct size centering clip is provided. The parts are supplied with the installation kit (P/N 28-3000-NG-6) are shown below in Figure 1-7. For other accessories, please contact Aquatrak.



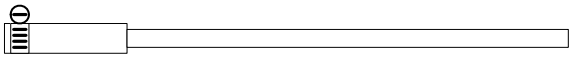
CAL TUBE
1.37 m (4.5 ft.)
1 ea. P/N 28-3001-NG-4



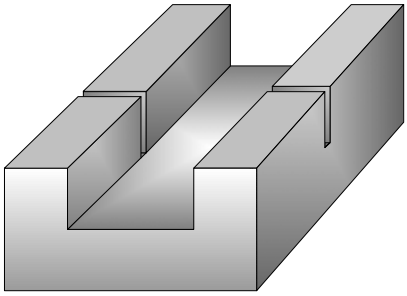
RANGE TUBE
1.52 m (5.0 ft.)
4 ea. P/N 28-3002-NG-3



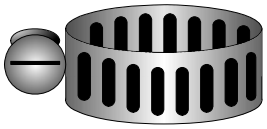
TRIM TUBE
1.52 m (5 .0 ft.)
1 ea. P/N 28-3002-NG-1



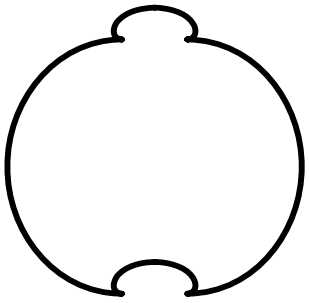
ANTI-FOULING TUBE
0.91 m (3.0 ft.)
1 ea. P/N 28-3004-NG-1



MITRE BLOCK
1 ea. P/N 28-3006-NG-1



HOSE CLAMP
2 ea. P/N 28-3005-NG-1



CENTERING CLIP (6,4,and 3 inch sizes avail)
Stainless Steel
5 ea. P/N 28-3003-6 (in)
-4 (in)
-3 (in)

Figure 1-7 Parts Supplied with the Installation Kit

2. INSTALLATION OF THE Model 41XX AQUATRAK

2.1 Protective Well Installation

> ***Caution:***
> ***The Model 41XX AQUATRAK should be installed in a properly designed protective well to protect it from physically damaging elements and to minimize thermal effects from direct sunlight.***

The protective well may be made from any rigid material or it may be procured from Aquatrak. An example of a suitable material is 3, 4 or 6 inch Schedule 40 PVC pipe. In severe locations where large waves or floating debris may be a problem, Schedule 80 pipe is recommended. Note that the pipe size chosen must match the centering clip diameter in the installation kit. For example, if a P/N 28-3000-NG-4 installation kit was ordered, use 4-inch pipe.

The protective well location is often determined by the availability of a support structure such as a pier or piling. Accessibility and security of the site should also be considered.

The following factors should be considered when locating the protective well:

1. **Thermal Environment** - The optimal installation will insure that the air in the entire protective well is at the same temperature. Temperature differentials may cause errors in the level measurement. In general, locate the well on the north side of a pier (in the Northern Hemisphere), or on the south side in the Southern Hemisphere. Avoid locations where a portion of the well is in direct sunlight while other portions are shaded.

   Note:

   The goal is to provide an isothermal environment inside the well. The ambient temperature is immaterial.

2. **Physical Considerations** - The protective well must be braced to the supporting pier to withstand the expected sea state conditions. In river gauging applications, consideration must be made for floating debris. The protective well should be mounted vertically.

3. **Availability of Indoor Location** - Be sure to carefully measure the distance that the transducer cable will have to run between the transducer head at the top of the protective well and the desired location of the Model 41XX controller. The standard cable length is 3 meters (10 feet). Up to 300 meters of cable can be provided.

The design of the well depends on several factors such as the highest high and lowest low water levels, bottom depth, and wave height. Several rules apply including:

- ✓ The lower orifice of the well should be approximately 0.5 to 1 meter off the bottom to keep the bottom materials from entering the well.
- ✓ The top of the well should be approximately1 m above the deck level to allow for easy access to the transducer.

- ✓ The Transducer must be at least 1.5 m above the expected extreme high water (including wave height).

Calculate the overall length, "W", using the formulas and figure below. Remember that the standard installation kit will only extend 9.88 m (32.4 ft). If the protective well length must be longer than 9.88 m, additional range tubes must be purchased.

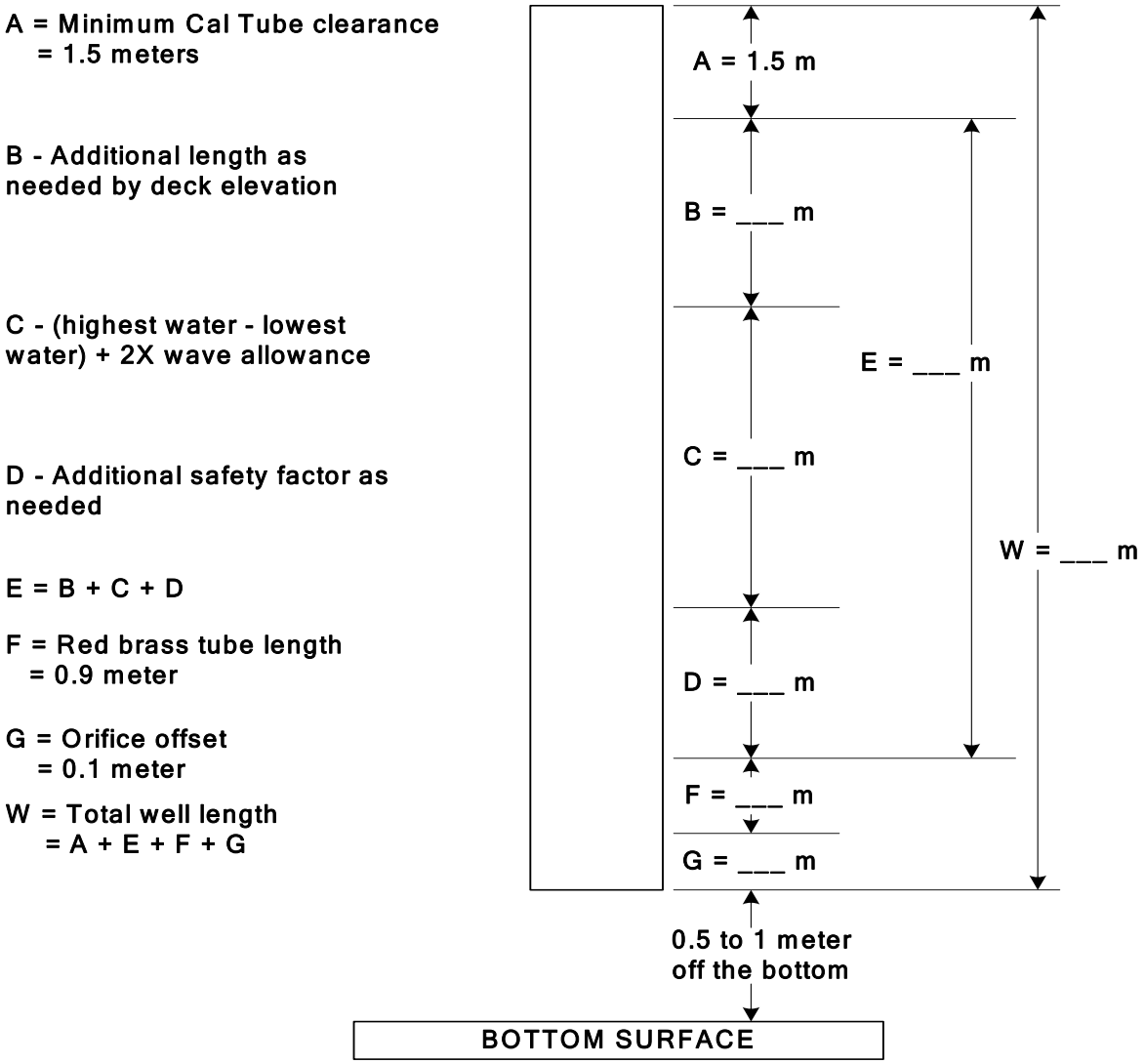


Figure 2-1 Protective Well Length Calculator

Cut the protective well pipe squarely so that the top opening is horizontal when mounted. Securely mount the protective well to a piling using non-corrosive user-supplied straps or clamps every meter of length.

2.2 Assembly of the Sounding Tubes

> ***Caution***
> ***After calculating the tube length, the tubes must be carefully cemented together with no gaps or internal cement beads, which may cause erroneous readings.***

Sounding Tube Length Calculation

The overall sounding tube length is a function of the protective well length calculated earlier and the length of the sounding tubes in the installation kit. The sounding tube is made up of the following tubes:

Calibration tube	(1)	length fixed and is never altered
Red brass tube	(1)	length fixed and is usually not altered
Range tubes	(4)	alter length by using more or less whole tubes
Trim tube	(1)	alter length by using whole, not using, or by cutting to length

Using the protective well length calculated in Section 2.1, calculate the overall sounding tube length as shown below:

Protective well length ____ meter
Bottom orifice offset - .1 meter
____ meters, sounding tube assembly total length
(known as "length" in rows 3 & 4 of table below)

Now that the length of the sounding tube assembly is known, use the table below to determine the number of range tubes needed and the length to cut the trim tube.

Table 2-1 Required Range Tubes

Ranging Length W/O Cutting	# of Sections Cal	Range	Trim	Brass	If Length is Less Than	Cut Trim Tube to	And Use X Range Tubes
2.29 m – (7.5 ft)	1	0	0	1	N/A	N/A	0
3.81 m – (12.5 ft)	1	0	1	1	3.81 m – (12.5 ft)	3.81 m – (12.5 ft) - length	0
5.33 m – (17.5 ft)	1	1	1	1	5.33 m – (17.5 ft)	5.33 m – (17.5 ft) - length	1
6.86 m – (22.5 ft)	1	2	1	1	6.86 m – (22.5 ft)	6.86 m – (22.5 ft) - length	2
8.38 m – (27.5 ft)	1	3	1	1	8.38 m – (27.5 ft)	8.38 m – (27.5 ft) - length	3
9.91 m – (32.5 ft)	1	4	1	1	9.91 m – (32.5 ft)	9.91 m – (32.5 ft) - length	4

Sounding Tube Assembly

Tools and materials needed:

1) AQUATRAK installation kit	2) Hacksaw, fine tooth	3) PVC primer
4) PVC cement	5) Trimming knife	6) Sandpaper

Note:

Before beginning the following installation steps below visually inspect and verify that each tube is clean and free of burrs and obstacles. If necessary, use the trim knife or sandpaper to smooth the edges. Layout the tubes on a clean surface and "dry" fit them in the order they will be connected.

✓ Using a hacksaw and miter block cut the trim tube to the length determined in column 4 of Table 2-1. Using the trim knife and/or sandpaper carefully deburr the inside and outside of the cut end.

✓ Using the PVC primer, lightly coat the uncut end of the trim tube and the coupler end of one of the range tubes.

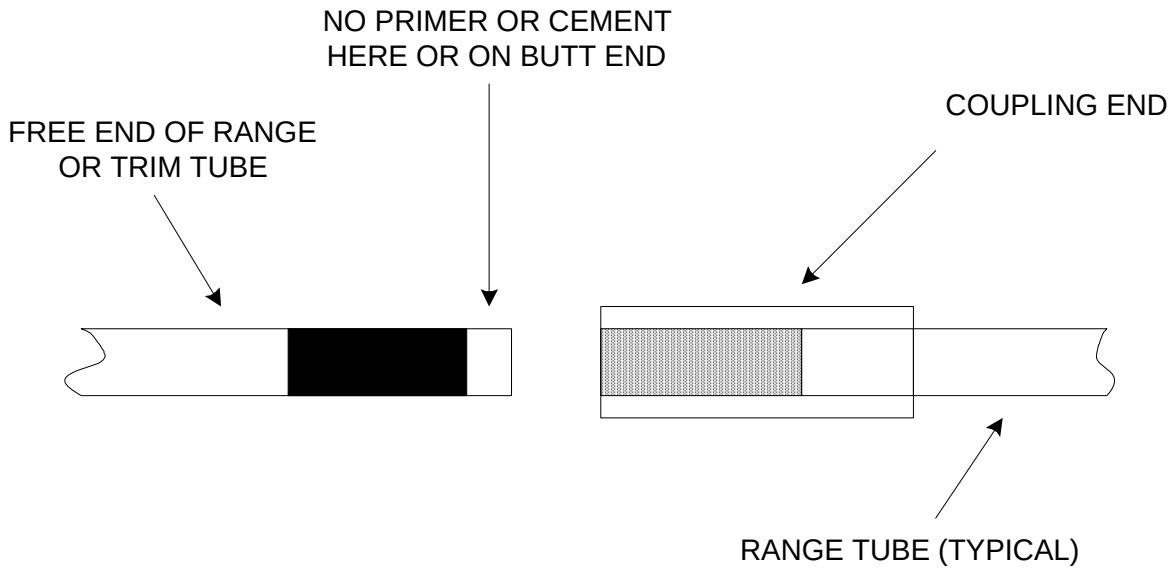


Figure 2-2 Cement Details

✓ Apply PVC cement sparingly to the uncut end of the trim tube in an even band ~1 cm from the end. Do not apply any cement to the butt end of the tube or allow it to enter the inside of tube.

- ✓ Immediately insert the cemented trim tube end into the primed coupler end of the range tube. Use a firm, twisting motion until the tube bottoms out in the coupler.
- ✓ Repeat the previous 3 steps to join the remaining range tubes. The number of range tubes needed was determined in column 5 of table 2-1.
- ✓ Attach the red brass tube coupling to the bottom of the cut end of the trim tube using one of the hose clamps provided in the installation kit.
- ✓ Connect the coupler end of the cal tube to the top end of the range tube using one of the hose clamps provided in the installation kit.
- ✓ Wait at least 30 minutes before moving or handling the sounding tube assembly to allow the cement to cure.
- ✓ Place a hand on either side of each joint and twist firmly to test the integrity of the connection.

2.3 Mounting the Sounding Tube Assembly in the Protective Well

Note:

After cutting the top of the, protective well, pipe the assembled transducer and sounding tube is lowered into the well and secured.

Preparation of the protective well top orifice

Using a hacksaw, cut the top opening of the protective well to a depth of ~ 4 cm (1.5 inch) making 2 cuts at right angles as shown in Figure 2.3-1. These cuts allow the user-supplied hose clamp to compress and secure the transducer in the well.

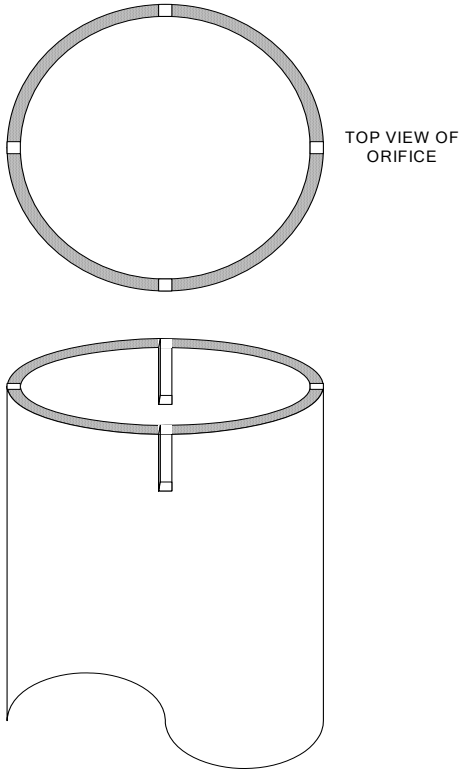


Figure 2-3 Protective Well Cutting Guide

Installing the transducer in the protective well

Attach the centering clips from the installation kit to the sounding tube assembly by clipping them over the sounding tube sections**. The lowest clip should be just above the red brass/trim tube coupling (i.e.; on the lowest part of the trim tube. Do not install a centering clip on the red brass tube).** Evenly space the remaining clips over the length of the sounding tube with the last of the five clips attached just above the cal tube/top range tube coupling (i.e.; on the lower part of the cal tube). One clip every 1.5 meters (5 ft) is usually adequate. Rotate the clips so that they are at right angles to each other.

Gently lower the assembly into the protective well. Stop lowering the assembly when the top of the tube is ~ 0.5 meter above the top of the well. Slip the stainless steel coupler of the transducer over the top end of the cal tube. Fully bottom the tube into the seat of the transducer coupler and tighten the 2 lower set screws securely.

Finish lowering the transducer and sounding tube assembly into the well until the step flange of the transducer sits squarely on the top orifice of the protective well. Use a hose clamp (user-supplied) to compress the top of the well until it tightens around the transducer body and holds it securely.

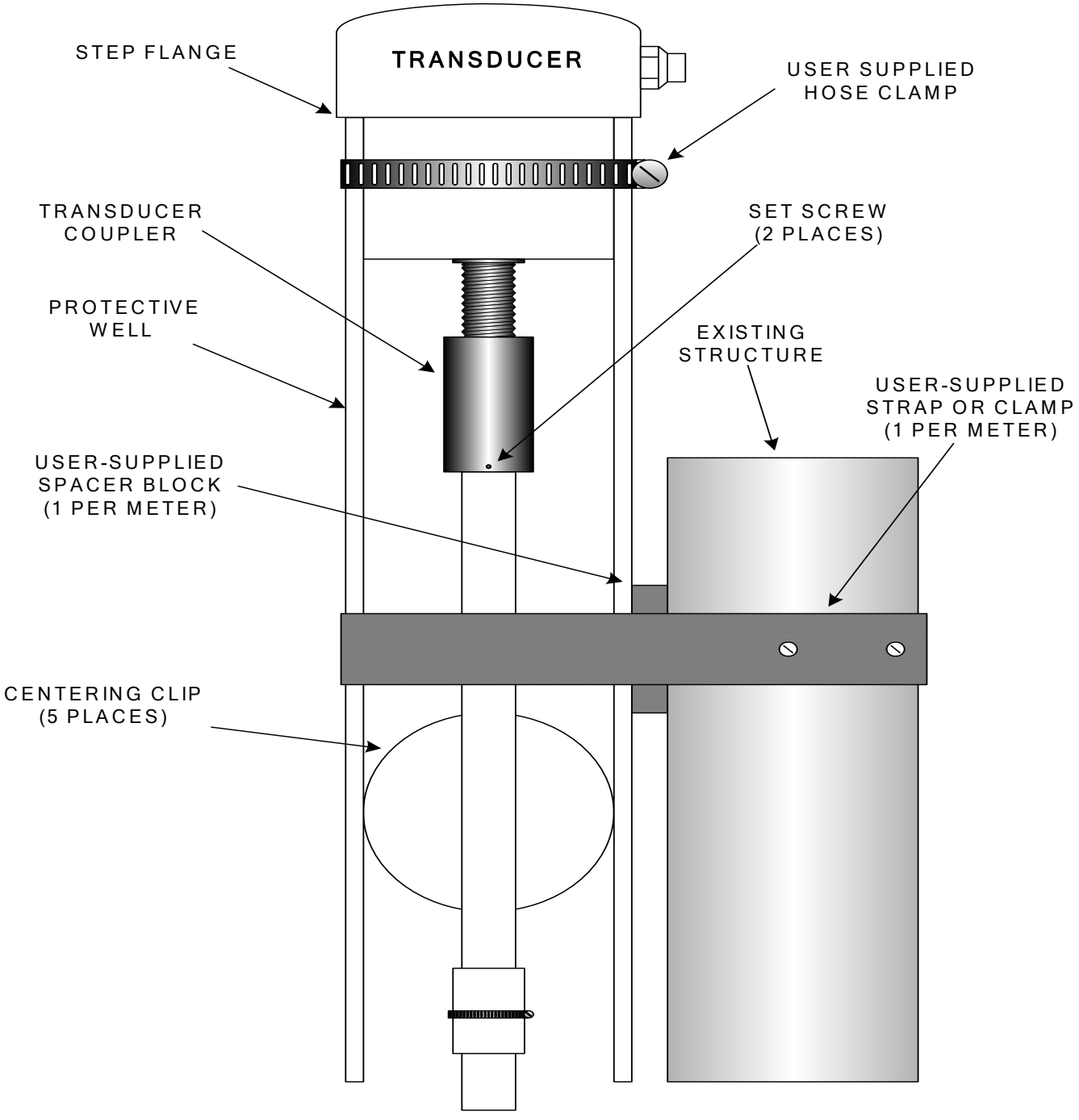


Figure 2-4 Final Installation Diagram

2.4 Making the Electrical Connections

Note:

The normal installation of the AQUATRAK requires the user to supply a 12 VDC power source and a data collection device capable of operating with either RS-232 or SDI-12 serial communications.

Transducer Connector - No Assembly Required

The transducer head has a short pigtail cable that is terminated with a 5-pin male Amphenol in-line connector. Using a small amount of silicone grease, lightly coat the mating surfaces of the Amphenol connectors on both the pigtail and the longer transducer cable. Plug the 2 connectors firmly together.

RS-232 Cable - Assembly Required

If an ASCII terminal or personal computer (PC) will be used as the serial communications device, wire the 3-foot pigtail cable (supplied with the controller) as shown in the Table 2-2 below and in Figure 2-5.

Table 2-2 RS-232 Wiring Identification

Pin #	Function	Wire Color	DB9*
1	Ground	Black	5
2	DTR In	Green	4
3	Data Out	Red	2
4	Data In	White	3

* ***For other PC connectors check functional connection***

Caution:
If the host RS-232 device can not assert an active DTR, insulate the green wire (pin 2 Do Not Connect) of the cable to prevent it from shorting. Refer to Section 3.1 for details of J5 jumper installation to force DTR.

Power and SDI-12 Cable - Assembly Required

This connector supplies both power and SDI-12 communications for the sensor.

- ✓ Power Connection - The user supplied power supply must be capable of supplying 50 ma @12 VDC. Wire the cable as shown in the Table 2-3 and in Figure 2-5.

- ✓ SDI-12 Connection - If a SDI-12 capable data collection device is being used, wire the cable as shown in the table below and in Figure 2-5.

Table 2-3 SDI-12 and Power Wiring Identification

Pin #	Function	Wire Color
1	Ground	Black
2	+12 VDC Power	Red
3	SDI-12 Data	White

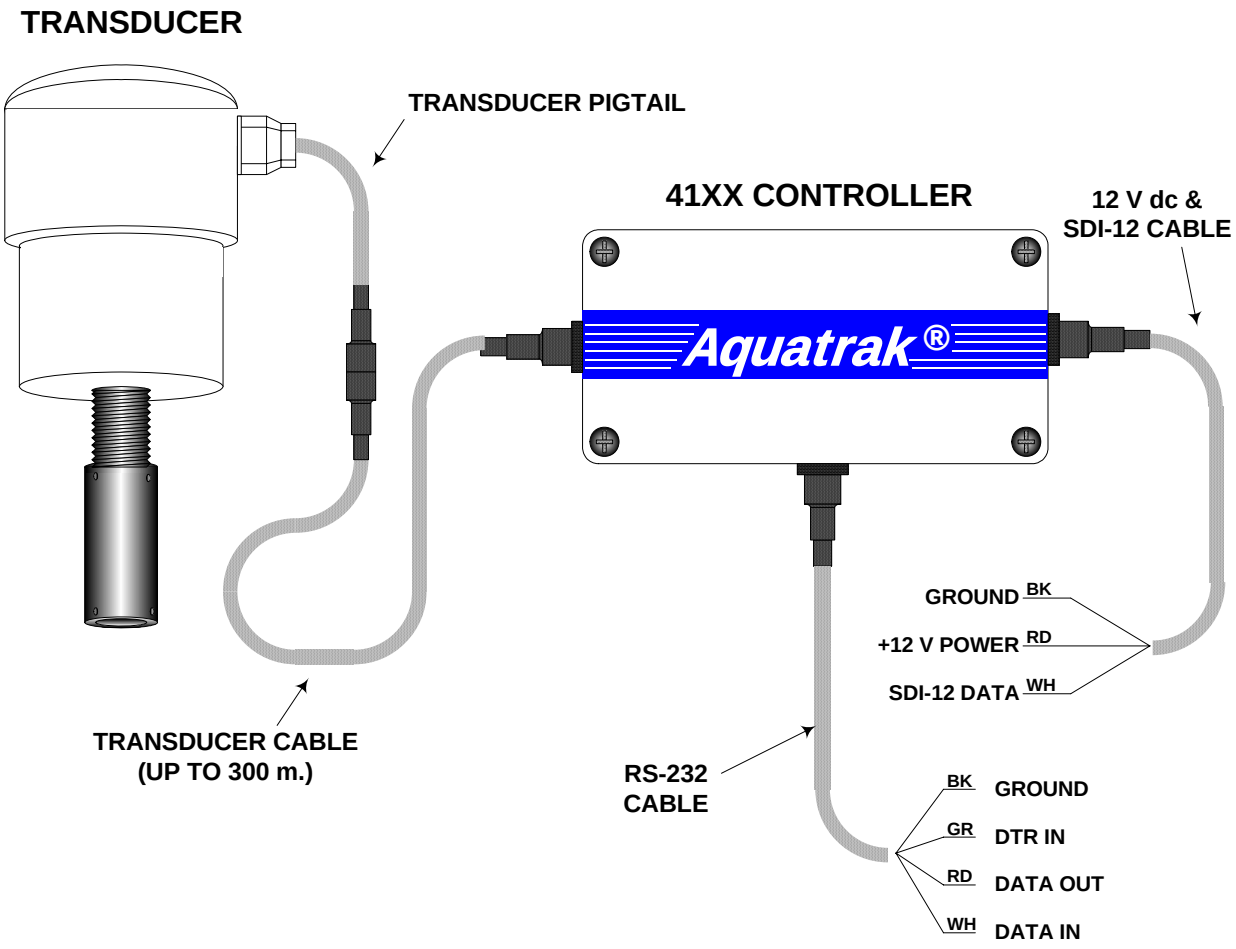


Figure 2-5 Cable Details

3.0 PROTOCOLS & COMMUNICATIONS

3.1 Jumper and Operating Modes

Note:

The Model 41XX Controller must be connected to a data acquisition system (DAS) capable of communicating with either RS-232 or SDI-12.

The sensor is factory configured for SDI-12 communications as follows:

ASCII / 7 bit / Even parity / 1 stop bit / 1200 baud

3.1.1 Jumper Selections

The Model 41XX Controller has three (3) jumpers (J2, 4, and 5), which may be configured by the user. To gain access to the jumpers, disconnect power to the controller and loosen the 4 screws on the top cover. Figure 3-1 illustrates the position of the jumpers.

- ✓ J2 - Not used (always in SDI-12 position)
- ✓ J4 - Micro-Power Mode

In normal operation, the Model 41XX Controller is in a low power (~ 1 ma) sleep mode until awakened to take a measurement. This mode of operation is selected when J4 is in the off position (factory default). To awaken the Model 41XX to take measurements, the Data Acquisition System (DAS) must send a <BREAK> of at least 12 ms duration.

If the DAS is not capable of sending a <BREAK>, install the jumper across the 2 pins of J4. This will prevent the Model 41XX from entering the sleep mode and make it constantly ready to accept commands. Power consumption will be ~ 30 ma for SDI-12 operation (~ 30 ma for RS 232 operation) when the J4 jumper is installed.

- ✓ J5 - Data Terminal Ready (DTR)

When using RS-232 communications, the factory default requires that a DTR be sent from the DAS to the Model 41XX Controller before the Model 41XX will transmit data. This mode of operation is selected when J5 is in the off position (factory default). To initiate communications with the Model 41XX, the host must assert DTR by setting it high.

If the RS-232 host can not assert an active DTR, install the jumper across the 2 pins of J5. This will force DTR internally in the Model 41XX and allow it to transmit data.

3.1.2 Modes of Operation

✓ Standby

In the Standby state, power to the Model 41XX's microprocessor is turned off to reduce power consumption to ~1 ma. A <BREAK> signal of at least 12 ms through either the RS-232 or SDI-12 port is required to awaken the Model 41XX from the Standby mode. If the J4 jumper is installed, sending a <BREAK> is unnecessary since the Model 41XX will always be in the Awake state.

✓ Command

In the Awake State, the Model 41XX is in the Command mode, waiting to accept either valid commands or to enter the Menu mode. If jumper J4 is installed, the Model 41XX will remain in the Command mode indefinitely. If jumper J4 is not installed, the Model 41XX will remain in the command mode for 10 seconds after receiving a <BREAK> before returning to the Standby mode.

✓ Menus

From the Command mode, sending an <ESC> will put the Model 41XX in the Menu mode. This feature is only available through the RS-232 port. It is used to establish the user settings and to initiate measurements.

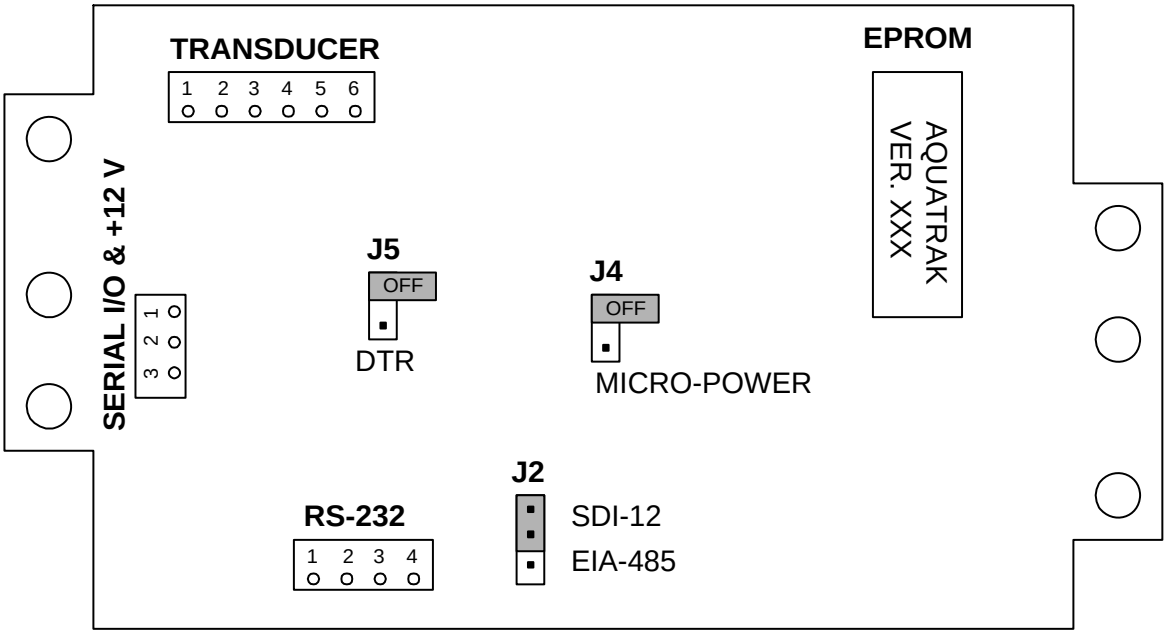


Figure 3-1 Model 41XX Jumper Locations

3.2 Operation with the RS-232 Protocol

Note:

When RS-232 is selected as the operating protocol, the Model 41XX can operate in either the command mode or the menu mode.

The signal interface consists of a 4-wire RS-232C connection with the transmit (Tx), receive (Rx), data terminal ready (DTR) and circuit common pins being used. Connecting the RS-232 cable to the Model 41XX Controller automatically switches from the SDI-12 port to the RS-232 port and **disables SDI-12 operation.**

Basic Steps To Establish RS-232 Communications

- ✓ Connect the host computer to the RS-232 port on the Model 41XX Controller.
- ✓ Establish communications with PROCOMM® or similar communications program. Set the program for the following parameters:

  8 bit / No parity / 1 stop bit / 1200 baud / Half or full duplex

- ✓ If the host computer is not capable of providing an active DTR signal, install a jumper across the 2 pins of J5 in the Model 41XX Controller enclosure.
- ✓ If the host computer is not capable of sending a <BREAK> signal of at least 12 ms in duration, install a jumper across the 2 pins of J4 in the Model 41XX Controller enclosure.

Note that data transmittals from the Model 41XX contain blank spaces between data fields for ease of parsing by commonly available spreadsheet programs. Each data transmittal line is terminated with a carriage return <CR> and line feed <LF>.

Note:

The following sections using RS-232 assume that both J4 and J5 jumpers are installed (on). If they are not installed, the host computer must supply a continuous DTR and a <BREAK> prior to each data request.

3.2.1 RS-232 Protocol, Model 4100

For the Model 4100, perform the following steps for a quick check of system operation, after the setup procedures under paragraph 3.2 above have been done.

- ✓ Press <ESC> to enter the MAIN MENU from the Command Mode.

3.2.1.1 RS-232 MAIN MENU DESCRIPTION, Model 4100

Note:

The MAIN MENU mode offers a series of menu choices that allow the operator to command the Model 4100 to make measurements.

✓ To enter the MAIN MENU from the Command Mode, press <ESC> and verify Model 4100 returns the following response:

```
Aquatrak Model 4100 V1.17 Menu    (Main Menu)

1.  User settings.
2.  Measurement, range proportionate.
3.  Measurement, One Hertz.
4.  Measurements, with counts.
5.  Continuous, NOS Averaging.
6.  Continuous, wave data.
Q.  Return to Command Mode.
```

Description of the Model 4100 MAIN MENU response:

The first line lists the firmware version number that was in use when this manual was prepared. The version number returned by your sensor may be different. Note that the <ESC> key may be pressed to return to the Menu.

✓ Entering a <1> provides access to the USER SETTINGS fully described in Section 3.2.1.2.

✓ Entering a <2> causes the Model 4100 to make measurements at the maximum rate, (proportional to the distance from the transducer to the water level) and outputs the measurement in the following format:

Selection: 2 **13.175** **1** **99**

Where **13.175** is the level measurement in the units selected (meters or feet) in the USER SETTINGS, **1** is the number of cal tubes, and **99** is the data quality indicator for "No Errors" (see figure 3-1). Spaces are always inserted between data fields.

- ✓ Entering a <3> causes the Model 4100 to make measurements at the rate of once per second and prints the measurement only in the following format:

Selection : 3 **13.175** **1** **99**

Where **13.175** is the level measurement in the units (meters or feet) selected in the USER SETTINGS, **1** is the number of cal tubes, and **99** is the data quality indicator for "No Errors".

- ✓ Entering a <4> causes the Model 4100 to make measurements at the rate of one per second and prints all the data in the following format (typical):

Selection 4: **43.048** **1** **99** **280535** **26037**

Where **43.048** is the level measurement in the units (meters or feet) selected in the USER SETTINGS, **1** is the number of Cal tubes, **280535** is the total number of counts received, and **26037** is the number of Cal counts received. In this example, 1 Cal tube was used. Had 2 Cal tubes been used, the "**1**" would have been replaced by a "**2**" and a second set of Cal counts would have followed the first set of Cal counts.

- ✓ Entering a <5> causes the Model 4100 to take the number of samples selected in the USER SETTING menu and calculate averages using the National Ocean Service (NOS) algorithm and prints the data in the following format.

Selection: 5 **43.048** **1.030** **0** **1.0** **99** **26037**

Where **43.048** is the level measurement in the units (meters or feet) selected in the USER SETTINGS, **1.030** is the standard deviation, **0** is the number of outliers discarded prior to calculation, **1.0** is the number of Cal tubes, **99** is the data quality indicator, and **26037** is the number of Cal counts received.

Note: ***The average wave height may be approximated by multiplying the standard deviation value obtained with the NOS algorithm by 5.***

Entering a <6> causes the 4100 to take the number of samples selected in the USER SETTINGS menu and prints the data in the following format.

Selection 6: **44.340** **0.00** **99**

Where **44.340** is the level measurement (meters or feet), **0.00** is the wave average, and **99** is the data quality indicator.

- ✓ Entering a <Q> causes the Model 4100 to return to the Command Mode

If the Data Quality Indicator is not "99", interpret the reported numeric code from the table below.

Table 3-1 RS-232 Data Quality Indicator Table

-DQ Code	Description
0	4100 Inoperative
99	No errors detected
1	Cal undetected
100	Liquid level out of range
101	Out of range and no cal

3.2.1.2 RS-232 USER SETTINGS DESCRIPTION, Model 4100

Note: ***The USER SETTINGS mode offers a series of menu choices that allow the operator to optimize the configuration of the Model 4100 for site specific needs.***

USER Menu Activation

✓ Press <1> from the MAIN MENU and verify the Model 4100 returns the following:

```
CURRENT USER SETTINGS  (Model 4100)

1.  Maximum number of cals:          1
2.  Polarity (D) down (U) up:        U
3.  Offset (xxx.xxx):                0.000
4   Sensor Address:                  0
5.  Samples To Average               181
6.  Enter ID, 13 chars:              XXX(SN)
7.  Protocol (R) RS232 (S) SDI-12    S
8.  Baud Rate:                       1200
9.  Units (F) Feet (M) Meters:       M
M.  Set M! Type (0, 1, 2, or 3):     0
W.  Wave Multiplier                  4
A.  Calculate offset automatically
Q.  Return to previous menu
```

The factory default values for each user setting are shown in the right column of the table above. If the user chooses different settings, those values will be displayed when the USER SETTING is selected.

Description of the USER SETTINGS response

✓ Entering a <1> allows the user to specify the number of valid reference signals the Model 4100 will accept. The number of 'cals' entered should equal the number of cal tubes installed (normally 1). A <0> will cause the Model 4100 to calculate the measured level based on the speed of sound at 20 degrees C (343.37 m/s). **The factory default is '1'**.

- ✓ Entering a <2> allows the user to set the level polarity for up or down. Entering a <U> specifies that the calculated level will increase as the liquid rises above the '0' offset entered. Entering a <D> specifies that the calculated level will increase as the liquid falls below the offset. **The factory default is <D>**.

- ✓ Entering a <3> allows the user to add or subtract an offset. Entering a value other than zero causes the calculated level to shift (offset) by the amount entered. An 'offset' may be used to compensate for the difference between the site surveyed "Bench Mark" (Datum) and the transducer '0' as calculated in Section 4.2. **The factory default is '0'**.

- ✓ Entering a <4> allows the user to select a sensor address. Entering a value between 0 and 9 provides a unique address when the Model 4100 is configured for the SDI-12 protocol. **The factory default is '0'**.

- ✓ Entering a <5> allows the user to specify the number of measurement samples (from 2 to 255) to average for each data request. Averaging is only performed when a <5> "Continuous NOS Averaging" data request is selected from the MAIN MENU. **The factory default is 181**.

- ✓ Entering a <6> allows the user to assign an alphanumeric identification, up to 13 characters long. Entering an alphanumeric identification causes the sensor to return this "ID" upon specific requests. **The factory default is the unit serial number**.

- ✓ Entering a <7> allows the user to establish the communications protocol. Entering an <R> selects the RS-232 protocol. Entering an <S> selects the SDI-12 protocol with 1200 baud. **The factory default is <S>**.

- ✓ Entering an <8> allows the user to change the baud rate. Enter one of the following baud rates (bits per second) if using the RS-232 protocol: 300, 1200, 4800, or 9600. The SDI-12 protocol automatically selects 1200 as the only baud rate.

- ✓ Entering a <9> allows the user to specify the unit of measure used when the Model 4100 reports the measured level. Entering <F> selects 'feet' and <M> selects 'meters'. **The factory default is <M>**.

- ✓ Entering an <M> allows the user to set the default measurement type when using the SDI-12 type commands. It designates "M0","M1", "M2"', or "M3" as the response to a M! **The factory default is <0>**.

- ✓ Entering a <W> allows the user to obtain an approximate wave height by multiplying the calculated sea state by a constant.

- ✓ Entering an <A> allows the user to automatically adjust the Model 4100 water level to an on-site staff gauge or other known reference. If the exact water height is known, the Model 4100 can be automatically adjusted to read the same by entering the known water level. Additional information on this command is provided in Section 4.1. **No factory default.**

- ✓ Entering a <Q> returns the Model 4100 to the MAIN MENU.

Note:

Both the 'Offset' and the 'Units' must be entered in the same units of measure. Changing the units of measure from <F> to <M> with the 'Units' function does not automatically change the 'Offset' units of measure from feet to meters!

3.2.2 RS-232 PROTOCOL, Model 4110

Establish RS-232 communications according to paragraph 3.2.

3.2.2.1 RS-232 MAIN MENU, Model 4110

To enter the MAIN MENU from the Command Mode, press <ESC> and verify that the Model 4110 **returns** the response shown in the table below.

Aquatrack Model 4110 Menu Version 4.03 (Main Menu)

1. User Settings.
2. Continuous Sampling, Raw Data.
3. Continuous Sampling, Scaled Data.
4. Continuous NOS Averaging, Sliding Window.
5. Continuous Wave Data, Sliding Window.
6. Continuous Scalar Average, Sliding Window.
7. Dump Sample Array.
8. Measurement Command Defaults.
9. Dump Setup Information.

EE. EEPROM Initialization Options.

Q. Return to Command Mode.

The following paragraphs describe the Model 4110 response to each of the menu items. Select by entering the item number and <enter>.

3.2.2.2 RS-232 User Settings, Model 4110.

Each User Setting may edited by <entering> the appropriate item shown in the following table.

```
Selection:  1    (Main Menu <1>)

USER SETTINGS MENU
1.      Primary Sensor Address:          0
2.      Secondary Address:               2
3.      Sensor ID, 13 chars:             0000
4.      Slope (x.xxxxxx)                 +1.000000
5.      Offset (xxx.xxx)                 +0.000
6.      Polarity  (D)own  (U)p           D
7.      Units  (F)eet   (M)eters         F
8.      Wave Multiplier                  4.000
9.      Calculate Offset
10.     Baud Rate:                       1200
11.     Comms Parity  (N)one  (E)ven     E
12.     Menu item not used
13.     Continuous Sampling:             Off
14.     Self-Report with each sample:    Off
Q.      Return to previous menu
Enter Selection:
```

RS-232 MainMenu <2> - Cont Sampling, Raw Data, Model 4110

```
Selection:  2
Index      Raw Data      Stat      Cal      Water      Celsius
  248        1.789         16     25879     37982       27.4
  248        1.789         16     25879     37982       27.4
<ESC> to Continue
```

RS-232 Main Menu <3> - Cont Sampling, Scaled Data, Model 4110

```
Selection:  3
Index       Raw Data      Stat      Cal       Water      Celsius
  248         1.789         16     25879      37982        25.3
  248         1.789         16     25879      37982        25.3

<ESC> to Continue
```

RS-232 Main Menu <4> - Cont NOS Avg, Slide Window, Model 4110

```
Selection:  4
    Mean        Sigma       Out       Bad
    1.790       0.000       0          1
    1.790       0.000       0          1
    1.790       0.000       0          1
<ESC> to Continue
```

RS-232 Main Menu <5> - Cont Wave Data, Slide Window, Model 4110

```
Selection:  5
Enter number of samples:  4
      Mean          Wave        Bad
      1.790         0.000         2
      1.790         0.000         1
      1.790         0.000         1
      1.790         0.000         1
<ESC> to Continue
```

RS-232 Main Menu <6> - Cont Scalar Avg, Slide Window, Model 4110

```
Selection:  6
Enter number of samples:  3
     Mean         Maximum         Minimum        Bad
    1.790          1.790           1.790          2
    1.790          1.790           1.790          2
    1.790          1.790           1.790          1
 <ESC> to Continue
```

RS-232 Main Menu <7> - Dump Sample Array, Model 4110

```
Selection:  7
Number of Prior samples, <enter> for all:
 Index        Value       Stat
    478       1.790        16
    479       1.790        16
    480       1.790        32
    481       1.790        16
<ESC> to Continue
```

RS-232 Main Menu <8> - Meas Command Defaults, Model 4110

```
Selection:  8
MEASUREMENT COMMANDS MENU
1.  Address A M/C!  Default Command:  1
2.  Address B M/C!  Default Command:  1
3.  NOS Samples to Average:          181
4.  C4 Averaging Period (secs):       15
5.  C5 Averaging Period (secs):       30
6.  C6 Averaging Period (secs):       60
Q.  Return to previous menu
Enter Selection:
```

RS-232 Main Menu <9> - Dump Setup Information, Model 4110

```
Selection:  9
Aquatrak MODEL=4110  Ver=4.03
A_ADD=0   B_ADD=2  ID=0000
SL=1.000000   OF=+0.000   WA=4.000   POL=D   UNIT=M
NOS=181   C4=15   C5=30   C6=60   DEF_A=1   DEF_B=1
BAUD=4   PAR=1
SAMP=0   RPT=0
PW=106   CB=60   LB=100   CL=4   CN=1
<ESC> to Continue
```

RS-232 Main Menu <EE> - EEPROM Init Options, Model 4110

```
Selection:  EE
EEPROM Initialization Options

1.  2 foot cal, Change Transducer settings only.
2.  4 foot cal, Change Transducer settings only.
3.  Complete Default Setup, 2 foot cal.
4.  Complete Default Setup, 4 foot cal.
<ESC> to quit.
```

Following are the four RS-232 returns that result from selecting 1 - 4. in the EEPROM menu above.

```
Selection:  1
Enter to Select 2 ft Cal Setup,  <ESC> to quit

(<ESC> or <ENTER> returns to the EEPROM
Initialization Options menu shown above.)
```

```
Selection:  2
Enter to Select 4 ft Cal Setup,  <ESC> to quit

(<ESC> or <ENTER> returns to the EEPROM Initialization
Options menu shown above.)
```

```
Selection:  3
Enter to Select 2 ft Cal Setup,  <ESC> to quit
Changing Baud to 1200…

(<ESC> or <ENTER> returns to the EEPROM Initialization
Options menu shown above.)
```

```
Selection:  4
Enter to Select 4 ft Cal Setup,  <ESC> to quit
Changing Baud to 1200…

(<ESC> or <ENTER> returns to the EEPROM Initialization
Options menu shown above.)
```

3.3 Operation with SDI-12 Protocol, Models 41XX

3.3.1 Overview of SDI-12 Communications

Following is a general description of the SDI-12 communications transactions between the Host system and the Aquatrak Models 41XX sensors.

Table 3-2 SDI-12 Command Sequence

Host		**Model 4100**
Request Measurement (M command)	→	
	←	Send "seconds until ready and # of data points"
	←	Send "Data Ready"
Request Data (D command)	→	
	←	Send Data

- ✓ Character Format: 7 data bits, even parity, 1 stop bit
- ✓ Character Description

HOST COMMAND	**4100 RESPONSE**
a = 41XX address	a = 41XX address
M = Measurement	ttt = Seconds until ready
D = Data request	nnn = Number of characters in a data string
# = Sub routine	
! = Execute	a<CR LF> = Data Ready

Data requests must be made within 10 seconds of the data ready flag request if the Model 41XX micro power mode is selected, (no jumper in J4).

Typical Example Sequence to Receive Averaged Data

Assume that the Model 41XX address is 0 and that averaged data is to be requested

Host → Send "0M2!	This will awaken the Model 41XX and have it begin collecting 181 samples of data (averaging default). "0" is the Model 4100 address and "M2!" is the command to initiate averaged measurements.
41XX → Send "0tttn"	This data tells the host that the data will be ready in ttt seconds. "0" is the Model 41XX address and "n" is the number of data points available.
41XX→ Send "0 CR/LF"	This data tell the host that data is ready and may be requested (within 10 seconds or the data is lost). The "0" is the Model 41XX address and the CR/LF causes the host to carriage return and skip a line.
Host → Send "0D0!"	This command will cause the Model 41XX to output the averaged water height data only.
41XX → Send "+/-XX.XXX <CR LF>	This data is the height of the water level in the units of measure selected with the USER SETTINGS.

3.3.2 SDI-12 Setup and Test

Note:

The Model 41XX-default configuration is set for SDI-12, a serial digital interface standard for hydrological and environmental sensors.

The Model 41XX is factory configured for SDI-12 operation. SDI-12 is a commonly used low power, multi-drop (up to 10 sensors) signal and power bus. The interface consists of a 3-wire connection for power, signal, and common. For a complete description of the current SDI-12 specification, visit the U.S. Geological Survey web site at www.sdi-12.org.

The Model 41XX supports all SDI-12 commands except those that obviate the host system from performing multi-tasking. Specifically, the AQUATRAK 1) does not abort measurements on the 2nd break command, 2) does not support the "A!" command, and does not lose data after 100 ms (it is held for 10 seconds). In addition, the Model 41XX supports some additional non SDI-12 specific commands, which perform useful functions in the operation of the sensor.

Basic Steps To Establish SDI-12 Communications

- ✓ Disconnect the RS-232 host from the Model 41XX and reconnect the weather-tight cap on the port.
- ✓ Verify that the J4 (micro-power) and J5 (DTR) jumpers on the Model 41XX board are in the off position.
- ✓ Connect the DAS to the SDI-12 connector and program it for the SDI-12 default parameters:

7 bit / Even parity / 1 stop bit / 1200 baud

Note that data blocks from the Model 41XX contain leading signs and no blank spaces between data fields. Carriage return <CR> and line feed <LF> are not used for data requests to the Model 41XX but are used in the sensor response.

Quick Check to Test SDI-12 Basic System Operation

- ✓ Transmit the "0I!" Command to the Model 41XX. If the sensor address is "0" (factory default), this command is entered as "0I!"

  Verify that the Model 41XX returns the following response:

010 AQUATRAK 41XX xxx yyyyyy

Where xxx is the firmware version number and yyyyyy is the unit ID (may be serial number).

Refer to the SDI-12 command tables (Table 3-5, Model 4100) or (Table 3-6, Model 4110)

- ✓ Transmit an <aMn!> Measurement Command followed by Data Commands <aD0!, aD1!, aD2!>……..
- ✓ Verify that the Model 41XX returns the proper responses to each data (D) request.
- ✓ If the reported water level does not appear to be correct, see Section 4.0 for user set-up parameters and offset calculations.
- ✓ If the number of cal tubes reported is not equal to the number of cal tubes used in the installation, the user set-up parameters will have to be changed as described in Section 3.2.1.2.
- ✓ If the error code is not '99', interpret the reported numeric code from the data quality (DQ) table below:

Table 3-3 SDI Data Quality Indicator Table, Model 4100

DQ Code	Description	DQ Code	Description
0	41XX inoperative	100	Liquid level out of range
99	No errors detected	101	Out of range & no 1st Cal
1	Cal undetected		

Table 3-4 Error Byte Bit Map, Model 4110

B7	B6	B5	B4	B3	B2	B1	B0
(reserved)	(reserved)	Data Not Calibrated	Data Valid	Outlier (Reset with each subsequent average)	No Water Return	Missed Calibration Point	No Transducer Response
128	64	32	16	8	4	2	1

3.4 SDI-12 Command Set, Model 4100

Table 3-5 Model 4100 SDI-12 Commands

	DESCRIPTION	RESPONSE	DATA BUFFER USE Unused data buffers will return: a<CL>	
aI!	Return ID String	a010 Aquatrak 4100 11700000(version and serial number)		
aM!	Initiate Single Measurement Only	00013<CL>	D0	Water Level xx.xxx
			D1	Number of Cals +1
			D2	Error Code 99
aM1!	Initiate Single Measurement Only	00013<CL>	D0	Cal count #1 xxxxx
			D6	Total cal and total liquid counts xxxxxx xxxxxx
aM2!	Compute NOS Average on next n samples. n samples pre-programmed in EEPROM. 181 sample default.	a(time)5<CL> time =nnn + 9 a1855<CL>	D0	Averaged water level xx.xxx
			D1	Standard deviation x.xxx
			D2	Number of outliers discarded xx
			D3	Number of cals used x.x
			D4	Error code 99
aM3!	Compute NOS average for last nnn samples. nnn samples is pre-programmed in EEPROM. 181 sample default.	A01854<CL>	D0	Averaged water level xx.xxx
			D1	Standard Deviation x.xxx
			D2	Number of outliers discarded xx
			D3	Average number of cals used x.x
aMAtt!	Perform average measurement after tt seconds and hold data for one minute.	"a" Address Response Only	D0	Averaged water level xx.xxx
			D1	Standard Deviation x.xxx
			D2	Number of outliers discarded xx
			D3	Number of cals used x.x
			D4	Error code 99
aV!	Load Data Buffers with Setup Parameters. .	000110<CL>	D0	Samples to average xxx
			D1	Polarity: + 68=(D)own + 85 = (U)p
			D2	Sensor offset x.xxx
			D3	Number of cals used x.x
			D4	Unit of Measure: 70 (F)eet, 77 (M)eters
			D5	a (addr), xxx (Drive pulse width), xx (Cal blanking), xxx (Liquid blanking), xx (Max range), x (Cal length),
aXAc!	Change sensor address	(none)	D0	Where <c> is new address from 0 - 9
aXCn!	Number of cal tubes used	(none)	D0	Cal points to use: n
aXDnnn!	Select maximum range	(none)	D0	Maximum range: nnn
aXLn.nnn!	Recalculate offset: Automatically takes a reading and sets the offset so that subsequent readings at same level will return n.n	(none)	D0	Offset: n.nnn
aXOn.nnn!	Change measurement offset	(none)	D0	Offset: n.nnn
aXPU!	Set polarity up for increasing with rising level	(none)	D0	Polarity: (U)p (D)own U
aXPD!	Set polarity down for decreasing with rising level.	(none)	D0	Polarity: (U)p (D)own D

Table 3-5 Model 4100 SDI-12 Commands (Cont'd)

aXRR!	Change protocol to RS-232	(none)	D0	Protocol: (R)S-232 (S)DI-12: R
aXRS!	Change protocol to SDI-12	(none)	D0	Protocol: (R)S-232 (S)DI-12: S
aXSnnn!	Reprogram number of samples to average	(none)	D0	Samples to average: nnn (default = 181)
aXT2!	Select 2 foot cal tube	(none)	D0	Sensor Cal Length: 2 ft
aXT4!	Select 4 foot cal tube	(none)	D0	Sensor Cal length: 4 ft
aXUM!	Set controller measurement units to meters	(none)	D0	Units (F)eet (M)eters: M
aXUF!	Set controller measurement units to feet	(none)	D0	Units (F)eet (M)eters: F
aXWn.n!	Change wave multiplier.	(none)	D0	Wave Multiplier: n.n (Default is 3.8)

3.5 SDI-12 Command Set, Model 4110

Table 3-6 Model 4110 SDI-12 Commands

	DESCRIPTION	Continuous Sampling	RESPONSE	DATA BUFFER USE Unused data buffers will return: a<CL>	
a!	Return sensor address.	ON/OFF	a<CL>		
aAb!	Reprogram primary sensor address	ON/OFF	b<CL>		
aBb!	Reprogram secondary sensor address	ON/OFF	b<CL>		
aC!	Set to user selected measurement type. Default is C1.	ON/OFF	See user-selected commands (aC1!-aC9!)		
aC1!	Perform Single Sample immediately and return Scaled Distance	ON	a00105<CL>	D0	Level, **+xx.xxx**
				D1	Sample Status, **+xx**
		OFF	a00305<CL>	D2	Calibration Counts, **+xxxxx**
				D3	Water Return Counts, **+xxxxxx**
				D4	Temp. Celsius, **+xx.x**
aC2!	Begin sampling immediately for next nnn samples. (181 sample Default) Perform NOS average. Return Mean Level, Std Dev, Outliers, Error code, Wave Height.	ON	a(time)05<CL> time = nnn + 9 a19005<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
		OFF 182 PINGS	a(time)5<CL> time =nnn + 9 a19005<CL>	D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+xxx**
aC3!	Return NOS average for last n samples (181 sample Default) n samples is pre-programmed in EEPROM Continuous Sample Mode must be enabled	ON	a00805<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+x**xx
aC4!	Return NOS average for last 60 seconds in 4 sample blocks of 15 each. Bad Samples is cumulative for all 4 data blocks. Continuous Sample Mode must be enabled.	ON	a00307<CL>	D0	Mean from 60 to 46 samples ago. **+xx.xxx**
				D1	Mean from 45 to 31 samples ago. **+xx.xxx**
				D2	Mean from 30 to 16 samples ago. **+xx.xxx**
				D3	Mean from 15 to 1 samples ago. **+xx.xxx**
				D4	Bad Samples, **+xxx**
				D5	Start Index, End Index **+xxx+xxx**
aC5!	Return NOS averages for last 60 seconds in two 30 sample blocks. Bad Samples is cumulative for both data blocks. Continuous Sample Mode must be enabled.	ON	a00305<CL>	D0	Mean from 60 to 31 samples ago. **+xx.xxx**
				D1	Mean from 30 to 1 samples ago. **+xx.xxx**
				D2	Bad Samples, **+xxx**
				D3	Start Index, End Index, **+xxx+xxx**
aC6!	Return NOS averages for last n samples (60 sample default) n samples is pre-programmed in EEPROM. Continuous Sample Mode must be enabled.	ON	a00305<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+xxx**

Rev 1 4-29-06

Table 3-6 Model 4110 SDI-12 Commands (Cont'd)

aC7!	Perform single sample immediately and return raw distance to water. (No offset and slope calculation.)	ON OFF	a00104<CL> a00304<CL>	D0	Level, **+xx.xxx**
				D1	Sample Status, **+xx**
				D2	Calibration Counts, **+xxxxx**
				D3	Water Return Counts, **+xxxxxx**
				D4	Temp, Celsius, **xx.x**
aC8!	Compute Scalar Average on Data Set Continuous Sample Mode must be enabled.	ON	a00304<CL>	D0	Mean, **+xx.xxx**
				D1	Max, **+xx.xxx**
				D2	Min, **+xx.xxx**
				D3	Bad Samples, **+xx**
aC9!	Calibration Tube Temperature	ON	a00102<CL>	D0	Temp. Celsius, **+xx.x**
		OFF	a00302<CL>	D1	Temp. Farenheight, **+xx.x**
aDn!	Return Data Buffer Contents, D0 through D9.	ON/OFF	aDn(+value)…….. (+value)<CL>		
aI!	Return ID String	ON/OFF	A012 Aquatrak 4110_00000(serial number)<CL>		
aM!	Set to user selected measurement type. Default is M1.	ON/OFF	See user-selected default commands (aM1!-aM9!)		
aM1!	Perform Single Sample immediately and return scaled distance to water.	ON	a0015<CL>	D0	Level, **+xx.xxx**
				D1	Sample Status, **+xx**
		OFF	a0035<CL>	D2	Calibration Counts, **+xxxxx**
				D3	Water Return Counts, **+xxxxxx**
				D4	Temp. Celsius, **+xx.x**
aM2!	Compute NOS Average on next n samples. n samples pre-programmed in EEPROM. 181 sample default.	ON/OFF	a(time)5<CL> time =nnn + 9 a1905<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+xxx**
aM3!	Compute NOS average for last nnn samples. nnn samples is pre-programmed in EEPROM. 181 sample default. Continuous Sample Mode must be enabled	ON	a0085<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+xxx**
aM4!	Compute NOS average for last 60 samples in 15 sample blocks. Bad Samples is cumulative for all 4 data blocks. Continuous Sample Mode must be enabled.	ON	a0037<CL>	D0	Mean from 60 to 46 samples ago. **+xx.xxx**
				D1	Mean from 45 to 31 samples ago. **+xx.xxx**
				D2	Mean from 30 to 16 samples ago. **+xx.xxx**
				D3	Mean from 15 to 1 samples ago. **+xx.xxx**
				D4	Bad Samples, **+xxx**
				D5	Start Index, End Index, **+xxx+xxx**
aM5!	Return NOS average for last 60 samples in 2, 30 second blocks. Bad Samples is cumulative for both data blocks. Continuous Sample Mode must be enabled.	ON	a0035<CL>	D0	Mean from 60 to 31 samples ago.
				D1	Mean from 30 to 1 samples ago.
				D2	Bad Samples, **+xxx**
				D3	Start Index, End Index, **+xxx+xxx**

Rev 1 4-29-06

Table 3-6 Model 4110 SDI-12 Commands (Cont'd)

aM6!	Return NOS averages for last n seconds, 60 second default. n seconds is programmed in EEPROM Continuous Sample Mode must be enabled.	ON	a0085<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+xxx**
aM7!	Perform single sample immediately and return raw distance to water. (No offset and slope calculation.)	ON	a0015<CL>	D0	Level, **+xx.xxx**
				D1	Sample Status, **+xx**
		OFF	a0035<CL>	D2	Calibration Counts, **+xxxx**
				D3	Water Return Counts, **+xxxxx**
				D4	Temp. Celsius, **+xx.x**
aM8!	Compute Scalar Average on Previous Data Set Continuous Sample Mode must be enabled.	ON	a0034<CL>	D0	Mean, **+xx.xxx**
				D1	Max, **+xx.xxx**
				D2	Min, **+xx.xxx**
				D3	Bad Samples, **+xxx**
aM9!	Compute Calibration tube temperature	ON	a0012<CL>	D0	Temp. Celsius, **+xx.x**
		OFF	a0032<CL>	D1	Temp. Farenheight, **+xx.x**
aMAtt!	Compute NOS Average on nnn samples Begin sampling in tt (must be two digits) seconds for next nnn samples. nnn samples is pre-programmed in EEPROM. 181 sample default.	ON/OFF	a(time)5<CL> time =nnn + tt + 9 a1905<CL>	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+x**
aMBnnn!	Compute NOS average on last nnn samples. nnn must be three digits Continuous Sample Mode must be enabled.	ON	a(time)5<CL> time = nnn + 9	D0	Mean, **+xx.xxx**
				D1	Sigma, **+0.0xx**
				D2	Outliers, **+xxx**
				D3	Wave, **+xx.x**
				D4	Bad Samples, **+xxx**
aV1!	Load Data Buffers with Setup Parameters.	ON/OFF	a0018<CL>	D0	Programmable samples +181(NOS)+ 15 (aC4!) + 30 (aC5!) +60 (aC6!)
				D1	Polarity+ 68=(D)own + 85 = (U)p
				D2	+ Slope, + Offset + Wave Multiplier
aV2!	Load Data Buffers with Setup Parameters.	ON/OFF	a0017<CL>	D0	Unit of Measure, + 70 (F)eet, + 77 (M)eters
				D1	+ Drive pulse width + Cal blanking + Liquid Blanking + Cal length
				D2	+ Timing Mode: + 83= (S)trict + 82 = (R)elaxed + Continuous Sampling: 1 = On, 0 = Off,
aX2!	Reset transducer settings only for 2 foot calibration tube.	ON/OFF	a0021<CL>	D0	+2=Sensor 2 foot cal
aX4!	Reset transducer settings only for 4 foot calibration tube.	ON/OFF	a0021<CL>	D0	+4=Sensor4 foot cal

Rev 1 4-29-06

Table 3-6 Model 4110 SDI-12 Commands (Cont'd)

aXDAn!	Set M! and C! command response type for virtual Sensor A. n is command type 1 through 9	ON/OFF	a0021<CL>	D0	+n= address A M! response: (0-9)
aXDBn!	Set M! and C! command response type for virtual Sensor B. n is command type 1 through 9	ON/OFF	a0021<CL>	D0	+n= address B M! response: (0-9)
aXE2!	Reset entire EEPROM with 2 foot calibration tube defaults.	ON/OFF	a0021<CL>	D0	+2= Cal Length 2 foot
aXE4!	Reset entire EEPROM with 4 foot calibration tube defaults	ON/OFF	a0021<CL>	D0	+4= Cal Length 4 foot
aXIxxx…xx	Reprogram serial number, optional field of up to 13 characters for S/N or other specific Sensor information that is not relevant for operation of the Sensor.	ON/OFF	a0011<CL>	D0	+1 = success
aXK!	Kill all measurement processes. Disable sampling and reporting.	ON/OFF	a0021<CL>	D0	+1= Kill Processes
aXLn.nnn!	Automatically takes a reading and sets the offset so that subsequent readings at same level will return n.n	ON/OFF	a0041<CL>	D0	+d.ddd= Offset calculated from desired and sample
			a0041<CL>	D1	+dd= Sample Error, Status
aXMffffffff!	Program Slope	ON/OFF	a0021<CL>	D0	+d.dddddd = Slope
aXN0!	Disable continuous sampling.	ON/OFF	a0021<CL>	D0	+0 = Continuous Sampling OFF
aXN1!	Enable continuous sampling.	ON/OFF	a0021<CL>	D0	+1 = Continuous Sampling ON
aXOfff!	Reprogram measurement offset	ON/OFF	a0021<CL>	D0	+d.ddd = Offset (feet)
aXPU!	Set polarity up for increasing with rising level	ON/OFF	a0021<CL>	D0	+85 = Polarity UP
aXPD!	Set polarity down for decreasing with rising level.	ON/OFF	a0021<CL>	D0	+68 = Polarity DOWN
aXQE!	Set Parity Even	ON/OFF	a0021<CL>	D0	+1 = Parity EVEN, can change from NONE
aXQN!	Set Parity None		a0021<CL>	D0	+0 = Parity EVEN, disabled wont change
aXSiii!	Reprogram number of NOS samples to average	ON/OFF	a0021<CL>	D0	+ddd = number of Samples 0-600
aXUM!	Set controller measurement units	ON/OFF	a0021<CL>	D0	+77 = Meters
aXUF!	Set controller measurement units	ON/OFF	a0021<CL>	D0	+70 = Feet
aXWfff!	Set wave multiplier.	ON/OFF	a0021<CL>	D0	+d.dddddd = Wave Multiplier
aXY!	Synchronize sampling.	ON/OFF	a0021<CL>	D0	+1 = Sync Sample
aXZiii!	Program number of C6 samples	ON/OFF	a0021<CL>	D0	+ddd = C6 Samples (1-600)

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4. AQUATRAK OPERATION

4.1 Leveling the Sensor to a Known Water Level - Option 1

Note:

Now that the AQUATRAK is installed and communicating with the host, it must be leveled to a known datum point in order to provide meaningful water level information.

If the Model 41XX is being installed in close proximity to a standard water level staff, the AQUATRAK can be offset to read the same water level as the staff. This is the simplest method of leveling the sensor.

In Figure 4-1, the illustration shows an AQUATRAK transducer collocated with a staff gauge reading a water level of 7.1 feet. If the staff has been surveyed (i.e.; referenced to a bench mark), the automatic offset feature of the Model 41XX may be used to match the reported water level with that read from the staff. Follow the steps below to match the Model 41XX to the staff:

4.1.1 Leveling the Sensor Using RS-232 Commands– Option 1

Send an <ESC> to the Model 4100 to cause it to enter the MAIN MENU.

At the MAIN MENU, enter a "1" to enter the USER MENU.

At the USER MENU, observe line "2" (for 4100) or line "6" (for 4110) verify that the polarity selected is "U" for up.

If not set to U, enter a "2" or "6" as appropriate to change the polarity - enter a "U" when prompted..

To change the automatic offset, enter an "A" (model 4100) or a "9" (model 4110), then enter the correct water level read from the staff (5.6 in this example).

Enter a "Q" to return to the MAIN MENU.

The Model 41XX will now read the same as the staff since the Model 41XX was offset by exact water height on the staff level. As the water rises on the staff, the Aquatrak Model 41XX water level reading will increase, as the water falls, the Model 41XX reading will decrease.

4.1.2 Leveling the Sensor Using SDI-12 Commands– Option 1

While in the SDI-12 command configuration, program the staff level offset as follows:

Send the aXPU to set the polarity to Up.

Then send the aXLn.nnn to enter the desired offset.

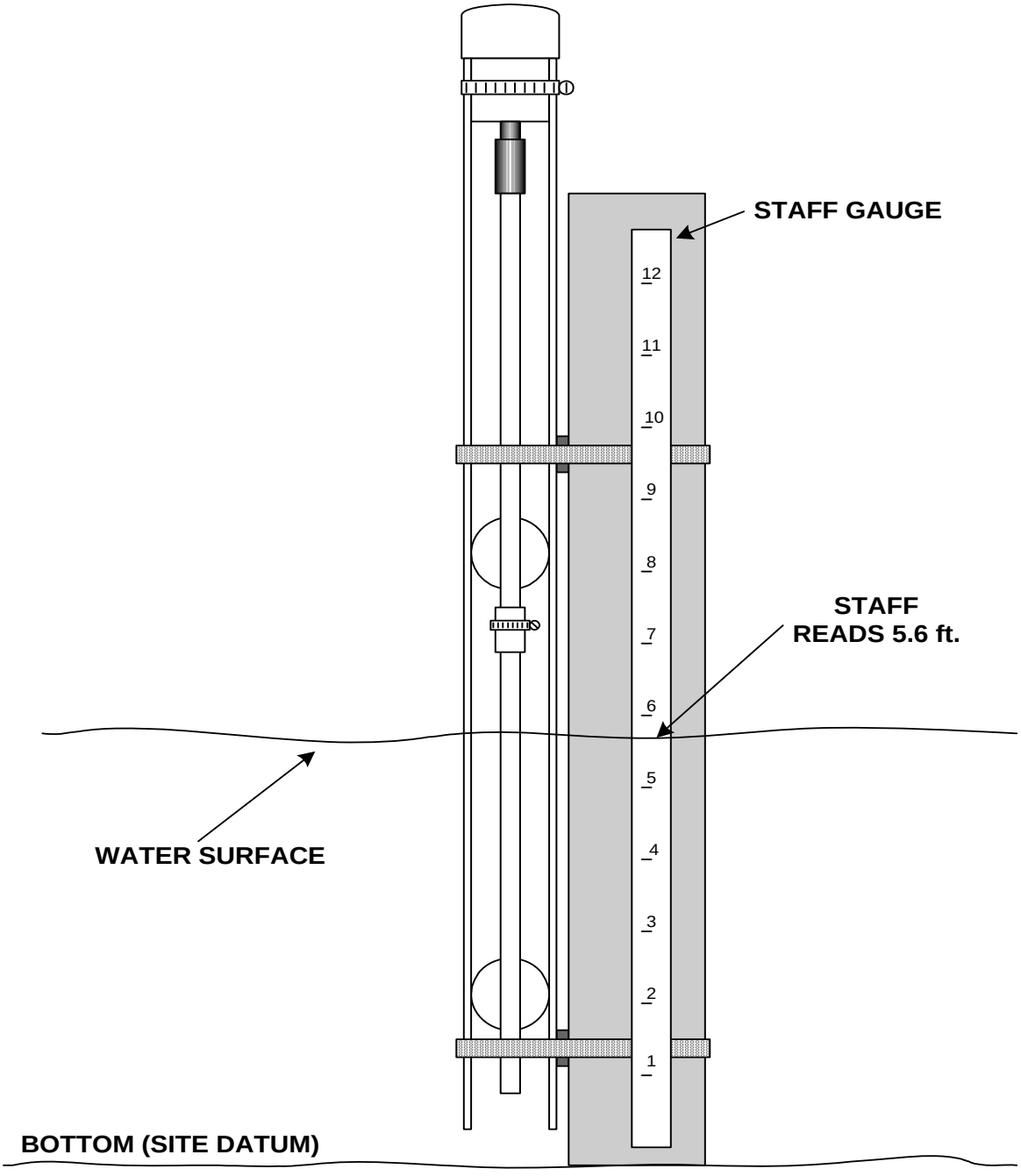

Figure 4-1 Leveling the Sensor to a Staff Gauge

4.2 Leveling the Sensor to a Primary Benchmark - Option 2

Note:

Now that the Model 41XX AQUATRAK is installed and communicating with the host, it must be leveled to a known datum point in order to provide meaningful water level information.

> ***Caution:***
> ***The establishment of the primary bench mark (PBM) may require the services of a trained surveyor.***

If a surveyed water level staff is not available, the Model 41XX must be leveled to another reference. A common reference point is the local primary benchmark (PBM) which may be considered to be the zero datum. When the Model 41XX is first installed and operated, it will correctly report the raw water level height from sensor zero to the surface. But the raw water level must now be referenced to a known point (datum) to have a significant (absolute) meaning to the user.

A convenient leveling reference point on the sensor is at the bottom of the stainless steel collar on the bottom of the transducer. The distance between the bottom of the collar and the transducer zero is precisely measured at the factory and recorded on the **AQUATRAK CALIBRATION CERTIFICATE as the '0' Offset.** This distance is shown as the **"S"** dimension in Figure 4.2.

To calculate the offset, determine whether the zero datum point will be above or below the transducer. Then, survey the length "X" between the zero reference and the bottom of the transducer collar. Use one of the two formulas below to calculate the offset (depending on zero datum location).

Zero Datum Above	**Zero Datum Below**
Offset = - (X) / _____ (S)	Offset = (X) / _____ (S)

Once the offset is determined, enter the offset value into the Model 41XX using either the RS-232 User Menu as (described in paragraph 4.1.1 above) or enter the offset value using the SDI-12 Commands (described in paragraph 4.1.2 above). Setting the polarity to down (D) will cause falling water levels to show an increasing distance from the zero reference.

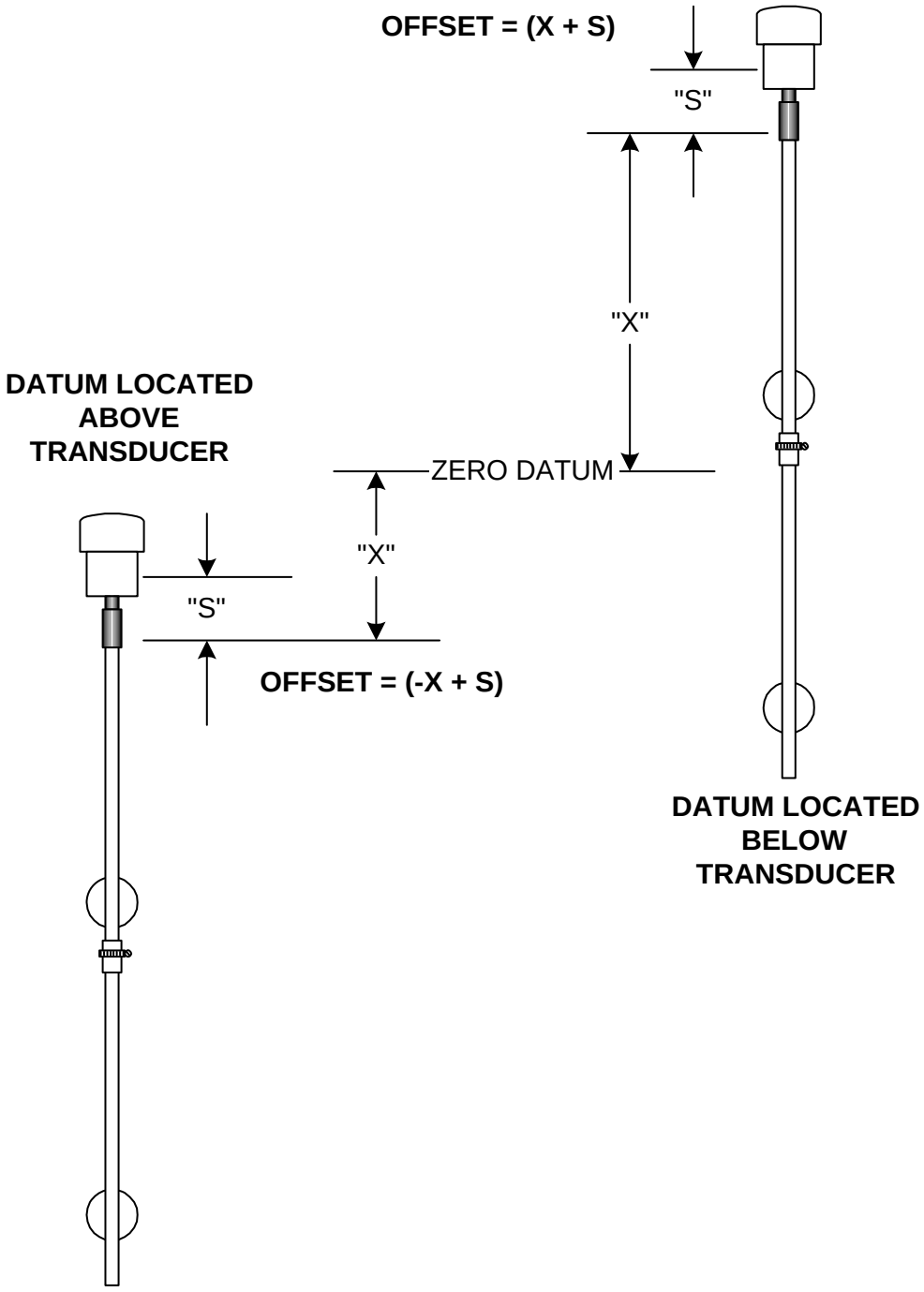

Figure 4-2 Leveling the Sensor to a Datum

APPENDIX

TECHNICAL SPECIFICATION OF MODEL 41XX SERIES AQUATRAK

Measurement		**Accuracy**	
Dynamic Range		Calibration	
Standard	>10 meters (35 feet)	Standard	± 0.025%
Optional	>15 meters (50 feet)	Optional	± 0.01%
Special	23 meters (75 feet)	Nonlinearity	± 0.02%
Rate of Change	± 3 m/sec. (±10 feet)	Precision, Repeatability	± 0.01%
Units	Metric (English)	Stability, Drift, 1 year	0
Resolution	1 mm (0.001 feet)	Temperature Drift	< 1 ppm/°C
Rate Proportionate	1.2 = 2.4 per sec.		
Rate Averaged 2 to 255:	1.0 per sec.		
Interval	Host determined		
Electrical		**ASCII Serial Communication**	
Voltage, d.c.	12.5 ± 2 volts	Selectable baud rate:	300 to 9600
Operating Current	< 30 ma	RS-232	N-8-1
Quiescent Current	< 1 ma	SDI-12	E-7-1
Average Power	20 mW (4 sample average)		
Environmental		**Physical**	
Operating Temperature	-40 to 55°C	Controller 41XX	
Storage Temperature	-55 to 60°C	Size	23 x 9 x 6 cm (9 x 3.5 x 2.5 inch)
Humidity	0 to 100%	Weight	1.5 lbs. (0.68 kg.)
		Sensor	
		Size	9 cm dia. 21 cm ht.) (4 inch dia. 8 inch. ht.)
		Weight	2.5 lbs. (1.14 kg.)
		Shipping (1 carton)	5 lbs. (2.23 kg.)