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# RiverSurveyor S5/M9 System Manual Firmware Version 2.00



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## RECORD OF CHANGES

<b>Effective</b>	<b>Description</b>
15 FEB 2009	Initial release; CPU firmware version 1.0
15 FEB 2010	RiverSurveyor Live v1.50 support
01 OCT 2010	SmartPulseHD™ Release; FCC and CE Declarations
15 OCT 2010	RiverSurveyor Stationary Live v1.00 support
28 MAR 2011	Software Updates including Loop Method
26 SEP 2011	Software Updates including CastAway CTD and ASCII Export



## Declaration of Conformity

**Manufacturer's Name:** SonTek, a Division of YSI Inc.  
**Manufacturer's Address:** 9940 Summers Ridge Road  
San Diego, CA 92121-3091 U.S.A.

**SonTek, a Division of YSI Inc. declares that the product(s):**

Equipment Type: Water Velocity Measurement Device  
Model: River Surveyor  
Product Name: River Surveyor S5; River Surveyor M9

**Conforms to the following European Union Council Directives and Standards as of 9/01/10:**

FCC PART 15, SUBPART B &  
EMC DIRECTIVE 2004/108/EC:

- EN 61326 (1997), A1 (1998), A2 (2001), Class "A"
- CISPR 11: 2003 /A1: 2004 /A2: 2006, Class "A"
- FCC 15B, Sec. 107, Class "A"
- FCC 15B, Sec. 109, Class "A"
- EN 61000-3-2: 2006
- EN 61000-3-3: 2008
- IEC 61000-4-2: 2008
- IEC 61000-4-3: 2006
- IEC 61000-4-4: 2004
- IEC 61000-4-5: 2005
- IEC 61000-4-6: 2008
- IEC 61000-4-11: 2004

**Director of Sales and Marketing,**

A handwritten signature in black ink, appearing to read 'Chris Ward', is written over a light gray background.

**Chris Ward**

## Release Notice

This is the September 26, 2011 release of the *RiverSurveyor S5/M9 System Manual*. During the creation of this manual, the following were the latest versions of firmware/software. As such, if you are using different firmware/software versions, not all aspects of this manual may apply.

- RiverSurveyor S5/M9 firmware version 2.00
- *RiverSurveyor Live* software version 3.00
- *RiverSurveyor Stationary Live* software version 2.00

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*This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

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## About This Manual

Thank you for your interest in using a SonTek RiverSurveyor S5 or M9 system. This *RiverSurveyor S5/M9 System Manual* describes how to install and configure the RiverSurveyor system and its associated software. It includes instructions and guidelines for the most common applications for which this system is used.

### Scope and Audience

Even if you have used other SonTek acoustic Doppler products, we recommend that you spend some time reading this manual to learn about the special features of this system.

This manual is more “application-oriented” in that it tries to explain how to use the RiverSurveyor system for specific, real-world applications. If you intend to use the instrument for other applications, or if you need detailed information about the instrument itself, please [contact us](#).

### How to Use This Manual

This manual was especially designed for on-line viewing through a computer. Even though you may now be reading a paper copy of this manual, an “electronic” copy of this manual was provided to you on the distribution disk (*RiverSurveyor.pdf*).

The use of this “PDF” file requires you to have the **Adobe® Acrobat Reader®** software installed on your computer. This software is freely available from Adobe at <http://www.adobe.com>.

This *RiverSurveyor.pdf* file is also used as a Help file within the *RiverSurveyor Live* software program. If you install *RiverSurveyor Live* on your computer using the default installation instructions, the *RiverSurveyor.pdf* file will be in the folder C:\Program Files\SonTek\Manuals.

The PDF version of this manual makes it easy for you to navigate within the document. Several hyperlinks (in blue) let you quickly go to referenced sections, figures, and tables. Additionally, you can use the built-in search features of Acrobat to find specific words and phrases. With the PDF copy, you can also print out high-quality copies of the manual to paper (for your organization’s personal use only and not for resale or redistribution).

### Reader Feedback

Your feedback about the RiverSurveyor system and this manual will help us to improve our products. Please let us know what improvements we can make by contacting us via telephone, fax, or e-mail (see next page for [Contact Information](#)).

## Contact Information

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## Section 1. Getting Started

### 1.1. What does the System do?

The SonTek RiverSurveyor system is a robust and highly accurate Acoustic Doppler Profiler (ADP) system specifically designed to measure river discharge, 3-Dimensional water currents, depths, and bathymetry from a moving or stationary vessel. The RiverSurveyor system combines proven state-of-the-art acoustic Doppler velocity profiler instrumentation with a Windows-based software package that can be used on a Personal Computer (PC) or Mobile device (using cell phone technology). The high degree of accuracy and ease of use allows you to measure confidently without having to change measurement settings for a specific river condition.

First-time users will find data collection and analysis a relatively simple task, while advanced users will benefit from the flexible processing and analytical tools that are provided. One of the major benefits of the RiverSurveyor system is that it is easy to program – time-consuming and complicated training courses are not required before you can start collecting meaningful data.

### 1.2. What's new?

**Shallow and/or deep water profiling solutions** – The ADP can be either one of the following types. Both of these profilers are described in detail in Section 2.

- **S5 ADP:** A five-beam system with four profiling beams and one vertical beam. The S5 has a velocity measurement range of up to 5 m and a discharge measurement range of 15 m (when referencing GPS and the vertical beam).
- **M9 ADP:** A nine-beam system with two sets of four profiling beams (each set having its own frequency) and one vertical beam. The M9 has a velocity profiling range of up to 30 m and a discharge measurement range of 80 m (when referencing GPS and the vertical beam).

**Multi-frequency** – Multiple acoustic frequencies fused with precise bandwidth control make for the most robust and continuous shallow-to-deep measurements ever for an ADP. A deterministic microcontroller automatically apportions the appropriate acoustics and pulse schemes as you cross the river. This allows you to focus on the measurement technique, and not on the instrument setup. The end result of the automatic adjustments is that it gives you the best measurement settings possible at all times, no matter the depth and velocity of the river.

**Automated cell size adjustments** – As you go from shallow to deep water, the cell size automatically adjusts to optimize performance and resolution. This feature further enhances your ability to measure continuously in dynamic river conditions.

**Vertical beam** – A low-frequency, fast-sampling vertical beam extends the maximum depth range of the system and provides superior channel definition for river discharge measurements and bathymetric surveys. The vertical beam also provides you the confidence that you will measure the proper depth during extreme conditions such as high-sediment flows and floods.

**Integrated GPS, Power, and Communications** – The RiverSurveyor Power and Communications Module (PCM) brings unmatched ease of use and flexibility to the S5 and M9 ADPs. The PCM contains a rechargeable battery pack for power, factory-configured Bluetooth® radio or Spread Spectrum (SS) radio (for communication with a PC or a compatible Mobile device; see §6.2), and an optional GPS enclosed in a water-tight housing.

**RTK GPS integration** – Available exclusively from SonTek, the RTK (real-time kinematic) GPS optional solution is easy to use and offers incredibly precise positioning and fast data sampling rates (10-Hz). This option can augment or be an alternative to Bottom-Track and positioning. Unlike existing “Differential” GPS solutions, which sometimes requires 50+ meters width for a

reliable discharge measurement, RTK GPS allows you to measure minimum stream widths consistently to less than 1 meter.

**Internal Discharge Calculations** – All calculations are performed inside the ADP. This gives you the increased flexibility to collect data, disconnect from the system, and then reconnect to the system during data collection without stopping the data collection process and without the fear of losing data. It avoids any possibility of data loss if communication is lost or becomes intermittent. You can even change communications devices (to/from PC or Mobile device) during a discharge measurement if needed.

**Quality and status feedback** – New, dynamic software interface and vibrant graphics for clear feedback in the office or field.

**Review and analyze data faster** – Load, view, and analyze multiple data sets simultaneously all from your PC.

**Flexible Mobile Device operation** – RiverSurveyor runs on both PC and Mobile device hosts giving you the flexibility to collect data to best suit your field requirements. Both software hosts also offer you the ability to make complete measurements without relying on secondary programs or utilities to extract or playback data.

**SmartPulse<sup>HD™</sup>** - SmartPulse<sup>HD</sup> is an intelligent algorithm that looks at water depth, velocity, and turbulence, and then adapts the acoustic pulse scheme to those conditions. It uses multi-band acoustics, pulse-coherent, broadband, and incoherent techniques to provide the highest resolution velocity data possible. And, just like an HD-TV, it lets you see the clearest velocity picture possible with cell sizes down to 2 cm.

Patent Pending on Multi-frequency, Automated cell size adjustments, Vertical beam, SmartPulse<sup>HD™</sup> and Internal Discharge Calculations

## Section 2. RiverSurveyor Instrument Configuration and Options

The RiverSurveyor discharge measurement system is flexible enough to fit most every field setup requirement you will need. The core system includes everything you need to make a direct-connect discharge measurement from a manned powerboat and external power supply. The options are modular, designed to be used with any S5 or M9 system, to best suit your field measurement needs. The following is a brief description of the core system and the options available with the new RiverSurveyor discharge measurement system.

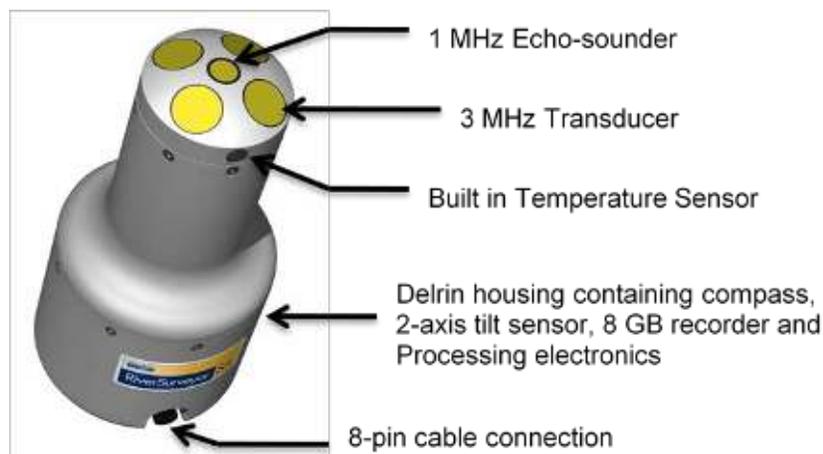
### 2.1. RiverSurveyor Core System S5 and M9

The core system includes:

Part Description	Qty
<b>Multi Frequency ADP (S5 or M9)</b>	<b>1</b>
User Software Disc	1
ADP QuickStart Guide	1
Power/Comm Cable (Std. 10m)	1
Power Supply (18V)	1
AC Power Cord	1

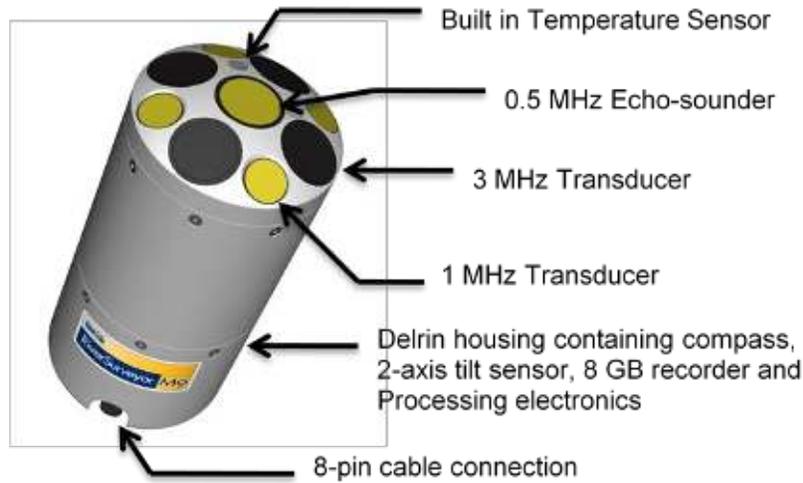
The S5 and M9 ADPs integrate a compass/2-axis tilt sensor, temperature sensor, 8-GB internal recorder, and a vertical acoustic beam (echo-sounder) for depth measurement.

- S5** (Figure 1): This portable, 5-beam ADP with a velocity profiling range of 0.2 to 5.0 m is ideal for use in shallow channels. The S5 has a 5-inch (13-cm) diameter Delrin housing that narrows to 3.2 inches (8.1-cm). It has four 3.0-MHz velocity measurement transducers in a Janus configuration. A 1.0-MHz vertical acoustic beam (echo sounder) provides depth data.



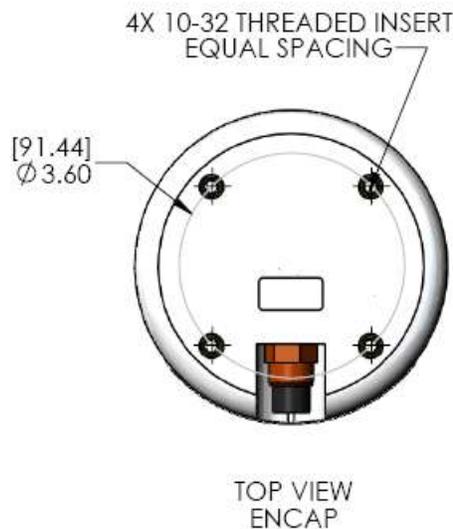
**Figure 1. S5 ADP Features**

- **M9** (Figure 2): This portable, 9-beam ADP with a velocity profiling range of 0.2 to 30 m is intended for use from moving or stationary boats/floating devices in both shallow and deep channels. The M9 has a 5-inch (13-cm) diameter Delrin housing. It has two sets of velocity measurement transducers, both in a Janus configuration – four 3.0-MHz transducers and four 1.0-MHz transducers. A 0.5-MHz vertical acoustic beam (echo sounder) provides depth data.



**Figure 2. M9 ADP Features**

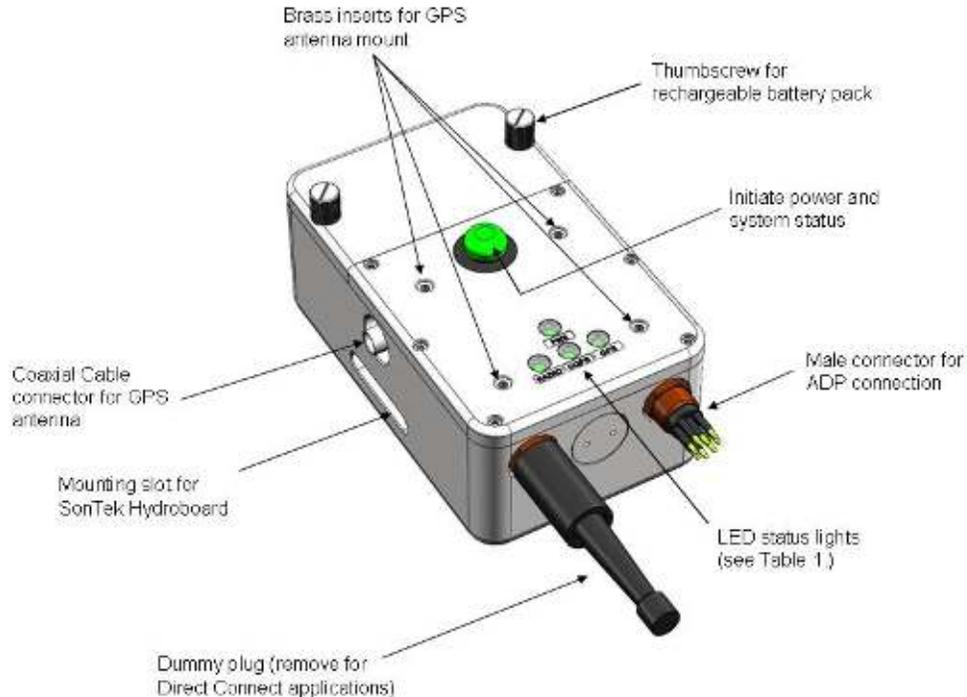
The four brass inserts on top of the ADP can be used to secure the ADP to a mount on the side of a boat or to mount the optional GPS antenna. Figure 3 shows a dimensioned drawing of the brass insert locations in inches and millimeters.



**Figure 3. Brass Insert Locations**

## 2.2. Power and Communications Module (PCM) - Optional

The PCM (Figure 4) connects directly to the S5 or M9 using a 1-m cable. It provides power to the ADP using a rechargeable battery pack. It allows for remote communications with a PC or Mobile device via a radio link. There are two different radio communications options depending on range.



**Figure 4. Power and Communications Module (PCM)**

The PCM has four LEDs. Table 1 describes their purpose. In all cases, a green light would indicate that the component is functioning while a red/orange light would indicate that the system is not functioning. Below is a description for the LED labels.

**Table 1. PCM LED Descriptions**

Label	Description
PWR	Power
Radio	Radio Communication
DGPS*	Differential Quality GPS (Green)
GPS*	GPS Lock (Green)

\*Note: Depends on optional GPS selection

**Important:** The dummy plug must be installed when using the PCM.

### 2.2.1. Bluetooth Option

A PCM with the Bluetooth option provides remote communication between the ADP and PC or Mobile device. The maximum range using the supplied Bluetooth dongle plugged into a PC is up to 200m. The Bluetooth range of the Mobile device is approximately 60m. Those approximate ranges assume a clear line-of-sight with no obstructions or poor weather.

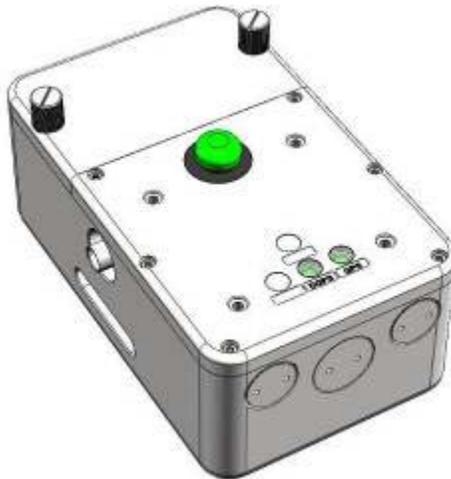
### 2.2.2. *Spread Spectrum (SS) Option*

A PCM with the Spread Spectrum radio option provides remote communication between the PCM and the SS Base radio connected to a PC. The operational range is about 2 km.

### 2.3. **GPS Components – Optional**

SonTek offers two GPS options integrated into the PCM. The first option provides RTK quality data ( $\pm 3$  cm). RTK quality data requires additional hardware in the PCM as well as a separate RTK Base Station (Figure 5). The Base Station provides RTK corrections to the GPS receiver built into the PCM. The Differential GPS (DGPS) option does not require a Base Station, but additional hardware is required for the PCM. Some general rules of thumb for connection times for the various communications are:

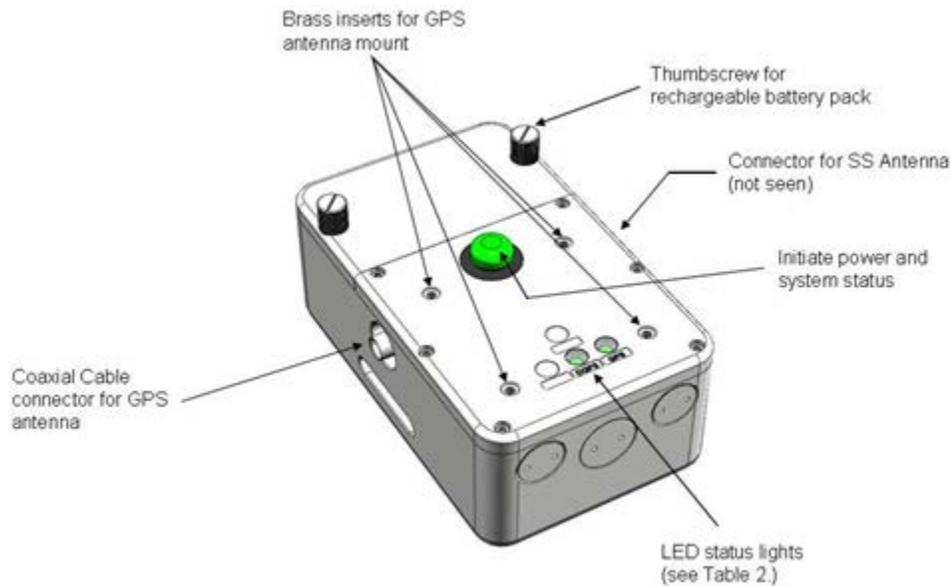
- **GPS Lock:** Typically takes 5 minutes to turn from Red to Green (greater than 1-m accuracy).
- **Differential Lock:** Typically takes up to about 5 minutes to turn from Red to flashing Red/Green (sub-meter accuracy).
- **RTK Lock:** Typically takes up to about 10 minutes to turn from alternatively flashing Red/Green to Green ( $\pm 3$  cm accuracy).
- **BT/SS LED:** Turns to Green as soon as connection is established between PC/Phone and the system (assuming you are within range).
- **Base Station Radio Link Established:** Red light



**Figure 5. Real-Time Kinematic (RTK) Base Station**

### 2.3.1. SonTek RTK GPS - Optional

The RTK GPS option provides precise ( $\pm 3$  cm) real-time kinematic position data to the ADP. The Bluetooth or SSpread Spectrum Spectrum PCM includes an internal RTK GPS receiver, an external, high-gain GPS antenna and a mounting mast. It also includes an additional Spread Spectrum Spectrum radio modem for communication with the RTK Base Station. The RTK Base Station consists of an RTK GPS receiver with an external, high-gain GPS antenna, a Spread Spectrum Spectrum radio modem for communication with the PCM, an external, high gain antenna and a mounting tripod. The Base Station receives GPS data at 10-Hz and provides RTK corrections at 1-Hz to the PCM connected to the ADP. The Base Station should be in a fixed location on shore. A direct line of sight is best for communication. The maximum communication range is about 2 km. Figure 6 shows the details for the Base Station. Table 2 describes the Base Station LED labels.



**Figure 6. RTK Base Station Components**

**Table 2. RTK Base Station LED label descriptions**

<b>Label</b>	<b>Description</b>
RTK	RTK Quality Connection (Green)
GPS	GPS Lock (Green)

The RTK Base Station receives GPS data via satellite and applies an RTK correction that is transmitted to the internal GPS of the PCM via Spread Spectrum Spectrum radio communications. The RTK correction data is transferred to the ADP's internal memory for processing. It is then transmitted along with the ADP data from the PCM to the PC or Mobile device.

**Note:** If communication between the RTK Base Station and PCM is lost, a sub-meter correction is typically valid for up to 45 minutes without having to re-establish communications.

### **2.3.2. SonTek DGPS - Optional**

The DGPS option provides sub meter differential GPS positioning data to the ADP. The Bluetooth or Spread Spectrum Spectrum PCM includes a DGPS receiver and external antenna. No Base Station is required for this option.

The GPS satellites communicate with the differential GPS receiver inside the PCM. The DGPS data is received by the PCM at 10-Hz and transferred to the ADP's internal memory for integration and processing. It is then transmitted along with the ADP data from the PCM to the PC or Mobile device.

### **2.4. SonTek Hydroboard - Optional**

The SonTek Hydroboard (Figure 7) is specifically designed to be used with the S5 and M9 ADP systems. It has easy to use, drop-in installation mounts for the ADP and the PCM. Simply insert the components into their corresponding mounts and tighten the thumb screws. The Hydroboard has two hydro-fins to provide increased stability. There are two embedded towing mounts near the front as well as one in the rear for an optional drag chute to increase boat track stability. A detailed description of the mounting procedure for the Hydroboard is explained in Section 3.7.2.



**Figure 7. SonTek Hydroboard with Optional GPS**

### **2.5. OceanScience Riverboat – Optional**

The OceanScience Riverboat is available for use in environments with higher flow rates. It provides a stable device for accurate measurements by reducing pitch, roll and yaw in flows up to 3 m/s. The flared box design reduces nose-diving and allows for wider selection of acceptable measurement sites.

## Section 3. System Configurations and Setup

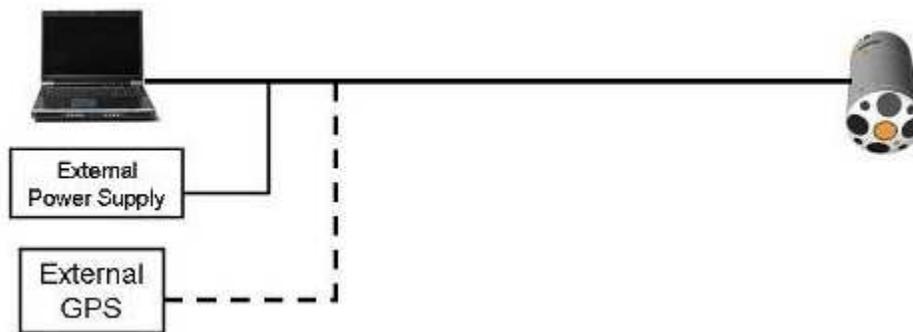
### 3.1. Overview

An important configuration concept to remember is that the RiverSurveyor system and all its components are completely interchangeable. Any PCM can be connected to any S5 or M9 ADP system. The S5 or M9 can be mounted with the PCM to the SonTek Hydroboard or any other boat with a custom installation. We encourage you to become familiar with the components, assembly instructions, and functionality of the system before going into the field. This section provides information on how to interconnect and prepare the system for data collection. The next several figures (Figure 8 through Figure 15) present some typical PCM configurations with system communications and setup details.

### 3.2. Configuration A – Direct Connection with S5 or M9 Core System

#### 3.2.1. Description

The core system is typically used in a manned powerboat application using a direct cable connection to the PC and the external power supply (Figure 8). The dashed line indicates the use of an optional third party external GPS. The use of an external GPS precludes the use of all wireless communications (i.e. Bluetooth and spread spectrum); therefore, a direct connection via serial communications is necessary.

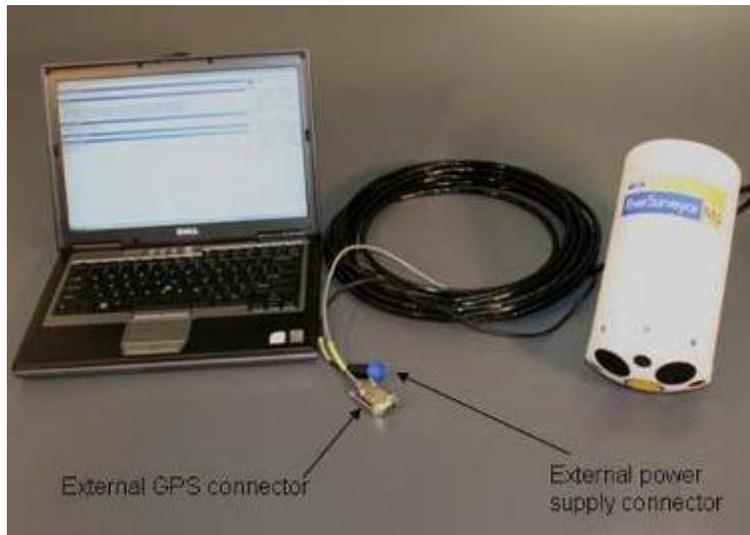


**Figure 8. Core System-Direct Connect Setup**

#### 3.2.2. Hardware Setup

Follow these instructions to set up the hardware for the core system:

1. Connect the underwater, 8-pin, male connector of the 10-m power and communications cable to the female ADP connector until the face of the cable connector is flush with the ADP connector. Screw-on the locking sleeve to secure the connection.
2. Connect the female, 9-pin, serial connector marked USER on the power and communications cable to the PC. If the PC does not have a serial port, use the USB to serial adapter included.
3. Mount the ADP to the boat. Be sure to mount the ADP deep enough that the transducers will remain submerged for the entire measurement.
4. Connect the external AC power supply to the system by connecting the 2-pin power cable from the 10-meter power/serial communications cable to the power source. Figure 9 shows the hardware necessary for this option.



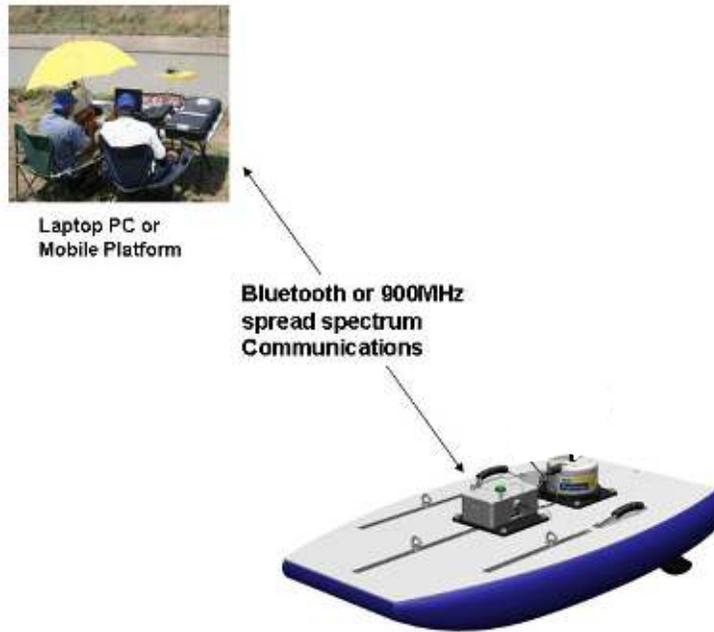
**Figure 9. Hardware Required for the Direct Connect Option**

5. Start the *RiverSurveyor Live for PC* software and connect to the system to start the measurement. Details for conducting a discharge measurement with a PC are presented in Section 6.
6. To integrate an external GPS system, connect the male, 9-pin, serial connector marked GPS on the power and communications cable to the GPS system. The external GPS needs to have the following settings:
  - Communications Protocol – 38400 N,8,1
  - Data Rate – 10 Hz
  - GPS String – VTG/GGA. To avoid possible communication issues it is always recommended to turn-off (or disable) any additional GPS strings being output by the external GPS.

### **3.3. Configuration B – Bluetooth Communications**

#### **3.3.1. Description**

Figure 10 shows the RiverSurveyor system with wireless communications, in this case Bluetooth, using a small unmanned boat, such as the SonTek Hydroboard. The maximum range using the supplied Bluetooth dongle plugged into a PC is up to 200m. The Bluetooth range of the Mobile device is approximately 60m. Those approximate ranges assume a clear line-of-sight with no obstructions or inclement weather.



**Figure 10. Bluetooth Communications Option (Without GPS)**

### 3.3.2. Hardware Setup

Please use the following directions for Bluetooth communications setup.

1. Be sure to use the mounting directions from section 3.2.2 for the ADP and PCM
2. The Mobile device requires no external hardware for Bluetooth. However, the PC requires a connection to a USB-powered Bluetooth Dongle into a serial port. A serial to USB adapter is provided for PCs without a built-in serial port. The Dongle comes preconfigured and should be recognized as plug-and-play.
3. Be sure that the Bluetooth Communications is activated. Start *RiverSurveyor Live for PC* and establish communications with the system. Be sure the Parani Bluetooth checkbox is selected in the communications of the Mobile device or PC.
4. Turn on System Power by pressing the white circular button on top of the PCM. The button should then glow solid green.

Follow the directions outlined in Section 5 to make a discharge measurement.

Figure 11 presents the hardware necessary for the Bluetooth communications option.



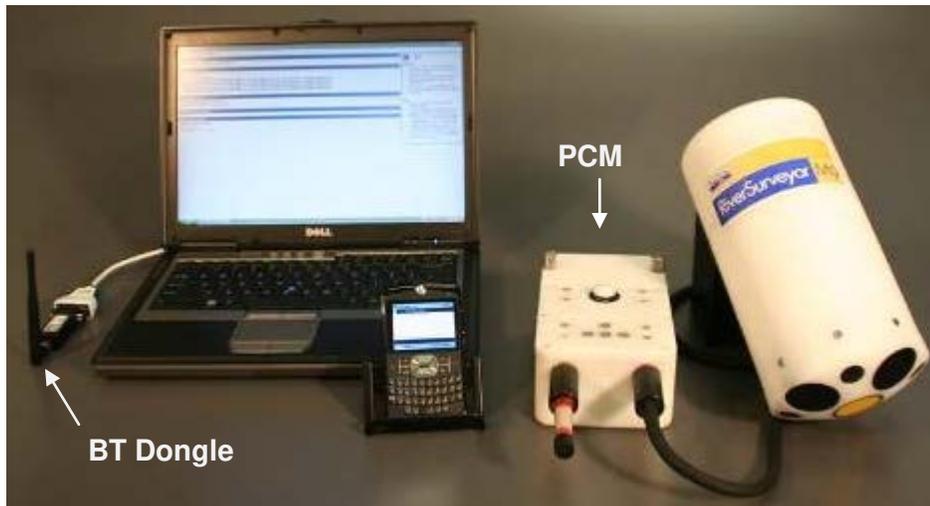


Figure 11. Hardware for Bluetooth Communications Option

### 3.4. Configuration C – Spread Spectrum Communications

#### 3.4.1. Description

Figure 12 shows the RiverSurveyor system with wireless communications, in this case Spread Spectrum communications using a PCM on a small unmanned boat, such as the SonTek Hydroboard. The maximum range of the Spread Spectrum radio link is approximately 2 km.

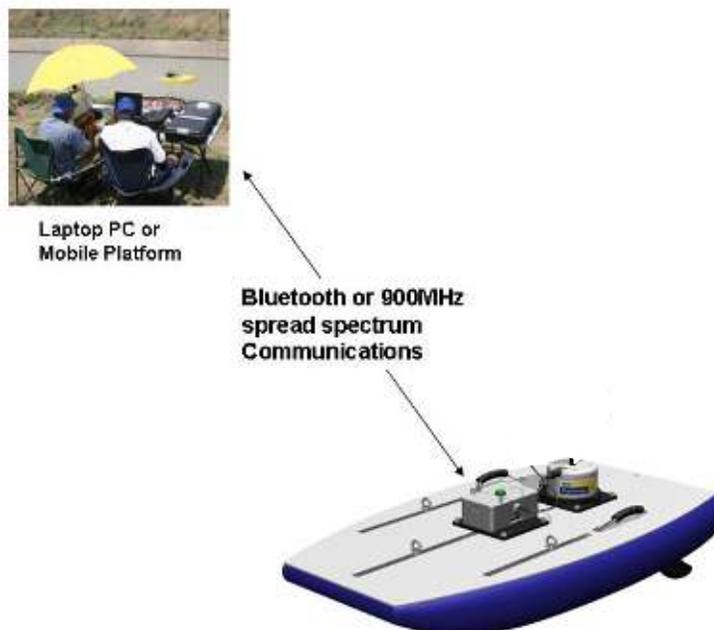


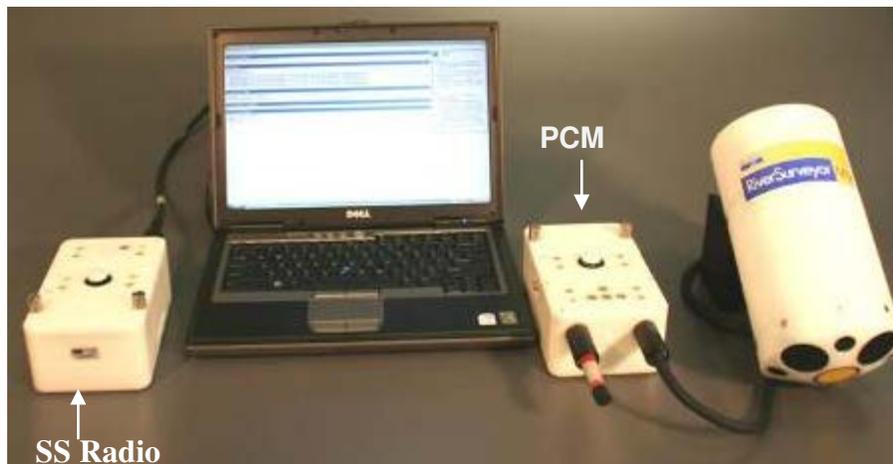
Figure 12. Spread Spectrum Communications Option (Without GPS)

### 3.4.2. Hardware Setup

Please use the following directions for Spread Spectrum communications setup.

1. Be sure to use the mounting directions from section 3.2.2 for the ADP and PCM
2. Connect the Spread Spectrum radio box to the PC by using the communications cable. Connect the serial end of the connector to the PC and the 8-pin female connector of the cable to the 8-pin male connector on the radio communications box.
3. Attach the external antenna (not pictured) to the base radio box.
4. Turn on System Power and Spread Spectrum radio box by pressing the white circular button on top of the PCM. The button should then glow solid green.
5. Follow the directions outlined in Section 5 to make a discharge measurement.

Figure 13 presents the hardware necessary for the Spread Spectrum communications option.



**Figure 13. Hardware for Spread Spectrum Communications**

### 3.5. Configuration D – RTK GPS

#### 3.5.1. Description

Figure 14 shows the RiverSurveyor system with RTK GPS (with precision to  $\pm 3$  cm) and wireless communications using a small, unmanned boat such as the SonTek Hydroboard. GPS position data is received at 10-hz by both the RTK Base Station and ADP (on the rover). The RTK GPS correction is transmitted at 1-hz from the RTK Base Station to the unmanned boat via Spread Spectrum communications. The SonTek Hydroboard is used below for conceptual purposes.

**Note:** A sub-meter correction will be maintained up to 45-minutes if communications with the RTK Base Station is lost and after an RTK correction has been established. If the RTK Base Station will not be used for the measurement the user must switch the GPS application to “DIFF” for differential measurements.

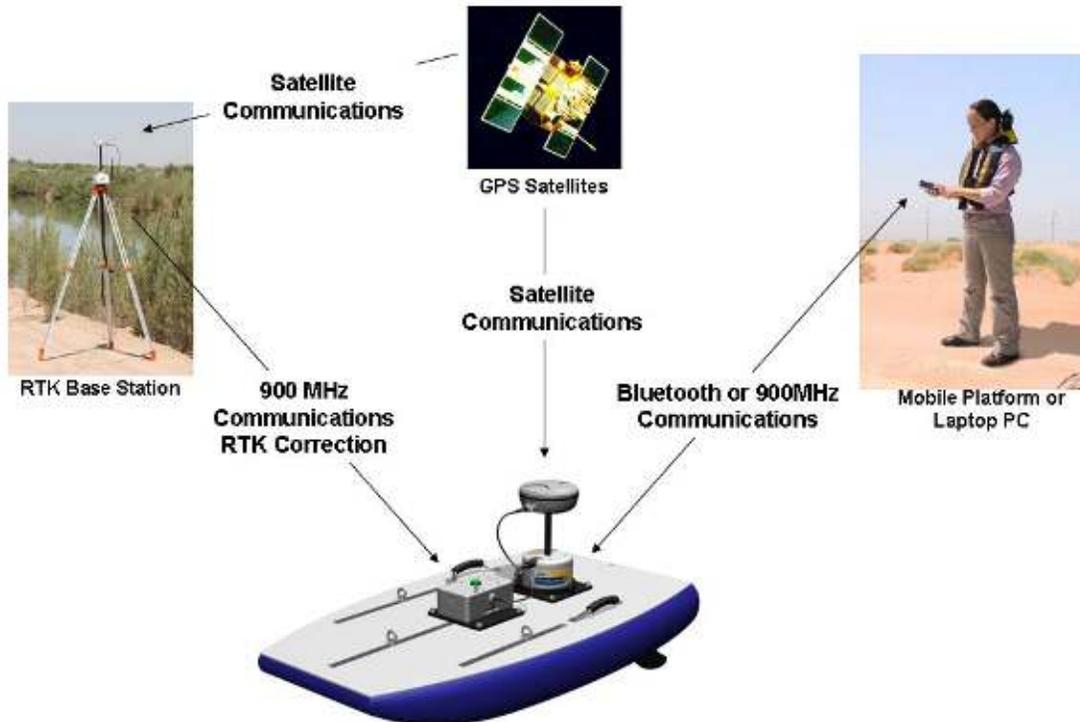
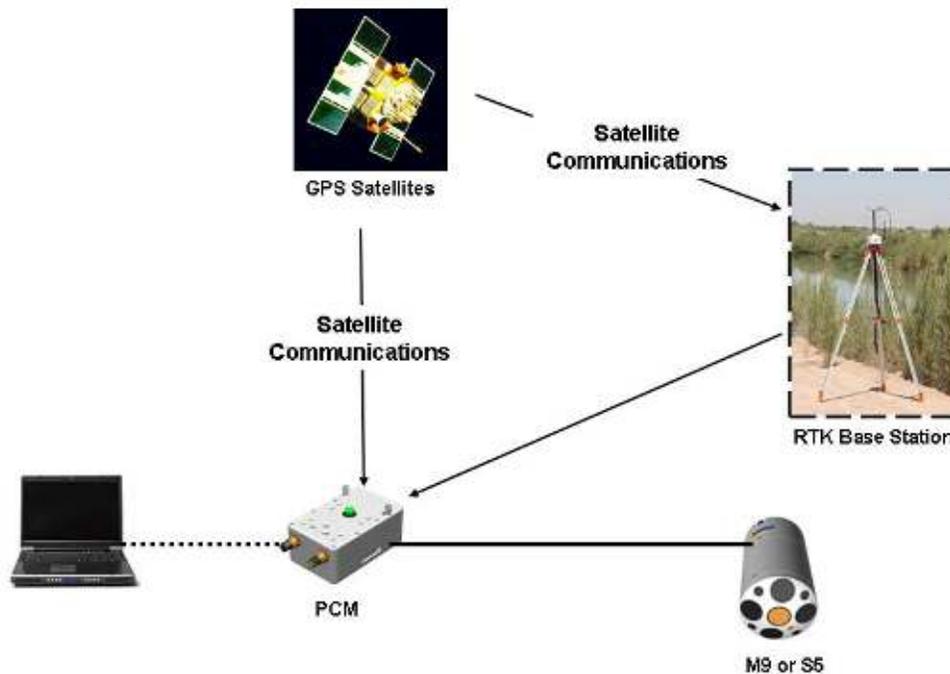


Figure 14. Wireless Communications with RTK GPS

Figure 15 presents a generic or over-the-boat setup using RTK GPS. The setup can utilize either wireless or direct connect communications, which is indicated by the dashed line between the PC and PCM. The dashed line indicates a connection to the PCM in three possible ways:

- Directly to the PCM via a cable for a direct connect configuration
- Connect to the PCM via Bluetooth communications
- Connect to the PCM via SS communications

For the wireless communications option, the dummy plug (8-pin plug) must be inserted into the PCM in order to complete internal circuitry and active wireless communications.



**\*PC communicates directly with the ADP, via direct connect or wireless communications (laptop PC or Mobile Platform)**

\*Note: The "dummy" plug is required in the direct connect port when not using the direct-connect option for PCM to PC connection.

**Figure 15. Direct Connect Application with RTK GPS**

### 3.5.2. **Hardware Setup**

There are two components used to collect RTK quality data – the RTK PCM mounted to the boat and RTK Base Station.

Figure 16 shows the Bluetooth option with the RTK option.

#### **RTK PCM (Boat) Assembly**

1. Connect the GPS high gain antenna to the aluminum mast by screwing the male threads on the mast into the antenna receiver.
2. Connect the mounting bracket for the antenna mount to the ADP by inserting the four thumb screws located on the mounting bracket into the four brass holes on the ADP.
3. Connect the coaxial cable to the PCM and the GPS antenna by connecting the female connectors on the coaxial cable to the male connectors in the PCM and GPS antenna.
4. Turn the system on by pressing the power button on the PCM.
5. RTK quality data requires that the RTK Base Station be installed within 2 kilometers of the PCM. The RTK Base Station setup is described below.

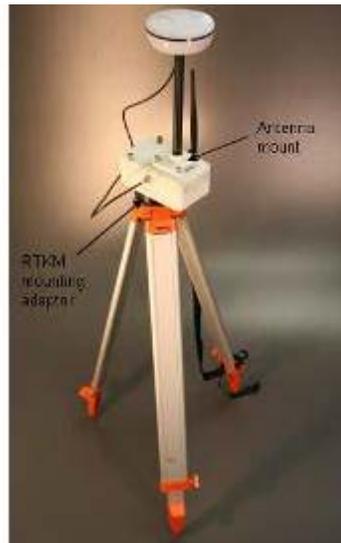


**Figure 16. Hardware for RTK GPS Option with Bluetooth Communications**

#### **RTK Base Station**

1. Figure 17 displays an assembled RTK Base Station and tripod. The tripod should be in close proximity to the measurement section (less than 2 km with good line-of-sight) and mounted so that it is reasonably level. Also, nearby obstructions such as bridges, buildings, or large trees should be avoided if possible. These obstructions limit the number of useful satellites increasing the required time to obtain an RTK correction.
2. Attach the tripod adaptor (round plastic disk) to the RTK Base Station until there is a tight fit. Now attach the tripod adaptor to the tripod by screwing the brass thumb screw into the bottom of the tripod adaptor.
3. Attach the Base Station antenna mount to the top of RTK Base Station housing over the brass inserts. Use the four thumb screws on the antenna base mount to secure the mount to the RTK Base Station.

4. Attach the screw-in Base Station antenna mast into the base mount. Screw in the Base Station antenna to the top of the mast. Make sure the antenna is high enough to avoid interference from nearby obstructions like overhead trees, bridges, or buildings. The antenna is typically mounted directly on top of the RTK Base Station; however, it can be dismantled and placed in a more ideal location as long as the antenna's coaxial cable remains connected to the RTK Base Station.
5. Open the RTK Base Station battery cover by loosening the two thumb screws on the battery cover. Insert the rechargeable battery pack by aligning the exposed cells with the spring contacts. Check to make sure the O-ring seal is clear of all debris. When closing the battery cover, securely tighten both thumb screws to maintain a waterproof seal.
6. Connect the SS Radio antenna male connector to the female connector in the RTK Base Station.
7. Plug the male connector of the Base Station antenna cable to the female connector embedded in the RTK Base Station.
8. Adjust the height of the tripod for the best line of sight to the remote PCM.
9. **Important:** If possible, avoid line of sight obstructions as they may decrease the communication range between the RTK Base Station and the PCM (on the boat). If needed, you can add an extension cable between the RTK Base Station and SS Radio antenna to place the SS antenna in a more ideal location.
10. Turn on system power by pressing the circular button on top of the communications box: it should turn solid green once turned on.
11. The RTK Base Station has two LEDs. In all cases, a green light would indicate that the component is functioning while a red/orange light would indicate that the system is not functioning.

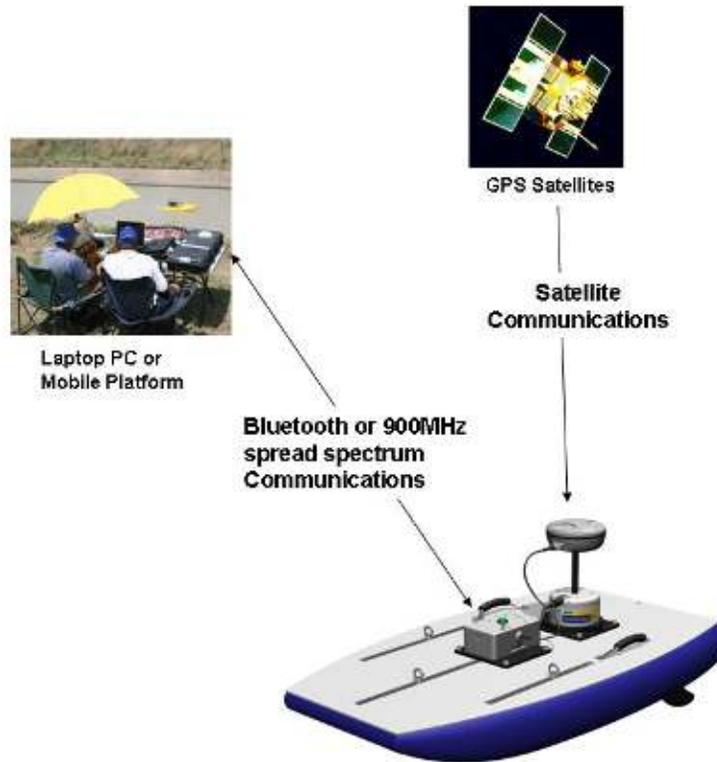


**Figure 17. Hardware for the RTK Base Station**

### 3.6. Configuration E – SonTek Differential GPS

#### 3.6.1. Description

Figure 18 shows the RiverSurveyor system with Standard DGPS and wireless communications using a SonTek Hydroboard. The standard differential GPS option has sub-meter precision. The SonTek Hydroboard is used below for conceptual purposes.



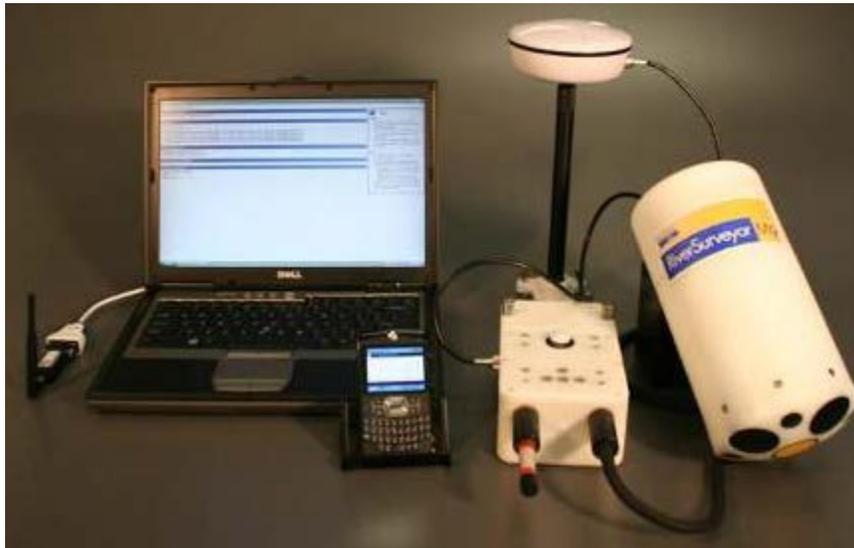
**Figure 18. Wireless Communications DGPS**

#### 3.6.2. Hardware

Below are the directions for mounting the hardware for the DGPS option.

Figure 19 displays the hardware necessary for the DGPS option.

1. Connect the female connector of the coaxial cable to the male connection on the receiving antenna. Run the coaxial cable through the antenna mast to the bottom, collecting all excess cable from the antenna mast.
2. Attach the GPS receiver to the mast by screwing the female connector of the antenna to the male connector on the mast.
3. Attach the GPS mounting bracket to the ADP by inserting the four thumb screws into the brass holes in the ADP. Now attach the antenna mast to the mounting bracket by screwing the male threads on the mast to the female threads inside the mounting bracket.
4. Connect the female connector of the coaxial cable to the male connection on the PCM.
5. Turn the system on by pressing the power button on the PCM. Follow the instructions in Section 5 to complete the discharge measurement.



**Figure 19. Hardware for the DGPS Option with Bluetooth Communications**

### **3.7. Configuration F - SonTek Hydroboard**

#### **3.7.1. Description**

The SonTek Hydroboard was designed to be lightweight enough for one person, completely assembled. The Hydroboard has easy to use drop-in installation mounts for the ADP and the PCM. Simply insert the components into their corresponding mount and tighten the thumb screws. In addition the Hydroboard has two hydrofins that provide increased track stability in water as well as embedded mounts that can be used for towing as well as the incorporation of a drag chute to increase boat track stability.

#### **3.7.2. Hardware Setup**

This section describes how to assemble the SonTek Hydroboard components (Figure 20).

1. Open the PCM's battery pack cover by loosening its thumb screws. Insert the rechargeable battery pack by aligning the cells with the contacts. Make sure the O-ring seal is clear of debris. Close the battery cover and securely tighten the thumb screws to maintain a water-proof seal. Set the PCM into position on the Hydroboard (in the rectangular cut-out in the mounting bracket) and tighten its thumb screws.
2. Insert the ADP face (transducers looking down) into the circular hole in the Hydroboard. Start from the topside of the Hydroboard and move the ADP downward (be sure the top of the ADP coincides with the top of the Hydroboard). If needed, slightly rotate the ADP left and right to raise and lower the ADP to the proper level. To properly align the transducers, make sure the female plug-in of the ADP lines up with the female plug-in of the PCM.
3. The Hydroboard is shipped with a fairing unit preinstalled on its bottom. The fairing is attached to the Hydroboard with four screws that pass through the top of the Hydroboard into the fairing unit on the underside of the Hydroboard.
4. The ADP should be installed so that the transducer head is flush with the fairing. The transducer can be installed deeper if required. Tighten the clamp around the transducer by rotating the thumb screw until the ADP is held firmly in place.
5. The white line on the side of the Hydroboard can be used to calculate the transducer depth. The transducer depth is defined as the distance from the vertical beam to the water surface. The distance for both the S5 and M9 with the fairing to the white line is 4.5 in

(114.3mm). If the ADP head is mounted flush with the fairing, simply subtract the distance of the white line to the waterline from 4.5 inches to get the transducer depth.

6. After the PCM and the ADP are in place, connect the data cable between them. Start by connecting the cable's 8-pin male connector to the female ADP connector until the face of the cable is flush with the connector; now tighten the connection with the protective locking sleeve. Next, repeat the same procedure to connect the data cable to the PCM. Connect the 8-pin male cable connector by pushing the connector into the female connector embedded in the PCM until the face of the cable is flush with the female connector; tighten the connection with the protective locking sleeve.



**Figure 20. An Assembled SonTek Hydroboard (With RTK GPS Option)**

7. GPS set-up information is in §3.5 and 3.6.
8. Attach the contoured hydro-fins to the bottom of the Hydroboard. Insert the fins into the slots in the bottom of the Hydroboard with the contour facing the back of the Hydroboard. Firmly tighten the fin to the board by sliding the screw through the small hole in the fin bottom brace. Align the small metal screw clip (in a slide frame) under the hole and firmly tighten the screw.
9. Turn on System Power by pressing the white circular button on top of the PCM. The button should glow solid green.
10. Follow the instructions in Section 5 for completing a discharge measurement.

## Section 4. System Maintenance

### 4.1. Overview

Under normal conditions, the ADP requires little maintenance for years of reliable performance. This section discusses some routine maintenance procedures that should be followed to ensure long-term operation of your system.

### 4.2. Cleaning the transducers

Periodic cleaning of the ADP transducer face may be needed to maintain optimal performance in areas of high biological activity or mineral build-up. To remove material build-up on the transducer faces, simply clean with a stiff (non-metallic) brush or apply soapy water and clean with a sponge. The transducers themselves are protected in a hard epoxy-resin and are very durable. Minor scratches on the transducer face are normal over a period of time and will not harm them or affect their performance. Direct impacts to the face should be avoided as this might crack the face of the transducer and allow moisture into the electronics housing as well as causing damage to the transducer itself.

### 4.3. Cables and connectors

Cables and connectors used with the ADP are often the most vulnerable portion of the system. All standard SonTek cables use a durable polyurethane jacket that provides excellent long-term wear and abrasion resistance. Rugged underwater flexible connectors are also used along with high-grade metal connectors to prevent connection failures. However, any cable or connector used in the field is susceptible to damage and reasonable precautions should be taken. Inspect all ADP cables and connectors for damage on a regular basis and replace if necessary.

GPS cables and connectors are industry standard (TNC male to male) and can be replaced if damaged using a local supplier of GPS/survey equipment or by contacting SonTek directly.

For connectors, a light coat of silicone grease or spray is useful in facilitating the connections. However, make sure the silicone does not contain cleaners or solvents that could damage the rubber part of the connector. Inspect both male and female connector pins to make sure they are clear of debris and excess grease, which could interfere with the connection or make it difficult to fully mate the connectors.

### 4.4. O-rings

Make sure that O-rings on the battery compartment of the PCM are completely clean and free of debris. Be sure that the O-ring is seated correctly, and that it is not twisted or broken. It is important to maintain a water-tight seal for the integrity of the instrument.

### 4.5. Batteries

The first thing to do with a new system is charge the battery packs. Please use the charger provided. Follow these steps:

1. Plug the charger into the wall and wait for the LED to turn orange.
2. Insert the battery pack into the charging cradle. Be sure the metal contacts on the battery pack are aligned with the metal springs in the charging cradle.
3. The LED should be red while it is charging. A full charge will take about 1-2 hours.
4. Charging is complete when the LED turns green.
5. Remove the battery from the cradle.
6. Wait for the LED to turn orange to charge another battery.
7. Repeat steps 2 through 6 to charge another battery

A description of all of the possible light patterns can be found on the bottom of the charger.

It is important to use only completely charged SonTek battery packs. A completely charged battery pack should have about 16-18 volts if you check it with a voltmeter. Be sure the battery pack is completely dry before placing it in the charging cradle. Also be sure the battery compartment in the PCM is completely dry before inserting the charged battery pack. Do not try to modify the battery packs shipped with the product. Third party battery packs will not be supported. Any damage incurred from using a third party battery pack will void the warranty.

#### **4.6. Mobile Device**

Be sure to use the clear plastic lanyard with the Mobile device to prevent any water damage in the field. The Mobile device is not water resistant. Water damage is not covered by the warranty.

#### **4.7. Factory Calibration**

Each system is individually calibrated during the manufacturing process. Since there are no moving parts and the beams are built into the ADP head, recalibration is not necessary unless the M9/S5 is physically damaged.

## Section 5. Introduction to Measurement Procedure

### 5.1. Overview

This section is a general guide to prepare for and conduct discharge measurements in the field. The information presented here will discuss pre-measurement tests as well as the general procedure for making a discharge measurement.

### 5.2. Applications

The procedures described in this section are useful for all moving boat discharge measurements made with the RiverSurveyor S5 and M9; this includes the use of the SonTek Hydroboard, custom remote device applications as well as over the boat applications. The protocol described below is applicable to measurements made with the PC and Mobile device software.

### 5.3. Pre-Measurement Tests

The steps described below are used to test the RiverSurveyor hardware prior to making a measurement. The pre-measurement tests should be done prior to each discharge measurement to ensure the functionality of the RiverSurveyor hardware for proper data collection.

#### 5.3.1. Check cables and connections

Prior to mounting the RiverSurveyor hardware, the structural integrity of all cables should be reviewed to ensure that there are no defects; this includes not only the cable but also the connectors. Once the hardware is mounted, connect all the necessary cables. Be sure the faces of the connectors are flush and secure before screwing down the locking sleeves. When using the SonTek Hydroboard or other remote device, be sure that all knots and clamps are sound and that the rope/cord is strong enough to withstand the onsite conditions.

#### 5.3.2. Communications

Communications are vital for remote measurements. There are three types of communications connections to the ADP: Direct Connect, Bluetooth and Spread Spectrum Radio. In the case of wireless communications, be sure to have the dummy plug installed in the PCM. It is important to note that the PCM requires power. Be sure to have the battery packs adequately charged and the spare available.

**Direct Connect** is a cable connection between the ADP and the PC. Confirm that the connection between the cable and the ADP is sound (that the wet mateable connector is flush with the face of the connector on the ADP) and that the locking sleeve is hand tightened. Also make sure that the serial connection to the PC is tight. There is a USB to serial adapter included for PCs without a DB9 serial port. The external AC power adapter is required for direct connections without a PCM.

**Bluetooth** communication is available with an optional PCM. It allows for wireless communication between the ADP and a PC with the Parani Bluetooth dongle (200m range) or the Motorola Q Mobile device (60m range).

**Parani Bluetooth Dongle** – This is an external Bluetooth radio that plugs into a PC serial port or through the USB to serial adapter. The dongle requires power from the PC through the included USB connector. It is automatically configured to 57600 baud by the *RiverSurveyor Live* software. In all cases, be sure to verify sound connections.

**Spread Spectrum Radio** provides extended range (up to 2 km). The optional PCM communicates with the Spread Spectrum base that plugs into a PC serial port via an 8-pin wet mateable connector. There is a USB to serial adapter included for PCs without a DB9 serial port. The

Spread Spectrum base radio is battery powered, so be sure to have fully charged batteries and to turn it on prior to starting the discharge measurement.

### 5.3.3. **System Test**

This is a 60 second verification that the components of the hardware are functional. The System Test verifies the battery voltage, compass, SD memory card and temperature sensor are all functioning properly. A system pass would indicate that all systems are sound for use, while a fail would require user action in order to conduct reliable discharge measurements. Below is a list of the system Fail messages:

- ❖ System battery voltage < 12 volts
- ❖ System compass is not working
- ❖ System SD card (memory) is not working
- ❖ Temperature sensor is not working

### 5.3.4. **Compass Calibration**

Compass calibration is necessary prior to each discharge measurement. It is used to compensate for magnetic interference in the vicinity of the ADP. A battery or steel clamp right next to the unit will have a much greater effect than, for example, a steel bridge 200 m away. That's why it is important to eliminate any magnetic material, including electronic/mobile devices and wristwatches from the immediate vicinity when performing a compass calibration.

To perform a compass calibration, rotate the ADP through two complete circles while varying pitch and roll angles as much as possible. Each rotation must take no less than one full minute to complete.

If the ADP is to be mounted on a boat, the *entire* boat needs to be rotated for the calibration, along with everything that is physically attached to the system, while varying the pitch and roll angles as much as possible (within the limitations of the vessel). Changes to metal components on the boat (such as toolboxes, engines or mounts) should not be made after the calibration is done, otherwise, the calibration must be repeated.

If a good calibration score cannot be achieved, try to reduce the speed of the rotations and increase the pitch and roll as much as possible. It may be necessary to complete the compass calibration by hand on the boat as close to the mounting location as possible. Heading corrections can be made in post-processing if necessary.

The compass calibration routine was updated in firmware v0.81. The new compass calibration procedure improves the ability to detect local magnetic distortion. The result is improved magnetic north heading readings during the actual calibration. The magnetic north readings are used to reference "True North". Improved magnetic north readings reduce the need to make minor heading corrections in order to properly align the compass to true north.

### 5.3.5. Recorder

The Recorder Menu is provided on the Systems Tab and provides a way of managing files stored on the 8 GB memory card. You can download all or a selection of files by using the options presented in the Recorder window.

**Download all files** – downloads all files from the recorder

**Download selected files** – allows you to select files using the tick box next to the file name. Simply select the files to download and then click on Download selected files.

**Format Recorder** – Clears the memory of the recorder by erasing all files.

Make sure that there is adequate memory available on the recorder prior to making a discharge measurement. It is suggested to download files and format the recorder between measurement sites. All files must be downloaded from the ADP for post-processing and data evaluation.

### 5.3.6. Measurement Procedure

Now that the pre-measurement tests and initial site specific entries are complete, it's time to understand the basic principles behind a discharge measurement. Basically, the total discharge is the amount of water flow (or net flux) through a section and is computed from the mean water velocity and the cross-sectional area of the measurement section.

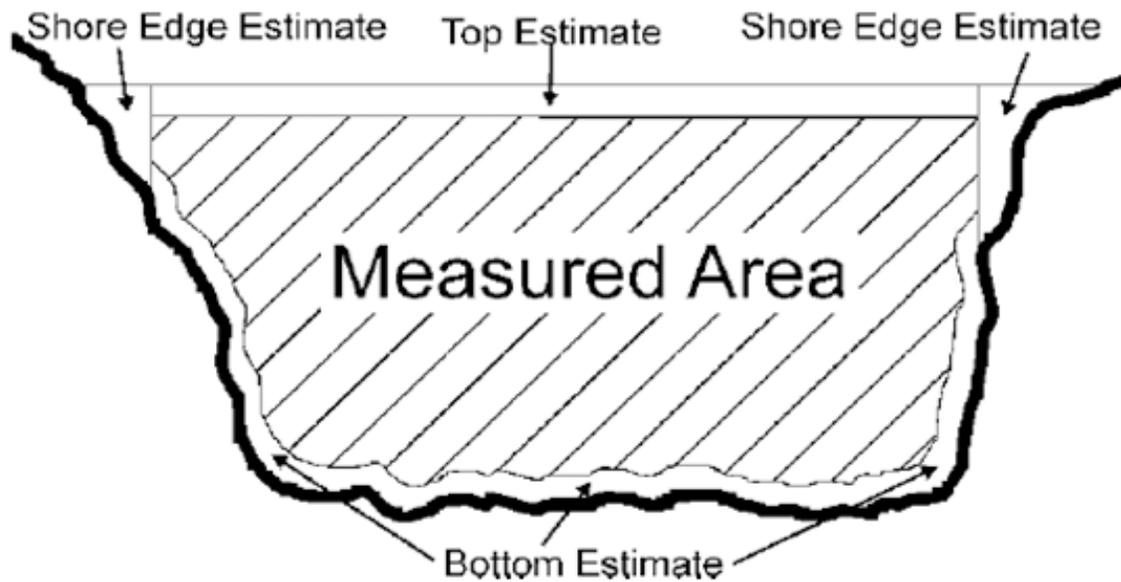
### 5.3.7. Overview

A single moving boat measurement of discharge can be broken into three key components: the Start Edge, the Transect and the End Edge. These components are shown in Figure 21 below:



**Figure 21. Measurement Sections**

The Transect component can be further broken up into the Top Estimate, Middle or Measured Area and Bottom Estimate as shown in Figure 22 below:



**Figure 22. Cross-Sectional Areas Not Measured by the ADP**

Therefore the Total Discharge can be calculated by summing the Start Edge, Top Estimate, Measured Area, Bottom Estimate and End Edge. Only the Measured Area is measured by the acoustic Doppler profiler. It is important to note that all other areas are estimated using industry recommended and approved calculations.

The reasons for breaking up the total discharge calculation into several components are due to limitations inherent in all acoustic Doppler profilers. An acoustic Doppler profiler cannot measure the entire river cross-section due to several issues:

- There is a minimum operating depth for the profiler. At depths lower than this minimum, the water velocity and therefore the discharge must be estimated based on the velocity and depth measurements on the edges. The Start and End Edges are measured in this way.
- The mounting depth plus a short distance (referred to as the blanking distance) from the profiler to the start of the measured velocity profile leave a section of the water at the surface unmeasured. This area is referred to as the Top Estimate.
- Potential data contamination in the last cell (i.e., the cell is partially or fully “touching” the riverbed), or potential side-lobe interference at the end of the profile, leaves a section of water at the bottom unmeasured. This area is referred to as the Bottom Estimate.

So, how do we calculate the velocities and discharges in each of these estimated and edge areas?

A technique known as Velocity Profile Extrapolation is used to estimate the unmeasured areas at the top and bottom. This theoretical approach to modeling of the velocities within the water column allows all velocities and therefore the discharge to be computed.

Velocity Profile Extrapolation uses a power law velocity profile proposed by Chen (1991), and Simpson and Oltmann (1990), to calculate velocities above and below the Measured Area.

$$\frac{u}{u_*} = 9.5 \cdot \left( \frac{z}{z_0} \right)^b$$

Equation 5-1. Velocity Profile Power Law

Where  $u$  is the velocity at height  $z$  measured from the river bottom,  $u^*$  is the bottom shear velocity,  $z_0$  is the bottom roughness height, and  $b$  is a constant (equal to 1/6 according to Chen, 1991). Use of this equation assumes the currents in the profile are traveling in approximately the same direction. In situations where this may not be the case, (e.g., Stratified Flows or bi-directional flow), one of the other extrapolation methods, available in the *RiverSurveyorLive* software, should be used. By default, the *RiverSurveyorLive* software uses the 1/6th Power Law velocity profile (described above) using the entire measured velocity profile to calculate velocities in the top and bottom unmeasured areas.

The velocities are now known for each of the estimated top and bottom areas. The discharges for each component are calculated based on the velocities, depth and movement of the vessel across the transect.

The discharge in the Start and End Edges is calculated from a mean velocity profile that is developed by maintaining a (relatively) fixed position at the edge. It is important that the vessel be kept as stationary as possible at the edge. The velocity profiles measured at this time will be combined together to produce a single average profile. The discharge calculation at the edge is based on the selection of a constant sloped bank or vertical wall and uses a combination of the mean depth and velocity profile at the edge.

In the Transect, the discharge calculation is based on the depth, distance travelled and the mean water velocity. During this time the system automatically compensates for changes in the vessel course and speed.

One of the key benefits is that the PC and mobile software step through this entire process and do the calculation of discharge automatically.

#### **5.3.8. Starting The System**

After the system is configured, start the system collecting data.

#### **5.3.9. Collecting Start Edge Data**

Position the vessel for the starting edge position and begin collecting edge data with the vessel as stationary as possible. It is recommended that a minimum of 10 profiles/samples are collected to perform the edge discharge calculation. Enter the edge distance and shape.

#### **5.3.10. Collecting Transect Data**

After collecting the start edge data, proceed to move the vessel across the channel. Keep the vessel speed and direction as constant as possible.

#### **5.3.11. Collecting End Edge Data**

After moving across the channel and arriving at an end edge location, enter the end edge distance and shape. Collect at least 10 samples/profiles with the vessel as stationary as possible.

#### **5.3.12. Making Additional Measurements/Transects**

After entering the end edge information, the measurement is complete. Another measurement can be started from the same location or the system can be shut down.

## Section 6. RiverSurveyor Live for PC Software

### 6.1. Overview – RiverSurveyor Live for PC Software

This section is a quick reference for using the *RiverSurveyor Live for PC* software. *RiverSurveyor Live for PC* software is a discharge measurement interface for RiverSurveyor S5 and M9 systems. The software includes everything needed to make real-time discharge measurements as well as post-process the data.

### 6.2. System Requirements

RiverSurveyor Live for PC requires the following specifications for the PC.

- Windows Vista or Windows XP
- 1.6 GHz processor
- 1 GB memory
- 1 GB disk space
- 1024 x 768 Screen Resolution

### 6.3. Installation

To install the RiverSurveyor Live for PC software on your PC, insert the distribution CD into your CD-ROM drive. The program should automatically start and display the Installation Menu (Figure 23). If the installation menu does not appear in a few seconds, click Start|Run on your PC and type D:\install.exe, where d:\ is the letter of your CD-ROM drive.

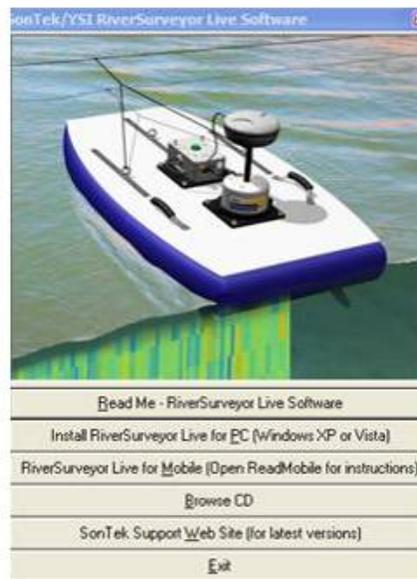


Figure 23. Installation Menu

Click the *Install RiverSurveyor Live for PC* option. The installation wizard (Figure 24) will display step-by-step instructions to install the software.

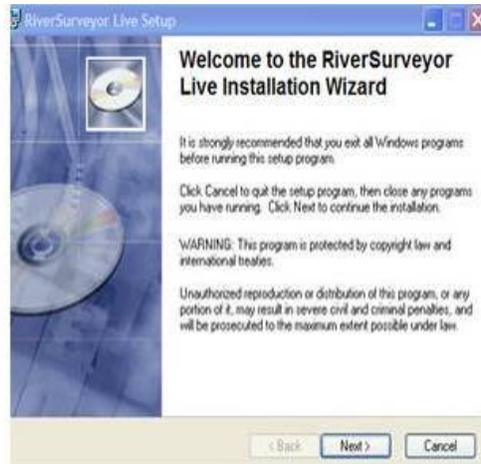


Figure 24. Desktop Installation

Follow the on screen instructions to complete installation of the software. You are now ready to use *RiverSurveyor Live for PC* to make a measurement.

## 6.4. Starting the Software

Upon starting the software, the main menu will be presented as shown in Figure 25 below:



Figure 25. RiverSurveyor Live Main Menu

## 6.5. Connecting to the System

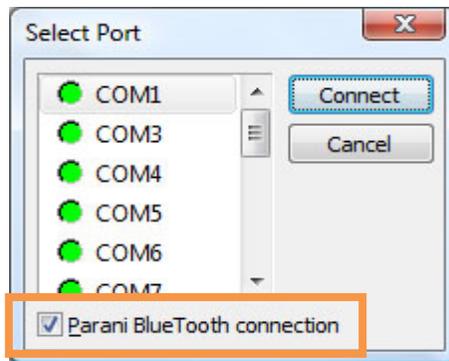
There are three ways to connect to the ADP using the *RiverSurveyor Live for PC* software.

- Click the Connect icon on the toolbar at the top of the screen



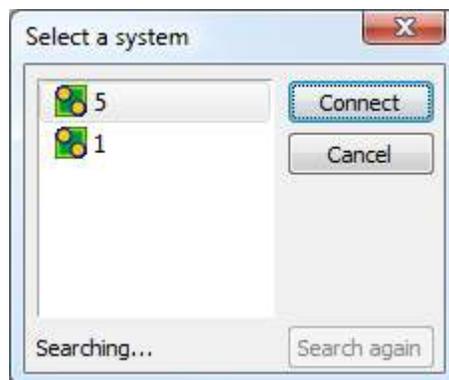
- Use the Connect to RiverSurveyor system link under Connection Options
- Use the hot key: Ctrl+N

After selecting the option to connect to the System, a popup window will prompt you to select the appropriate COM Port. For Direct Connect, Spread Spectrum Radio or integrated Bluetooth, select the appropriate Com Port and click Connect. Check the Parani Bluetooth connection box highlighted in Figure 26 only when using the Parani Bluetooth dongle. That automatically configures and connects to the Parani Bluetooth dongle at 57600 baud.



**Figure 26. COM Port Selection Window**

Following the COM port selection, you will be presented with a search window displaying the serial numbers of systems available for connection (Figure 27). Should no system be detected, click Search again. Be sure that the systems have power. If the power is not turned on, the system cannot be detected to communicate with the PC.



**Figure 27. System Select Window**

When the connection is established, the System Tab is displayed as shown in Figure 28. This tab allows you to enter Site Information, System Settings and Measurement Settings; download files from the Recorder and perform Pre-Measurement Tests. The COM port and baud rate ( COM2 57600 ) are shown at the top.



Figure 28. System Tab Following Connection

### 6.6. Site Information

Site information can be entered by clicking Change Site Information. This opens a popup window that allows you to enter site specific details. (Figure 29). The maximum number of characters allowed for each data field is in parentheses. Entering more than the maximum allowable characters will display an error message that will prompt you to enter the information within the allotted number of characters. This information can be changed during post processing.

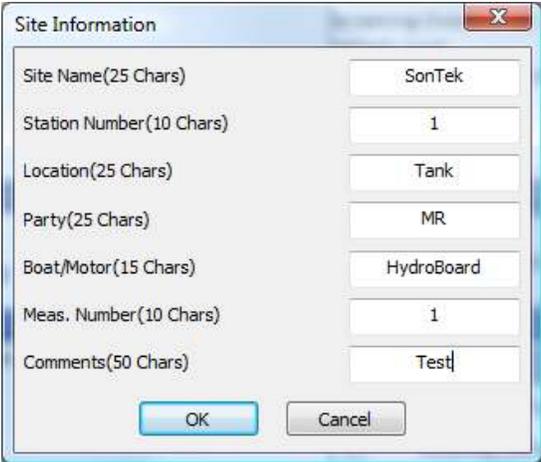


Figure 29. Site Information Menu

## 6.7. System Settings

System settings are specific to the measurement site. The information is entered by clicking Change System Settings. This will allow you to enter setup information for the site as well as select the Track Reference, Depth Reference and Coordinate System. Figure 30 presents the System Settings menu. This information can be changed during post processing. The data changed in post-processing will be indicated with green text. Below is an explanation of each field in the System Settings menu.

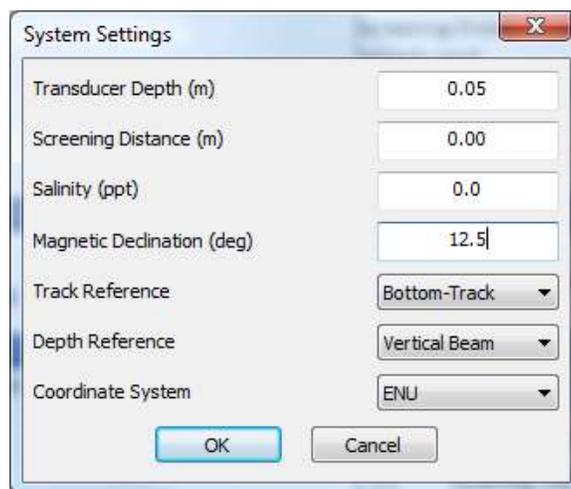


Figure 30. System Settings menu

**Transducer Depth** – This is the distance (m) that the vertical beam transducer is submerged below the water surface. Figure 31 shows a basic diagram that depicts an ADP's transducer face submerged in water. Transducer depth corresponds to the depth of water that the transducer face is submerged.

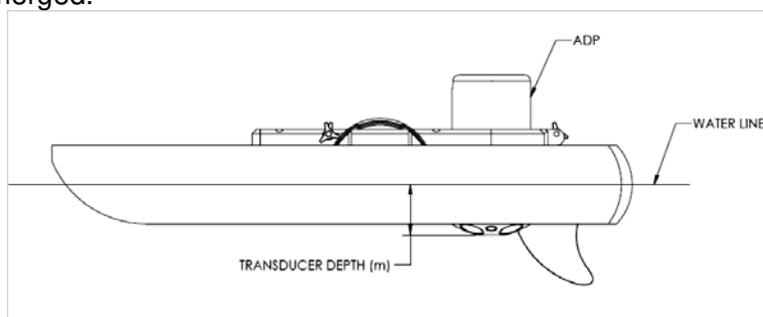


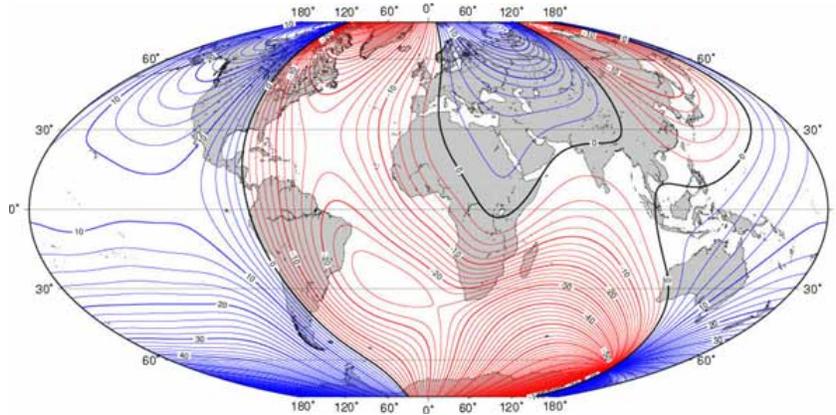
Figure 31. Explanation of Transducer Depth Measurement

**Screening Distance** – This is the distance below the face of the ADP that you want to start collecting data rather than relying on the default setting of the instrument. In essence this setting allows you to program the ADP to start collecting data below a certain point. This is primarily used for over-the-boat applications where the screening distance can be set to avoid flow disturbance from the wake of the boat.

**Salinity** – This user-defined parameter allows for a correction of the speed of sound in water based on the salinity in parts per thousand (ppt) at the face of the ADP. A value representative

of the local water conditions must be entered manually to avoid potential erroneous calculations. For reference, the salinity range is between 0 ppt (freshwater) to 34.5 ppt (seawater). Water temperature is also a factor for speed of sound in water calculations. The ADP has a built-in temperature sensor that automatically compensates for this effect.

**Magnetic Declination** – On the earth's surface, a calibrated compass indicates magnetic North rather than geographic North. The angular difference between these two directions is called magnetic declination (also known as variation, magnetic variation, or compass variation). Magnetic declination varies across the earth's surface and over time. The ADP compass is calibrated at the factory; however, calibration is required at each site to remove any local magnetic interference. Compass calibration will ultimately give better measurement accuracy. The magnetic declination angle ( $\theta$ ) can be found on maps, like the one presented in Figure 32. Magnetic declination resources can also be found on many sites on the internet.



**Figure 32. Magnetic Declination Map of the World**

**Track Reference** – The ADP measures a water velocity using the Doppler shift principle, using multiple acoustic pulses transmitted and received throughout the water column. When the ADP is in motion, the water velocity actually measured by the ADP is a combination of boat velocity and water velocity. In order to determine true water velocity the boat speed must be known and then subtracted from the actual water velocity measurement. The RiverSurveyor “moving boat” discharge application uses three methods (references) to determine boat velocity.

1. **Bottom-Track reference velocity:** The ADP itself is capable of determining boat speed using a technique called “Bottom-Track”. In this case, bottom-track velocity is calculated using the Doppler shift received from multiple acoustic pulses (transmitted from the ADP) that have reflected off of the riverbed. If the riverbed is stationary (i.e. non-moving bottom), then the Doppler shift velocity will consist entirely of boat speed velocity which is acceptable for discharge calculations. If the riverbed is in motion the Doppler-shift-based velocity will consist of both boat speed and riverbed speed which will bias discharge calculations. In this case, the following two references would be preferred to determine boat velocity.
2. **GGA GPS-referenced velocity:** GP GGA (GGA) refers to a specific NMEA-0183 protocol for outputting GPS position data. In this case, the GGA “string” contains actual position (latitude/longitude) information along with several other GPS quality parameters. Boat velocity is calculated by measuring the distance between two successive GGA positions divided by the travel time between those two positions. Differential corrections are required for the GGA data to reduce the amount of position error as-

sociated with each measurement. The RiverSurveyor uses two types of differential corrections: “Sub-meter” differential and “Real-Time Kinematic” (RTK).

3. **VTG GPS**-referenced velocity: GPVTG (VTG) refers to a specific NMEA-0183 protocol for outputting GPS velocity data. In this case, the VTG string contains the actual boat speed information along with several other GPS parameters. The GPS velocity is calculated based on the Doppler shift of the received satellite signals.

There is a drop down menu to select the appropriate track reference. All available track references will be available for analysis or to recalculate discharge in post-processing. There are four options:

- **Bottom-Track:** The ADP uses the bottom-track feature to measure the velocity of a vessel relative to the river bottom. The vessel velocity is then subtracted from the measured water velocity to give the absolute water current profile independent of vessel motion. This is the only track reference available for systems without an optional GPS.
- **GPGGA:** The ADP uses the GGA string (from the GPS data) to measure velocity of a vessel based on GPS position data. This is only available for systems configured with a GPS option. It is recommended that GGA data use a sub-meter differential or RTK correction for discharge calculations. The highest quality and most accurate method applies RTK-corrected data.
- **GPVTG:** The ADP uses the VTG string (from the GPS data) to measure the velocity of a vessel based on GPS velocity data. This method requires additional review of data quality parameters to verify data quality.
- **System:** The ADP references all velocities only to itself. This should only be used in specialized applications by experienced users. It is ***not recommended*** for discharge measurements from a moving vessel.

**Depth Reference** - This is a drop down menu that has two options for determining water depth. Both options are available for post-processing, however you can decide the default measurement.

- **Vertical Beam:** This is highly accurate echo sounder data used to determine water depth.
- **Bottom-Track:** This uses data from the four angled beams to determine the depth of the water column using the average depth from each beam.

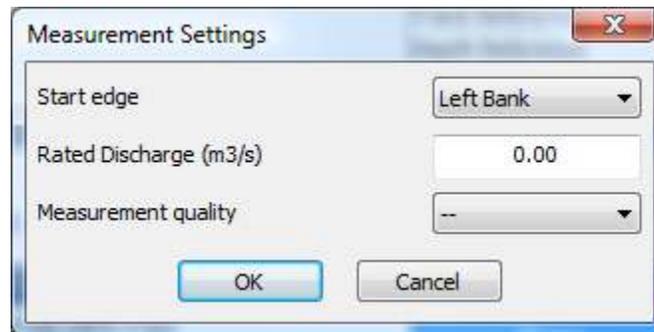
**Coordinate System** - This drop down menu has three options. All three options are available for post processing; however you can set the default for the measurement.

- **ENU:** This is the traditional East, North, and Up coordinate system.
- **System:** This uses the ADP as a reference. Used for internal testing only.
- **XYZ:** This is a three-dimensional “relative position” coordinate system used only for specialized applications by experienced users.

## 6.8. Measurement Settings

Measurement Settings can be entered by clicking Change Measurement Settings. They apply to the specific discharge measurement. The information from this menu (Figure 33) can be changed in post-processing. Below is an explanation of the fields for the Measurement Settings window.

- **Start Edge** – Sets the default starting edge for discharge measurements (right or left bank).
- **Rated Discharge** – Enter a rated discharge pre- or post-measurement. This information is useful for post-processing data analysis and evaluation.
- **Measurement Quality** – Used as a post-processing qualitative input to evaluate the discharge measurement quality.



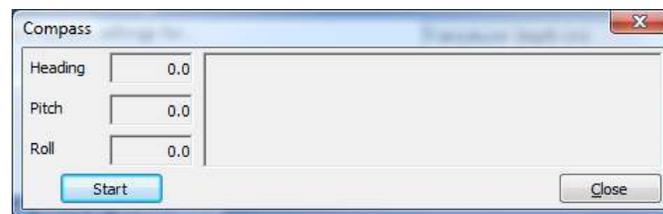
**Figure 33. Measurement Settings Menu**

## 6.9. Pre-Measurement Tests and Utilities

The steps described below are used to test the RiverSurveyor hardware prior to making a measurement. The pre-measurement tests should be done prior to each discharge measurement to ensure the functionality of the RiverSurveyor hardware for proper data collection.

### 6.9.1. Compass Calibration

A compass calibration is necessary prior to each discharge measurement to compensate for magnetic fields specific to the site. To perform a compass calibration, click the Compass Calibration link in the Utilities menu and click **Start** in the pop up window (Figure 34). Rotate the ADP through two complete circles while varying pitch and roll angles as much as possible. It is important to calibrate the compass on the boat or mount and as close to the measurement location as possible. Be sure to remove any Mobile devices (including any Mobile device operating the system), PDAs or other metal objects from the area prior to calibration.



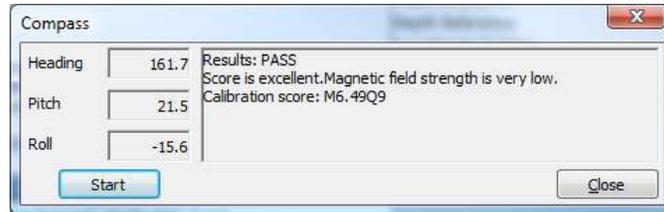
**Figure 34. Compass Calibration Window**

Click **Stop** upon completion of the compass calibration procedure. The calibration results and score (Figure 35) are displayed in the window. Using the example below, the calibration score is M6.49Q9. The M “value” should always be less than 10 and the Q “value” should always be

very high (based on a scale from 1-10). If the result is anything other than “Pass” the process should be repeated. A file is saved for quality control procedures in the following directory:

C:\Documents\SonTek Data\YYYY\_MM\_DD\CompassCal

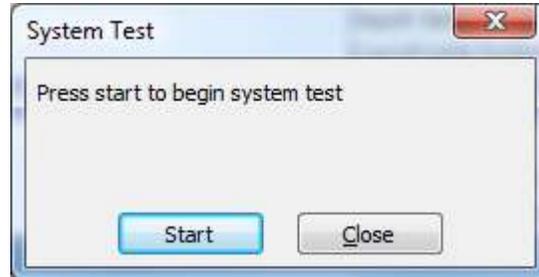
where YYYY\_MM\_DD is the year, month and day format.



**Figure 35. Calibration Score Window**

### 6.9.2. System Test

The System Test performs a series of checks to confirm the battery, compass, recorder and temperature sensor are in good operating condition. Click **Start** to initiate the test (Figure 36). The test typically takes 60 seconds and will present a dialog window indicating a system test Pass or Fail. A failure would indicate that user action is required to ensure proper functionality of the system.



**Figure 36. System Test Window**

Below is a list of the following system Fail messages:

- System battery voltage < 12 volts
- System compass is not working
- System SD card (memory) is not working
- Temperature sensor is not working

### 6.9.3. Set Time

Set Time allows you to verify and set the time used for the discharge measurement. The popup window allows you to click the check-box to use the PC time or set the time manually (Figure 37). Click the **Set Time** button to apply the time setting and close the window.

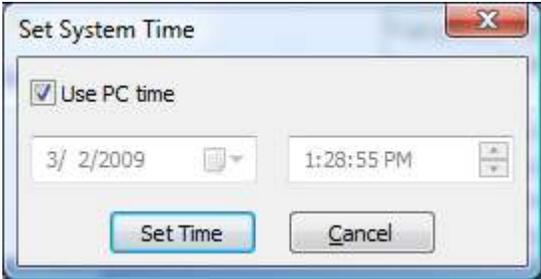


Figure 37. Set System Time Window

6.9.4. **BeamCheck**

BeamCheck displays the SNR (Signal to Noise Ratio) of each beam versus range. Click the BeamCheck link to start the utility. A popup window (Figure 38) will appear displaying the serial number of the system and the selected beam frequency.



Figure 38. BeamCheck Menu

Beam check will start automatically for the selected beam frequency showing a plot of each beam (Figure 39). The other beam frequencies can be selected from the drop down menu as the system runs.

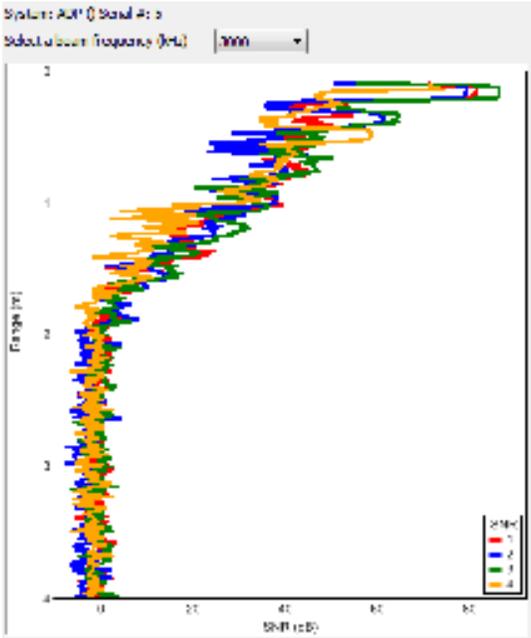


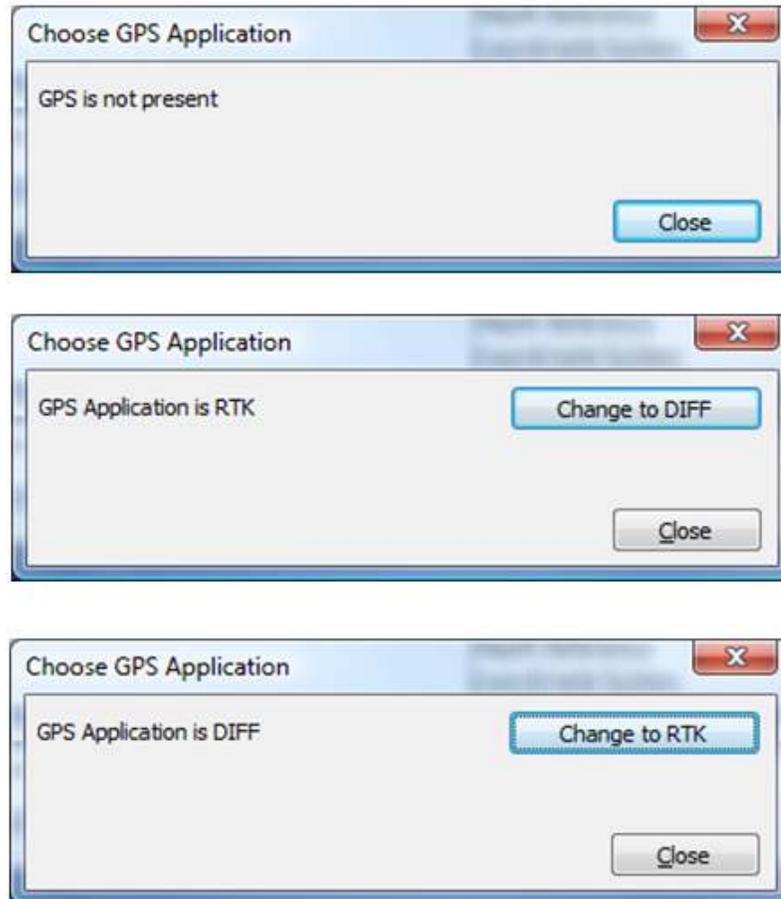
Figure 39. BeamCheck Graph

### 6.9.5. Update Firmware

This allows users to update firmware from the utilities window by selecting a file from the PC. Typically users can download new firmware files (.a79 extension) from the SonTek webpage. After finding the file on the PC, select “Open” to load the firmware file to the ADP. After the update is loaded, make sure that the firmware version is correct in the Systems Tab.

### 6.9.6. SonTek GPS Option

The SonTek GPS Option provides information about SonTek GPS options available. Clicking this option in the Utilities menu provides a way of verifying the GPS options available. If the GPS option is not available, this will be indicated in a dialog window. If the SonTek GPS application is RTK and you want to change to Differential (DGPS), click Change to Diff. Changing from Differential GPS to RTK GPS works in the same way (Figure 40). It is important to note that the SonTek DGPS option is not upward compatible with the SonTek RTK GPS option as it requires a more advanced hardware. There is no capability of integrating a shore-station differential GPS correction at this time. The SonTek GPS options use the WGS 84 horizontal datum.



**Figure 40. SonTek GPS Option Menu**

## 6.10. Recorder

The Recorder Menu is provided on the Systems Tab and provides a way of managing files stored on the 8 GB memory card. You can download all or a selection of files by using the options presented in the Recorder window.

**Download all files** – downloads all files from the recorder

**Download selected files** – allows you to select files using the tick box next to the file name. Simply select the files to download and then click on Download selected files.

**Format Recorder** – Clears the memory of the recorder by erasing all files.

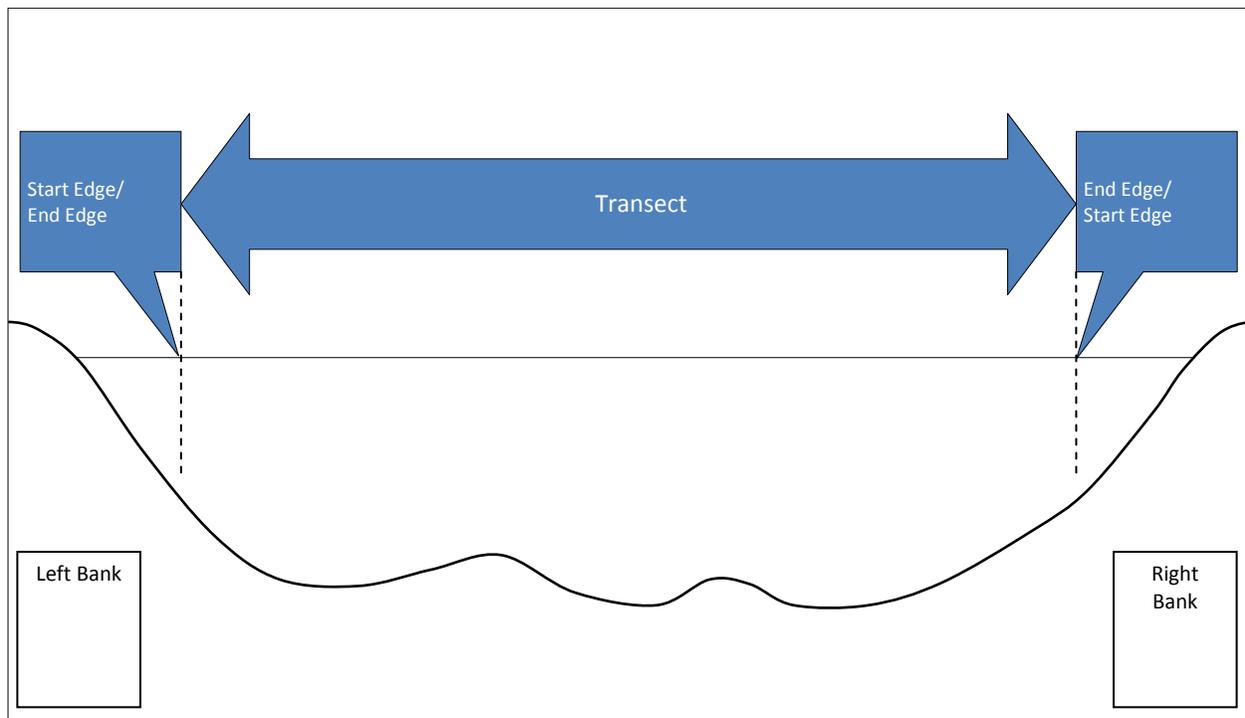
Make sure that there is adequate memory available on the recorder prior to making a discharge measurement. It is suggested to download files and format the recorder between measurement sites. At the very least, all files should be downloaded and the recorder formatted at the end of the day.

**Important:** To complete any post processing on the recorded data, the file(s) must be downloaded from the ADP and opened in the *RiverSurveyor Live for PC* software.

## 6.11. Data Collection

After completing the Pre-measurement tests and initial site specific entries to configure the System, you can begin the measurement procedure. The software provides a step-by-step procedure outlined below. Each step is explained in detail in the following sections.

Figure 41 displays key concepts for making a discharge measurement



**Figure 41. Steps for Making a Discharge Measurement**

### 6.11.1. Start System

Click the **Start a Measurement (F5)** button to start data collection. Figure 42 shows where that button is located on the System tab. Note that this does not record any data. Instead it allows the data from the system to be viewed to make sure the system is operating correctly. Make sure that all indicators (shown in the top left) are all valid (not red). Position the vessel at the start edge of the transect.

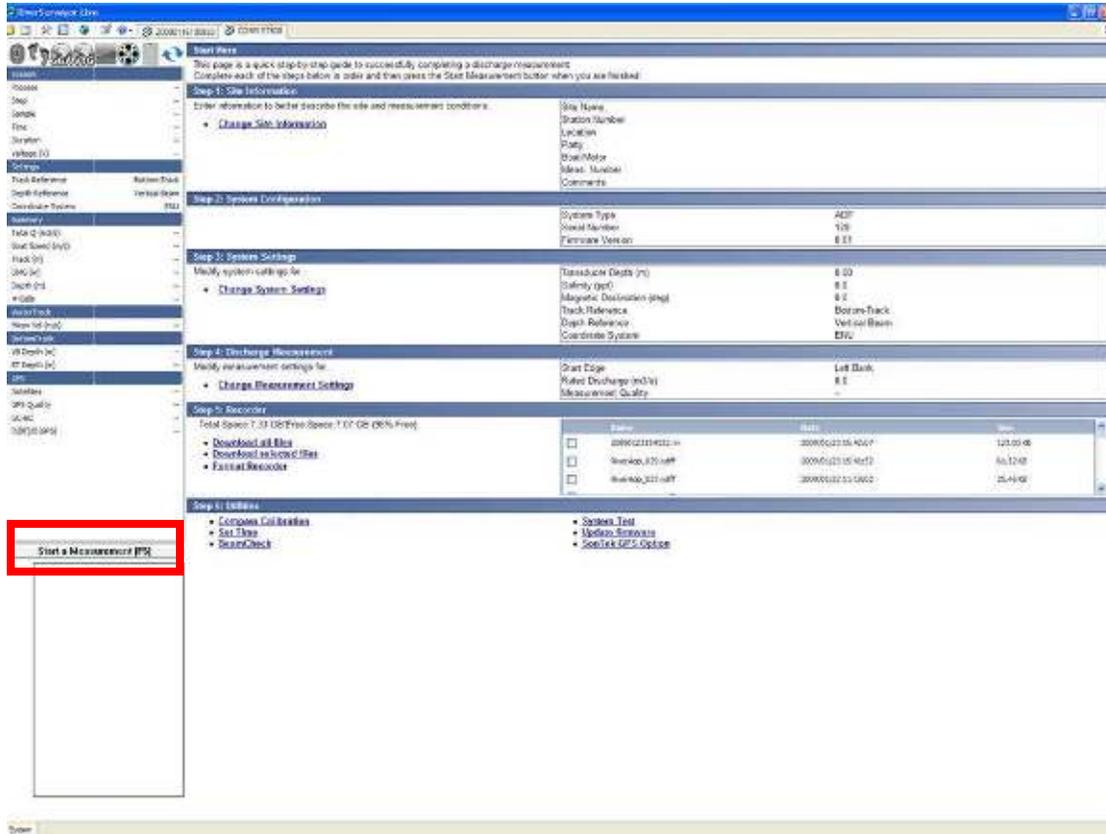


Figure 42. Data Collection – Start a Measurement (F5)

### 6.11.2. Start Edge

Click the **Start Edge** button (or **F5**) as shown in Figure 43 and collect at least 10 edge samples. The Edge window will be displayed (Figure 44) showing information for both edges. Try to keep the vessel as stationary as possible during this time. Input the start edge information into the Edge dialog that pops up and press OK.



### 6.11.3. Start Moving

Click the **Start Moving** button (or **F5**) and the Transect window (Figure 45) will be displayed. Try to keep the vessel speed and direction constant as it progresses across the river to the end edge.

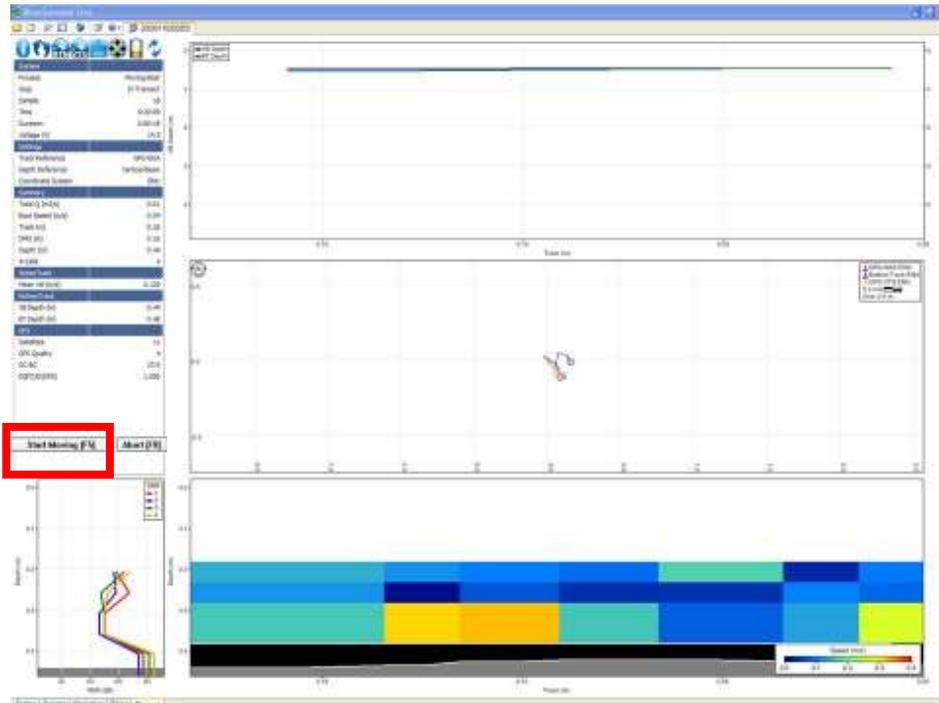


Figure 45. Data Collection – Start Moving

### 6.11.4. End Edge

Click the **End Edge** button (or **F5**) when the vessel reaches the edge of the opposite bank (Figure 46). A dialog box will prompt you to describe the End Edge (Figure 47). Note that the screen changes from the Transect Tab to the Edges Tab. This allows detailed viewing of the edge data collection. Be sure to collect at least 10 samples at the ending edge. Try to keep the vessel as stationary as possible.

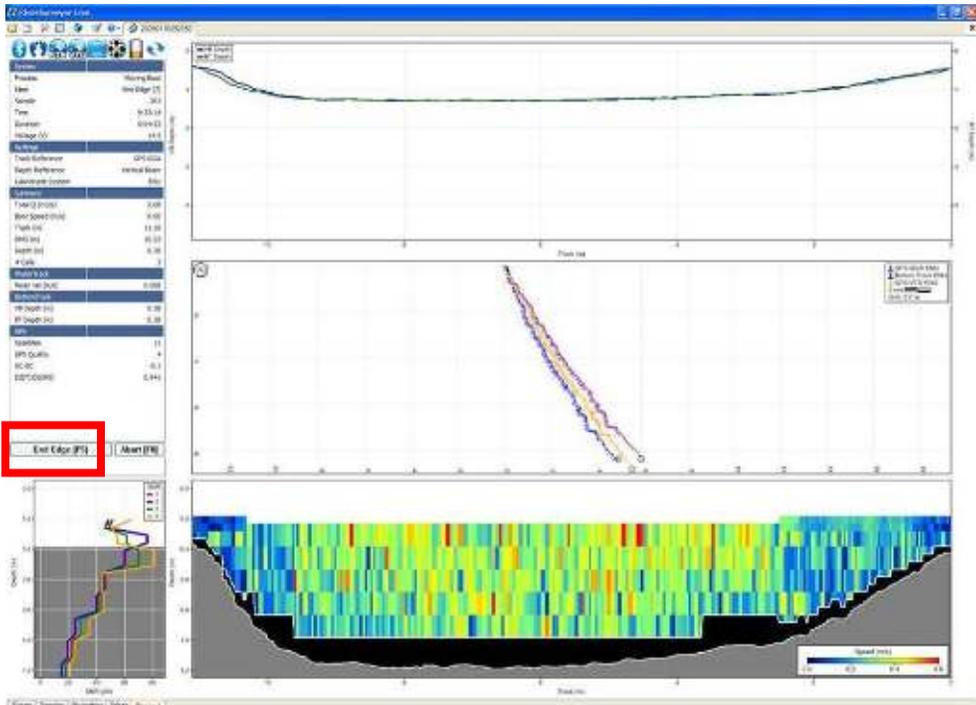


Figure 46. Data Collection – End Edge

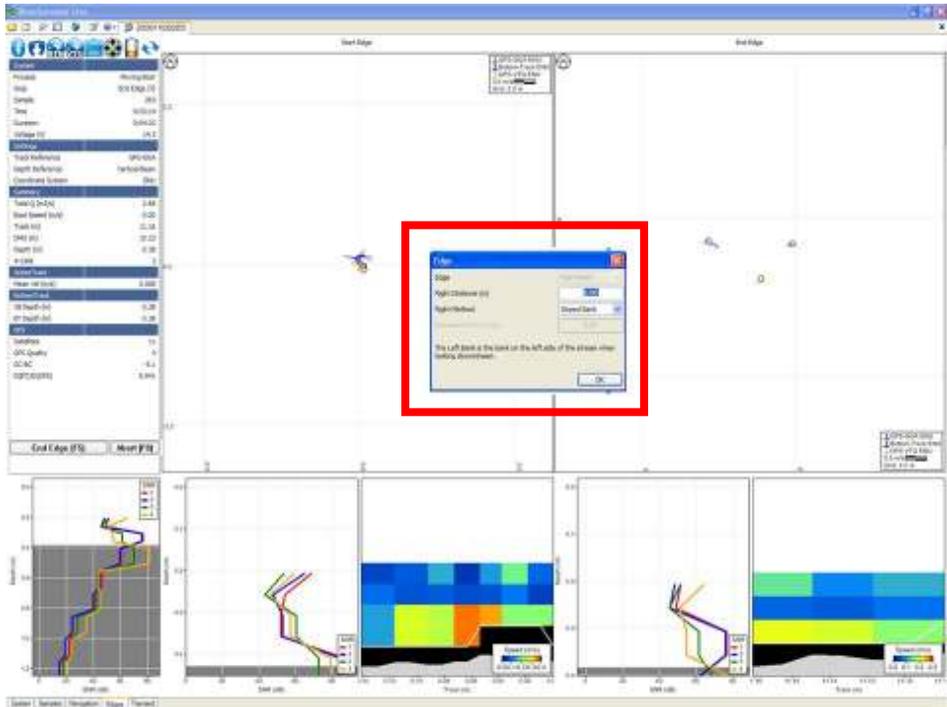


Figure 47. Data Collection - End Edge dialog box

**6.11.5. End Transect**

Click the **End Transect** (Figure 48) button upon completion of the end edge. This automatically opens a new data collection window so you can start a new measurement. The system is still running, so if you need to make another measurement, click the **Start Edge** button (or **F5**) to begin again as instructed in Section 6.11.2. If data collection is complete, click the **Abort** button

or press F8 to stop. It is recommended to go to the System tab and download the recorded data files upon completion of all the measurements.

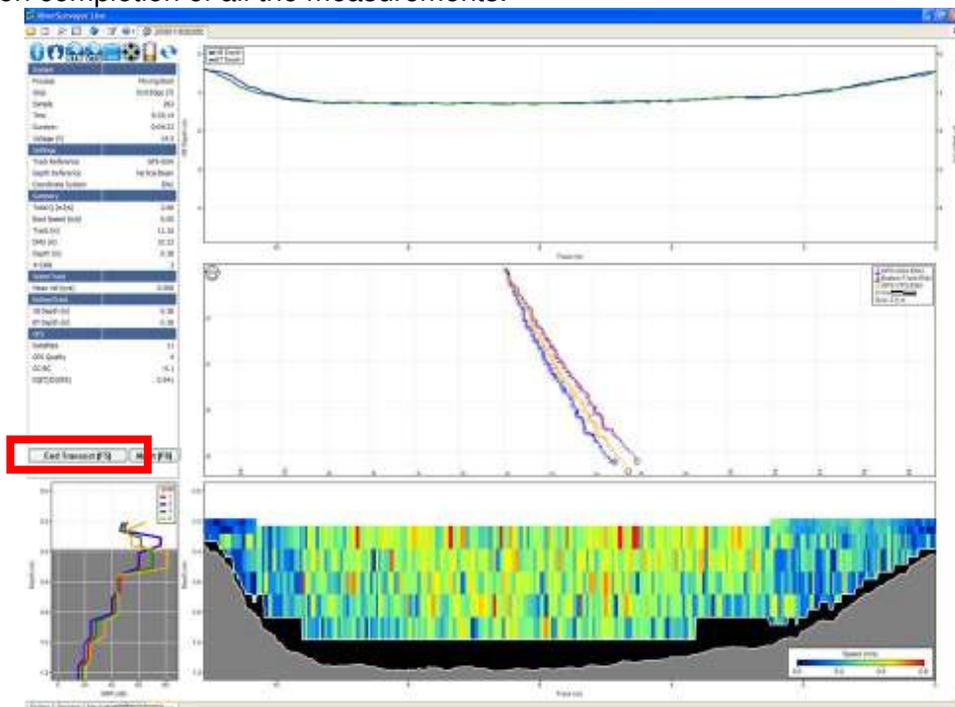


Figure 48. Data Collection - End Transect

## 6.12. Discharge Measurement Summary

By clicking the Discharge Summary icon, you can show or hide the Discharge Summary window at the bottom of the desktop. This window presents the collected data in tabular format and includes the status icons to evaluate the measurement (Figure 49). If desired, resize the window by using the slider arrow when the mouse pointer is positioned over the window border.

File	Start Date	Start Time	Duration	Width (m)	Area (m <sup>2</sup> )	Total Q (m <sup>3</sup> /s)
20090224080752.riv	24/02/2009	8:06:24	0:02:10	10.71	12.6	-8.98
20090224081053.riv	24/02/2009	8:07:26	0:02:09	9.86	13.4	-8.77
20090224081424.riv	24/02/2009	8:14:57	0:02:44	10.91	13.4	8.05
20090224081816.riv	24/02/2009	8:18:48	0:01:55	0.49	12.5	-8.37
		Mean	0:02:05	10.17	12.9	-8.29
		Std Dev	0:00:18	0.54	0.7	0.15
		CV%	0.000	0.053	0.008	-0.017

Figure 49. Discharge Measurement Summary

All records are ordered by date/time with icons for starting edge, depth and track reference and coordinate system. All records can be selected or deselected by clicking with the mouse; this affects the statistics presented and is a quick and easy to understand what effect each measurement has on the overall average of the measurements for the site.

Additionally, you can select data to include or exclude from the discharge calculation by simply clicking to activate or deactivate the check box. The Discharge Summary has the following options that can be used in post processing:



**Discharge Summary Report:** Generates a printer friendly report that summarizes all data used in the discharge calculation as well as the associated statistics (unchecked records are not displayed).



**Export Discharge Summary to ASCII:** Exports the information found in the discharge summary to an ASCII file (.txt).



**Delete selected discharge record(s):** Deletes the selected records (the ones with the red check). These records will not be used for the discharge calculation.



**Delete all discharge records:** Deletes all records present, essentially removing all transects for discharge calculation

Links between open files and records on the discharge summary are as follows:

- An open file will update its corresponding discharge record with changes to settings or as sample number changes.
- Closing a file leaves the record displayed in the discharge measurement summary, but the record will no longer update
- Deleting the record severs the link to the data file. To add the record back, the file must be reopened.
- Click on a record to switch to the matching data file.
- Delete or uncheck a record to re-compute statistics

## Section 7. RiverSurveyor Live for Mobile

### 7.1. Overview—RiverSurveyor Live for Mobile Software

Due to combined portability and ease of use, we recommend the Mobile device for making discharge measurements. The *RiverSurveyor Live for PC* software (described in section 6) can also be used for making discharge measurements and has the added ability to apply powerful data viewing and post-processing capabilities (described in section 8).

Before getting started in the field, remember that the Mobile device has some setup requirements, as does any mobile device/phone: Battery must be installed and charged, necessary software installed, and Bluetooth configured.

### 7.2. Mobile Device Requirements

*RiverSurveyor Live for Mobile* requires the following:

Operating System: Windows Mobile Smartphone v6.0 or higher

Bluetooth Technology: BroadComm stack and Bluetooth v2.0 with A2DP

Note: The Motorola Q, Q9h, Q9m and Q9c have been tested for full compatibility. Other Mobile devices with these specifications not supplied by SonTek may work, but they are not supported.

### 7.3. Installation

Prior to installing *RiverSurveyorLive for Mobile* on the Mobile device, please make sure that Microsoft ActiveSync is installed on your desktop or laptop PC. If you do not have ActiveSync installed it can be downloaded from the distribution CD or online at:

<http://www.microsoft.com/windowsmobile/en-us/help/synchronize/device-synch.aspx>

To install the software follow these steps:

1. Connect the Mobile device to your PC with a USB cable.
2. Copy the RiverSurveyor Live.CAB file from CD-ROM.
3. Open ActiveSync on your PC (Figure 50).

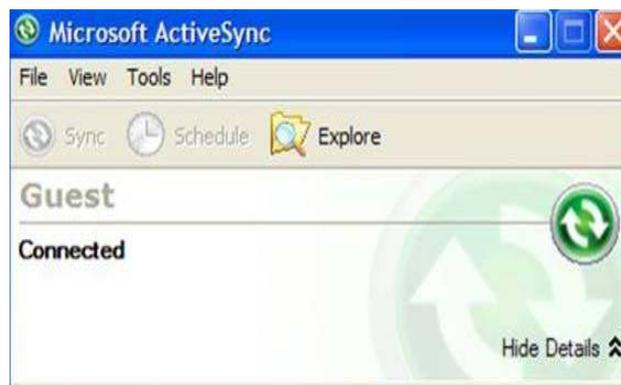
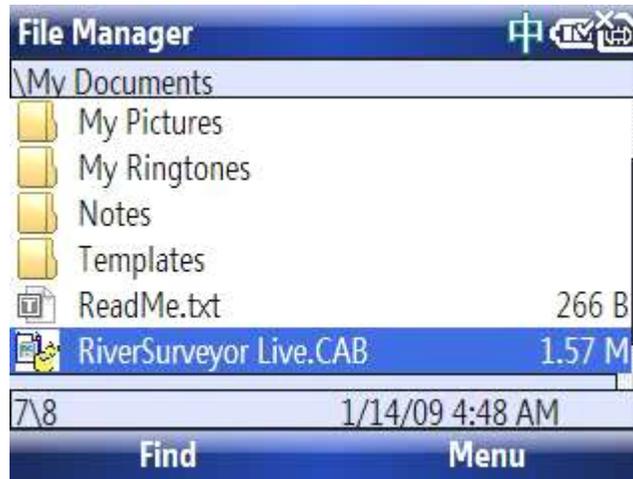


Figure 50. Active Sync Menu

4. Click the Explore button in ActiveSync (My Documents folder on the Mobile).
5. Paste the RiverSurveyor Live.CAB file to the open folder (My Documents) from the Explore window
6. In the Mobile device, use File Manager to open My Documents (Figure 51).



**Figure 51. File Manager Menu - My Documents**

7. Click the RiverSurveyor Live.CAB file.
8. The RiverSurveyor Live application will automatically install on the Mobile device and automatically confirm the installation of the application (Figure 52).



**Figure 52. Software Confirmation Window**

When the installation is complete, disconnect the Mobile device from the PC and click on the Start button of the Mobile. Verify that the RiverSurveyor icon is displayed in the list of applications (Figure 53). Following the first use of the RiverSurveyor, the icon will be displayed on the shortcut key (Figure 54).



Figure 53. RiverSurveyor Icon in Application List



Figure 54. RiverSurveyor Icon on Shortcut List

#### 7.4. Navigation and Controls for Mobile Device

*RiverSurveyor Live for Mobile* has an intuitive design for navigation and control through its various menus. Text can be entered in various fields using the letter keys on the phone. Navigation from field-to-field in various menus is done using the arrow keys at the top center of the phone. Soft keys can select options, change between screens, and even start and stop data collection. Figure 55 shows an example of the Mobile device with indicators of various functions. Below are a few tips for using the Mobile device:

1. For numerical entry, press the Function key and then the number in edit boxes
2. To lock numerical input (more than one number), press the Function key twice
3. To select or “click” on an item, press the Enter key
4. To view the previous screen, press the Back key
5. To erase all content in a data field, press the Back key
6. To minimize an application, press the End key (minimizing does not close an application)



**Figure 55. Mobile Device Functions**

## 7.5. Starting the Software and Connecting to the System

To start *RiverSurveyor Live for Mobile*:

1. Select Start on the bottom left of the Mobile device screen.
2. Use the arrow keys to navigate to the *RiverSurveyor Live for Mobile* application icon  and select it. Or, select the icon from the short cut key.

A Search screen appears (Figure 56) when you start the software. The software will automatically search for any Bluetooth capable *RiverSurveyor* systems within range of the Mobile device (60m). Any *RiverSurveyor* systems within range will be listed on the screen.



**Figure 56. System Search Screen**

From the list, select the desired system and press the corresponding soft key to Connect (Figure 57). In the case that only one system is found, the software will connect automatically. In the case that no RiverSurveyor system is found or within range, a “No device found” will be displayed. Make sure that the dummy plug is installed, all system LEDs on the PCM are correct, and the battery is charged and installed correctly. Then, click Search Again.

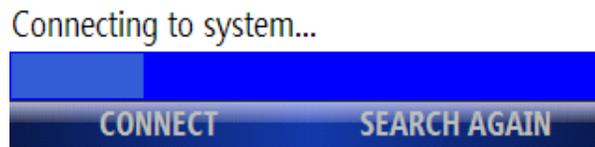


Figure 57. Connection to ADP with Serial Number ADP-S5 5

## 7.6. Preparing for a Measurement - Main Menu

Once a connection is established, the Main Menu (Figure 58) is displayed and is used to enter site information and initial site parameters. Each of the menu items can be accessed using the control pad or by pressing the corresponding number on the keypad. The START and QUIT options (bottom bar) are selected using the soft keys.

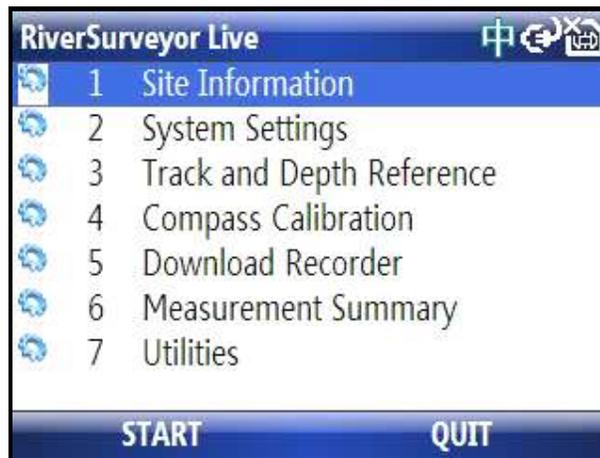
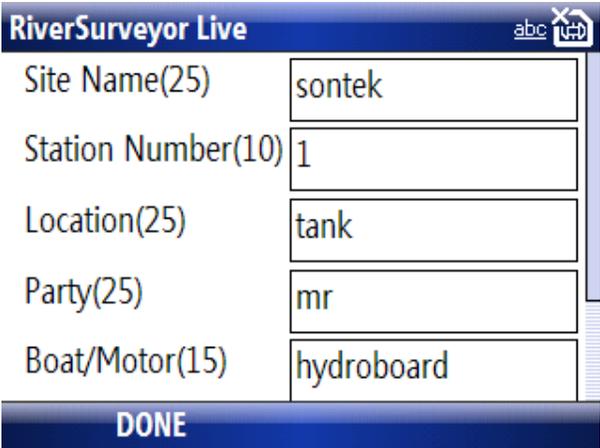


Figure 58. Main Menu

**7.6.1. Site Information (1)**

On the Site Information screen (Figure 59), specific site information such as Site Name, Station Number, Location, Party, Boat/Motor, Measurement Number, and Comments can be entered. To enter data, use the letter keys and the arrow keys to move between fields.

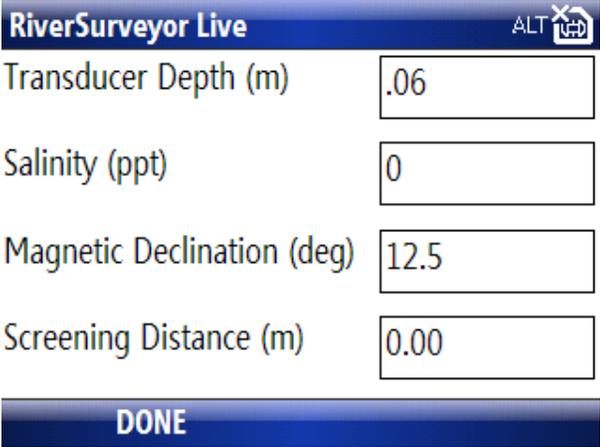


**Figure 59. Site Information Screen**

The number in parentheses following each field in Figure 59 indicates the number of characters allowed in the field. If this value is exceeded, an error message is displayed. The information entered in this menu is applied to all future measurements, until the system is powered off.

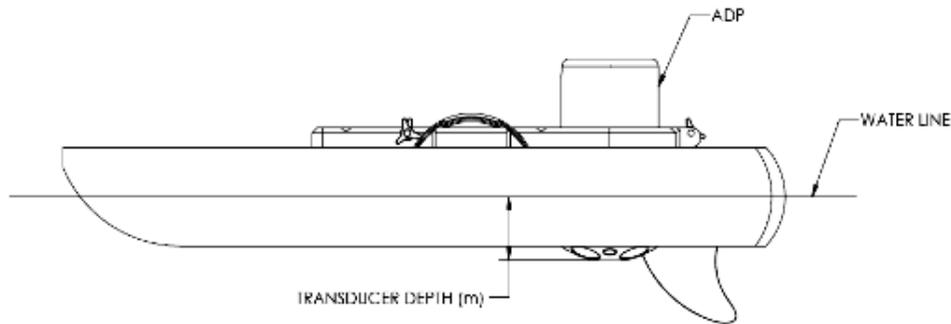
**7.6.2. System Settings (2)**

The System Settings screen (Figure 60) is for entering transducer depth, salinity, and magnetic declination. A description of each field is presented below. After entering System Settings parameters, select DONE to update the values in the system and return to the Main Menu.



**Figure 60. System Settings Menu**

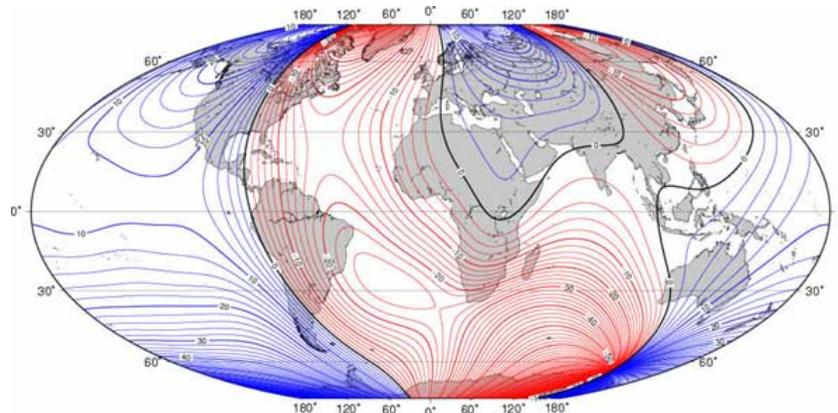
**Transducer Depth** – This is the distance that the vertical beam transducer is submerged below the surface. Figure 61 shows a basic diagram that depicts an ADP’s transducer face submerged in water. Transducer depth corresponds to the depth of water to which the transducer face is submerged.



**Figure 61. Explanation of Transducer Depth Measurement**

**Salinity** – This user-defined parameter allows for a correction for the speed of sound in water based on the salinity in parts per thousand (ppt) at the face of the ADP. A value representative of the local water conditions must be entered manually to avoid potential erroneous calculations. For reference, the salinity range is between 0 ppt (freshwater) to 34.5 ppt (seawater). Water temperature is also a factor for speed of sound in water calculations. The ADP has a built-in temperature sensor that automatically compensates for this effect.

**Magnetic Declination** – On the earth’s surface, a calibrated compass indicates magnetic North rather than geographic North. The angular difference between these two directions is called magnetic declination (also known as variation, magnetic variation, or compass variation). Magnetic declination varies across the earth’s surface and over time. The ADP compass is shipped pre-calibrated; however, calibration is required at each site to remove any magnetic bias present at the site. Compass calibration will ultimately give better measurement accuracy. The magnetic declination angle ( $\theta$ ) can be found on maps, like the one presented in Figure 62. Magnetic declination maps can be found on many sites on the internet. However, it is important to note that ALL of the magnetic declination values obtained from the internet and/or software are *modeled* values and not actual values measured in the field. As such, variations between the values obtained from websites and/or software may contain small errors. Correcting for such errors can be made with the “Heading Correction” field in the Thresholds menu of the Processing Toolbox (see p.**Error! Bookmark not defined.**).

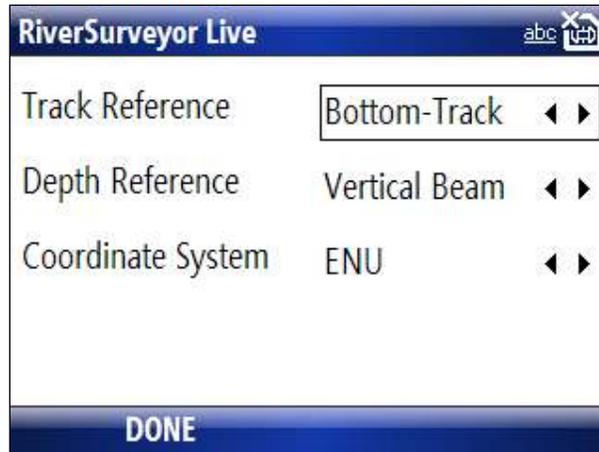


**Figure 62. Magnetic Declination Map of the World**

**Screening Distance** – This is the distance below the face of the ADP that you want to start collecting data. In essence, this setting allows you to program the ADP to start collecting data below a certain point. This is primarily used for over-the-boat applications where the screening distance can be set to avoid flow disturbance from the wake of the boat.

### 7.6.3. Track and Depth Reference (3)

The Track and Depth Reference menu (Figure 63) displays options for the track reference, depth reference, and coordinate system. Use the up/down keys to move between fields. To change an option in a field use the left/right keys. When finished, select DONE (at the bottom) to update the settings and return to the Main Menu.



**Figure 63. Track and Depth Reference Menu**

**Track Reference** – The ADP measures a water velocity using the Doppler shift principle, using multiple acoustic pulses transmitted and received throughout the water column. When the ADP is in motion, the water velocity actually measured by the ADP is a combination of boat velocity and water velocity. In order to determine true water velocity, the boat speed must be known and then subtracted from the actual water velocity measurement. The RiverSurveyor “moving boat” discharge application uses three methods (references) to determine boat velocity.

1. **Bottom-Track reference velocity:** The ADP itself is capable of determining boat speed using a technique called “ ”. In this case, bottom-track velocity is calculated using the Doppler shift received from multiple acoustic pulses (transmitted from the ADP) that have reflected off of the riverbed. If the riverbed is stationary (i.e. non-moving bottom), then the Doppler shift velocity will consist entirely of boat speed velocity which is acceptable for discharge calculations. If the riverbed is in motion the Doppler-shift-based velocity will consist of both boat speed and riverbed speed which will bias discharge calculations. In this case, the following two references would be preferred to determine boat velocity.
2. **GGA GPS-referenced velocity:** GP GGA (GGA) refers to a specific NMEA-0183 protocol for outputting GPS position data. In this case, the GGA “string” contains actual position (latitude/longitude) information along with several other GPS quality parameters. Boat velocity is calculated by measuring the distance between two successive GGA positions divided by the travel time between those two positions. Differential corrections are required for the GGA data to reduce the amount of position error associated with each measurement. The RiverSurveyor uses two types of differential corrections: “Sub-meter” differential and “Real-Time Kinematic” (RTK).

3. **VTG GPS-referenced velocity:** GPVTG (VTG) refers to a specific NMEA-0183 protocol for outputting GPS velocity data. In this case, the VTG string contains the actual boat speed information along with several other GPS parameters. The GPS velocity is calculated based on the Doppler shift of the received satellite signals.

Select the default track reference for the measurement. All available track references will be available for analysis or to recalculate discharge in post-processing. There are four options:

- **Bottom-Track:** The ADP uses the bottom-track feature to measure the velocity of a vessel relative to the river bottom. The vessel velocity is then subtracted from the measured water velocity to give the absolute water current profile independent of vessel motion. This is the only track reference available for systems without an optional GPS.
- **GPGGA:** The ADP uses the GGA string (from the GPS data) to measure velocity of a vessel based on GPS position data. This is only available for systems configured with a GPS option. It is recommended that GGA data use a sub-meter differential or RTK correction for discharge calculations. The highest quality and most accurate method applies RTK-corrected data.
- **GPVTG:** The ADP uses the VTG string (from the GPS data) to measure the velocity of a vessel based on GPS velocity data. This method requires additional review of data quality parameters to verify data quality.
- **System:** The ADP references all velocities only to itself. This should only be used in specialized applications by experienced users. It is **not recommended** for discharge measurements from a moving vessel.

**Depth Reference** – Select the default depth reference for the measurement. Both options are available for analysis or to recalculate discharge in post-processing. There are two options:

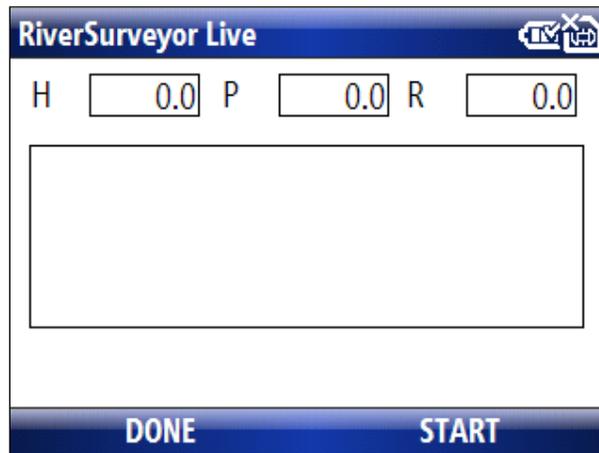
- **Vertical Beam:** This is highly accurate echo sounder data used to determine water depth.
- **Bottom-Track:** This uses data from the four angled beams to determine the depth of the water column using the average depth from each beam.

**Coordinate System** - Select the default coordinate system for the measurement. All options are available for analysis or to recalculate discharge in post-processing. There are three options:

- **ENU:** This is the traditional East, North, and Up coordinate system.
- **System:** This uses the ADP as a reference. Used for internal testing only.
- **XYZ:** This is a three-dimensional “relative position” coordinate system used only for specialized applications by experienced users.

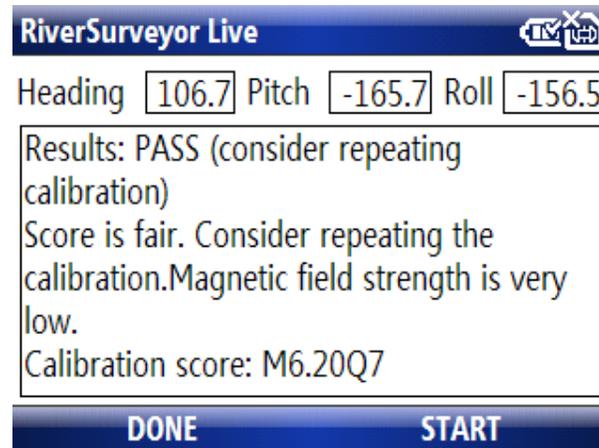
#### 7.6.4. **Compass Calibration (4)**

A compass calibration is necessary prior to each discharge measurement to compensate for magnetic fields specific to the site. When ready to perform the calibration, click START. Rotate the ADP through two complete circles while varying pitch and roll angles as much as possible. It is important to calibrate the compass on the boat or mount and as close to the measurement location as possible. Be sure to remove any mobile phones, PDAs or other metal objects from the area prior to calibration. Figure 64 shows the Compass Calibration menu.



**Figure 64. Compass Calibration Menu**

At the end of calibration process, select DONE, and a calibration score will be displayed as shown in Figure 65, and will be saved to the SD memory card. Using the example below, the calibration score is M6.20Q7. The M “value” should always be less than 10 and the Q “value” should always be very high (based on a scale from 1-10). If the result is anything other than “Pass” the process should be repeated.



**Figure 65. Calibration Score**

In the case that the SD memory card is not installed in the Mobile device, you will be notified. The calibration can still be run, but will not be saved.

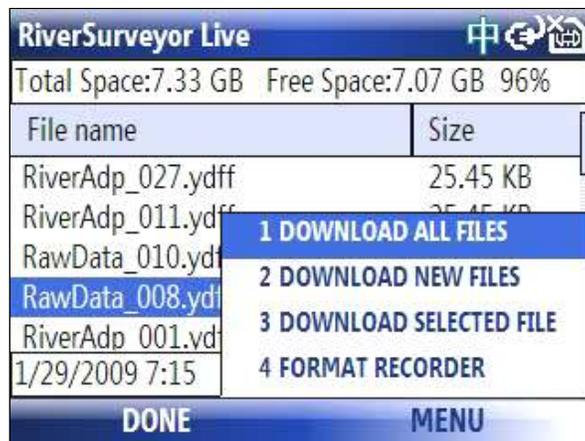
### 7.6.5. **Download Recorder (5)**

This menu displays the status of the recorder or memory of the ADP. The Download Recorder menu (Figure 66) shows the recorder’s Total Space, Free Space, remaining capacity (as a percentage), and recorded file names and sizes. The file names use a four-digit year, two-digit month, day, hour, minute, and second format (YYYYMMDDHHMMSS). All RiverSurveyor Live files have an .riv extension. Within this menu, additional options are available through the MENU soft key. This submenu has the following options.

- **Download All Files:** Downloads all data files into the SD storage card on the Mobile device (if no card, an error is displayed). A folder on the Mobile device is created named SonTek Data. Gauging data is saved in a subfolder name based on the date/time recorded.
- **Download New Files:** Downloads all files which are not already on the storage card.

- **Download Selected Files:** Downloads individually selected files to the SD storage card.
- **Format Recorder:** Erases all data files on the ADP/system recorder.

Transferring files from the Mobile device to PC is easy: Simply insert the SD card from the Mobile device into the PC, and access the files as you would a USB drive. Alternatively, connect the Mobile device to the computer via a USB cable to transfer files using Windows Explorer.



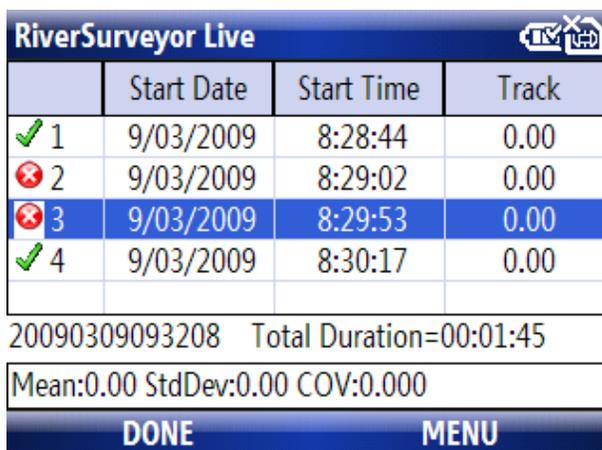
**Figure 66. Download Recorder Menu**

Make sure that there is adequate memory available on the recorder prior to making a discharge measurement. It is suggested to download files and format the recorder between measurement sites. At the very least, all files should be downloaded and the recorder formatted at the end of the day.

**Important:** To complete any post processing on the recorded data, the file(s) must be downloaded from the ADP and opened in the *RiverSurveyor Live* for PC software.

### 7.6.6. Measurement Summary (6)

The Measurement Summary displays a running list of the discharge measurements you have made, sorted by date/time (Figure 67). The Measurement Summary helps you evaluate data collected in the field. Using the Menu or numeric keys allows for various views of the available data fields. A checkmark next to a measurement indicates that the measurement is used in the statistics provided at the bottom of the window. A red "x" indicates the measurement is excluded from the statistics. Simply use the arrow keys to scroll through the measurements, and the Enter key to select or deselect measurements for the statistics.



**Figure 67. Discharge Measurement Summary**

Using the Menu Key, you can display 12 different data fields using 4 different view options. Alternatively, you can press the number keys 1, 2, 3 or 4 to change views (Figure 68).

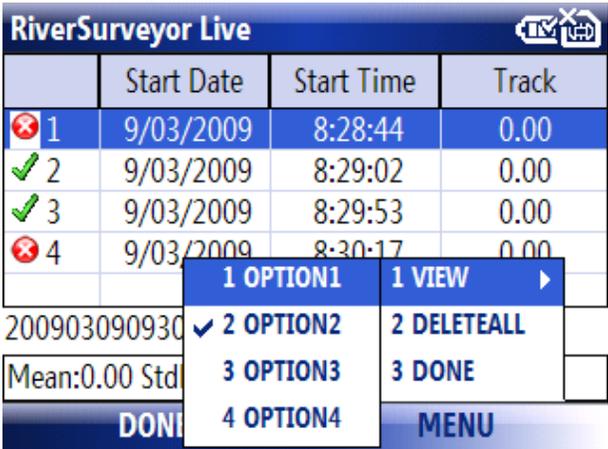


Figure 68. Menu Options in the Measurement Summary

**Important Note:** Turning off the Mobile device will clear all records from the Measurement Summary on the Mobile device. The full Discharge Measurement Summary is still stored on the ADP system’s internal recorder, however, and can be viewed when the data files are downloaded from the recorder. Also, the **DeleteAll** option deletes all Measurement Summary records from the Mobile device.

7.6.7. Utilities (7)

The Utilities Menu (Figure 69) provides several options explained below. The System Test (option 3) is recommended prior to data collection. Select DONE to exit the Utilities Menu.

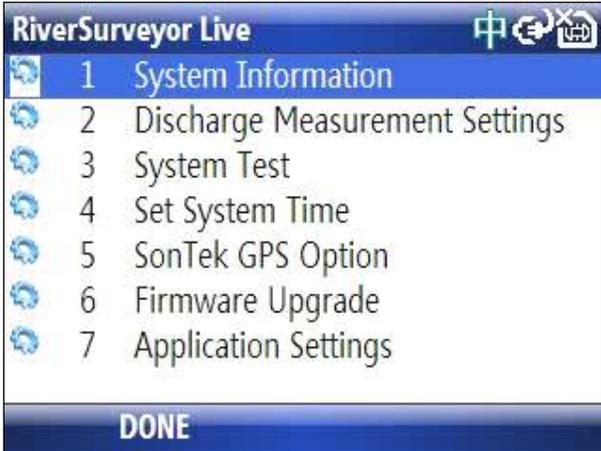


Figure 69. Utilities Menu

**System Information** (Figure 70): Shows system type, serial number and firmware version.

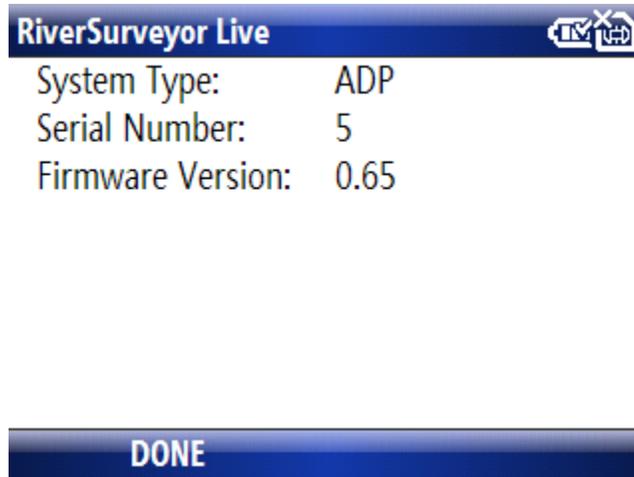


Figure 70. Utilities – System Information

**Discharge Measurement Settings** (Figure 71): Information that is applied to the discharge measurement.

- **Start Edge** – Sets the default starting edge for discharge measurements (right or left bank).
- **Rated Discharge** – Enter a rated discharge pre- or post-measurement. This information is useful for post-processing data analysis and evaluation.
- **Measurement Quality** – A post-processing qualitative input to evaluate the discharge measurement quality.

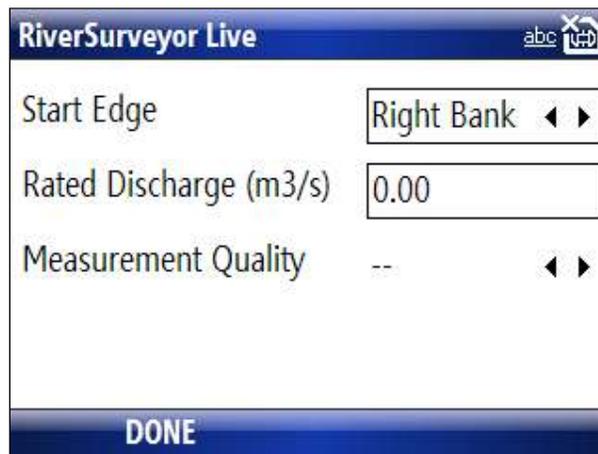
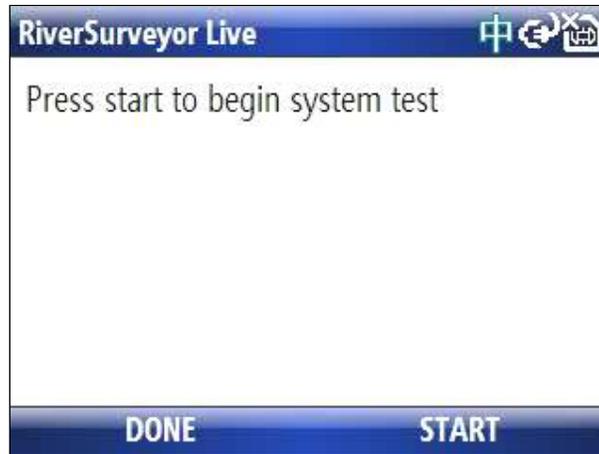


Figure 71. Utilities – Discharge Measurement Settings

**System Test** (Figure 72): Runs a diagnostic test confirming the status of the battery, temperature sensor, internal 8-GB recorder, and compass. When finished, the system reports the test results and saves them to a file in the SonTek Data folder of the SD card of the Mobile device. You will be notified of either a System Test PASS or FAIL result.

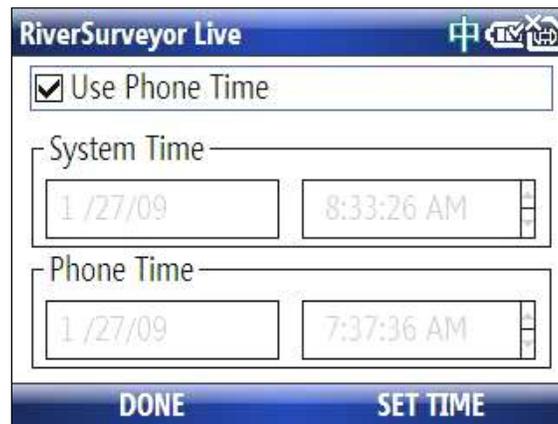


**Figure 72. Utilities – System Test**

There are four possible System Test failure messages (provided below), all of which require user action prior to making valid discharge measurements.

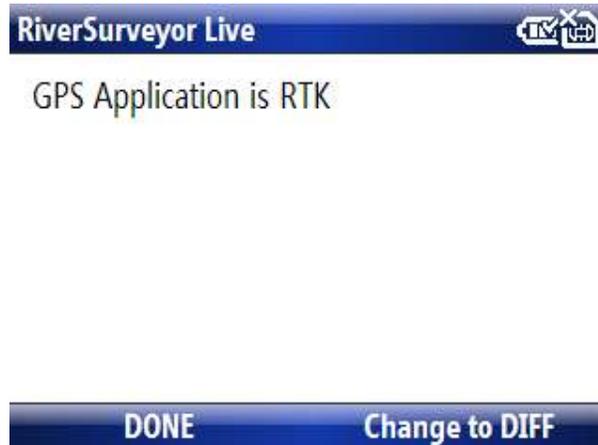
- System battery voltage > 12 volts
- System compass is not working
- System SD card is not working
- Temperature sensor is not working

**Set System Time** (Figure 73): Used to set system time to the Mobile device time or to a manual entry. Typically, this is a pre-processing setting that can be used as a default for all measurements. Use the up/down keys to navigate between fields and the number keys to enter data. Select SET TIME to update the system time and DONE to return to the Utilities Menu.



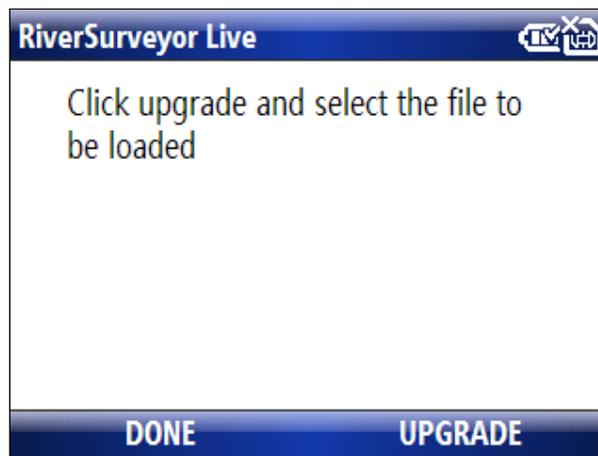
**Figure 73. Utilities – Set System Time**

**SonTek GPS Option:** Confirms the current SonTek GPS application and provides the option to change to a different application (Figure 74). For RTK GPS applications, you can change from RTK quality GPS to Differential quality GPS and vice versa. However, systems with only Differential quality GPS cannot change to RTK quality GPS based on hardware constraints. There is no capability of integrating a shore-station differential GPS correction.



**Figure 74. Utilities - SonTek GPS Option**

**Firmware Upgrade** (Figure 75): This menu lets you update ADP firmware by selecting a firmware file (\*.a79) stored in the phone's memory card (SD) or internal memory. Select UPGRADE and follow the on-screen instructions to install new firmware.



**Figure 75. Utilities – Firmware Upgrade**

Figure 76 shows the Find File screen that displays a menu for finding the firmware upgrade file. If a file is not selected, an error message is displayed. You can navigate with the up/down keys and select with the enter key. Additional options are available via the MENU option. Select Open to upload the firmware file.

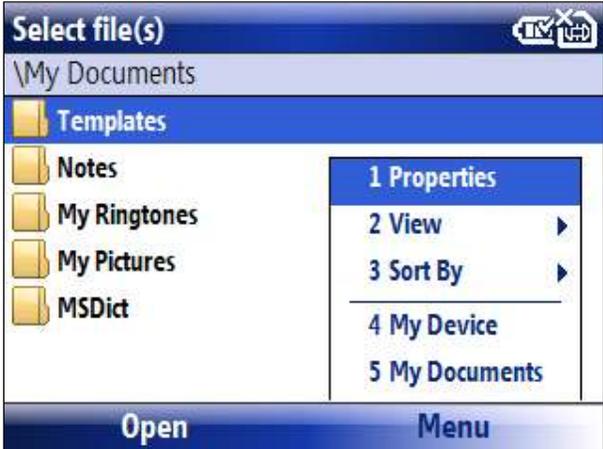


Figure 76. Utilities – Firmware Upgrade Find File Screen

**Application Settings** (Figure 77): Activating the check-box for Bluetooth: Connect Automatically enables the software to connect to the first system detected. This menu is also used to apply either Metric or English units. Typically, these options are applied as default settings. Select DONE to update these settings and return to the Utilities Menu. In the bottom right of the window, the version of the software is indicated.

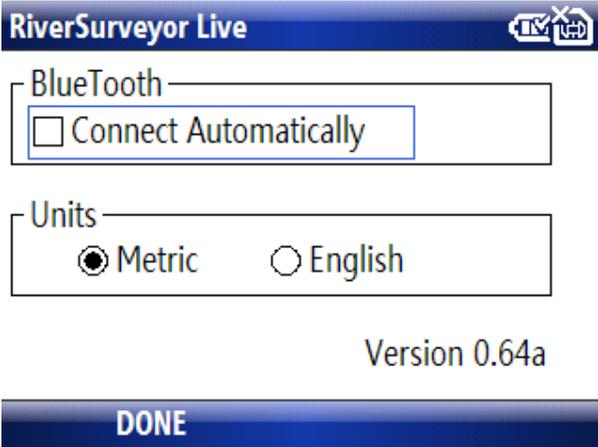


Figure 77. Utilities - Application Settings

## 7.7. Discharge Measurement - Data Collection

Below is a detailed procedure for conducting a discharge measurement. In general the process has five steps which include the following:

1. Start a Measurement
2. Start Edge
3. Start Moving/Transect
4. End Edge
5. End Transect

Once a measurement is started, the software prompts you at each step, allowing you to focus on the measurement.

### 7.7.1. Starting the measurement

To start data collection using the moving boat method, select START from the Main Menu view (Figure 78). The system starts “pinging” and collecting data profiles.

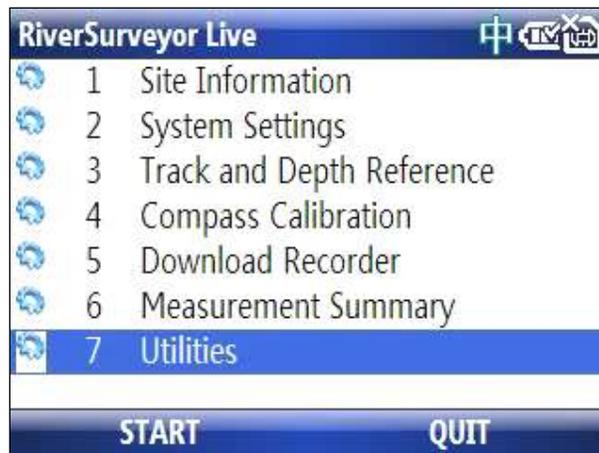


Figure 78. Main Menu – Start Data Collection

Appendix A provides a description and list of icons used on the software’s status bar. Note that icons are color coded – typically moving from the color blue (indicating optimal status) to red (indicating nonfunctional). Gray indicates the option is not installed.

### 7.7.2. Start Edge

By pressing the soft key corresponding to **Start Edge** (Figure 79) you are prompted to enter Starting Edge (Left or Right bank), Method (slope bank, vertical bank, user input), and Distance (i.e., distance from Starting edge) as displayed in Figure 80. After entering the edge information, select **OK** to view start-edge samples. In order to collect precise and accurate information, make sure the boat is as motionless as possible



Figure 79. Data collection - Start Edge

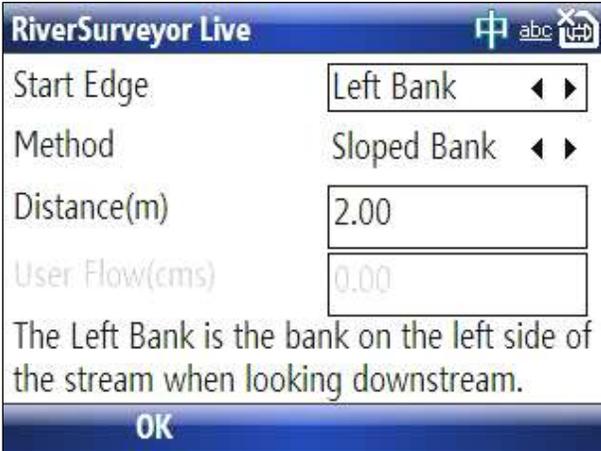


Figure 80. Data Collection - Start Edge Inputs

Figure 81 shows the RiverSurveyor collecting data after entering START EDGE inputs. Collect at least 10 profiles/samples edge and select **START MOVING** to go to the next step. At this point, it is important to make sure the system is running and collecting samples. It is also important to confirm the status icons are valid (see Appendix A).



Figure 81. Data Screen After Start Edge

### 7.7.3. Start Moving

Before moving the vessel across the transect, press **Start Moving**. Now start moving the system smoothly and slowly across the channel. Figure 82 displays the Start Moving screen.

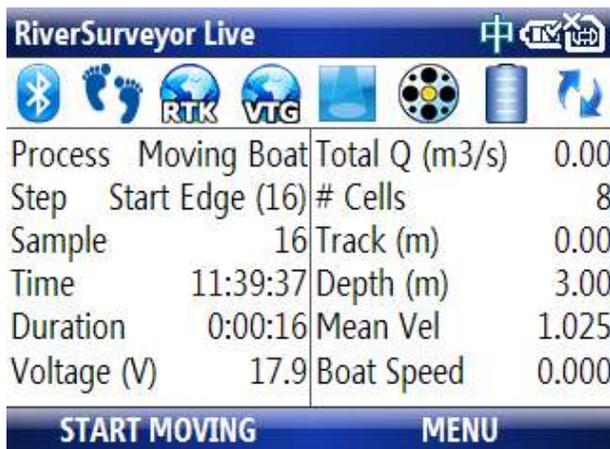


Figure 82. Data collection - Start Moving

This window shows the data as it's being collected across the channel. Additional views are available to display the other data parameters being collected. Press the Menu key to select the data display to view. The number keys 1, 2, 3 or 4 can also be used to change the views, as shown in Figure 83.



Figure 83. Data Collection – Start Moving Data View

### 7.7.4. End Edge

After arriving at the opposite bank, select **END EDGE** (Figure 84). You are then prompted (Figure 85) to enter Method (Vertical Bank, Sloped Bank, User Input) and Distance (i.e., distance from ending edge). If you set Method to User Input, use the User Flow field to enter an estimate of flow for this area starting from the ending edge. Select **OK** to go to the END TRANSECT menu. Be sure the vessel stays as motionless as possible to collect the best edge data. Collect at least 10 samples/profiles before going to the End Transect step.

RiverSurveyor Live 20090309113923			
Process	Moving Boat	Total Q (m <sup>3</sup> /s)	8.88
Step	In Transect	# Cells	8
Sample	29	Track (m)	3.00
Time	11:39:50	Depth (m)	3.00
Duration	0:00:29	Mean Vel	0.773
Voltage (V)	17.9	Boat Speed	1.001
END EDGE		MENU	

Figure 84. Data collection - End Edge

RiverSurveyor Live	
End Edge	Right Bank ◀ ▶
Method	Sloped Bank ◀ ▶
Distance(m)	<input type="text" value="2.00"/>
User Flow(cms)	<input type="text" value="0.00"/>
The Left Bank is the bank on the left side of the stream when looking downstream.	
OK	

Figure 85. Data collection - End Edge information

7.7.5. End Transect

Figure 86 shows the End Transect screen. Press the End Transect button to complete the measurement.

RiverSurveyor Live			
Boat/Water	0.0	Satellites	10
DMG (m)	121.08	GPS Quality	4
Temperature	23.9	D(BT)/D(GPS)	1.000
Heading (deg)	273.6	GC-BC	0.0
Pitch (deg)	0.1	GPS Age	1.00
Roll (deg)	0.1	HDOP	0.9
END TRANSECT		MENU	

Figure 86. End Transect Screen

After the transect ends, the Measurement Summary screen appears (Figure 87). It shows data from each transect as well as statistical calculations. Arrow keys allow movement from cell to cell. Using the Select key in the left column includes/excludes transects, which changes the statistics. This lets you discard invalid transects, making the final discharge calculation available in the field.

	Start Date	Start Time	Track
✓ 1	27/01/20...	9:18:03	0.00
✓ 2	27/01/20...	9:34:22	0.00
20090127082213 Total Duration=00:18:01			
Mean:0.00 StdDev:0.00 COV:0.000			
CONTINUE		MENU	

Figure 87. Discharge Measurement Summary Screen

Select CONTINUE to make another measurement, or MENU and DONE to go to Main Menu. At any step in the moving boat process, you select MENU and then ABORT to cancel the measurement and go back to main menu. Also at any step, you can select MENU and then DISCONNECT to disconnect the Mobile device from the system, but leave the system still running. You can reconnect to the ADP with the same or different Mobile device, or with a PC, all while the system continues to collect data without losing any information. Figure 88 displays the Abort and Disconnect options.

RiverSurveyor Live 20090309113923			
Boat/Water	1.3	Satellites	10
DMG (m)	80.05	GPS Quality	4
Temperature	23.9	D(BT)/D(GPS)	1.000
Heading (deg)	273.6	H	0.0
Pitch (deg)	0.1		0.0
Roll (deg)	0.1		0.9
END EDGE		MENU	

Figure 88. Data Collection - Abort and Disconnect Options

### 7.7.6. Data collection - Swapping between Mobile Device and PC

The *RiverSurveyor Live* software allows you to swap between measurement devices (Mobile device and PC) while the system is collecting data. Data collected by the RiverSurveyor system (ADP) is stored inside the ADP, so there is no risk of losing data when swapping between devices. More importantly, the data will not be lost if communications to the ADP is interrupted for any reason.

To swap from the Mobile device to a PC, disconnect from the system during data collection. This is done by pressing the Menu button and then Disconnect as displayed in Figure 88. Simply connect to the system with a PC or other Mobile device to continue with the measurement.

### 7.7.7. Transferring Data from Mobile Device to PC

Transferring data files from the Mobile device to the PC is done by simply connecting the Mobile device to the PC via a USB cable. Make sure that ActiveSync is installed on the PC so the Mobile device and PC can communicate. After the Mobile device is powered on and connected to the PC, ActiveSync will recognize the Mobile device and display it as a Mobile device on the PC in Windows Explorer.

You can then go to the appropriate folder that contains the collected data (data files have a .riv extension) and download (Save, Copy and Paste, or Cut and Paste) the files to the desired folder on the PC. The PC folder is where you will access the data for viewing, post-processing, and analysis using the *RiverSurveyor Live for PC* software. Figure 89 shows the Main Menu window for *RiverSurveyor Live for PC*. In the section titled Data Files (highlighted in red), files can be selected manually, or they can be opened using hot links to the most recently used files.



Figure 89. Main Menu for *RiverSurveyor Live for PC*

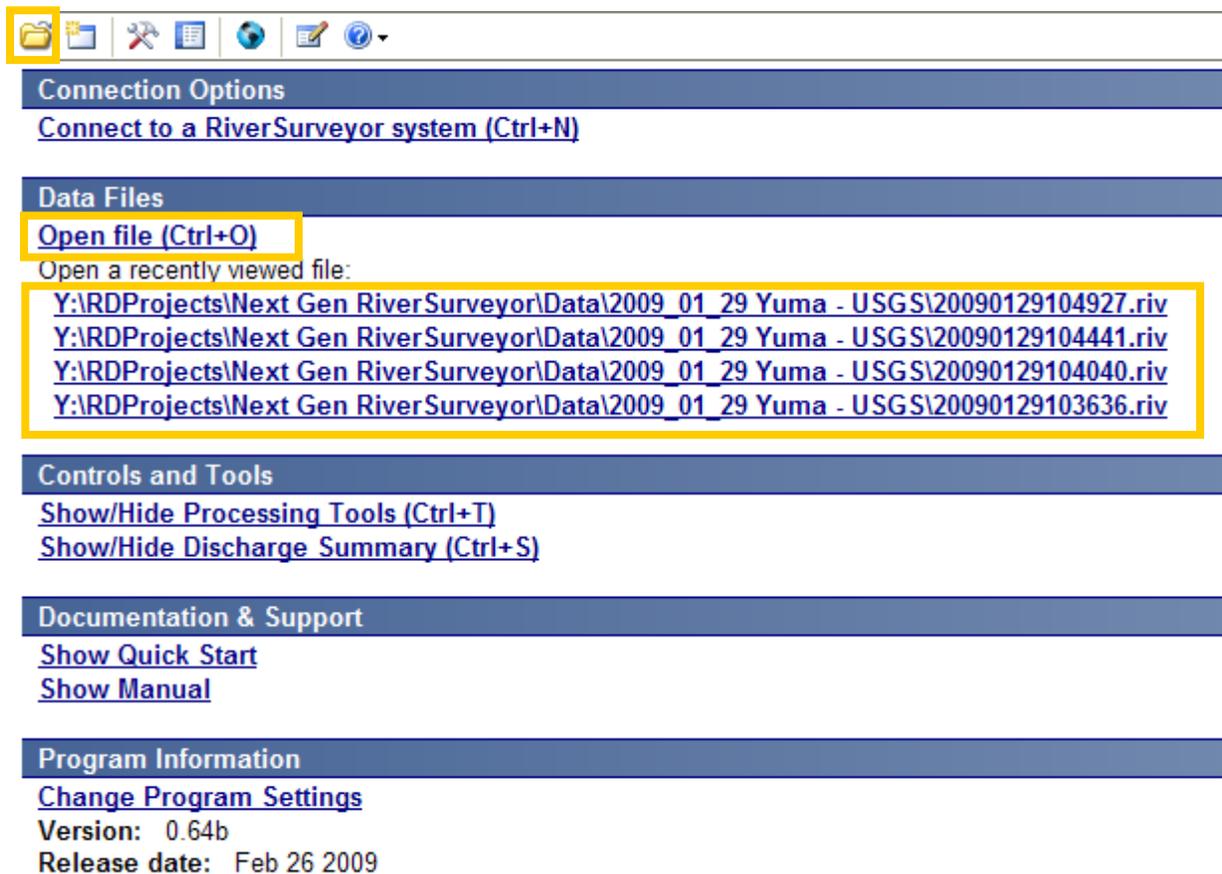
## Section 8. Reviewing Data Files/Post-Processing

### 8.1. Overview

This section is to be used as a guide to open, view and post-process data files using the *RiverSurveyor Live for PC* software. An initial explanation will describe the layout of the data and the various tabular views. A detailed description of the post-processing options will follow.

### 8.2. Opening Data Files

To open and process data in *RiverSurveyor Live for PC*, all data files must have the .riv extension. Figure 90 shows three ways to open data files. Click the open file icon (the folder) on the top toolbar to browse for and select a file. Alternatively, you can click on the **Open file (Ctrl+O)** link or one of the most recently viewed files.



**Figure 90. Open Data Files in RiverSurveyor Live for PC**

### 8.3. Application Layout

The application layout is divided into seven sections, shown below in Figure 91.

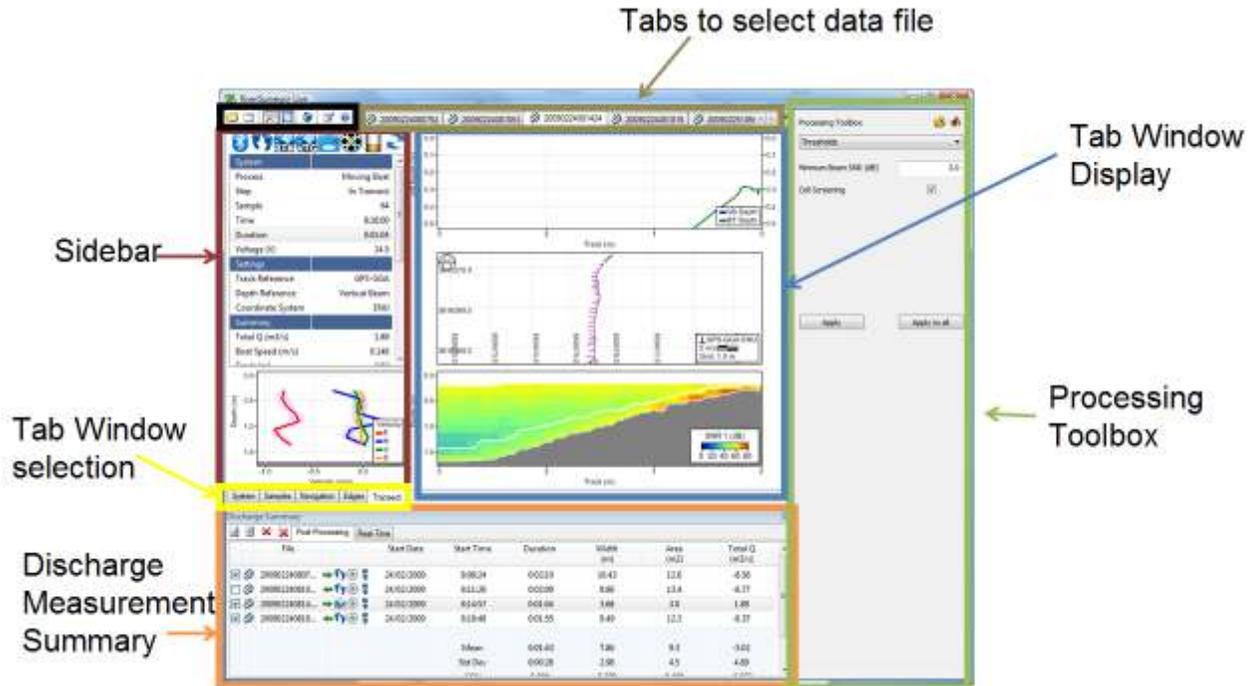


Figure 91. Application Layout for PC Software

#### 8.3.1. Main Toolbar Icons

The Main Toolbar at the top of the screen provides quick links to open files, connect to an ADP and change the program views and settings. Below is an explanation of each:



**Open File (Ctrl + O)** – Opens a window to select files for viewing and post-processing.



**Connect (Ctrl + N)** – Allows the selection of communications types with the RiverSurveyor: for a direct connect option or a SS radio connection select a Com Port, while Bluetooth users should click on the tick-box at the bottom of the window.



**Show/Hide Processing Toolbox (Ctrl + T)** – Toggle button shows or hides the Processing Toolbox for post-processing analysis.



**Show/Hide Discharge Summary (Ctrl + S)** – Toggle button shows or hides the Discharge Summary for post-processing analysis.



**Load GIS Shape File** – Opens a window and presents options to look for and load pre-saved geo-referenced Shape File that can be used as a background for the data collected. This is a useful visualization tool for user in post-processing.



**Change Program Settings** – Opens a pop-up window which presents default program settings--English or Metric Units for example.



**View Documentation** – Presents help documents.

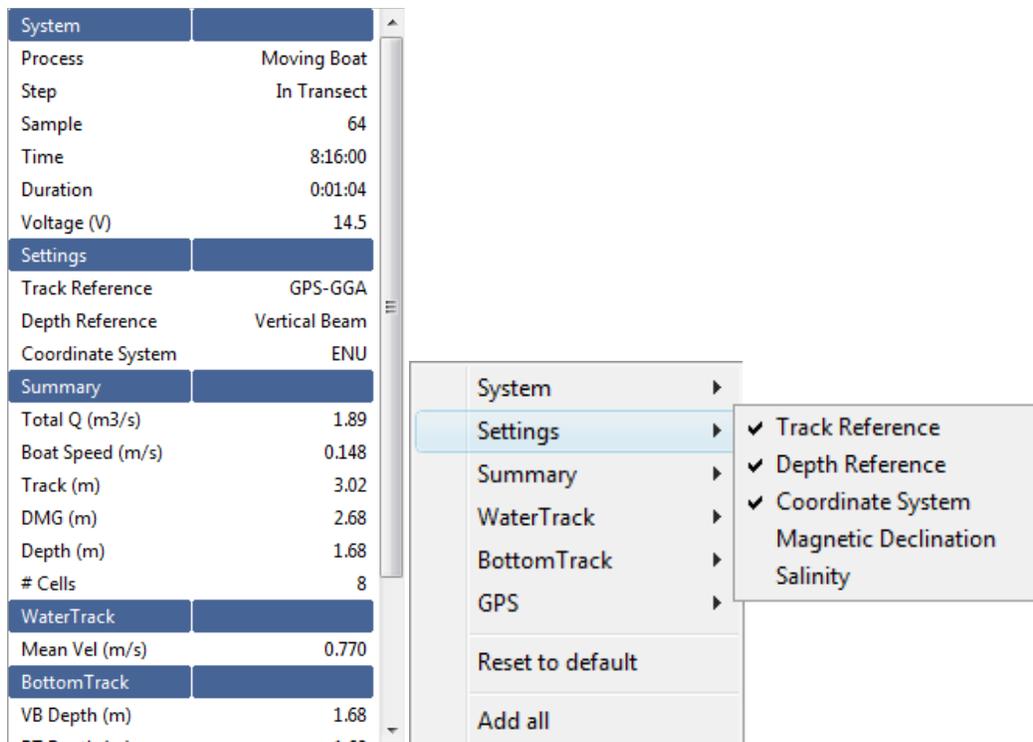
### 8.3.2. Data file Tabs



Figure 91 highlights the location of the Data file tabs. Each tab is an open file with the year, month, day, hour, minute, second format (i.e. YYYYMMDDHHMMSS). The tabs are used to toggle between open data files. Multiple files can be opened simultaneously. Users can swap between tabs by clicking or using Ctrl+Tab or Ctrl+Shift+Tab. To close tabs, click the X or use the Ctrl+F4 hot key.

### 8.3.3. Sidebar

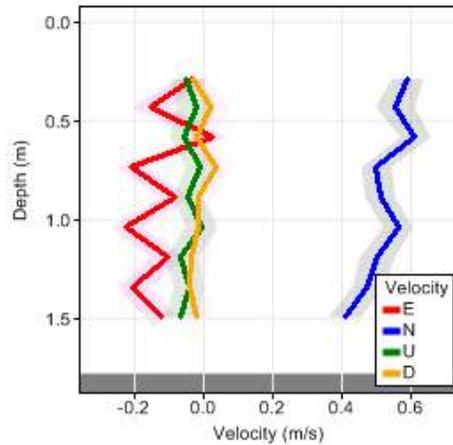
The Sidebar displays the status icons as well as customizable tabular data and a profile graph for the current sample. Status icons are explained in Appendix A. Right-click on the tabular data to select the display options shown in Figure 92. In addition to the various data display options, there is an “Add all” option to include all data fields or a “Reset to default” option to apply the standard view.



**Figure 92. Sidebar Tabular Data with Right Clicking Menu Options.**

The graph portion of the Sidebar displays the vertical profile through the water column. Double-click on the axes to change the scale. Right-click on the graph to display a pop-up menu that allows for further customization of the graph. Below is an example for viewing the velocity profile.

After right clicking on the graph, select WaterTrack and then Velocity. This will display each velocity component along with the Standard Deviation as a shaded band around each line (Figure 93).



**Figure 93. Profile View – WaterTrack**

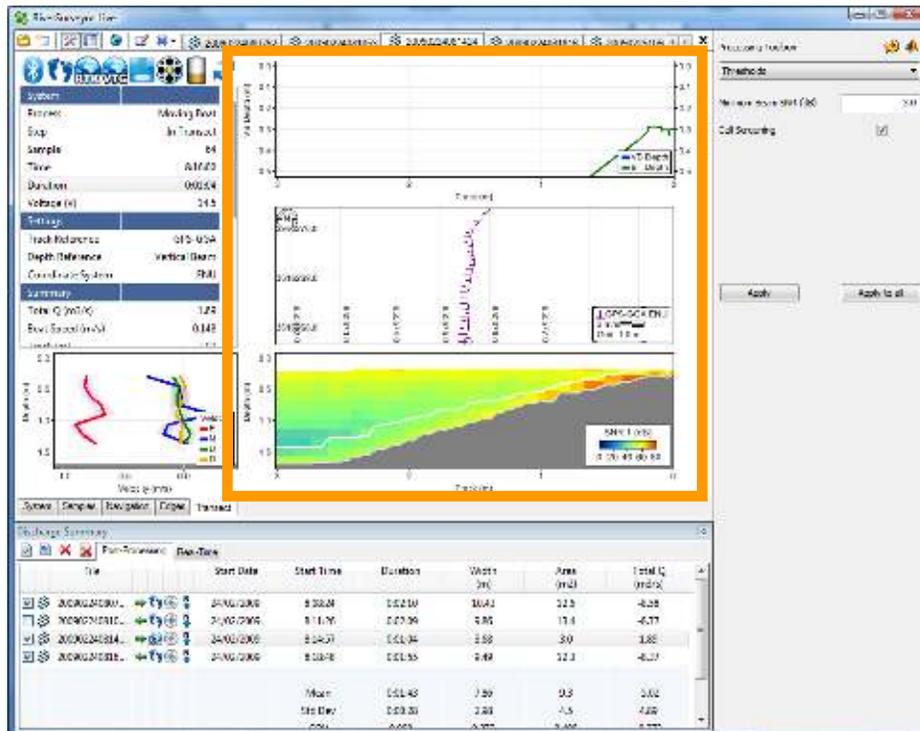
Another useful plot for the profile graph is to select Summary and then Discharge. This will present a graph that plots the profile extrapolation with the area under the graph being the incremental discharge for the sample/profile.

### 8.3.4. Tab Windows Selection

There are five views or data tabs in the software. Each tab presents a specific view of the data explained below.

### 8.3.5. Tab Window Display

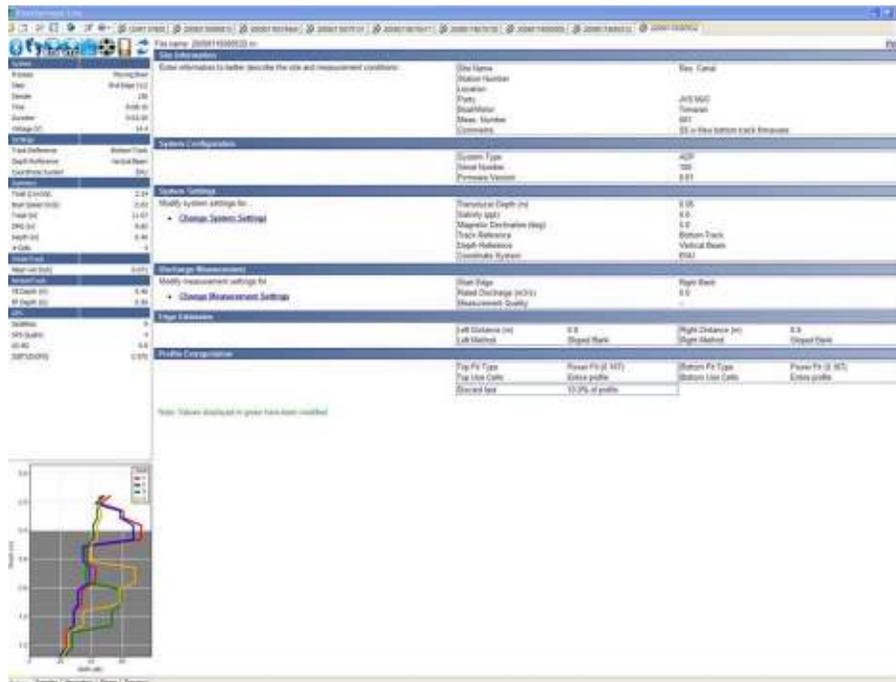
The Tab Window (Figure 94) shows different views of the data as different tabs are selected. When a tab is selected, it becomes the active tab for all data files which are open in the program. The PageUp and PageDown keys can be used to toggle between the tabs. Below is an explanation of each Tab Window.



**Figure 94. Tab Window Display**

## System Tab

Figure 95 shows the System tab view of a data file in *RiverSurveyor Live for PC*. To alternate between the views, select the tabs at the bottom of the window to view and analyze the data.



**Figure 95. System Tab**

The information on the Systems tab shows the following user inputs and settings.

- **Measurement Type** shows the method used to collect the data. Moving Boat is the only option available at this time. Other measurement types will be available in future releases.
- **Site Information** shows a summary of Site Information entered before data collection.
- **System Configuration** shows the System Configuration used during data collection.
- **System Settings** shows a summary of the System Settings. Information in this block can be modified for post-processing by clicking Change System Settings.
- **Discharge Measurement** shows a summary of Measurement Settings. This information can be modified for post-processing by clicking on Change Measurement Settings.
- **Edge Estimates** shows a summary of information entered during the measurement.
- **Profile Extrapolation** shows a summary of how the profile data was extrapolated for velocity profiles and discharge measurement.

**Important:** You can modify the presentation of graphic and tabular data displays by right clicking and selecting from the options in the context menu.

## Samples Tab

The Samples tab (Figure 96) displays tabular data for all samples collected along with a contour and profile graph. The left side shows status icons for each sample. The main window shows tabular transect data. You can scroll through the data using the up/down keys or predefined Hotkeys/Accelerators (Section 8.4) for viewing and post-processing. The graphics at the bottom show vertical profile data and complete transect data. You can toggle through the vertical profile data using the up/down keys to browse the samples and use the left/right arrow keys to start at the left/right bank respectively.

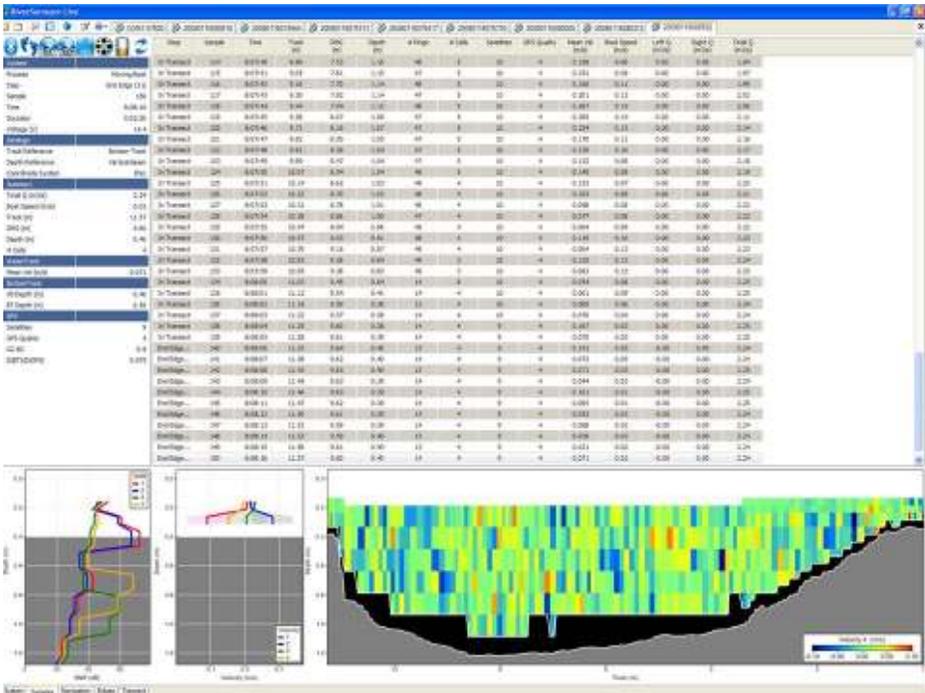


Figure 96. Samples Tab

**Navigation Tab**

The Navigation tab (Figure 97) has three sections – incremental profile data (left), navigational graphics (main area) and transect view (bottom). The navigational graphics show system trajectory or navigation during the measurement. You can also view collected data superimposed over your own background graphic.

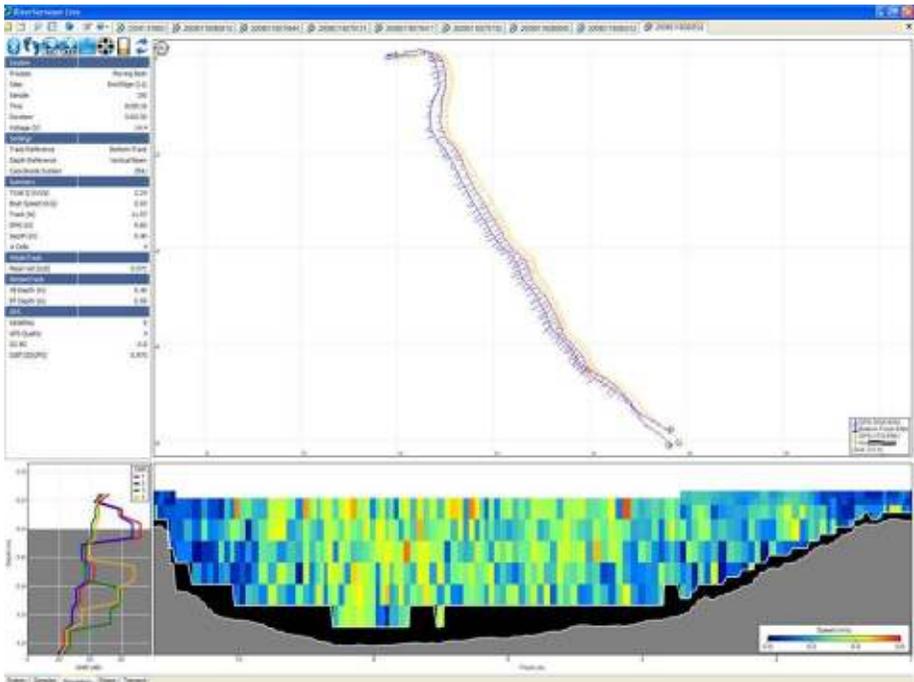
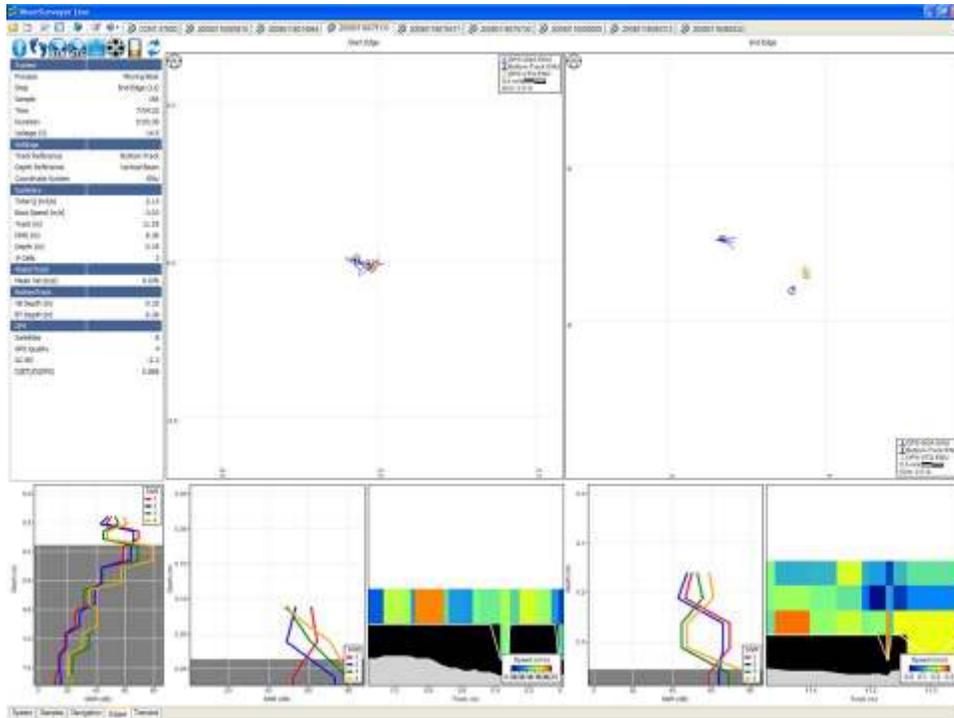


Figure 97 Data View – Navigation Tab

## Edges Tab

The Edges tab (Figure 98) provides a detailed tool for evaluating data collected on the start/end edges of a discharge measurement. The Edges tab has three sections – incremental profile data (left), navigation data for both edges (main) and transect data for both edges (bottom).



**Figure 98. Data View – Edges Tab**

**Incremental Profile Data** – Presents the incremental profile data collected in the field. The up/down keys page through the data one sample at a time. The left arrow key goes to the first profile of the starting edge; the right arrow key goes to the last profile of the ending edge. The information presented in this section allows evaluation of the data from each sample. Status icons help to determine system performance.

**Navigation Graphics** – Present a view of the trajectory of the system during a measurement. The left arrow key goes to the first profile of the starting edge; the right arrow key goes to the last profile of the ending edge. The up/down keys cycle through the data.

**Edge Graphics** – Presents a view for evaluating starting and ending edges. The left arrow key goes to the first profile of the starting edge; the right arrow key goes to the last profile of the starting edge. The up/down keys cycle through the data.

## Transect Tab

The Transect tab (Figure 99) has three sections – incremental profile data (left), user-selected graphics (main area) and transect view (bottom). As an example, the top graph in Figure 99 shows the depth-to-bottom information taken from the vertical beam data (blue) and the transducer data (green).

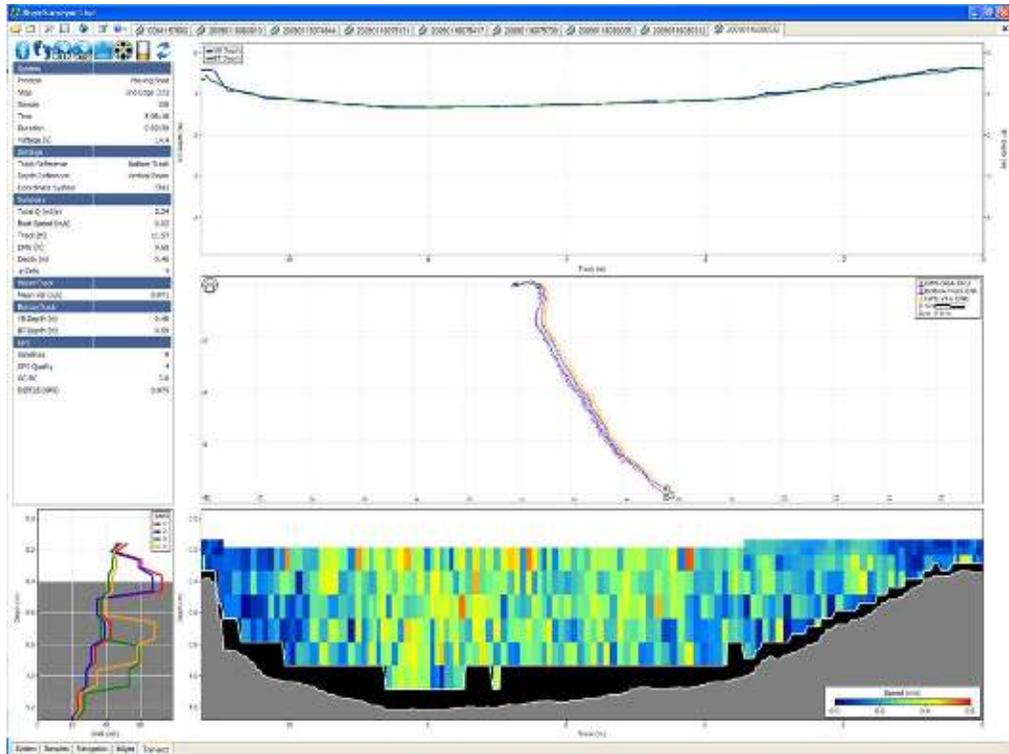


Figure 99. Data View -Transect Tab

Graphs can be modified by right-clicking on the left or right vertical axis and selecting from the options provided. The middle graph displays the path of the boat with the velocity vectors. The velocity vectors at a good site should be roughly perpendicular to the path of the boat.

The bottom graph shows the measured transect with the vertical profile data included. Right-clicking allows various plotting options, while left-clicking provides scaling options. In this window, using the up/down keys allows you to cycle through the data, profile by profile, changing all the graphs simultaneously. This displays the same data from different perspectives along the transect.

8.3.6. Discharge measurement summary

By clicking the Discharge Summary icon, you can show or hide the Discharge Summary window at the bottom of the desktop. This window presents the collected data in tabular format and includes the status icons to evaluate the measurement (Figure 100). If desired, resize the window by using the slider arrow when the mouse pointer is positioned over the window border.

File	Start Date	Start Time	Duration	Width (m)	Area (m <sup>2</sup> )	Total Q (m <sup>3</sup> /s)
20090224080752.riv	24/02/2009	8:06:24	0:02:10	10.13	12.6	-8.38
20090224081053.riv	24/02/2009	8:11:28	0:02:09	9.88	13.4	-8.77
20090224081434.riv	24/02/2009	8:14:57	0:02:44	10.01	13.4	-8.65
20090224081816.riv	24/02/2009	8:18:48	0:01:55	9.49	12.3	-8.37
		Mean	0:02:05	10.17	12.9	-8.39
		Std Dev	0:00:18	0.54	0.3	0.15
		COV	0.008	0.053	0.023	-0.017

Figure 100. Discharge Measurement Summary

All records are ordered by date/time with icons for starting edge, depth and track reference and coordinate system. All records can be selected or deselected by clicking with the mouse; this affects the statistics presented and is a quick and easy way to understand what effect each measurement has on the overall average of the measurements for the site.

Additionally, you can select data to include or exclude from the discharge calculation by simply clicking to activate or deactivate the check box. The Discharge Summary has the following options that can be used in post processing:



**Discharge Summary Report:** Generates a printer friendly report that summarizes all data used in the discharge calculation as well as the associated statistics (unchecked records are not displayed).



**Export Discharge Summary to ASCII:** Exports the information found in the discharge summary to an ASCII file (.txt).



**Delete selected discharge record(s):** Deletes the selected records (the ones with the red check). These records will not be used for the discharge calculation.



**Delete all discharge records:** Deletes all records present, essentially removing all transects for discharge calculation

Links between open files and records on the discharge summary are as follows:

- An open file will update its corresponding discharge record with changes to settings or as sample number changes.
- Closing a file leaves the record displayed in the discharge measurement summary, but the record will no longer update
- Deleting the record severs the link to the data file. To add the record back, the file must be reopened.
- Click on a record to switch to the matching data file.
- Delete or uncheck a record to recomputed statistics.

### 8.3.7. Processing toolbox



The Processing Toolbox (Figure 101) gives you access to tools to post-process the discharge data. The Processing Toolbox has the following options in its dropdown menu: System Settings, Edge Estimates, Profile extrapolation and Thresholds. Each is described in detail below.

The two icons in the top right corner are always present in the Processing Toolbox.



The Reset icon allows you to reset all modified values back to those entered in the field. Since any changes to the settings have an impact on the discharge calculation, this option is important for users to have the option of post-processing, but the luxury of not losing the initial field settings.



The MATLAB icon exports data from *RiverSurveyor Live* to a MATLAB friendly format explained in Appendix C. The velocities, track and summary data are exported in the reference and coordinate system that are set at the time of export.

To export the raw ADP data, and therefore complete all the velocity coordinate transformations, track referencing and processing manually in MATLAB, you will need to follow this procedure:

1. Open the data file you need to export
2. Open the Processing Toolbox
3. Select the System Settings page
4. Set the Track/Velocity Reference to “System”
5. Set the Coordinate System to “Beam”
6. Press the Export to MATLAB button

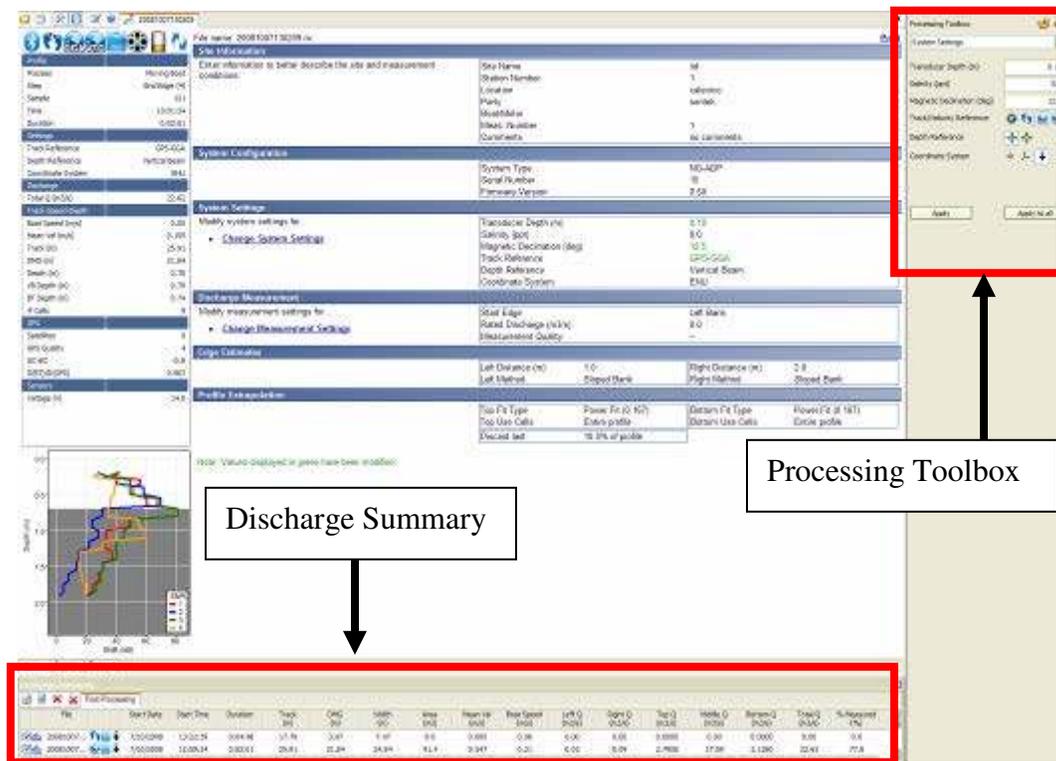
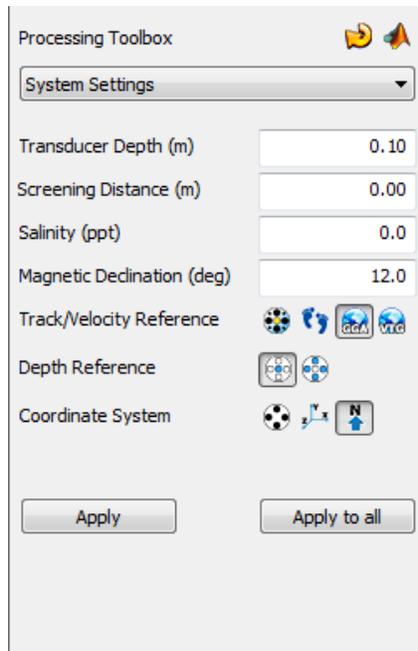


Figure 101. Discharge Measurement Summary and Processing Toolbox

### Processing Toolbox dropdown menu

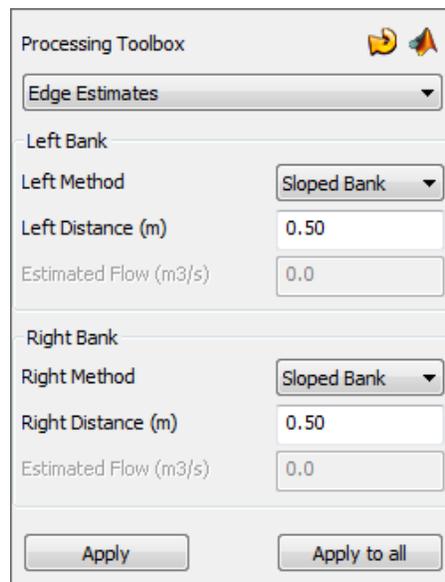
**System Settings** – Allows post-processing of the data collected in the field. Figure 102 displays the options available. Transducer depth, Screening Distance, Salinity, and Magnetic Declination require a manual entry. The Track/Velocity Reference, Depth Reference, and Coordinate System icons allows the user to see the prior setting and change that setting by simply clicking on the icon.

Click the “Apply” button to make the changes to a single data file. Use the “Apply to all” button to apply the post-processing changes to all of the data files that are open. Be sure all of the open files have identical settings before using the “Apply to all” button. The previous settings cannot be retrieved.



**Figure 102. System Settings - Processing Toolbox**

**Edge Estimates** (Figure 103) – Allows the modification of Left/Right Bank settings in order to better define the characteristics regarding channel width and the slope of the edges. These settings have an important impact on the discharge calculation. Left/Right Method are selected from a dropdown box. Left/Right Distance and Estimated Flow are manual entry fields.



**Figure 103. Edge Estimates - Processing Toolbox**

**Profile Extrapolation** (Figure 104) – Allows you to change the way the top/bottom estimates are calculated. In general, the default settings are adequate for most applications. The Method, Cells to Use, and % of Profile fields have dropdown menus. The Coefficient, Discard Last, and Cell(s) fields are manual entries.

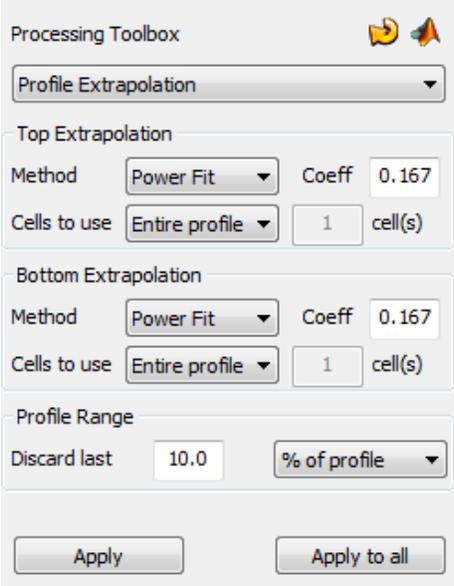


Figure 104. Profile Extrapolations - Processing Toolbox

**Thresholds** (Figure 105) – Shows an option to set the minimum beam SNR threshold used for water velocity calculations (default = 1.0 dB). This value corresponds to the minimum SNR value needed to make a water velocity measurement. In clear water the SNR values are lower, and an adjustment can be made to the threshold to compensate for low sediment load. **Important:** No changes will be made to the calculated discharge or associated data until Apply or Apply to All has been clicked. Apply only applies the post-processing options to the open/active tab; Apply to All applies the post-processing changes to all the active tabs.

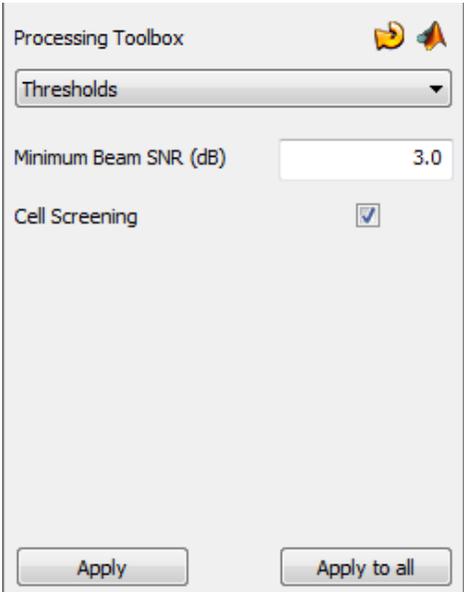


Figure 105. Thresholds - Processing Toolbox

## 8.4. Hot Keys/Accelerators

Table 3 presents a list of Hotkeys/Accelerators which can be used via the keyboard, often in place of a mouse click. These Hot Keys are useful in many processes including data collection, data processing, managing data files and viewing data. It is also important to remember for graphic and tabular display, a right-click presents data viewing options.

**Table 3. Summary of Hotkeys/Accelerators for *RiverSurveyor Live for PC***

Hot Keys	Description/Function	Location/Process
F5	Go to Next Step	Data Collection
F8	Abort	Data Collection
Ctrl+N	Connect to RiverSurveyor System	Start Data Collection
Ctrl+O	Open a data file	Data Processing
Ctrl+T	Show/Hide Processing Toolbox	Data Processing
Ctrl+S	Show/Hide Discharge Measurement Summary	Data Processing
Ctrl+R	Show Discharge Summary Report	Data Processing
Ctrl+Tab	Next File/Connection Tab (top of screen)	Data Processing
Ctrl+Shift+Tab	Previous File/Connection Tab (top of screen)	Data Processing
PageUp	Next Display Tab (bottom of screen)	Data Processing
PageDown	Previous Display Tab (bottom of screen)	Data Processing
Ctrl+F4	Close Current Tab	Data Processing
Ctrl++	Increase Vector Length	Track Window
Ctrl--	Decrease Vector Length	Track Window
Z	Zoom in	Track Window
Shift+Z	Zoom out	Track Window
Left Arrow	First Sample	Data Files
Right Arrow	Last Sample	Data Files
Up Arrow	Previous Sample	Data Files
Down Arrow	Next Sample	Data Files
Ctrl+Up Arrow	Back 20 Samples	Data Files
Ctrl+Down Arrow	Forward 20 Samples	Data Files
Ctrl+Shift+Up Arrow	Back 100 Samples	Data Files
Ctrl+Shift+Down Arrow	Forward 100 Samples	Data Files

## 8.5. Processing Data Files – Step by Step

This section is a guide for analyzing and post-processing data files collected in the field.

1. Open all files from a measurement site (the same measurement site with the same flow conditions).
  - Review the System settings. Be sure that the settings are consistent amongst files. To do this go to the Systems tab and cycle through each file (Click on each tab individually or use Ctrl+Tab).
  - If necessary, change the Track and Depth reference to best represent the best field measurement (in Processing Toolbox – System Settings).
  - Select the Navigation tab to evaluate the collected data across the channel. Deactivate the UTM Display and activate the AutoScale option: available by right clicking.
  - Use the Sidebar tabular data to evaluate specific settings (i.e. Duration of the measurement, GPS Quality).
    - Visually review each measurement by clicking on each tab or by using Ctrl+Tab

- Evaluate BottomTrack vs. GPS (if applicable) to observe any compass, GPS or moving bed issues.
  - Make sure the magnetic declination is set appropriately for the site (the default setting is zero).
  - Make sure that the GC-BC (angle of average GPS course since start of transect minus ADP bottom-track course; value near 0 is desired) is less than 2 degrees and the D(BT)/D(GPS) (Ratio of Bottom Track track distance to GPS track distance) is approximately 1 (Sidebar data).
  - Be sure the number of GPS satellites is good and the GPS quality is valid
2. On the Transect tab, evaluate different plots by right-clicking on the vertical axes.
- Plot the depth measured by the Vertical Beam as well as Bottom Track depth. Make sure the VB and BT depth scales are the same. Check for any major discrepancies.
  - Evaluate Boat Speed and Water speed plotted on the same graph. Ideally, the Boat speed should not exceed the water speed where possible.
  - Make sure that Heading/Pitch/Roll and Temperature are relatively constant.
  - Verify that the SNR data and beams are valid with special focus on the edges and shallow water.
  - Verify water velocity in ENU: U (up) and D (Delta) should be close to zero.
  - Make sure that discharge curve and profile extrapolation is applicable (using Processing Toolbox – Profile Extrapolation).
  - Verify that the SNRs are valid for the contour (graph at the bottom).
  - Verify that the velocity cell cutoff on the contour plot is valid, also look at the screening distance and make sure that is graphically correct.
3. In the Discharge Measurement Summary make sure that:
- References and Coordinates should be the same
  - Starting edges should alternate
  - Date/times should be consecutive
  - Duration of measurements should be similar
  - Use the Statistics to identify any outliers
  - Channel width and discharge areas should be similar
  - Uncheck or delete problematic records

## Appendix A. Description of RiverSurveyor Live Icons

**Bluetooth** is a wireless short-range communications technology allowing data transmission over short distances from fixed and mobile devices. When users apply this method of communication between their PC or Mobile device and the ADP, a blue icon indicates that Bluetooth is active, while a red icon represents inactive (icons below). Bluetooth signal strength is indicated with a green icon square, a full square indicates a strong Bluetooth signal, while squares not completely filled indicates proportional signal strength.



**Bottom Track** is used to remove vessel motion from measured water velocity to determine the “true” water velocity, track distance and depth. That is, when you mount the ADP to a vessel, bottom-track measures the velocity and direction of the ADP/vessel movement over ground. There are four icons (below) for bottom track quality: blue corresponding to depth and track data (optimal); yellow means bottom track only depth is valid (functional); red indicates that bottom track does not have a lock; and the grey icon indicates that the feature is not available.

				
Depth	Valid	Valid	Invalid (no lock)	Disabled /Inactive
Track Velocity	Valid	Invalid (no lock)	Invalid (no lock)	Disabled /Inactive

**RTK GPS** is the essential GGA GPS fix data which provides 3-D location and accuracy data for the system. This data string includes: Latitude, Longitude, Fix quality, Number of satellites used, Altitude as well as many other types of information. There are five icons for RTK GPS, as seen below, ranging from RTK (Real-time kinematic--blue) to the Inactive (gray).

					
4 RTK Quality Position	2 Differential Quality Position	1 Uncorrected Position	0 Invalid or no data	Disabled /Inactive	

- RTK Quality GPS provides 0.03 m accuracy
- Differential Quality GPS provides sub 1-meter accuracy
- GGA Uncorrected provides greater than 1-m accuracy

**VTG** is the GPS vector track and speed over ground data string for the system. The VTG (Vector track and speed over ground) data string presents Track and ground speed information (boat speed over the water) as well as other information. There are four icons (below) for VTG ranging from Measured Velocity (blue) to Inactive (grey).

			
Valid Velocity	Valid Velocity* (Limited Satellite Coverage)	Invalid or no data	Disabled /Inactive

\*Acceptable for discharge measurements but additional GPS parameters should be monitored for guidance.

See Appendix D—Troubleshooting for additional guidance on using VTG data.

**Depth Reference** refers to the method used to measure depth. The RiverSurveyor presents two options for Depth Reference: Vertical Beam (using the echo sounder) and Bottom Track (using the velocity transducers). The indicator for no depth lock is the red icon, meaning that water depth cannot be determined. The grey icon below indicates the depth reference is not available.

			
Vertical Beam	BottomTrack	No Depth Lock	Disabled /Inactive

**System Connection** indicates that the system is connected and communicating with external sources (PC or Mobile device).

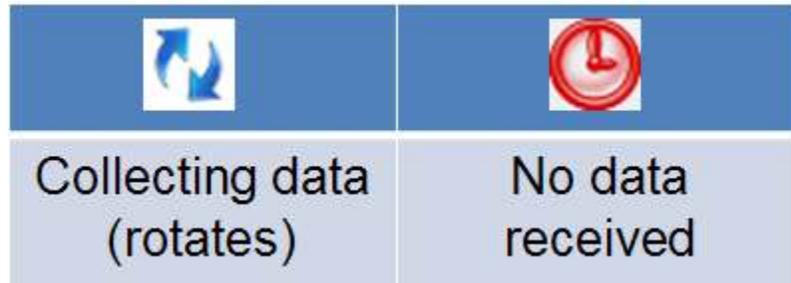


System Connected

**System Battery** is monitored using the status icons indicated below. Typically, a fully charged battery pack has about 5 hours of use. The icons below indicate battery status ranging from 10 to 100%. Users are advised to change the system battery immediately after reaching the 10% level in order to prevent loss of data. If applying a direct power source to the ADP the icon below will still be applied and with 17 V applicable to 100% and 12 V corresponding to 10%.

					
100%	80%	60%	40%	20%	10%

**Data Collection** is verified using the two icons below. Blue rotating arrows indicate that the system is actively collecting data. The red clock-like icon indicates that the system is not collecting data and a detailed review of system and application settings should be completed in order to identify any possible problems.



- **Collecting Data** – During data collection the blue arrows (above) will move in a circular motion, indicating that data collection is active.
- **No Data Reception** – The red icon (above) indicates loss of communications. Re-check communications connections and the range of the system.

**RiverSurveyor Live for PC Menu Bar** is used for the initial setup and startup. Icon utilities are self explanatory; however a brief description is included below:



**Open File (Ctrl + O)** – Opens a window that allows users to select files to open and evaluate using post-processing tools.



**Connect (Ctrl + N)** – Allows the selection of communications types with the RiverSurveyor: for a direct connect option or a SS radio connection select a Com Port, while Bluetooth users should click on the tick-box at the bottom of the window.



**Show/Hide Processing Toolbox (Ctrl + N)** – Toggle button shows or hides the Processing Toolbox for post-processing analysis.



**Show/Hide Discharge Summary (Ctrl + S)** – Toggle button shows or hides the Discharge Summary for post-processing analysis.



**Load GIS Shape File** – Opens a window with options to look for and load pre-saved geo referenced Shape File that can be used as a background for the data collected. This is a useful visualization tool for user in post-processing.



**Change Program Settings** – Opens a pop-up window which presents default program settings--English or Metric Units for example.



**View Documentation** – Presents help documents.

**Discharge Summary Menu Bar (Desktop version)** presents four icons that allows various post processing options and are described below:



**Discharge Summary Report** – Opens a printer-friendly window that presents the collected data in a pre-defined report format.



**Export Discharge Summary to ASCII** – Opens a dialog box that allows a file to be saved in ASCII format. The file has a plain text format for importing the data into another application for further processing.



**Delete Selected Discharge Record(s)** – A post processing option used to delete a record in the Discharge Summary Window. This option will have an effect on the overall discharge measurement summary as the record is deleted from the summary; however the file is still saved in PC or Mobile device memory. Multiple records can be selected and deleted by checking the tick-mark boxes next to the record.



**Delete All Discharge Records** – Using the Delete All Records button deletes all loaded records from the Discharge Summary.

### Processing Toolbox Icons (Desktop version)



**Reset to Field Settings** – Allows you to reset the values that were used in the field for the discharge calculation.



**Export to MATLAB** – Opens a pop-up window used to name and save the file for import into MATLAB.

### Coordinate System Icons (Desktop version)



**Beam Coordinates** – Beam coordinates are relative to the orientation of the transducers on the head of the ADP. Beam coordinates are typically used for diagnostics purposes only.



**XYZ Coordinates** – Applies the standard XYZ coordinates to the data, where: X is the North axis, Y is East axis and Z is the vertical axis.



**ENU Coordinates** – Applies the ENU (East, North, Up) coordinate system to the data. Local ENU coordinates are formed from a plane tangent to the Earth's surface fixed to a specific location.

### Depth Reference (Desktop Version)



**Vertical Beam** – Applies data from the 0.5 MHz transducer for M9 systems and the 1.0 MHz data from the S5 system to determine water depth for the cross-sectional area.



**Bottom Track** – Applies data from the velocity transducers from the S5 (four 3 MHz transducers) and M9 (four 3 MHz transducers and four 1 MHz transducers) to determine water depth for the cross-sectional area.

## Appendix B. Parameter and Hotkey Descriptions

This appendix describes the parameters that can be displayed during data collection using the RiverSurveyor Live for Mobile software. There are a number of views available during data collection. Each may be accessed using a Hotkey or selecting a viewing option from the menu. Typically, six to twelve parameters or settings are displayed at one time. Press one of the hotkeys (1-4) during data collection using the Mobile device to change to a different view.

Parameter	Description	Key/Menu Option
Process	Moving Boat (Default)	1
Step	Profiling (default)	1
Sample	Number of samples taken (typically 1 per second)	1
Time	Time set by the user	1
Duration	Duration of the measurement (HH:MM:SS)	
Voltage	Voltage of system battery on RiverSurveyor	1
Total Q	Total accumulated discharge for the transect	1
# Cells	Number of cells used in the last vertical profile	1
Track	Shows the accumulated total distance the vessel has traveled through the last completed profile for this data set	1
Depth	Depth measured for the last profile processed (m or ft)	1
Mean Vel	Mean velocity of last profile in m/s or ft/s	1
Boat Speed	Shows speed of vessel over ground for the last profile processed	1
Boat/Water	Ratio of boat speed to water speed	2
DMG	Distance made good is the distance from your last position to your present position	2
Temperature	Temperature in °C or °F (system settings Metric or English) for the last profile processed	2
Heading	Shows vessel heading based on the Track Display	2
Pitch	Shows the pitch angle of the ADP for the last profile processed	2
Roll	Shows the pitch angle of the ADP for the last profile processed	2
Satellites	Number of satellites used in location determination (GPS option)	2
GPS Quality	Quality indicator based on number of satellites used in track data	2
D(BT)/D(GPS)	Ratio of Bottom Track track distance to GPS track distance	2
GC-BC	Shows angle (degrees) of average GPS course since start of transect minus ADP bottom-track course; value near 0 is desired.	2
GPS Age	Age of differential GPS connection in seconds	2
HDOP	Horizontal dilution of precision	2
Total Q	Total discharge measure for the cross section in m <sup>3</sup> /s or ft <sup>3</sup> /s	2
Top Q	Shows the total accumulated discharge in the top layer that is estimated by the program	3
Middle Q	Shows the total accumulated discharge in the middle layer that is estimated by the program	3
Bottom Q	Shows the total accumulated discharge in the bottom layer that is estimated by the program	3
Left Q	Shows the total accumulated discharge in the left edge of the survey area that is estimated by the program	3
Right Q	Shows the total accumulated discharge in the right edge of the survey area that is estimated by the program	3
Total Q	Shows total discharge estimated and measured for entire cross-section	3

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Transducer Depth	Distance the vertical beam transducer is submerged into water column	4
Salinity	User defined parameter that allows for a correction of the speed of sound in water based on the salinity in parts per thousand (ppt)	4
Magnetic Declination	User defined value for difference in magnetic North and true North	4
Track Reference	User defined criteria used in determining navigation information (i.e. Bottom Track and Boat Speed)	4
Depth Reference	User defined criteria used in determining water depth (i.e., Vertical Beam or Bottom Track (4 beams))	4
Coordinate System	Navigation coordinate system applied by user (ENU, System, XYZ)	4

## Appendix C. MATLAB Export

The MATLAB output is ordered into a series of structures each containing their related parameters and settings. The tables below describe each structure and their contents and it is current as of version 2.50 of the RiverSurveyor Live software.

### IMPORTANT NOTES:

- The term “sample” refers to a single vertical profile, taken over a period of 1 s.
- For the four parameters containing *Velocity* data (BottomTrack.BT\_Vel, Summary.Mean\_Vel, Summary.Boat\_Vel, and WaterTrack.Velocity), the data is in the same coordinate system that was selected in the software when the .mat file was exported. For example:
  - BT\_Vel when exported in *ENU coordinates* will be:
    1. East Velocity (i.e. velocity *to* the East)
    2. North Velocity
    3. Up Velocity
    4. Difference Velocity (aka Error Velocity; the difference between measuring the vertical component of the velocity from the two pairs of opposing beams)
      - BT\_Vel when exported in *XYZ coordinates* will be:
        1. X Velocity
        2. Y Velocity
        3. Up Velocity
        4. Difference Velocity
          - BT\_Vel when exported in *Beam coordinates* will be:
            1. Beam 1
            2. Beam 2
            3. Beam 3
            4. Beam 4
- GPS Altitude (from the GGA string) is based on a proprietary, non-published geoid, and referenced to the bottom-center of the antenna.

The basic order of the root structures is as follows. For the Size Column:

- NS is the number of samples;
- NC is the maximum number of cells;
- If the structure contains another structure inside it, or the parameter is a scalar, the size is NA.

Structure Name	Description
Bottom Track	Bottom Track Velocity, Depth and Frequency variables (includes Vertical Beam).
GPS	GPS data and quality information.
Processing	Processing settings.
RawGPSData	The raw GPS data from either the internal GPS or an external serially connected GPS system. This data is stored in its raw format with the same frequency that was output from the GPS. For example, if the GPS outputs data at 10 Hz, then 10 GPS data values are stored for each ADP sample.
Setup	System settings, edge information and profile extrapolation
Summary	Calculated discharge variables and the data used to compute them.
System	Core system related parameters: Compass, Temperature, Time,

	SNR, Voltage and Profiling settings.
Transformation_Matrices	System frequencies and transformation matrices.
WaterTrack	Water velocity and profiling variables in coordinates selected for output.

**Bottom Track structure**

Parameter Name	Description	Size
VB_Depth	Vertical Beam depth for each sample, including the Transducer Depth and compensation for tilt.	NS x 1
BT_Depth	Mean Bottom Track depth for each sample, including the Transducer Depth and compensation for tilt. This is the mean of the depth measured by each active transducer and projected in vertically below of the ADP.	NS x 1
BT_Vel	Bottom Track Velocity for each direction (or beam, if exported in Beam coordinates) for each sample.	NS x 4
BT_Beam_Depth	Bottom Track depth for each beam for each sample, including the Transducer Depth and compensation for tilt.	NS x 4
BT_Frequency	Frequency used for Bottom Track data for each sample (correlate with Frequency parameter from Transformation_Matrices structure)	NS x 1
Units	Units for above parameters (BT_Frequency is kHz)	NA

**GPS structure**

Parameter Name	Description	Size
Longitude	Longitude for each sample	NS x 1
Latitude	Latitude for each sample	NS x 1
Utc	Universal Time Coordinated (UTC) for each sample, in HHMMSS.S	NS x 1
Satellites	Number of satellites in view for each sample	NS x 1
HDOP	Horizontal Dilution of Precision for each sample	NS x 1
GPS_Age	Time since the last corrected GPS signal received at the rover GPS antenna, whether from the RTK Base Station or from the satellite if using the SonTek DGPS option.	NS x 1
Altitude	Altitude above mean sea level for each sample.	NS x 1
GPS_Quality	GPS Quality for each sample (4 = RTK, 2 = Differential, 1 = Standard, 0 = Invalid).	NS x 1
GpsGeoid	Gps Geoid Height is the distance between the geoid (mean sea level) and the WGS84 ellipsoid	NS x 1
UTM	Universal Transverse Mercator (UTM) coordinate system in X and Y coordinates for each sample.	NS x 2
Units	Units for above parameters (GPS_Age are in seconds).	NA

**Processing structure**

Parameter Name	Description	Size
Screening	User-applied minimum SNR filtering settings, in dB	NA
Corrections	User-applied heading correction, in degrees	NA

**RawGPSData structure** (This structure contains 50 columns per sample because the instrument samples the GPS port at 50 Hz. However, because we require the GPS to output normally only up to 10 Hz, typically only the first 10 columns contain data, while the remaining 40 are filled with 0)

Parameter Name	Description	Size
VtgTimeStamp	\$GPVTG time stamp for each high frequency GPS sample	NS x 50
VtgTmgTrue	\$GPVTG true course made good for each high frequency GPS sample (degrees)	NS x 50
VtgTmgMag	\$GPVTG magnetic course made good for each high frequency GPS sample (degrees)	NS x 50
VtgSogMPS	\$GPVTG speed over ground for each high frequency GPS sample (m/s)	NS x 50
VtgMode	\$GPVTG active mode for each high frequency GPS sample	NS x 50
GgaTimeStamp	\$GPGGA time stamp for each high frequency GPS sample	NS x 50
GgaLatitude	\$GPGGA latitude for each high frequency GPS sample	NS x 50
GgaLongitude	\$GPGGA longitude for each high frequency GPS sample	NS x 50
GgaQuality	\$GPGGA fix quality for each high frequency GPS sample (4 = RTK, 2 = Differential, 1 = Standard, 0 = Invalid)	NS x 50
GgaAltitude	\$GPGGA altitude above sea level for each high frequency GPS sample (m)	NS x 50
GgaUTC	\$GPGGA UTC for each high frequency GPS sample (HHMMSS.S)	NS x 50

### Setup structure

Parameter Name	Description	Size
startEdge	Start edge (0 = Left bank; 1 = Right bank)	NA
magneticDeclination	Magnetic Declination (degrees)	NA
transectAzimuth	Transect azimuth (Stationary measurements)	NA
coordinateSystem	Coordinate system (0 = Beam; 1 = XYZ; 2 = ENU)	NA
trackReference	Track reference (0 = System; 1 = Bottom Track; 2 = GPS GGA; 3 = GPS VTG)	NA
velocityReference	Velocity reference (0 = System; 1 = Bottom Track; 2 = GPS GGA; 3 = GPS VTG)	NA
depthReference	Depth reference (0 = Vertical beam; 1 = Bottom Track)	NA
userSalinity	User input salinity (ppt)	NA
sensorDepth	Transducer depth (m)	NA
screeningDistance	Vertical screening distance (m)	NA
Edges_0_DistanceToBank	Start Edge: Distance to the bank	NA
Edges_0_EstimatedQ	Start Edge: Estimated discharge	NA
Edges_0_Method	Start Edge: Method (0 = User input discharge; 1 = Vertical bank; 2 = Sloped bank)	NA
Edges_1_DistanceToBank	End Edge: Distance to the bank	NA
Edges_1_EstimatedQ	End Edge: Estimated discharge	NA
Edges_1_Method	End Edge: Method (0 = User input discharge; 1 = Vertical bank; 2 = Sloped bank)	NA
RatedDischarge	User input rated discharge	NA
extrapolation_Top_nFitType	Profile Extrapolation - Top: Fit equation type (0 = Constant fit; 1 = Power fit)	NA
extrapolation_Top_nEntireProfil	Profile Extrapolation - Top: Fit (0 = Use entire profile; 1 = User selected number of cells)	NA
extrapolation_Top_dExponent	Profile Extrapolation - Top: Power fit exponent	NA
extrapolation_Top_nCells	Profile Extrapolation - Top: Number of cells used in extrapolation	NA
extrapolation_Bottom_nFitType	Profile Extrapolation - Bottom: Fit equation type (0 = Constant fit; 1 = Power fit)	NA

extrapolation_Bottom_nEntirePro	Profile Extrapolation - Bottom: Fit (0 = Use entire profile; 1 = User selected number of cells)	NA
extrapolation_Bottom_dExponent	Profile Extrapolation - Bottom: Power fit exponent	NA
extrapolation_Bottom_nCells	Profile Extrapolation - Bottom: Number of cells used in extrapolation	NA
extrapolation_nDiscardType	Method for discarding cells at the bottom of the profile (0 = user selected number of cells; 1 = percentage of profile)	NA
extrapolation_nDiscardCells	Number of cells discarded	NA
extrapolation_dDiscardPercent	Percentage of profile discarded	NA
MeasurementQuality	User input measurement quality	NA
disableAutovelocity	Enable or disable SmartPulse <sup>HD</sup>	NA
UserTemperature	User input temperature	NA
fixedSoundSpeed	User input sound speed	NA
useMeasuredTemperature	0 = Use User Input Temperature; 1 = Use Measured Temperature	NA
useFixedSoundSpeed	0 = Use Calculated Sound Speed; 1 = Use User Input Sound Speed	NA
Units	Units for above parameters	NA

### Summary structure

Parameter Name	Description	Size
Top_Q	Discharge for the top section for each sample	NS x 1
Middle_Q	Discharge for the middle (measured) section for each sample	NS x 1
Bottom_Q	Discharge for the bottom section for each sample	NS x 1
Left_Q	Discharge for the left edge for each sample	NS x 1
Right_Q	Discharge for the right edge for each sample	NS x 1
Total_Q	Total discharge for each sample	NS x 1
Depth	Depth used for discharge calculation for each sample	NS x 1
Cells	Number of cells used for discharge calculation for each sample	NS x 1
Track	Track location for each sample in X and Y coordinates	NS x 2
Mean_Vel	Mean water velocity for each sample, inclusive of the top and bottom extrapolation, for the horizontal velocity components.	NS x 2
Boat_Vel	Boat velocity used for discharge calculation for each sample	NS x 4
Track_Reference	Track reference (0 = System; 1 = Bottom Track; 2 = GPS GGA; 3 = GPS VTG)	NS x 1
Units	Units for above parameters	NA

### System structure

Parameter Name	Description	Size
Pitch	Compass pitch for each sample	NS x 1
Roll	Compass roll for each sample	NS x 1
Heading	Compass heading for each sample	NS x 1
Temperature	Temperature for each sample	NS x 1
Time	Time for each sample	NS x 1
SNR	Signal to Noise Ratio (SNR) for each cell for each beam for each sample	NC x 4 x NS
Sample	Sample number for each sample	NS x 1
Voltage	Battery voltage for each sample	NS x 1
Cell_Start	Start of the first cell for each sample	NS x 1

Cell_Size	Size of depth cells for each sample	NS x 1
Step	Step in data collection process for each sample For Moving Boat Discharge measurement: 2 = Start Edge 3 = In Transect 4 = End Edge	NS x 1
Pings	Number of pings for each sample	NS x 1
Units	Units for above parameters (Time is seconds from 01/Jan/2000)	NA

**Transformation matrices structure**

Parameter Name	Description	Size
Frequency	Frequencies available for the system	3 x 1
Matrix	Transformation matrices for each frequency	4 x 4 x 3

**WaterTrack structure**

Parameter Name	Description	Size
Velocity	Water Velocity for each cell for each beam for each sample	NC x 4 x NS
Vel_StdDev	Standard deviation of water velocity for each cell for each beam for each sample	NC x 4 x NS
Correlation	Correlation for each depth cell for each beam for each sample. Only applicable for samples collected with SmartPulse <sup>HD</sup>	NC x 4 x NS
WT_Frequency	Frequency used for WaterTrack data for each sample (correlate with Frequency parameter from Transformation_Matrices structure)	NS x 1
Amb_Velocity	Ambiguity Velocity for each sample. Only applicable for samples collected with SmartPulse <sup>HD</sup>	NS x 1
Units	Units for above parameters (BT_Frequency is kHz)	NA

## Appendix D. Troubleshooting

### 1. Communications

- a. PCM (Power and Communications Module)
  - a) Be sure the dummy plug is installed and the locking sleeve is secured
  - b) Be sure the battery pack in the PCM is fully charged
  - c) Bluetooth Radios
    1. Bluetooth communications (BT) PCMs are always active and have an internal antenna. Make sure BT communications are active in the Mobile device or the PC.
    2. The Bluetooth dongle requires power from a PC USB port
  - d) Spread Spectrum (SS) Radios
    1. The SS base radio requires a rechargeable battery pack. Be sure the battery pack is fully charged.
- b. Software
  - a) If the COM port shows a red light instead of green, then it is being occupied by another program. The most common cause is Microsoft ActiveSync. Disable the program. If the red light doesn't turn green, restart the computer.

### 2. Interconnection and cables

- a. Please be sure to follow assembly instructions to interconnect correctly to maintain secure connections.
- b. Make sure that all cables are properly connected. The connections between the transducer (S5 or M9) and PCM should be firm. Make certain that the locking sleeves are tightened.

### 3. Data Collection

- a. The Status Bar in the *RiverSurveyor Live* software is a good place to start to diagnose any potential problems. Here is a list of the icons and description as well as a suggested corrective action.



- a) Bluetooth in the system is not activated. Activate in the Mobile device as indicated above and be sure that antenna is installed properly.



- b) Bottom track is not functioning. Please check cable connection between the PCM and S5 or M9 ADP. Also check that the transducers are clean and unobstructed. Some environmental conditions (such as bed conditions or grass/weeds) may also result in invalid bottom detection.



- c) RTK RTK quality GPGGA data (accurate to 3 cm or less). No action required by the user. Important Note: After powering on both systems (Base Station and RiverSurveyor) it typically takes approximately 10 minutes to connect to the system to achieve this quality of data.



- d) GGA Differential quality GPGGA data (sub meter accuracy). It usually takes approximately 5 minutes to connect to this level of quality of data. No action required

by user unless RTK quality is required. Be sure that the systems (Base Station and RiverSurveyor) have clear sky view antenna and that SS connections are correct.

- e)  Indicates that communications have been established between the system and satellites, however there is no sub-meter differential correction. Generally not recommended for discharge calculations. Users should make sure that they have a clear sky view. Time needed to establish a connection between System and Satellites: 5 minutes for Differential quality data or up to 10 minutes for RTK quality data.
- f)  Connection not valid. Action required: Revise all cable connections and be sure to have a clear sky view for antenna. Be sure that the battery pack is sufficiently charged.
- g)  GPS not available or not installed. If you are using an external, serially connected GPS, make sure that you have the correct baud rate (38400) and the \$GPGGA and the \$GPVTG serial data strings are being output from your GPS unit.
- h)  GPVTG data (highest quality VTG data—measured velocity data). It typically takes approximately 5 minutes to connect. No action is required as this is the highest level of VTG data available. To maintain this level of data quality, make certain that RiverSurveyor have clear sky view. At least 6-7 satellites are required for reliable VTG data. Satellite changes can affect track data and should be monitored during data collection. Similar to differentially-corrected (not RTK) GGA data, VTG data are best suited to streams greater than 20 meters across. The best VTG data are obtained when the vessel motion is constant. Additional transects may be advisable if VTG accuracy is in question during a discharge measurement.
- i)  Indicates that communications have been established between the system and satellites. Velocity is estimated. Generally not recommended for discharge calculations. Users should make sure that they have a clear sky view.
- j)  Mean Bottom Track depth is used for depth calculation.
- k)  Vertical Beam depth is used for depth calculation.
- l)  No depth-lock for either the Bottom Track or Vertical Beam. Some environmental conditions (such as bed conditions or grass/weeds) may also result in invalid depth detection.

- m)  Bottom Track not available or not installed.
- n)  Battery level in the system is at 10%. Finish data collection immediately or risk losing data. Communications will have to be re-established after installing a re-charged battery pack.
- o)  The data collection device (PC or Mobile device) is not receiving data. This does not mean that the system is not collecting data. The system will continue to collect data even if the communications link is lost. If using a wireless link such as Bluetooth (range is 60 m) or Spread Spectrum radios (range is 2 km), the system may be out of range or there may be obstacles preventing communication. Aim to maintain direct line of sight between the system and communications device at all times. For direct connection, most likely the cable has been disconnected.

#### 4. Multiple discharge calculations across the same transect do not match

- a. Flow conditions may have changed since you completed the last transect. This may be the case in areas of high tidal variation or when the measurement section is downstream of a man-made structure that regularly alters the flow conditions. Constant stage or water level is not a clear indication the flow conditions have been maintained.
- b. Be sure to keep a written record of water level at the site during the discharge measurement. The water level can be referenced to a stream gauge that is permanently installed or to a staff that can be temporarily installed on the water's edge.
- c. Make sure the site depth and location that you measured for the first transect match the measured values for the second transect in the data collected. You may have moved up or downstream since the last transect.
- d. Visible landmarks are always a good guide when making a measurement. Check the positional and depth measurements for both transects.
- e. Make sure the distance made good (DMG) is consistent between transects.
- f. The acceptable error between two to four measurements is typically less than 2 to 5%, but may be potentially higher depending on your application and the conditions.
- g. The edge positions should be the same or very close. Therefore the edge distances should be the same or similar for all transects.

#### 5. Mobile Device

- a. Be sure that the *RiverSurveyor Live for Mobile* software is installed correctly on the Mobile device prior to field data collection.
- b. Please use the clear plastic lanyard with the Mobile device to prevent any water damage in the field. The Mobile device is not water resistant. Water damage is not covered by the warranty.
- c. The operational range can be affected by inclement weather.
- d. The *RiverSurveyor Live for Mobile* software will automatically activate the Bluetooth even if it is manually turned off. It can also be activated manually with these steps:
  - a) Select Start on the Mobile device to open a list of Programs
  - b) Select the Applications Icon to open an additional list of Programs
  - c) Select Bluetooth and then Bluetooth Manager
  - d) Select option 6, Settings
  - e) Use arrow keys to activate Bluetooth

- e. If Bluetooth or other issues persist, there are two ways to reset the mobile device
  - a) If the phone is on:
    - 1. Press **Start**
    - 2. Scroll to and Select **System Tools**
    - 3. Scroll to and Select either **Master Reset** or **Master Clear**
    - 4. Press **Yes** (Left Soft Key) when Alert appears
    - 5. Enter Master Code (normally 000000)
  - b) If the phone is off or frozen:
    - 1. Press and Hold the Center Select Key, while powering up the phone  
or  
Press and Hold the Z & E keys, while powering up the phone
    - 2. The MASTER RESET screen will appear
    - 3. Press Yes
    - 4. This will restore the phone to factory settings

## 6. GPS

- a. Be sure the GPS antenna(s) have a clear view to the sky. Large trees or structures like bridges and buildings nearby can obstruct the satellite signals. Move away from any over-head obstructions to avoid multi-path errors or GPS dropouts.
- b. The GPS antenna on the ADP should be connected to the PCM with the coaxial cable.
- c. GPS Quality
  - a) Zero indicates no GPS signal detected
  - b) One indicates a non-differential GPS signal detected
  - c) Two indicates a differential GPS (DGPS) signal detected
  - d) Four indicates an RTK GPS signal detected
- d. GPS HDOP
  - a) Horizontal Dilution of Precision is a GPS term used to describe the geometric strength of satellite configuration on GPS accuracy.
  - b) Table 4 describes the possible values

**Table 4: HDOP Value Descriptions**

<b>HDOP Value</b>	<b>Rating</b>	<b>Description</b>
1	Ideal	This is the highest possible confidence level to be used for applications demanding the highest possible precision at all times.
2-3	Excellent	At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
4-6	Good	Represents a level that marks the minimum appropriate for making a good-quality discharge measurement. Positional measurements could be used to make reliable in-route navigation suggestions to the user.
7-8	Moderate	Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.
9-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.
21-50	Poor	At this level, measurements are inaccurate by as much as 300 meters with a 6 meter accurate device (50 DOP x 6 meters) and should be discarded.

## e. RTK

- a) Be sure the SS antenna is connected to the RTK Base Station
- b) Be sure the battery pack in the RTK Base Station is fully charged
- c) Be sure the RTK Base Station is within the 1 mile range limit of the ADP
- d) The GPS antennas should be mounted to the RTK Base Station and ADP.
- e) Connect time for Differential Quality GPS data is approximately 5 minutes
- f) Connect time for RTK quality GPS data is approximately 10 minutes
- g) Use the status icons to evaluate GPS (RTK and DGPS) Communications Quality. The tables below provide a quick reference for the software status icons and the LEDs on the PCM and RTK Base Station.



**Before RTK Lock:**

Scenario	Base Station		PCM		Software Indicator for PCM			Status	Action
	GPS Lock LED	RTK Lock LED	GPS Lock LED	RTK Lock LED	GPS Quality	GPGGA Icon	GPVTG Icon		
Hardware failure in Base Station and PCM					0			No power to GPS board in both PCM and Base Station	Send back both the power/comm. boxes to the factory
Hardware failure in Base Station and no GPS lock in PCM					0			No power to GPS board in Base Station	Send back RTK Base Station to the factory
Hardware failure in Base Station with GPS lock in PCM					1			No power to GPS board in Base Station	Send back RTK Base Station to the factory
No GPS lock in Base Station and hardware failure in PCM					0			No power to GPS board in PCM	Send back PCM to the factory
No GPS lock in Base Station and PCM					0			No clear view of the sky for Base Station GPS antenna	Make sure Base Station GPS antenna has clear view of the sky to get GPS lock

GPS lock in Base Station but no DGPS lock					0			No clear view of the sky for Base Station GPS antenna	Make sure Base Station GPS antenna has clear view of the sky to get DGPS lock
No GPS lock in PCM					0			No clear view of the sky for PCM GPS antenna	Make sure PCM GPS antenna has clear view of the sky to get GPS lock
GPS lock in PCM but no differential lock					1			GPS antenna of the PCM may be near a bridge or some obstruction	Move away from the bridge or a structure to get full view of all the available satellites to get differential lock
GPS lock in PCM and no radio link between Base Station and PCM					1			Spread Spectrum radios in PCM and RTK Base Station are not working	Send back PCM and RTK Base Station to the factory
GPS lock in PCM with differential lock				Flashing Green	2			GPS antenna of the PCM may be near a bridge or some obstruction	Move away from the bridge or a structure to get full view of all the available satellites to get RTK lock
GPS lock in PCM with RTK lock					4				

**After RTK Lock:**

Scenario	Base Station		PCM		Software Indicator for PCM			Reason	Solution to get RTK lock
	GPS Lock LED	RTK Lock LED	GPS Lock LED	RTK Lock LED	GPS Quality	GPGGA Icon	GPVTG Icon		
GPS lock in PCM with DGPS lock				Flashing Green	2			GPS antenna of the PCM may be near a bridge or some obstruction	Move away from the bridge or a structure to get full view of all the available satellites to get RTK lock
GPS lock in PCM with DGPS lock and no radio link between Base Station and PCM					2			PCM Spread Spectrum radio is out of range from Base Station radio	Go back towards Base Station to get radio link for RTK lock
Hardware failure in Base Station					2			Low battery voltage in RTK Base Station	Change battery in Base Station to get RTK lock
GPS lock in PCM with no DGPS lock and no radio link between Base Station and PCM					1			PCM Spread Spectrum radio is out of range from base radio for more than 45 minutes	Go back towards Base Station to get radio link for RTK lock
No GPS lock in PCM					0			GPS antenna on the PCM may be under a tunnel or no view of sky	Move away from the tunnel to get full view of all the available satellites to get RTK lock



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## Appendix E. Software Changes

### *RiverSurveyor Live v1.50*

#### 1. Multi-Language Support

RiverSurveyor Live software has full language and date/time/numerical support for the following languages:

- English
- Spanish
- Catalan
- Chinese (Simplified)
- French
- German
- Italian
- Korean
- Japanese
- Portuguese (Brazil)
- Turkish
- Hungarian

The currently selected language is displayed in the toolbar at the top left on the main screen as an icon representing the flag for the language. The language can be changed at any time in the software by clicking on the flag and selecting the desired language from the drop down list. All text, dates, times and numbers are displayed in the current language. **This means that numerical input must correspond with the language.** For example: The number **1,000.1** when English is selected, must be input as **1.000,1** when German is selected.

The Summary Report and ASCII export have Multi-Language support.

All log files (Compass Calibration, System Test) are recorded in English for troubleshooting purposes.

#### 2. All Graphs

All graphs can be saved to the clipboard by right clicking on the graph and selecting **Save to Clipboard** from the popup menu.

#### 3. Time Series Window

The Time Series Window displays multi-parameter parameters such as individual Bottom-Track Beam Depths. Additional parameters can be displayed including:

- GC-BC
- Bottom-Track beam Depths

A space on either side of the Time Series Window has been added to illustrate that edges are present.

#### 4. Track Window

The Track Window now only displays Tracks that are practical for the current coordinate system. For example GPS-GGA and GPS-VTG cannot be displayed in XYZ or System coordinates.

Track Window settings are now global (i.e. a change to the setting on one graph affects ALL Track Windows). Settings include:

- AutoScale
- AutoRotate
- Show Velocity Vectors
- UTM Display
- Tracks

When a GIS Map is loaded, right clicking on the Track Window displays the popup menu with a GIS sub-menu. On this menu are the following options:

- Zoom to Full Extents – Zooms out to display both the full map and all data
- Zoom to GIS Map – Zooms to the limits of the full map
- Zoom to Data – Zooms to the limits of all the data

5. **Contour Window**

The Contour Window displays a tooltip for highlighted cells.

A space on either side of the Contour Window has been added to illustrate that edges are present.

6. **Profile Window**

When displaying Discharge in the Profile Window, the profile extrapolation extends to the bottom.

7. **All Tables/Tabular Data**

All tabular data can be saved to the clipboard by right clicking on the table and selecting **Save to Clipboard** from the popup menu. This data can then be pasted into Excel or a text editor for ASCII export.

The order of the columns can be changed and is saved in the application settings. The columns should be adjusted to match the user display preferences or requirements for ASCII export.

Columns support multi-dimensional parameters (e.g. individual Bottom-Track Beam Depths).

8. **System Tab**

Column selections have been updated.

9. **Edges tab**

The **Edges** tab displays the **Left Bank** and **Right Bank** instead of the **Start Edge** and **End Edge**.

10. **Times Series Tab**

A new tab titled **Time Series** has been added that displays five multi-parameter Time Series windows.

11. **Discharge Measurement Summary**

Active Records (records that are checked) that have discharge values that are outside of +/- 5% of the mean discharge are now displayed in red.

This feature can be enabled/disabled using the **Highlight Records** button on the Discharge Summary toolbar.

The icons for the Start Edge - Left Bank and Right Bank have been swapped. The arrows now point in the direction of travel across the river.

The splitter for the Discharge Measurement Summary has been repositioned to display 6 measurements plus statistics by default.

The Summary only displays data for completed transects.

Export to .dis from discharge summary table includes Start Date.

## 12. Site Information

Site Information can be edited/changed in post-processing and all changes saved to the workspace. Any modified values are displayed in green text – just like all other fields. Note: In some cases fields that have not been changed are displayed in green. This is because the original Site Information fields may have been initialized incorrectly.

## 13. Lock Measurements

Individual measurements can now be locked. This means that once a measurement is locked by pressing the **Lock Measurement** button on the **Processing Toolbox** toolbar any changes to the settings will not be saved to the workspace. A measurement can be unlocked by pressing the **Lock Measurement** button a second time.

## 14. Processing Tools

**Heading Correction** added to the **Thresholds** tool. This setting should be used for corrections to the Heading for individual transects. The **Magnetic Declination** should be constant for all transects at a site and the **Apply to All** button can be used for all transects without affecting individual heading corrections.

**Composite Tracks** option added to the **Thresholds** tool. This setting by default is ON, in both software and firmware. When disabled the track is calculated only using the selected reference and not a combination of the best possible references.

## 15. System Test

System Test is logged to a text file.

## 16. MATLAB Export

Bottom-Track Velocity label is output as BT\_Vel (previously Bt\_Vel).

Units are removed from the names and are stored in a separate substructure within each of the root structures.

## 17. Loading Data File

Data files are loaded in chronological order.

## 18. Increased Precision on ALL Parameters

The precision has been increased (from float to double) on all values used in the software. Float has a precision of about 6 digits and doubles have 15. This means that the previous version may have done some rounding when dealing with large numbers of samples. The most observable difference between 1.00 and 1.50 could potentially be in the third or more significant digit of the discharge, but in most cases the variation would be extremely small.

## ***RiverSurveyor Live Mobile v1.50***

### **1. Multi-Language Support**

RiverSurveyor Live software has full language and date/time/numerical support for the following languages:

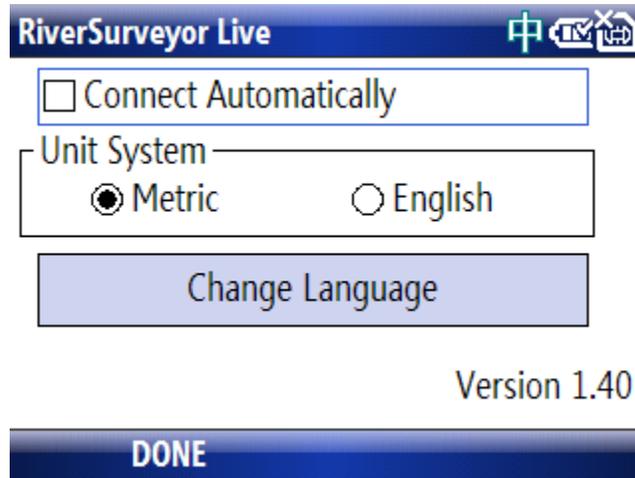
- English
- Spanish
- Catalan
- Chinese (Simplified)
- French
- German
- Italian
- Korean
- Japanese
- Portuguese (Brazil)
- Turkish
- Hungarian

**Following are the steps to select a language:**

1. When you run this version of the software for the very first time, the following language selection dialog will open before searching for any RiverSurveyor systems.



2. Select a language and click “SELECT” button.
3. The software will start searching for Bluetooth RS systems and it will operate just as v1.00.
4. If you close this application and start it again, the software will automatically start in the language selected.
5. If you would like to change the language again, click “Utilities” on main menu and click “Application Settings”. The following dialog will open:



6. Click the “Change Language” button and it will take you to the language selection dialog.
7. Unlike the RiverSurveyor Live PC software, you can only change languages from “Application Settings” dialog.
8. To change decimal and thousand separators to particular locale in the software application, you have to change locale manually in the phone. You can do this by going to /Settings/Regional Settings/Locale.

**To display Chinese, Japanese and Korean fonts:**

9. Windows mobile doesn’t have built-in support for Chinese, Japanese or Korean font.
10. Third party software called “CE-Star for SP” is available online to display Chinese, Japanese and Korean characters.

All log files (Compass Calibration, System Test) are recorded in English.

**2. Mobile Graphics**

One main addition in this version is mobile graphics in moving boat dialog. Measurement procedure is same but hotkeys 1, 2, 3 and 4 do not work to show different tabular views. To view different tabular and graphical views in moving boat dialog, follow the steps below:

1. Use up and down arrow keys to scroll between following views:
  - a. Tabular
  - b. Graphical
2. Use right and left arrow keys to scroll between pages in each view:
  - a. Tabular – 4 Pages
  - b. Graphical – 4 Pages (time series, profile, track and contour plots)

**3. Summary Table**

Hotkeys 1, 2, 3 and 4 do not work to show different tabular summary options. To view different summary options in summary view, use right and left arrow keys to scroll between summary options.

## ***RiverSurveyor Live v2.50***

## ***RiverSurveyor Stationary Live v1.50***

### **1. Data Storage**

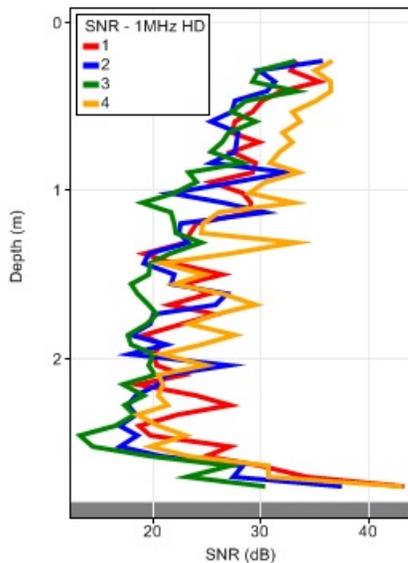
- Data files are saved to the computer as well as the M9/S5 recorder. This eliminates the need to download files to process them if communications are not lost during a measurement. Files saved on the computer are appended with the letter 'r', i.e. \*r.rivr.
- The system serial number is embedded in the compass calibration and system test file.

### **2. Temperature and Speed of Sound Correction**

Water temperature and speed of sound can be manually input prior to a measurement and in post-processing.

### **3. Data Display**

- Beam frequency added to the SNR profile plot



- The following variables can be plotted on the Time Series tab and displayed in the Samples tab:

Track Reference Code - 3 MHz, 1 MHz, GGA, VTG or invalid

Depth Reference Code - VB, 3 MHz, 1 MHz or invalid

Water Profiling Code - 3 MHz PC, 3 MHz IC, 1 MHz PC or 1 MHz IC

### **4. Lock Measurement**

A transect that is locked remains displayed as locked after the file is closed and reopened.

---

## 5. **Discharge Summary Report**

- Water temperature, compass calibration, system test and moving bed test results are displayed.
- Comments for each transect are displayed.
- A change in the Site Information is updated properly.
- Measurement number is included.
- *Date Created* is replaced with *Measurement Date*.
- A locked transect is displayed as such.

### ***RiverSurveyor Mobile v2.50***

### ***RiverSurveyor Stationary Mobile v1.00***

#### 1. **Data Storage**

- Data files are saved to the mobile device as long as a memory card is installed. This eliminates the need to download files to process them if communications are not lost during a measurement. Files saved on the computer are appended with the letter 'r', i.e. \*r.rivr.
- The system serial number is embedded in the compass calibration and system test file.

#### 2. **Temperature and Speed of Sound Correction**

Water temperature and speed of sound can be manually input prior to a measurement and in post-processing.

### ***RiverSurveyor Live v2.50***

### ***RiverSurveyor Mobile v2.50***

#### 1. **Loop Method**

A USGS developed method to correct moving-boat discharge measurements using bottom-tracking is integrated in the software. See Appendix H for details.

## ***RiverSurveyor Live v3.00***

## ***RiverSurveyor Mobile v3.00***

### **1. Smart Page Setup**

This feature provides a step by step guide through the system setup with real-time feedback to collect the most reliable discharge measurements. System functional test results (such as a compass calibration) as well as system settings are stored in the data file for easier access in post-processing. The initial screen after connecting now displays red or green icons depending on the status of system functional test and system settings.

There is also an option to turn off/on the Composite Tracks feature. This setting by default is ON, in both software and firmware. When disabled the track is calculated only using the selected reference and not a combination of the best possible references.

### **2. GPS Compass Integration**

This feature lets you collect true north heading from a GPS Compass sensor. This capability lets you collect reliable heading data where magnetic interference is an issue and GPS coverage is available. In addition to true-north heading information, the GPS compass simultaneously outputs GPGGA (differential using SBAS) and GPVTG NMEA data strings, which are used by the M9/S5 to compute position and boat-speed. In addition, the firmware and software let you input the X and Y distance between the GPS antenna and the M9/S5. This allows the GPS compass antenna to be mounted virtually anywhere on the boat.

The system requirements for using GPS compass sensor:

- a. Data output rate at 10 Hz
- b. Ability to output GPGGA, GPVTG and HEHDT NMEA sentences
- c. Communication baud rate of 38400

Note: To collect GPS Compass Heading data, you must obtain a security code that allows you to enable this feature in the system's firmware. For details on obtaining this code, you will need to contact SonTek.

### **3. USGS SMBA Method**

The SMBA-method correction is used when a moving-bed is present and a DGPS or compass is not available or reliable. The calculations are all based on the "Algorithms Used in SMBA" by David S. Mueller and USGS calculations and procedures documented in the USGS "Scientific Investigations Report 2006-5079" by Mueller and Wagner. The USGS recommends a moving-bed test prior to the start of any discharge measurement and the SMBA method is routinely used to identify the magnitude of the moving-bed. The RiverSurveyor software now guides you step by step through this procedure, and then allows you to apply the correction to the appropriate discharge measurements without having to export data to the USGS SMBA program. This saves time and effort in the field and in the office whenever you use this procedure.

### **4. Additional Profile Extrapolation Methods**

This version of the firmware supports one additional top and bottom extrapolation method. The top methods are Constant, Power, and 3-point slope; the bottom methods are Constant,

Power, and No Slip. The new 3-point slope method for top extrapolation uses the top three cells to calculate a best-fit line (least squares regression); this slope is then applied from the top cell to the water surface. The new No Slip method for bottom extrapolation uses the cells available in the lower 20% of the water depth to determine a power-fit forcing it through zero at the bed. In addition, this allows you to input the percentage of lower cells to calculate power-fit.

### ***RiverSurveyor Live v3.00***

### ***RiverSurveyor Stationary Live v2.00***

#### **1. ASCII Export**

The Processing Toolbox includes the ability to export three ASCII comma delimited files (.vel, .sum and .snr). These files contain cell velocity data, cell SNR data and summary of various parameters. The files are exported to the same directory as the recorded measurement file. The column headers and units are listed at the top of the CSV files.

#### **2. CastAway CTD Integration**

The CastAway CTD is a sophisticated CTD that makes it simple to improve the accuracy of RiverSurveyor discharge measurements by integrating seamlessly with the RiverSurveyor Live software. This new feature provides a turnkey solution for applying sound speed correction to ADCP data. The built in GPS in CastAway CTD marks the location and timestamp of the sound speed profile and allows the software to automatically select which sound speed profile to use for your discharge calculation. The software displays the CTD profile data and the location of CTD cast on the ship track plot.

See Appendix I. [CastAway CTD Integration](#) for further information.

## Appendix F. SmartPulse<sup>HD</sup>™ Principles

SmartPulse<sup>HD</sup>™ is a name chosen for the new profiling capabilities of the RiverSurveyor M9 and S5. In general terms, it works as follows:

- The RiverSurveyor continuously tracks water velocity and depth. Based upon these values, it selects the optimum processing configuration.
- At any given time, the system is sending multiple pulse types, potentially at multiple frequencies, using different processing techniques to achieve the optimum system performance.
- For the M9, up to three frequencies are used (3 MHz, 1 MHz, 0.5 MHz); for the S5, up to two frequencies are used (3 MHz, 1 MHz).
- A variety of different ping types and processing techniques: bottom tracking, bottom detection, incoherent, pulse coherent, and broadband. Many of these ping types are used in combination with each other. The exact ping types being used at any given time will depend on the operating conditions.
- The system tracks velocity and depth on a second-by-second basis, and updates the ping types and processing methods as needed based on changing conditions.

For the S5, two primary data types are output.

- When the water is sufficiently shallow and slow, the system reports data from 3 MHz pulse coherent pings using a 2 cm cell size.
  - o Maximum operating depth is about 1.5 m.
  - o At a depth of 1.5 m, the maximum velocity is about 0.4 m/s. The maximum velocity increases significantly in shallower water.
- In water depths and velocities greater than above, the system uses 3 MHz incoherent pings with the cell size optimized based on the current water depth.
  - o Depths less than 2 meters use 0.1 m cells
  - o Depths 2-4 meters use 0.2 m cells.
  - o Depths greater than 4 meters use 0.4 m cells.

For the M9, several different data types are output.

- When the water is sufficiently shallow and slow, the system reports data from 3 MHz pulse coherent pings using a 2 cm cell size.
  - o Maximum operating depth is about 1.5 m.
  - o At a depth of 1.5 m, the maximum velocity is about 0.4 m/s. The maximum velocity increases significantly in shallower water.
- In moderate depth/velocity conditions, the system reports data from 1 MHz pulse coherent pings using a 6 cm cell size.
  - o Maximum operating depth is about 5.0 m.
  - o At a depth of 5.0 m, the maximum velocity is about 0.4 m/s. The maximum velocity increases significantly in shallower water.
- In water depths less than 5.0 m with velocities greater than the above, the system uses 3 MHz incoherent pings with the cell size optimized based on the current water depth.
  - o Depths less than 2 meters use 0.1 m cells

- Depths 2-4 meters use 0.2 m cells.
- Depths greater than 4 meters use 0.4 m cells.
- In water depths greater than 5.0 m, the system uses 1 MHz incoherent pings with the cell size optimized based upon the current water depth.
  - Depths less than 10 meters use 0.5 m cells
  - Depths 10-20 meters use 1.0 m cells.
  - Depths greater than 20 meters use 2.0 m cells.

The RiverSurveyor SmartPulse<sup>HD</sup> uses a powerful CPU with multi-thread parallel processing routines; some key advantages from this are listed below.

- The RiverSurveyor runs multiple ping types from multiple frequencies at the same time. At any given site, the RiverSurveyor may use a total of 8-10 different ping types; at any given moment, it is typically running 3-5 ping types simultaneously.
- The parallel processing capabilities allows the system to collect new acoustic pings while at the same time analyzing data from the last set of pings. This continuous evaluation of data allows the system to modify operation, on a second by second basis, to ensure it always uses the best ping types for the conditions at that moment.
- In the case of the M9, the RiverSurveyor has the added advantage of using multiple acoustic frequencies for velocity profiling. It combines different frequencies and different Doppler processing techniques to optimize performance for the current operating conditions. The added power and flexibility provided by the additional acoustic frequency is significant, and makes a major difference in final instrument performance.
- The speed of the CPU means that the RiverSurveyor has no limits in the type of processing or analysis that is done. The final performance of the RiverSurveyor is limited only by the physics of underwater sound.

SmartPulse<sup>HD</sup> processing should be able to automatically adapt to any operating condition without any user input. Despite this (as a safety precaution), the updated RiverSurveyor Live PC and Mobile software includes an option to disable SmartPulse<sup>HD</sup> processing.

- This option should be needed only rarely for very particular conditions where the SmartPulse<sup>HD</sup> algorithms may fail.
- We have not yet encountered conditions where SmartPulse<sup>HD</sup> does not work properly, but it is conceivable.
- If you use the RiverSurveyor Live option to disable SmartPulse<sup>HD</sup> processing, the system will run incoherent pings only exactly as done with previous firmware releases.

## Appendix G. Stationary Measurement Software

### G-1. Overview

The SonTek *RiverSurveyor Stationary Live* software uses an alternative approach to the standard moving boat method of measuring water currents and discharge. Both methods use an Acoustic Doppler Profiler (ADP) to measure water currents. When using the *RiverSurveyor Stationary Live* software, however, the ADP operates from a fixed mounted position, stationary vessel, or platform (such as a SonTek Hydroboard or Tri-hull boat).

This measurement procedure is similar to that used for the SonTek FlowTracker and is in adherence to ISO velocity area measurement techniques. Measurements are made at stationary positions, usually along a tagline, to obtain a more precise representation of the mean velocity profile and therefore determine discharge.

Stationary-Measurement can be used in a wide range of applications such as:

- Discharge Measurements
- Current Profiling across transects
- Under Ice Measurements (available in future release)

### G-2. System Requirements

*RiverSurveyor Stationary Live* requires the following specifications for the PC.

Windows Vista or Windows XP

1.6 GHz processor

1 GB memory

1 GB disk space

1024 x 768 Screen Resolution

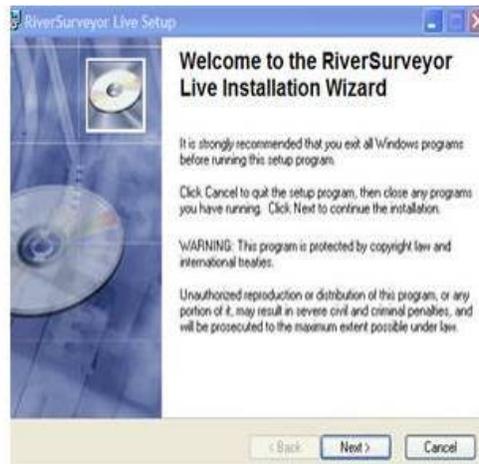
### G-3. Installation

To install the *RiverSurveyor Stationary Live* software on your PC, insert the distribution CD into your CD-ROM drive. The program should automatically start and display the Installation Menu (Figure 106). If the installation menu does not appear in a few seconds, click Start|Run on your PC and type D:\install.exe, where d:\ is the letter of your CD-ROM drive.



**Figure 106. Installation Menu**

Click the *Install RiverSurveyor Stationary Live* option. The installation wizard (Figure 107) will display step-by-step instructions to install the software.



**Figure 107. Desktop Installation**

Follow the on screen instructions to complete installation of the software. You are now ready to use *RiverSurveyor Stationary Live* to make a measurement.

#### **G-4. Making a Measurement**

The primary purpose of the Stationary-Measurement system is to measure the total discharge of a river cross-section. Because velocity measurements are made from a stationary position, the system does not require bottom-tracking or DGPS referenced velocity measurements. This becomes advantageous when one or both reference techniques are unavailable due to site conditions.

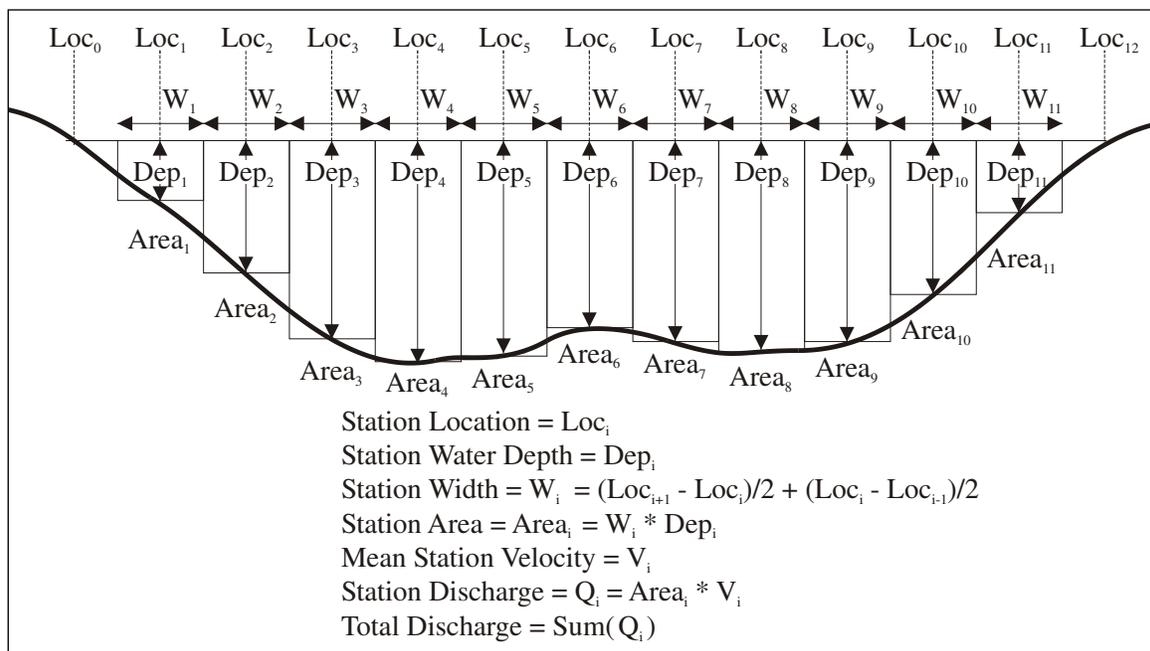
Stationary discharge measurements also provide additional opportunities for measurement applications such as:

- Accurate discharge measurements under ice
- Velocity profile measurements in conditions where there are significant temporal changes in flow conditions (e.g. pulsing rivers, moving beds and channels with conditions of variable moving beds). This also includes areas of significant turbulence (such as behind bridge pilings) where instantaneous or moving vessel measurements will have significant inaccuracies.

### G-4.1 Mid-Section Measurement Procedure

The procedure for making a discharge measurement follows the well-established methodology as outlined by the U.S. Geological Survey (USGS) for Discharge Measurement by Conventional Current Meters (ISO standards 768 (1997) and 9196 (1992)). This method is also referred to as the “Mid-Section method” of computing discharge and is the same method adopted by the SonTek FlowTracker.

The mid-section method involves making a series of velocity and depth measurements at a specific number of locations (more commonly known as stations, panels or verticals) across a river cross-section. At each station, the depth and mean velocity profile are measured. The depth is computed using either the 4-velocity beams, the low-frequency vertical beam, or manually measured (using a rod or other device) and entered into the software. The mean velocity profile for each station is computed from data from all valid cells above the riverbed. The width of a single station is determined to be the sum of half the distance to the previous station and half the distance to the following station. This method assumes that the velocity profile at each station represents the mean velocity for the entire rectangular station area.



**Figure 108. Basic River Discharge Measurement Method**

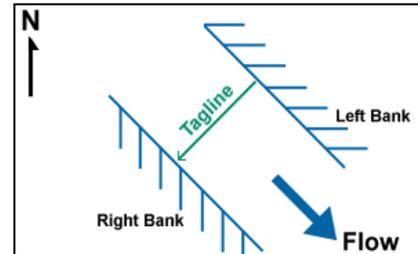
Each station is measured for a significant time to remove any environmental and temporal variation in the water velocities. Typically within the USGS, the recommended duration of measurement for a single station is 40 seconds. However, in particularly turbulent waters, extremely low-velocities, or in areas or rapidly changing water-level, a longer period may be required. This

recommended sample time might vary from country to country and even within different organizations.

The basic procedure for making a discharge measurement using the Stationary- Measurement system is as follows:

### 1. Setting up the Location

- A measurement section is selected based on the criteria outlined in Section G-5 below.
- A graduated tag line is strung across the river. In an ideal measurement site, the flow should be perpendicular to the tag line at all points with no flow reversals or obstructions. For ice measurements, a series of holes (one for each station) are drilled in the ice.
- The spacing of the stations along the tagline is selected so as to provide about 20-30 stations. Each of these stations should also be positioned so that no station is expected to yield more than 10 % of the total discharge. Ideally, no station should have more than 5% of the total discharge. This generally means that the stations are not equally spaced but are instead spaced closely together in deeper and high velocity areas and further apart in shallower and slower flowing areas.
- The magnetic-north heading (azimuth) of the tagline is measured. This is the compass orientation of the tagline in the direction of the right river bank. Setting the tagline azimuth is important because it allows the M9/S5 to rotate freely around the sample location and still measure the correct mean-station velocity by using its internal compass to resolve the true direction of velocity and then calculate the normal velocity to the tagline. In the example to the right, the tag line is oriented to the southwest (225°). The azimuth should be measured with the internal compass in the ADP (preferred) or a hand-held compass.



### 2. Setting up the Software

- Connect to the ADP through the software.
- Enter the site and system information into the software. This information includes the site name, number, location, starting bank, gauge heights, azimuth, velocity-reference method, depth reference method, rated discharge and any additional weather or measurement conditions comments.

### 3. Make the Measurement

- The operator starts at one edge (the start bank), recording the starting-edge location, water depth and gauge heights.
- The operator then proceeds to the first station and enters the station location, transducer depth, and gauge heights (not required).. If ice is present, the values for the ice thickness, depth of water and slush thickness should also be entered.
- The M9/S5 is positioned with the transducers submerged and the system as vertical as possible. Ideally the system will be mounted to a platform, vessel, or mounting structure.
- Data collection begins and the M9/S5 measures the 3D current velocities and bottom depth throughout the water column.
- Only the component of water velocity perpendicular to the transect line (or azimuth) is used to ensure proper discharge calculations, regardless of the flow direction. This normal component of the velocity is known as the “Normal Velocity”. The true flow direction

or “True Velocity” is still measured, recorded and will be displayed on screen or as a comparison with the Normal Velocity.

- At the end of the averaging time for the measurement, the discharge is calculated using the formula shown in **Figure 108**.
- Repeat the steps above at each station along the transect until the last station is completed. Press the End Section button when the last station is completed.
- The ending-edge location and depth are recorded.

#### 4. Post Measurement

- The quality of the entire measurement is assessed and recorded.
- The total discharge (the sum of all station discharges), the total area and mean velocity are displayed with graphs of parameters for the entire transect.
- A report of the entire measurement can then be generated for review.
  - The report includes the estimated uncertainty of the final discharge calculation; the uncertainty calculation is described in G-8.1.

#### G-5. Selecting a Measurement Location

The key issues to consider when selecting the location of your measurement cross-section are:

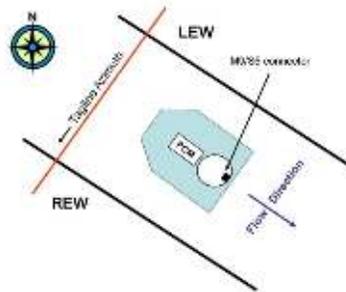
- Select an area of relatively uniform and steady flow. Try to avoid areas with standing eddies or strong turbulence. Note that a measurement may still be made in these areas however it may take longer to establish a mean profile (i.e. the averaging interval may need to be increased).
- The cross-section should have gradual changes in depth.
- Flow along the riverbanks should be low or close to zero.

#### G-6. M9/S5 Mounting and Instrument Orientation

Mounting: The mount to which the M9/S5 will be attached should meet the following criteria as closely as possible. Please remember that while the transducer depth should be as shallow as possible, the transducers must be completely submerged at **all** times during data collection. The key to good Stationary-Measurement data collection is that the transducers remain in a position that is relatively constant in location to the riverbank.

- Rigid and level when the transducer is in the water to minimize vibration.
- For some applications it is advantageous that the mount be easily retractable when the vessel is moving from one station to the next.
- As with a moving vessel measurement; on small to mid-sized boats (10' – 25') - the mount can extend over the bow; on larger boats, it is preferable to mount the ADP on either the port or starboard side near mid-ship.
- Transducer depth should be adjustable.
- Constructed of non-ferrous material (ideally aluminum).
- Make sure the M9/S5 is at least a few meters away from the engine or any other ferromagnetic objects mounted to the boat to ensure proper operation of the compass (if used in ENU orientation).
- The vessel maintains as much as possible a constant and steady position and orientation to the riverbank. Note: Bottom-tracking velocity reference is preferred if there is significant motion of the vessel during data collection.

**Instrument Orientation:** This is important when making measurements with using the XYZ orientation (i.e. similar to the FlowTracker reference) and/or when using the internal compass (ENU) to determine the tagline azimuth. In the first case, the x-velocity measured by the system is used to compute discharge for that particular station. This will require that the systems x-axis is pointed facing downstream as shown in **Figure 109** below. In this orientation, the connector located on the M9/S5 housing will be facing directly downstream. In addition, the M9/S5 should not be allowed to rotate during data collection (similar to using a FlowTracker).



**Figure 109. Instrument Orientation**

In most cases, the ENU orientation will be preferred during data collection. The primary reason is that when using the ENU orientation the system will always measure the true velocity and the normal velocity regardless of its angle to the tagline. This ability is helpful in many river conditions especially when you are deploying the system from a small boat with a line. In this case, the boat can freely rotate into the current as it changes in the cross-section and using the internal compass it will accurately compute the true velocity and normal velocity. The same system orientation shown in the figure above must be used when measuring the tagline azimuth using the internal compass of the M9/S5. This procedure (Get Tagline Azimuth) is described in Section G-7.4.

## G-7. Software Operation

### G-7.1 Connecting to the System

Ensure that all other software programs that access the serial ports are closed before starting the software.

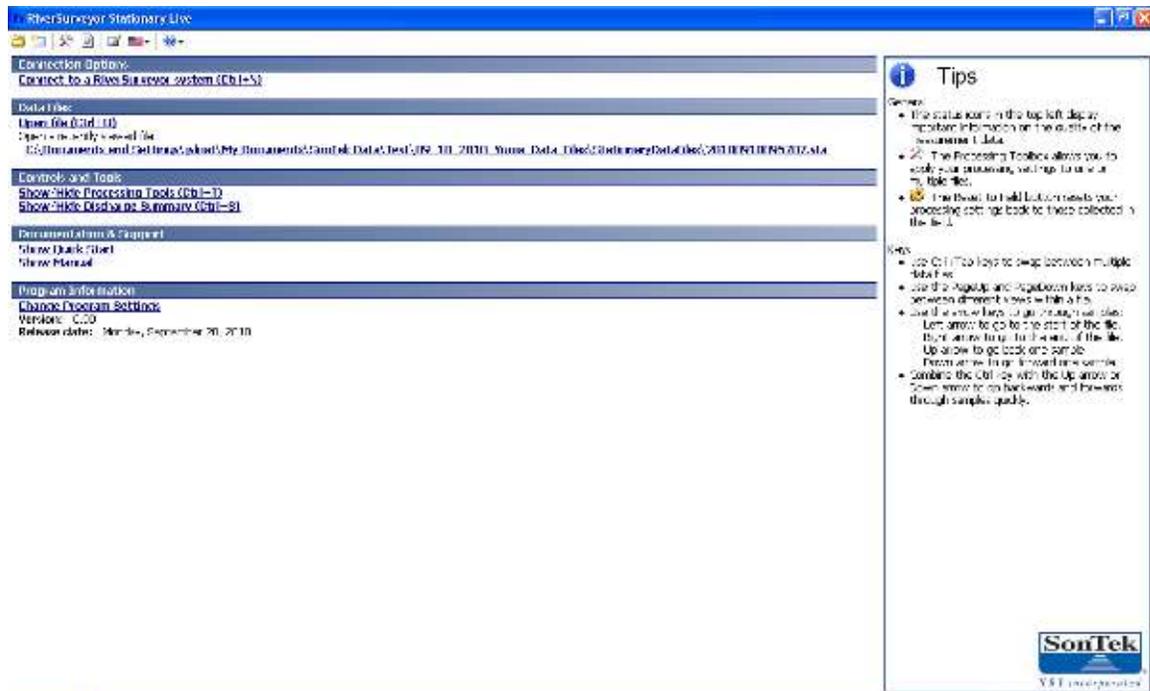


Figure 110. Main Menu

Start the software from the **Start** button and then **Programs | SonTek Software | Stationary-Measurement**. The start screen will be displayed as shown above in **Figure 110**.

Connect to your system by selecting the **Connect to RiverSurveyor System (Ctrl-N)**.

This will display the **Select Port** dialog. Select the serial port that your system is connected to and click the **Connect** button or press the **Enter** key. Note: If you are communicating using a Parani BlueTooth connection select the check box in the lower left hand corner as shown in **Figure 111**.

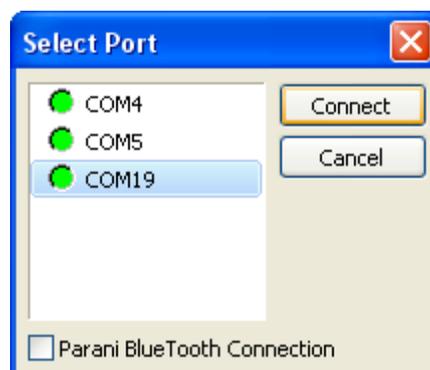


Figure 111. Communications Port

The Start Page screen, shown below in **Figure 112**, will be displayed once communication with the system has been established.



**Figure 112. Start Page**

This screen is used to input site information, program system settings, rated discharge (to compute percent measured for each station), and perform utility functions. Once you have input this information you can press the **Start a Measurement (F5)** button to begin your measurement.

### G-7.2 System Configuration

System configuration displays the system type (M9 or S5), the system serial number, and the firmware version for reference purposes. No inputs are required in this section.

### G-7.3 Step 1: Site Information

The Site Information dialog covers information related to the site itself, including the name and personnel involved in the measurement.

It is recommended that all fields on this page be filled in prior to starting the measurement. This data will be displayed in the Discharge Measurement Report, and will improve both the record keeping and data review processes.

The Site Information dialog (**Figure 113**) will be displayed. Press the **Tab** key to step through each of the displayed parameters.

**Figure 113. Site Information**

### G-7.4 Step 2: System Settings

Click **System Settings** to input Tagline Azimuth, Salinity, Track Reference, and Depth Reference. This will display the System Settings dialog (**Figure 114**). Just like the Site Information dialog, press the **Tab** key to step through each of the displayed parameters.

**Figure 114. System Settings**

Tagline Azimuth: It is important to set the tagline azimuth if you are using the ENU orientation. The tagline azimuth (**Figure 115**) is the heading (direction) in degrees from magnetic north of the tagline going towards the right bank. The normal velocity is used to compute discharge for each station. The following illustration shows the proper orientation of the M9/S5 (connector should always be oriented pointing downstream), the tagline azimuth relative to magnetic north and the REW, and the downstream flow direction.

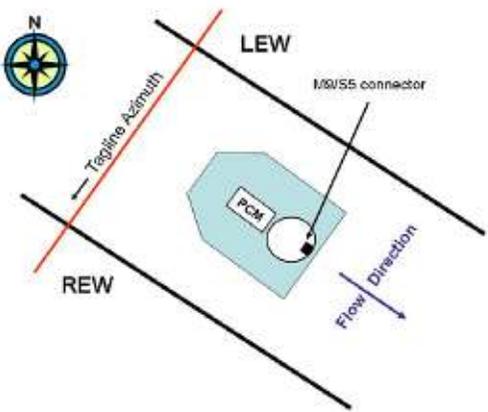


Figure 115. Tagline Azimuth

If you have previously determined the tagline azimuth for this site then simply input that value and proceed to the next tab. If you do not know the azimuth you can use the system's internal compass to determine the tagline azimuth by pressing press **Get Tagline Azimuth** which will display the Get Tagline Azimuth dialog, shown below in **Figure 116**.

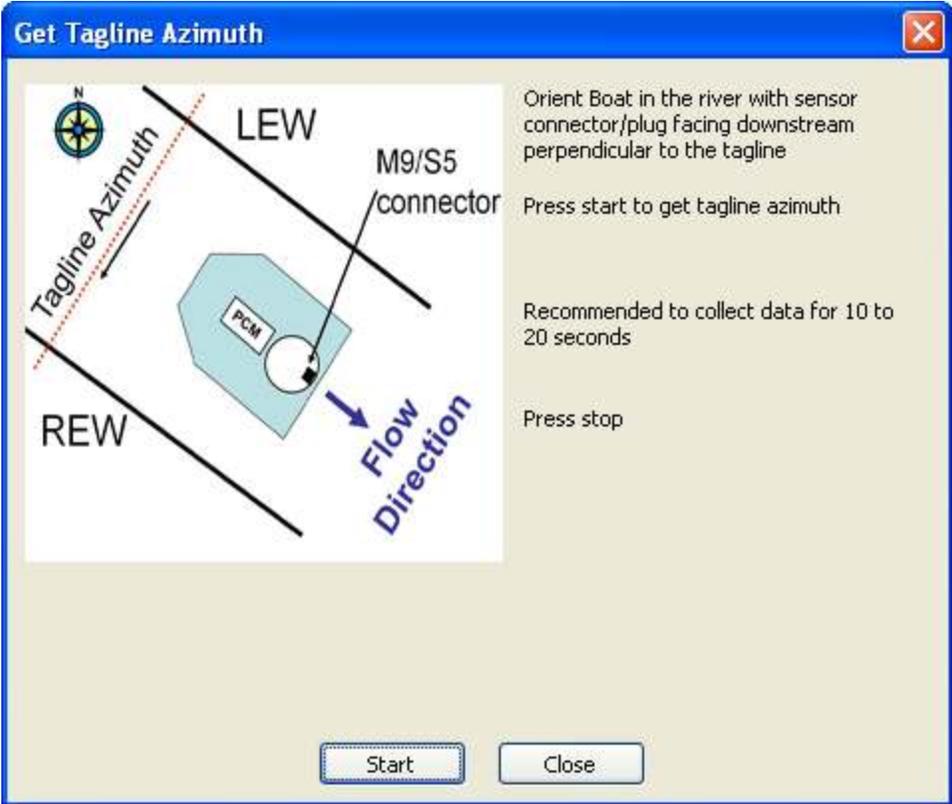


Figure 116. Get Tagline Azimuth

Follow the simple procedure outlined in the *Get Tagline Azimuth* dialog as follows:

1. Align the M9/S5 power and communications connector to point directly downstream. If you are deploying the instrument from a floating platform (i.e. boat, tri-hull, hydroboard, etc...) then simply lower the boat into the water and allow it to align itself with the flow. This is typically best done in a location near the center of the river in a section of flow that flowing directly downstream.
2. Once the M9/S5 has been correctly aligned with the river and is relatively steady press **Start** to collect data. During this time the compass will display instrument heading at 1-second intervals, average instrument heading, computed tagline azimuth, and the number of samples (in seconds) as shown in **Figure 117**. After 20-30 seconds of data collection press **Stop** and close the dialog. The tagline azimuth field in the system settings dialog box will automatically be updated with the tagline azimuth measured using *Get Tagline Azimuth*.

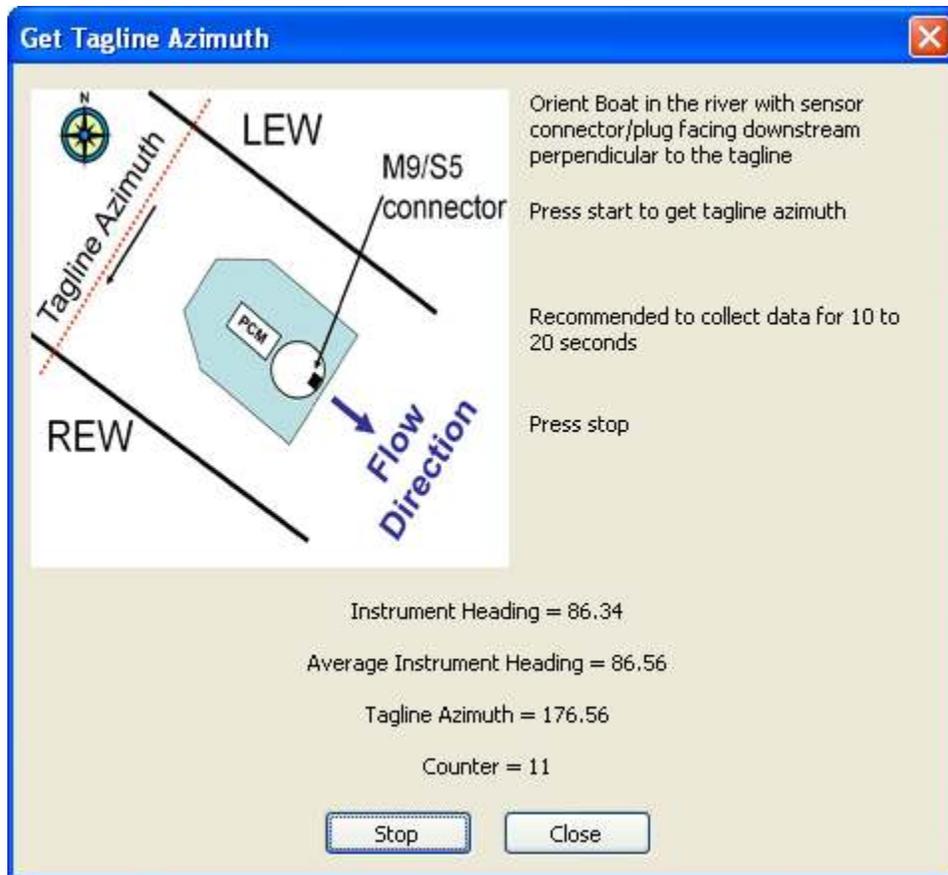
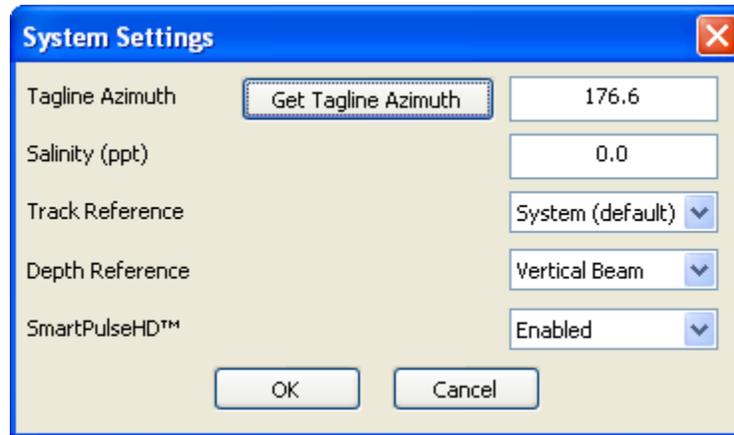


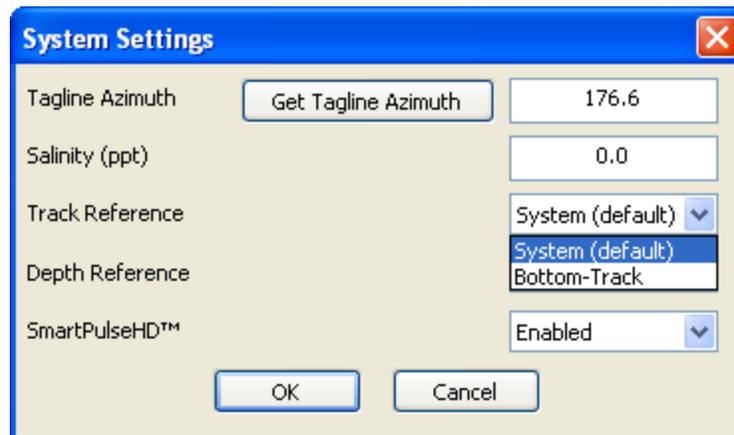
Figure 117. Get Tagline Azimuth

**Salinity:** Input the water salinity (0 – 34.5 ppt) at the transducer face (freshwater = 0, sea water = 34.5 ppt).



**Figure 118. Salinity**

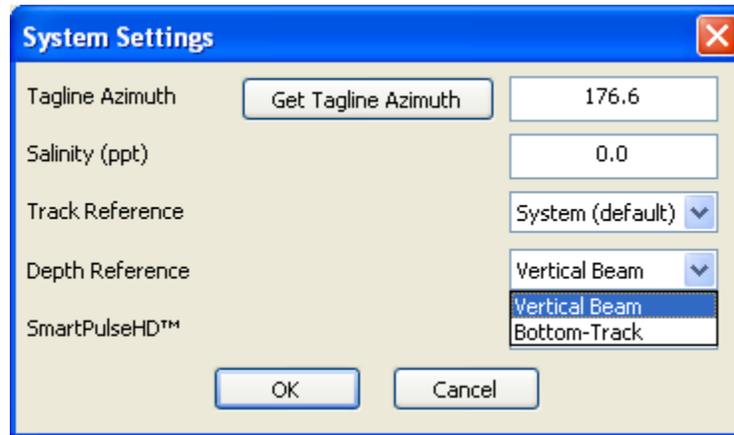
**Track Reference:** Select either **System (default)** or **Bottom-Track** as a track reference



**Figure 119. Track Reference**

In most cases, because the M9/S5 is stationary during a measurement the *System* track reference will be preferred. Selecting *Bottom-track* as a track reference is also acceptable for discharge calculations; however it will typically be used as a check against the stationary reference in post-processing for quality assurance purposes. Both *System* and *Bottom-Track* reference data are recorded and can be changed in post-processing if desired.

Depth Reference: Select either **Vertical Beam** or **Bottom-Track** as a depth reference



**Figure 120. Depth Reference**

The M9/S5 measures depth using a center vertical beam and also a 4-beam averaged depth. In most cases, the vertical beam will be preferred to provide a depth reading directly below the instrument. If the vertical beam depth measurement is unavailable then the M9/S5 will automatically use the 4-beam *Bottom-Track* depth.

Once the azimuth, salinity, track and depth reference have been set press **OK** to continue.

### **G-7.5 Step 3: Rated Discharge**

The rated discharge used to calculate the percent discharge measured for each station. To input the rated discharge click the update button and input the correct value.

The percent measured discharge is used as a data quality parameter to assist in determining the correct width of a section.

### **G-7.6 Utilities**

The Utilities section includes links to the Compass Calibration, Set Time, Beam Check, System Test, and Update Firmware. Please refer to Section 6.9 of the manual for a complete description of each.

### **G-7.7 Data Collection**

To begin data collection, press the **Start a Measurement (F5)** button located towards the upper left hand side of the screen.

The *Start Edge* dialog box will open as shown in **Figure 121**.

Start Edge	LEW(left bank)
Location (m)	0.00
User Input Water Depth (m)	0.00
Transducer Depth (m)	0.000
Screening Distance (m)	0.00
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.00
Gauge Height (m)	0.000
Auxillary Gauge Height (m)	0.000
GH Observation Time	11:50:15 AM
Water Surface Type	Open Water
Ice Thickness (m)	0.00
Water Surface To Bottom Of Ice (m)	0.00
Water Surface To Bottom Of Slush Ice (m)	0.00
Island Edge	<input type="checkbox"/>

**Figure 121. Start Edge**

Press the **Cancel** button to return to the system settings page and review the current system and data collection settings.

The Start Edge (Station 1) dialog will show several parameters, but only the relevant fields will be enabled in this step. Input the correct start bank (Left or Right), the starting location (edge of water on river bank measured from the tagline), the water depth at the start location (0 is typically used for a slope bank), velocity correction factor (1 is typical for most start and end locations), gauge height and auxiliary gauge height (i.e. water-level) if known, and the observation time of the gauge height reading.

Once the fields are updated press the **OK (Enter)** button and move the instrument to the first measurement location (Station 2). The station dialog will automatically open. The instrument will also start “Pinging” showing you the SNR (signal to noise ratio) profile plot for each beam and the number of valid cells for measurement (as shown in Figure 122). This information is provided to help make a better determination of the first measurement location. In addition, once the measurement is complete the system continues “Pinging” and displays this data as you move it to the next measurement location. Typically, it is recommended that you have a minimum of 2 valid cells and that the SNR profile plot shows the beams are measuring similar depths and are not obstructed by something below the water surface.

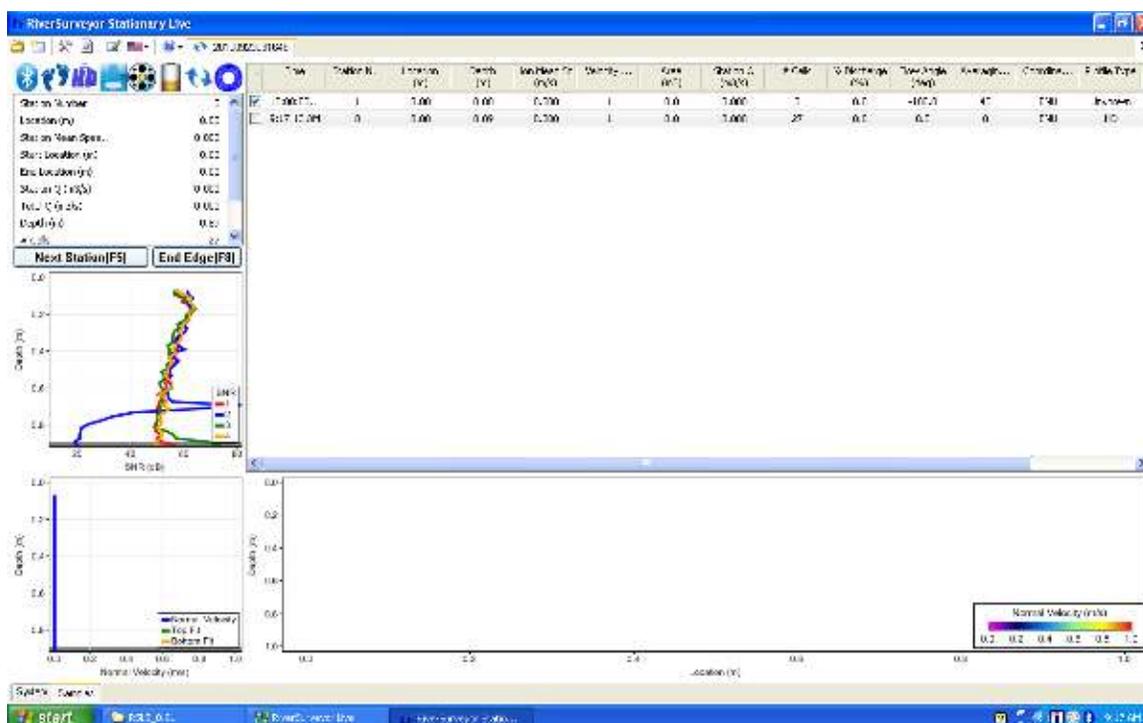


Figure 122. Raw Sample Display

Once the M9/S5 is in position, enter all relevant information into the appropriate field. On the far right side of the station dialog is the graphical display of the vertical water column for the Station. This graphical display is known as the **Station Window** and is visible for all stations.

The following is a brief description of each field in the station dialog:

**Location:** Distance measured from start bank using tagline.

**User Depth:** Only required if M9/S5 depth measurement is not available.

**Transducer Depth:** Depth of instrument below water surface

**Screening Distance:** Screens velocity cells near surface that may be contaminated due to interference from large boat hull.

**Coordinate System:** ENU or XYZ. ENU enables compass and references measurements from magnetic north. XYZ disables compass and references measurements from the internal system axis. Coordinate reference can be changed on a station by station basis if required.

**Averaging Time:** Time data will be collected and averaged for each station. Longer averaging times in general tend to better represent a true mean discharge in the river. For example - USGS recommends minimum 40-seconds.

**Velocity Correction Factor:** 0 – 1. Value of 1 is most common. Please refer to your agencies' guidelines for reducing this factor.

**Gauge Height:** Observed water level from a known datum at your measurement location. Not required for data collection.

**Auxiliary Gauge Height:** Second water-level reference measurement from a similar datum. Not required for data collection.

**Water Surface Type:** Open Water, Ice Cover or Ice with Slush. Open Water is the only option available in this release.

**Ice thickness:** Available in future release.

**Water Surface to Bottom of Ice:** Available in future release.

**Water Surface to Bottom of Slush Ice:** Available in future release.

**Island Edge:** Select to insert an island in the measurement section

The Station dialog box contains the following fields and controls:

- Location (m): 2
- User Input Water Depth (m): 0.00
- Transducer Depth (m): 0.05
- Screening Distance (m): 0.00
- Coordinate System: ENU
- Averaging Time: 40
- Velocity Correction Factor: 1.00
- Gauge Height (m): 0.000
- Auxillary Gauge Height (m): 0.000
- GH Observation Time: 11:51:27 AM
- Water Surface Type: Open Water
- Ice Thickness (m): 0.00
- Water Surface To Bottom Of Ice (m): 0.00
- Water Surface To Bottom Of Slush Ice (m): 0.00
- Island Edge:

At the bottom of the dialog are three buttons: Measure [Enter], Cancel, and End Edge. To the right is a diagram showing a transducer emitting a conical beam of light into a body of water, with a red double-headed arrow indicating the transducer depth and the label 'Bottom' at the water's base.

**Figure 123. Station Dialog**

Press the **Measure** button to begin collecting data, **Cancel** to go back to review the measured station information, or **End Edge** to input the end edge location information. If you press Cancel to go back, you must press Next Station (F5) in the upper left hand corner of the window to proceed with the measurement.

Once the station measurement is complete, a Measurement Results dialog (shown in Figure 124) will automatically display a summary of the measurement. Review this information and then press **Accept** to proceed to the next station or **Repeat** to measure the same station again.

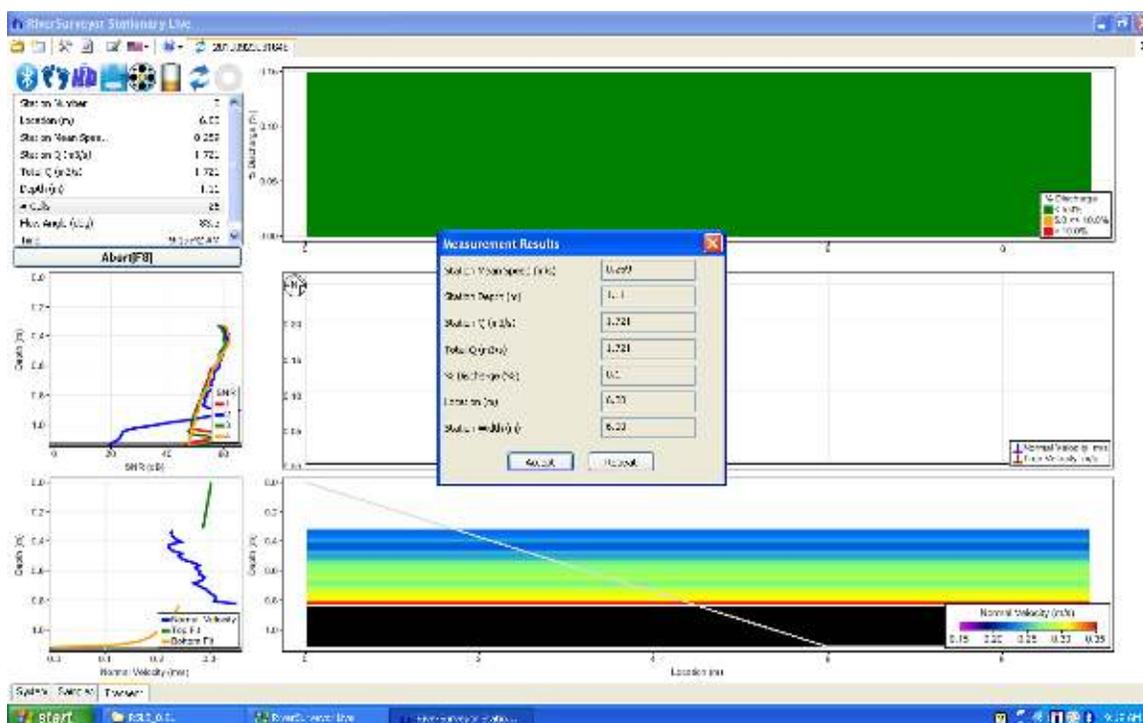


Figure 124. Measurement Results

Duplicate this process for the entire transect. When you have completed data collection of the last station, press **End Edge** to input the ending edge location. Press **OK** to end the measurement. Once the measurement has ended you will not be allowed to insert any additional stations. If you want to continue your data collection, press Cancel then press Next Station (F5).

Once all of the Stations and the End Edge have been entered, press the **End Transect** button to complete the measurement. The discharge summary report will be automatically generated and displayed.

### Station Data Collection

Once the **Measure** button has been pressed, the system will start up and begin profiling. The station data will be displayed at 1-second intervals and displayed similar to the screen below.

The screen layout is similar to the moving-boat software. Icons in the upper left of the screen indicate the operation and system performance on a second by second basis. A summary table is located below the icons to provide real-time and summary information for the particular station. The two profile plots on the lower left show the SNR (averaged signal-to-noise ratio) and normal velocity (averaged).

The upper time-series plot displays quality assurance information, the middle plot display the normal and true velocity for each station, and the lower graph display the normal velocity contour. The contour plot can be changed to display several other variables if required.

After the first profile is collected, the graphs and tabular results of the measurement will be displayed and will continue to update as additional data is collected.

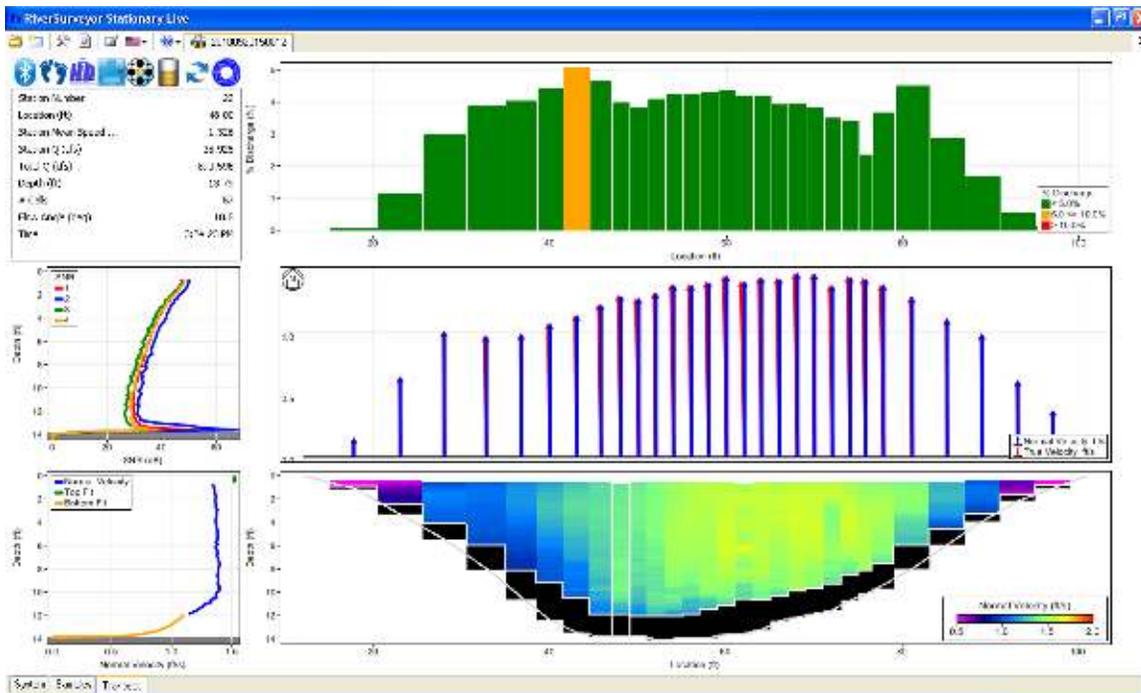


Figure 125. Data Collection Screen

### Inserting a Station

The operator can insert a station at any time during the measurement. In the station dialog, the operator will input a station location to be inserted and click **Measure**. The inserted station will be sorted and included in the total discharge calculation.

In order to prevent data loss in the event of a power, communications or computer issue during a measurement, the data file stored on the computer can be reopened to complete the measurement.

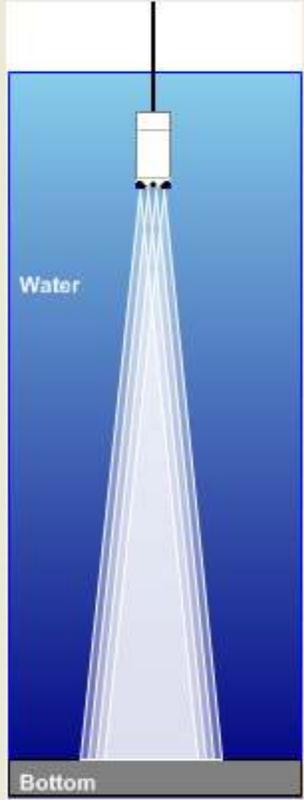
### Island Edges

If a river is split into multiple channels, any internal island(s) must be accounted for in the discharge calculation. The stations at each edge of the internal island(s) are treated like the river edges.

The operator can click the **Island Edge** box at the bottom of the station dialog window. The window header will change from *Station* to *Island Start Edge* as shown in Figure 126. Enter the location, depth and other information where appropriate. Click **OK (Enter)** and the software will prompt the operator to enter *Island End Edge* information automatically before continuing to the next measurement station.

**Island Start Edge** ✕

Location (m)	<input type="text" value="4.00"/>
User Input Water Depth (m)	<input type="text" value="0.00"/>
Transducer Depth (m)	<input type="text" value="0.050"/>
Screening Distance (m)	<input type="text" value="0.00"/>
Coordinate System	<input type="text" value="ENU"/> ▾
Averaging Time	<input type="text" value="5"/>
Velocity Correction Factor	<input type="text" value="1.00"/>
Gauge Height (m)	<input type="text" value="0.000"/>
Auxillary Gauge Height (m)	<input type="text" value="0.000"/>
GH Observation Time	<input type="text" value="11:53:08 AM"/> ▾
Water Surface Type	<input type="text" value="Open Water"/> ▾
Ice Thickness (m)	<input type="text" value="0.00"/>
Water Surface To Bottom Of Ice (m)	<input type="text" value="0.00"/>
Water Surface To Bottom Of Slush Ice (m)	<input type="text" value="0.00"/>
Island Edge	<input checked="" type="checkbox"/>



**Figure 126. Island Edge**

## G-8. Discharge Measurement Report

The Discharge Measurement Report is a formatted report-style summary of the current measurement. Click the Report button in the toolbar to display the Report.

The Summary is designed to be informative, easy to use and output the data in exactly the same format as it is entered.

If the report is too large for the monitor on your computer use the vertical scrollbar on the right to move the report up and down.

**Discharge Measurement Summary Report** Print

**Discharge Measurement Summary** Date Measured: Thursday, January 20, 2011

*Recorded file is located under My Documents\SonTek Data\YYYY\_MM\_DD\StationaryDataFiles*

Site Information		Measurement Information	
Site Name	401 cmm 815	Party	TT
Station Number	11186000	Boat/Motor	riverboard
Location	cable	Meas. Number	815

System Information		System Setup		Units	
System Type	RS-M9	Tagline Azimuth (deg)	272.9	Distance	m
Serial Number	221	Salinity (ppt)	0.0	Velocity	m/s
Firmware Version	1.00	Rated Discharge (m3/s)	19.0	Area	m <sup>2</sup>
Software Version	0.91	Discharge Method	Mid-Section	Discharge	m <sup>3</sup> /s
		Measurement Quality	--	Temperature	degC

Discharge Calculation Settings				Discharge Uncertainty		
Track Reference	System (default)	Top Fit Type	Power Fit	Category	ISO	Stats
Depth Reference	Vertical Beam	Bottom Fit Type	Power Fit	Depth	0.11%	2.12%
<b>Discharge Results</b>				Velocity	0.28%	1.74%
Total Area			32.30	Width	0.11%	0.11%
Mean Velocity			0.59	# Cells	0.11%	--
Total Width			18.90	# Stations	1.82%	--
Total Q			19.13	Instrument	0.25%	0.25%
Rated Discharge			19.00	Overall	1.87%	2.76%
% difference Q			0.70			

Measurement Results									
#	Time	Location	Temperature	Depth	Flow Angle	Mean Velocity	Area	Station Q	% Measured
1	1:54:48 PM	0.61	0.0	0.00	0.0	0.000	0.0	0.000	0.0
2	1:54:48 PM	1.83	5.2	2.34	-5.3	0.290	2.5	0.724	3.8
3	1:56:07 PM	2.74	5.2	2.65	-1.1	0.277	2.4	0.669	3.5
4	1:57:13 PM	3.66	5.1	2.83	5.5	0.274	2.2	0.591	3.1
5	1:58:20 PM	4.27	5.1	2.42	9.5	0.541	1.5	0.798	4.2
6	1:59:22 PM	4.88	5.0	2.31	1.8	0.627	1.4	0.884	4.6
7	2:00:21 PM	5.49	5.1	2.23	6.4	0.738	1.4	1.003	5.2

Figure 127. Discharge Measurement Summary Report

Discharge Measurement Summary Report									
8	2:01:17 PM	6.10	5.0	2.12	4.8	0.820	1.3	1.062	5.6
9	2:02:15 PM	6.71	5.0	2.00	3.1	0.928	1.1	0.990	5.2
10	2:03:18 PM	7.16	5.0	1.94	0.5	0.900	1.0	0.931	4.9
11	2:04:22 PM	7.77	5.0	1.91	0.3	0.989	1.0	1.007	5.3
12	2:05:25 PM	8.23	5.0	1.88	1.3	1.002	0.9	0.862	4.5
13	2:06:25 PM	8.69	5.0	1.86	-0.2	1.009	0.8	0.856	4.5
14	2:07:20 PM	9.14	5.0	1.84	-0.9	1.004	1.0	0.987	5.2
15	2:08:20 PM	9.75	5.0	1.81	0.2	0.893	1.1	0.987	5.2
16	2:09:16 PM	10.36	5.0	1.79	-2.2	0.847	1.1	0.923	4.8
17	2:10:11 PM	10.97	4.9	1.79	-3.6	0.771	1.2	0.944	4.9
18	2:11:19 PM	11.73	4.9	1.78	-3.4	0.772	1.4	1.044	5.5
19	2:12:16 PM	12.50	4.9	1.79	-4.2	0.695	1.5	1.041	5.4
20	2:13:23 PM	13.41	5.0	1.76	-1.1	0.606	1.6	0.976	5.1
21	2:14:25 PM	14.33	4.9	1.61	-4.3	0.440	1.5	0.649	3.4
22	2:15:24 PM	15.24	4.9	1.47	-6.9	0.340	1.3	0.458	2.4
23	2:16:24 PM	16.15	4.9	1.30	-3.7	0.268	1.0	0.265	1.4
24	2:17:28 PM	16.76	4.9	1.21	-4.8	0.221	0.9	0.203	1.1
25	2:18:33 PM	17.68	4.9	0.92	-3.1	0.223	1.3	0.280	1.5
26	2:18:33 PM	19.51	0.0	0.00	0.0	0.000	0.0	0.000	0.0
Locked									
Comments									
Good									
Compass Calibration									
File Name:- CompassCal20110208092615.txt									
Results: PASS									
Score is excellent.Magnetic interference is very low.									
Calibration score: M7.00Q9									
System Test									
File Name:- SystemTest20110210124014_Pass.txt									
System Tes: PASS									
Parameters and settings marked with a * are not constant for all files.									
Report generated using SonTek RiverSurveyor Stationary Live v1.10									

### G-8.1 Discharge Uncertainty Calculation

The Discharge Measurement Report includes the estimated uncertainty of every discharge measurement. This calculation is done two different ways: Statistical or ISO.

- The **Statistical** (abbreviated **Stats**) uncertainty calculation uses a method developed by researchers at the U.S. Geological Survey. In general this provides the most reliable indicator of measurement quality.
- The **ISO** method is based on the international standard and provides the results of a published, standard technique. In some cases it may not provide as reliable an indicator of data quality, as it makes limited use of data from the site.

The uncertainty calculations are based on several different parameters. In addition to overall uncertainty, the calculation looks at the contribution of each parameter.

- Accuracy: the accuracy of RiverSurveyor velocity.
- Depth
  - In the **Statistical** calculation, this term includes both uncertainty in the depth measurement and the effect of changes in depth between stations.
  - In the **ISO** calculation, this term includes only the uncertainty in depth measurements.

- Velocity
  - In the **Statistical** calculation, this term includes both uncertainty in the velocity measurement and the effect of changes in velocity between stations.
  - In the **ISO** calculation, this term includes only the uncertainty in velocity measurements.
- Width: estimated uncertainty in width measurements.
- Method: estimated uncertainty from not measuring velocity throughout the entire water column (velocity near the surface and bottom must be estimated).
  - Used for the ISO calculation only.
- Number of stations: estimated uncertainty from measuring velocity and depth at a limited number of locations across the river.
  - Used for the ISO calculation only.

The Discharge Measurement Report shows both uncertainty calculations and the contribution of each parameter to the overall uncertainty.

## Appendix H. Loop Method

### Introduction:

The “Loop Method” is used for correcting discharges biased by a moving bed. The *RiverSurveyor Live* moving-boat software uses calculations and procedures documented in the USGS Scientific Investigations Report 2006-5079 by David S. Mueller and Chad R. Wagner, prepared with the cooperation of Environment Canada (<http://pubs.usgs.gov/sir/2006/5079/>). This USGS report describes in detail the procedures and techniques for collecting Loop Method field data and the proper calculations used to correct discharge for a moving-bed bias. The report also addresses the sources and magnitude of measurement uncertainty when performing this type of calculation. Based on field measurements from 13 locations the report concludes that when properly applied the Loop Method represents a valid alternative to the use of DGPS when measuring discharge in stream with moving-bed conditions. SonTek highly recommends that you review this document before applying the Loop Method to your data sets.

**It should be noted:** All computer code and output analysis used for this loop-method calculation was provided to SonTek/YSI, Inc. by the USGS Office of Surface Water (OSW). As such, moving-bed results provided using the existing MATLAB program (v3.30 or later) developed by David S. Mueller with the USGS OSW will produce identical results when computed using the *RiverSurveyor Live* software. The actual moving bed velocity calculation is based on the “distributed correction” method which is described in detail in the report mentioned above.

### Background

For moving-boat discharge measurements, the RiverSurveyor M9/S5 measures boat speed using either bottom-tracking or an integrated DGPS system. Bottom-tracking requires that the riverbed be stationary (motionless) in order to properly compute boat-speed. During certain flow conditions, sediment will be transported along the riverbed (i.e. a moving-bed) and will produce a bias in the bottom-tracking results which will ultimately result in a biased discharge measurement. DGPS is a good alternative to bottom-tracking because it is not affected by the moving-bed.

In some instances DGPS will not be available or reliable at your measurement site. As an alternative, when used properly the Loop Method can be used to correct the bottom-tracking bias produced by the moving bed.

The Loop Method is used to correct discharges that are biased by sediment transport (moving-bed) when bottom-tracking is used as a reference to measure boat speed. The basic premise is based on a “back and forth crossing closure error” where the apparent upstream movement of the ship-track is used along with the measurement time to determine the mean velocity of a moving bed. In this case, the discharge will be biased LOW by a certain percentage based on the velocity magnitude of the moving-bed.

### Loop Method Procedure

The Loop Method procedure described here follows explicitly the step-by-step procedure documented in the appendix section of the USGS Scientific Investigations Report 2006-5079 by Mueller and Wagner. SonTek/YSI recommends that this step-by-step procedure is reviewed prior to attempting a Loop Method measurement using the *RiverSurveyor Live* software.

The Loop Method can be performed using either the PC or mobile *Riversurveyor Live* software. The procedure is essentially identical. The only difference is the graphical screens available in the PC software. In addition, following the completion of the loop measurement results will only be available using the PC software.

Although moving-bed results are available prior to the discharge measurements to be performed, the actual “Loop Correction” will only be applied to discharge measurements in post-processing (if required). In addition, if the moving bed is determined to be insignificant it will not be possible to apply the correction to the processed data – this is in accordance to USGS procedures.

**Step-by-step procedure:**

1. Start the *RiverSurveyor Live* PC or mobile software and connect to the M9/S5.
2. In the start menu, input all necessary parameters as usual to measure discharge.
3. Calibrate the compass (Utilities menu). A proper compass calibration is required to produce reliable results when using the Loop Method correction as the compass is used to determine the tagline azimuth.
4. Establish a starting point in the river. It will be helpful to select this location such that the boat can easily be controlled when starting and ending a measurement. Keep in mind that you will need to return to this same location in order to compute properly the moving-bed speed—the greater the difference between the start and end locations, the greater the uncertainty in the Loop Method’s results. Also, the point does not need to be located as near to the bank as a regular discharge measurement.
5. Click on **Loop Method** located in the Utilities Menu of the PC software as shown in Figure 128. It is in the Main Menu when using the mobile software. The instrument will begin profiling.



Figure 128. Utilities Menu - Loop Method

- In the PC software, a Loop Method window will appear in front of the transect page as shown in Figure 129. Make sure the boat is stationary and located at your starting position. Press the **Start** button and proceed to make a steady pass back and forth across the stream. The ship-track and contour plot are displayed.

It is essential to a quality measurement to maintain a uniform and steady boat speed during the entire measurement. As you approach the far stream bank, do not spend any extra time along the edge. Rather, gently turn the boat and return to the starting stream bank. Per the USGS recommendation, the boat speed should be the lesser of a.) the boat speed that requires no less than 3-minutes to complete the loop or b.) the boat speed that is less than 1.5 times the mean water speed.

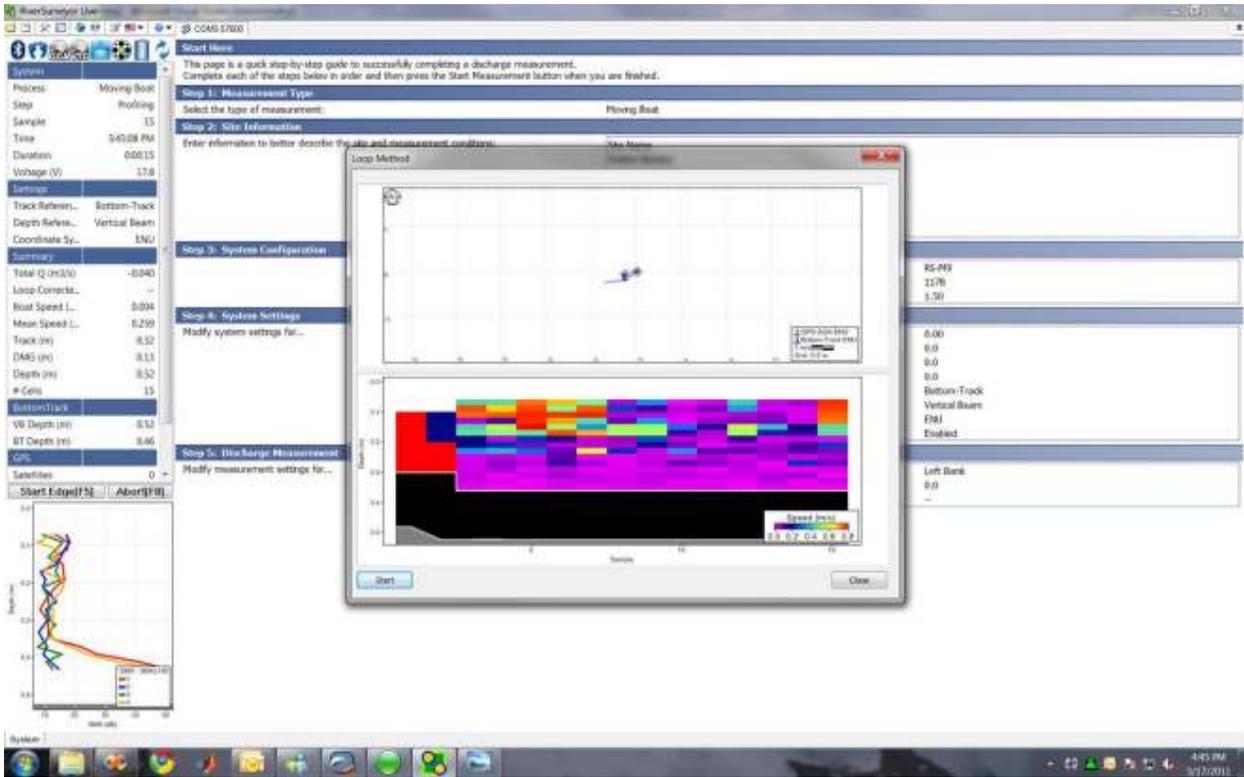


Figure 129. Start Loop Method

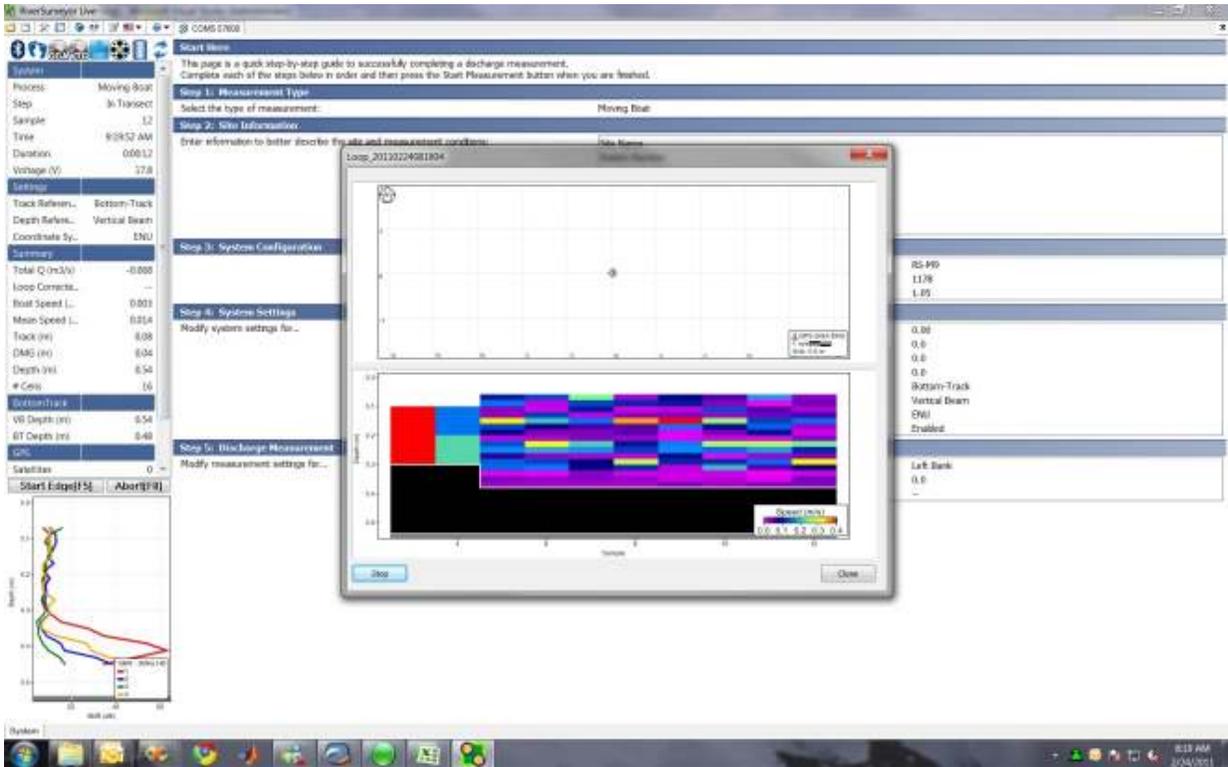


Figure 130. Stop Loop Method

- After returning to the starting position and the boat is stationary, press the **Stop** button (Figure 130). There will be a slight pause as the loop calculation is performed. The results will be displayed the PC software as shown in Figure 131:

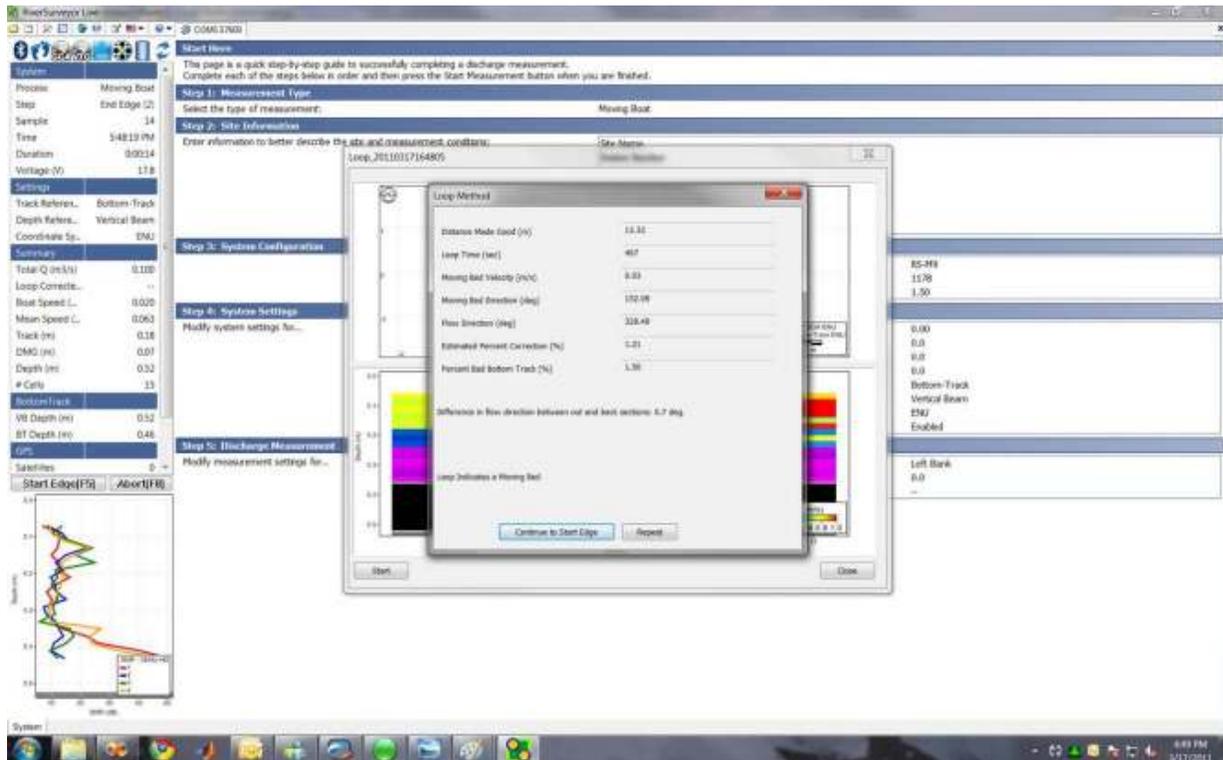


Figure 131. Loop Method Results

- Press **Continue to Start Edge** to begin regular discharge measurements or **Repeat** to perform the Loop Method again. A Loop Method file will be stored on the M9/S5 internal recorder and on the PC or mobile device that will contain all data collected during the Loop Method measurement in addition to the moving-bed results. The file name will start with "Loop\_" to identify it from a regular discharge measurement.

## Post-Processing Loop Method Measurements

- Start the *RiverSurveyor Live* PC software.
- Open** the regular discharge measurement files as usual.
- Open the associated Loop Method file by clicking on the **LC** icon located on the top tool bar. Select the appropriate file associated with the regular discharge measurements to be processed. For data collected using firmware v1.50 or later, the loop file name will begin with the word "Loop\_" as shown in Figure 132. For loop measurements made with earlier firmware versions, the file name will begin in the same format as the regular discharge measurements. It should be noted, this is the only way you can load a Loop Method file.

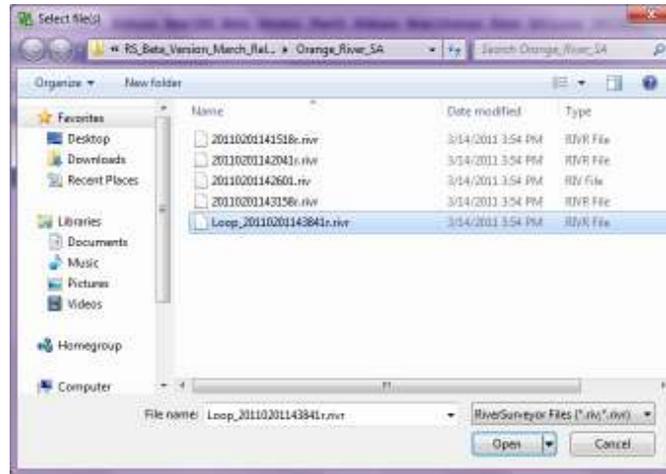


Figure 132. Loop Correction File

- The Loop Method results will be processed and displayed as shown in Figure 133. Click **Close** after the results are reviewed.

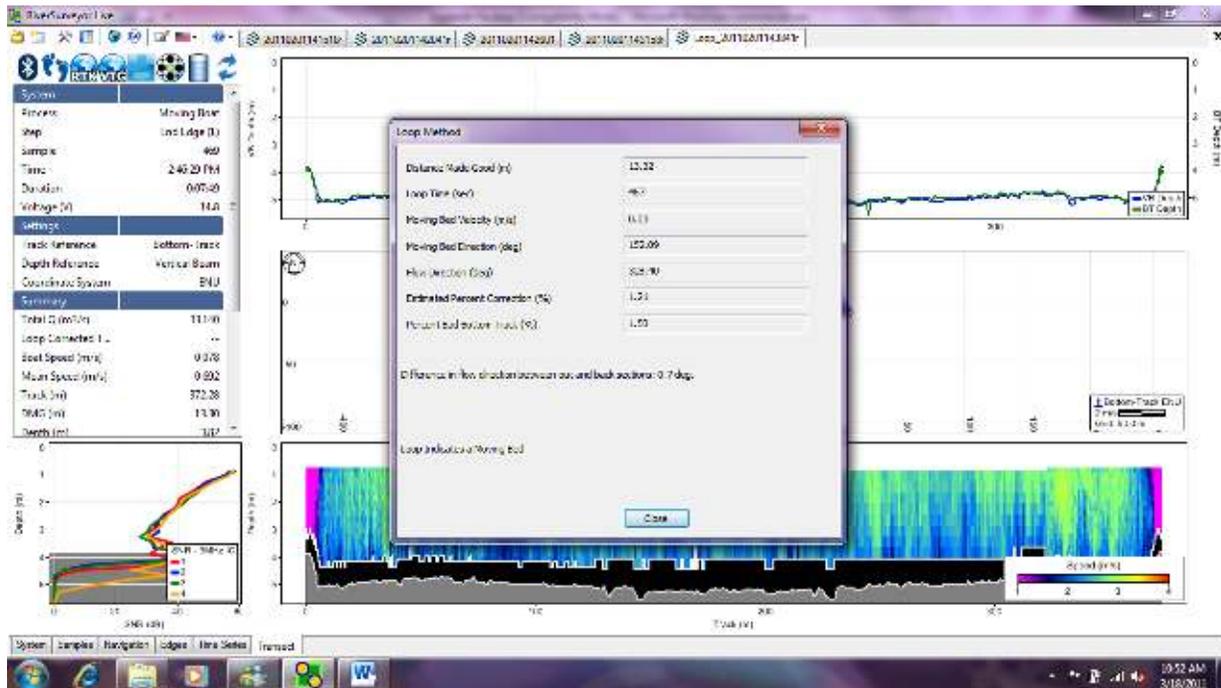


Figure 133. Loop Method Results

- The moving bed speed is now calculated. Prior to applying the correction, you must first open the Processing Toolbox by clicking the Tools icon (**Ctrl+T**) on the tool bar located at the top of the screen. It is also helpful to open the Discharge Summary (**Ctrl+S**) by clicking the summary icon located on the toolbar. The screen should appear as shown in Figure 134.

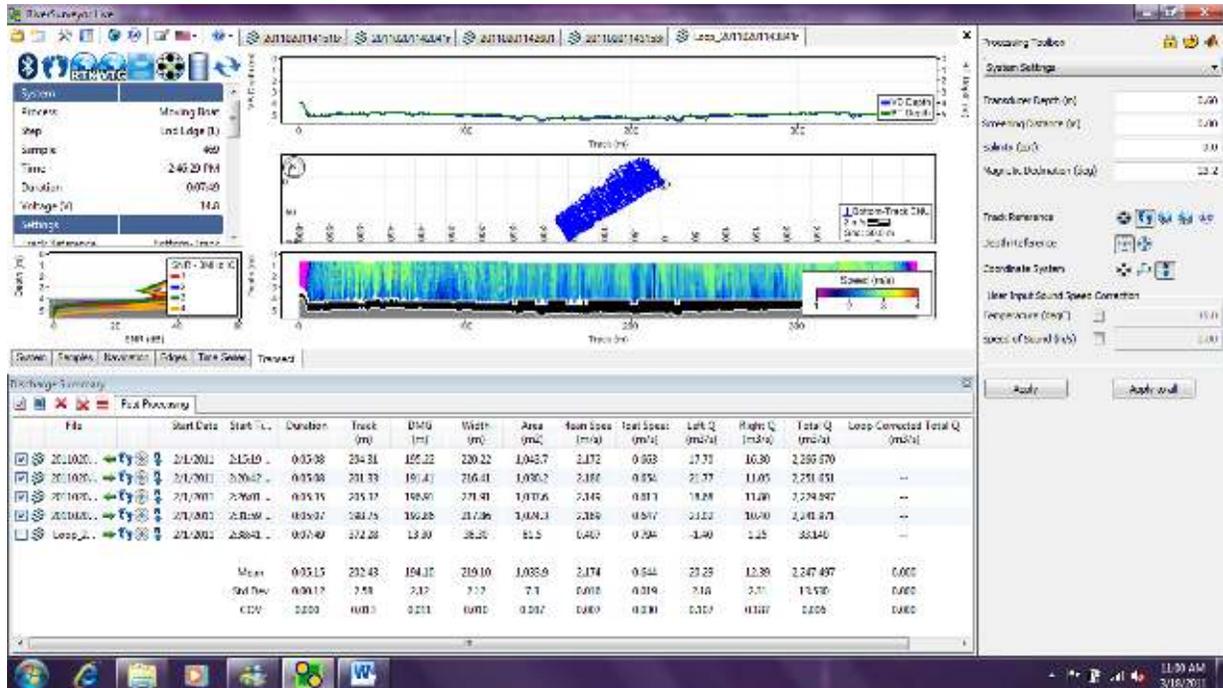


Figure 134. Loop Method Processing

- Click on the **LC** icon at the end of the Track Reference options in the Processing Toolbox on the right side of the screen. Click **Apply to all** to apply the loop correction to the open measurements. As soon as the correction (if valid) is applied, the Discharge Summary and the side bar summary table will update to show the “Loop Corrected Total Q” as shown in Figure 135:

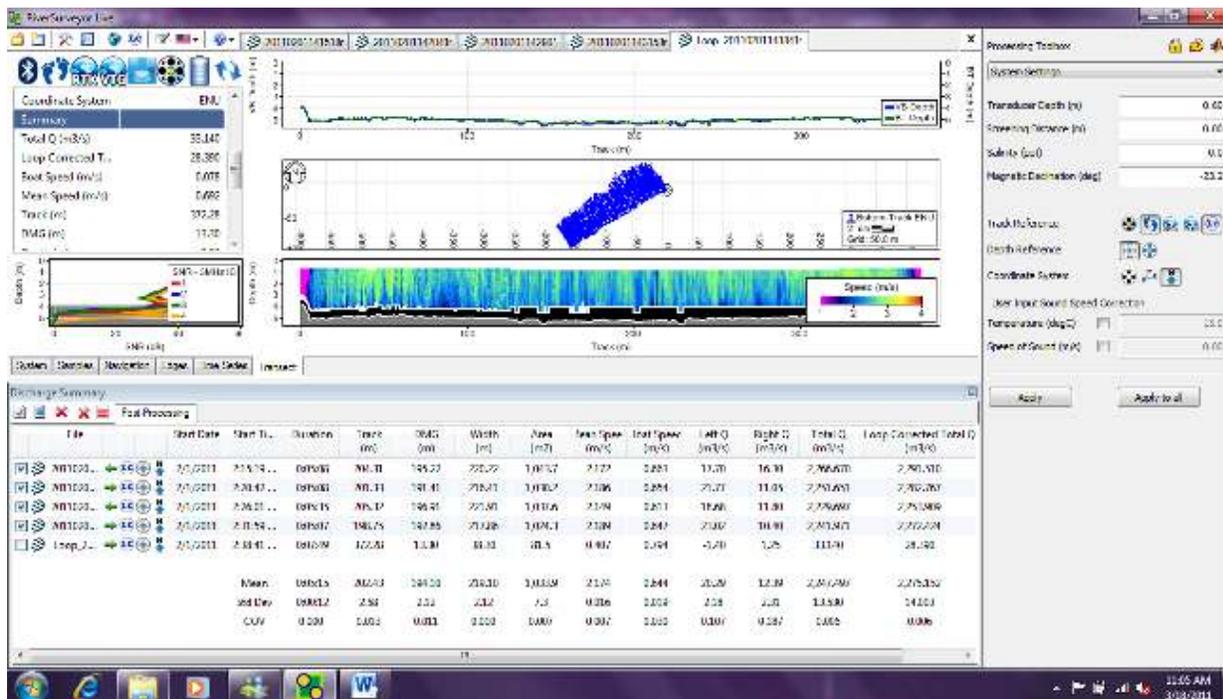


Figure 135. Loop Method Correction

- Click the **Discharge Summary Report** icon under the Discharge Summary table to generate the final discharge summary report. The final report will display the entire Loop Method analysis along with measured and loop corrected discharge values as shown in Figure 136:

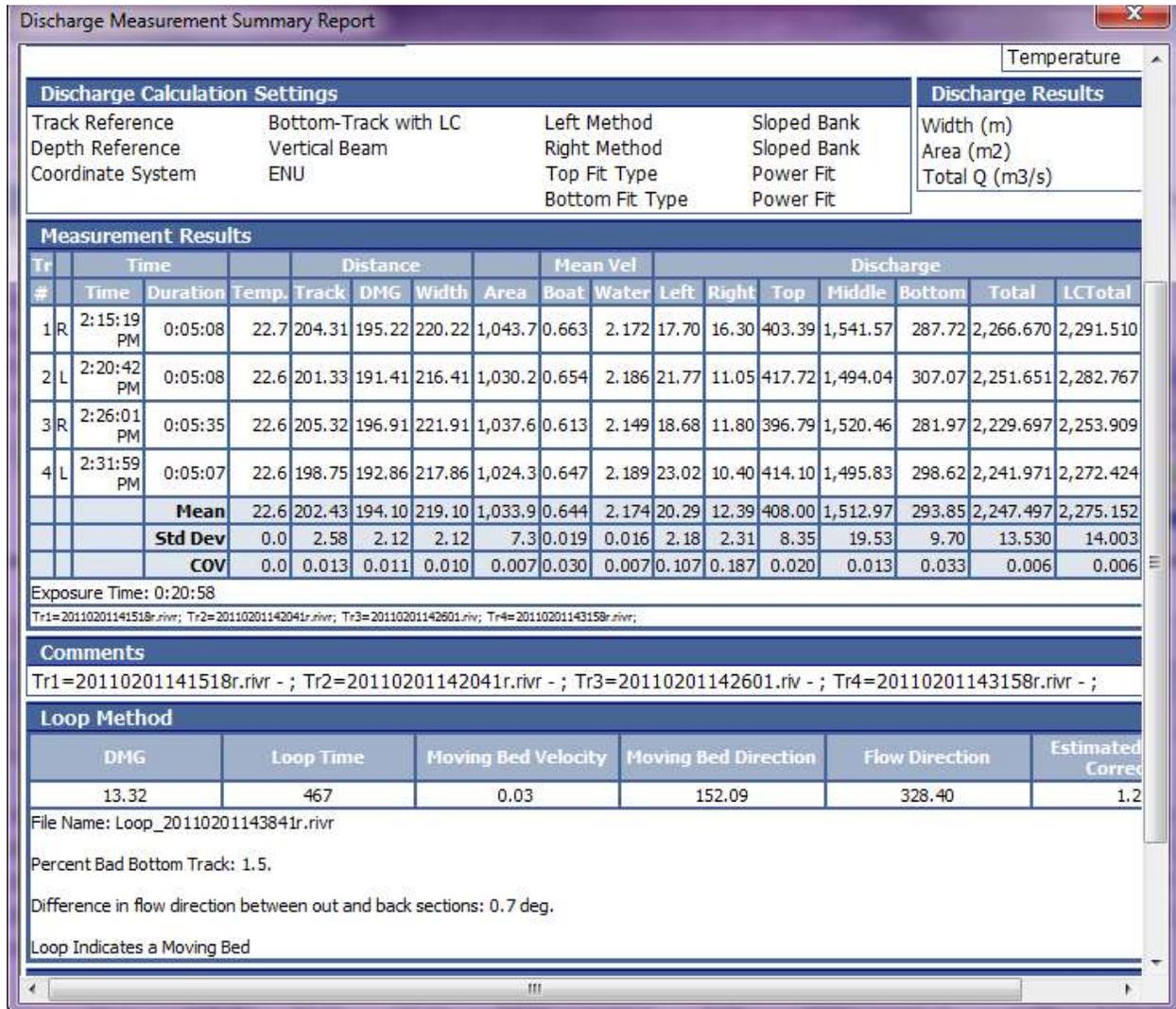


Figure 136. Discharge Summary Report

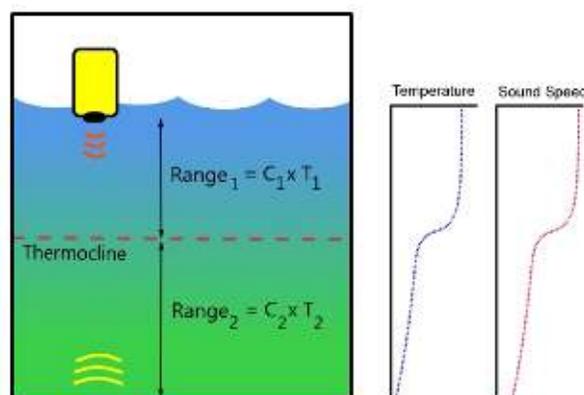
## Appendix I. CastAway CTD Integration

### Background - Sound Speed and Acoustic Measurements

Underwater acoustic measurements, particularly acoustic depth range measurements, are dependent on information about the speed of sound in the water to collect accurate data. Sound can travel through the water at different speeds based on changes in temperature, salinity and density (Table 5). For example, sound will travel faster in hot salty water and travel slower in cold fresh water.

	Change	Effect on Sound Speed
<b>Temperature</b>	1° C	4.0 m/s
<b>Salinity</b>	1 PSU	1.4 m/s
<b>Depth</b>	100 m	1.7 m/s

**Table 5. Effect of temperature, salinity and depth changes on the speed of sound in water**



**Figure 137. A stratified Water Column**

The water in almost every lake, river, estuary and ocean is stratified into different layers. Temperature conditions in one layer may be notably different from conditions in another layer (Fig. 137). As sound transitions from one layer to the next it will also refract and change direction. These changes in sound speed and direction throughout the water column cause errors in acoustic depth measurements. Depth measurement errors are generally largest in deeper rivers or in estuaries where water temperature and salinity at the surface can vary significantly from the water beneath it. For more detailed information about how temperature and salinity affect depth calculations, refer to SonTek Technical Note: *Range, Velocity, Sound Speed and Snell's Law*.

Similar to acoustic current measurement systems, hydrographic surveying instruments (i.e. multibeam echosounders, side scan sonar) measure the time it takes a sound pulse to travel from the instrument to the seafloor to calculate distance. Hydrographic surveyors apply sound speed corrections to their data to reduce depth measurement errors induced by sound speed variability. To measure sound speed surveyors use a CTD (Conductivity, Temperature, Depth) sensor to collect a vertical sound speed profile during a hydrographic survey. The sound speed correction is then applied to the acoustic sounding data yielding more accurate depth measurements. These sound speed corrections can also be applied to ADP measurements to improve their accuracy.

### Application to ADP measurements

While it has been common practice for hydrographic surveyors to apply sound speed corrections to bathymetric data, corrections have not commonly been applied to ADP data for two primary reasons. First, the advantage of higher accuracy measurements has been overshadowed by the complexity of applying corrections and velocity measurements are impacted less by sound speed than depth measurements. In many environments sound speed corrections will only slightly improve ADP measurement accuracy; however there are environments such as estuaries where corrections will significantly increase accuracy. With growing requirements for

highly accurate flow measurements in our rivers and oceans and with more ADP data being used for measurements other than velocity such as discharge and bathymetry, the need for applying sound speed corrections to ADP data is increasing.

Sound speed corrections improve the accuracy of ADP discharge calculations by increasing the accuracy of the river cross-sectional area. Accurate sound speed measurements at the ADP transducer face are important for velocity measurement accuracy. The fast response of the CastAway thermistor eliminates the need for waiting for the ADP thermistor to equilibrate to water temperature. Measuring temperature and conductivity at the surface allows for the most accurate sound speed equation to be used in the velocity calculations.

### CastAway CTD and RiverSurveyor Integration

The CastAway is a small sophisticated CTD that provides a turnkey solution for applying sound speed corrections to RiverSurveyor measurements by integrating seamlessly with RiverSurveyor Live 3.0 and RiverSurveyor Stationary Live 2.0. Collecting sound speed profiles is simple with the CastAway: it can be lowered by hand, requires no preprogramming, and after a cast automatically transfers data to your PC. A built in GPS marks the location and timestamp of the sound speed profile and also allows the software to automatically select which profile to apply to the discharge calculation. In the software, there is also a summary page that displays temperature, salinity and sound speed information from the CastAway (Fig. 138).

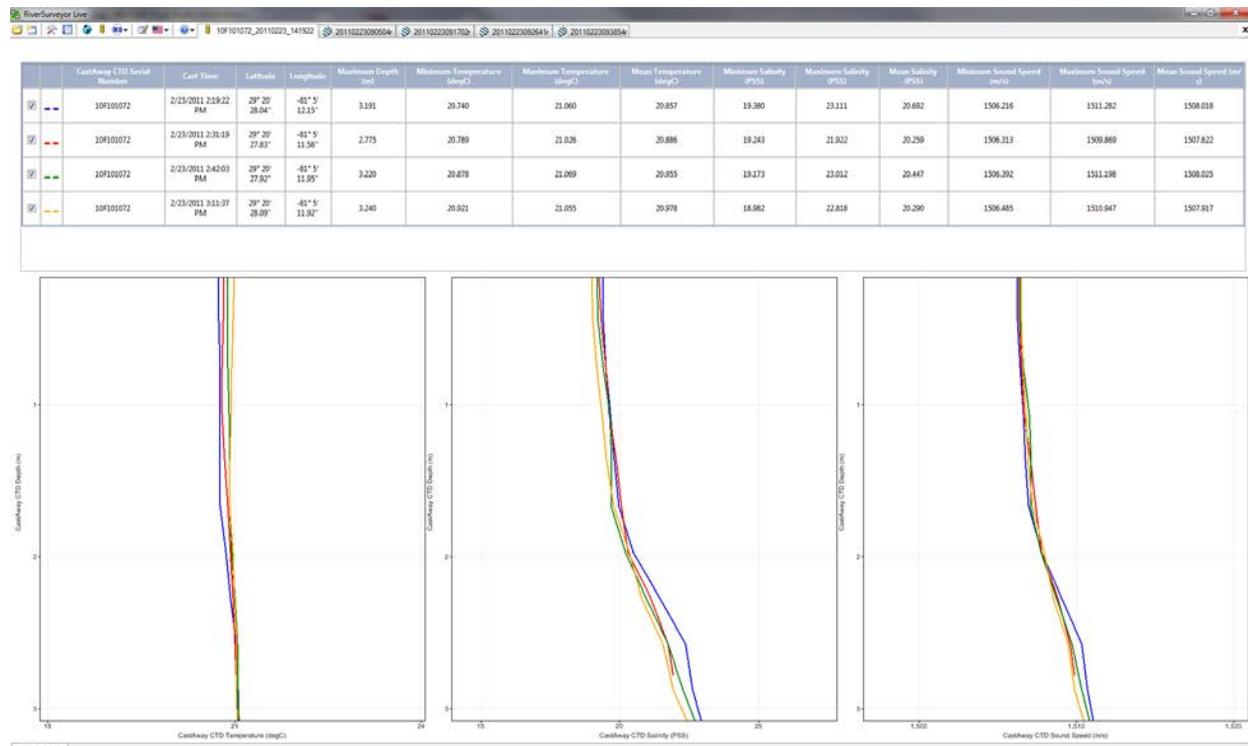


Figure 138. CastAway CTD Summary Information Tab.

The RiverSurveyor Live (v3.0 or later) software adds a marker for the CastAway profile location on the center ship track plot (Fig. 139). The GPS coordinates must be changed to **UTM Display** by right-clicking on the track plot. Open the Processing Toolbox to select the *CastAway CTD Sound Speed Correction* from the drop-down box. There are two options for applying the CastAway sound speed correction to a discharge calculation: using ADP surface temperature data and CastAway surface salinity, or using the full CastAway temperature and salinity profile. The correction can be done manually by selecting the appropriate .ctd file or automatically. If

automatically, the software applies the .ctd file collected closest to the start of the discharge measurement. After applying the sound speed correction you can instantly view the effect of the correction on the discharge calculation.

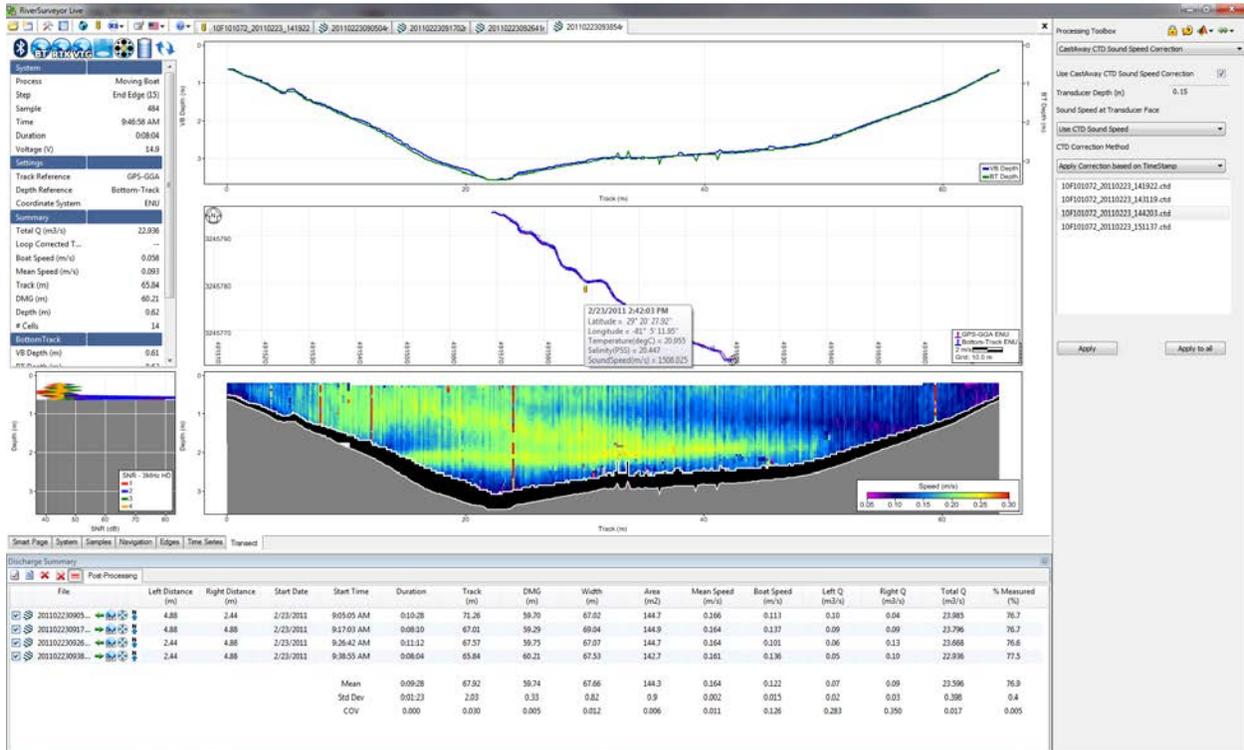


Figure 139. CastAway CTD Sound Speed Correction and UTM Track Location

## Summary

Using CTD measurements to apply sound speed corrections to ADP data helps to further improve the measurement accuracy. ADP discharge measurements in rivers with large cross-sectional profiles and areas with high stratification such as estuaries will benefit the most from sound speed corrections. The fast response thermistor of the CastAway also ensures accurate temperature data required for all velocity measurements. The CastAway CTD and RiverSurveyor integration is a user-friendly way to apply sound speed corrections to ADP measurements and increase ADP measurement accuracy.

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