WinRiver
User's Guide
International Version

RD Instruments
Acoustic Doppler Solutions

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WinRiver User's Guide

1 Introduction

WinRiver is RDI's real-time discharge data collection program. This program creates a configuration file to operate the ADCP, checks each command, and verifies that the ADCP has received the commands.

Making accurate discharge measurements is less difficult than you probably believe now. You will soon see that you need to use only a few keystrokes on the computer to collect data in the field.

Please take the time to read this entire manual. It will be useful to have the ADCP and a computer available to follow along. You may also want to keep the other ADCP Technical manuals handy for reference when you want more detail.

> **NOTE.** This guide covers version 1.03 or higher.

1.1 System Requirements

WinRiver requires the following:

- Windows 95®, Windows 98®, or Windows NT 4.0® with Service Pack 4 installed

- Pentium class PC 233 MHz (350 MHz or higher recommended)

- 32 megabytes of RAM (64 MB RAM recommended)

- 6 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended)

- One Serial Port (two or more High Speed UART Serial Port recommended)

- Minimum display resolution of 800 x 600, 256 color (1024 x 768 recommended)

- CD-ROM Drive

- Mouse or other pointing device

1.2 Software Installation

To install *WinRiver*, do the following.

a. Insert the compact disc into your CD-ROM drive and then follow the browser instructions on your screen. If the browser does not appear, complete Steps "b" through "d."

b. Click the **Start** button, and then click **Run**.

c. Type **<drive>:launch**. For example, if your CD-ROM drive is drive D, type **d:launch**.

d. Follow the browser instructions on your screen.

1.3 Communications Setup

When *WinRiver* is first started in the Acquire mode, you must set up the communications with the ADCP, GPS (if used), External Heading (if used), and Depth Sounder (if used). Once setup, *WinRiver* will remember the settings and use them each time the program is started.

a. Connect and power up the ADCP as shown in the appropriate ADCP User's Guide.

b. Start *WinRiver* in the Acquire mode. If you are in the Playback mode, click **File**, **Acquire Mode**. To open the **Communications Settings** dialog box, click **Settings**, **Communications**.

> **NOTE.** If this is the first time the Acquire mode is started, you will be prompted to configure the communication settings.
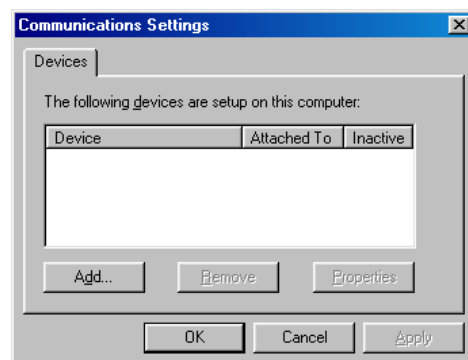
c. Press the **Add** button.

d. Select the device you want to setup and press **Next.**
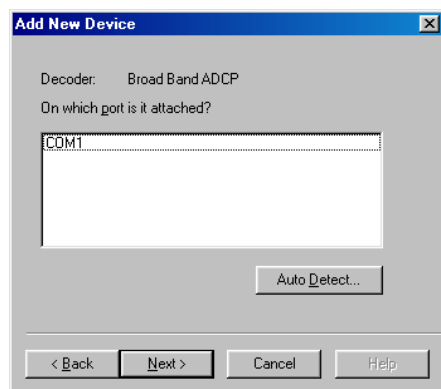
e. Select the COM port that the device is connected to. If you are unsure of the setting, use **Auto Detect**. Only the communication ports installed and available on your system will be displayed. Press **Next** to continue.
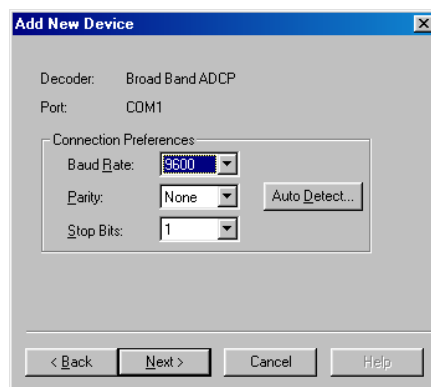
f. Select the baud rate, parity, and stop bits. If you are unsure of the settings, use **Auto Detect**. Click **Next** to continue. *WinRiver* will connect to the device and confirm the communication setting.
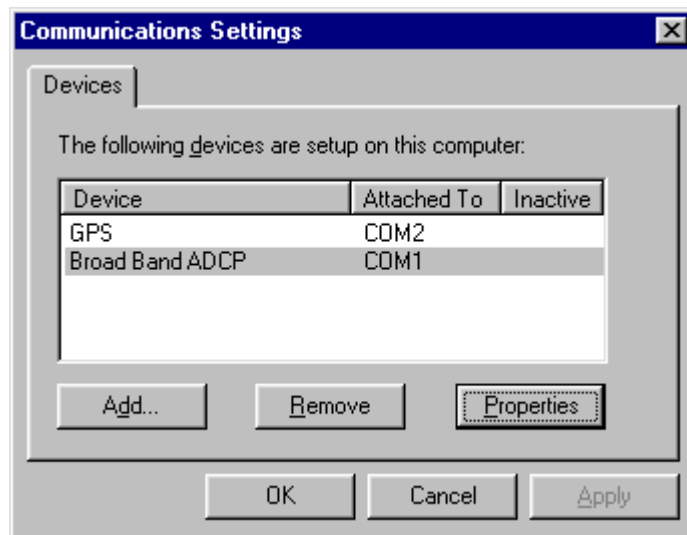
Figure 1. **Communications Port Setting Screen**

g. To temporally inactive a device, click on the device to be inactivated and click the **Properties**, **General** tab. Select the **Inactive** box. The device would not be used during data collection, but its' parameters would be remembered.

h. On the **Properties**, **General** tab there is another option for the ADCP to use the "===" string instead of a break. Only Rio Grande firmware 10.05 and above accepts this option.

2 Customizing WinRiver

WinRiver can be customized to look and act, as you prefer.

2.1 General Preferences

a. You can change the size of the fonts in windows by right clicking on the widow and selecting **Properties**. Choose the font for labels and data.

b. On the **Settings** menu, click **Units**. You can switch the displays between **SI** (metric) and **English** units.

c. On the **Settings** menu, click **Reference**. Select the desired reference: **Bottom Track**, **GPS (GGA)**, **GPS (VTG)**, or **None**.

> **NOTE.** If the wrong reference is selected during Playback, data may not display. For example, if you select GPS (GGA) as the reference during Playback and this was not collected when the data file was created, no data will display.

2.2   Workspace

A Workspace is a collection of windows arranged and sized, as you prefer. To create a Workspace file, open all the windows you want to see during data collection. Open and arrange the views you are interested in. When you have the displays set up the way you prefer, on the **File** menu, click **Save Workspace File**. You will need to do this step for both Playback and Acquire modes. To return to the default workspace, on the **File** menu, click **Open New Workspace**.

2.3   Shortcut Keys

Use the shortcut keys to quickly perform tasks.

Table 1:   *WinRiver* **Shortcut Keys**

Key	Description
F1	Help
F3	Configuration Setting menu
F4	Acquire mode = Start/Stop Pinging, Playback mode = Start/Stop Play
F5	Acquire mode = Start/Stop Transect, Playback mode = Next Data File
F6	File subsection (Playback mode only)
F7	User Options
F8	Configuration Items
F9	Toggle Ensemble Header and Tabular view
F11	Swap Composite Tabular view and Discharge Detail Tabular
F12	Toggle Discharge History Tabular view
Ctrl-A	Output ASCII data file (Playback mode only)
Ctrl-C	Copy
Ctrl-L	View Command Log (Acquire mode only)
Ctrl-M	Switch to Acquire/Playback mode
Ctrl-N	New Configuration File
Ctrl-O	Open ADCP Raw Data File (Playback mode only)
Ctrl-P	Print (Playback mode only)
Ctrl-S	Save Configuration File
Ctrl-R	The Unfreeze button unfreezes all frozen items (blue text).
Shift-F2	Set PC clock (Acquire mode only)
Shift-F4	Set ADCP Clock (Acquire mode only)
Shift-F6	Run Configuration Wizard
Minus	Previous Ensemble (Playback mode only)
Space	Next Ensemble (Playback mode only)
Ctrl-Space	Several Ensembles (Playback mode only)
Home	First Ensemble (Playback mode only)
End	Last Ensemble (Playback mode only)
Z	Zoom to data

2.4   User Options

On the **Settings** menu, click **User Options**. The **User Options** menu sets
how *WinRiver* behaves in the Acquire and Playback modes.

2.4.1   Acquire Mode Tab
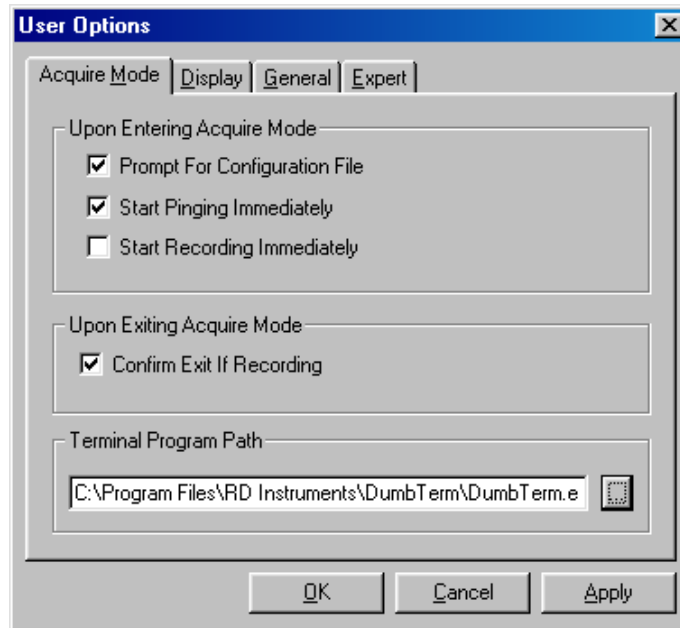
Upon Entering Acquire Mode

- **Prompt for Configuration File** – If this option is selected you
   will be prompted to select a configuration file to load.

- **Start Pinging Immediately** – Select this option if you want the
   ADCP to begin pinging as soon as the Acquire mode is started.

- **Start Recording Immediately** – Select this option if you want
   the ADCP to begin recording as soon as the Acquire mode is
   started.

Upon Exiting Acquire Mode

- **Confirm Exit if Recording** – If this option is selected you will
   be prompted to confirm exiting the Acquire mode if recording.
   This helps prevent accidentally exiting during a transect.

Terminal Program Path

- Enter the path to your terminal program (normally *DumbTerm*).
   Use the **Browse** button to enter the path. This will allow you to
   call the terminal program in the Acquire mode. This can be
   useful if you want to test the ADCP or perform the compass
   calibration.

2.4.2 Display Tab
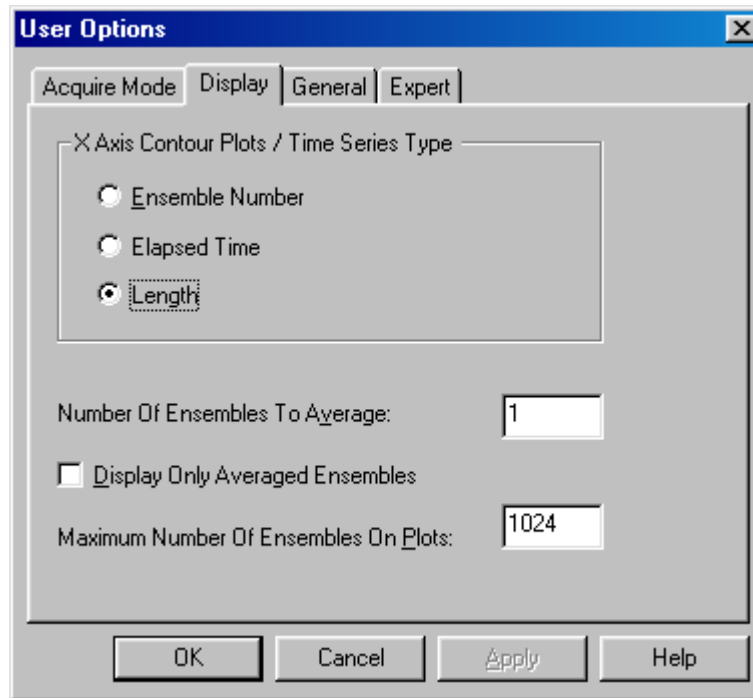
- **X Axis Contour Plots**/**Time Series Type** – Select if the X-Axis on Contour Plots and Time Series will use **Ensemble Number**, **Elapsed Time**, or **Length** (distance traveled during the transect).

- **Number of Ensembles to Average** – Averaging applies to displays and ASCII Out data only.

- **Display Only Averaged Ensembles** – Check this box to display only the averaged ensembles.

- **Maximum Number of Ensembles on Plots** – This limits the number of ensembles displayed on contour and time series plots.

2.4.3   General Tab
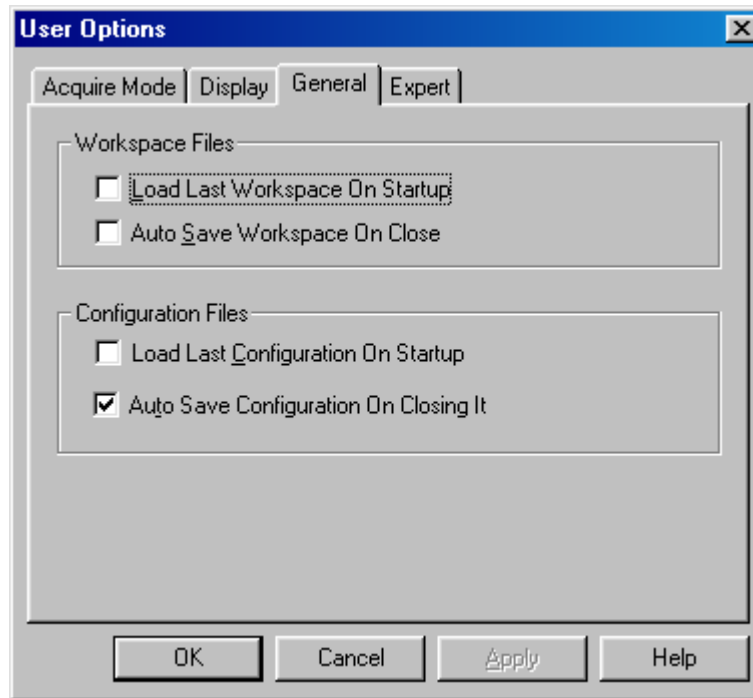
Workspace Files

- **Load Last Workspace On Startup** – Select this option if you want the same plots and displays opened as soon as the Acquire or Playback mode is started. *WinRiver* saves separate setting for both modes in the *.wrw file.

- **Auto Save Workspace On Close** – Select this option if you want to automatically save any changes to the workspace whenever *WinRiver* is exited or you switch modes.

Configuration Files

- **Load Last Configuration On Startup** - Select this option if you want the last configuration file to be loaded as soon as *WinRiver* is started.

- **Auto Save Configuration On Close** - Select this option if you want to automatically save any changes to the configuration file whenever a new configuration file is loaded or *WinRiver* is exited.

2.4.4   Expert Tab
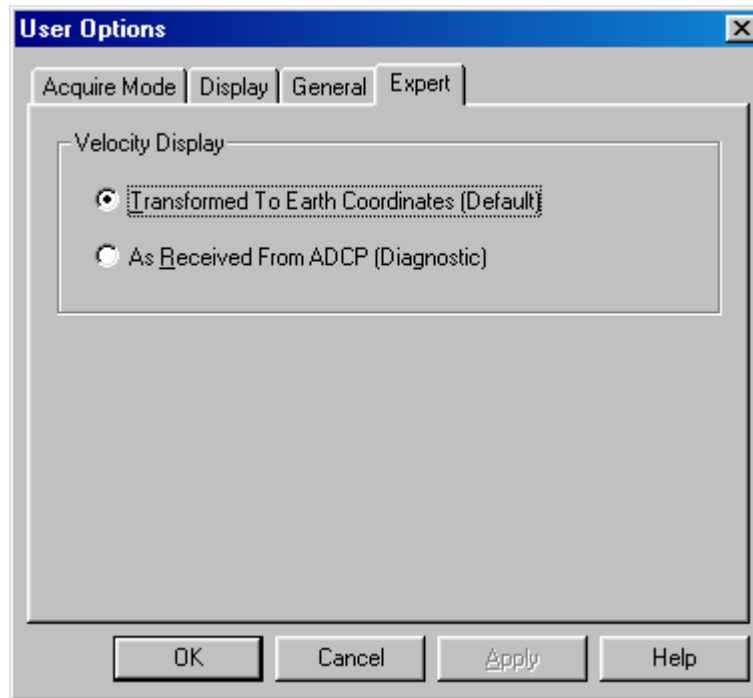
- **Velocity Display** – Select **Transform to Earth Coordinates** to view velocity data in Earth coordinates (default setting). To view the velocity data in the coordinate system the data was collected in, select **As Received From ADCP**.

> **NOTE.** If **As Received From ADCP** is selected, it will be set back to **Transform to Earth Coordinates** (default) when the *WinRiver* is exited.

3   File Naming Convention

There are several files associated with *WinRiver* software. These files are:

- *Data Files* (*r.NNN) – These files contain all data sent from the ADCP and other devices during data collection. Refer to the ADCP Technical Manual for a complete description of the format of raw ADCP data files. For any specific deployment, raw data files contain the most information and are usually the largest. Data for this file type is collected through *WinRiver*'s Acquire mode. *WinRiver*'s Playback mode accepts raw ADCP data files for display or reprocessing.

- *Configuration Files* (*.wrc, *w.000, *w.001) – These ASCII files contain user-specified setup and deployment information. This file shares information between the different *WinRiver* modes. You can create different configuration files to suit specific applications through the **Settings** menu, **Configuration Settings**.

> **NOTE.** In the **Settings** menu, **User Options**, **General** tab you can specify if the last configuration file opens on startup and/or auto save the configuration file on close of the application. Configuration files can be loaded/saved through the **File** menu.

- *Workspace Files* (*.wrw) – Binary file that contains information about open views, their size, and position. Contains workspace information about Acquire and Playback modes. Normally, Acquire will have different window selections and sizes than the Playback mode.

> **NOTE.** In the **Settings** menu, **User Options**, **General** tab you can specify if the last workspace opens on startup and/or auto save the workspace on close of the application. Workspace files can be loaded/saved through the **File** menu.

- *Navigation Files* (*n.NNN) – These files contain ASCII data collected from an external navigation device during data acquisition. *WinRiver* reads the navigation data from a user-specified serial port.

- *Depth Sounder Files* (*d.NNN) – These files contain ASCII data collected from an external Depth Sounder device during data acquisition. *WinRiver* reads the depth data from a user-specified serial port.

- *External Heading Files* (*h.NNN) – These files contain ASCII data collected from an External Heading device during data acquisition. *WinRiver* reads the external heading data from a user-specified serial port.

- ***ASCII-Out Files*** (*t.NNN) – These files contain a fixed format of ASCII text that you can create during post-processing. During playback, you can subsection, average, scale, and process data. You also can write this data to an ASCII file. You can then use these files in other programs (spreadsheets, databases, and word processors).

- ***Processed Data File*** (*p.NNN) – Processed Data files are used for backward compatibility with the DOS based *TRANSECT* program.

- ***Summary Files*** (*.sum) – These files contain ASCII information about the whole transect. The information is written at the end of the file or subsection.

3.1   Data Files

File Name Format: *ddddMMMx.NNN*

dddd   Filename prefix (set in **Settings** menu, **Configuration Settings**, **Recording** tab)

MMM   *TRANSECT* number. This number starts at 000 and increments each time you stop and then start data collection. The maximum number of transects is 999.

x   File type (assigned during data collection or playback)

   r – Raw ADCP data
   w – copy of the configuration file created during Acquire mode
   c – Unique configuration file (DOS *TRANSECT* only)
   h – External heading data
   n – Navigation GPS data
   d – Depth Sounder data
   p – Processed data
   t – ASCII-out data (This convention is the default for ASCII-out data, but you can use other names and extensions.)

NNN   File sequence number. This number starts at 000 and increments when the file size reaches the user-specified limit (set in **Settings** menu, **Configuration Settings**, **Recording** tab).

Examples:

NOAA001r.000   (Deployment name = NOAA, ADCP data file, transect number = 001, file number = 000)

SN11005w.000   (Deployment name = SN11, configuration data file, transect number = 005, file number = 000)

3.2   Configuration Data Files

File Name Format (*.wrc, *w.000, or *w.001)

Extension	Description
*.wrc	Original configuration file used to collect data.
*w.000	Copy of the *.wrc configuration file created when the transect is completed (recording stopped) that saves the **Setting** menu, **Configuration Settings** items.
*w.001	This file contains the changes (if any) made to the *w.000 file.

The *w.000 Configuration Data File is a copy of the *wrc configuration file used to collect data. The Playback mode will automatically load the *w.000 configuration file that was created while acquiring the data and the *w.001 file if it exists. Any editing changes made to the *w.000 file are saved to the *w.001 file. If a *c.000 (DOS TRANSECT unique configuration file) exists, it will be used and saved as a *w.001 file. The *c.000 file will not be modified – any editing changes are saved to the *w.001 file.

All items except the **Chart Properties 1** and **2** tabs in the **Setting** menu, **Configuration Settings** will be grayed out in the Playback mode meaning that the values are used from the *w.000 configuration file. Once the data file has been loaded changes can be made to the configuration file by right-clicking the item. Select between the following choices.

Right-Click Option	Description
Use *w.000 value	Returns the item to the value as data was collected.
Open for Edit	Changes the value for the current *w.001 file only. Editing changes are saved to the *w.001 file.
Open for Edit and Freeze	Changes the value for the current *w.001 file and will stay in effect for each data file used in the Playback mode. Use this mode if the same correction is needed for playing back subsequent transects. For example, if the ADCP depth was incorrectly set for all transects, after loading the first data file, change the ADCP depth by right-clicking the **ADCP Depth** on the **Settings** menu, **Configuration Settings**, **Offsets** tab and select **Edit and Freeze**. Enter the correct value. When the next data file is opened, the correct ADCP depth value will be in effect.

3.3 Navigation Data Files

Navigation Data Files are ASCII files created during Acquire. These files are not used to playback data.

File Name Format (ddddMMMn.NNN)

dddd	= File prefix
MMM	= Transect number
n	= File type (Navigation)
NNN	= File sequence number

The external device sending the navigation data determines the format of the navigation data file. The navigation device can be any external device linked to *WinRiver* by a serial communication port.

The navigation data should be ASCII, with a carriage return and line feed (CR/LF) generated after each data transmission. *WinRiver* receives the data from the navigation device and writes it to the navigation file. Every time an ADCP ensemble is received, *WinRiver* also writes the ensemble number and the computer time to the navigation file. Here is a sample navigation data format and program sequence.

a. Navigation device sends data to the serial port. For example:

```
$GPGGA,190140.00,3254.81979,N,11706.15751,W,2,6,001.3,00213.4,M,-
032.8,M,005,0262*6F
$GPGSA,M,3,1,14,22,16,,,18,19,,,,,3.5,1.3,3.3*08
$GPVTG,108.0,T,,,000.3,N,000.6,K*21
```

b. *WinRiver* writes this information to the ASCII (*n.000) navigation data file and to the *r.000 raw data file (see "Bottom Track Output Data Format," page 82 and "Navigation Data Output Data Format," page 90). *WinRiver* only uses the data in the *r.000 file.

c. *WinRiver* receives an ensemble of data from the ADCP and writes the ensemble number and computer time to the navigation data file in the following format:

```
<CR/LF>$RDENS,nnnnn,ssssss,PC<CR/LF>
```

where:

nnnnn = sequential ensemble number

ssssss = computer time in hundredths of seconds

3.4   Depth Sounder Data Files

Created during Acquire. These files are not used to playback data.

__File Name Format__ (ddddMMMd.NNN)

dddd	= File prefix
MMM	= Transect number
d	= File type (Depth Sounder)
NNN	= File sequence number

The external device sending the depth data determines the format of the depth sounder data file. The depth sounder device can be any external device linked to *WinRiver* by a serial communication port.

The depth sounder data should be ASCII, with a carriage return and line feed (CR/LF) generated after each data transmission. *WinRiver* receives the data from the depth sounder device and writes it to the depth sounder data file. Every time an ADCP ensemble is received, *WinRiver* also writes the ensemble number and the computer time to the depth sounder data file. Here is a sample depth sounder data format and program sequence.

a. Depth sounder device sends data to the serial port. For example:

```
$SDDBT,0084.5,f,0025.7,M,013.8,F
```

b. *WinRiver* writes this information to the ASCII (*d.000) depth sounder data file and to the *r.000 raw data file (see "Bottom Track Output Data Format," page 82 and "Navigation Data Output Data Format," page 90). *WinRiver* only uses the data in the *r.000 file.

c. *WinRiver* receives an ensemble of data from the ADCP and writes the ensemble number and computer time to the depth sounder data file in the following format:

```
<CR/LF>$RDENS,nnnnn,ssssss,PC<CR/LF>
```

where:

nnnnn = sequential ensemble number

ssssss = computer time in hundredths of seconds

3.5   External Heading Data Files

Created during Acquire. These files are not used to playback data.

File Name Format (ddddMMMh.NNN)

dddd   = File prefix

MMM   = Transect number

h   = File type (External Heading)

NNN   = File sequence number

The external heading device sending the heading data determines the format of the data file. The external heading device can be any external device linked to *WinRiver* by a serial communication port.

The external heading data should be ASCII, with a carriage return and line feed (CR/LF) generated after each data transmission. *WinRiver* receives the data from the external heading device and writes it to the external heading data file. Every time an ADCP ensemble is received, *WinRiver* also writes the ensemble number and the computer time to the external heading data file. Here is a sample external heading data format and program sequence.

a. The external heading device sends data to the serial port. For example:

`$INHDT,245.8,T*2E`

b. *WinRiver* writes this information to the ASCII (*h.000) external heading data file and to the *r.000 raw data file (see "Navigation Data Output Data Format," page 90). *WinRiver* only uses the data in the *r.000 file.

c. *WinRiver* receives an ensemble of data from the ADCP and writes the ensemble number and computer time to the external heading data file in the following format:

`<CR/LF>$RDENS,nnnnn,ssssss,PC<CR/LF>`

where:

nnnnn = sequential ensemble number

ssssss = computer time in hundredths of seconds

3.6 ASCII-Out Files

ASCII-out files contain a fixed format of text that you can create during post-processing by using the **File** menu, **Start ASCII Out** during Playback mode. During playback, you can subsection, average, scale, and process data. You also can write this data to an ASCII file. You can then use these files in other programs (spreadsheets, databases, and word processors).

The same control over data scaling, averaging, subsectioning, and processing available during playback influences the ASCII-out file. *WinRiver always* writes velocity data (in earth coordinates) to the ASCII-out file. For example, you may select only depth cells (bins) 4 through 9 for display on the screen, metric units (m, m/s), and use speed of sound corrections for a portion of data to be sent as ASCII-out. *WinRiver* will scale, display, and write the velocity data to the ASCII-out file based on your processing specifications.

> **NOTE.** The profile data will include bins with the depth in between the minimum and maximum depth specified in **Configuration Settings**, **Chart Properties 1** tab, **Depth**.

Example ASCII-Out File

```
This is WinRiver comment line #1
This is WinRiver comment line #2
    50      25      91      50      1     16      1
0 3 27 8 18 37 26      29      1   -2.860   1.870  248.030   14.500
-0.27     0.18      0.05     0.04     0.00    15.16     0.00    11.08    31.32    25.80    28.85
30.04
2.04       7.30       1.16       -0.98       1.52
31.0098587  -91.6261329    -0.08     0.37       2.0
94.5        40.2          16.6          1299.2          50.0          0.0          0.0  6.54  22.95
15 ft BT dB 0.43  0.161
  6.54     4.20     225.21   -3.0   -3.0   -0.7    1.2   72.5   73.0   73.0   74.7   100     -3.87
  8.18     3.05     237.19   -2.6   -1.7   -0.3    0.3   80.3   82.5   81.2   82.0   100     -2.63
  9.82     3.94     236.55   -3.3   -2.2   -0.2    1.0   81.6   87.6   83.3   82.0   100     -3.41
 11.46     3.91     245.09   -3.5   -1.6   -0.4   -0.1   83.6   87.5   84.9   83.2   100     -3.13
 13.11     4.55     242.24   -4.0   -2.1   -0.3    0.9   83.6   86.6   85.8   82.7   100     -3.76
 14.75     1.94     224.59   -1.4   -1.4    0.0    0.8   88.5   92.4   85.1   82.9   100     -1.79
 16.39     3.84     175.29    0.3   -3.8    0.5    1.6   89.8   94.1   85.5   85.1   100     -2.84
 18.03     2.89     258.70   -2.8   -0.6   -0.3   -0.1   85.8   86.7   86.7   85.0   100     -1.91
 19.67     4.54     223.45   -3.1   -3.3    0.1    1.4   85.2   86.5   89.1   86.5   100     -4.20
 21.31     3.66     239.28   -3.2   -1.9   -0.2    0.2   86.2   92.2   91.8   89.6   100     -3.10
 22.95     2.08     228.31   -1.6   -1.4    0.3   -0.3   87.1   96.1   92.3   89.7   100     -1.89
 24.59   -32768   -32768 -32768 -32768 -32768 -32768   89.2   94.8   91.8   92.7     0 2147483647
 26.23   -32768   -32768 -32768 -32768 -32768 -32768   88.3    255   93.5   93.1     0 2147483647
 27.87   -32768   -32768 -32768 -32768 -32768 -32768   90.4    255  100.3   93.0     0 2147483647
 29.51   -32768   -32768 -32768 -32768 -32768 -32768   94.6    255    255    255     0 2147483647
```

3.7 Processed Data Files

Processed Data (P-out) files can be created during post-processing by using the **File** menu, **P-Out** in the Playback mode. During playback, you can subsection, average, scale, and process data. You can then use processed data files with our DOS based *TRANSECT* program.

4   Quick Start Guide

The Quick Start Guide has simple instructions for a typical discharge measurement using the ADCP only (no GPS, External Heading or Depth Sounder).

4.1   Setup the ADCP

Step 1.   Connect the ADCP and computer as shown in your ADCP User's Guide. Mount the ADCP on the boat at the desired depth (see the WorkHorse Installation Guide. If you have not already installed the *WinRiver* and *DumbTerm* programs do so as outlined in "Software Installation," page 2. Run *DumbTerm* to verify the ADCP is functioning properly (see the RDI Tools User's Guide
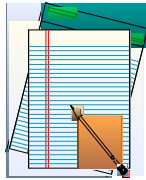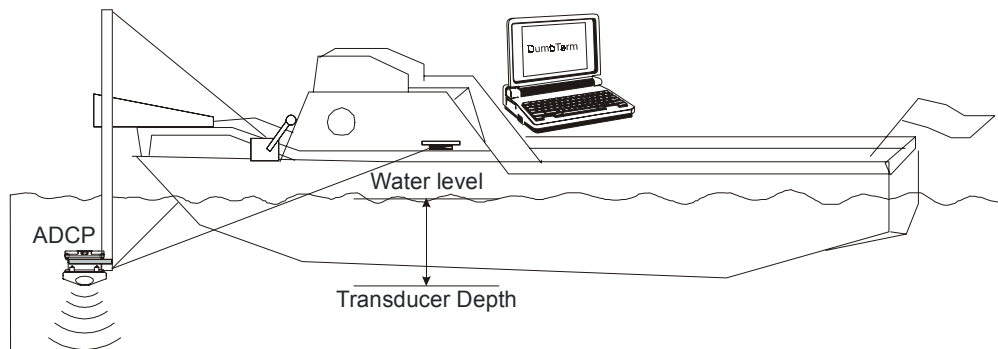
Use this area for notes.

4.2   Start *WinRiver*
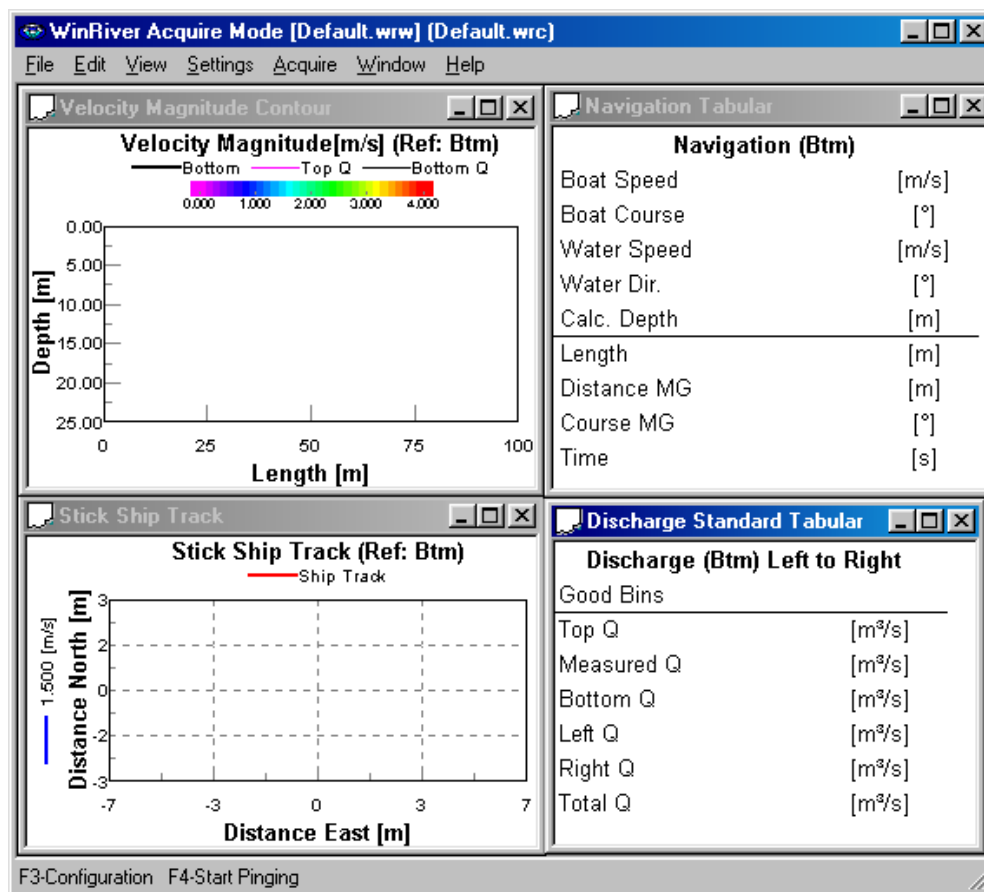
Step 2. Start *WinRiver* in the Acquire mode. If you are in the Playback mode, click **File**, **Acquire Mode**.
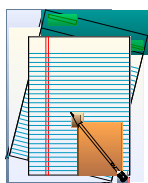
Use this area for notes.

4.3   Setup Communications

Communications Settings [×]

Devices

The following <u>d</u>evices are setup on this computer:

Device	Attached To	Inactive
GPS	COM2	
Broad Band ADCP	COM1	

[A<u>d</u>d...]   [<u>R</u>emove]   [<u>P</u>roperties]

[OK]   [Cancel]   [Apply]
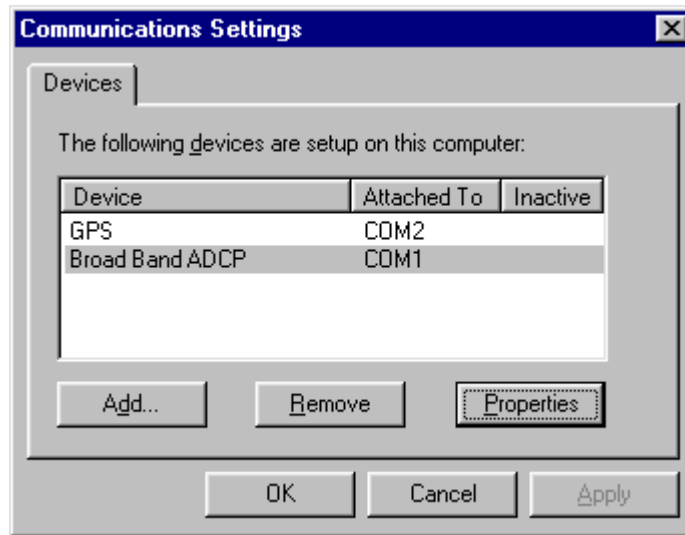
***Step 3*.**   On the **Settings** menu, click **Communications** to specify the communications port parameters with the ADCP.
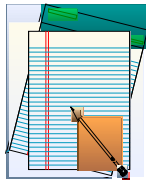
Use this area for notes.
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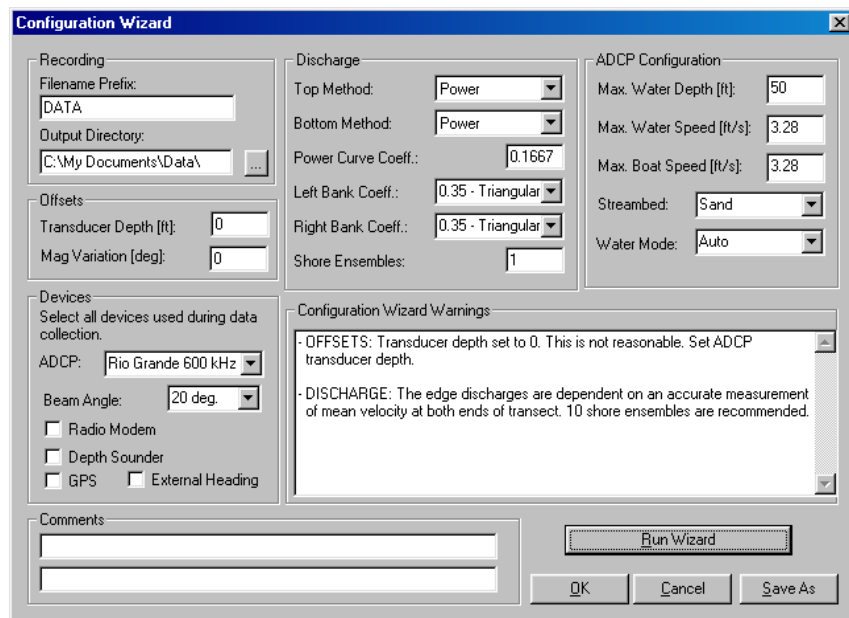
NOTE. If you want to change the Com Port selection, use the **Remove** button and then **Add** the port back in. If you want to change the baud rate or other properties, click the **Properties** button.

NOTE. The Quick Start Guide has simple instructions for a typical discharge measurement using the ADCP only (no GPS, External Heading, or Depth Sounder). For information on how to integrate GPS/External Heading/Depth Sounders, see "Integrating Depth Sounder, External Heading, and GPS Data," page 57

4.4 Configuration Wizard

Step 4. The **Configuration Wizard** will create a configuration file and enter the most important information needed for data collection and display during Acquire mode.

On the **Settings** menu, click **Configuration Wizard**. Enter your choices for **Recording**, **Discharge**, **ADCP Configuration**, **Offsets**, and **Devices**. Click the **Run Wizard** button. If any error messages appear in the **Configuration Wizard Warnings** box, correct the error and click the **Run Wizard** button again to verify the configuration file. Click **OK** to save the configuration file or **Save As** to save the configuration file as a new file.
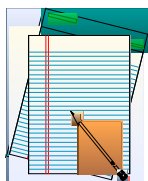
	Use this area for notes.

NOTE. The configuration file names (*w.000 and *w.001) are keyed to the file name prefix.

4.5   *WinRiver* Workspace File
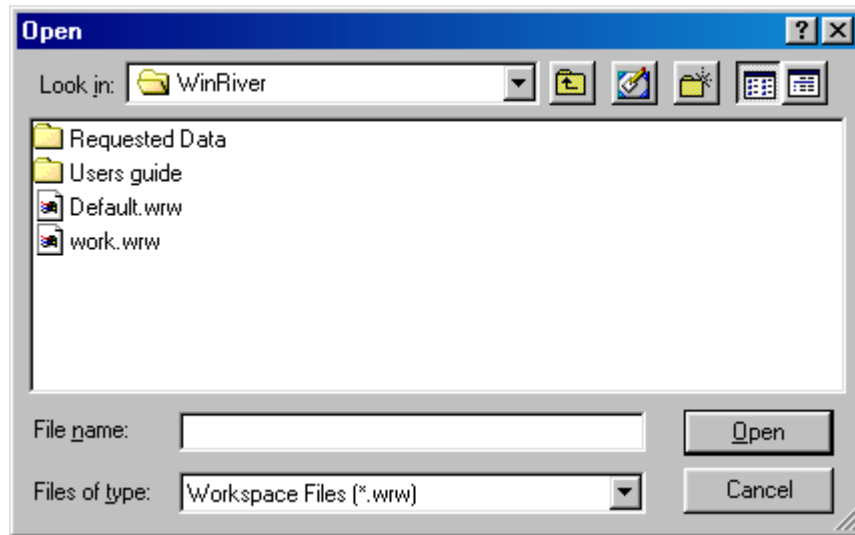
Step 5. A Workspace file contains the windows and arrangement of the windows that you are interested in. To open a workspace file click **File**, **Open Workspace File** (you can customize *WinRiver* to automatically load the last used workspace file when the Acquire mode is started).

To create a new Workspace file, set up the displays the way you prefer and then click **File**, **Save Workspace File**. You will need to do this step for both Acquire and Playback modes.

NOTE. Click **File**, **New Workspace File** to bring up the default workspace.
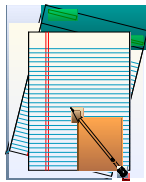
Use this area for notes.

4.6   Perform Pre-Run

Discharge Standard Tabular		
Discharge (Btm) Left to Right		
Good Bins	**6**	
Top Q	**0.07**	[m³/s]
Measured Q	**0.16**	[m³/s]
Bottom Q	**0.03**	[m³/s]
Left Q	**0.00**	[m³/s]
Right Q	**0.00**	[m³/s]
Total Q	**0.26**	[m³/s]

Step 6. On the **File** menu click **Start Pinging** (you can customize *WinRiver* to automatically start pinging when the Acquire mode is started).

On the **View** menu, select **Tabular Views**, **Discharge Standard Tabular** if this window is not visible. Move out from the shore until the water is deep enough to show **Good Bins** of two or greater. Values of 0.0 are acceptable, but "bad" values are invalid. Mentally note or mark this position with a float. This is the starting/stopping position for this shore. You will later start/stop data file recording at this location depending on the direction of your transect. Move out from the shore traveling *slowly* with the bow of the boat pointed upstream. When you approach the other shore, note or mark the closest distance to shore where two the top two depth cells show discharge values. This will be the start/stopping point for this shore.
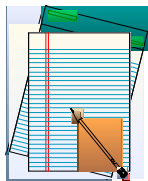
Use this area for notes.

4.7 Acquire Data – Near Shore
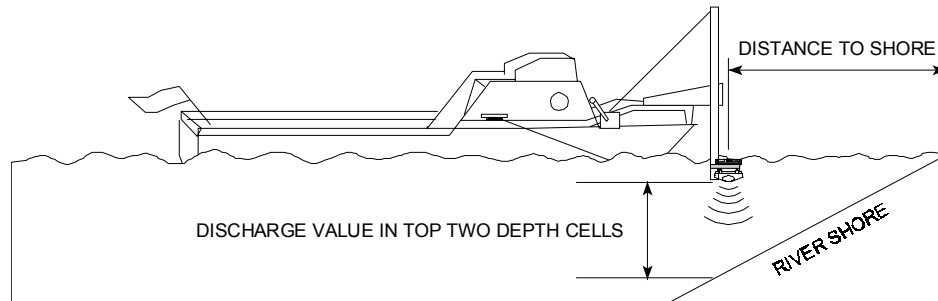
Step 7. Starting near the edge position determined during the pre-run, move out from the shore until the water is deep enough to show a discharge value in the top two depth cells. This is the starting position for this transect. Press **F5** to begin recording.

When prompted, enter the beginning distance to the bank and define if this is the left or right bank. The edge distance parameters will be saved to the configuration file (*w.000) associated with the raw ADCP data file recorded.

> **NOTE.** When facing downstream, the left bank is on your left side.

Hold this position until 4 or 5 measurements are recorded. If you made a false start, you can click **F5** to stop recording and restart at the edge by clicking **F5** to record to a new file. The Left/Right bank toggles at the end of each transect, so click **F5** once more to stop recording, and **F5** again to start recording so the bank is back to the correct side.

> **NOTE.** The edge distance parameters can be changed during Playback mode if a mistake was made by selecting the **Edge Estimates** tab in the **Settings**, **Configurations Settings** menu and right-click the box.
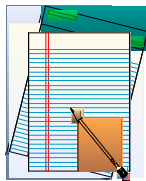
Use this area for notes.

4.8   Acquiring Data – River Transect
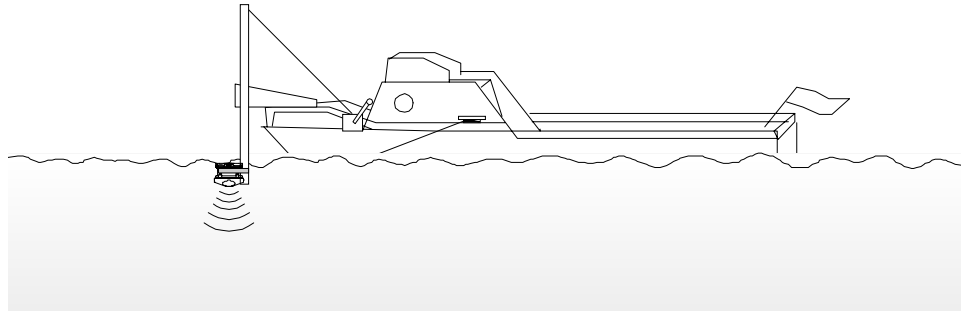
Step 8. Move across the river as *slowly* as possible. For the best measure-ment results, the boat's speed over the bottom should be no greater than the water speed of the river. Pointing the bow of the boat upstream and slowly crabbing across the river will help to maintain a transect path that is per-pendicular to the flow.
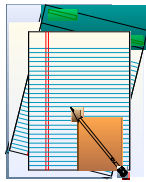
Use this area for notes.

4.9   Acquire Data – End Shore

DISTANCE TO SHORE

RIVER SHORE

DISCHARGE VALUE IN TOP TWO DEPTH CELLS
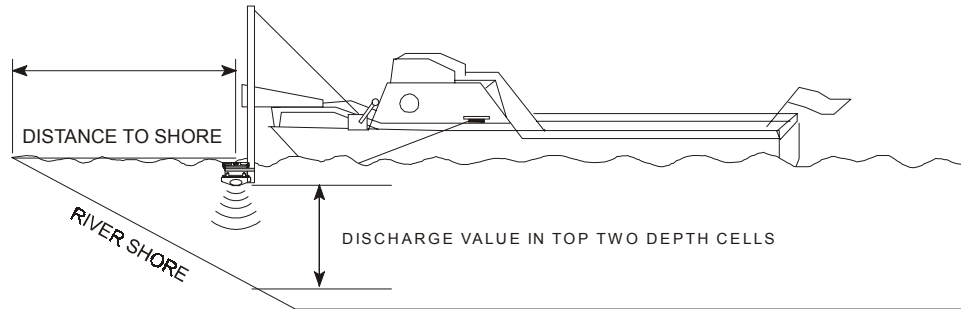
Step 9. Continue across the river until you reach the edge position determined during the pre-run on the opposite shore. You should have discharge values in only the top two depth cells. Stop at this position and wait for 4 or 5 measurements to be recorded. Press **F5** to stop recording. When prompted, enter the ending distance to the bank. That parameter will be saved to the configuration file (*w.000).
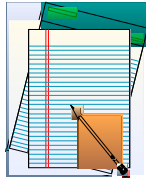
Use this area for notes.

4.10   Acquire Data - Average
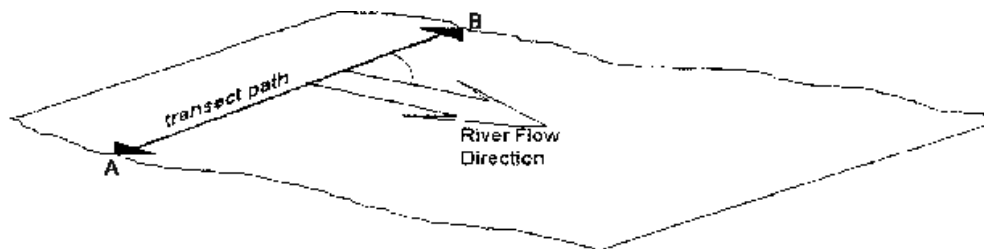
Step 10. Repeat steps 7 through 9 as many times as required for your application. An even number of *at least four* transects are recommended. When you are finished acquiring the data, press **F4** to stop the ADCP pinging. Turn off the power to the ADCP and disconnect the cable. Remember to replace the dummy plug to protect the connector.
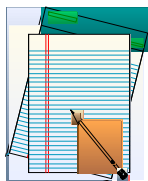
	Use this area for notes.

4.11   Playback Data

a. Start *WinRiver* in the Playback mode. If you are in the Acquire mode, click **File**, **Playback Mode**.

b. On the **File** menu click **Open ADCP Raw Data File** and select the file to be played. WinRiver automatically creates a *w.001 configuration file.

- If the *w.000 configuration file exists, all of the values in the **Settings** menu, **Configuration Settings** tabs except the **Chart Properties 1** and **2** tabs will be used. The values will be grayed out. No changes can be made unless the item is right-clicked. Items that you decide to change during data playback will be saved in the *w.001 configuration file. The *w.000 files will not be changed.

- If a *w.000 configuration file does not exist you can modify all of the items in the *w.001 configuration file.

c. Create a new Workspace file by clicking **File**, **New Workspace File**. To open a workspace file, click **File**, **Open Workspace File**.

d. On the **Playback** menu, click **Play** to start playing the data. To quickly process the data select **Last Ensemble**. The playback tool bar has functions to start, stop, rewind, and go to the end of the data file.

e. To quickly see what files are in use look at the *WinRiver* Title Bar. This lists the files in use.
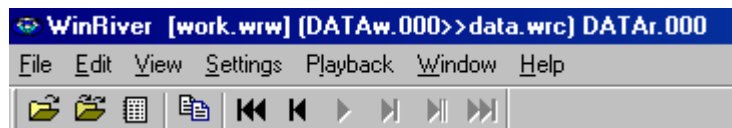
Figure 2.   *WinRiver* **Playback Mode Title Bar**

work.wrw =	Workspace file in use
DATAw.000 =	Unique configuration file (created during data collection)
data.wrc =	Configuration file in use
DATAr.000 =	Raw ADCP data file in use
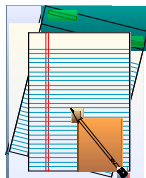
Use this area for notes.

4.12 Compute Total Discharge

File Name	# Ens.	Start Time	Total Q [m³/s]	Start Bank	Left Dist. [m]	Left Ens#	Left Q [m³/s]	Top Q [m³/s]	Meas. Q [m³/s]	Bottom Q [m³/s]	Rig
T118006r	422	10:13:30	11357.96	Left	15.24	507	27.99	2276.48	7926.40	1085.43	1
T118007r	185	10:32:07	11772.48	Right	15.24	222	27.17	2701.81	8027.83	985.90	1
T118008r	142	10:47:13	11754.44	Left	15.24	225	16.43	2709.58	8001.03	993.28	1
Average	250		11628.29				23.86	2562.62	7985.09	1021.54	
Std. Dev.	151		234.29				6.45	247.83	52.56	55.46	
Std./| Avg.|	0.60		0.02				0.27	0.10	0.01	0.05	

Play back the individual data files with their associated configuration files in the Playback mode. After playing through the data file, press **View**, **Tabular Views**, **Discharge Tabular Views**, **Discharge History** to obtain the total discharge for each measurement.

As each data file is played in the Playback mode, the file is added to the **Discharge History Tabular** screen. To remove a file from the table, double-click the file name. You will be prompted to clear only the selected file or the entire table. The **Discharge History Tabular** display will automatically calculate the average and other statistics useful in determining the discharge value.
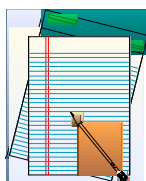
Use this area for notes.

5 Creating a *WinRiver* Configuration File

In the following, you will be creating a configuration file that will be used to program both the ADCP and *WinRiver* software processing.

a. In the Acquire or Playback mode, click **File**, **New Configuration File**.

b. To change configuration parameters click **Settings**, **Configuration Settings**.

c. When creating a configuration file for Acquire mode the most important parts in a configuration file are the **Commands** and **Recording** tabs. Set them to the desired parameters. The rest of the parameters can be changed during playback and do not influence data collection.

d. For correct data display while acquiring data you can enter the following values.

- On the **Offsets** tab set the **ADCP Transducer Depth**.

- On the **Discharge** tab, specify if you have any preference how to calculate discharge and if you know the shape of your edge bank.

- On the **DS/GPS** tab, select **Depth Sounder** to be used in processing if you are using a depth sounder and you do not have valid bottom track data.

> **NOTE.** To easily set the configuration file parameters for data collection see "Using the Configuration Wizard," page 30.

e. When creating a configuration file for Playback mode, items will be read from the corresponding *w.000 file and *w.001 (if it exists) or *c.000 (DOS Transect configuration file) and will not be accessible in the **Settings**, **Configuration Settings** menu. To modify an item, see "Configuration Data Files," page 12.

f. Once you have set the parameters save the configuration file by clicking **File**, **Save Configuration File**. Click **File**, **Save Configuration File As** to save the configuration file under a unique name.

5.1 Using the Configuration Wizard

The Configuration Wizard creates a configuration file and enters the most important information needed for data collection and correct data display during **Acquire** mode.

> **NOTE.** The Configuration Wizard is not available in the **Playback** mode.

Figure 3.   Configuration Wizard

a. On the **Settings** menu, click **Configuration Wizard**.

b. Enter your choices for the **Recording** section. The **Filename Prefix** and **Output Directory** are part of the **Recording** tab (see "Recording Tab," page 41).

c. Enter your choices for the **Discharge** section. For more information on these settings, see the "Discharge Tab," page 37.

d. Enter your choices for the **ADCP Configuration** section. Based on the entered information, the wizard will enter commands on the "Commands Tab," page 43.

e. Enter your choices for the **Offsets** section. For more information on these settings, see the "Offsets Tab," page 32.

f. Enter your choices for the **Devices** section. Selecting any of the boxes will prompt you to set up the communication settings and the "DS/GPS/EH Tab," page 39.

g. Click the **Run Wizard** button. If any error messages appear in the **Configuration Wizard Warnings** box, correct the error and click the **Run Wizard** button again to verify the configuration file.

h. Click **OK** to save the configuration file or **Save As** to save the configuration file as a new file.

i. To see the configuration file settings that the wizard entered, on the **Settings** menu, click **Configuration Settings** (see "Configuration Settings," page 31).

5.2   Configuration Settings

This section has detailed explanations of each of the **Setting** menu, **Configuration Setting** tabs needed to create a configuration file. There are ten tabs that configure different portions of the configuration file.

Offsets Tab	Recording Tab
Processing Tab	Commands Tab
Discharge Tab	Chart Properties 1 Tab
Edge Estimates Tab	Chart Properties 2 Tab
DS/GPS Tab	Resets Tab

5.2.1 Offsets Tab

The Offsets tab lets you set system alignment offsets that only affect the displays, **not** the raw data files. *WinRiver* saves these settings in the configuration file.
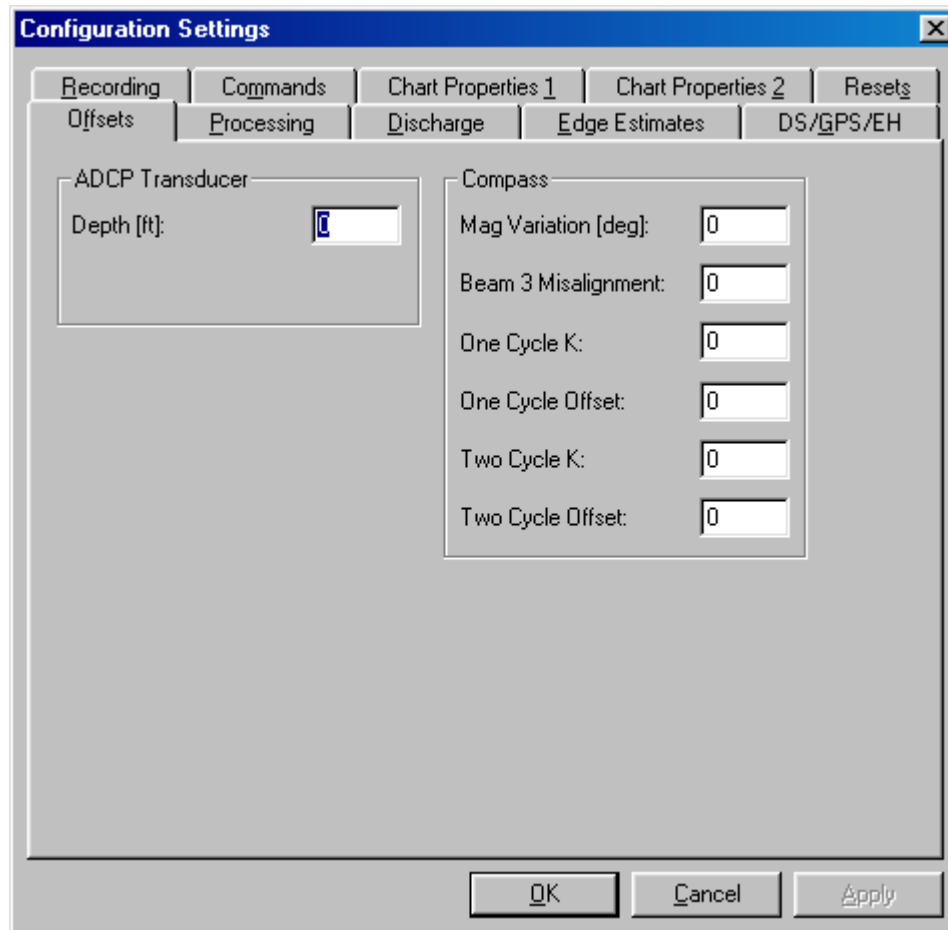
Figure 4.   Offsets Tab

The functions of this submenu are:

- **ADCP Transducer Depth** - Use the **Transducer Depth** field to set the depth from the water surface to the ADCP transducer faces. *WinRiver* uses this value during data collection and post-processing to create the vertical depth scales on all displays. *WinRiver* also uses the depth value to estimate the unmeasured discharge at the top part of the velocity profile. Therefore, depth affects the estimate of total discharge on the data collection and post-processing displays. The depth value does not affect raw data, so you can use different values during post-processing to refine the vertical plot scales and discharge estimates.

> **NOTE.** The ADCP's ED-command (Depth of Transducer) is used for internal ADCP speed of sound processing and is stored in the raw ADCP file leader. The ED-command has no effect on the vertical depth scales in *WinRiver*. **For normal transect work, do not add an ED-command.**

- **Magnetic Variation** – Use the **Magnetic Variation** field to account for magnetic variation (declination) at the deployment site. East magnetic declination values are positive. West values are negative. *WinRiver* uses magnetic variation in the data collection and Playback displays to correct ADCP velocities and bottom-track velocities.

> **NOTE.** The ADCP's EB-command (Heading Bias) and EX-command (Coordinate Transformation) process ADCP data before creating the raw data. The Magnetic Variation field in WinRiver processes the raw data received from the ADCP for data display. The magnetic variation field is not converted to an EB-command (raw data is not effected). This allows you to use the Magnetic Variation field to make changes during post-processing. **For normal transect work, do not add an EB-command.**
>
> The WinRiver compass corrections will only be applied to the profile data when the data was collected in Beam, Instrument, or Ship coordinates.

- **Beam 3 Misalignment** – *WinRiver* uses the **Beam 3 Misalignment** value to align the ADCP's north reference (Beam 3) to the ships bow (see the WorkHorse Installation Guide).

- **Compass Correction** – See "Compass Correction," page 65, for details on how to do the compass correction.

5.2.2   Processing Tab

The **Processing** tab lets you set several system processing options and save
them to a configuration file. Most values in the **Processing** tab affect the
displays during data collection and post-processing. *WinRiver* saves these
values only to the configuration file, not to the raw data files.
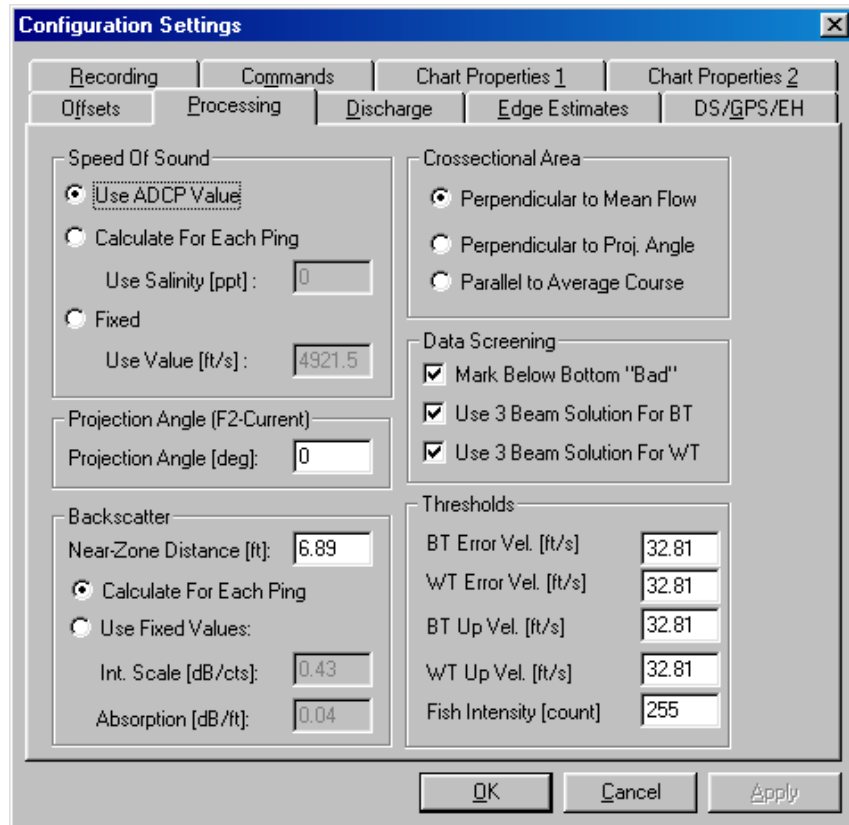
Figure 5.   Processing Tab

The functions of this submenu are:

Speed of Sound

The **Speed Of Sound** box lets you correct velocity data for speed of sound
variations in water. *WinRiver* can make these corrections dynamically with
every ping or use a fixed speed of sound value. Use the **Use ADCP Value**
option to select the value being used by the ADCP. The EC and EZ-
commands determine the ADCP's speed of sound value. Choosing the **Use
ADCP Value** tells *WinRiver* not to do any speed of sound scaling of veloc-
ity data after it is received from the ADCP.

Selecting the **Calculate For Each Ping** option uses the **Salinity Value**,
ADCP transducer depth, and the water temperature at the transducer head to
compute speed of sound for each raw ADCP ensemble. *WinRiver* then uses

this value to scale the ADCP velocity data dynamically. *WinRiver* uses scaled velocity data in the displays and for discharge calculations.

Use the **Fixed** option to set a fixed value for sound speed. Select this option if you made a mistake during data collection. *WinRiver* uses the fixed value to re-scale the velocity data from the ADCP.

Projection Angle

This is the angle used to calculate the projected velocity that is displayed in the **Projected Velocity** contour plot.

Backscatter

The Backscatter options control the values used to convert between measured Receive Signal Strength (RSSI) to backscatter. These parameters have no affect on discharge and only affect backscatter.

The **Near Zone Distance** is the distance away from the transducer where the beam transitions from cylindrical to conical. The angle of the cone is the beam width. The default value should be used for 600 and 1200kHz Rio Grande. Other transducers should use the formula shown in Figure 6.

Near Zone Distance = D^2/λ
λ = 1500/frequency
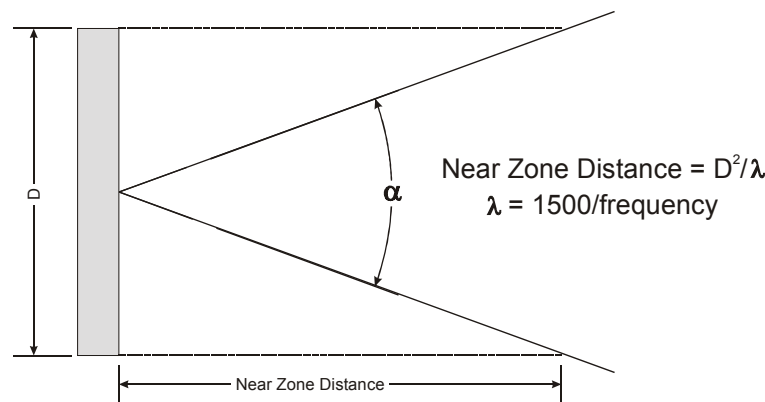
Figure 6.   Near Zone Distance

WinRiver uses the **Echo Intensity Scale** (dB per RSSI count) value to convert the ADCP signal strength (RSSI, AGC) from counts to dB before correcting it for absorption and beam spreading beyond the **Near Zone Distance**. Echo intensity in decibels (dB) is a measure of the signal strength of the returning echo from the scatterers. It is a function of sound absorption, beam spreading, transmitted power, and the backscatter coefficient. For more information on echo intensity, see RDI's *Principles of Operation: A Practical Primer*. The echo intensity scale is temperature dependent based on the following formula. Echo intensity scale (dB per RSSI count) = 127.3 / (Te + 273) where Te is the temperature (in °C) of the ADCP electronics and is calculated by *WinRiver* unless overridden by the user. At ambient temperature, the nominal scale is 0.43dB per count. Speed of Sound

is based on temperature and salinity and uses that value unless overridden by the user.

The sound absorption coefficient, which is used to estimate echo intensity in decibels, is a function of frequency. Beyond the **Near Zone Distance**, *WinRiver* range-normalizes echo intensity using the formula:

I[dB] = (Echo Intensity Scale[dB/counts]) x I[counts]

+ 20 x Log(R)   [spreading]

+ 2 x (Sound absorption coefficient) x R   [absorption]

Where *R* = Distance from transducer to ADCP depth cell in meters.

Cross Sectional Area

Cross Sectional Area can be calculated using three different methods: as perpendicular to the mean flow, perpendicular to the projection angle, or parallel to the average course.

Data Screening

Select **Mark Below Bottom Bad** to mark data below the ADCP-detected bottom or Depth Sounder detected bottom (if selected for processing). Check the **Use 3 Beam Solution for BT** box to allows 3-beam solutions if one beam is below the correlation threshold set by the BC command. Check the **Use 3 Beam Solution for WT** box to allows 3-beam solutions if one beam is below the correlation threshold set by the WC command.

Thresholds

Bottom Track Error Velocity - The ADCP uses this parameter to determine good bottom-track velocity data. If the ADCP's error velocity value exceeds this threshold, it flags data as bad for a given depth cell.

Water Track Error Velocity - The ADCP uses this parameter to set a threshold value used to flag water-current data as good or bad. If the ADCP's error velocity value exceeds this threshold, it flags data as bad for a given depth cell.

Bottom Track Up Velocity - The ADCP uses this parameter to determine good bottom-track velocity data. If the ADCP's upward velocity value exceeds this threshold, it flags data as bad for a given depth cell.

Water Track Up Velocity - The ADCP uses this parameter to set a threshold value used to flag water-current data as good or bad. If the ADCP's upward velocity value exceeds this threshold, it flags data as bad for a given depth cell.

Fish Intensity - The ADCP uses this parameter to screen water-track data for false targets (usually fish). If the threshold value is exceeded, the ADCP rejects velocity data on a cell-by-cell basis for either the affected beam (fish detected in only one beam) or for the affected cell in all four beams (fish detected in more than one beam).

5.2.3 Discharge Tab

WinRiver uses these setting to determine what formulas and calculations will be used to determine the discharge value.
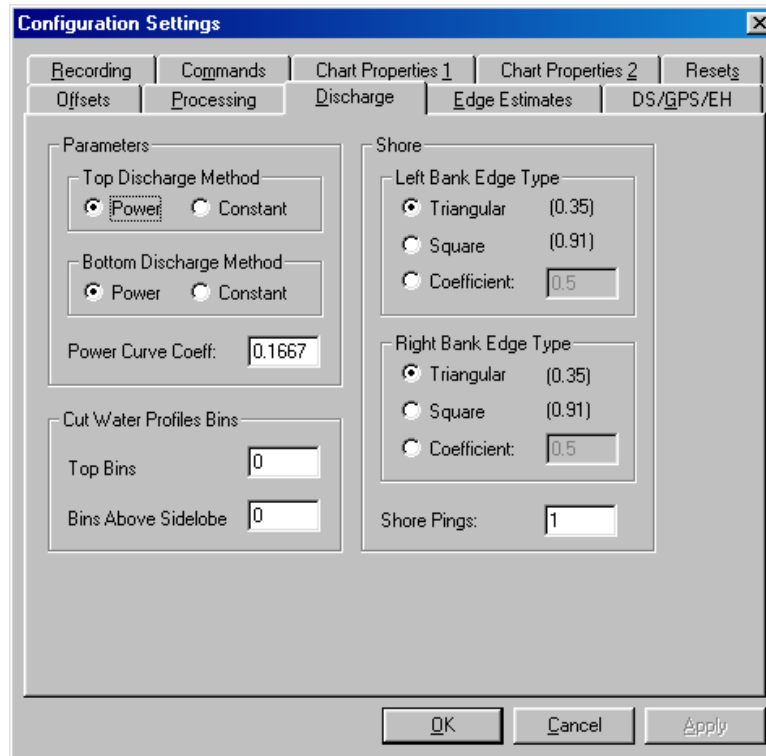
Figure 7.   Discharge Tab

- **Parameters** – There are two methods available in *WinRiver* to estimate discharge in the unmeasured top/bottom parts of the velocity profile based on the Top/Bottom Discharge Method settings. The two methods are **Constant** and **Power**. The **Power Curve Coefficient** can be changed if the **Power** Method is used. The default is set to 1/6. The Power fit is always used to fill in "missing" data in the profile. For more details, see the *WinRiver* help file.

- **Cut Water Profiles Bins** – You can select additional bins to be removed from the top or bottom measured discharge.

- **Shore** – The **Left/Right Bank Edge Type** is used in estimating shore discharges. You can select a predefined shape of the area as **Triangular** or **Square**, or set a coefficient that describes the shore. Several pings can be averaged as determined by **Shore Pings** in order to estimate the depth and mean velocity of the shore discharge. For more details, see the *WinRiver* help file.

5.2.4   Edge Estimates Tab

This menu lets you estimate the near-shore discharge, that is, near the banks of a channel where the ADCP cannot collect data. These settings should account for the beginning and ending areas of the transect not measured by the ADCP.
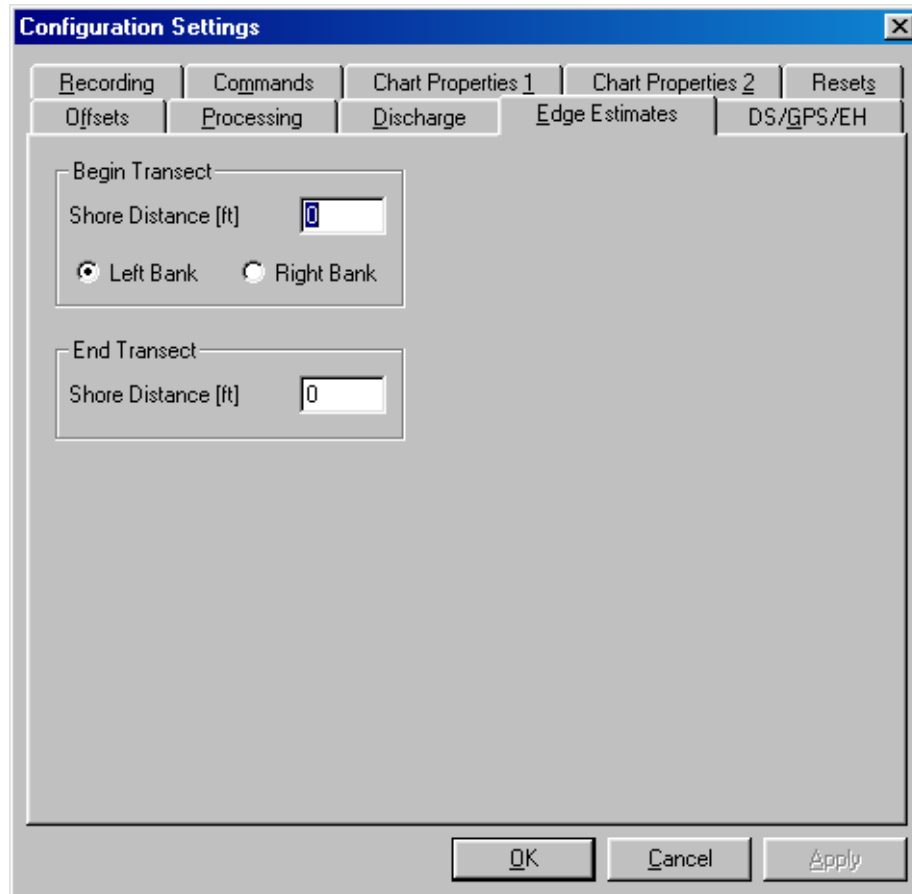
Figure 8.   Edge Estimates Tab

Begin Transect

- Shore Distance – Enter the distance to the shore at the beginning of the transect.

- Left/Right bank. Define if the shore when you start the transect is the left or right bank. When facing downstream, the left bank is on your left side.

End Transect

- Shore Distance – Enter the distance to the shore at the end of the transect.

5.2.5   DS/GPS/EH Tab

The depth sounder is another external sensor that can be used to track the depth of the water. Areas with weeds or high sediment concentrations may cause the ADCP to lose the bottom.
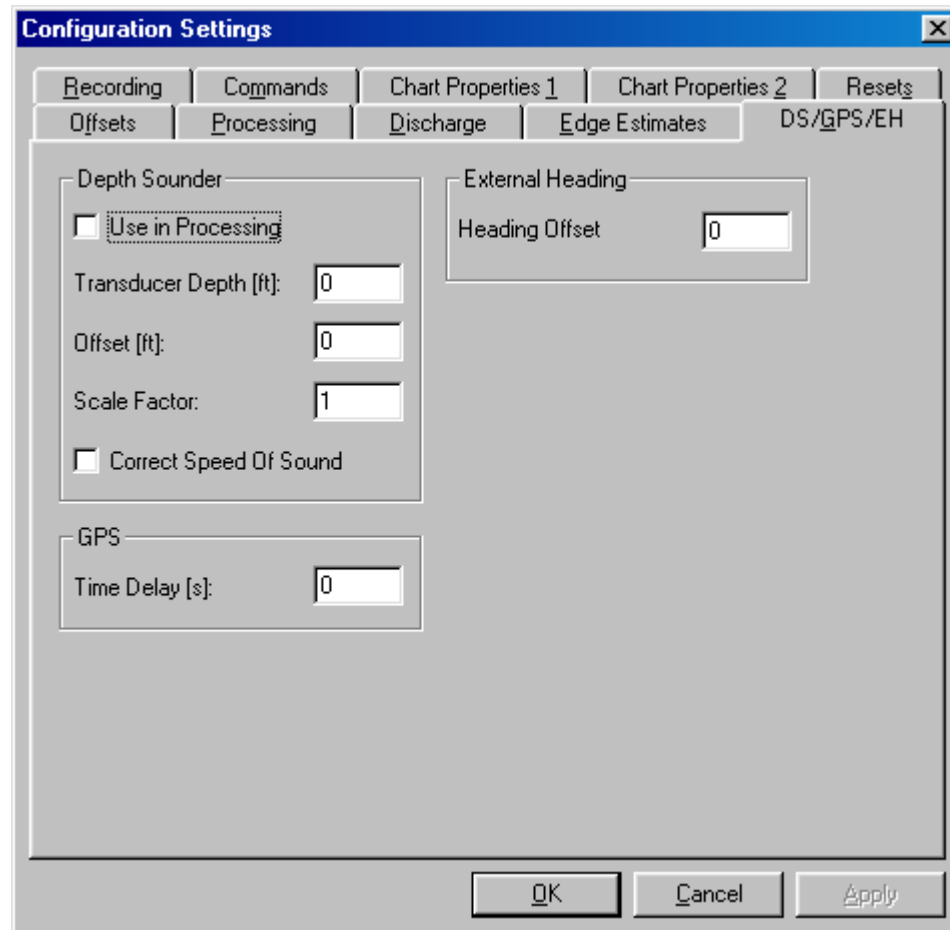
Figure 9.   DS/GPS Tab

Depth Sounder

- **Use in Processing** – This will instruct *WinRiver* to use the depth sounder value in the discharge calculation rather then the ADCP beam depths.

- **Transducer Depth** – Use the **Transducer Depth** to set the depth from the surface of the water to the Depth Sounder transducer face.

- **Offset** – In addition to the **Transducer Depth**, you can also add an additional offset to reconcile any differences between the ADCP bottom track depths and those reported by the DBT

NMEA string. Entering a value in the **Offset** box enables this additional offset.

- **Scale Factor** – Many depth sounders only allow a fixed value of 1500 m/s for sound speed. You can apply a scaling factor to the raw NMEA depth sounder output by entering a number in place of the **Correct Speed Of Sound** command. Note that the depths reported by the DBT NMEA string do not include the depth of the sounder, so the scaling is applied to the range reported from the depth sounder to the bottom.

- **Correct Speed Of Sound** – *WinRiver* can scale the depth sounder depths by the sound speed used by *WinRiver* by selecting the **Correct Speed Of Sound** box.

GPS

- **Time Delay** – If desired, you can allow for a lead-time between the GPS position updates and the ADCP data. Inserting a value in the **Time Delay** box does this. If you enter a value of 1, the lead is set for 1 second. This assumes GPS data is one second old compared to the ADCP.

> **NOTE.** The recommended value is zero.

External Heading

Use the **Heading Offset** field to reconcile any differences between the ADCP bottom track heading and those reported by the External Heading NMEA string. Entering a value in the **Offset** box enables this additional offset.

5.2.6   Recording Tab

The **Recording** tab lists the parameters used to define where the data is recorded during data collection.
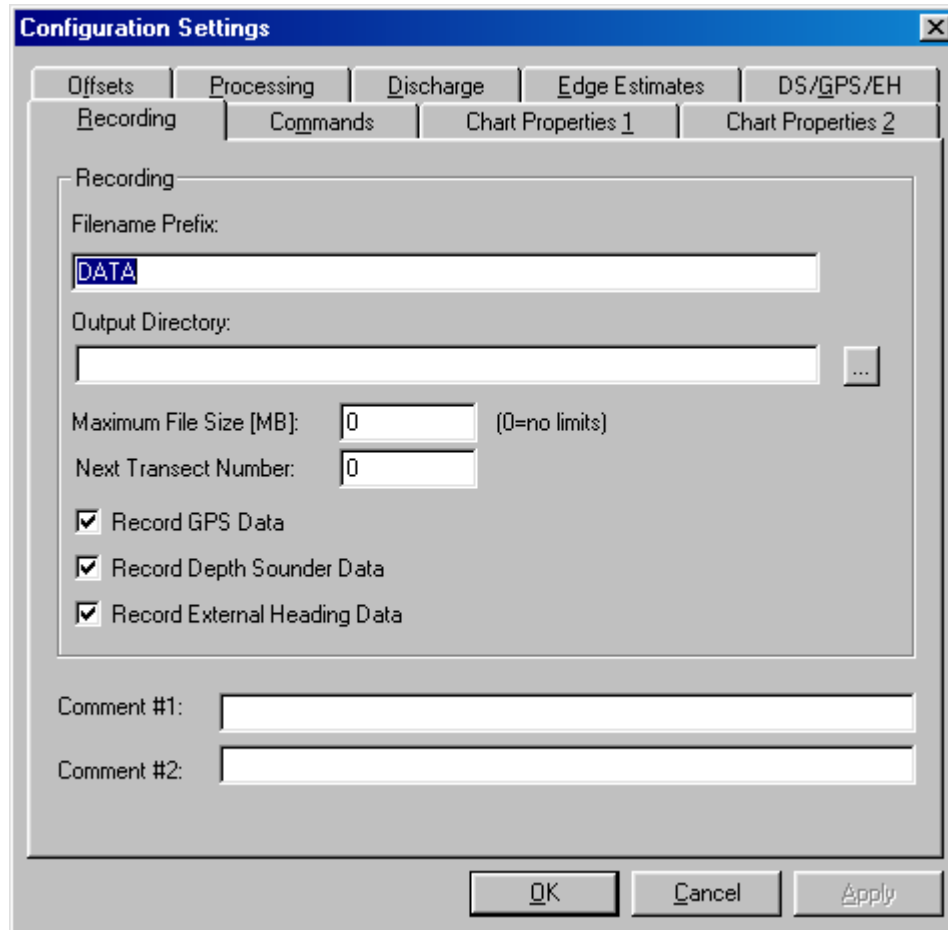
Figure 10.   Recording Tab

- **Filename Prefix** – *WinRiver* uses the **Filename Prefix** to create the data file names made during data collection. Use the **Output Directory** field to select where the data file will be stored.

  During data collection, if the **Filename Prefix** is set to TEST, *WinRiver* creates data files with the prefix TEST (TEST####.###) and stores them in the directory specified in the **Output Directory** field until the disk is full. *WinRiver* will then stop data collection and alert you to the disk space problem.

NOTE. A file name can contain up to 255 characters, including spaces and the **Filename Prefix**. It cannot contain the following characters: \ / : * ? " < > |

- **Maximum File Size** – Use the **Maximum File Size** field to limit the size of a data file. The default for the maximum data file size is unlimited. If you set the Maximum File Size to 1.44, then when the size of the recorded data file reaches 1.44 MB, the file name extension increments.

- **Next Transect Number** – The program will start with the number specified in the **Next Transect Number** box. If the transect already exists, the next number available will be used.

- If you want to record ASCII External Heading, GPS, and Depth Sounder data, select the appropriate box.

> **NOTE.** If you want to use the depth sounder data in place of the ADCP depth, then you must select **Use in Processing** on the **DS/GPS** tab.

> **NOTE.** If you use External Heading, GPS, or Depth Sounder devices during data collection the data will always be written to the raw ADCP data file. Collecting ASCII External Heading, GPS, or Depth Sounder files is not required and are not used by WinRiver.

- **Comment #1, #2** – Use these two lines for your notes.

5.2.7 Commands Tab

You can directly control the profiling parameters sent to the ADCP using the **User Commands** box. The ADCP Technical Manual explains all direct commands in detail. The **Fixed Commands** box lets you view the direct commands that will always be sent to the ADCP. The Configuration Wizard will enter the **Wizard Commands** based on information entered in the Configuration Wizard (see "Using the Configuration Wizard," page 30).

> ⚠ **CAUTION**. The fixed commands are sent before any user commands. Sending a **User Command** will OVERRIDE the **Fixed** and **Wizard Commands**.

When the Acquire mode is first started, the commands in the **Fixed Commands** box are sent by *WinRiver* to the ADCP to set its profiling parameters. The **Wizard Commands** are sent next and will *override* some of the **Fixed Commands**. In the following, we will describe each command and give guidelines for setting these commands for acquiring reliable discharge data. Refer to the ADCP Technical Manual for more detailed information about each command.
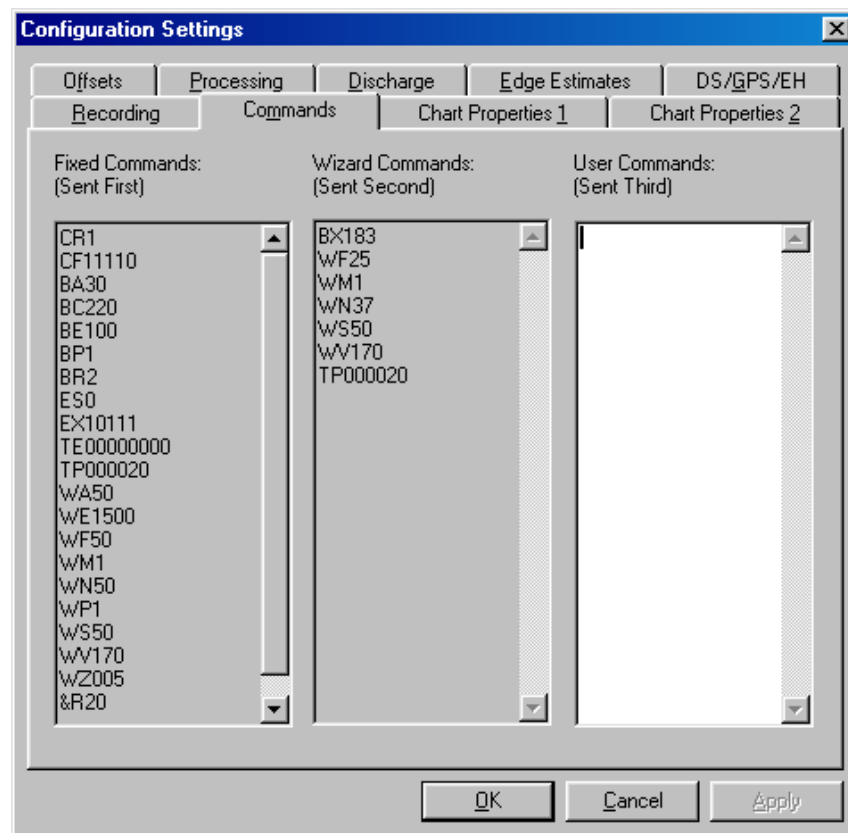
Figure 11.   Commands Tab

Table 2: Fixed Commands

Command	Choices	Description
CR1	Sets factory defaults	This is the first command sent to the ADCP to place it in a "known" state.
CF11110	Flow control	CF11110 selects automatic ensemble cycling, automatic ping cycling, binary data output, enables serial output, and disables data recording.
BA30	Evaluation Amplitude Minimum	Sets the minimum value for valid bottom detection to 30 counts.
BC220	Correlation Magnitude Minimum	Sets minimum correlation magnitude for valid bottom track velocity data to 220 counts.
BE100	Bottom Track Error Velocity Maximum	Sets maximum error velocity for good bottom-track water-current data to 100mm/s.
BP1	Bottom track pings	The ADCP will ping 1 bottom track ping per ensemble.
ES0	Salinity	Salinity of water is set to 0 (freshwater).
EX10111	Coordinate transformations	Sets Ship coordinates, use tilts, allow three-beam solutions, and allow bin mapping to ON.
TE00:00:00.00	Time per ensemble	Ensemble interval is set to zero.
TP00:00.20	Time between pings	Sets the time between pings to 0.2 seconds.
WA50	False Target Threshold Maximum	Sets a false target (fish) filter to 50 counts.
WE1500	Water Track Error Velocity Threshold	Sets the maximum error velocity for good water-current data to 1500mm/s.
WF50	Blank after transmit	Moves the location of the first depth cell 50 cm away from the transducer head (see Table 3).
WM1	Water mode	Sets the ADCP to Water Track mode 1.
WN50	Number of depth cells	Number of bins is set to 50 (see Table 3).
WP1	Pings per ensemble	The ADCP will ping 1 water track ping per ensemble.
WS50	Depth cell size	Bin size is set to 0.5 meters (see Table 3).
WV170	Ambiguity velocity	Sets the maximum relative radial velocity between water-current speed and Workhorse speed to 170 cm/s.
WZ005	Mode 5 Ambiguity Velocity	Sets the minimum radial ambiguity for profiling Mode 5 (WM5) and Mode 8 (WM8) Ambiguity Velocity to 5 cm/s.
&R20	Bottom Illumination	The &R command is used to set the "Bottom Illumination". This value determines the size of the Bottom Track transmit pulse in relation to the Depth. &R is entered in percent. If you were bottom tracking in 100m of water and had &R=20, the Bottom Track transmit pulse would be 20% of 100m, or 20m. If &R=30, then the transmit pulse would be 30m.

Table 3: Wizard Commands

Command	Choices	Description
BXxxx	Maximum Bottom Search	Limits how far the ADCP will search for the bottom
WFxx	Blank after transmit	Moves the location of the first depth cell away from the transducer head.
WMx	Water Mode	Sets the Water Mode
WNxxx	Depth cell number	Based on the maximum water depth entered in the Configuration Wizard, WinRiver will set the depth cell size and number of depth cells.
WSxxx	Depth cell size	
WVxxx	Ambiguity velocity	Sets the maximum relative radial velocity between water-current speed and Workhorse speed.
TPxx:xx.xx	Time between pings	Sets the time between pings.

NOTE. The values for the **Wizard Commands** are based on information entered in the **Configuration Wizard** (see "Using the Configuration Wizard," page 30).

5.2.8 Chart Properties 1 Tab

The **Chart Properties 1** tab lets you select display and scaling options for all graphics screens in real-time. By selecting the appropriate minimum and maximum values for the displays, specific features in the data become more visible. *WinRiver* saves all scaling information to the configuration file.

> **NOTE.** To quickly access the graph scales right-click on the graph and select Properties.

Figure 12.   Chart Properties 1 Tab

Scalable parameters include the following.

East Velocity (in m/s or ft/s)	Velocity Magnitude (in m/s or ft/s)	Intensity (in counts)
North Velocity (in m/s or ft/s)	Velocity Direction (in degrees)	Backscatter (in dB)
Up Velocity (in m/s or ft/s)	Projected Velocity (in m/s or ft/s)	Correlation (in counts)
Error Velocity (in m/s or ft/s)	Depth (in m or ft)	Discharge

> **NOTE.** If the **Auto Save Configuration file** mode is on (see **Users Option** menu) the chart properties will be re-saved to the *w.001 file. The file will play back with the same chart properties the next time the file is opened.

5.2.9　Chart Properties 2 Tab

The **Chart Properties 2** tab lets you select display and scaling options for all graphics screens in real-time. By selecting appropriate the minimum/maximum values for the displays, specific features in the data become more visible. *WinRiver* saves all scaling information to the configuration file.

> **NOTE.** To quickly access the graph scales right-click on the graph and select Properties.

Figure 13.　Chart Properties 2 Tab

Scalable parameters include the following.

East Displacement (in m or ft)	Pitch, Roll (in degrees)
North Displacement (in m or ft)	Water Speed (in m/s or ft/s)
Heading (in degrees)	Boat Speed (in m/s or ft/s)

> **NOTE.** If the **Auto Save Configuration file** mode is on (see **Users Option** menu) the chart properties will be re-saved to the *w.001 file. The file will play back with the same chart properties the next time the file is opened.

5.2.10 Resets Tab

The **Unfreeze (Ctrl-R)** button resets the configuration controls to unfreeze all frozen parameters. This allows the next *w.000 and *w.001 files to have complete control. This is the same as exiting *WinRiver* and restarting the program.

If you want to reset the configuration parameters back to the *w.000 values, use the **Reset to *w.000** button.
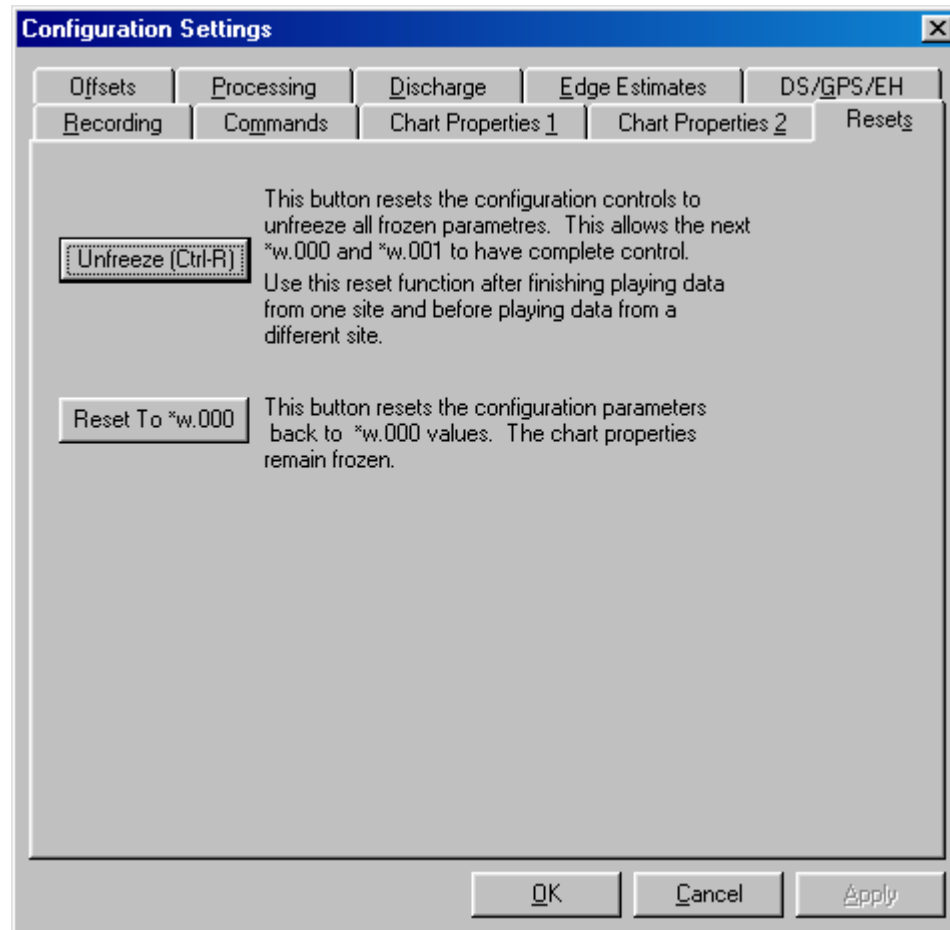
Figure 14.   Resets Tab

6 Acquiring Discharge Data

Starting WinRiver in the Acquire mode loads the direct commands from the configuration file to the ADCP and controls data recording for acquisitions of individual transect discharge data. Data can be displayed in tabular, ship's track, profile, or contour formats. *WinRiver* calculates discharge as it is calculated in real-time and accumulated as a transect is made across the river.

> **NOTE.** It is a good idea to run *DumbTerm* before collecting data at a particular site to check the ADCP's operation. *DumbTerm* runs a series of tests and creates a log file that records the results of the tests that are performed.

a. Start *WinRiver* in the Acquire mode. If you are in the Playback mode, click **File**, **Acquire Mode**.

b. You may want to record a note about the instrument setup or factors such as wind conditions, the passage of other vessels, and any other noteworthy events that occur during your transect of the channel. Use the **Settings** menu, **Configuration Setting**, **Recording** tab to add a comment to the configuration file.

> **NOTE.** The note will be saved to the configuration file (a *w.000 file is created for every transect), <u>not</u> with the data file.

c. Press **F4** to start the ADCP pinging. The Acquire **Tabular** window will now show *ADCP PINGING*.

In a few seconds, you will see changing values in several of the data windows. The ensemble number will update, the time displayed just below the ensemble number will change to show the ADCP time of each ensemble, the position sensors will update, and so on. And, if you have the ADCP in sufficiently deep water, you will see velocity profiles on the graph. *WinRiver* will not display meaningful data if your system is not in water.

In general, after you have started the ADCP pinging, there is no reason to stop pinging until you are finished and ready to remove the ADCP from the water. An exception would be if you were operating off of batteries with limited capacity. Then stopping pinging will conserve power.
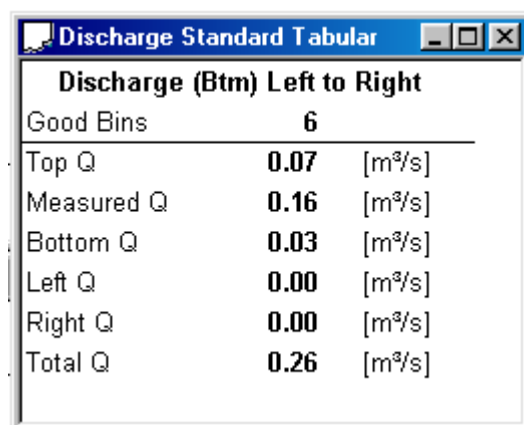
> **NOTE.** You can let the ADCP ping even if it is not in the water. Unlike many other acoustic devices, no damage to the ADCP will occur. It is often useful to operate the ADCP out of the water to test configuration files, practice with *WinRiver*, or perform other tests.

d. Before going forward, on the **Settings** menu, click **Reference**. Choose **Bottom Track** from the list. This will ensure that the velocity reference for the data display is set to bottom track. When bottom track is used as the velocity reference, the speed of the ADCP over ground is subtracted from the measured relative velocity to give true Earth referenced water velocity. You can always determine what velocity reference is in use by looking at the text lines just above and below the scales at the top and bottom of the graph display. At the end of each line is an indication of the reference being used.

6.1 Performing a Pre-Run

It is a good idea to perform a pre-run transect before actually acquiring data. This gives you the opportunity to ensure that the ADCP is working as expected with the loaded configuration file. You will also determine the starting/stopping locations at each side of the channel. As you cross, you can monitor the depth to see if there are areas with abrupt depth changes. Later, during data acquisition, you will want to cross very slowly over these regions to help bottom tracking maintain a valid lock on the bottom.

a. On the **View** menu, select the **Tabular**, **Discharge Standard Tabular** (see Figure 15) if you are not already viewing this plot. When making an individual discharge measurement, you want to start and stop the recording of data in water sufficiently deep to allow valid data to be recorded. Use the tabular display to determine when the water is deep enough to give a discharge value in the top two depth cells (**Good Bins** = 2 or more). You will be using a power fit for the extrapolation of the top and bottom, and at least two depth cells with valid discharge are needed in order to compute a more accurate power fit.

Discharge Standard Tabular		
Discharge (Btm) Left to Right		
Good Bins	**6**	
Top Q	**0.07**	[m³/s]
Measured Q	**0.16**	[m³/s]
Bottom Q	**0.03**	[m³/s]
Left Q	**0.00**	[m³/s]
Right Q	**0.00**	[m³/s]
Total Q	**0.26**	[m³/s]

Figure 15.   Discharge Standard Tabular Display

b. Move out from the shore until the water is deep enough to show a discharge value in the top two depth cells. Mentally note or mark this posi-

tion with a float. This is the starting/stopping position for this shore. You will later start/stop data file recording at this location depending on the direction of your transect.

c. Move out from the shore traveling slowly with the bow of the boat pointed upstream. On the **View** menu, select **Contour Plots**, **Velocity**, **Velocity Magnitude Contour**. The display will look similar to that shown in Figure 16. Use this display to see how the water depth changes as you make your transect. Note regions where the bottom depth changes quickly.
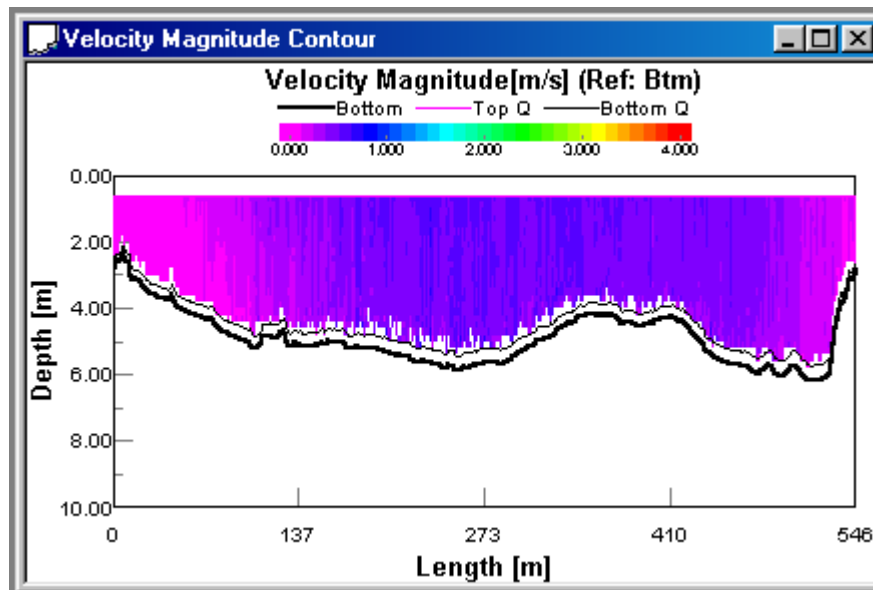
Figure 16.   Velocity Magnitude Contour Plot

d. As you approach the other shore, change the display back to tabular, and note or mark the closest distance to shore where two the top two depth cells show discharge values. This will be the start/stopping point for this shore.

6.2   Holding Position at the Starting Channel Edge

a. Starting at one of your marked edges, use the **Discharge Standard Tabular** display to ensure that you have at least two valid discharge measurements.

b. While holding position at the location where you have two valid cells of data, determine the edge distance to shore, and then press **F5** to start data recording. You will be prompted for a starting distance to shore. A unique configuration file, *w.000, will be created and saved in the same directory as the raw data file. This configuration file will contain the

starting edge distance as well as the ending edge distance you will enter later at the end of the transect.

> **NOTE.** Data processing continues while *WinRiver* is prompting for the edge distance.

c. Holding position for 4 to 5 ensembles after beginning the recording of data, enter the value for the starting shore distance. The extra ensembles that are recorded to the raw data file during this stationary period will help to ensure that you have a good starting ensemble for estimation of the side discharge. This must be enabled on the **Settings** menu, **Configuration Settings**, **Discharge** tab, **Shore Pings** box.

6.3   Crossing the Channel

a. Once several ensembles are recorded at the edge, slowly move away from the shore. Head for the desired ending point on the other side of the channel. Avoid fast accelerations, and keep the transect speed at or less than the water speed. Since you will be crossing slowly, you will be forced to point the bow nearly upriver and crab across. The slower you cross, the better your results will be.

b. As you make your transect, take some time to experiment with the different display options. The display scales can be changed on the **Chart Properties 1** and **2** tabs or right-click on a plot and select **Properties**.

c. You can see the discharge for the top, middle and bottom layers on the **Discharge Tabular** screen.

6.4   Holding Position at the Ending Channel Edge

Continue across the river until you reach the edge position determined during the pre-run on the opposite shore. You should have discharge values in at least the top two depth cells. Stop at this position and wait for 4 or 5 measurements to be recorded. Press **F5** to stop recording data. You will be prompted to enter the ending edge distance. Enter the value of the distance to shore.

6.5   Acquiring Discharge Data for Multiple Transects

Congratulations, you have just completed your first discharge measurement. You can now repeat the discharge measurement procedure to make additional transects. You will typically use **F5** to start and stop recording data for each passage across the channel while letting the ADCP ping continuously. An even number of transects is recommended, and the discharge from each individual transect can be averaged together to provide a discharge measurement for the site with lower variance than that of a single

transect (see "Compute Total Discharge," page 28). A new data and con-figuration file will be created each time you start and stop recording, and the starting and ending edge distances along with any entered notes will be saved in the unique configuration file.

When you have finished your desired number of transects and you are ready to stop data collection, press **F4** to stop pinging.

7   Post-Processing of Discharge Data

The Playback mode of *WinRiver* is used for post-processing data to get a total discharge value for the channel. Within the Playback mode, you can subsection the data to remove bad ensembles or create ASCII data files to use in other programs.

Modifying the *WinRiver* configuration file in the **Setting**, **Configuration Settings** tabs allows you to re-scale the raw data file to correct for variables that may have been incorrectly set during data collection such as the trans-ducer depth, the salinity value, or the edge distances.

7.1   Loading a Data File

a. Start *WinRiver* in the Playback mode. If you are in the Acquire mode, click **File**, **Playback Mode**.

b. On the **File** menu click **Open ADCP Raw Data File** and select the file to be played. WinRiver automatically creates a *w.001 configuration file.

- If the *w.000 configuration file exists, all of the values in the **Settings** menu, **Configuration Settings** tabs except the **Chart Properties 1** and **2** tabs will be used. The values will be grayed out. No changes can be made unless the item is right-clicked. Items that you decide to change during data playback will be saved in the *w.001 configuration file. The *w.000 files will not be changed.

- If a *w.000 configuration file does not exist you can modify all of the items in the *w.001 configuration file.

c. Create a new Workspace file by clicking **File**, **New Workspace File**. To open a workspace file, click **File**, **Open Workspace File**.

d. On the **Playback** menu, click **Play** to start playing the data. To quickly process the data select **Last Ensemble**. The playback tool bar has func-tions to start, stop, rewind, and go to the end of the data file.

7.2   Viewing Discharge Data

The Playback data display options are the same as those for the Acquire mode. Take some time to experiment with the formats, and refer to the *WinRiver* help file for more details on the **Playback** menu and available displays.

a. *WinRiver* can single-step through the data or run through at maximum speed. You can toggle between the pause/resume states by pressing **F4**. When the pause-state is enabled, SPACEBAR-STEP is displayed in the Status Bar. Press the space bar to single step through each ensemble of data. When the data file is played through to the end, press **Home** to rewind it to the beginning. Press **End** to play the data file to the end.

b. On the **Setting**, **Reference** menu, choose **Bottom Track** as the velocity reference. You will want to use this reference for data display and the calculation of discharge. In this reference, the boat's velocities are subtracted from the measured velocities to present true water velocities.

c. Use the **Setting** menu, **Configuration Setting**, **Chart Properties 1** and **2** tabs or right-click the display and select **Properties** to change the scaling fields of the different data displays.

d. Press **Z** to zoom in on the **Ship Track** and **Stick Ship Track** plots, and then **End** to play back the data file completely.

7.3   Editing an Item During Playback

Most of the parameters in the **Configuration Settings** can be changed while playing back data. Only the parameters that control data collection (**Recording** and **Commands** tab) does not change the way data is reprocessed.

Example – The Shore Distance for the Begin Transect was incorrectly entered. This error applies to only one of the data files.

a. Open the data file.

b. On the **Settings** menu, **Configuration Settings**, **Edge Estimates** tab, right click on the **Begin Transect Shore Distance** box.

c. Select **Open for Edit**.

d. Enter the correct shore distance. Click **OK**.

e. Play the file to see the results.
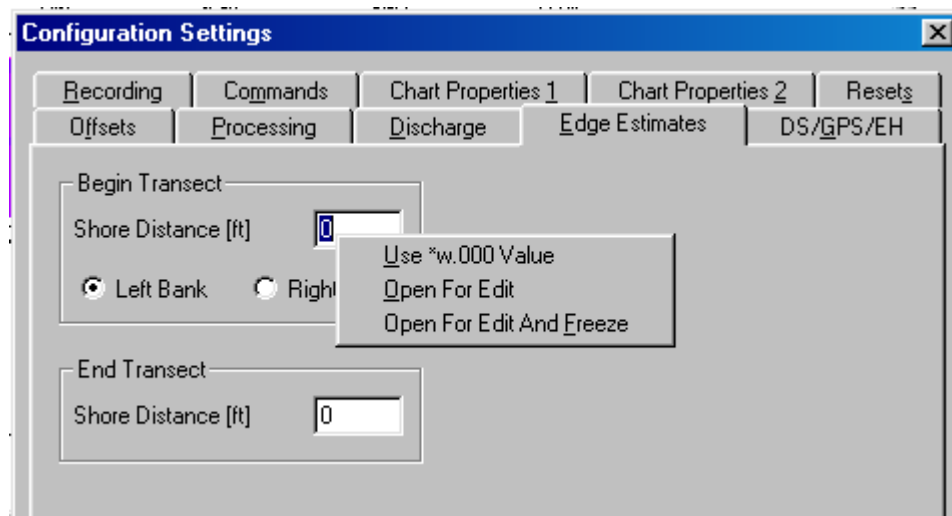
Figure 17.   Open an Item for Edit

Example – Data was collected using an ADCP depth of 0 meters. The correct ADCP depth was 0.2 meters. This error applies to all of the data files collected that day.

a. Open one of the data files.

b. On the **Settings** menu, **Configuration Settings**, **Offsets** tab, right click on the **ADCP Depth** box.

c. Select **Open for Edit and Freeze**.

d. Enter the correct ADCP depth. Click **OK**.

e. Play the file to see the results. The correction will apply to all subsequent data files opened.

> **NOTE.** To return the value to the parameter as collected, right click the item and select Use *w.000 Value.

7.4   Subsection a File

You can use the **Ensemble File Subsection** box to subsection raw data files before display, writing to ASCII files, or printing a display. *WinRiver* resets all elapsed data counters (Made Good, Length, Time) and total discharge values (Q) at the start of your subsection, so it computes the elapsed information or discharge for the subsection only. For example, you could subsection the middle 500-meters of a 2-km river transect. Replaying the subsectioned data would then show the discharge in that 500-m section of the river.

a. Start *WinRiver* in the Playback mode. If you are in the Acquire mode, click **File**, **Playback Mode**.

b. On the **File** menu click **Open ADCP File**. Select the data file to be sub-sectioned.

c. On the **Settings** menu, click **File Subsection**.

d. To select a portion of the data file, uncheck the **Select All Ensembles** box. Enter the **First Ensemble Number** and **Last Ensemble Number** and select **OK**.

e. Play the subsectioned data file. To quickly process the entire data set, click **Playback**, **Last Ensemble**. When subsectioning, *WinRiver* tries to jump to the **First Ensemble Number** in the data file before processing. If *WinRiver* cannot jump to that ensemble number, it resets the data file to the beginning of the file. If *WinRiver* reaches the end-of-file before finding the **Last Ensemble Number**, it sets the last ensemble number to the last ensemble number read from the file.

f. To return to the entire data file, On the **Settings** menu, click **File Sub-section**. Check the **Select All Ensembles** box. Replay the data file.

7.5   Creating an ASCII-Out Data File

Playback can be used to create ASCII-Out data files (see). These files are, as the name implies data files that are in a text format that can be directly read by you or imported into other post processing software.

a. Start *WinRiver* in the Playback mode. If you are in the Acquire mode, click **File**, **Playback Mode**.

b. On the **File** menu click **Open ADCP File**. Select the data file to be converted.

c. On the **File** menu, click **Start ASCII Out**. Type the name of the data file you want the data to be written to. The symbol "->" and the file name will indicate successful opening of the file.

d. *WinRiver* will jump to the first ensemble, playback the data file, and then close the ASCII file.

7.6 Creating a Processed Data File

Playback can be used to create Processed Data files (see "File Naming Convention," page 10). Processed Data files are used for backward compatibility with the DOS based *TRANSECT* program.

a. Start *WinRiver* in the Playback mode. If you are in the Acquire mode, click **File**, **Playback Mode**.

b. On the **File** menu click **Open ADCP File**. Select the data file to be converted.

c. On the **File** menu, click **P-Out**. Type the name of the data file you want the data to be written to.

d. *WinRiver* will jump to the first ensemble, playback the data file, and then close the processed data file.

7.7 Print a Plot or Display

a. Start *WinRiver* in the Playback mode. If you are in the Acquire mode, click **File**, **Playback Mode**. Printing is only available in the Playback mode.

b. On the **File** menu click **Open ADCP File**. Select the data file to be played.

c. Play the data file. To quickly process the entire data set, click **Playback**, **Last Ensemble**.

d. Click on the plot/display to be printed. The title bar will be highlighted.

e. On the **File** menu, click **Print Setup**. Select the desired setting and printer.

f. On the **File** menu click **Print Preview**. If the display is acceptable, click **Print**.

8 Integrating Depth Sounder, External Heading, and GPS Data

WinRiver can integrate External heading, GPS data, and depth sounder data into real-time discharge calculations. These devices are used when environmental conditions make it difficult to get unbiased boat velocity and/or depth using bottom tracking. See "Unable to Bottom Track," page 121 in the Trouble Shooting section of this guide for more details on these conditions. This section addresses the Depth Sounder, External Heading, and GPS requirements for integration.

Depth Sounder Requirements

- The depth sounder must be capable of outputting the DBT data string via the NMEA0183 format.

- A third serial port is required on your computer to accept the depth sounder data if you are also acquiring differential GPS in addition to ADCP data.

External Heading Requirements

- The external heading must be capable of outputting the HDT, HDG, or PRDID data string via the NMEA0183 format.

- Two serial port are required on your computer to accept the external heading data in addition to the ADCP data.

GPS Requirements

- The GPS must be a high quality, accurate differential GPS system.

- The GPS must be capable of outputting GGA and GSA (optional) data strings via the NMEA0183 format. The GGA string contains GPS positions. The GSA string provides optional diagnostic information, and it is not required.

- Two serial ports are required on your computer to accept both ADCP and differential GPS data.

8.1 How to Use Depth Sounders

The depth sounder is another external sensor that can be used to track the depth of the water. Areas with weeds or high sediment concentrations may cause the ADCP to lose the bottom. *WinRiver* will display the corrected depth (depth of water from the surface) in the **Navigation** tabular screen (See Figure 19, page 60).

> **NOTE.** In conditions where a depth sounder is required to measure water depth, a GPS is also required to measure the boat speed.

8.1.1 System Interconnections with the Depth Sounder

a. Connect the depth sounder system to your computer using a serial interface (see your depth sounder manual for details). You must have a depth sounder capable of serial NMEA 0813 output with DBT format in feet.

b. Configure the depth sounder to output the DBT data string via the NMEA0183 format.

c. Connect the ADCP system and the GPS to your computer as described in System Interconnection with GPS. Apply power to the system (see the ADCP Technical Manual for details).

d. **Three** serial ports are required on your computer to accept the depth sounder and differential GPS in addition to ADCP data. For laptops, two PCMCIA serial cards may be used to provide the second and third ports.

8.1.2 Enabling the Depth Sounder Port

In order to use the depth sounder data, the depth sounder must be enabled. To enable depth sounder communications with *WinRiver*, do the following steps.

a. In the Acquire mode, select the **Settings**, **Communications** menu click the **Add** button.

> **NOTE.** *WinRiver* can be customized to begin pinging as soon as the Acquire mode is started. On the **File** menu, click **Stop Pinging**. You are not allowed to change communications parameters while pinging.

b. Choose **Depth Sounder**, and then click **Next**. Choose the COM port that the depth sounder is connected to.

> **NOTE.** Three serial ports are required on your computer to accept ADCP, differential GPS data, and depth sounder data.

c. Click **Next**. Enter the Depth Sounder communication Baud Rate, Parity, and Stop Bit settings.

d. Click **Next**. Verify the port and communication settings. Click **Next**.

> **NOTE.** If you do not want to use depth sounder for this transect, you can select the Inactive box. This will disable depth sounder, but retain the communication settings.

e. Click **Finish**.

f. Start pinging. You can select **View**, **Device Logs**, **Depth Sounder Log**. That will open a window in which all the characters coming from the port assigned for the depth sounder are shown. If the communication parameters are set properly you should see "$ DBT" strings on the display.

8.1.3   Using Depth Sounder Data

Once the Depth Sounder communications port is set up the data is recorded. To use and view the Depth Sounder data rather than the ADCP beam depths, do the following.
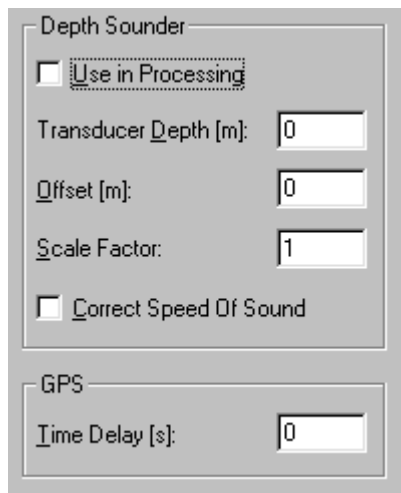
a. On the **Settings**, **Configuration Settings**, **DS/GPS** tab, select the **Use in Processing** box. The ADCP beam depths will be replaced by the Depth Sounder data.

b. Under the **Setting** menu, **Configuration Settings**, **Recording** tab you can select to collect depth sounder data to an ASCII file (*d.*).

> **NOTE.** The Depth Sounder data is ALWAYS recorded to the raw ADCP data file. The ASCII files (*d.*) are only recorded if requested and are not used by WinRiver..

c. On the **Settings**, **Configuration Settings**, **DS/GPS** tab, enter the depth from the surface of the water to the depth sounder's transducer face in the **Transducer Depth** box.

d. In addition to the **Transducer Depth** command, you can also add an additional offset to reconcile any differences between the ADCP bottom track depths and those reported by the DBT NMEA string. Enter a value in the **Offset** box.

e. You can apply a scaling factor to the raw NMEA depth sounder output by entering a number in the **Scale Factor** box. Note that the depths reported by the DBT NMEA string do not include the depth of the sounder, so the scaling is applied to the range reported from the depth sounder to the bottom.

f. Many depth sounders only allow a fixed value of 1500 m/s for sound speed. *WinRiver* can scale the depth sounder depths by the sound speed used by *WinRiver* by selecting the **Correct Speed of Sound** box.

Figure 18.   Depth Sounder Offsets

g. Save the configuration file with a unique name by selecting **Save Configuration File As** from the **File** menu. In naming the configuration file, use a name that will indicate that the depth sounder is being used in place of bottom track depths in the discharge calculation, i.e. RDGPS_DS.wrc for GPS and depth sounder.

NOTE. The decoded data will be displayed in the **Navigation Tabular** view if the **Settings**, **Configuration Settings**, **DS/GPS** tab, **Use in Processing** box is selected.

Figure 19.   Viewing Depth Sounder Data

8.2 How to Use the External Heading

The external heading is another external sensor that can be used to track the heading. Boats with metal hulls may cause the ADCP's compass to be biased. *WinRiver* will display the corrected heading in the **Standard** tabular screen (See "Using External Heading Data," page 62).

8.2.1 System Interconnections with the External Heading

a. Connect the external heading system to your computer using a serial interface (see your external heading manual for details). You must have an external heading device capable of serial NMEA 0813 output with HDT, HDG, or PRDID format.

b. Configure the external heading to output the data string via the NMEA0183 format.

c. Connect the ADCP system to your computer as described in the ADCP User's Guide. Apply power to the system.

d. **Two** serial ports are required on your computer to accept the external heading in addition to ADCP data.

8.2.2 Enabling the External Heading Port

In order to use the external heading data, the external heading must be enabled. To enable external heading communications with *WinRiver*, do the following steps.

a. In the Acquire mode, select the **Settings**, **Communications** menu click the **Add** button.

> **NOTE.** *WinRiver* can be customized to begin pinging as soon as the Acquire mode is started. On the **File** menu, click **Stop Pinging**. You are not allowed to change communications parameters while pinging.

b. Choose **External Heading**, and then click **Next**. Choose the COM port that the external heading is connected to.

> **NOTE.** Two serial ports are required on your computer to accept ADCP data and the external heading data.

c. Click **Next**. Enter the external heading communication Baud Rate, Parity, and Stop Bit settings.

d. Click **Next**. Verify the port and communication settings. Click **Next**.

> **NOTE.** If you do not want to use external heading for this transect, you can select the Inactive box. This will disable the external heading, but retain the communication settings.

e. Click **Finish**.

f. Start pinging. You can select **View**, **Device Logs**, **External Heading Log**. That will open a window in which all the characters coming from the port assigned for the external heading are shown. If the communication parameters are set properly you should see "$__HDT", "$__HDG" or "$PRDID" strings on the display.

8.2.3 Using External Heading Data

Once the external heading communications port is set up, the data is recorded. To use and view the external heading data, do the following.

a. Under the **Setting** menu, **Configuration Settings**, **Recording** tab you can select to collect external heading data to an ASCII file (*h.*).

> **NOTE.** The External Heading data is ALWAYS recorded to the raw ADCP data file. The ASCII files (*h.*) are only recorded if requested and are not used by *WinRiver*.

b. You can add an offset to reconcile any differences between the ADCP heading and those reported by the external heading NMEA string. Enter a value in the **Heading Offset** box.

c. Save the configuration file with a unique name by selecting **Save Configuration File As** from the **File** menu. In naming the configuration file, use a name that will indicate that the external heading is being used in place of bottom track heading in the discharge calculation, i.e. RDGPS_EH.wrc for GPS and external heading.

> **NOTE.** The decoded data will be displayed in the **Standard Tabular** view.

Figure 20.   Viewing External Heading Data

8.3   How to Use GPS

In high flow (flood) or high sediment concentration conditions, the ADCP may make biased bottom track measurements. The bias is caused by two different environmental sources:

- Fluid layer of sediment flowing along the bed of the stream (Moving Bottom)

- High sediment concentration in the water column near the bottom (Water Bias)

The consequences of these environmental sources and the biased ADCP bottom track are:

- Discharge computed with the ADCP is biased low

- The vessel track (shiptrack) is biased upstream

> **NOTE.** The ADCP is not malfunctioning – but measuring the environment as designed.

8.3.1   Using GPS Versus Bottom Track

When the ADCP cannot make unbiased bottom track measurements, an external differential GPS system should be used as the velocity reference. *WinRiver* can integrate the GPS data, replacing the bottom track velocity to compute real-time discharge. If the ADCP can detect the bottom to obtain depth, then there is no need to use a depth sounder.

In some cases, the suspended sediment concentrations are very high, and the ADCP cannot make a valid detection of the bottom depth. In this case, a depth sounder can be used to provide the depth for the real-time discharge calculation. In conditions where a depth sounder is required to measure water depth, a GPS is also required to measure the boat speed.

To use GPS as a vessel speed reference, three conditions must be met:

1. The GPS must be a high quality, accurate differential GPS system.

2. The compass used to rotate ADCP velocities to earth coordinates must be accurate and unbiased. The internal ADCP compass must be corrected for magnetic effects caused by any ferromagnetic objects, e.g. steel tools or motor, on the boat or in the nearby environment. The Compass Correction section describes the procedures to correct the internal ADCP compass heading data for local magnetic variation and to calibrate the compass for one-cycle deviation errors.   These corrections will help to reconcile the magnetic coordinate system of the ADCP with the GPS true earth coordinate system. You must be able to acquire valid bottom-track data to perform these corrections. If you anticipate mov-

ing bottom conditions during flood season, you should determine the compass corrections before flood season.

3. Transects must be made slowly to obtain the best quality discharge data when using GPS as the velocity reference. Slow boat speeds will reduce the error contribution to the discharge calculation caused by incorrectly rotating the ADCP velocities into the differential GPS earth coordinate system. This rotation is necessary to put both the ADCP velocities and the boat velocities determined by the GPS into the same coordinate system.

> **NOTE.** Bottom-track must be enabled in order to use the GPS data even though it is not used as the velocity reference.

> **NOTE.** If you can obtain valid bottom track data, and you use this as your reference system, there is no need to perform the compass correction procedures. Both the water and boat velocities are in the same coordinate system, and no rotation from one coordinate system to another is required.

8.3.2 System Interconnections with GPS

a. Connect the GPS system to your computer using a serial (RS- 232 or RS- 422) interface (see the GPS Manual for details).

b. Mount the differential GPS antenna as close to the ADCP as possible – less than one meter horizontally is the optimum distance. Apply power to the GPS.

c. Configure the GPS to output GGA, GSA (optional), and VTG (optional) data strings via the NMEA0183 format. The GGA string contains GPS positions. The GSA string provides optional diagnostic information, and it is not required. The VTG string provides velocity information calculated by the GPS.

d. Connect the ADCP system to your computer using a serial (RS- 232 or RS- 422) interface. Apply power to the system (see the ADCP Technical Manual for details).

e. Two serial ports are required on your computer to accept both ADCP and differential GPS data.

8.3.3 Enabling the GPS Port

To enable GPS communications with *WinRiver*, do the following steps.

a. On the **Settings**, **Communications** menu click the **Add** button.

b. Choose **GPS**, and then click **Next**. Choose the COM port that the GPS is connected to.

> **NOTE.** Two serial ports are required on your computer to accept both ADCP and differential GPS data.

c. Click **Next**. Enter the GPS communication Baud Rate, Parity, and Stop Bit settings.

d. Click **Next**. Verify the port and communication settings. Click **Next**.

> **NOTE.** Selecting the **Inactive** box will disable GPS, but retain the communication settings.

e. Click **Finish**. The GPS data will be recorded to the raw data file.

Optional Settings

- GPS Latitude and Longitude data can be saved to a separate ASCII file by choosing **Record GPS Data** on the **Settings**, **Configuration Settings**, **Recording** tab.

- For best results, make sure the ADCP is using ship coordinates (EX**10**nnn command (default value), where the nnn values are set to 0 or 1 as desired) in the **Settings**, **Configuration Settings**, **Commands** tab.

- If desired, you can allow for a lead-time between the GPS position updates and the ADCP data. This is done by inserting a value in the **GPS Time Delay** box in the **Settings**, **Configuration Settings**, **DS/GPS** tab. For example, if the lead-time is set for 1 second, this assumes that the GPS data is one second old compared to the ADCP. The recommended value is zero.

8.4 Compass Correction

The following section describes the procedure to correct the ADCP's compass for use with the GPS data. The first correction to the compass is for local magnetic variation and the second correction is for one-cycle magnetic deviation errors.

> **CAUTION.** *Both of these corrections are important because an uncorrected difference between the earth coordinate system of the differential GPS and the ADCP's internal magnetic compass will translate into significant errors in the discharge calculation.*

If you plan on using GPS, it is strongly recommended that you perform the compass correction procedures outlined in this section. A new compass correction should be determined if you are working more than 10 to 40 miles from the site where the last correction was performed, if you will be working in significantly different temperatures from the last compass calibration, or if your ADCP mounting has changed.

> **NOTE.** We recommend installing the ADCP with beam 3 forward for making discharge measurements (refer to the installation guide) and for the compass correction procedures. If beam 3 is not forward, you will need to carefully measure the rotation angle of beam 3.

> **NOTE.** If you have a Rio Grande ADCP with firmware 10.05 or greater, perform the Method 3 calibration before you do the Magnetic Variation Correction.

8.4.1   Magnetic Variation Correction

Local magnetic variation correction can be estimated by referring to a chart of the local area, but many times this information is not adequately precise. Use the following steps to determine the local magnetic variation.

a. Find a calm low current area where there is no moving bottom affects to do the compass correction. You must be collecting and using GPS data and be able to bottom track in the chosen location.

b. Create or open a workspace file (see "Customizing WinRiver," page 4) that has the **Standard**, **Navigation**, and **Compass Calibration** tabular displays, and a **Ship Track** display.

c. On the **Settings** menu, **Reference**, set the reference to **GPS (GGA)**.

d. On the **Settings**, **Configuration Settings**, **Offsets** tab, set the **Magnetic Variation** value and compass correction (**One Cycle K** and **One Cycle Offset**) values to zero. Ensure that the **Beam 3 Misalignment** angle is set to the Beam 3 misalignment.

e. Mark a starting point. This should be a point that you can easily reference to (an end of a pier, or a stationary marker).

f. Start *WinRiver* in the Acquire mode. Press **F4** to start pinging. Press **F5** to start recording.

g. Drive a straight track with constant heading (accelerate slowly and maintain a slow steady speed) for at least 200 meters (the longer the course the better) as shown in Figure 21, page 67. Monitor the heading display in the **Standard Tabular** view, and adjust your course to stay on a constant heading (not a constant course).
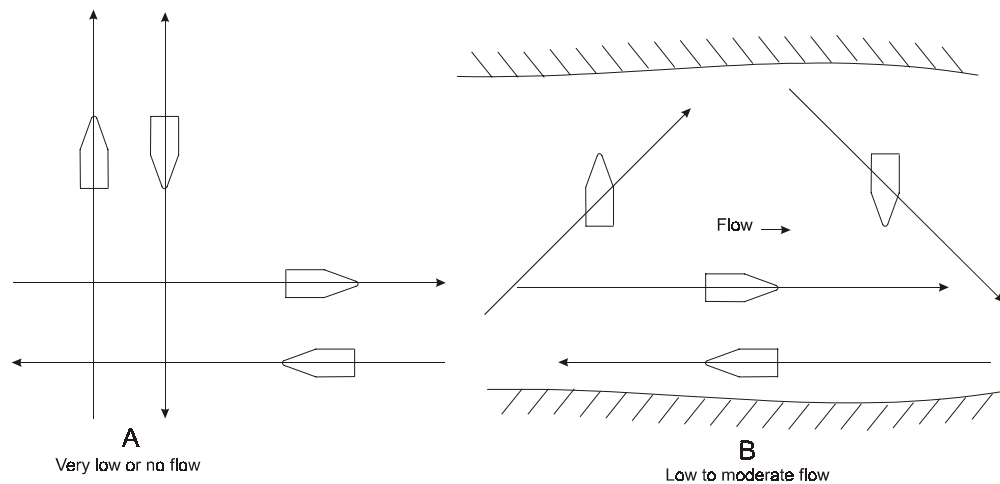
Figure 21. **Reciprocal Constant Heading Tracks for Determining Magnetic Variation**

h. Record the value of **GC-BC** from the **Compass Calibration Tabular** screen as shown in Figure 22. This is the compass error on this course (variation + deviation). Press **F5** to stop recording.
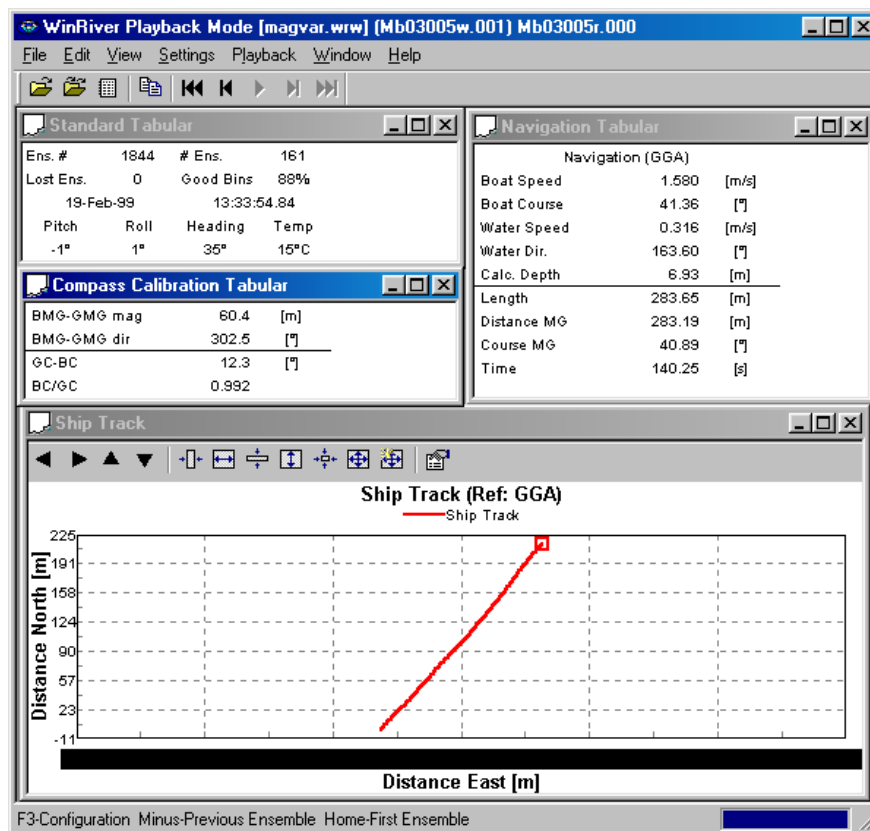
Figure 22. **Determining Local Magnetic Variation**

i. Drive a track along the opposite heading direction as shown in Figure 21, page 67. Press **F5** to start recording.

j. Record the value of **GC-BC**. Use the average of the two values to estimate the magnetic variation. Use as many pairs of reciprocal tracks along other heading directions as desired to get a better value (a total four vectors, that is two track pairs in approximately orthogonal directions, is recommended). Average the values of **GC-BC** for all of the tracks. This averaged value is the local magnetic variation.

k. Modify the **Configuration Settings**, **Offsets** tab and enter the **Magnetic Variation** value. In the example below, we have entered a magnetic variation of 12.2 degrees.
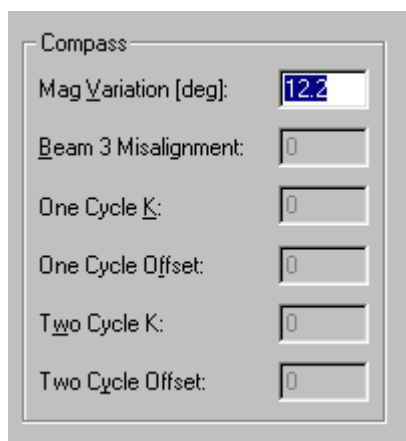
Figure 23.   Entering Local Magnetic Variation

> **NOTE.** In the Acquire mode it is a good idea to rename the configuration file to reflect that it has been corrected for magnetic variation. For example, if you original file was RDGPS1.wrc, then the modified file could be named RDGPS2.wrc to show that it has undergone one level of correction. In the Playback mode, simply edit the *w.001 file and freeze the values to apply them to all subsequent transects.

l. Start *WinRiver* in the Playback mode. When the data is played back, average the **GC-BC** value for two reciprocal headings. This value should be close to zero if the correction was made correctly (Figure 24).

Figure 24.   Data Corrected for Local Magnetic Variation

8.4.2   One-Cycle Compass Correction

Ferrous objects in the vicinity of the ADCP can affect the internal flux-gate compass. These affects will show up as one and two cycle errors in the compass heading. The one-cycle error can be corrected by using one of two methods described later in this section. The two-cycle error is typically negligible, but can be checked by using the AX-command as outlined in the Maintenance manual. Perform the AX-command with the ADCP mounted in the boat, and drive the boat in a small circle. If the two-cycle error is more than 0.5 degrees, check to see if there are any large ferrous objects close to the ADCP mounting that can be removed.

There are three methods of compass corrections. The first two require you to drive in a circle, starting and stopping at exactly the same point. Bottom-track may show that you have not returned to the same location. This non-closure error is caused by the one-cycle compass deviation, and it can be estimated from the magnitude and direction of the non-closure.

After you have driven in a circle, the magnitude of the non-closure error is indicated by the **Distance MG** (Made Good) value. The ratio between distance made good and the length of the track (**Distance MG** and **Length**, respectively) is the one-cycle magnitude of the compass error and the one-cycle offset is the **Course MG** angle.

There are three ways to determine and correct this non-closure error. The first procedure is the preferred method for BroadBand and WorkHorse ADCPs such as the Sentinel and Monitor. It provides a more accurate estimation of the one cycle compass error than the second method, but it requires that you have a stable dock or marker that you can drive away from in your boat and then return to within 30 cm (1 ft.). If you do not have a marker that will allow this kind of accuracy, use the second procedure to determine the one-cycle error. For both of these procedures, you must be in a location where you can obtain valid bottom track data.

The third method provides the easiest way to calibrate the compass for on-cycle errors but it can only be used with the WorkHorse Rio Grande ADCPs with firmware version 10.05 and higher. If you have a Rio Grande with an earlier version of firmware, contact RDI to upgrade the firmware. You do not need to be able to collect valid bottom track data for this third method to work. This procedure can be performed at sites with a "moving bottom".

Method 1

To reduce the error, do the following steps.

a. Find a calm low current area where you can obtain valid bottom tracking data to perform the compass calibration procedure. Mark a starting point that you can easily return to and maintain position (an end of a pier, or a stationary buoy). You will need to be able to return to this location to within about 30 cm (1 ft.) (even closer is better!).

b. Make sure that *bottom track is the velocity reference* for the Method 1 compass calibration procedure. On the **Settings** menu, **Reference**, set the reference to **Bottom Track**.

c. On the **File** menu, select **Save Configuration File As** and create a new configuration file from the file that was modified for the magnetic variation. We suggest naming the configuration file to reflect that Bottom Tracking is being used and that the magnetic variation correction has been applied, i.e. *BTM2.wrc.

d. Create or open a workspace file (see "Customizing WinRiver," page 4) that has the **Standard**, **Navigation**, and **Compass Calibration** tabular displays, and a **Ship Track** display.

e. Start *WinRiver* in the Acquire mode. Press **F4** to start pinging. Press **F5** to start recording.

f. Drive in a circular course with a circumference of about 1000 meters or larger (as large as possible). It is important to make a large circular track to make a good estimate of the one-cycle compass correction factors, and it is also important to make the path as close to a true circle as possible. Use the **Ship Track** screen to help make the circular course at a slow steady speed. If your location does not allow you to run a large circular course, you can run several continuous circles (say 3 to 5) being sure to pass your original starting point as you complete each circle. You would then use the combined course length from all of the circles in determining the one-cycle errors as described in the following steps. In Figure 25, page 71, three circular tracks were made to provide a total track length of 1754.50 meters.
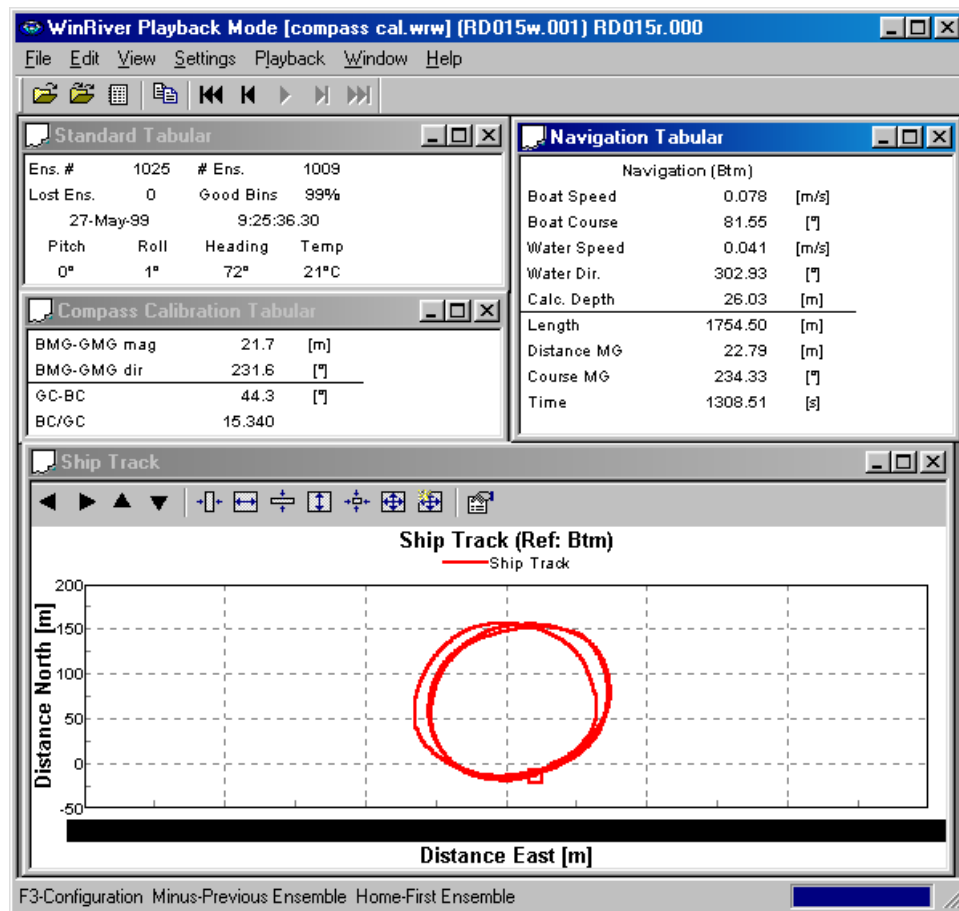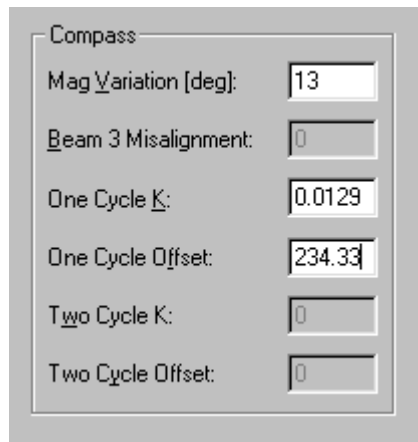
Figure 25. Method 1 Compass Correction Procedure

g. Come back as close as you can to the starting point (within 30 cm or less). Press **F5** to stop recording.

h. Record the **Course MG**, **Distance MG**, and **Length** values in the **Navigation Tabular** display. For example, in Figure 25, the **Course MG** is 234.33°, the **Distance MG** is 22.79 meters, and the **Length** is 1754.50 meters.

i. Take the ratio between **Distance MG** and **Length**; this is the magnitude of the one-cycle error (**One Cycle K**). In our example as shown in Figure 26, page 72, you would determine the ratio as 22.79/1754.50 = 0.0129. The **Course MG** 234.33° is the one-cycle error offset (**One Cycle Offset**).

j. On the **Settings**, **Configuration Settings**, **Offset** tab, enter the values for the **One Cycle K** and **One Cycle Offset**.

Figure 26.   Entering the Compass Corrections

k. If the ADCP is mounted with beam 3 pointed in a direction other than forward along the ship's centerline, determine the clockwise rotation of beam 3 relative to the ship's centerline and insert the value in the **Beam 3 Misalignment** box.

l. Apply the One Cycle K and One Cycle offset corrections to the configuration file that contains the magnetic variation corrections.

m. Start *WinRiver* in the Playback mode and replay the data using the corrected configuration file. The circle non-closure error as indicated by **Distance MG** should now be minimized (Figure 27, page 73). If the compass has been adequately corrected, the ratio of **Distance MG** to **Length** should be 0.01 or less (2.83/1754.50 = 0.0016).

n. You can now use the corrected configuration file for acquiring discharge measurements.
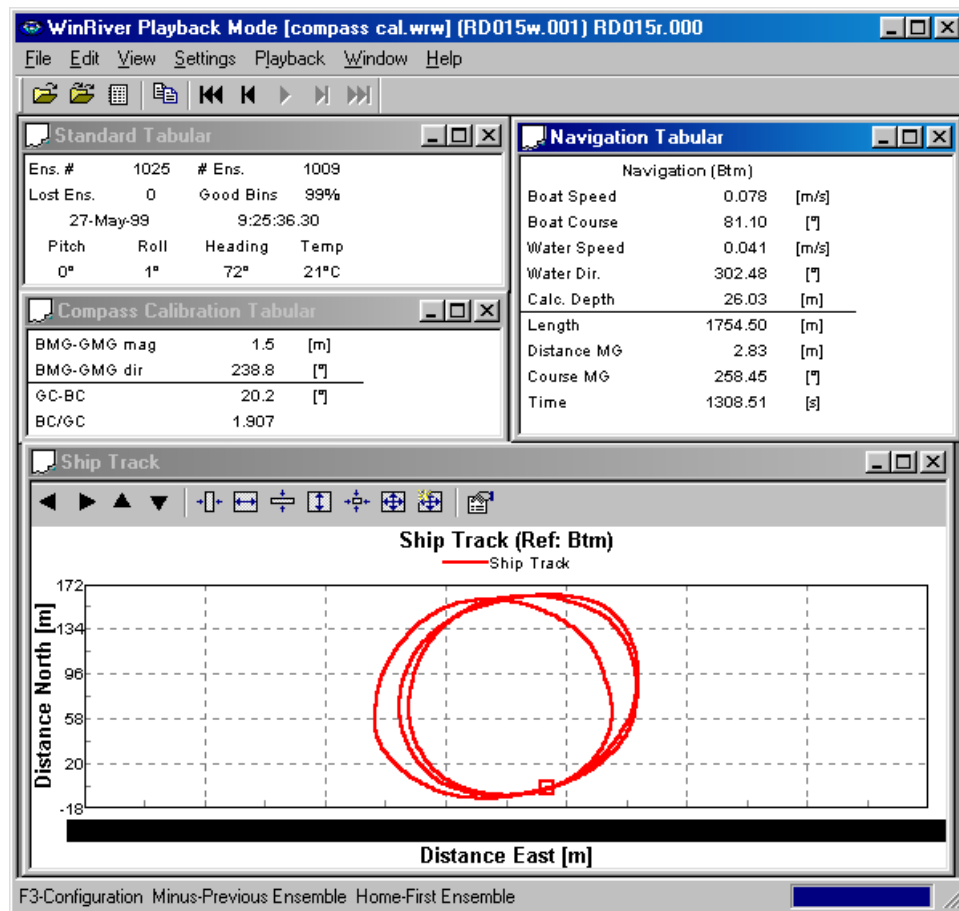
Figure 27.   Method 1 Compass Correction Procedure with Correction Applied

> **NOTE.** It is a good idea to rename the configuration file to reflect that the compass corrections have been applied. For example, if the configuration file with magnetic variation has been named *M2.wrc, then the new file could be named *M3.wrc to indicate that both the magnetic variation and the one-cycle corrections have been applied.
>
> To apply the corrections to subsequent data files during Playback, right-click each of the shore estimates boxes and bank type (left/Right) on the **Settings** menu, **Configuration Setting**, **Shore Estimate** tab and select **Use *w.000 value**. The value will become grayed out. Click **Apply**. Now save the configuration file as a unique name. When a new data file is opened, the shore estimate values will be taken from the *w.000 file and the compass corrections will already be applied.

Method 2

If you don't have a marker available that allows you to return to the same location (within 30 cm), you can still determine the one-cycle correction factors. For this procedure, *GPS is used as the reference* rather than the dock or stationary marker used in Method 1. The magnitude of the non-closure error is estimated by the magnitude of the **BMG-GMG** vector, and the **BMG-GMG** angle is the course made good direction. The ratio between distance made good and the length of the track (**BMG-GMG** and **Length**, respectively on the *WinRiver* display in) is the magnitude of the one-cycle compass error and the one-cycle offset is the **BMG-GMG** angle.
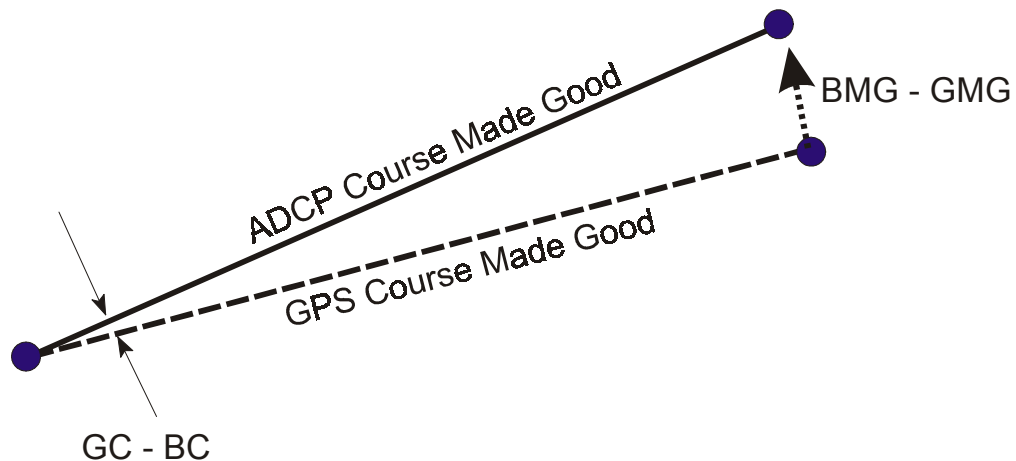
Figure 28.   GPS Versus Bottom Track

To reduce the error, do the following steps.

a. Find a calm low current area where you can obtain valid bottom tracking data to perform the compass calibration procedure. Mark a starting point. You will need to be able to return to this general location to within about 3 meters (10 feet).

b. Make sure that *GPS (GGA) is the velocity reference* for the method 2 compass calibration procedure. On the **Settings** menu, **Reference**, set the reference to **GPS (GGA)**.

c. On the **File** menu, select **Save Configuration File As** and create a new configuration file from the file that was modified for the magnetic variation. We suggest naming the configuration file to reflect that GPS is being used and that the magnetic variation correction has been applied, i.e. *S2.wrc.

> **NOTE.** GPS is used for the velocity reference in Method 2, while Bottom-Track is the reference in Method 1.

d. Create or open a workspace file (see How to Customize WinRiver) that has the **Standard**, **Navigation**, and **Compass Calibration** tabular displays, and a **Ship Track** display.

e. Start *WinRiver* in the Acquire mode. Press **F4** to start pinging. Press **F5** to start recording.

f. Drive in a circular course with a circumference of about 1000 meters or larger (as large as possible). It is important to make a large circular track to make a good estimate of the one-cycle compass correction factors, and it is also important to make the path as close to a true circle as possible. Use the **Ship Track** screen to help make the circular course at a slow steady speed. If your location does not allow you to run a large circular course, you can run several continuous circles (say 3 to 10) being sure to pass as close as possible to your original starting point as you complete each circle. You would then use the combined course length from all of the circles in determining the one-cycle errors as described in the following steps. In Figure 29, page 76, three circular tracks were made to provide a total track length of 1731.76 m.

g. Monitor the **BMG-GMG** vector display in the Compass Calibration Tabular display as you come back to your starting location. Press **F5** to stop recording.

h. Record the **BMG-GMG** vectors (magnitude and direction) and **Length** values. For example, in Figure 29, page 76, the **BMG-GMG Direction** is 231.6°, the **BMG-GMG Magnitude** is 21.7 m, and the **Length** is 1731.76 m.

i. Take the ratio between **BMG-GMG Magnitude** and **Length**; this is the magnitude of the One-Cycle Error (**One Cycle K**). In our example as shown in Figure 29, page 76, you would determine the ratio as 21.7/1731.76 = 0.0125. The **BMG-GMG Direction** 231.6° is the One-Cycle Error Offset (**One Cycle Offset**).
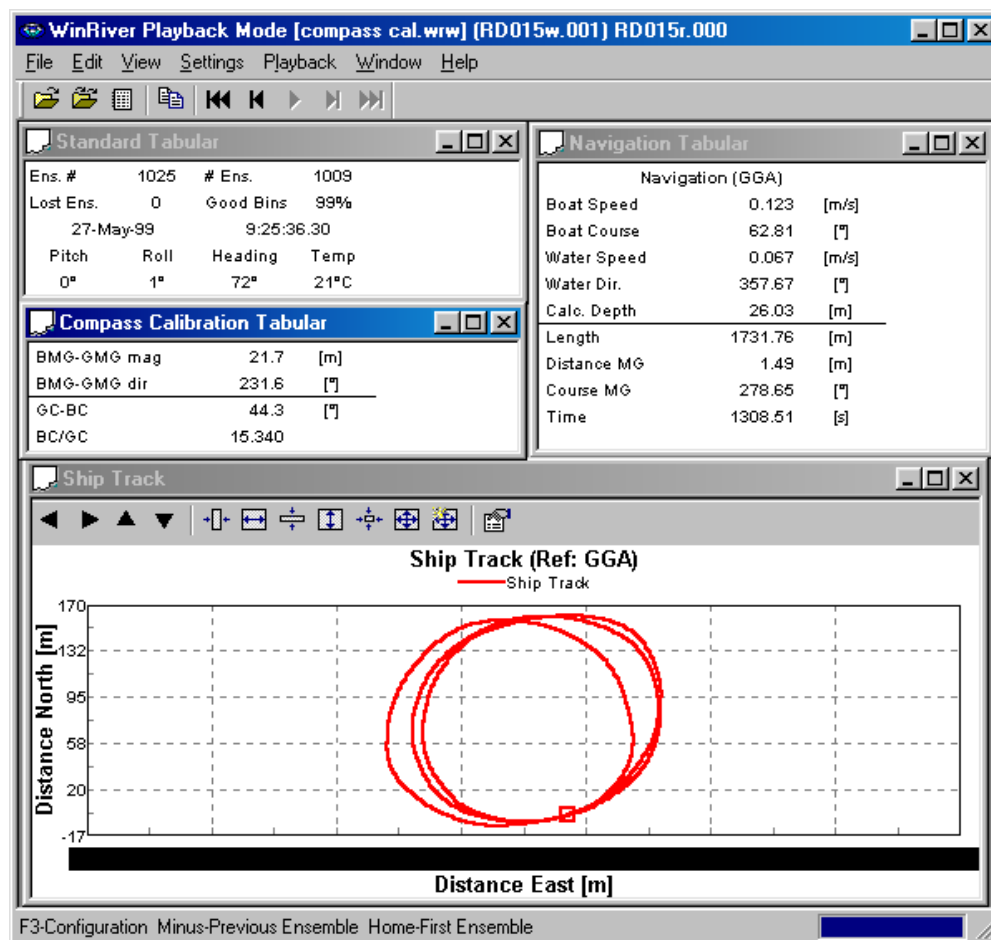
Figure 29.   Method 2 Compass Correction Procedure

j. On the **Settings**, **Configuration Settings**, **Offset** tab, enter the values for the **One Cycle K** and **One Cycle Offset**.

Figure 30.   Entering the Corrections for Method 2 Compass Correction Procedure

k. If the ADCP is mounted with beam 3 pointed in a direction other than forward along the ship's centerline, determine the clockwise rotation of beam 3 relative to the ship's centerline d insert the value in the **Beam 3 Misalignment** box.

> **NOTE.** It is a good idea to rename the configuration file to reflect that the compass correction has been applied. For example, if the configuration file with magnetic variation has been named *S2.CFG, then the new file could be named *S3.CFG to show that both the magnetic variation and the one-cycle corrections have been applied.

l. Start *WinRiver* in the Playback mode and replay the data using the corrected, GPS-referenced configuration file. The circle non-closure error indicated by the **BMG-GMG Magnitude** will be minimized. If the compass has been adequately corrected, the ratio of **BMG-GMG Magnitude** to **Length** should be 0.01 or less (2.4/1731.50 = 0.0013 in Figure 31).

m. You can now use the corrected configuration file for acquiring discharge measurements.

> **NOTE.** RDI recommends using a bottom-track referenced configuration file (Method 1). If you have a Rio Grande ADCP, RDI recommends using Method 3.
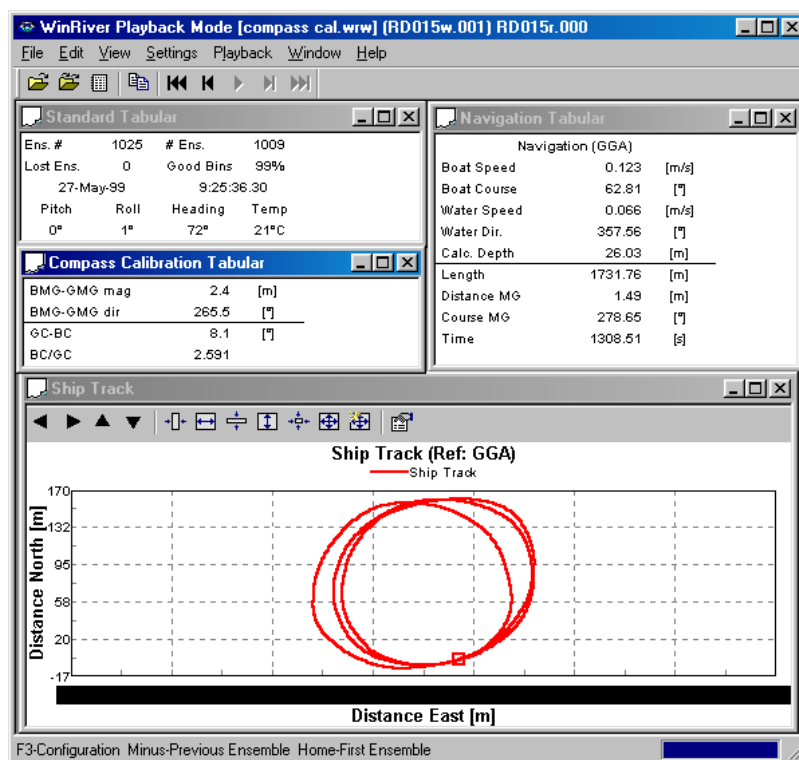
Figure 31.   Method 2 Compass Correction with Correction Applied

Method 3

This procedure is used to correct the Rio Grande's internal flux-gate compass for one-cycle deviation errors. The compass correction procedure given here can be used in place of the Method 1 or 2 compass correction procedures if you are using a Rio Grande with firmware version 10.05 and higher.

> **NOTE.** The Rio Grande firmware has been modified to allow the correction of the one-cycle errors with the AF command. BroadBand and other WorkHorse ADCPs, such as the Sentinel and Monitor, do not have this capability.

a. Mount the Rio Grande ADCP in the boat as it will be used to acquire data.

b. Start *DumbTerm* and press the **END** key to send a BREAK and establish communication with the Rio Grande. Refer to the RDI Tools User's Guide and the *DumbTerm* help file for details on using the *DumbTerm* program. *DumbTerm* is a simple "dumb terminal" program that can be used to send direct commands to the ADCP. You will be using the AF-command to examine the compass performance and correct the one-cycle magnitude and offset correction factors.

c. During this procedure, you will drive your boat in continuous, small circles. You can accomplish this by adjusting the throttle to just above idle and steering either hard left or hard right. You will want to reduce any pitch and roll effects during the turn (do not move about the boat, this may cause the boat to change how it sits in the water) and avoid any accelerations. If you are working on a river, you will find that you drift downstream as your perform the circles. This will not affect the correction procedure.

d. Press **F3** to turn on the *DumbTerm's* logging capability, and enter a desired filename for the log file.

e. While you continue to drive the boat in circles, type **AF** at the command prompt. The following represents what you will see on the screen:

```
>AF
-------------------------------------------------------------------------
                    Field Calibration Procedure
Choose calibration method:
    a.  Remove hard iron error (single cycle) only.
    b.  Remove hard and soft iron error (single + double cycle).
    c.  Calibration for a single tilt orientation (single + double cycle).
    d.  Help.
Quit.
```

f. Choose option "c" to Calibrate the compass for a single tilt orientation, and the following will be displayed:

```
C
------------------------------------------------------------------------
Field Calibration Procedure
          Calibration for Constant Tilt Applications (e.g., Rivers)
Select one:
     a.  Start calibration procedure.
     b.  Zero calibration coefficients (only constant tilt coefs).
     c.  Display correction coefficients.
     d.  Instructions.
     e.  Quit.
```

g. Choose option "a" to start the calibration procedure. As you turn a cir-
   cle in the boat, the program will accumulate data as you point in differ-
   ent heading directions. Once the data is accumulated, the total compass
   error will be displayed as highlighted below. In the example shown, a
   large magnet was place close to the ADCP to create a large one-cycle er-
   ror that results in a Total Error of 7.8°. You will not likely see such a
   large compass error when you perform the calibration yourself.

```
A
------------------------------------------------------------------------
                    RDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.

Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5ø/sec.  Press Q to quit.

 N       NE       E       SE       S       SW       W       NW       N
 ^                ^                ^                ^                ^


Accumulating data ...
Calculating compass performance ...

                         >>> Total error:   7.8ø <<<

Press D for details or any other key to continue...
```

h. When prompted, press **D** for details, and you will see a message similar
   to the following:

```
D

HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5ø):  ± 7.78ø

   DETAILED ERROR SUMMARY:
      Single Cycle Error:                      ± 8.09ø
      Double Cycle Error:                      ± 1.28ø
      Largest Double plus Single Cycle Error: ± 9.37ø
      RMS of 3rd Order and Higher + Random Error:    ± 0.64ø

      Orientation:    Down
      Average Pitch:   0.05ø      Pitch Standard Dev:    0.77ø
      Average Roll:    0.22ø      Roll Standard Dev:     0.30ø

Successfully evaluated compass performance for the current compass calibra-
tion.

Press C to display Percent Horizontal Field Components
     Relative to Calibration or any other key to continue....
```

i. At this point, check the Pitch and Roll Standard Deviation values as highlighted above. These values should be below 1°. It is best to use data with less than 1° standard deviation in both pitch and roll. If the boat pitched more than 1° during the turn, you will be given a warning message that the compass performance data may be suspect, and if the boat has pitched more than 3° during the turn, the AF command will stop.

j. Press **C** at the prompt to display the horizontal field components.

```
Percent Horizontal Field Component Relative to Calibration:
     a0 + a1*cosé + b1*siné + a2*cos2*é + b2*sin2*é
     a0 =                                        55.895%
     a1 =                                         6.361%
     b1 =                                        -4.755%
     a2 =                                         0.115%
     b2 =                                        -1.244%

Press any key to continue...
Calibration parameters have been updated in NRAM.
```

k. The last message indicates that the compass parameters have been updated to NRAM to correct for one-cycle errors. Press any key to return to the command prompt.

l. You can now evaluate the corrected compass by typing **AX** at the command prompt. You will need to continue turning in circles to accumulate data on all headings as you did for the AF command. The screen display will be as follows:

```
>AX
--------------------------------------------------------------------------
                    RDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.

Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5ø/sec.  Press Q to quit.

 N      NE      E       SE      S       SW      W       NW      N
 ^              ^               ^               ^               ^
Accumulating data ...
Calculating compass performance ...

                    >>> Total error:   0.8ø <<<

Press D for details or any other key to continue...
```

m. Note the total compass error shown on the screen (highlighted above). This value should now be reduced because the one-cycle errors were corrected by the AX command procedure.

n. At the prompt type **D** for details to see the following display.

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5ø):  ± 0.84ø

   DETAILED ERROR SUMMARY:
      Single Cycle Error:                       ± 0.29ø
      Double Cycle Error:                       ± 0.66ø
      Largest Double plus Single Cycle Error: ± 0.94ø
      RMS of 3rd Order and Higher + Random Error:    ± 0.60ø

      Orientation:    Down
      Average Pitch:  0.21ø          Pitch Standard Dev:   0.78ø
      Average Roll:   0.17ø          Roll Standard Dev:    0.27ø

Successfully evaluated compass performance for the current compass calibra-
tion.

  Press C to display Percent Horizontal Field Components
     Relative to Calibration or any other key to continue....
```

o. Press any key to complete the compass evaluation. As you can see from the display summary above, the one-cycle error was reduced from 8.09° (see step h) to 0.29°. Note that the double-cycle error was not corrected. For typical deployments this value will be much smaller. In the example data shown above, a large magnet was in the vicinity of the ADCP causing the relatively large double cycle error.

p. You can now use the Rio Grande with its corrected compass and a configuration file that contains the magnetic variation correction to collect discharge measurement data with integrated GPS.

8.5   Bottom Track Output Data Format

If Navigation (GGA, VTG, and/or GSA) or Depth Sounder (DBT) is enabled in the *WinRiver* configuration file, the data in the Bottom Track raw data structure is replaced with the navigation data.

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1				BOTTOM-TRACK ID					LSB 00h
2									MSB 06h
3			BT PINGS PER ENSEMBLE {BP}						LSB
4									MSB
5			BT DELAY BEFORE RE-ACQUIRE {BD} or						LSB
6			**GPS (GGA) LONGITUDE (PART 1)**						
7			BT CORR MAG MIN {BC}						
8			BT EVAL AMP MIN {BA}						
9			BT PERCENT GOOD MIN {BC}						
10			BT MODE {BM}						
11			BT ERR VEL MAX {BE}						LSB
12									MSB
13			RESERVED or						LSB
14			**GPS (GGA) LATITUDE**						
15									MSB
16									
17			BEAM#1 BT RANGE						LSB
18									MSB
19			BEAM#2 BT RANGE						LSB
20									MSB
21			BEAM#3 BT RANGE						LSB
22									MSB
23			BEAM#4 BT RANGE						LSB
24									MSB
25			BEAM#1 BT VEL						LSB
26									MSB

Continued next page

Continued from previous page

27	BEAM#2 BT VEL	LSB
28		MSB
29	BEAM#3 BT VEL	LSB
30		MSB
31	BEAM#4 BT VEL	LSB
32		MSB
33	BEAM#1 BT CORR.	
34	BEAM#2 BT CORR.	
35	BEAM#3 BT CORR.	
36	BEAM#4 BT CORR.	
37	BEAM#1 EVAL AMP	
38	BEAM#2 EVAL AMP	
39	BEAM#3 EVAL AMP	
40	BEAM#4 EVAL AMP	
41	BEAM#1 BT %GOOD	
42	BEAM#2 BT %GOOD	
43	BEAM#3 BT %GOOD	
44	BEAM#4 BT %GOOD	
45	REF LAYER MIN {BL} or	LSB
46	**GGA Altitude value (m) x 10 + 32768**	MSB
47	REF LAYER NEAR {BL} or	MSB
48	**GPS (GGA) LONGITUDE (PART 2)**	
49	REF LAYER FAR {BL} or	LSB
50	**DBT (see note)**	MSB
51	BEAM 1 REF LAYER VEL or	LSB
52	**GGA East/West velocities in mm/s (with reversed sign)**	MSB
53	BEAM 2 REF LAYER VEL or	LSB
54	**GGA North/South velocity in mm/s (with reversed sign)**	MSB
55	BEAM 3 REF LAYER VEL or	
56	**VTG East/West velocities in mm/s (with reversed sign)**	
57	BEAM 4 REF LAYER VEL or	
58	**VTG North/South velocity in mm/s (with reversed sign)**	

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59	BM#1 REF CORR or **GSA VDOP value**	
60	BM#2 REF CORR or **GSA PDOP value**	
61	BM#3 REF CORR or **GSA # of satellites**	
62	BM#4 REF CORR FLAG	
63	BM#1 REF INT or **GSA satellite 5 used in solution**	
64	BM#2 REF INT or **GSA satellite 6 used in solution**	
65	BM#3 REF INT or **GGA quality (0-invalid, 1-GPS fix, 2-DGPS fix)**	
66	BM#4 REF INT or **GGA HDOP value x 10**	
67	BM#1 REF %GOOD or **GSA satellite 1 used in solution**	
68	BM#2 REF %GOOD or **GSA satellite 2 used in solution**	
69	BM#3 REF %GOOD or **GSA satellite 3 used in solution**	
70	BM#4 REF %GOOD or **GSA satellite 4 used in solution**	
71	BT MAX. DEPTH {BX}	LSB
72		MSB
73	BM#1 RSSI AMP	
74	BM#2 RSSI AMP	
75	BM#3 RSSI AMP	
76	BM#4 RSSI AMP	
77	GAIN	
78	(*SEE BYTE 17)	MSB
79	(*SEE BYTE 19)	MSB
80	(*SEE BYTE 21)	MSB
81	(*SEE BYTE 23)	MSB

Table 4: Binary Bottom-Track Data Format

The LSB is always sent first. The WorkHorse Commands and Output Data Format guide has descriptions of the commands used to set these values.

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (00 06h).
5-8	3,4	BP / BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP-command). If BP = 0, the ADCP does not collect bottom-track data. The ADCP automatically extends the ensemble interval (TE) if (BP +WP) x TP > TE.
			Scaling: LSD = 1 ping; Range = 0 to 999 pings
9-12	5,6	BD / BT delay before reacquire or GGA Longitude part 1	Stores the number of ADCP ensembles to wait after losing the bottom before trying to reacquire it (BD-command).
			Scaling: LSD = 1 ensemble; Range = 0 to 999 ensembles
			If navigation (GGA) is enabled the GGA Longitude in Binary Angular Measure (BAM) will be displayed. Longitude in degrees/180 x 2147483647. East = positive, West = negative.
13,14	7	BC / BT Corr Mag Min	Stores the minimum correlation magnitude value (BC-command).
			Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA / BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA-command).
			Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	BG / BT %Gd Minimum	Stores the minimum percentage of bottom-track pings in an ensemble that must be good to output velocity data (BG-command).
19,20	10	BM / BT Mode	Stores the bottom-tracking mode (BM-command).
21-24	11,12	BE / BT Err Vel Max	Stores the error velocity maximum value (BE-command).
			Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s (0 = did not screen data)
25-32	13-16	GGA Latitude	If navigation (GGA) is enabled the GGA Latitude in Binary Angular Measure (BAM) will be displayed. Latitude in degrees/180 x 2147483647. North = positive, South = negative.
33-48	17-24	BT Range / Beam #1-4 BT Range	Contains the two lower bytes of the vertical range from the ensonified sea bottom (or surface to the ADCP altitude) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = 0. See bytes 78 through 81 for MSB description and scaling.
			Scaling: LSD = 1 cm; Range = 0 to 65535 cm
49-64	25-32	BT Velocity / Beam #1-4 BT Vel	The meaning of the velocity depends on the EX (coordinate system) command setting. The four velocities are as follows:
			a) Beam Coordinates: Beam 1, Beam 2, Beam 3, Beam 4
			b) Instrument Coordinates: 1 → 2, 4 → 3, toward face, error
			c) Ship Coordinates: Starboard, Forward, Upward, Error
			d) Earth Coordinates: East, North, Upward, Error

Continued next page

Table 4: Binary Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
65-72	33-36	BTCM / Beam #1-4 BT Corr.	Contains the correlation magnitude in relation to the sea bottom (or surface) as determined by each beam. Bottom-track correlation magnitudes have the same format and scale factor as water-profiling magnitudes.
73-80	37-40	BTEA / Beam #1-4	Contains the evaluation amplitude of the matching filter used in determining the strength of the bottom echo.
		BT Eval Amp	Scaling: LSD = 1 count; Range = 0 to 255 counts
81-88	41-44	BTPG / Beam #1-4 BT %Good	Contains bottom-track percent-good data for each beam, which indicate the reliability of bottom-track data. This data is the percentage of bottom-track pings that have passed the ADCP's bottom-track validity algorithm during an ensemble.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
89-92	45,46	Ref Layer Min	Stores the minimum layer size of the BT water-reference layer (BL-command).
		GGA Altitude	Scaling (minimum layer size): LSD = 1 dm; Range = 0 to 999 dm
			Scaling (near/far boundaries): LSD = 1 dm; Range = 0 to 9999 dm
			If Navigation (GGA) is enabled in the *WinRiver* configuration file, the GGA altitude value (m) x 10 + 32768 will be displayed.
93-96	47,48	Near Ref or GPS (GGA) Longitude part 2	Stores the near boundary of the BT water-reference layer (BL-command).
			Scaling (minimum layer size): LSD = 1 dm; Range = 0 to 999 dm
			Scaling (near/far boundaries): LSD = 1 dm; Range = 0 to 9999 dm
			If navigation (GGA) is enabled the GGA Longitude in Binary Angular Measure (BAM) will be displayed. Longitude in degrees/180 x 2147483647. East = positive, West = negative.
97-100	49,50	Layer Far	Stores the far boundary of the BT water-reference layer (BL-command).
		DBT depth	Scaling (minimum layer size): LSD = 1 dm; Range = 0 to 999 dm
			Scaling (near/far boundaries): LSD = 1 dm; Range = 0 to 9999 dm
			If Depth Sounder (DBT) is enabled in the *WinRiver* configuration file, the DBT depth in centimeters will be displayed.
101-104	51-52	Ref Vel / Beam #1 Ref Layer Vel	Contains velocity data for the water reference layer for beam 1. Reference layer velocities have the same format and scale factor as water-profiling velocities. WorkHorse Commands and Output Data Format Guide (BL-command) explains the water reference layer.
		GGA vel	If Navigation (GGA) is enabled in the *WinRiver* configuration file, the GGA East/West velocities in mm/s (with reversed sign) will be displayed.

Table 4: Binary Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
105-108	53-54	Ref Vel / Beam #2 Ref Layer Ve GGA vel	Contains velocity data for the water reference layer for beam 2. Reference layer velocities have the same format and scale factor as water-profiling velocities. WorkHorse Commands and Output Data Format Guide (BL-command) explains the water reference layer. If Navigation (GGA) is enabled in the *WinRiver* configuration file, the GGA North/South velocities in mm/s (with reversed sign) will be displayed.
109-112	55-56	Ref Vel / Beam #3 Ref Layer Vel VTG vel	Contains velocity data for the water reference layer for beam 3. Reference layer velocities have the same format and scale factor as water-profiling velocities. WorkHorse Commands and Output Data Format Guide (BL-command) explains the water reference layer. If Navigation (VTG) is enabled in the *WinRiver* configuration file, the VTG East/West velocities in mm/s (with reversed sign) will be displayed.
113-116	57-58	Ref Vel / Beam #4 Ref Layer Vel VTG vel	Contains velocity data for the water reference layer for beam 4. Reference layer velocities have the same format and scale factor as water-profiling velocities. WorkHorse Commands and Output Data Format Guide (BL-command) explains the water reference layer. If Navigation (VTG) is enabled in the *WinRiver* configuration file, the VTG North/South velocities in mm/s (with reversed sign) will be displayed.
117-118	59	RLCM/Bm #1 Ref Corr GSA VDOP	Contains correlation magnitude data for the water reference layer for beam 1. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes. If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA VDOP value will be displayed.
119-120	60	RLCM/Bm #2 Ref Corr GSA PDOP	Contains correlation magnitude data for the water reference layer for beam 2. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes. If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA PDOP value will be displayed.
121-122	61	RLCM/Bm #3 Ref Corr GGA # of satellites	Contains correlation magnitude data for the water reference layer for beam 3. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes. If Navigation (GGA) is enabled in the *WinRiver* configuration file, the GGA # of satellites will be displayed.
123-124	62	RLCM/Bm #4 Ref Corr	Contains correlation magnitude data for the water reference layer for each beam. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes.
125-126	63	Bm #1 Ref Int or GSA Sat 5	Contains echo intensity data for the reference layer for beam 1. Reference layer intensities have the same format and scale factor as water-profiling intensities. If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA satellite 5 used in the solution will be displayed.

Table 4:   Binary Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
127-128	64	Bm #2 Ref Int or GSA Sat 6	Contains echo intensity data for the reference layer for beam 2.
			If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA satellite 6 used in the solution will be displayed.
129-130	65	Bm #3 Ref Int or GGA Quality	Contains echo intensity data for the reference layer for beam 3.
			If Navigation (GGA) is enabled in the *WinRiver* configuration file, the GGA quality (0 = invalid, 1 = GPS fix, 2 = DGPS fix) will be displayed.
131-132	66	Bm #4 Ref Int or GGA HDOP	Contains echo intensity data for the reference layer for beam 4.
			If Navigation (GGA) is enabled in the *WinRiver* configuration file, the GGA HDOP value x 10 will be displayed.
133-134	67-70	RLPG/Bm #1 Ref %Good GSA Sat 1	Contains percent-good data for the water reference layer for beam 1. Reference layer percent-good data indicates the reliability of reference layer data. They are the percentages of bottom-track pings that have passed a reference layer validity algorithm during an ensemble.
			If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA satellite 1 used in the solution will be displayed.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
135-136	68	RLPG/Bm #2 Ref %Good GSA Sat 2	Contains percent-good data for the water reference layer for beam 2. Reference layer percent-good data indicates the reliability of reference layer data. They are the percentages of bottom-track pings that have passed a reference layer validity algorithm during an ensemble.
			If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA satellite 2 used in the solution will be displayed.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
137-138	69	RLPG/Bm #3 Ref %Good GSA Sat 3	Contains percent-good data for the water reference layer for beam 3. Reference layer percent-good data indicates the reliability of reference layer data. They are the percentages of bottom-track pings that have passed a reference layer validity algorithm during an ensemble.
			If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA satellite 3 used in the solution will be displayed.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
139-140	70	RLPG/Bm #4 Ref %Good GSA Sat 4	Contains percent-good data for the water reference layer for beam 4. Reference layer percent-good data indicates the reliability of reference layer data. They are the percentages of bottom-track pings that have passed a reference layer validity algorithm during an ensemble.
			If Navigation (GSA) is enabled in the *WinRiver* configuration file, the GSA satellite 4 used in the solution will be displayed.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
141-144	71,72	BX / BT Max. Depth	Stores the maximum tracking depth value (BX-command).
			Scaling: LSD = 1 decimeter; Range = 80 to 9999 decimeters

Table 4:   Binary Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
145-146	73-76	RSSI/Bm #1 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam.
			Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
147-148	74	RSSI/Bm #2 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam.
			Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
149-150	75	RSSI/Bm #3 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam.
			Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
151-152	76	RSSI/Bm #4 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam.
			Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
153,154	77	GAIN	Contains the Gain level for shallow water (WJ-command).
155-162	78-81	BT Range MSB / Bm #1-4	Contains the most significant byte of the vertical range from the ADCP to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range=0. See bytes 17 through 24 for LSB description and scaling.
			Scaling: LSD = 65,536 cm, Range = 65,536 to 16,777,215 cm

8.6 Navigation Data Output Data Format

WinRiver can read in, decode, and record ensembles from an ADCP and NMEA data from some specific (i.e. GPS and attitude sensors) external devices. *WinRiver* stores this data in the *r.000 raw data file (leaving all original data input from the ADCP in its original format).

Table 5: Navigation Data Structure

ALWAYS OUTPUT	**HEADER** (6 BYTES + [2 x No. OF DATA TYPES])
	FIXED LEADER DATA (53 BYTES)
	VARIABLE LEADER DATA (65 BYTES)
WD-command WP-command	**VELOCITY** (2 BYTES + 8 BYTES PER DEPTH CELL)
	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
BP-command	**BOTTOM TRACK DATA** (81 BYTES)
NMEA Strings	**DEPTH SOUNDER (DBT)** (38 BYTES)
	GPS GGA (94 BYTES)
	GPS VTG (45 BYTES)
	GPS GSA (60 BYTES)
	EXTERNAL HEADING HDT, HDG, or PRDID) (38 BYTES)
ALWAYS OUTPUT	**RESERVED** (2 BYTES)
	CHECKSUM (2 BYTES)

> **NOTE.** The other formats (Header, Fixed Leader Data, etc.) are explained in the WorkHorse Commands and Output Data Format guide.

Use the Binary Header Data Format (see the WorkHorse Commands and Output Data Format guide) to locate the offset to the specific ID of the data type you wish to decode. The table below shows the navigation IDs.

Table 6: Fixed Leader Navigation ID Word

ID	Description
0x2100	$xxDBT
0x2101	$xxGGA
0x2102	$xxVTG
0x2103	$xxGSA
0x2104	$xxHDT, $xxHDG or $PRDID

Once the ID of the data type is located use the data format section to locate the bytes you wish to decode using the data format for your ADCP.

8.7   General NMEA Data Format

Much of the following information was abstracted from the NMEA 0183 standard. Discussion is limited to NMEA strings that *WinRiver* under-stands. All NMEA messages are ASCII strings with the general format as shown in Table 7.

Table 7:   NMEA Data Format

String	Description
$	HEX 24 – start of sentence
<Address field>	Approved address fields consist of five characters defined by the NMEA 0183 standard. The first two characters are the TALKER identifier. The next three characters identify the message.
	The proprietary address field consists of the proprietary character "P" followed by a three-character Manufacturer's Mnemonic Code, used to identify the TALKER issuing a proprietary sentence, and any additional characters as required.
	(*WinRiver* accepts any two valid characters as the TALKER identifier in approved address fields.)
	(RD Instruments uses the RDI Mnemonic Code for proprietary address fields, even though it is assigned to Radar Devices. *WinRiver* also uses the unassigned ADC Mnemonic Code for its own data files).
[","<data field>] . . . [","<data field>]	Zero or more data fields, each preceded by a "," (comma, HEX 2C) delimiter. The number of data fields and their content are determined by the address field. Data fields may be null (contain no characters). The comma delimiter is required even when a data field is null.
["*"checksum field]	Checksum
	The checksum is the 8-bit exclusive OR (no start or stop bits) of all characters in the sentence, including "," delimiters, between but not including the "$" and the "*" delimiters.
	The hexadecimal value of the most significant and least significant 4 its of the result are converted to two ASCII characters (0-9, A-F) for transmission, The most significant character is transmitted first.
<CR><LF>	HEX 0D 0A – End of sentence

Data Fields

Detailed descriptions of each message *WinRiver* uses are provided below. These descriptions use format specifiers for data fields. The meanings of some of the format specifiers are listed in Table 8.

Table 8: Data Fields

Field	Description
hhmmss.ss	A mixed fixed/variable length time field. 2 fixed digits of hours, 2 fixed digits of minutes, 2 fixed digits of seconds, and a variable number of digits for decimal-fraction of seconds.
	Leading zeros are always included for hours, minutes, and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
x.x	A variable length integer or floating numeric field with optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required. (example: 73.10 = 73.1 = 073.1 = 73).
	A negative sign "-" (HEX 2D) is the first character if the value is negative. The sign is omitted if value is positive.
hh	A fixed length HEX number. The most significant digit is on the left.
a aa aaa	A fixed length alpha field. This type of field contains a fixed number of upper-case or lower-case alpha characters.
etc.	In all strings recognized by *WinRiver*, all these fields have a length of one character.
x xx xxx	A fixed length numeric field. This type of field contains a fixed number of numeric characters (0 - 9).
etc.	Some fields allow negative values. If needed, a negative sign "-" (HEX 2D) is the first character, increasing the length of the field by one. The sign is omitted if value is positive.
A	A single character status field.
	A = Yes, Data Valid, or Warning Flag Clear.
	V = No, Data Invalid, or Warning Flag Set.
Other single letter	A single character field with fixed content. The letter is the content of the data field.
	When used below, the HEX value of the letter is also given.

NOTES. Spaces should not be used anywhere in these NMEA strings. Spaces may only be used in variable text fields. No NMEA string recognized by *WinRiver* uses a variable text field.

If data is not available or unreliable, a null field is used. A null field is a field with no characters in it. When a null field is present, two delimiters (comma, *, or <CR>) are found side by side. A null field does NOT contain the zero character (HEX 30), the ASCII NUL character (HEX 00), a space (HEX 20), or other character.

WinRiver ignores some fields when it decodes messages. The fields it reads are explained in "NMEA Input," page 93.

8.8   NMEA Input

The messages *WinRiver* reads are standard DBT, GGA, VTG, GSA, and HDT, HDG or PRDID messages.

8.8.1   DBT – Depth Below Transducer

Water depth referenced to the transducer

$__DBT,x.x,f,x.x,M,x.x,F*hh<CR><LF>

Table 9:   DBT NMEA Format

Field		Description
1*	x.x	Water depth, feet
2	f	HEX 66
3	x.x	Water depth, Meters
4	M	HEX 4D
5	x.x	Water depth, Fathoms
6	F	HEX 46

* This field is used by *WinRiver*.

8.8.2   GGA – Global Positioning System Fix Data

Time, position, and fix related data for a GPS receiver.

$__GGA,hhmmss.ss,llll.ll,a,yyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh<CR><LF>

Table 10:   GGA NMEA Format

Field		Description
1*	hhmmss.ss	UTC of position - 2 fixed digits of hours, 2 fixed digits of minutes, 2 fixed digits of seconds, and a variable number of digits for decimal-fraction of seconds. Leading zeros are always included for hours, minutes, and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
2*	llll.ll	Latitude - Two fixed digits of degrees, 2 fixed digits of minutes, and a variable number of digits for decimal-fraction of minutes. Leading zeros are always included for degrees and minutes to maintain fixed length of the first 4 chars. The decimal point and associated decimal-fraction are optional if full resolution is not required.
3*	a	Latitude hemisphere. N or S.
4*	yyyy.yy	Longitude - 3 fixed digits of degrees, 2 fixed digits of minutes, and a variable number of digits for decimal-fraction of minutes. Leading zeros are always included for degrees and minutes to maintain fixed length of the first 5 chars. The decimal point and associated decimal-fraction are optional if full resolution is not required.
5*	a	Longitude hemisphere. E or W.
6*	x	GPS Quality indicator: 0 = fix not available or invalid 1 = GPS fix 2 = Differential GPS fix 3 = GPS PPS Mode, fix valid 4 = Real Time Kinematic. System used in RTK mode with fixed integers 5 = Float RTK. Satellite system used in RTK mode, floating integers 6 = Estimated (dead reckoning) mode 7 = Manual Input Mode 8 = Simulator mode This shall not be a null field.
7*	xx	Number of satellites in use, 00 – 12, may be different from the number in view
8	x.x	Horizontal dilution of precision
9*	x.x	Antenna altitude above/below mean-sea-level (geoid)
10	M	HEX 4D. Units of antenna altitude, meters
11	x.x	Geoidal separation. The difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid), "-" = mean-sea-level below ellipsoid.
12	M	HEX 4D. Units of geoidal separation, meters
13	x.x	Age of Differential GPS data. Time in seconds since last SC104 Type 1 or 9 update, null field when DGPS is not used.
14	xxxx	Differential reference station ID, 0000-1023

* This field is used by *WinRiver*.

8.8.3   VTG – Track Made Good and Ground Speed

The actual track made good and speed relative to the ground.

$__VTG,x.x,T,x.x,M,x.x,N,x.x,K,a*hh<CR><LF>

Table 11:   VTG NMEA Format

Field		Description
1*	x.x	Track, degrees true
2	T	HEX 54
3*	x.x	Track, degrees magnetic
4	M	HEX 4D
5	x.x	Speed, knots
6	N	HEX 4E
7*	x.x	Speed, km/hr
8	K	HEX 4B
9	a	Mode indicator
		A=Autonomous mode D=Differential mode E=Estimated (dead reckoning) mode M=Manual input mode S=Simulator mode N=Data not valid
		This shall not be a null field.

* This field is used by *WinRiver*.

8.8.4   GSA – GPS DOP and Active Satellites

GPS receiver operating mode, satellites used for navigation and DOP values.

$__GSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xxx.x,x.x,x.x*hh<CR><LF>

Table 12:   GSA NMEA Format

Field		Description
1*	a	Mode
		M = Manual, forced to operate in 2D or 3D mode A = Automatic, allowed to automatically switch 2D/3D
2*	x	Mode
		1 = Fix not available 2 = 2D 3 = 3D
3 – 14*	xx	PRN number of Satellites used in solution (null for unused fields)
15*	x.x	PDOP
16*	x.x	HDOP
17*	x.x	VDOP

* This field is used by *WinRiver*.

8.8.5 HDT – Heading – True

Actual vessel heading in degrees True produced by any device or system producing true heading.

$ __HDT,x.x,T *hh<CR><LF>

Table 13:   HDT NMEA Format

Field		Description
1*	x.x	Heading, degrees True
2	T	HEX 54

* This field is used by *WinRiver*.

8.8.6 HDG – Heading, Deviation, and Variation

Heading (magnetic sensor reading), which if corrected for deviation, will produce Magnetic heading, which if offset by variation will provide True heading.

$ __HDG,x.x,x.x,a,x.x,a*hh<CR><LF>

Table 14:   HDG NMEA Format

Field		Description
1*	x.x	Magnetic sensor heading, degrees
2*	x.x	Magnetic deviation, degrees
		This field and the following direction field are null if deviation is unknown.
3*	a	Direction of magnetic deviation. E or W.
4*	x.x	Magnetic variation, degrees
		This field and the following direction field are null if variation is unknown.
5*	a	Direction of magnetic variation. E or W.

* This field is used by *WinRiver*.

To obtain Magnetic Heading:

a. Add Easterly deviation (E) to Magnetic Sensor Reading.

b. Subtract Westerly deviation (W) from Magnetic Sensor Reading.

To obtain True Heading:

a. Add Easterly variation (E) to Magnetic Heading.

b. Subtract Westerly variation (W) from Magnetic Heading.

8.8.7   PRDID – Heading, Pitch, and Roll

RDI defines a proprietary NMEA message that contains heading, pitch, and roll data.

$PRDID,x.x,x.x,x.x,*hh<CR><LF>

Table 15:   PRDID NMEA Format

Field		Description
1	x.x	Vessel Pitch, degrees. + = bow up.
2	x.x	Vessel Roll, degrees. + = port up.
3*	x.x	Vessel Heading, degrees True

* This field is used by *WinRiver*.

8.9   Further Information About NMEA Strings

Users who need full details about NMEA data strings can find more information in the NMEA 0183 standard, available from the National Marine Electronics Association at.

P O Box 3435	252-638-2626 (voice)	nmea@coastalnet.com (e-mail)
New Bern, NC	252-638-4885 (fax)	http://www.nmea.org/ (web site)
28564-3435		

9   ADCP Measurement Basics

The ADCP is an <u>A</u>coustic <u>D</u>oppler <u>C</u>urrent <u>P</u>rofiler. It measures vertical profiles of the water's velocity using acoustic energy. A pulse of energy (known as a *ping*) is transmitted into the water much like a submarine's SONAR but at much higher frequencies. This energy is reflected off particles suspended in (and moving with) the water and some of it returns to the ADCP. The ADCP measures the Doppler shift (change in frequency) of the reflected energy and from this, computes the velocity of the water relative to the ADCP. We won't go into the details in this manual. If you would like to learn more about how the ADCP measures velocity, please read the BroadBand ADCP Primer.

The ADCP also measures its own speed and direction across the bottom of the channel using the same technique used to measure the velocity of the water. The details of the measurement are different since the bottom is solid (or nearly so) compared to the water. The BroadBand ADCP Primer also has additional details concerning how bottom tracking operates.

9.1   Velocity Profiles

As the ADCP processes the signal reflected off the particles in the water, it divides the water column into a number of discrete segments stacked in the vertical. These segments are called *depth cells*. The ADCP determines the velocity and direction of each depth cell. If we graph the velocity as a function of depth, we get a velocity profile from near the surface to near the bottom. The thickness of the depth cells is something that you get to select (within certain constraints set by the instrument's design and the laws of physics). With a 1200 kHz ADCP these depths cells can be as small as 5 cm, or 10 cm for a 600 kHz system. So in water a few meters deep, you can make many simultaneous velocity measurements in the vertical dimension.
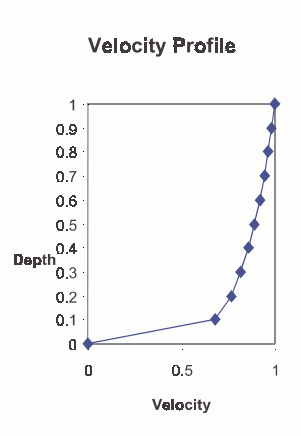
Figure 32.   Velocity as a Function of Depth

9.2   Bottom Track

When water profiling, the ADCP measures the speed and direction of the water relative to the ADCP. So, an ADCP moving north at 1 m/s in calm water or water flowing south at 1 m/s past a stationary ADCP will both produce the same output from the ADCP for water velocity (see Figure 33). An ADCP moving north at 1 m/s through water flowing south at 1 m/s would produce an apparent water velocity of 2 m/s toward the south. The ADCP *bottom track* measures the speed and direction of the bottom motion relative to the ADCP. By subtracting the ADCP velocity from the apparent (relative) water velocity, the true velocity of the water (with respect to the bottom) is determined.
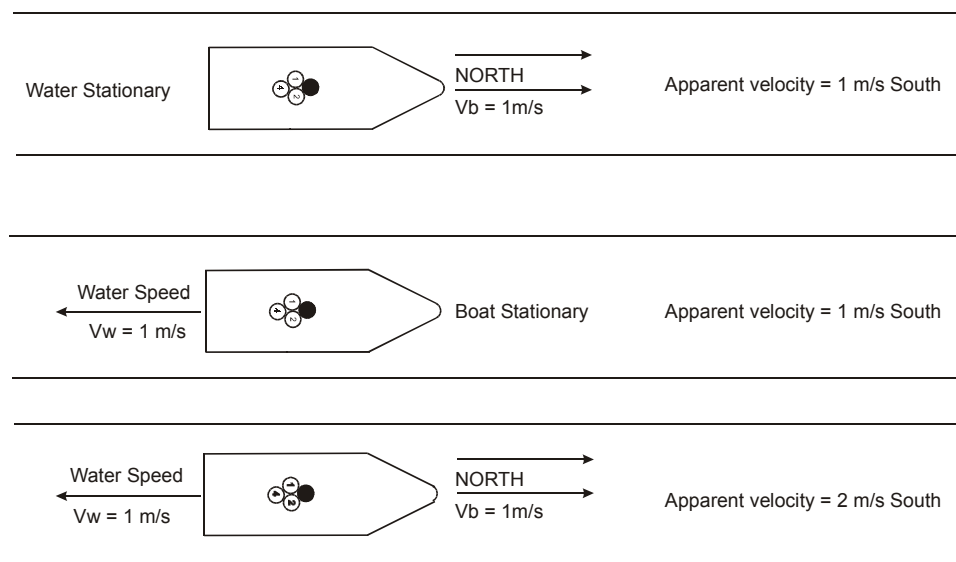
Figure 33.   Boat versus Water Velocity

9.3   Other Data

The ADCP also records several other pieces of information that are related to the measurement of the velocity of the water. These are briefly described below.

__Temperature__. The ADCP has a sensor in the transducer head to measure the temperature of the water at the ADCP. Measurement of the velocity of the water (and the bottom) depends on the speed of sound in the water at the ADCP. The ADCP uses the measured water temperature along with a user-input value of salinity to calculate the sound speed.

__Compass__. The ADCP has a flux-gate compass that measures the orientation of the ADCP relative to the earth's magnetic field. If you have requested earth coordinates for data collection (EX-command) the compass data will be used by the ADCP to output velocities in earth coordinates. *WinRiver*

will use the heading information to transform the raw data to earth coordinates before display if it has been collected in beam, instrument or ship coordinates.

Pitch and Roll. The ADCP also has pitch and roll sensors. These allow either the ADCP or the *WinRiver* software to correct the velocity measurements for rocking or tilting of the ADCP.

Intensity. The ADCP also records the intensity of the acoustic echoes received back from the energy scattered off the particles suspended in the water. This information is useful for verifying ADCP operation. It also provides a visual display of how sediment backscatter is distributed.

Correlation. The amplitude of the correlation function, in each depth cell, output by the ADCP is quality assurance for your data.

ADCP Percent Good. The ADCP can average data from individual pings internally to create ensemble data before sending it out. If for some reason, one ping of the ensemble has bad data, that information is not used in the average. Single ping ensembles are recommend, and in this case, the percent-good will be 100% (good data) or 0% (bad data).

Transect Percent Good. *WinRiver* presents a percent good value that is different from that in the raw ADCP data. Within *WinRiver*, this value represents the percentage of discharge calculations that are valid in a particular depth cell.

Real-time Clock. The ADCP has a real-time clock that measures time to 0.01-second precision and is accurate to within a few seconds per month for operating temperatures between 5 and 40 degrees Celsius. The date and time of a ping or ensemble is output as part of the data. The time between ensembles multiplied by the boat velocity is the displacement of the boat between ensembles. This is used to compute the discharge as well as to plot the boat trajectory.

10 Discharge Measurement Basics

A typical discharge measurement is calculated from several transects of data. Referring to Figure 34, a transect goes across the river from point A to point B, and the total discharge (ΣQ_1) is recorded. A second transect is then made starting at point B and ending at point A, and the second total discharge (ΣQ_2) is determined. Continue this process until you have the desired number of transects. An even number of at least four transects is recommended to calculate the discharge at a site. The actual river discharge estimate will then be the average of the N individual transect discharge values (see equation 1).

$$\Sigma Q = \frac{(\Sigma Q_1 + \Sigma Q_2 + \Sigma Q_3 + \Sigma Q_4 + ...)}{N} \qquad (1)$$
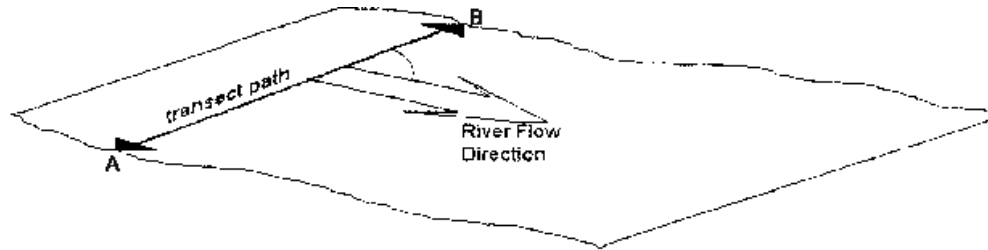
Figure 34.   Transect Path

10.1 Path Independence

Discharge is the accumulated flow crossing perpendicular to the boat's path (see Figure 35, page 102). Any arbitrary line can define the cross-section across the river. It does not need to be straight across the river. The ADCP measures the actual path of the boat from the change in the boat's position. As well, it measures the flow across the path throughout the water depth. You do not need tag lines or even try to steer a straight course. This makes it much easier and safer to obtain a discharge measurement, particularly at high flood stages or at sites with high traffic or wide channels.

The *WinRiver* software calculates the discharge using this information. *WinRiver* can replace bottom tracking by using GPS data to measure the boat velocity and an external depth sounder to measure water depth.
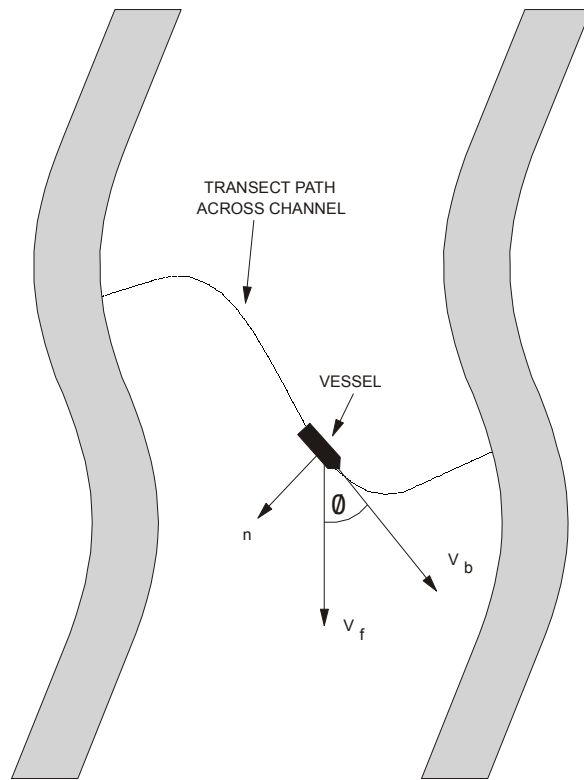
Figure 35.   Discharge Calculation is Independent of the Boat's Path

10.2   Directly Measured Flow and Estimated Regions

The ADCP measures most of the water velocity from just in front of the ADCP to 6% above the bottom. At the channel edges, where the water is very shallow, the water depth is too shallow for the ADCP to profile. The *WinRiver* software will estimate the discharge in these regions using several input values from the user. Each of these unmeasured regions will be discussed below. Refer to Figure 36, page 103 for an illustration of the unmeasured areas.
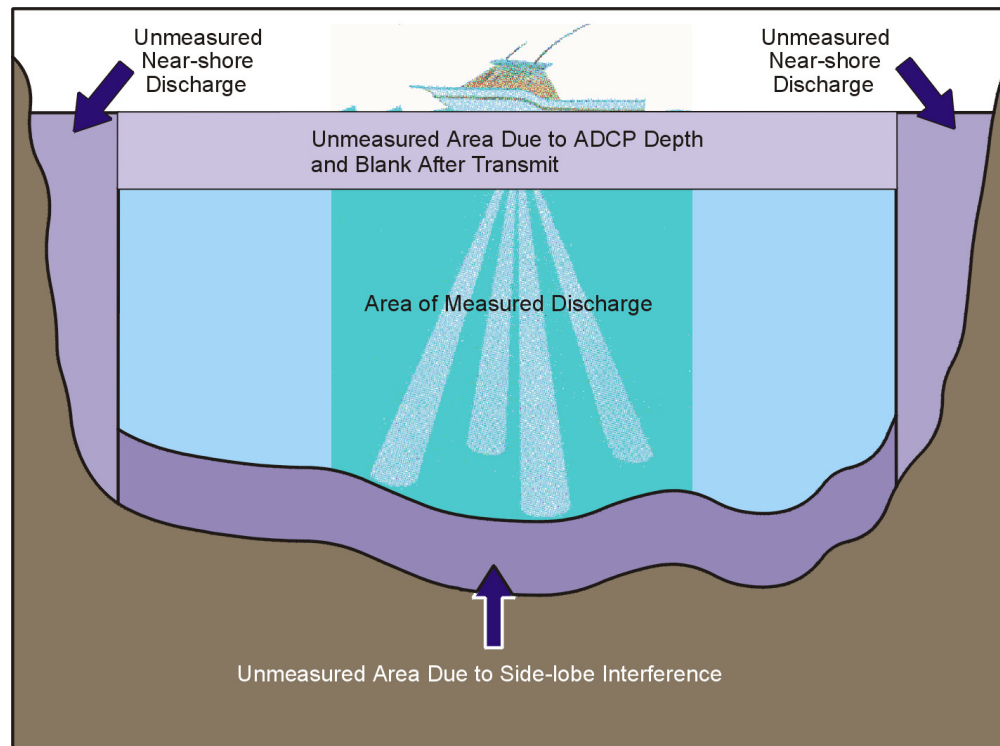
Figure 36.   Unmeasured Regions in the Water Column

10.2.1 Near Surface Region

ADCP Depth. The acoustic transducers of the ADCP need to be completely covered with water. A typical transducer depth is around 20 cm, which will totally immerse the ADCP. This allows reasonable boat speeds before air is pulled beneath the transducer (which blocks the acoustic energy from getting into the water) and allows for some rocking of the boat. In calm water, you may be able to put the ADCP less deep and you may need to put it deeper if the water is rough or very fast.

Blank After Transmit. The same transducer is used to receive the acoustic energy after transmitting a pulse. A short time (or a short sound travel distance) must pass before receiving is possible. This delay is called the blanking distance, and it allows the ADCP to ring down and become acoustically quiet before receiving the return signal. For the 600 kHz and 1200 kHz Rio Grande ADCPs, this distance is 25 cm.

Pulse Structure – Lag. For general profiling (mode 1), the acoustic pulse sent out is actually two or more distinct pulses that are closely spaced. The spacing is called the lag. One lag is required beyond the blanking distance to start processing the data in the first bin.

The distance below the surface to the middle of the first cell for Mode 1 general purpose profiling is the sum of the ADCP depth, the blanking dis-

tance, and (bin +transmit length + lag)/2. For a 600 kHz ADCP in mode 1 with 50-cm depth cells, the distance to the top of the first depth cell is about 90 cm (see Table 16, page 113). The ADCP and the software will automatically calculate this distance for you (you have to tell the software the depth of the transducer).

10.2.2 Bottom Region

Side Lobes. There is also a shallow layer of water near the bottom for which the data is not used to compute discharge. When the ADCP sends out an acoustic pulse, a small amount of energy is transmitted in *side lobes* rather than in the direction of the ADCP beam. Side lobe reflection from the bottom can interfere with the water echoes. This gives erroneous velocities for the water near the bottom. *WinRiver* does not use data in the region that may be affected. The ADCP has beams oriented at 20 degrees from the vertical, and the thickness of the side lobe layer is 6% of the distance from the transducers to the bottom (see Figure 37).
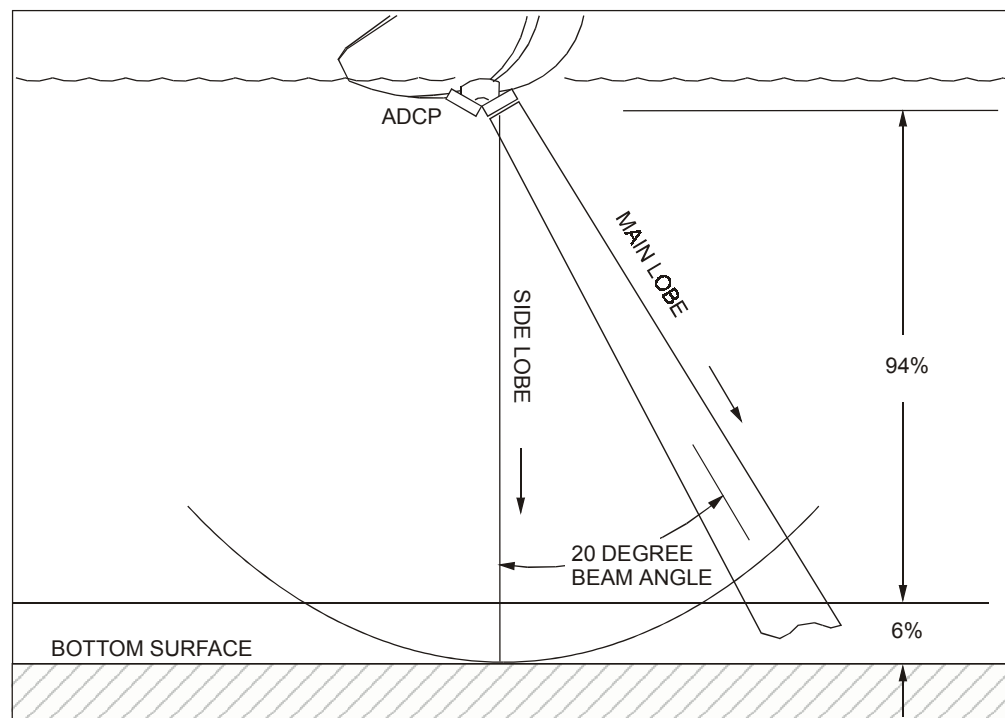
Figure 37.   Side Lobes

Pulse length. *WinRiver* also does not use any data within one depth cell of the bottom or the side lobe layer. The reason is that in the last depth cell, energy at the front of the pulse is reflecting off of the bottom while energy at the rear of the pulse is reflecting off of the water. The energy reflected from the front of the pulse contaminates the reflection from the rear of the

pulse. So, no data from within the 6% side lobe layer plus one depth cell from the bottom is used.

10.2.3 Channel Edges

Minimum Depth. From the discussion of the top and bottom layers, you have probably deduced that there is a minimum depth in which you may acquire meaningful data. As you approach the sides of your channel, the water will become too shallow for the ADCP to make a valid measurement. The edges are determined by the last segment to have two valid bins and bottom track.

10.3   Computation of Discharge

Measured Flow. *WinRiver* computes the discharge from the first depth cell to the last good cell not affected by the bottom or side lobes. But what about the discharge in the top layer that isn't measured at all, the layer above the bottom that isn't used because of effects due to the bottom, and the edges that are too shallow to obtain a valid measurement? The discharge in these regions is extrapolated from the good data that was measured.

Extrapolation: Top and Bottom. The extrapolation of the discharge (see Figure 38, page 106) in the top and bottom layers can be done two ways with *WinRiver*. One-way is to use the velocity from the depth cell closest to the surface or bottom as the velocity across the missing region: this is called *constant* extrapolation. The other technique is to fit a power law curve to the data in the good part of the profile and extend the curve to the boundaries. The power law method for the top and bottom portion is a good choice for typical flow conditions. You can select the exponent in the power law method to get the best fit to the profiles in your channel. The formulas describing the details of the extrapolation are provided in the *WinRiver* help file.
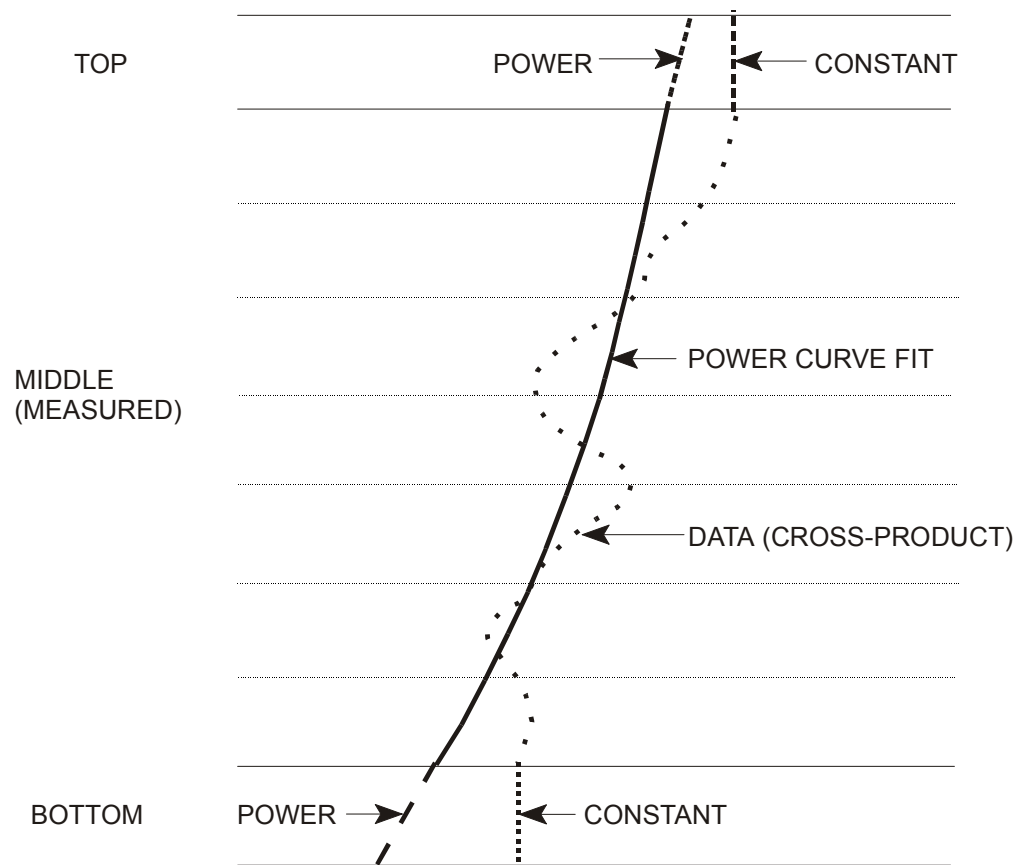
Figure 38.   Discharge Extrapolation Method

Extrapolation: Sides. *WinRiver* includes a method to estimate the side discharge using the data from the ensemble closest to the shore on either side. This is not done while you are acquiring the data but at a later time when you play back the data. *WinRiver* uses the user supplied edge distances in estimating the side discharge. Again, the details of the calculations are in the *WinRiver* help file. You will learn the actual procedure later in this manual.

Extrapolation: Bad velocity bins. As *WinRiver* calculates the discharge through the water column (Middle measured discharge), the bins with bad velocities are noted. After the power fit is computed, these bins are "re-filled" using the fitted power curve and accumulated into the "Mid Q" total discharge.

Examining the discharge profile will identify the bins with estimated discharge. That is, anywhere there is a discharge value in a bin and there is not a corresponding good velocity for that bin, the discharge was estimated.

11   ADCP Commands

These commands are contained in the **Direct Commands** portion of the *WinRiver* configuration file. These commands are added to the configuration file in the **Setting** menu, **Configuration Settings**, **Commands** Tab. When the Acquire mode is first started, these commands are sent by *WinRiver* to the ADCP to set its profiling parameters. In the following, we will describe each command and give guidelines for setting these commands for acquiring reliable discharge data. Refer to the WorkHorse Commands and Output Data Format Guide for more detailed information about each command.

11.1   Send Commands to the ADCP

a. Start *WinRiver* in the Acquire mode. If you are in the Playback mode, click **File**, **Acquire Mode**.

b. Click **Setting** menu, **Configuration Settings**, **Commands** Tab.

c. Enter the commands in the **User Commands** box.

d. Save the Configuration file by clicking, **File**, **Save Configuration File** or **File**, **Save Configuration File As** to save the file as a unique name.

e. Click **File**, **Start Pinging**. The **Command Log** window will open automatically and show the commands sent to the ADCP and the response from the ADCP. After the commands have been successfully sent, this window closes.

f. To view this window again on the **View** menu, click **Command Log**. This will show the history of the dialog between *WinRiver* and ADCP.

Water Mode (WM Command)

Three modes are available for water profiling in the Rio Grande and Workhorse ADCPs with the High Resolution Water Profiling upgrade. They are Water Modes 1 (all ADCPs), 5, and 8. Each mode has its own envelope of operation. Mode 1 is the general-purpose mode, and should be used for most flow conditions. Modes 5 and 8 are the high-resolution modes, and they are for use in shallow water with relatively low velocities.

Maximum Bottom Depth (BX Command)

Set the maximum bottom tracking depth (BX-command) to 50% greater than the maximum expected depth. This will keep the ADCP from trying to search deeper than a realistic bottom depth.

> **NOTE**. The maximum bottom tracking range is 98 m for the 600 kHz and 28 m for the 1200 kHz in water with 10°C temperature and 0.0 ppt salinity.

Depth Cell Size (WS Command)

This command sets the length of the water for one cell measurement. Refer to Table 16, page 113 for recommended settings. The cells size range is 0.10– 8 m (WS10 to WS800) for the 600 kHz and 0.05– 4 m (WS5 to WS400) for the 1200 kHz.

Number of Depth Cells (WN Command)

Set the number of water profiling depth cells (WN command) to cover the maximum expected water depth plus 2 additional cells. As a rule of thumb,

WN = Maximum Expected Depth (in centimeters) / WS + 2

Blanking Distance (WF Command)

The blanking distance should be set to 25 cm (WF25) to maximize the ADCP performance and minimize the unmeasured layer thickness at the surface. If you see trouble in your data, try doubling the blanking distance.

Pings per Ensemble (WP and BP Commands)

Single ping ensembles are recommended for performing discharge measurements (WP1 and BP1). Averaging in either space or time can be done to the data by *WinRiver* while collecting data in the ACQUIRE module or later during post-processing in the PLAYBACK module to reduce the standard deviation of the velocity measurements. The advantage of having the *WinRiver* software do the averaging rather than the ADCP is that the raw data remains unchanged and you have the flexibility to vary the averaging interval to suit your application.

Ensemble-Out Data (WD Command)

This command selects the types of data collected by the ADCP. The default setting is WD111100000, which tells the ADCP to collect velocity, correlation magnitude, echo intensity, and percent-good status data.

If you want to maximize your ping rate, you can do so by reducing the amount of data that must be transferred serially for each ensemble. To do this, you can choose not to record percent-good status by selecting WD111000000.

Mode 1 Ambiguity Velocity (WV Command)

The Mode 1 ambiguity velocity represents the maximum relative velocity (ADCP motion plus the maximum actual water velocity) the ADCP can measure along a beam. This must be set correctly to avoid ambiguity errors. The default value of 170 cm/s (WV170) corresponds to a horizontal relative velocity of about 5 m/s, and the maximum ambiguity velocity of 480 cm/s (WV480) corresponds to a maximum relative velocity of 15 m/s. Use the default ambiguity velocity for most applications. If you plan on using Mode 1 in flows faster than 5 m/s, use the following formula to set WV.

WV = Maximum Relative Water Velocity x sin (Beam Angle) x 1.5

Where Beam Angle = 20° for the Rio Grande ADCP

Mode 5 and 8 Ambiguity Velocity (WZ Command)

The ambiguity velocity for modes 5 and 8 is set using the WZ command. The default value is WZ05, and this value should be used for all moving boat applications.

Time Between Pings (TP Command)

The TP command sets the time between pings, and ensures that you will not have ping-to-ping interference. This value should be set to 0.2 seconds (TP000020) for the 600 kHz system and 0.05 seconds (TP000005) for the 1200 kHz system. These values were determined by considering the travel time for the bottom track ping to travel to its maximum possible range.

Sensor Source (EZ Command)

The EZ-command selects the source of environmental sensor data. The Rio Grande default value is EZ1011101, which tells the ADCP to use internal heading, pitch, roll, and temperature sensors.

Coordinate System (EX Command)

There are four different coordinate systems that can be used for ensemble averaging: beam, instrument, ship, and earth. Refer to the EX-command in the WorkHorse Commands and Output Data Format Guide for a description of each of the coordinate systems. We recommend using ship's coordinates for your measurements. We recommend 4-beam solutions only because an error velocity will be calculated and presented for each ADCP ensemble. If you have consistent trouble with bottom tracking or are working in a location where one beam will be masked due to dam walls or pier pilings, modify the EX command to EX10111 to allow for 3-beam solutions.

WinRiver transforms the raw data to earth's coordinates before displaying it in either the Acquire or Playback modes. This transformation does not change the contents of the original raw data file.

Salinity (ES Command)

It is critical to set the salinity (ES command) to the proper value. All of the velocities and distances measured by the ADCP are proportional to the speed of sound. If ES is set to the wrong value, it can produce an error in the calculated discharge.

WinRiver can re-scale the raw ADCP data to correct for the speed of sound if the ES0 command was set incorrectly in the configuration file when the data was collected. The re-scaled data displayed by *WinRiver* will reflect the corrected sound speed, though the raw data file will not be corrected.

> **NOTE**. The discharge calculated using 35.0 ppt is 8-10% higher than the discharge calculated using 0.0 ppt. If you obtain discharge values that are consistently too high by this margin, check the salinity setting in *WinRiver*.

Transducer Depth (ED Command)

This value is used by the ADCP to calculate the speed of sound at the transducer face. It is not necessary to set the command if the ADCP depth is less than five meters. The default value is ED000. Enter the depth value in decimeters. For example, a 10-meter transducer depth would be entered as ED100.

11.2   *WinRiver* Processing Settings

These settings affect how the raw ADCP data is displayed and how the discharge is calculated within the Acquire and Playback modes. They do not affect the raw data. When you play the data back, the velocities, depths, and discharge values will reflect whatever processing settings are contained in the loaded configuration file.

ADCP Depth

Set the depth of the ADCP transducer faces below the surface (see the "Offsets Tab," page 32). The depths of the ADCP data presented in *WinRiver* will be determined from this value. If you need to re-scale your velocities within *WinRiver* by recalculating the sound speed, *WinRiver* will use the ADCP depth and the salinity you have entered along with the temperature measured by the ADCP to calculate a new sound speed value for each ensemble.

Magnetic Variation (Declination)

Use a chart to determine the local magnetic variation in your area (see the "Offsets Tab," page 32). If there is an eastern variation in your area, the output of the ADCP's magnetic compass when pointed to true North will read less than 360°. If the local variation is to the West, the magnetic compass will read greater than 0° if pointed to true North. East variations are positive (entered as **12.5°**) and West variations are negative (entered as **–12.5°**). The magnetic variation value does not affect the calculated discharge unless you are using GPS. This is because both the water velocity and the boat velocity (from bottom tracking) are measured in the same coordinate system (ADCP magnetic compass), while GPS positions are reported in true earth coordinates. If you are using GPS, you must do the Magnetic Variation correction (see "Magnetic Variation Correction," page 66).

Speed of Sound

The **Speed Of Sound** box lets you correct velocity data for speed of sound variations in water. *WinRiver* can make these corrections dynamically with every ping or use a fixed speed of sound value (see the "Processing Tab," page 34). This setting directs *WinRiver* to one of three choices:

- **Use ADCP Value** – (recommended setting) this setting will perform unity scaling to the raw ADCP velocities. The sound speed calculated by the ADCP using the ED, ES, and temperature measured at the ADCP transducer head will be used for *WinRiver* data display. When the ADCP depth is less than five meters the sound speed calculation is not significant and it is not necessary to set the ED command.

- **Calculate for Each Ping** – *WinRiver* will use the salinity and transducer depth values entered in *WinRiver* along with the ADCP measured temperature to calculate a new sound speed for each ensemble. The new sound speed will be used to scale the velocities in each ensemble before display. Note: changes only affect the processed data, not the raw data.

- **Fixed** – *WinRiver* will use this fixed value to scale the raw ADCP velocities for display on the screen. Again, changes only affect the processed data, not the raw data.

Backscatter

The sound absorption coefficient is used to estimate the relative backscatter in dB (decibels) (see the "Processing Tab," page 34). The relative backscatter when expressed in dB is a measure of the intensity of the returning echo from the scatterers. It is a function of sound absorption, beam spreading, transmitted power, and the backscatter coefficient. The sound absorption coefficient itself is dependent on frequency, temperature, and salinity.

Data Screening

Select **Mark Below Bottom Bad** to mark data below the ADCP-detected bottom or Depth Sounder detected bottom (if selected for processing) (see the "Processing Tab," page 34). Check the **Use 3 Beam Solution for BT** box to allows 3-beam solutions if one beam is below the correlation threshold set by the BC command. Check the **Use 3 Beam Solution for WT** box to allows 3-beam solutions if one beam is below the correlation threshold set by the WC command.

> **NOTE.** The **Mark Below Bottom Bad** setting only affects the data display. Cells below the bottom and those within the side lobe layer are never used in the discharge calculation.

Thresholds

The ADCP uses these parameters to determine good data. If the ADCP's data value exceeds these thresholds, it flags data as bad for a given depth cell (see the "Processing Tab," page 34).

Extrapolation Method

- *Top and Bottom Discharge Method* – two methods, **Power** or **Constant**, are provided to extrapolate the discharge in the upper and lower layers of the water that are not directly measured by the ADCP (see the "Discharge Tab," page 37). Constant extrapolation uses the velocity at the nearest depth cell for the remainder of the water column. Power extrapolation fits a power curve to the directly measured portion of the water column, and then uses that power law fit to compute the discharge in the unmeasured portions. The details of both computations are documented in the *WinRiver* help file. A good starting point is to use power for both the top and bottom layers. After you have taken some data on one of your channels, you can see how good the power law fit actually is by looking at the **Profiles, Discharge** display in Playback. You can then try other exponents in playback to attempt to improve the fit.

- *Power Curve Coefficient* – this value is used in the power extrapolation fit. An exponent of 0.1667 ($1/6^{th}$ power law) is a theoretical solution for open channel flow. For more information on the theory of power law for flow resistance see Chen, Cheng-Lun, "Unified Theory on Power Laws for Flow Resistance", Journal of Hydraulic Engineering, Vol. 117, No. 3, March 1991, 371-389.

- *Left/Right Bank Edge Type* – Use this field to describe the geometry of your edges. Choose **Triangular**, **Square**, or a user-specified **Coefficient**.

Velocity Reference

Use the **Settings** menu, **Reference** to set the velocity reference (see "General Preferences," page 4). **Bottom Track** should always be used for river measurements from a moving vessel. With this setting, true water velocities will be presented in the *WinRiver* displays because the boat velocity has been subtracted from the relative velocities measured by the ADCP. If **None** is chosen as the velocity reference, relative velocities will be displayed.

12   Water Profiling Modes

This section explains all of the water-profiling modes available for the Workhorse Rio Grande and Mariner ADCPs and Workhorse ADCPs with the high-resolution water profiling upgrade installed. For each mode, we provide a general description, an explanation of the best place to use this mode, specifics about the mode, and any setup considerations. Use Table 16 as a guide for choosing the appropriate mode for your water flow conditions. Some details are contained here but not all. As RDI learns more from your experiences, we will be able to add information to help you better collect data.

Table 16:   Workhorse River Water Modes

	Mode 1	Mode 5	Mode 8
Typical application	Fast water of all depths. Rough and dynamic situations. Good in streams too fast or deep for modes 5 & 8.	Slow, shallow streams with velocities < 0.5 m/sec with low shear and/or turbulence.	Shallow streams with velocities < 1 m/sec and with moderate shear (rough bed) and/or turbulence. Works in shallow water where mode 5 does not work well.
Minimum recommended cell size (meters)	**0.50*** 0.25	**0.10** 0.10	**0.10** 0.10
Recommended Cell Size (meters)	**0.50** 0.25	**0.25** 0.10	**0.25** 0.10
Single ping standard deviation (cm/s) (using rec. cell size)	**18.0** 18.0	**0.3** 0.4	**5.2** 7.8
First range cell (meters)	**0.87** 0.56	**0.50** 0.35	**0.50** 0.35
Minimum profiling range (meters)	**1.7** 1.0	**1.6** 0.9	**0.9** 0.6
Maximum profiling range (meters)	**45** 12	**7.0** 3.5	**7.0** 3.5
Maximum relative velocity (m/s)	10 m/sec	0.5 m/sec	1 m/sec

* 600 kHz values are in **bold** font, and 1200 kHz values are in regular font. Specifications are for 25 cm blank, 10° C temperature, and 0.0 ppt salinity.

> **NOTE.** The ranges in Table 16, page 113 are measured from the transducer face. Add the transducer depth to determine the actual minimum and maximum profiling depths.

> **NOTE.** Maximum range depends on water temperature and depth cell size. Use PLAN to compute the maximum range for a particular ADCP set-up and water temperature. The standard deviation of modes 5 & 8 varies with water speed, boat speed, bed-form roughness, channel depth, and turbulence.

12.1   General Purpose Profiling - Mode 1

General Description - This is our most robust mode of operation. It allows for good data collection in all environments.

Best Use Areas - Mode 1 is good for all areas. It works well in areas of slow currents, turbulent currents, strong shears, low backscatter concentrations (or where signal returns are apt to be weak), high background noise (such as being used from a ship), and in areas where the water changes from shallow (1 m) to deep (>6 m).

Specifics - The standard deviation determined by the bin size (WS command) and the ambiguity velocity (WV). The ambiguity velocity tells the ADCP what maximum velocity it will see. If you are operating the ADCP from a moving platform, the maximum velocity would be the ADCP's maximum speed (motion through the water) plus the maximum water speed. We call this the maximum "apparent velocity" the ADCP will see.

Setup Considerations - To set the Mode 1 ambiguity velocity correctly, you must have an idea of the maximum apparent velocity to set the WV command. Use the following formula to set the WV-command:

WV = (max. apparent velocity in cm/s) * (sin B) * (1.5)

Where:

- B = Beam angle (20 degrees for the Rio Grande)

- (1.5) = Safety margin. You can reduce this safety margin if you are sure you will not exceed the maximum apparent velocity. We recommend a minimum safety margin of 1.1.

NOTE.

The **minimum** suggested setting for the WV-command is 100 cm/s (WV100), which corresponds to an apparent horizontal velocity of 3 m/s.

The **default** setting for the WV-command is 170 cm/s (WV170), which corresponds to an apparent horizontal velocity of 5 m/s.

The **maximum** setting for the WV-command is 480 cm/s (WV480), which corresponds to an apparent horizontal velocity of 15 m/s. Higher settings will produce bad velocity data.

The values shown here do not include a safety factor.

Table 17:   Mode 1 Minimum and Maximum Profiling Ranges

Frequency	Cell Size (m)	Profiling Range (m)	
		Minimum	**Maximum**
600	0.50	1.7	45.0
	1.00	2.7	52.0
	2.00	4.8	60.0
	4.00	9.0	67.0
1200	0.25	1.0	12.0
	0.50	1.6	14.0
	1.00	2.6	16.0
	2.00	4.7	18.0

Specifications are for 25 cm blank, 10° C temperature, and 0.0 ppt salinity.

NOTE. The ranges in Table 17 are measured from the transducer face. Add the transducer depth to determine the actual minimum and maximum profiling depths.

12.2   High Resolution Profiling - Mode 5

General Description - Mode 5 is our high-precision, shallow-water mode. Mode 5 allows for very low standard deviation (less than 3 cm/s) in shallow water. Mode 5 should be used with bottom tracking enabled.

Best Use Areas - Mode 5 is ideal for shallow water with water currents less than 50 cm/s.

Mode 5 is not good for areas where there is shear, turbulence, background noise, or fast ADCP motion (above 0.5 to 1 m/s). If high shears, turbulence, background noise, or fast ADCP motion occurs, the ADCP will not collect data.

12.3   High Resolution Profiling - Mode 8

General Description - Mode 8 is our medium-precision shallow-water mode. The standard deviation of Mode 8 is about 10 times greater than Mode 5 for the same size depth cell and water speed. Mode 8 should be used with bottom tracking enabled.

Best Use Areas - Mode 8 is ideal for shallow water (8 m and less), where there is any shear, turbulence, background noise, or fast ADCP motion (maximum 1-2 m/s). Mode 8 can be used in fixed measurements or slow-moving platform measurements where the water velocity flows are very low. However, Mode 5 is better suited for those areas.

Note that if the shears, turbulence, background noise, or ADCP motion is too great, the ADCP will not collect data.

12.3.1   Mode 5 and 8 Specifics

Mode 5 and 8 use short encoded pulses that travels to the bottom, where it is reflected, and then back up to the ADCP. When the signal is received at the transducer face, the ADCP transmits another pulse. The ADCP knows how long to wait before sending the second transmission because Bottom-Track measures the water depth. For this reason, it is important to use bottom tracking for downward-looking deployments.

For Modes 5 and 8, two pulses are processed to create the velocity estimate. The standard deviation for Mode 5 and 8 is very low because there is a relatively long lag between the two pulses. Mode 5 estimates the velocity based on the Doppler shift, and its algorithm is sensitive to ambiguities. Therefore, this mode is highly sensitive to conditions with high shear, turbulence, and fast ADCP motion. Mode 8 makes the estimation based on a proprietary scheme. Mode 8 has no ambiguity problems, and therefore it can operate in areas that Mode 5 cannot. However the method of estimating velocity used by Mode 8 has a higher standard deviation as compared to Mode 5 operation. Use an ambiguity velocity value of 5 cm/s WZ005 (lag setting) for most deployments to allow for the deepest possible profiling range. The ADCP automatically adjusts this setting higher based on the depth of the water measured by bottom tracking.

There are some applications where you may wish to obtain only valid data near the ADCP when the bottom is out of range of the system. In these cases, the setting of WZ005 will still work. It allows the system to collect data as deep as it can.

The profiling range of the high-resolution modes is limited by two factors: (1) the very short encoded pulses used, and (2) the maximum velocity water velocity. These pulses do not put much energy in the water, so the signal return is weak. The deeper the profile, the slower the water must move or

an ambiguity error will occur. Higher boat and water velocities will result in maximum profiling ranges that can be half of the values specified in Table 18, page 118.

12.3.2 Comparision of Water Modes 5 and 8

Water-Profiling Mode 5

Mode 5 advantages compared to Mode 8 (see Table 16, page 113):

- Mode 5 gives a lower single-ping standard deviation than Mode 8 for the same size depth cell (bin)

Mode 5 disadvantages compared to Mode 8:

- A larger minimum profiling depth may be required than Mode 8

- A reduction in the maximum velocity the ADCP can measure

- Does not work well in dynamic water environments that have water velocity changes greater than 50 cm/s (e.g., eddies, shear)

Water-Profiling Mode 8

Mode 8 advantages compared to Mode 5 (see Table 16, page 113):

- May be able to profile in shallower water the Mode 5

- An increase in the maximum velocity the ADCP can measure

- Works in dynamic water environments that have water velocities changes up to 100 cm/s (e.g., turbulence, eddies, shear)

Mode 8 disadvantages compared to Mode 5:

- The single-ping standard deviation is about 10 times greater than Mode 5 for the same size depth cell (bin) and relative water speed.

12.3.3 Mode 5 and 8 Minimum Profiling Range Capability

Mode 5 and 8 must have a minimum water depth in order to profile. Table 18 shows the minimum profiling range as a function of system frequency and cell size. The minimum profiling capability is dependent upon cell size (WS) and the blanking distance (WF) for each system frequency.

Table 18:   Mode 5 and 8 Minimum and Maximum Profiling Ranges

Frequency	Cell Size (m)	Profiling Range (m) Mode 5		Profiling Range (m) Mode 8	
		Minimum	**Maximum**	**Minimum**	**Maximum**
600 kHz	0.10	0.9	7.0	0.6	7.0
	0.25	1.6	7.0	0.9	7.0
	0.50	2.2	7.0	1.4	7.0
1200 kHz	0.10	0.9	3.5	0.6	3.5
	0.25	1.6	3.5	0.9	3.5

Specifications are for 25 cm blank, 10° C temperature, and 0.0 ppt salinity. Relative water velocity is 0.5 m/s for Mode 5 and 1 m/s for Mode 8.

> **NOTE.** The ranges in Table 18 are measured from the transducer face. Add the transducer depth to determine the actual minimum and maximum profiling depths.

13   Troubleshooting

Use the following suggestions to guide you if you are having trouble obtaining reliable discharge data. If you cannot arrive at a solution after trying the suggested solutions below, send a description of the problem, some example data files along with their associated configuration files, and a *DumbTerm* log file to your local representative or to RD Instruments via email. We will assist in analyzing the problem.

Email: rdifs@rdinstrumets.com

13.1   Why can't I see my data?

If you do not see any data on contour plots or other displays during Playback mode, check the following items.

- **Mark Below Bottom "Bad"** is selected in the **Configuration Settings**, **Processing** tab and you do not have valid bottom depth data.

- Your reference data is not valid. If your reference is GPS on the **Settings**, **Reference** menu and you did not have GPS active during data collection; your data will always be invalid.

- Check the contour or profile plots minimum and maximum depth axis is setup properly. On the **Velocity Tabular** view, look at the left column where the depth of the water profile depth cells are displayed and set the minimum and maximum depth accordingly on the **Configuration Settings**, **Chart Properties 1** tab.

- On the **Velocity Tabular** view, if you see negative depths, your system is up-looking and you need to adjust the **ADCP Transducer Depth** on the **Configuration Settings**, **Offsets** tab.

- The data is not present. Check the commands sent to the ADCP on the **Configuration Settings**, **Commands** tab. For example, sending WD 11**0** 100 000 will override the default WD 11**1** 100 000 command and tell the ADCP to **not** collect echo intensity data. This will result in displaying "Bad" on Tabular views and not displaying at all on contour or profile plots.

13.2   Lost Ensembles

If the Number of lost ensembles on the **Standard** and/or **Composite Tabular** views starts to increase, it may indicate a problem with the communications setup between the ADCP and WinRiver. You may have the serial communications speed set too high for your computer or you are inadvertently holding a key down too long. Since a computers keyboard has a higher priority than its serial port, serial data can get lost if the keyboard is used too long at the same time that serial data is being received. One solution is to minimize the amount that you use the keyboard while the computer is receiving data from the ADCP. Another solution is to lower the serial communications speed of the ADCP and the computer; this reduces the computer's load with respect to serial port processing. A third option is to use a computer equipped with a 16550 UART, which buffers the serial port, allowing the computer to keep up with the flow of data.

To change the ADCP and computer baud rate, use *DumbTerm* to communicate with the ADCP. Send a CB-command with the desired baud rate value (see the WorkHorse Commands and Output Data Format Guide). Press **F5** to change the serial port baud rate to match the ADCP. Enter **CK** to save the new baud rate for the ADCP. This must be done before pressing **END** to send a Break signal or the ADCP will reset back to the default 9600-baud rate. Press **END** to check the communications using the new baud rate.

Another source of the problem is interference in the transmission of data. Try not to place the ADCP's underwater cable near a generator, the engine, or other large electrical equipment. Do not coil the ADCP's underwater cable around large metal objects.

13.3   Missing Depth Cell Data

Missing depth cell data will be marked as bad in the data displays. The data within these cells has not met echo intensity, correlation, or percent-good thresholds. Bad cells do not generally effect a discharge measurement because discharge is extrapolated for missing bins.

13.4   Unable to Bottom Track

If you are losing bottom track, indicated by "bad" bottom track velocities or no depth indicated, then one or more of the following is possible:

- The depth set in the BX-command is not deeper than the maximum depth of the channel: increase BX and try again.

- Change the EX10101 command to EX10111 to allow for 3-beam solutions.

- If there are abrupt depth changes in your river channel, bottom track may have trouble locking on to the rapidly changing depths as you transect. If you know where the abrupt changes are located in your channel try to move slowly over these regions.

- There is something blocking one or more of the beams. It may be air being pulled below the transducer: try putting the ADCP deeper in the water. Some kind of debris has become caught on near the ADCP and is interfering with the beams: check the ADCP and its mount to see if debris has become entangled on the ADCP.

  - The bottom has grass, weeds, brush, or other submerged materials that are disrupting the beams near the bottom: try moving to a different nearby location to see if the problem changes.

  - There is a high sediment concentration near the bottom, and there is not enough contrast between the suspended sediment layer and the actual bottom to determine the true bottom range. Some users have found success detecting the bottom in these conditions by substituting a lower frequency ADCP, i.e. a 300 kHz in place of a 600 kHz, but at some point the sediment concentration will be so high the ADCP won't work.

If you cannot get valid bottom track depths using the suggestions above, an echo sounder can be used in place of bottom tracking.

13.5 Biased Bottom Track Velocities

If one or more of the following occurs, it is an indication of bias in the bottom tracking data:

- The *course made good* is longer than expected.

- The shiptrack plot shows an upstream offset compared to the actual track taken by the boat.

- If you hold station at a position in the channel, the shiptrack indicates that you are moving upstream.

The bias can be caused by two different environmental sources:

- High sediment concentration in the water column (Water Bias)

- Fluid layer of sediment flowing along the bed of the stream (Moving Bottom)

These two environmental sources produce biased values for ADCP bottom track, which in turn will bias the discharge calculation. The consequences of the these environmental sources and the biased ADCP bottom track are:

- Discharge computed with the ADCP is biased low

- The vessel track (shiptrack) is biased upstream

> **NOTE.** The ADCP is not malfunctioning – but measuring the environment as designed.

If you obtain biased bottom track data at your river site, you can use GPS as the velocity reference in place of bottom tracking as described in the section on "Integrating Depth Sounder, External Heading, and GPS Data," page 57. *WinRiver* can calculate discharge in real-time using the GPS data in place of bottom track velocities.

13.6 Inconsistent Discharge Values

If the measured discharge is lower than expected and not reproducible to better than 5%, you may be experiencing one or more of the following conditions:

- Biased Bottom Track (see the previous section)

- There are tidal or other time dependent factors affecting the discharge.

A small repeatable difference in discharge values can be expected between transects made going different directions across the channel. This difference can be caused by several factors:

• Wind can cause the boat to heel causing the ADCP depth to be slightly deeper when traveling in one direction versus another.

• The ADCP may be mounted so that it is shadowed from the flow when a transect is made with the ADCP on the downstream side of the boat. Mounting the ADCP from the front of the boat may reduce the difference in discharge values between reciprocal transects.

13.7   Trouble Profiling in High Turbidity Conditions

In flows with very high sediment concentrations, the acoustic energy transmitted by the ADCP into the water undergoes high levels of absorption. The ADCP will not receive enough returned energy to make valid velocity measurements. In this case, the echo intensity profile will show the received signal level reaching the noise floor before the bottom is encountered. Some ADCP users have been able to successfully profile in these conditions by using a lower frequency system, i.e. a 600 kHz rather than a 1200 kHz, or a 300 kHz rather than a 600 kHz.

13.8   Trouble Profiling with Modes 5 and 8

Modes 5 and 8 are designed for use in shallow and slow moving water, and though they provide reduced standard deviation over Mode 1, they are highly sensitive to shear and turbulence. We strongly recommend Mode 1 for most profiling conditions. If you are having trouble profiling using Modes 5 or 8, review the section on "Water Profiling Modes," page 113. Check that the maximum relative water speed (water plus boat speed) and profiling range do not exceed the limitations given in Table 16, page 113. Both Modes 5 and 8 must have a minimum water depth to profile. These depths are listed in Table 18, page 118.

If the relative velocity and minimum and maximum depth requirements for modes 5 and 8 are met, and you still cannot get reliable performance, there may be turbulence and shear conditions in your river channel which are causing these modes to fail. You will need to profile using general purpose profiling Mode 1.

<u>NOTES</u>