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December 7, 2001

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM NO. 2002.01

SUBJECT: Configuration of Acoustic Profilers (RD Instruments) for Measurement of Streamflow

The purpose of this memorandum is to provide guidance regarding the configuration and proper setup of acoustic profilers (also known as acoustic Doppler current profilers or ADCP's) for the measurement of streamflow. The guidance provided herein applies only to ADCP's manufactured by RD Instruments (San Diego, CA).

### **Background**

As our knowledge and experience with ADCP's has increased, recommendations on how to properly configure ADCP's for streamflow measurements have changed. The following guidance reflects recommendations of the Office of Surface Water (OSW) Hydroacoustics Work Group (HAWG) in consultation with RD Instruments (RDI). As the usage of acoustic profilers from other vendors increases, additional instrument-specific guidance will be given in future memos.

OSW Technical Memorandum 2000.03 states that WinRiver software is the only approved software for the collection and processing of data collected with an RDI acoustic profiler for the calculation of discharge. The following sections provide policy on direct commands that should be used in configuring the hardware and software for making discharge measurements. Items italicized in the text of this memo refer to specific menus in WinRiver.

### **WinRiver and Direct Commands**

Prior to the collection of streamflow and velocity data using RDI ADCP's, the user must configure the ADCP by sending a set of instructions known as direct commands. Direct commands are used to configure the profiler and to specify the size of depth cells, the blanking distance, the number of depth cells to be collected, and other parameters.

The WinRiver software allows three sets of direct commands to be sent to the ADCP. The set of commands first transmitted to the profiler are called the Fixed Commands and can be viewed in the *Commands* section of the *Configuration Settings* menu (figure 1). These commands have been set so that if no other commands were sent to configure the profiler, and the measurements would be acceptable in most flow-measurement situations. They also provide a mechanism for standardizing the basic configuration for both Broadband and Rio Grande ADCP's. A complete description of the direct commands can be found in the Workhorse Technical Manual (RD Instruments, 2001).

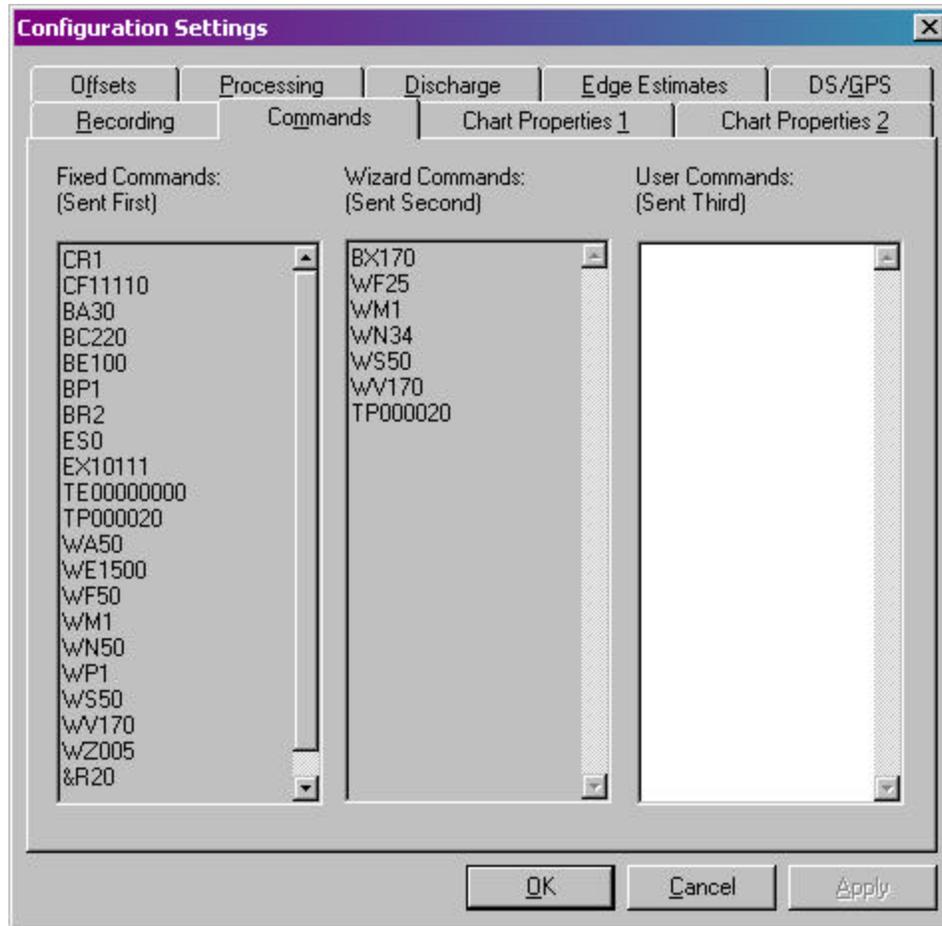


Figure 1.—Screen capture showing the Commands Tab of the *Configuration Settings* menu in WinRiver version 10.03.

The second set of commands transmitted to the ADCP are known as Wizard Commands and also can be viewed in the *Commands* tab in the *Configuration Settings* menu of WinRiver. Wizard Commands are commands that are created by running the Configuration Wizard within WinRiver. For additional information on the Configuration Wizard, please refer to OSW Technical Memorandum No. 2002.03 and the WinRiver Users Guide (RD Instruments, 2001). These commands may be used to over-ride the Fixed Commands. In general, use of the Configuration Wizard is encouraged.

The third set of commands transmitted to the ADCP are known as User Commands and also can be viewed in the *Commands* Tab in the *Configuration Settings* menu of WinRiver. These commands may be used to override the Wizard and Fixed Commands. If the Configuration Wizard is not used or you wish to override the Wizard and Fixed Commands, please use the recommended direct commands listed below in the User Commands section.

Table 1.—Recommended User Commands

*[Question marks in the table below indicate values that must be specified by the user]*

<b>Direct Commands</b>	<b>Description</b>	<b>Explanation</b>
WS????	Depth cell size	See Table 2
WN???	No. of depth cells	Maximum Depth (cm)/WS(cm)
WF????	Blanking distance	See Table 3
WM?	Water mode	WM1, WM5, or WM8
WV170	Ambiguity velocity	Equations 1 or 2
BP1	Bottom pings	Use BP2 when bottom tracking problems occur

For most applications, the depth cell size (WS command) should be set to the minimum recommended depth cell size specified in table 2 for the specific instrument frequency and water mode being used. When using water mode 1 in deeper water (depths greater than 10 depth cells) and channels with steep banks on both edges, users may consider using larger depth cell sizes. In such situations, increasing the depth cell size will result in a more accurate velocity measurement. The number of depth cells (WN command) should be set to the maximum depth in the measuring section divided by the depth cell size. It is important to ensure that consistent units are used when performing this calculation. Proper setting of the WN command is necessary in order to ensure that the ADCP profiles through the entire range of depths at the measuring location. The blanking distance (WF command) should be set using the distances specified in table 3. The water mode (WM) command should be selected based on the acoustic frequency of the instrument, maximum relative velocities expected, and profiling range (table 2). In general, water mode 1 is for general-purpose applications, whereas modes 5 and 8 can only be used in relatively shallow, slow-moving water (see table 2 for the range of depths and water velocities possible). The maximum profiling ranges for modes 5 and 8 in table 2 are theoretical maximums. In practice, most users will not be able to profile to that range. However, the mode 1 profiling ranges shown are nominal ranges and may vary depending on water temperature and backscattering conditions. The values shown in table 2 for maximum profiling range and maximum relative velocities are approximate operational limits of the profiler and should be considered for planning purposes.

Table 2.—Minimum Recommended Depth Cell Sizes, Maximum Profiling Ranges, and Maximum Relative Velocities for RDI ADCP's.

<b>Water Mode</b>	<b>1200 kHz</b>	<b>600 kHz</b>	<b>300 kHz</b>	<b>Remarks</b>
<i>Minimum Recommended Depth Cell Sizes, in centimeters</i>				
1	25	50	100	
5	5	10	20	
8	5	10	20	
<i>Maximum Profiling Ranges, in meters (feet)</i>				
1	20 (66)	60 (197)	130 (426)	Nominal range
5	4 (13)	8 (26)	16 (53)	Maximum range
8	4 (13)	8 (26)	16 (53)	Maximum range
<i>Maximum Relative Velocities, in meters/sec (feet/sec)</i>				
1	10 (32.8)	10 (32.8)	10 (32.8)	
5	0.5 (1.64)	1.0 (3.28)	1.0 (3.28)	
8	2 (6.56)	2 (6.56)	2 (6.56)	

Table 3.—Recommended Blanking Distances for RDI ADCP's.

	<b>Blanking distance, in centimeters, by frequency</b>		
<b>ADCP Type</b>	<b>1200 kHz</b>	<b>600 kHz</b>	<b>300 kHz</b>
Broadband	50	50	100
Rio Grande	25	25	75

The mode 1 ambiguity velocity (WV command) should be included in the user commands as a reminder that it may need to be adjusted to a higher value when measuring velocities greater than 5.6 ft/s, which corresponds to an ambiguity velocity of 170 cm/s. Equations for computing the mode 1 ambiguity velocity are shown below.

English units:

$$WV = [\text{maximum relative velocity (ft/s)}] * 15.6 \quad (1)$$

Metric units:

$$WV = [\text{maximum relative velocity (cm/s)}] * 0.5 \quad (2)$$

The maximum relative velocity is the maximum apparent velocity, as measured relative to the ADCP, expected during the measurement. The maximum relative velocity is usually approximated by adding the maximum expected boat speed and maximum expected water speed. Lower values of WV result in more accurate mode 1 measurements. However, it is important to not set WV to less than 170 cm/s. Equations 1 and 2 assume a 20-degree beam angle for the ADCP.

In general, users should collect single-ping data (direct commands WP1 and BP1). Although multi-ping ensembles were suggested in the past, there are major drawbacks to the use of multi-ping data and advantages to the use of single-ping data. Single-ping data are required when using differential GPS instead of bottom tracking, in order to properly rotate the measured velocity vectors into a consistent reference frame. In addition, single-ping data allow users to more readily identify and remove errors caused by acoustic contamination by fish, ambiguity errors, and other problems. Users do not need to insert a WP command in the User Command section, as a WP1 command is included in the Fixed Commands.

We recommend that the number of bottom pings (BP command) be set to 1 or 2. A BP1 command is appropriate in most instances, but users may need to use 2 bottom pings (BP2) if they experience invalid bottom-tracking measurements, such as may occur in mobile bed streams or beds of variable-bottom roughness.

If the ADCP has a firmware version less than 5.55, it is necessary to include the BR0 command because BR2 may cause some bottom tracking problems with older firmware versions (less than 5.55). We suggest that users upgrade their firmware to 5.55 or greater. In all other systems the BR2 Fixed Command is appropriate. The most up-to-date firmware for Rio Grande ADCP's is available from the OSW ADCP Web pages (<http://hydroacoustics.usgs.gov/>).

### **Configuring WinRiver for Data Collection**

Prior to each measurement it is necessary to configure both the ADCP and the WinRiver software. Configuration of the software includes setting communication parameters, ADCP depth, salinity, display properties, and discharge estimation near the top and bottom of the water column and at the edges.

#### ***Communications***

When first connecting to an ADCP using the *Communications* menu in WinRiver, select the current ADCP baud rate. We recommend that each ADCP be set to communicate at its maximum baud rate: 115,200 baud for Rio Grande or 57,600 for Broadband ADCP's. The baud rate specified in WinRiver must match the baud rate to which the profiler previously has been set. With some older laptops, it is possible to have a large number of lost ensembles when collecting data at the highest baud rates. In these situations, the baud rate can be reduced to minimize the number of lost ensembles. However, users are encouraged to use a laptop with a processor speed greater than 200 MHz and greater than 32 MB of memory.

When using radio modems, it also is necessary to configure WinRiver with a software break (3 equals signs "==="). The selection of the software break can be made in the *Communications* menu under the Properties setting. Radio modems will not work with the ADCP unless the software break is enabled.

#### ***ADCP Depth and Salinity***

Prior to making a discharge measurement, the depth of the ADCP should be measured and recorded both on the measurement note sheets and in WinRiver. The ADCP depth can be set in WinRiver in the *Configuration Settings* menu, under the *Offsets* section.

By default, the salinity is set to zero for all discharge measurements. However, when collecting data in estuaries, the salinity of the water should be measured and set in WinRiver. Salinity measurements should be made at the approximate depth of the ADCP transducers. The value for salinity should be entered in WinRiver in the *Configuration Settings* menu under the *Processing* section.

### ***Discharge Estimation***

Because acoustic profilers cannot measure near the riverbed (a distance above the bed equivalent to at least 0.96 time the water depth), near the water surface, and in the areas near the edges of water, it is necessary to estimate the near-bed, near-surface, and near-shore discharges in WinRiver. Accurate near-shore discharge estimates require that the user properly select the edge shape coefficient and accurately measure and record the distance from the edge of water to the starting and stopping point of each transect. Near-shore discharge estimates tend to be more reliable if 5 or more velocity measurements are averaged. The default number of shore ensembles (velocity measurements) used in near-shore discharge estimates is 10. This parameter, along with the edge-shape coefficient, is set in the *Discharge* section of the *Configuration Settings* menu. Values for the edge distances may be set in the *Edge Estimates* section of the *Configuration Settings* menu.

Accurate estimation of the near-bed and near-surface discharges requires that the user select the correct extrapolation method, either the constant or power-law method. By default, WinRiver assumes a one-sixth power law for estimating the near-bed and near-surface discharges. This assumption is acceptable for most streams. However, when shear in the velocity profile occurs because of upstream winds, or temperature or salinity gradients, it may be necessary to use the constant method. These methods, along with the exponent of the power law, are selected in the *Configuration Settings* menu, *Discharge* section.

### ***Display Properties and Recording Information***

To facilitate review of data during collection and for subsequent review, users are encouraged to select appropriate scaling parameters for plots in WinRiver. These parameters can be specified in the *Chart Properties* section of the *Configuration Settings* menu. Similarly, users should specify the filename and output directory information in the *Recording* section.

For further information on use of the WinRiver, please refer to the *Help* menu and to the software release notes and documentation. If you have any questions or comments about the policies and recommendations in this memo, please contact Kevin Oberg ([kaoberg@usgs.gov](mailto:kaoberg@usgs.gov)) or the OSW Hydroacoustics Work Group ([adcpcom@simon.er.usgs.gov](mailto:adcpcom@simon.er.usgs.gov)).

### ***References cited***

RD Instruments, 2001, Workhorse Technical Manual: San Diego, RD Instruments, 24 p.  
RD Instruments, 2001, WinRiver User's Guide: San Diego, RD Instruments, 117 p.

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