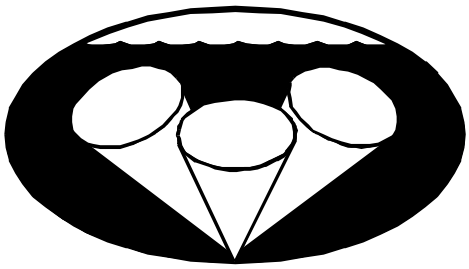

RD Instruments

Acoustic Doppler Current Profilers

High Resolution Water-Profiling Addendum

This binder contains specific information on your ADCP system. It contains additional documentation on commands for High Resolution Water-Profiling. Please read the information within this binder and keep it for future reference.

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P/N 957-6065-00 (February 1999)

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Chapter 1

Introduction

1-1 Introduction

Congratulations on your purchase of the High Resolution Water Profiling Upgrade for your Workhorse ADCP! This upgrade will now allow you to collect water profiles using Water Modes 1, 5, and 8.

This package includes:

- 5 diskettes
  - 1 disk containing the latest Workhorse Firmware Version X.XX
  - 1 disk containing the Workhorse High Resolution Upgrade s/n HRXXXX
  - 3 disks containing the Workhorse Electronic Documentation
- High Resolution Water Profiling addendum

NOTE. The Workhorse Firmware and High Resolution Upgrade disks are not supplied if the high resolution water profiling upgrade is factory installed.

The following explains how to upgrade your Workhorse to include the High-Resolution Water Profiling feature.

1-2 Installing the High Resolution Upgrade Feature

The following describes how to install the High Resolution Water Profiling Upgrade. This information also appears in the README.DOC file on the Workhorse High Resolution Water Profiling Upgrade Disk.

1. Connect your Workhorse ADCP as you would normally and apply power.
2. Confirm that the Workhorse ADCP is communicating normally and which communication port you are using (COM 1 or COM 2).
3. You must first install the latest firmware version. This firmware version can be found on the disk labeled Workhorse FIRMWARE Version X.XX, where the X.XX represents the latest firmware version.

   To install this firmware version place the Workhorse FIRMWARE disk into your floppy drive. Change to the directory that you have the Workhorse FIRMWARE disk installed, i.e. A: .

- If your ADCP is connected to communication port 1 of your computer at the DOS prompt type UPGRADE 1.
- If your ADCP is connected to communication port 2 of your computer at the DOS prompt type UPGRADE 2.

4. Follow the instructions listed and type "Y" and press enter when asked if you want to update the Boot Code.
5. Once the install has been "successfully completed" start the BBTALK program and send the PA command to be sure that the system passes all tests. Note, the bandwidth and transmit tests may fail if you are in air. If these tests fail in air then you are most likely OK and can continue.
6. Remove the Workhorse Firmware disk from your floppy drive and install the Workhorse HIGH-RESOLUTION WATER PROFILING UPGRADE disk.
7. Change to the directory that you have the Workhorse High Resolution Water Profiling Upgrade disk installed, i.e. A: .
   - If your ADCP is connected to communication port 1 of your computer at the DOS prompt type FINSTALL /COM1 BT*XXXX*.dat. Where the *XXXX* stands for the serial number that is on the label of the disk.
   - If your ADCP is connected to communication port 2 of your computer at the DOS prompt type FINSTALL /COM2 BT*XXXX*.dat. Where the *XXXX* stands for the serial number that is on the label of the disk.
8. Once the install has been "successfully completed" start the BBTALK program and send the PA command to be sure that the system passes all tests. Note, the bandwidth and transmit tests may fail if you are in air. If these tests fail in air then you are most likely OK and can continue.
9. Type the command OL. A table will list the available Features installed in your Workhorse. The table should say yes under the INSTALLED title for both High Resolution Water Profiling and the Water Profile.
10. Type the command W?. You should get a list of the High-Resolution Water Profiling commands. If all the above checks out then you have successfully upgraded your ADCP to include the High-Resolution Water Profiling commands.

1-3 High Resolution Water Profiling Addendum

Included in this package is the Workhorse High Resolution Water Profiling Addendum. This addendum contains information on the installation of the High Resolution Water Profiling Upgrade, the Firmware Installation, and a List of the High Resolution Water Profiling Commands.

This addendum should be added to your current Workhorse Technical Manual. This addendum will be the only details of the High-Resolution Water Profiling feature you have installed. If you should order additional Workhorse Technical manuals from us or if you should receive an updated copy of the Workhorse Technical manual be sure that you copy or move this addendum into these new copies. If you wish to receive a new copy of the addendum with your

Workhorse Technical Manual please be sure to specify when you order to include a copy of the Workhorse High Resolution Water Profiling Addendum.

1-4 Electronic Documentation

RD Instruments is pleased to announce that we have moved our documentation to a new electronic format. This way, information is always available, whether you are at the office or on a deployment, and the online format is an environmentally friendly way to provide a large set of reference information. To install the documentation, follow the instructions on the disk.

1-5 Summary

The Workhorse ADCP High Resolution Water Profiling upgrade is intended to allow you to use the Workhorse ADCP for fast, high resolution, 3D surveys of coastal, in-shore, and estuarine regions. Adding this new capability to the small, light Workhorse ADCP package, you can profile currents quickly, accurately, and affordably from rubber boats to research vessels. With this upgrade, the Workhorse ADCP measures water profiles using modes 1, 5, and 8.

We trust that you will find that this upgrade will give you the added capabilities you require in these types of environments. If you should have any questions or problems please contact the RD Instruments Customer Service Department at:

EMAIL: rdifs@rdinstruments.com
FAX: 619-578-4016
MAIL: RD Instruments
Customer Service
9855 BUSINESSPARK Ave
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Also, do not forget to visit our WEB site

NOTES

Chapter 2

Water Profiling Modes

2-1 Introduction

This chapter explains all of the water-profiling modes available for Workhorse ADCPs. We will explain the pros and cons of each mode. This information should help you select the best mode for your particular data collection site. 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.

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.

NOTE. The *TRANSECT* program (v2.0 and later) will not display any data if you use Mode 5 or Mode 8 unless you modify the configuration file. Using any ASCII-text editor, you must add a line to the processing section of the configuration file (*.CFG). For example, here is how an existing CFG file was modified:

```
PROCESSING
{
Average every (30.00 s)
Depth sounder (  NO )
Btm Layer % ( 100 )   <- - - - - - - - - - - - - - - - - THIS LINE WAS ADDED
External_formats ( N N N N )   [ HDT HDG RDID RDIE ]
External_decode  ( N N N N )   [ heading pitch roll temp ]
 :
 :
```

2-2 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 is set after you have selected the bin size (WS command) and the ambiguity velocity (WV). The ambiguity velocity tells the ADCP what maximum velocity it will see. If you were 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 up Mode 1 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
- (1.5) = The highest 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 velocity of 3 m/s.

The **default** setting for the WV-command is 175 cm/s (WV175), which corresponds to an apparent velocity of 5 m/s.

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

2-3 High Resolution Modes

2-3.1 Mode 5

General Description - Mode 5 is our high-accuracy, 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, fixed measurements (7 m and less), or for slow-moving platform measurements where water velocity flows are very low (less than 100 cm/s).

Mode 5 is not good for areas where there is shear, turbulence, background noise, or fast ADCP motion (above 2-3 m/s). If high shears, turbulence, background noise, or fast ADCP motion occurs, the ADCP will not collect data.

2-3.2 Mode 8

General Description - Mode 8 is our robust shallow-water mode. The standard deviation of Mode 8 is about 3-5 times greater than Mode 5 (or 10 cm/s) in shallow water. 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 4 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.

2-3.3 Mode 5 and 8 Specifics

Mode 5 and 8 use pulse-to-pulse correlation to calculate water velocity. These modes transmit a short encoded pulse 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 changes in phase, 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 the position of the correlation peak. 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.

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 2-1.

2-3.4 Comparision of Water Modes 5 and 8

Water-Profiling Mode 5

Mode 5 advantages compared to Mode 8:

- 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 reduction in the maximum profiling range (see Table 2-1)
- A larger minimum profiling depth may be required than Mode 8 (see Table 2-2)
- A reduction in the maximum velocity the ADCP can measure (see Table 2-1)
- Does not work well in dynamic water environments that have water velocity changes greater than 80 cm/s (e.g., eddies, shear)

Water-Profiling Mode 8

Mode 8 advantages compared to Mode 5:

- A longer maximum profiling range (see Table 2-1)
- May be able to profile in shallower water the Mode 5
- An increase in the maximum velocity the ADCP can measure (see Table 2-1)

- Works well in dynamic water environments that have water velocities changes up to 250 cm/s (e.g., turbulence, eddies, shear)

Mode 8 disadvantages compared to Mode 5:

- The single-ping standard deviation is 10-15 times greater than Mode 5 (see Table 2-1) for the same size depth cell (bin)

2-4 Downward-Looking Deployments

The shallow-water profiling feature for both Modes 5 and 8 has been designed to work with bottom-tracking applications. We recommend using Bottom-Track Mode 5 (BM5) whenever you use either water profiling Mode 5 (WM5) or Mode 8 (WM8). These modes can be used in shallow-water upward-looking deployments, but the ambiguity velocity (WZ) must be set correctly. Please see Section 2-5 on upward-looking deployments for set-up considerations.

Mode 5 and 8 must use WZ005 (lag setting) for most deployments, which limits the profiling range. The higher WZ is set the lower the profiling range. WZ005 provides for the deepest possible range. The ADCP automatically adjusts this setting higher based on the depth of the water. Therefore, for most applications, bottom-track should also be turned on.

Bottom-track is also important because Modes 5 and 8 place two pulses in the water column at once. We must keep both pulses from returning signals from different parts of the water column at the same time. The bottom-track depth lets us time the transmission of the second pulse to occur at the same time the first pulse is bouncing off the transducer face.

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.

2-4.1 Recommended ADCP Command Settings

The setups for water profiling Modes 5 and 8 (including the settings for the associated commands) are listed in the following table. Please note that the standard deviation, minimum and maximum profiling ranges, and the maximum profiling ranges are given as a guide for setting up the ADCP. These performance values may be different for different flow conditions.

Table 2-1. Setup Specification for Mode 5 and 8

Freq.	Mode	Blanking	Bin Size	Single-Ping Std Dev.	Profiling Range (m)		Max Water Velocity
					Min.	Max	
300kHz	5	WF50	WS50	0.7 cm/s	3.1	11	1 m/s
	5	WF50	WS50	1.4 cm/s	3.1	5.3	2 m/s
	8	WF50	WS50	7.8 cm/s	1.6	16	1 m/s
	8	WF50	WS50	15.9 cm/s	1.6	8	2 m/s
600kHz	5	WF25	WS25	0.4 cm/s	1.6	8	1 m/s
	5	WF25	WS25	0.7 cm/s	1.6	4	2 m/s
	8	WF25	WS25	3.6 cm/s	0.9	8	1 m/s
	8	WF25	WS25	7.1 cm/s	0.9	4	2 m/s
1200kHz	5	WF25	WS10	0.4 cm/s	0.9	4	1 m/s
	5	WF25	WS10	0.8 cm/s	0.9	2	2 m/s
	8	WF25	WS10	4.7 cm/s	0.6	4	1 m/s
	8	WF25	WS10	9.4 cm/s	0.6	2	2 m/s

NOTES:

1. Ambiguity Velocity is set to WZ005.
2. The Maximum Velocity refers to the total apparent water velocity, which is the sum of the water and vessel velocities.
3. The values for the Maximum Velocity are the absolute maximum. In about 50% of applications, users find the Maximum Velocity to be about 30% less than what is shown because of shallow-water dynamics.
4. In about 50% of the applications, users find the Maximum Range to be about 30% less than shown because of shallow-water dynamics.

2-4.2 Minimum Profiling Range Capability

Mode 5 and 8 must have a minimum water depth in order to profile. Table 2-2 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 2-2. Mode 5 and Mode 8 Minimum Profiling Depth

Frequency	Cell Size (m)	Minimum Profiling Range (m) Mode 5	Minimum Profiling Range (m) Mode 8
300 kHz	0.25	2.2	1.1
	0.50	3.1	1.6
	1.00	4.4	2.6
600 kHz	0.10	0.9	0.6
	0.25	1.6	0.9
	0.50	2.2	1.4
1200 kHz	0.05	0.8	0.5
	0.10	0.9	0.6
	0.25	1.6	0.9

NOTE. The blanking distance (set with the WF-command) is 50 cm for 300kHz systems, and 25 cm for the 600 and 1200kHz systems.

NOTE. The minimum profiling range is measured from the transducer face. Add the transducer depth to the given range for the minimum profiling depth.

2-5 Upward-Looking Deployments

For Mode 5 and Mode 8 upward-looking applications it is necessary to set an appropriate ambiguity velocity that is dependent on the water depth. Most upward-looking deployments do not use bottom-track (which adjusts the ambiguity velocity for you). The correct ambiguity velocity is necessary to prevent the first pulse in the ping group from contaminating the reception of the following pulses in the group. Use the formula in Table 2-3 for your system frequency to calculate the appropriate ambiguity velocity (in cm/s) to be input into the WZ command. Determine the distance from the transducer faces to the water surface. In doing this, consider the shallowest expected water depth which will be low tide in tidally affected areas (Figure 2-1).

Table 2-3. Mode 5 and Mode 8 Ambiguity Velocity for Upward-Looking Deployments

System Frequency (kHz)	WZ (cm/s)
300	22/Ds
600	44/Ds
1200	88/Ds

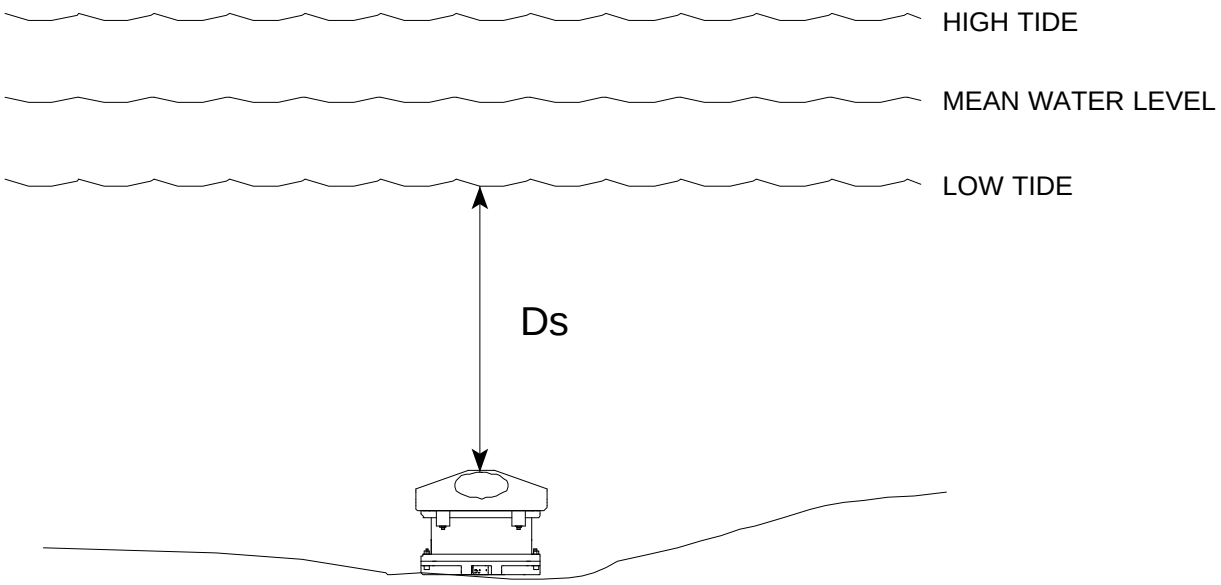

Figure 2-1. Upward-Looking Deployments

In the equations in Table 2-3, the value for Ds above should be expressed in meters, and the ambiguity velocity is inversely proportional to the water depth. The minimum allowable ambiguity velocity is WZ of 5 cm/s which equates to profiling ranges of about 11 m (Mode 5) and 16 m (Mode 8) for the 300 kHz, 8 m for the 600 kHz, and 4 m for the 1200 kHz. For practical profiling conditions, decorrelation effects will occur towards the outer reaches of this range, and you can expect actual profiling ranges of 8 m (Mode 5) and 10 m (Mode 8) for the 300 kHz, 7m for the 600 kHz, and 3.5 m for the 1200 kHz. Even though you can expect this range degradation, it is necessary to use the actual distance from the transducers to the surface for Ds.

NOTES

Chapter 3

High Resolution Water-Profiling Commands

3-1 Introduction

This section defines the optional High Resolution Water-Profiling commands used by the Workhorse ADCP. These commands let you set up and control the ADCP without using an external software program such as our *PLAN* program. However, we recommend you use *PLAN* to control the ADCP because entering commands directly from a terminal can be difficult. Most Workhorse settings use factory-set values. If you change these values without thought, you could ruin your deployment. *Be sure you know what effect each command has before using it.* Call RDI if you do not understand the function of any command.

3-2 Command Descriptions

This section lists all Workhorse help and High-Resolution Water-Profiling commands. Each listing includes the command's purpose, format, range, and description. When appropriate, we include amplifying notes and examples. If a numeric value follows the command, the Workhorse uses it to set a processing value (time, range, percentage, processing flags). All measurement values are in metric units (mm, cm, dm).

? – Help Menus

Purpose : Lists the major help groups.

Format : *x*? (see description)

Description : Entering ? by itself displays all command groups. To display help for one command group, enter *x*?, where *x* is the command group you wish to view. When the Workhorse displays the help for a command group, it also shows the format and present setting of those commands. To see the help or setting for one command, enter the command followed by a question mark. For example, to view the WP-command setting enter WP?.

Examples : See below.

```
>?
DEPLOY? ------------------ Deployment Commands
SYSTEM? ------------------ System Control, Data Recovery and Testing Commands
```

```
>deploy?
Deployment Commands:
PA ---------------------- Pre-Deployment Tests

RE ---------------------- Recorder ErAsE
RN ---------------------- Set Deployment Name

WF = 0176 ---------------- Blank After Transmit (cm)
WN = 020 ----------------- Number of depth cells (1-128)
WP = 00001 --------------- Pings per Ensemble (0-16384)
WS = 0400 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

BP = 000 ----------------- Bottom Track Pings per Ensemble

TE = 00:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 00:05.00 ------------ Time per Ping (min:sec.sec/100)
TS = 97/09/19,14:01:30 --- Time Set (yr/mon/day,hour:min:sec)

ES = 35 ------------------ Salinity (0-40 pp thousand)

CF = 11110 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CS ----------------------- Start Deployment

>system?
System Control, Data Recovery and Testing Commands:
CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CK ----------------------- Keep Parameters as USER Defaults
CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CZ  ---------------------- Power Down Instrument

RR ----------------------- Recorder diRectory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host

PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices
```

3.2.1 Features Command

The ADCP uses this command to list the available/installed firmware upgrade features.

OL - Features

Purpose : Lists available/installed firmware upgrade features.

Format : OL

Description : Send the command OL. A table will list the available Features installed in your Workhorse. The table should say yes under the INSTALLED title for each feature that is installed.

Example : See below.

```
>ol                              FEATURES
------------------------------------------------------------------------
Feature                                                        Installed
------------------------------------------------------------------------
Bottom Track                                                        No
Water Profile                                                      Yes
High Resolution Water Modes                                        Yes
Lowered ADCP                                                        No

See your technical manual or contact RDI for information on how to
install additional capability in your WorkHorse.
```

3.2.2 High Resolution Water-Profiling Commands

The ADCP uses these commands for High-Resolution Water-Profiling applications.

WL - Water Reference Layer

Purpose : Sets depth cell range for water-track reference layer averaging.

Format : WL*sss,eee*

Range : *sss* = Starting depth cell (0-128; 0 disables this feature)
eee = Ending depth cell (1-128)

Default : WL0

Description : You can use WL to lower the effects of transducer motion on present measurements for multiple-ping ensembles (WP>1). The ADCP does this by averaging the velocities of a column of water and subtracting that average from each of the depth cell velocities. The ADCP accumulates the resulting average velocity and depth cell velocities. At the end on an ensemble, the ADCP adds the average reference velocity back to the normalized depth cell velocities. This results in quieter data for depth cells in which there were few good samples.

WM - Profiling Mode

Purpose : Selects the application-dependent profiling mode used by the ADCP.

Format : WM*n*

Range : *n* = 1, 5, 8 (see description)

Default : WM1

Description : WM lets you select an application-dependent profiling mode. The chosen mode selects the types of pings transmitted. The ping type depends on how much the water-current is changing from ping-to-ping and from cell-to-cell.

Table 3-1. Water Modes

Mode	Description
WM1	Dynamic sea state
WM5	Shallow-water environments
WM8	Close-in mode

WV - Mode 1 Ambiguity Velocity

Purpose : Sets the radial ambiguity velocity for profiling Mode 1 (WM1) and Mode 6 Ambiguity Velocity.

Format : WV*nnn*

Range : *nnn* = 002 to 480 cm/s

Default : WV175

Description : Set WV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. Use the following forumla to determine the WV setting.

$$WV = (\text{Max Water Velocity}) \times \sin(H) \times 2 \qquad (1)$$

Where:

H = mamimum relative horizontal velocity between water-current speed and the ADCP's speed

WZ - Mode 5 and 8 Ambiguity Velocity

Purpose : Sets the minimum radial ambiguity for profiling Mode 5 (WM5) and Mode 8 (WM8) Ambiguity Velocity.

Format : WZ*nnn*

Range : *nnn* = 0 to 999 cm/s

Default : WZ10

Description : Allows for very high resolution (small bins) with very low standard deviation. This command should always be set to WZ05.

NOTES