

APPENDIX C

QA/QC Procedures for ADCP Flow Transect Measurements

F.1 INTRODUCTION

The Acoustic Doppler Current Profiler, ADCP, is an electronic instrument developed to measure water velocity. The instrument transmits acoustic signals (*ping*) into the water column, and by measuring the Doppler shift between the transmitted and reflected signals, it computes the velocity of the water relative to the ADCP. In order to reduce the statistical uncertainty of the ADCP measurement, a collection of *pings* is averaged into an *ensemble* to produce the velocity output.

The ADCP data are collected on a continuum in the water column from the instrument transducer to a specified range. Within this range, velocity measurements are taken at uniform intervals, known as *bins*. A vertical profile of the velocity field consists of the measurements at each *bin*. An important feature that determines the usefulness of an ADCP is the ability to properly calculate its speed and position relative to the bottom, the so-called *bottom-tracking*. The bottom-tracking data contains information about the instrument settings, ranges, velocities, correlation magnitude, evaluation amplitude, and percentage of good data.

The ADCP manufactured by RD Instruments uses the software *TRANSECT* to collect and analyze data for moving vessel applications. The DOS-based software is user interactive, and consists of several programs that communicate, configure, collect, and play/process data.

The purpose of this report is to provide a quality assurance plan, which will ensure that data collected by ATM personnel meet the required accuracy standards, and the procedures used to collect them are consistent throughout the monitoring program. The guidelines described herein were reproduced from two reports: "Guidelines for the Use of an Acoustic Doppler Current Profiler" by the South Florida Water Management District, and "Quality Assurance Plan for Discharge Measurements Using Broad-Band Acoustic Doppler Current Profilers" by U.S. Geological Survey – Office of Surface Water.

According to the USGS guidelines, the ADCP can accurately measure discharge for only a limited range of flow conditions. Based on manufacturer recommendations and preliminary measurement-verification information, the following conditions must be met for general use of the ADCP to measure velocity profiles or discharges. Measurements made at or beyond these limits generally will not produce accurate results and will require specific error analysis:

Average Depth	Average Velocity	Maximum Immeasurable Flow due to Limited Depth or Velocity
$1.0 < D < 130 \text{ m}$	$0.1 < V < 10 \text{ m/s}$	10%

F.2 PRE-FIELD PROCEDURE

In order to avoid delays in the field and to ensure completeness of the data collected, the following preparations should be made prior to departure:

Instrument Test. According to the BBADCP TECHNICAL MANUAL (RD Instruments, 1995), an ADCP should be tested:

- When you first receive the ADCP
- Before each deployment or every six months
- When you suspect instrument problems
- After each deployment

The program BBTEST that comes with the instrument thoroughly checks the ADCP and helps isolate any problem to a major functional area of the instrument. Refer to Chapter 5 of the manual for the step-by-step procedures to perform the tests. BBTEST records tests results in an ASCII text file named TEST nnn .LOG file where nnn is the number of times the BBTEST program has been run. After the test procedure is concluded, rename the file to better describe the application (e.g., project, site, date) and store it with the data.

Laptop and Software Revision. This topic refers to the determination as to whether the instrument is utilizing the most recent software and firmware upgrades and that the complete system including the field computer and power supply is operational. Prior to taking the

instrument into the field, it is recommended that the most recent version of the TRANSECT software package should be installed on the primary and backup field computers. In addition, a backup of this software should be copied to a diskette and kept with the computer.

Hardware and Boat-Mount Preparation. A pre-field inspection of all the parts and hardware for the boat mount should be performed. Extra parts and tools should be packed.

F.3 FIELD PROCEDURES

Vessel Installation. Figure F-1 shows the vessel-mounted ADCP deployed forward over the bow of the boat. The instrument should be rigidly attached in a vertical position with the transducers submerged at least 3 inches (8 cm) below the water surface. The transducers may have to be lowered further when working in rough water to ensure that the heads stay submerged and no cavitation is present in their vicinity during the entire measurement. The mount used to attach the ADCP to the boat should be designed to withstand the combined forces of water velocity resulting from the boat's movement and the ambient stream velocity. It is desirable to have a mount designed in such a way as to be able to quickly raise or rotate the instrument out of the water before moving from one site to another or for quickly traversing the cross section. It is also critical that the ADCP not be mounted in proximity to steel or any other ferrous material, which would affect the functioning of the internal flux-gate compass. For this reason a boat with a steel hull should not be used and the instrument should be mounted as far as possible from any ferrous objects on the boat, such as an engine with a cast iron block or heads. A rule of thumb is to keep the compass, located near the top of the ADCP pressure cam, away from any ferrous object on the boat by at least one, longest dimension, length of the object. For instance, if a steel davit mounted on the boat has a longest dimension of 4 feet the ADCP should be mounted no less than 4 feet from the davit to avoid interference with the compass.

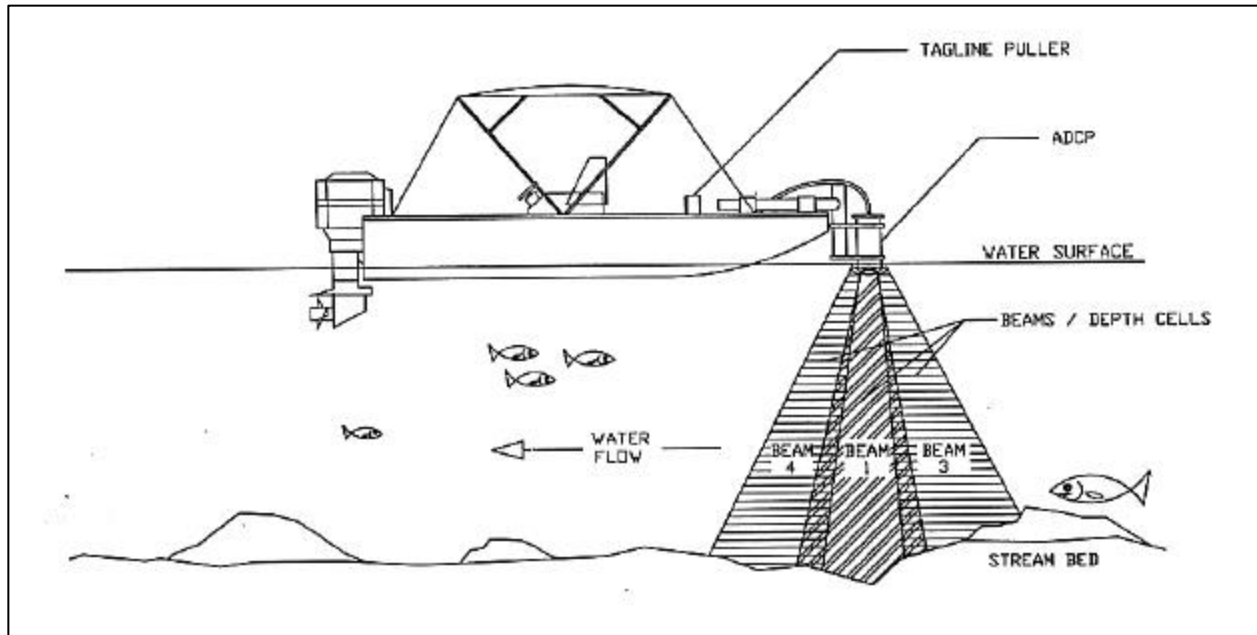


Figure F-1 – Vessel-mounted ADCP (from SFWMD report “Guidelines for the Use of an ADCP”).

Instrument Check. After mounting the ADCP and connecting the required cables to the computer and power supply, check the instrument to ensure that all of the circuits and sensors are operating properly. This check is done by running the BBTALK program, which is provided as part of the ADCP software package. In BBTALK there are several programs that perform internal diagnostic and calibration tests on the ADCP and display its internal setup. These programs will test all of the circuits and sensors of the ADCP and upon request will write the results to a user designated file. Specific procedures for initializing the self-test programs in BBTALK are provided in a test procedures document BBADCP TECHNICAL MANUAL (RD Instruments, 1995). The procedures detailed in this document must be performed prior to each deployment of the ADCP. If the instrument fails to pass any of the self-test programs, consult the ADCP and Transect User's Manuals (RD Instruments). If the problem cannot be corrected, contact a field service engineer from the manufacturer and take collective action as required. Any data collected without successfully passing all of the self-tests should be clearly marked as suspect and the nature of the test failure documented in the remarks section of the ADCP fieldnote sheet. A second test is done in the Acquire mode of Transect during the initiation of

communication between the computer and the ADCP. A comparison of the configuration file and the ADCP setup is performed at this time. If the ADCP fails to respond, or if any error messages are displayed, consult the ADCP and Transect User's Manuals (RD Instruments). Many times, the problem can be solved by ensuring that all connections are properly made, including the power supply to the ADCP. Sometimes an error message will warn that the configuration file is not in agreement with the ADCP setup. Again, these problems usually can be solved by rechecking the configuration file for proper communication settings, transducer frequency, or head orientation (upward or downward looking). If the problem cannot be discerned by consulting the User's Manual, it is advisable that a manufacturer's field service representative be contacted. Resolve all problems related to failure of self tests or error messages before proceeding.

Configuration File Setup. It is critical that the configuration file be matched to the physical conditions of the cross section. Such parameters as bin size, mode, bottom track and water pings per ensemble, and blanking distance require setting by a trained user to optimize the quality of data collected for the existing conditions. Proper setup of the configuration file is beyond the scope of this report but is addressed in the instrument technical manual. That report provides specific details on cross section selection and setting up configuration files for a variety of conditions and should be consulted by ADCP users prior to collecting data. Currently, the configuration file is stored on the computer separate from the raw data files that contain the velocity data. Because of this, it is imperative that each raw data file be linked in some way to the configuration file used during data collection. This procedure will ensure that during playback and post processing of the raw data files the same parameters are used as during data acquisition. The configuration file used for a specific measurement will be saved on the harddrive and should be copied to a diskette for a backup along with the raw data files as soon as possible following completion of the discharge measurement. An ADCP fieldnote sheet should be adopted by the field crew with space designated for the listing of raw data filenames and associated configuration file names.

Environmental Conditions. All site-specific conditions that are relevant to the discharge measurements (e.g., bottom characteristics, channel edge, pitch and roll of boat platform, transect starting and stopping procedures, compass errors, shallow-depth-caused errors, vessel course and speed during measurement) should be properly documented in the ADCP Discharge Measurement Notes. In addition, when a measurement condition appears problematic, the documentation should also include: (1) a brief description of the condition; (2)

methods used to determine if the condition is significant to the measurement; (3) how the effects of the conditions were accounted for (i.e., appropriate instrument operating modes, configuration file settings, tests, and error analyses).

Discharge Measurements. Prior to collecting discharge data using the ADCP, preliminary information describing the site, date, personnel, equipment, and versions of software and firmware used, are to be entered on the ADCP field note sheet. The remainder of this sheet is to be filled in during the collection of data. Information related to the distance to river banks at the beginning and ending of individual measurements and the filenames of raw data and configuration files must be entered immediately. This information is critical to the accurate calculation of discharge and any delays in entering it onto the field note sheet will increase the likelihood of errors. Individual transects can be viewed as instantaneous discharge at a particular site. It is therefore necessary to average multiple transects to reduce variation due to turbulence and velocity surges. In general, at least two transects will be made at each site to make a valid determination of discharge. If any one of the transects differs from the mean discharge by more than 10 percent it should first be evaluated to determine if there is any reason to justify discarding it. A determination to discard a single transect might be made based on a bad ensemble, a “Made Good” distance that differs significantly from the total distance, anything that might have affected the velocity profiles during the measurement such as boat traffic in the vicinity, or any number of other factors. If the transect is discarded, another should be made so that the discharge measurement is calculated from the average of at least two transects. If there is no justifiable reason for discarding the transect, make two additional transects and average them all including the outlier, to make a determination of discharge. During a transect, the ADCP measures the velocity in the water column relative to the movement of the vessel to which it is attached. The vessel velocity relative to the channel bed is also measured and is used to calculate the actual water velocity. This calculation assumes a fixed bed. If, however, the bed is in motion the calculation of actual water velocity will be in error. When measuring discharge in a river it is necessary to assess whether there is any bed movement prior to making the discharge measurement. This task is accomplished either by anchoring the vessel to the bed or to a fixed object such as a bridge, or holding the boat at a fixed location within the channel while collecting a series of ensembles. If the bed is stable, the Shiptrack display will indicate no significant movement of the vessel for a period of a few minutes. However, if the bed is moving, it will be reflected in the Shiptrack display by an apparent gradual movement of the vessel in an upstream direction. If this movement is

significantly relative to the average water-column velocity, an alternate site should be sought. Often, bedload movement is less pronounced in the thalweg of the channel than in other areas. As a result, it may be necessary to check for bed movement at several locations across the channel. Following completion of the discharge measurement, each raw data file should be reviewed using the "Playback" mode in Transect to ensure that the data are complete and do not include any bad ensembles, that depths and velocities did not exceed the prescribed limits set for the instrument in use, and that no velocity spikes were recorded due to stream velocity equaling the ambiguity velocity. The instrument limitations and discussion of ambiguity velocity for specific instruments can be found in the instrument technical manual. Measurements that exceed these limitations or where velocity spikes were recorded should not be included in the determination of a final discharge value. If a raw data file contains bad velocity ensembles or velocity spikes, the measurement should be repeated until at least two complete measurements with no bad data have been obtained. Once a sufficient number of transects have been made and reviewed for completeness, the nearshore discharge estimate section on the back of the fieldnote sheet must be completed to determine total discharge including the unmeasured sections near each bank. The Transect software contains a utility for making the nearshore estimates based on the first and last valid velocities and depths measured. Procedures for using this function are provided in the Transect User's Manual (RD Instruments). Care should be taken to determine the direction of boat movement during the collection of the ensemble that is used for determining the nearshore discharge. This will enable the field person to assign the proper sign (positive or negative) to the estimated value before calculating the total discharge. A gage height from a staff or some other reference should be obtained before and after each measurement and entered into the space provided on the front of the fieldnote sheet. Otherwise the gage heights corresponding to the time of each measurement should be obtained from the gage recorder and entered. A mean gage height and discharge can then be calculated and entered into the space provided in the upper part of the fieldnote sheet.

Data Assessment. An overall assessment of the mean discharge measurement should be made after completion of the transects comprising the measurement. This assessment is based both on the field person's judgment of conditions encountered in making the measurements as well as a quantitative evaluation of the individual transects. Criteria for evaluating the discharge measurements are their completeness in terms of the percent of the total cross section measured, and overall measurement conditions. Conditions such as turbulence, eddies, reverse flows, surface chop, and proximity of the instrument to ferrous objects, which under

certain circumstance might affect the results of the measurements and velocity profiles, should be noted under the appropriate sections on the fieldnote sheet and used in rating the measurement. The mean and standard deviation of the discharge measurement should be calculated as well as the coefficient of variation (CV), which is the ratio of the standard deviation to the mean (s/Q). The CV should then be entered as a percentage in the space provided on the fieldnote sheet. This CV is a measure of the grouping of individual transects around their mean and is a useful statistic for making a quantitative assessment of the measurement. If the CV is greater than five percent it is recommended that additional transects be made. In some cases one or more transects will be apparent outliers, resulting in a large CV. If, in the judgment of the ADCP user, there is an obvious reason for the discrepancy, after noting the circumstances on the fieldnote sheet the transect can be eliminated from the mean discharge calculation. Additional transect may be needed if one or more are eliminated so that at least two are used for computing the average discharge. If the mean discharge varies from the applicable rating or shift curve by more than plus or minus five percent the measurements should be repeated. Assign a rating to the final discharge value by circling the appropriate entry on the front of the fieldnote sheet. This rating is based on the field person's qualitative evaluation of the measurement as well as the CV, which provides a more quantitative measure of precision. After completing the fieldnote sheet, copy all raw data and configuration files resulting from the discharge measurements onto a diskette as a backup in case of damage to the computer's internal harddrive.

F.4 POST-FIELD OFFICE PROCEDURES

Equipment Check. Upon return from the field, inspect the ADCP to determine the condition of the transducers, pressure case, connectors, cables, and laptop. Report damage or undue wear to any of the components to the project manager responsible for the field operation.

Discharge Measurement Review. All discharge measurements must be checked by a second qualified person in the office. Special attention should be given to the calculation of total discharge including nearshore estimates. The person reviewing the measurement must initial the front of the fieldnote sheet upon completion.

Documentation and Archival of Discharge Measurement. A copy of the configuration, subsystem self-test, and the discharge measurement summary should be printed and attached to the fieldnote sheet for filing as soon as practicable upon returning from the field. In addition,

the field crew is responsible for producing a report (in ASCII format) containing all the information in the configuration files as well as a summary of the discharge measurements. The document should also include information about width, depth, area, mean velocity, and discharge at the location of each transect.

F.5 REFERENCES

- Kellman, O., 1998: "Guidelines for the Use of an Acoustic Doppler Current Profiler." South Florida Water Management District. Hydrologic Data Management Division Technical Report.
- Lipscomb, S. W., 1995: "Quality Assurance Plan for Discharge Measurements Using Broad-Band Acoustic Doppler Current Profilers." U.S Geological Survey Open-File Report 95-701.
- RD Instrument, 1995: "Broadband Acoustic Doppler Current Profiler – Technical Manual." RD Instruments.