Standard Operating Procedure for:

Operation of the SonTek/YSI FlowTracker Handheld Acoustic Doppler Velocimeter (ADV) (VelocimeterR01)

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and

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1 Identification of the method

Operation of the SonTek/YSI FlowTracker Handheld Acoustic Doppler Velocimeter (ADV) to directly measure velocity and calculate discharge in a stream.

2 Applicable matrix of matrices

This instrument measures water velocity in streams and open channels.

3 Detection Limit

The shallow-water 2-axis (2D) probe measures velocity in depths as shallow as 2 cm. It can measure velocities between ± 0.001 m/s to 4.5 m/s with a resolution of 0.0001 m/s and accuracy of ±0.001 m/s.

4 Scope of the method

This method details the office diagnostic, field diagnostic, and field operating procedures of the SonTek/YSI FlowTracker Handheld ADV which measures velocity and calculates discharge.

5 Summary of method:

5.1 The SonTek/YSI FlowTracker Handheld ADV accurately and precisely measures water velocity and computes discharge automatically using USGS/ISO methods and acoustic Doppler technology.

5.2 Pre-measurement diagnostics will be performed prior to leaving the office. Field diagnostics will be performed prior to taking measurements at each site.

5.3 Cross-sections are divided into stations and the X-axis of the velocimeter is placed perpendicular to the tape line. Velocity is measured using one of three methods as dictated by the physical characteristics of the cross-section.

5.4 Mean velocity, station discharge, and total discharge are calculated and the FlowTracker handheld controller stores cross-section information in separates files that are downloaded to a computer and imported into MS Excel for processing.

6 Definitions

6.1 Probe: Contains the acoustic transmitter, acoustic receivers, and temperature sensor.

6.2 Transmitter: Generates a short pulse of sound concentrated in a 6 mm diameter beam.

6.3 Receivers: Are mounted on arms from the central probe head and are focused on a common sample volume taken at a fixed distance of10 cm from the arms. See Figure 1 below.

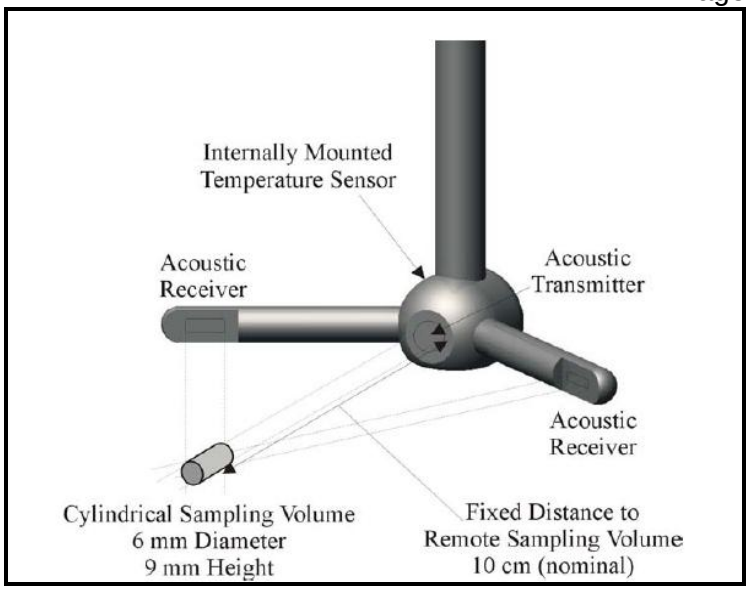

Figure 1: 2D FlowTracker receiver focus and sample volume.

6.4 Sample volume: The physical location of the water velocity measurement.

6.5 Temperature sensor: Internally mounted in the probe head and automatically collect temperature data.

6.6 Signal-to-noise ratio (SNR): The ratio of the received acoustic signal strength to the ambient noise level (dB).

6.7 Averaging time: Data recording frequency of the instrument that is user-specified and ranges from 10 to 1000 seconds.

7 Interferences

An improperly calibrated instrument can lead to erroneous results. See the manufacturer's instruction manual for proper calibration procedures and see Section 13 for performance check procedures.

8 Health and safety

8.1 When wading in streams where water depths may be 1 meter deep or more, wear a life preserver and/or remove hip boots or chest waders.

8.2 When walking through densely vegetated areas along streams, be sure to look for and avoid toxic plants like poison ivy. Be sure to wear appropriate insect repellent and protective clothing for protection from mosquitoes, chiggers, and ticks. In addition, probe areas in your path with a walking stick to warn and disperse poisonous snakes like the cotton mouth and copperhead which may inhabit riparian areas.

8.3 Be sure to clean up with bacteria disinfectant soap and water after wading in streams. This is particularly important for streams that drain livestock areas, sewage treatment plant effluents, and other obvious pollution

sources. Under no circumstances should you drink the water from any stream.

9 Personnel qualifications

All measurements will be made by OEWRI personnel who have received appropriate training, prior coursework, and field experience regarding cross section set up, data collection and interpretation.

10 Equipment and supplies

10.1 Field Book and Pen

10.2 SonTek/YSI FlowTracker Handheld ADV: Probe, probe cable, probe mounting bracket, handheld controller, and carrying case

10.3 30 meter tape

10.4 Two surveying pins or stakes to hold ends of tape

10.5 Wading rod (short rod = feet, long rod = meters)

10.6 At least eight AA batteries

11 Quality control

11.1 The FlowTracker automatically accounts for quality control measures such as signal to noise ratio (SNR), standard error of velocity, boundary adjustment, spike filtering, and flow angle which are defined throughout this section

11.2 Signal to noise ratio (SNR): SNR is the most important measure of QC from this instrument. SNR is the ratio of the strength of the reflected signal to the ambient noise level. Under the best conditions, the SNR should be > 10 dB. However, the FlowTracker can operate reliably with an SNR as low as 3 dB. Low SNR values can occur in very clear water which can occur in Ozark streams in baseflow conditions. When the SNR is below 4 dB, the FlowTracker will display a warning. If this occurs the operator will take the reading again after they go upstream and kick up the substrate to increase the suspended sediment passing the cross-section.

11.3 Standard error of velocity: This is a direct measure of the accuracy of the mean velocity measurement. Standard error of velocity is calculated by dividing the standard deviation of the one-second samples by the square root of the number of samples. This gives an idea of the variability of the measurements in respect to the mean velocity.

11.4 Boundary adjustment: Acoustic interference from underwater objects can skew velocity measurements. This is especially true in shallow water conditions where reflections can come from the channel bed. The FlowTracker automatically makes adjustments to avoid interferences and

reports these as boundary adjustments and reports these with one of the following values:

a. 0 (Best) - No adjustments necessary with little to no impact on system performance.

b. 1 (Good) - Minor adjustments necessary with moderate impact on system performance.

c. 2 (Fair) - Large adjustments necessary with notable impact on system performance.

d. 3 (Poor) - Major adjustments necessary with significant impact on system performance. The FlowTracker will still provide good performance for lower flows.

11.5 Spike filtering: Data spikes are filtered from dataset and not used to calculate mean velocity when both of the following two conditions are met:

a. Velocity measurement is at least 3 standard deviations from the mean velocity , and

b. Velocity measurement is at least 3 cm/s (0.1 ft/s) from the mean velocity

Typically, < 2 spikes occur in a 60 second reading.

11.6 Flow angle: The Flowtracker should always be held perpendicular to the tape line when collecting discharge measurements. A flow angle of 0^o indicates the flow direction is perpendicular to the tape line. In the field, good measurements will have variability in the flow angle but all angles should be < 20^o.

12 Calibration and standardization

The receivers, transmitter, and temperature sensor are factory calibrated and does not require regular calibration. The velocimeter performance can be checked with the ADVCheck software, see procedures below.

13 Procedure

13.1 Office Diagnostics: The following diagnostics should be performed in the OEWRI office to verify velocimeter performance using the ADVCheck software.

a. Connect the data recorder to a computer with the cable provided.

b. Place probe in a small bucket of water.

c. Open the FlowTracker software.

d. Click “ADVCheck”.

e. Click “Connect” and “Go!”

f. The software will go through a series of diagnostic procedures and display the results in graphical form. Refer to section 6.6 in the manual which illustrates numerous deviations from the “normal” curve and explains troubleshooting techniques that address potential problems. A computer in the OEWRI office contains the FlowTracker software and manual.

13.2 Field Diagnostics: The following diagnostics should be performed at each site prior to the discharge measurement. These functions are available under the System Functions Menu on the data recorder.

a. Vent the Handheld Controller: The handheld controller should be vented prior to every data run. To vent, loosen the dummy cap on the external communication connector a few turns, wait a few seconds, and tightened the cap.

b. Recorder status: The data recorder can hold up to 32 files. Make sure there is enough room on the recorder to store the site discharge information. Delete the oldest file on the recorder if necessary.

c. Temperature data: Temperature is an important component of the velocity estimate. Check that the meter is recording an appropriate temperature for the specific conditions in the field.

d. Battery data: This function tells the operator how much battery life is remaining. Fully charged alkaline batteries should have a life span of 25 hours. The FlowTracker requires eight AA batteries and a set of new batteries should be in the case.

e. Display raw data: Set the probe in the water and check the SNR value. It should be > 10 dB, but the FlowTracker can operate properly with an SNR as low as 3 dB in very clear water.

f. System clock: Verify the clock is set correctly.

13.3 Field Procedures: After diagnostic completion, collect discharge measurements as follows.

a. Select a cross-section site with minimal flow obstructions upstream or downstream and without areas of near-zero velocity or eddies. In addition, avoid areas where velocities and depths exceed the range for which the velocity-measuring and depth-measuring devices give accurate results. Only choose sections that can be safely negotiated.

b. Pull a tape tight across the stream and anchor on both side with stakes or surveyor’s pins. The zero reading on the tape is staked on the left bank of the channel and tape readings increase toward

the right bank. The left and right sides of the channel are determined looking downstream.

c. The width of the water surface is divided into10 stations at equal intervals across the stream.

d. After cross sections are divided into stations and field diagnostics have been performed, place the X-axis of the velocimeter perpendicular to the tape line.

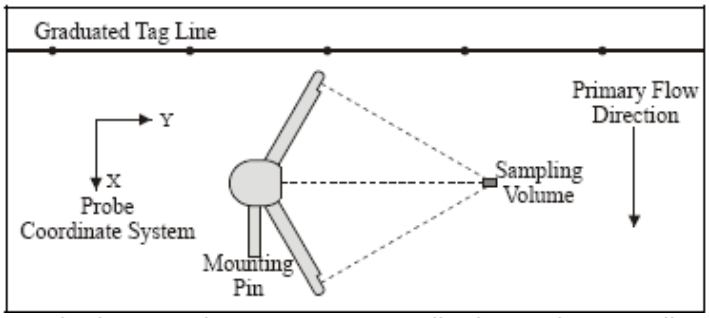

Figure 2: Velocimeter placement perpendicular to the tape line.

e. The horizontal location on the tape, water depth, and the flow velocity is recorded at the appropriate depths dependent on the method (single, two-point, or three-point) chosen. Section 17 includes a procedure flowchart that facilitates the determination of which method to use.

1. Single Point Method - This is the standard method that will be used the majority of the time. This method measures velocity at 0.6 times the water depth. Wading rods available for use are pre-set to hold the probe at the appropriate location for the single point method based on water depth. This method should be used when the station water depth is < 0.3 meters (1 foot)

2. Two-Point Method - The two-point method measures velocity at 0.2 and 0.8 times the water depth. This method will be used when the water depth exceeds 0.3 meters (1 foot) .

3. Three-Point Method - This method is reserved for non-standard profiles where one of the following situations occur: (1) Near surface velocity is < near bottom velocity, (2) near surface is 2 times higher than near bottom velocity, or (3) Near surface and near bottom velocities are in opposite directions.

f. Start the velocity measurements by turning the controller on.

g. Press the Enter key to display the Main Menu.

h. Press 1 to enter the Setup Parameters Menu. Review the current settings and change the values to meet your requirements. When using the short wading rod, “ENGLISH” units should be selected. When using the tall wading rod, “METRIC” units should be used. Averaging time should always be “60 s”. Mode should be “DISCHARGE”. Press “9” when finished.

i. Press 3 to Start Data Run and display the Data File Name Menu.

j. Enter the site information. All sites will have a unique three digit site identification which is followed by the date that is in a six digit number (month/day/year) format. For example M04121807 would be site m-4 visited on December 18, 2007.

k. Press 9 to accept the name and enter the Starting Gauge Menu.

l. Press the Next Station button when you are done.

m. Collect station data:
   1. In the Starting Edge screen, enter the location, depth, correction factor and starting edge using the marked buttons on the keypad.

   2. Press Next Station to continue. Enter the location, depth, and the method of measuring velocity.

   3. When the station information is complete and the probe is at the correct depth and orientation, press the Measure Button. An updating display will illustrate the measured velocity and SNR values. Keep the probe as steady as possible.

   4. On completion of the average time, a summary will be displayed.

n. Press 1 to accept and go to the next station or 2 to repeat this measurement. Repeat these steps for each station.

o. When the final edge section data is collected, press End Section. The ending-edge information will be displayed. Enter the information for this edge.

p. Press the Previous Station and Next Station buttons to review completed stations.

q. Discharge calculation:
   1. Press Calc Discharge to compute the total cross sectional discharge for all completed stations.

2. Check the calculated discharge validity by using common sense and visual interpretation of the cross sectional area of the channel.
3. Review data for errors if the discharge does not match estimated discharge for the cross section.

r. Press 9 to make sure that the data has been saved and to return to the Main Menu.

14 Data acquisition, calculations, and reporting

14.1 Record the stage from the staff gage, discharge, mean velocity, cross-sectional area, and width in a field book, for back-up purposes.

14.2 Download Data

a. Connect the data recorder to a computer with the cable provided.
b. Open “FlowTracker” software.
c. Click “Recorder”.
d. Click “Connect”.
e. Select data files in the “Recorder File Listing” window.
f. Save file to appropriate files on computer.
g. Click “Download”.

14.3 Export Files

a. Connect data recorder to a computer with appropriate cable.
b. Open “FlowTracker” software.
c. Click “Data Export”.
d. Click “Open File”.
e. Select data file for the site of interest and open.
f. Select “Discharge Data” from the output variables.
g. Save file to appropriate files on computer.
h. Click “Export Selected Variables”.

14.4 “FlowTracker” software saves a discharge file with the extension .dis that can be opened in spreadsheet in Excel. This file contains discharge, mean velocity, cross-sectional area, and width of the site selected.

15 Computer hardware and software

Requires SonTek FlowTracker software

16 References

16.1 FlowTracker Handheld ADV Operation Manual (Firmware Version 2.6; Software Version 1.30)
16.2 http://www.sontek.com
16.3 http://www.il.water.usgs.gov/adcp/policy/**flowtracker**.field.test.pdf

17 Tables, diagrams, flowcharts and validation data

The procedure flowchart illustrated below facilitates the determination of which method (single, two-point, or three-point) to use.

Procedure Flowchart