Background information on Acoustic Doppler Current Profilers (ADCPs)

1 Purpose and scope

This document provides some background information on Acoustic Doppler Current Profilers (ADCPs) and their use for creating flow and total suspended sediment concentration profiles. ADCPs are instruments commonly used to measure the velocity of flow in rivers and creeks. Detailed instructions on the installation and use of ADCPs are available in National Industry Guidelines for the *Application of Acoustic Doppler Current Profilers to Measure Discharge in Open Channels (WISBF GL 100.08-2013)* and *Application of in-situ Point Acoustic Doppler Velocity Meters for Determining Velocity in Open Channels (WISBF GL 100.09-2013)*[1]. These standards should be followed.

2 Using ADCPs for continuous flow measurement at a fixed point

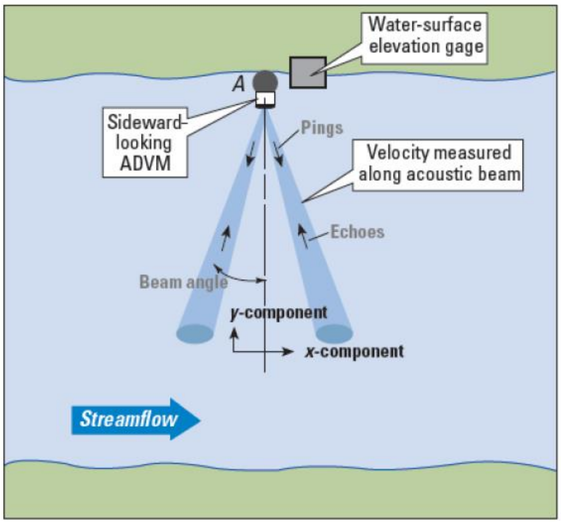
ADCPs are instruments commonly used in the collection of stream velocity data. They function by sending acoustic pulses from their transducer faces into the water column, where they are reflected back by particles and the exact time of their return to the transducer face is measured. The time of the returning signal is affected by the doppler effect of the moving particles in the water. The time differences measured in the returned signal are used to infer the velocity of the water in which the particles are travelling.

There are two types of fixed ADCP units (also known as acoustic doppler velocity meters or ADVM) that may be permanently mounted:

1. A horizontal ADCP (H-ADCP), which is mounted on the bank of a waterway. It is used to measure the velocity of a fixed horizontal slice of a cross section of the river (Figure 1 and Figure 2).
2. A bottom-mounted ADCP (B-ADCP), which is mounted on the bed of a waterway. This is used to measure the velocity of a fixed vertical slice of the river (Figure 3).

Figure 1: Example of a horizontal Acoustic Doppler Current Profiler

[1] http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml



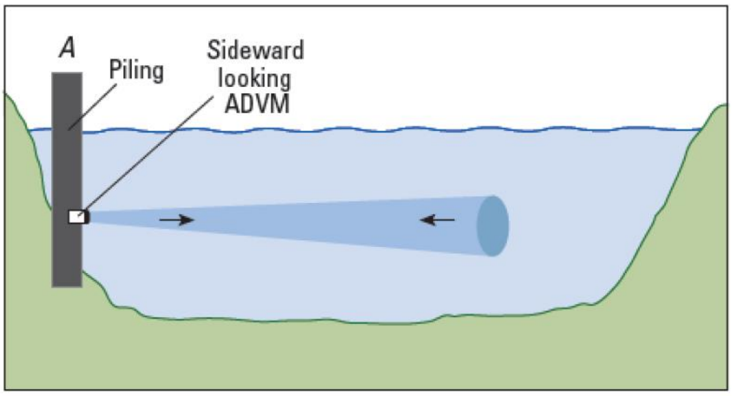


Figure 2: Bird's eye view (left) and channel view (right) - illustration of a horizontally mounted ADCP installation *(Source: Ruhl and Simpson 2005)*

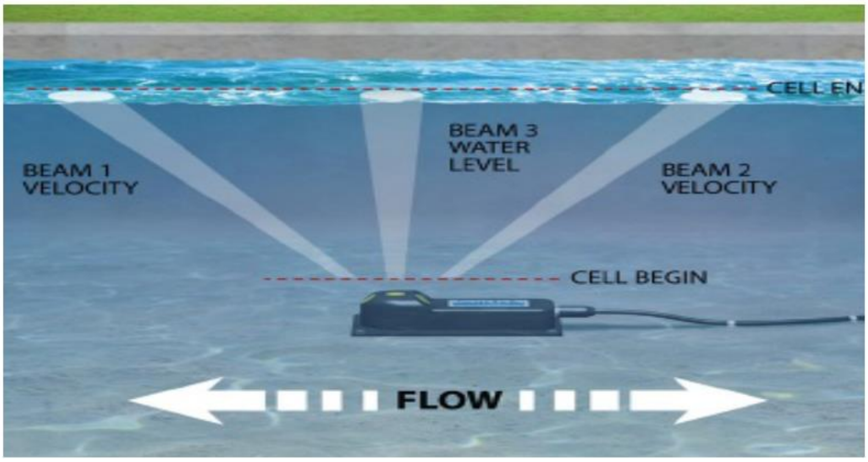


Figure 3: Illustration of a typical bed-mounted ADCP installation *(Source: Sontek/YSI Argonaught product brochure, 2009. www.sontek.com/pdf/brochures/Argonaught-SW-2009-06-23.pdf)*

The distance across the channel for which an H-ADCP can be used to make velocity measurements is dependent on the unit frequency and river depth. The choice of unit should always be one that can measure velocities across the entire channel width where possible. Bottom mounted ADCPs must be installed in the section of the channel that represents the mean velocity. During different flow events this location may change.

Because ADCPs are generally installed in a fixed location, changes in the river stage[2] will also change the spatial variation of the velocity structure. It is therefore necessary to correct the measured H-ADCP and B-ADCP velocities for these changes to ensure reported river discharges are accurate. This is most commonly achieved by measuring the flow of the river under a range of flow conditions using a boat mounted ADCP (Figure 4) at the same time that the fixed ADCP is collecting data. From this, an index-velocity relationship can be established and in conjunction with the site stage-area relationship, can be used to correct the stream flow data measured and reported by the fixed ADCP.

An index-velocity relationship is specific to an installation height. If the H-ADCP or B-ADCP is removed and replaced at an alternative height or location within the same channel then the index-velocity equation is no longer valid and a new relationship is required.

The measurement of the channel's mean velocity at different stages using a boat mounted ADCP (Figure 4) is

[2] Stage is the water level above some arbitrary point, usually with the zero height being near the river bed.

beyond the scope of this document, but should be carried out in accordance with the National Industry Guidelines (Section 1).

Figure 4: A boat-mounted ADCP prepared to collect velocity data

3 Using ADCPs to estimate cross sectional suspended sediment concentrations

In addition to the flow velocity data calculated by the ADCP, data related to the 'noise' of the returned acoustic signal is typically recorded by ADCPs. This data is commonly called 'backscatter'. If water quality grab samples are collected in conjunction with an ADCP measurement, it may be possible to correlate the total suspended solids (TSS) contained in the water quality samples, and the backscatter signal of the particles in the water. If land use upstream of the fixed ADCP is reasonably stable, and sufficient suspended sediment data is collected across a range of flow conditions (ambient to flood events), it is possible to generate estimates of continuous TSS concentrations at a site using either a permanent horizontal or bottom mounted ADCP. TSS samples can be collected using an isokinetic sampling device (for further guidance see USGS 2006).

To calibrate the ADCP backscatter data with TSS concentrations, it is necessary to collect grab samples at the same location that the ADCP is recording backscatter data. Calibration grab samples must be collected at times of differing levels of backscatter intensity to ensure robust inferred TSS concentrations calculations. Figure 5 demonstrates the positions within a channel profile where grab samples need to be collected to provide an accurate calibration of a boat mounted ADCPs back scatter.

Grab samples need to also confirm that the increase in backscatter is due to increased TSS concentrations and not increased particle size.

Note: The installer/operator should be aware that there is an area directly in front of the ADCP transducers known as the 'blanking distance'. The blanking distance is a zone where data is disregarded due to the potential of signal interference. The size of the blanking distance depends on the instrument configuration, frequency and waterway conditions.

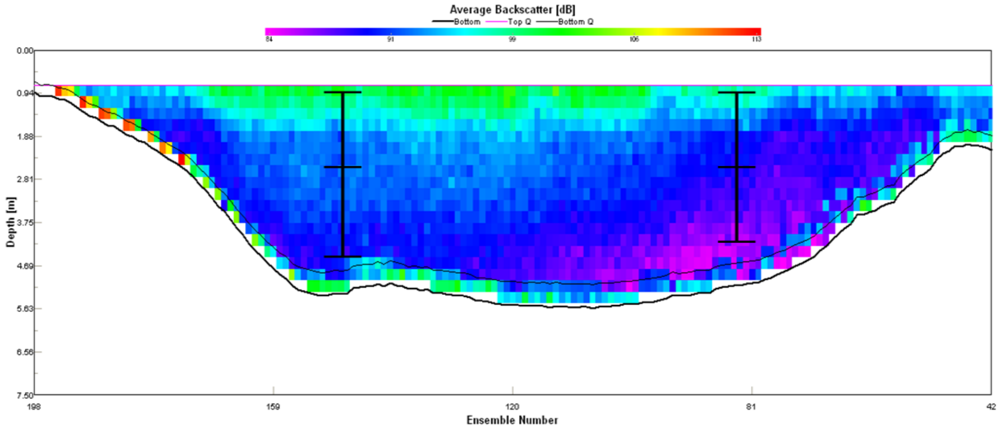


Figure 5: A channel profile showing the spatial variation in the measured backscatter intensity using a boat mounted ADCP. The black bars represent the three locations in each vertical where grab samples must be collected to accurately calibrate backscatter intensity with TSS concentrations (*Source: Mark Randall, Department of Natural Resources and Mines, QLD*)

4 References and additional reading

National Industry Guidelines for hydrometric monitoring. Part 8: Application of Acoustic Doppler Current Profilers to Measure Discharge in Open Channels (WISBF GL 100.08-2013). Available from: http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml.

National Industry Guidelines for hydrometric monitoring. Part 9: Application of In-Situ Point Acoustic Doppler Velocity Meters for Determining Velocity in Open Channels (WISBF GL 100.09-2013). Available from: http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml.

Ruhl CA and Simpson MR 2005, *Computation of discharge using the index velocity-method in tidally affected areas*, U.S. Geological Survey Scientific Investigations Report 2005-5004.

USGS 2006, 'Isokinetic, depth-integrated sampling methods at flowing-water sites', page 37. In: *National Field Manual for the Collection of Water-Quality Data.* Available from:, https://water.usgs.gov/owq/FieldManual/chapter4/pdf/Chap4_v2.pdf.