THE USE OF HYDROACOUSTIC CURRENT METERS TO MEASURE THE FLOW OF GEORGIA STREAMS

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Abstract. Hydroacoustic current meters use the Doppler effect to measure the velocity of suspended sediment particles in water, which can then be used as a measure of the water velocity. Along with measured cross-sectional area, these measured water velocities are used to compute the discharge of a stream. The U.S. Geological Survey (USGS) Georgia District has recently implemented the use of hydroacoustic current meters to measure the discharge of streams throughout Georgia. Hydroacoustic current meters have many advantages over conventional current meters, such as measuring discharge in a timelier and more efficient manner and measuring discharge during unsteady conditions. These advantages allow the USGS Georgia District to measure the discharge at sites that could not have been measured with the use of conventional current meters. Hydroacoustic current meters also can be used for other applications, such as using acoustic backscatter as a surrogate for suspended sediment concentration.

INTRODUCTION

The U.S. Geological Survey (USGS) streamgaging program provides streamflow data for a variety of purposes, including flood forecasting, water-resources planning and design, hydrologic research, and operation of water-resources projects (Wahl and others, 1995). Streamflow records are produced from more than 7,000 USGS streamgaging stations across the Nation. The accuracy of streamflow records depends on measurements of river and stream discharge made by USGS personnel. The USGS Georgia District has recently implemented the use of hydroacoustic current meters to measure the discharge of streams throughout Georgia. Hydroacoustic current meters have many advantages over conventional current meters. These advantages include: no moving parts, simple maintenance, stable instrument calibration provided components are not damaged, velocity accuracies of 0.01 foot/second are attainable, high sample and data output rates, and additional quality-assurance data.

This paper discusses how the hydroacoustic technology works. This paper also discusses the type of hydroacoustic current meters used by the USGS Georgia District to measure discharge. Last, this paper discusses other applications the hydroacoustic current meter can be used for besides measuring discharge.

HYDROACOUSTIC TECHNOLOGY

Hydroacoustic current meters use the Doppler effect to measure the water velocity. Hydroacoustic current meters have transducers that produce a short pulse of sound or “ping” at a known frequency. This pulse of sound propagates along a path that is perpendicular to the face of the transducer (Fig. 1).

This path is also known as the acoustic beam. Sound from the outgoing pulse is reflected or scattered in all directions by particulate matter or “backscatterers” in the water. Some portion of this scattered energy travels back along the acoustic beam axis to the transducer. This return signal has a frequency shift proportional to the velocity of the scattering material.

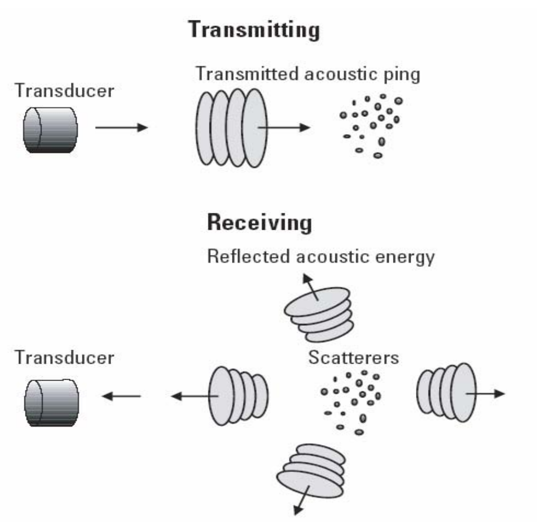

Figure 1. An acoustic pulse being backscattered (from Simpson, 2001).

This frequency change or Doppler shift is measured by the hydroacoustic current meter and is proportional to the projection of the velocity onto the axis of the acoustic beam. It is then assumed that the speed of the particulate matter is also the speed of the water.

TYPES OF HYDROACOUSTIC CURRENT METERS

The USGS Georgia District uses three types of hydroacoustic current meters to measure streamflow. These three types of hydroacoustic current meters are the acoustic Doppler current profiler (ADCP), the acoustic Doppler velocimeter (ADV), and the acoustic Doppler velocity meter (ADVM).

Acoustic Doppler Current Profiler

The USGS has been measuring river discharge with ADCPs since the early 1990s (Oberg and Mueller, 1994). ADCP use has been limited mainly to rivers with depths greater than about 4 feet. Because of recent advances in ADCP technology, these instruments have the potential to be used in shallower rivers. ADCPs measure three-dimensional velocities at numerous points in the water column. ADCPs also measure water depth and track the movement of the ADCP unit with respect to the channel bed or with the use of a Global Positioning System (GPS). The measured depth, velocity, and position data are used to calculate the discharge through software applications. A discharge measurement using an ADCP can be made in a timelier manner when compared to the use of a conventional meter.

Acoustic Doppler Velocimeter

ADVs measure a single two-dimensional point velocity. The ADV can be placed on a wading rod. The measured point velocities can then be used in the velocity-area method, which is commonly used by the USGS to measure discharge (Wahl and others, 1995). Unlike conventional current meters, the horizontal velocities that are measured by the ADV are not affected by vertical velocities in the water column.

Acoustic Doppler Velocity Meter

ADVMs measure two-dimensional velocity at multiple points along the acoustic beam. ADVMs can be attached to stationary structures in the water. The measured velocities by the ADCP are used as an index velocity, which can then be used to calculate discharge using index velocity methods (Morlock and others, 2002). If a relationship exists between the index velocity and the mean channel velocity, then the index velocity is converted to a mean channel velocity and multiplied by the cross-sectional area to calculate the discharge. Also, continuous discharge can be calculated at sites that are affected by backwater or tides with the use of an ADVM.

OTHER APPLICATIONS FOR HYDROACOUSTIC CURRENT METERS

Besides measuring velocity, hydroacoustic current meters can also be used for other applications. The measure of the backscatter energy by the hydroacoustic current meter can be used as a surrogate for suspended sediment concentration. The magnitude of the backscatter energy is a function of the suspended sediment concentration in water (Thorne and others, 1991). Two hydroacoustic current meters of different output frequencies can be used to determine both particle size and concentration (Hay and Sheng, 1992). Also, the measured depths from the ADCP can be used as bathymetry data, which can be used to determine scour and fill in the channel.

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