Measuring River Discharge in High Flow (Flood) or High Sediment Concentration Conditions

Conditions Characterized by:

- Unstable (Moving) Bottom
- High Suspended Sediment Near River Bed
- Biased Bottom Track Data
- High Water Velocities

Not Characterized by:

- Stable Bottom
- Unbiased Bottom Track
- Valid Bottom Track Depths

Introduction

The primary function of bottom-track is to measure the ADCP's speed-over-bottom and detected range-to-bottom. In the discharge calculation, these two pieces of information are used to

1. Calculate the absolute water velocity by subtracting the boat's velocity from the relative water velocity measured by the ADCP,
2. Estimate the cross-sectional area of the transect.

During high flow or high sediment concentration conditions, the environment may result in biased bottom track measurements. When the bottom track data is biased, it is necessary to have an external means for estimating the boat's velocity.

Measuring Discharge when Bottom Track Velocity Data is Biased

Differential GPS (dGPS) provides this means to estimate the boat's velocity while underway. The dGPS calculates the boat's position to an accuracy of about 1-3m and supplies it every second or so. These waypoints can be differentiated to calculate the boat's velocity. *TRANSECT v. 4.04* and higher incorporates the GPS data into the real-time calculation of discharge. For more information on using differential GPS, refer to the When to Use Differential GPS in Place of Bottom Track application note and Appendix D - Using GPS and Depth Sounders of the *TRANSECT 4.0* Manual.

Bottom Detection in High Suspended Sediment Concentrations

In order for the ADCP to correctly detect the bottom, the signal reflected from the bottom must be significantly higher than the signal reflected from the suspended scatterers in the water column. If there is a high sediment concentration near the bottom, there may not be enough contrast between the water and bottom returns, and the ADCP will not detect the true range to the bottom.

Some users have gotten around this problem by using a lower frequency ADCP. The lower frequency allows the acoustic signal to "punch through" the suspended sediment and better detect the bottom. The reason for this is that the acoustic wavelength longer

for lower frequency systems, and these longer wavelengths are not as effectively backscattered by the water. This allows for more contrast between the reflected energy of the suspended particles and the highly reflective bottom. If a valid detection of the bottom cannot be made by the ADCP, *TRANSECT v. 4.04* (and higher) can be used to integrate depth sounder data in place of bottom track depths in the discharge calculation.

Symptoms of Biased Bottom Track Measurements

If one or more of the following occurs, it is an indication of bias in the bottom tracking data:

- The *course made good* is longer than expected.
- The shiptrack plot shows an upstream offset compared to the actual track taken by the boat.
- If you hold station at a position in the channel, the shiptrack indicates that you are moving upstream.
- Discharge is lower than expected and not reproducible to better than 5%

NOTE. The ADCP is not malfunctioning – but the moving bottom conditions lead to biased data.

Identifying Bottom Track Bias

You can test your measurement site to identify if the bottom track velocities are biased. In the *TRANSECT* **ACQUIRE** module, press **F4** to start pinging. Hold or anchor the boat in a fixed position near the center of the channel (where the flow and depth is greatest). Press **F5** to start recording data. Keep the boat as stationary ("on-station") as possible (small ship movements are unavoidable). In Transect, switch to the SHIPTRACK display (ShipTrack - Bottom Track). When you begin to see data being plotted on the shiptrack display, press **Alt-Z** to "zoom in". Continue holding your position for 5 to 10 minutes.

If you begin to see a red shiptrack plot moving in a general upstream direction (against the river flow direction) as shown in Figure 1, you have biased bottom track velocities. This is also identified by a steadily increasing value for "Made Good" on the right side of the Transect screen. When you have acquired your desired amount of data, press **F5** to stop recording.

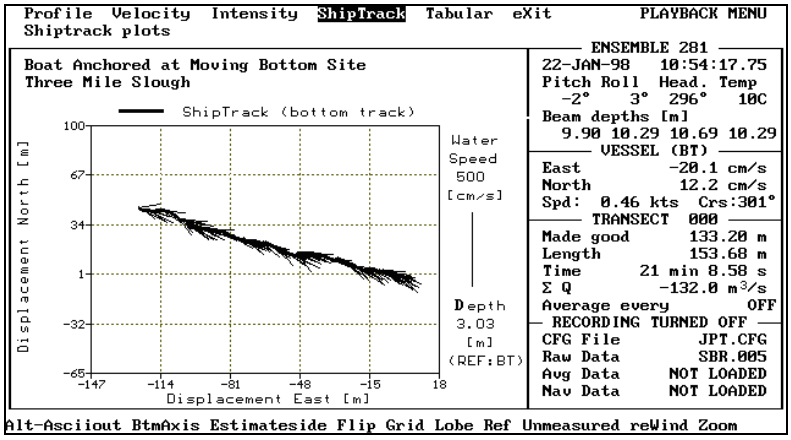

Figure 1. Ship's Track showing Bottom Track Bias

To determine if the bottom motion is fast enough to significantly affect your discharge values, divide the displacement reported by the ship's track plot by the time spent holding th of the value of the water flow, it will only introduce a 1.6% error in the discharge, and Bottom Track can by used as the velocity reference. If the value is greater than 1/60th, you should use dGPS in place of Bottom Track as the velocity reference. Another way to look at this is that you can accept one ft/min of bottom motion per 1ft/sec of water velocity. For example, if the water velocity is 5 ft/sec, than we can neglect bottom motion if it is less than 5 ft/min.

Effects of Biased Bottom Track Velocities

In high flow (flood) and high sediment concentrations, the environmental conditions are such that it may become difficult to make valid bottom track measurements, and in some cases with extremely high turbidity, the ADCP cannot measure water profiles due to very high levels of absorption. A schematic of the environmental conditions is shown Figure 2.

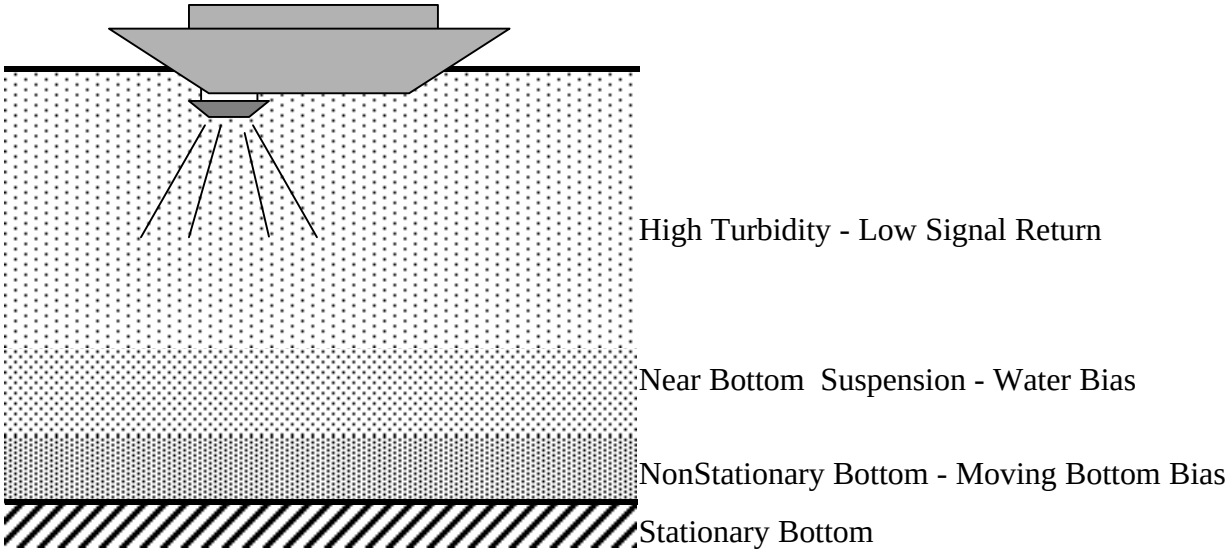

Figure 2. High Flow and Sediment Concentration Effects on Water Profiling and Bottom Tracking

Environmental Sources of Biased Bottom Track Velocities

There are two environmental sources that can produce biased values for ADCP bottom track velocities.

1. **High sediment concentration in the water column (Water Bias)**

   During the time that the bottom tracking sound pulse is in contact with the riverbed (river bottom), echoes (backscattered energy) from the sediment in the water are mixed with the echo from the river bottom. Since this near-bottom water is moving and the bottom is not moving, the mixing of the "water mass" echo with the bottom track echo biases the true velocity over ground.

2. **Fluid layer of sediment flowing along the bed of the stream (Moving Bottom)**
   If the streambed is actively transporting sediment, it is not a good stationary reference for making bottom track measurements. In this case, the ADCP assumes that the bottom is stationary and the ship's track will show an upstream path when the boat is anchored.