August 31, 2006

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Mail Stop 415

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2006.04

SUBJECT: Availability of the report "Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport" by David S. Mueller and Chad R. Wagner (Scientific Investigations Report 2006-5079) and guidance on the application of the Loop Method

This memorandum (1) announces the availability of the report "Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport" (SIR 2006-5079), and (2) provides guidance on the application of the loop method.

The loop method may be used to correct a discharge measurement made with an acoustic Doppler current profiler (ADCP) that is biased low by sediment transport, often referred to as a moving bed, and to make the required moving-bed test (OSW Technical Memorandum 2002.2). When a moving bed is present, the use of a differentially corrected global positioning system (DGPS) for the navigation reference is the preferred method of making a discharge measurement with an ADCP. However, there are situations where a DGPS is unavailable or cannot be used reliably. In these situations, the loop method is a valuable alternative for correcting biases in discharge measurements caused by a moving bed.

The loop method must be applied properly or it may produce incorrect results. Anyone planning to use the loop method should read and follow the subject report (SIR 2006-5079), which describes the procedures, limitations, and uncertainties associated with the loop method. Some key aspects of the loop method are summarized here.

1. The ADCP compass must be properly calibrated using the manufacturer's internal compass calibration routines. For Rio Grande instruments, the compass should be evaluated after the calibration is completed. It is recommended that the compass error during evaluation should be less than 1-degree.

2. The navigation reference must be set to bottom track in the ADCP data-collection software (WinRiver or RiverSurveyor).

3. Bottom track must be maintained throughout the loop. Loss of bottom track during the loop will cause inaccuracies in the computed moving-bed velocity. The amount of bottom track data that can be lost without significant impact on the method is difficult to specify. The hydrographer must consider how much data are lost and if the lost data are accurately represented by adjacent data. If it is

determined that lost bottom track is adversely impacting the loop method, the loop method may not be appropriate for that location and flow condition and another method of determining the moving-bed bias or means of measuring the discharge may be needed.

4. The loop should begin with the boat located at a fixed, nonferrous marker. The boat is maneuvered to make the discharge measurement at a uniform speed back and forth across the channel, including while turning the boat at the far shore. The boat must return to the exact same starting point marker. Uniform speed is required to obtain a spatially uniform sampling of the moving-bed conditions throughout the cross section. If boat speed varies, the moving-bed computation will be biased by the part of the cross section with the most data.

5. The duration of the loop should be 3 minutes or greater, and the boat speed should not exceed 1.5 times the mean downstream water velocity.

When appropriate, using the loop method as a moving-bed test has the advantage of measuring bed conditions throughout the part of the cross section that can be directly measured with the ADCP. The loop method, therefore, results in a more representative moving-bed test than a single-location stationary moving-bed test. Either a loop test or stationary test can be used to satisfy the moving-bed test requirement described in OSW Technical Memorandum 2002.2.

The subject report describes an analysis of the uncertainty associated with the loop method and concludes that the uncertainty is 0.02 ft/s. A measured moving-bed velocity of less than 0.04 ft/s (2σ) may be caused by method uncertainty rather than sediment transport. When using the loop method, a measured mean moving-bed velocity of at least 0.04 ft/s indicates the presence of a moving-bed. If the measured moving bed velocity exceeds 0.04 ft/s, the ratio of the mean moving-bed velocity and mean water velocity should be computed by dividing the mean moving-bed velocity by the mean water velocity. If this ratio is greater than 0.01, the apparent bed movement will cause at least a 1-percent negative bias in the computed discharge and a method that accounts for or corrects for a moving bed should be used. NOTE: The guidance provided in this paragraph supersedes the guidance described in Step 4, Processing for Moving-Bed Test, in the Appendix—Step-by-Step Procedures for Using the Loop Method of SIR 2006-5079.

EXAMPLE 1: The mean water velocity is 2 ft/s and the loop method measured a moving bed of 0.03 ft/s. It can be assumed that there is no moving bed condition because the moving bed velocity is less than 0.04 ft/s.

EXAMPLE 2: The mean water velocity is 2 ft/s and the loop method measured a moving bed of 0.05 ft/s. The ratio of the mean moving-bed velocity and mean water velocity should be computed by dividing 0.05 ft/s by 2 ft/s to yield 0.025, which is greater than 0.01 and indicates that a method that accounts for or corrects for the moving bed should be used.

EXAMPLE 3: The mean water velocity is 6 ft/s and the loop method measured a moving bed of 0.05 ft/s. The ratio of the mean moving-bed velocity and mean water velocity should be computed by dividing 0.05 ft/s by 6 ft/s to yield 0.0083, which is less than 0.01 and thus no significant bias in discharge will be caused by a moving bed.

The mean moving-bed velocity measured by the loop method can also be used to correct the measured discharge for the bias caused by the moving bed. The loop method correction only adjusts the discharge; the measured velocities are still biased low. To use the loop method to correct the measured discharge, the discharge should be measured in accordance with OSW Technical Memorandum 2002.02 and the moving-bed velocity measured using the loop method as described in the subject report (SIR 2006-5079). The subject report presents two methods, mean and distributed, for applying this correction to the discharge measurement. The mean-correction method, which can be easily computed by hand, uses the mean moving-bed velocity and the cross-sectional area perpendicular to the flow to compute the discharge under calculated due to the moving bed. This discharge is simply added to the measured discharge to obtain the final corrected discharge. The second correction method distributes the mean moving-bed velocity across the cross section based on the near-bed water velocity in each ensemble or profile. This distributed correction should provide a more accurate correction for those cross sections that have significant spatial variations in depth and moving-bed velocity. Computations needed to apply the distributed correction method are best accomplished by a computer program such as the program Loop Correction (LC).

Loop Correction is a computer program written to determine if a moving bed is present from the loop method data and to correct the measured discharge using the distributed correction method. The computer program reads ASCII files in the standard ASCII output format from Teledyne RD Instruments WinRiver. SonTek/YSI RiverSurveyor can also output files consistent with this format. The LC program first requests the user load the loop data file. The mean moving-bed velocity is computed and the direction checked to verify that it is in the upstream direction. The criteria for determining if the data reflect a moving bed are applied and reported to the user. If a moving-bed is detected, the user can select the files (transects) for the discharge measurement. The program will read the files and compute the corrected discharge. The results of the entire process are displayed for the user and can be saved to a file and printed for inclusion in the measurement archive.

A copy of subject report, SIR 2006-5079, can be downloaded from:
http://pubs.usgs.gov/sir/2006/5079/

A revised Appendix for the subject report (SIR 2006-5079) of the step-by-step procedures for using the loop method that are consistent with this memorandum can be downloaded from: http://hydroacoustics.usgs.gov/policy/. It is recommended that this revised Appendix be printed out and placed in the subject report.

A copy of the LC program can be downloaded from:
http://hydroacoustics.usgs.gov/equipment/software/

If you have any questions or comments about the policies and guidance in this memo, please contact David S. Mueller (dmueller@usgs.gov), Kevin Oberg (kaoberg@usgs.gov), or the OSW Hydroacoustics Work Group (hawg@simon.er.usgs.gov)

Stephen F. Blanchard *(signed)*
Chief, Office of Surface Water