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April 23, 2009

Memorandum

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2009.05

SUBJECT: Publication of the Techniques and Methods Report Book 3-Section A22 “Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat” and associated policy and guidance for moving boat discharge measurements.

This memorandum (1) announces the availability of the Techniques and Methods (T&M) report “Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat” (Techniques and Methods Report Book 3-Section A22) and (2) provides a summary of the updated guidance for moving boat acoustic Doppler current profilers (ADCP) measurements. The report presents techniques and guidance for moving boat ADCP discharge measurements in a logical progression, from pre-deployment planning, to field-data collection, and finally to post-processing of collected data.

The techniques and policies described in this T&M report represent the most up-to-date guidance on moving boat discharge measurements with ADCPs. The guidance is based on the experience of U.S. Geological Survey (USGS) employees and published reports, papers, and memorandums of the USGS. The policies and guidance provided in this report supersede certain policies and guidance previously published in Office of Surface Water (OSW) technical memoranda and reports. A summary of important new policies is provided below.

1. For every discharge measurement, the temperature measured by the ADCP must be compared with an independent water temperature measurement made adjacent to the ADCP and recorded on the field measurement form.
2. Every moving-boat discharge measurement made with an ADCP must have a recorded moving-bed test (MBT), even if a Global Positioning System (GPS) is used with the ADCP.
3. The loop MBT is preferred if conditions permit, but stationary MBTs are acceptable. The criteria for the loop MBT as described in OSW Technical Memorandum 2006.02 remains unchanged; however, the criteria for a stationary MBT have changed.
4. For stationary MBTs where the ADCP deployment is anchored, tethered, or has GPS data collected simultaneously, the duration of the stationary MBT must be at least 5 minutes; otherwise the duration of stationary MBTs must be at least 10 minutes.

5. The criterion for determining if a moving-bed condition exists when a stationary MBT is conducted from an anchored or tethered boat, or when GPS data are collected simultaneously, is a moving-bed velocity greater than 1 percent of the mean velocity. Otherwise, the criterion for stationary MBTs is a moving bed velocity greater than 2 percent of the mean velocity.
6. If the moving-bed velocity criterion is reached, use of GPS is the preferred method for measuring discharge with an ADCP. If GPS cannot be used, the loop (MBT) method is recommended. If the loop method cannot be applied due to invalid bottom track or compass errors, then (a) multiple stationary MBTs should be conducted and used to correct the moving-boat discharge measurement or (b) the mid-section measurement method with ADCPs should be used.
7. A beam alignment test must be done for each ADCP equipped with a compass used by USGS personnel for measurements of streamflow according to the criteria specified below.

Additional detail on these policies is provided below and in the subject T&M report.

### **Water Temperature Measurements**

It is OSW policy that the temperature measured by the ADCP must be compared with an independent water temperature measurement made adjacent to the ADCP. This check must be performed prior to every discharge measurement and the results recorded on the measurement field form. If the temperature measured by the ADCP temperature sensor differs consistently from the independent temperature measurement by 2 °C or more, or if the ADCP temperature sensor has failed, the ADCP should not be used to make discharge measurements until the temperature sensor is repaired and checked. In the event that a discharge measurement is necessary and another ADCP is not readily available, it may be possible to enter a temperature manually for use in the speed-of-sound calculations. This action is not recommended as standard practice; however, and it may decrease the accuracy of the discharge measurement (see page 18 of the subject T&M report).

### **Moving Bed Tests**

Effective with the release of this report, every moving-boat discharge measurement made with an ADCP must have a recorded MBT. If a site routinely has a moving bed, and GPS is always used with the ADCP, an MBT is still required. The loop MBT is preferred if conditions permit; stationary MBTs are acceptable also.

For stationary MBTs, if the stationary position is maintained by a tether or anchor so that upstream or downstream movement of the ADCP is not possible, or when GPS data are collected simultaneously, the stationary MBT must be recorded for no less than 5 minutes; however, if the ADCP can move either upstream or downstream, such as when the boat operator is trying to maintain the position of the boat (without anchoring), the stationary MBT must be recorded for

no less than 10 minutes. These criteria supersede the guidance on stationary MBTs that have been previously published in OSW Technical Memorandum 2002.02 and Oberg and others (2005).

If the stationary MBT was completed with a fixed tethered deployment, an anchored manned boat, or a manned boat where little movement of the boat was ensured, a moving-bed velocity greater than 1 percent of the mean water velocity at the test location indicates that a moving-bed condition exists. If the MBT was conducted using a manned boat that was not anchored and the boat may have moved either upstream or downstream, a criterion of 2 percent instead of 1 percent is used to determine if a moving-bed condition exists, because of the uncertainty introduced by the boat's movement.

OSW policy on the use of the loop method for doing MBTs is unchanged, but is restated here for convenience. When using the loop method, a moving-bed condition is determined to be present if the measured moving-bed velocity from the loop MBT exceeds 0.04 ft/s, and the moving-bed velocity is greater than 1 percent of the mean water velocity. The minimum duration for loop MBTs remains 3 minutes. For more information, see OSW Technical Memorandum 2006.04 (<http://water.usgs.gov/admin/memo/SW/sw06.04.html>) and Mueller and Wagner (2006).

If a moving-bed condition exists, discharge-measurement methods that are not affected by a moving bed (use of GPS for velocity reference), or methods that correct for the effect of a moving bed, must be used. Use of GPS is the preferred method for measuring discharge using ADCPs at sites where a moving-bed condition exists. If GPS is not available or it is not suitable for use due to site conditions, OSW recommends one of the following methods:

1. Loop method with distributed correction method (implemented in the Loop Correction (LC) program),
2. Multiple stationary moving-bed tests and distributed method using the Stationary Moving-Bed Analysis (SMBA) program, or
3. Mid-section method using ADCPs.

It is OSW policy that the LC software must be used to apply corrections for loop MBTs. Corrections based on stationary MBTs should be applied using the SMBA software (Mueller and others, 2009) unless site conditions do not meet the assumptions in SMBA (that higher moving-bed velocities are associated with higher near-bed water velocities). If the assumptions in SMBA do not apply to a particular site, the hydrographer is responsible for documenting the logic and computations used to apply a discharge correction from the stationary MBTs. For more information on these methods, including details as to their application and the detection of a moving-bed condition, please see Appendix B of the subject T&M report.

## **Beam Alignment Tests**

A beam alignment test is described in the subject T&M report and by Oberg and others (2005). This test is useful for detecting beam misalignment errors in ADCPs equipped with a compass and such errors will result in biased velocity measurements.

Each ADCP equipped with a compass used by USGS offices for measurements of streamflow must be tested: (1) when the ADCP is first acquired; (2) after factory repair and prior to any data collection; (3) after firmware or hardware upgrades and prior to any data collection; and (4) every three years. The tests should be conducted on a lake or a stream where a moving-bed condition does not exist and where the ADCP can be used to obtain accurate bottom-track data (for example, not too shallow or too deep for bottom tracking). A sub-meter GPS should be used in conjunction with the ADCP. For any USGS office that does not own a suitable GPS, the USGS Hydrologic Instrumentation Facility will rent them to the offices. It is NOT necessary to do a compass calibration prior to conducting the tests. For a detailed description of the test and interpreting results, see Appendix D of the subject T&M report.

If you have any questions or comments about the policies and guidance in this memo, please contact Kevin Oberg ([kaoberg@usgs.gov](mailto:kaoberg@usgs.gov)), Dave Mueller ([dmueller@usgs.gov](mailto:dmueller@usgs.gov)), Chad Wagner ([cwagner@usgs.gov](mailto:cwagner@usgs.gov)), or the OSW Hydroacoustics Work Group ([hawg@simon.er.usgs.gov](mailto:hawg@simon.er.usgs.gov)).

/signed/

Stephen F. Blanchard  
Chief, Office of Surface Water

## **References**

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Mueller, D.S., Rehm, M.S., and Wagner, C.R., 2009, Using a StreamPro Acoustic Doppler Current Profiler in Moving-Bed Conditions: Problems and Solutions: Proceedings of the 33<sup>rd</sup> IAHR Congress, Vancouver, Canada, American Society of Civil Engineers, in press.