In Reply Refer To: December 7, 2001
Mail Stop 415

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM NO. 2002.02

SUBJECT: Policy and Technical Guidance on Discharge Measurements using Acoustic Doppler Current Profilers

The purpose of this memo is to provide policy and technical guidance for the measurement of discharge using acoustic Doppler current profilers (ADCP's). The term ADCP is used here to describe acoustic Doppler profiler instruments used for making velocity-profile and discharge measurements from moving platforms and does not refer to any specific brand or model. This memo supersedes Office of Surface Water (OSW) Technical Memorandum 96.02, *Interim Policy and Technical Guidance on Broadband Acoustic Doppler Current Profilers.*

Policy and technical guidance described in this memo is based on knowledge and experience with ADCP's obtained by the USGS during the past 8 years, OSW training materials, and the report *Quality Assurance Plan for Discharge Measurements Using Broadband Acoustic Doppler Current Profilers* (Lipscomb, 1995). Although this report still is mostly applicable, it currently is in revision. Policies and guidance discussed in this memo supercedes information found in Lipscomb (1995). The policies described in this memo have been reviewed by the OSW Hydroacoustics Work Group (OSW Memorandum).

ADCP performance and operational characteristics are changing frequently as hardware and software continue to improve. Frequent revisions of software, firmware, and documentation revisions are expected in the foreseeable future. Thus, policy and technical guidance will be subject to change and revision, and some information may be specific to a particular system, version, or manufacturer.

Policies

The following policies apply to use of the ADCP's for making velocity-profile and streamflow measurements from moving vessels.

Field Measurements

The following policies for measurements of streamflow using ADCP's are provided:

1. After the ADCP is mounted and deployed on the boat and prior to each measurement, the depth of the ADCP in the water should be measured and recorded. The depth of the ADCP is the vertical distance from the water surface to the center of the transducer faces. When measuring the ADCP depth, make sure that the roll and the pitch of the boat are

similar to roll and pitch during the discharge measurement. A bias in the ADCP depth measurement can result in a significant bias in the resulting measured discharges.

2. A minimum of four (4) transects (two in each direction) will be made under steady-flow conditions. The measured discharge will be the average of the discharges from the 4 transects. If the discharge for any of the 4 transects differs more than 5 percent from the measured discharge, a minimum of 4 additional transects will be obtained and the average of all 8 transects will be the measured discharge. Whenever possible, reciprocal transects should be made to reduce potential directional biases.

3. It may be necessary to use individual transects as discrete measurements of discharge under rapidly varying flow conditions. The rationale for using individual transects as measurements should be documented and permanently stored with the discharge measurement or applicable station analyses or files. However, whenever possible, pairs of reciprocal transects should be made to reduce directional biases.

4. It is important to select appropriate sites for streamflow measurements. The guidelines provided in Water Supply Paper 2175 (Rantz and others, 1982) still are applicable and should not be ignored when using an ADCP. Many ADCP measurement problems can be solved by moving to a better measurement section.

5. A moving bed test must be recorded prior to making any measurements. At least one section of the river should be identified where the potential for bed movement is greatest. Although the location of maximum potential bed movement cannot easily be predicted a priori, it often occurs in the region of maximum water velocity. However, at times, bed movement is observed in the low-water flood plain area. When in doubt, make moving-bed tests at 3-5 sections across the river.

   The vessel used to make the moving bed test should be held in a stationary position for about 10 minutes, provided that this can be done safely. While in this stationary position, ADCP data should be recorded and examined for any apparent upstream movement of the boat relative to the channel bottom. If apparent upstream boat movement is measured, then the water velocity measured by the ADCP will be less than the true water velocity and the discharge measured by the ADCP will be less than the true discharge.

6. For sites where a moving bed condition is observed, a differentially corrected global positioning system (DGPS) supporting NMEA-0183 output (Trimble Navigation Limited, 1999, Appendix D) should be used instead of bottom-tracking to compute vessel velocity when this condition is present. The presence of a moving bed condition likely will be flow-dependent. This information should be included in the station description for the streamgaging station in question. If you discover a moving bed condition at your site and do not have a DGPS with you, it is suggested that you make multiple moving bed tests at different locations in the measurement cross section and then proceed with your discharge measurement (using bottom tracking as the velocity reference). Although this measurement will be biased low – at least it will provide some indication of the true discharge and is better than not having a measurement.

The DGPS must be capable of sub-meter accuracy. When using a DGPS, it is necessary to properly calibrate the internal compass of the ADCP, and to measure or obtain an accurate estimate of the local magnetic variation. For more information on compass calibrations and use of DPGS, users are directed to the OSW ADCP Web pages, manufacturer help files, and are encouraged to attend the Advanced ADCP Applications training class (http://hydroacoustics.usgs.gov/training/).

7. Average boat speed for each transect should be less than or equal to the average water speed. Where safe and practicable, a non-ferrous tag line can be used to allow more control over boat speed when making low-velocity measurements. Under certain conditions it may not be possible to keep the boat speed less than the water speed. As a result, additional transects should be made or the estimate of measurement quality downgraded. When using DGPS it is very important to keep the boat speed as low as practical because errors in compass calibrations are additive and will increase with boat speed.

8. Edge distances for estimation of edge discharge must be measured using an electronic-distance measuring device, a tagline, or some other accurate measuring device. OSW ADCP Web pages contain information on various devices for measuring edge distances (http://hydroacoustics.usgs.gov/distance.html).

9. ADCP's may not accurately measure depths in streams with high sediment concentrations and/or high bedload transport. In these instances it may be necessary to use a vertical depth sounder. The sediment concentration or bedload transport rate at which it becomes necessary to use a depth sounder is not presently known. As we learn more about his issue, further guidance will be provided. If you have a "moving bed condition" at your measurement site we recommend that you make several trial measurements using a vertical depth sounder to determine if the ADCP depths are representative under a variety of flow conditions. It may be possible for USGS offices to temporarily borrow an echo sounder by contacting Kevin Oberg (kaoberg@usgs.gov).

Training

Personnel collecting and reviewing ADCP data for discharge measurements must have completed the USGS training class, *Measurement of Streamflow using ADCP's*. For more advanced applications and measurement situations, including the use of DGPS; users are strongly encouraged to complete the USGS training class, *Advanced ADCP Applications*. Information regarding USGS ADCP training classes may be found at http://hydroacoustics.usgs.gov/training/.

Users are responsible to keep current with policies, and recommended procedures and practices. Attendance of a recent ADCP training classes or the USGS Hydroacoustics Workshop, subscription to the acoustics mailing list, and review of the OSW ADCP Web pages are all valid ways of keeping current.

Measurement Documentation And Processing

Measurements made with the ADCP should be documented using the acoustic profiler discharge measurement note sheet (Attachment A--http://il.water.usgs.gov/adcp/memos/index.html). When processing ADCP measurements, measurement data should be carefully reviewed. Listed below are the most common problems found when reviewing ADCP data.

- No moving bed test
- Boat speed too fast
- Edge distances not measured
- Incorrect blanking distance
- Poor data-archival procedures
- ADCP depth incorrectly set
- Incorrect extrapolation method
- Poor field notes
- Incorrect number of depth cells
- Use of ferrous metal mounts

The Hydroacoustics Work Group currently is developing tutorials on finding and correcting some of these problems. When they become available on the OSW ADCP Support World Wide Web pages (http://hydroacoustics.usgs.gov/), an announcement will be made to the acoustics mailing list (acoustics@simon.er.usgs.gov).

For additional information regarding these policies and guidance, please contact Kevin Oberg by phone (217-344-0037 ext 3004) or by email (kaoberg@usgs.gov).

References

Trimble Navigation Limited, 1999, AgGPS 124/132 Operation Manual: Trimble Navigation Limited, Sunnyvale, CA, USA, 170 p.

Lipscomb, S.W., 1995, Quality assurance plan for discharge measurements using Broadband acoustic Doppler current profilers: U.S. Geological Survey Open File Report 95-701, 12 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow, Volume 1, Measurement of discharge: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

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Attachment

SUPERCEDES OSW Technical Memorandum No. 96.02

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