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January 9, 2012

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2012.01

Subject: Processing ADCP Discharge Measurements On-site and Performing ADCP Check Measurements.

Purpose:

This memorandum clarifies policies on processing acoustic Doppler current profiler (ADCP) discharge measurements at the field site and techniques for performing ADCP check measurements.

Background:

It has been a long-standing practice for hydrographers in the U.S. Geological Survey (USGS) to compute the measured discharge and compare the measured discharge to the rated discharge prior to leaving the site. Techniques and Methods 3-A8 "Discharge Measurements at Gaging Stations" states:

> *"Computing and plotting the measurement on site.*—Compute a discharge measurement as soon as possible after it is completed. Do this at the site before leaving. If the measurement does not plot within 5 percent (or other specified percentage) of the rating curve in use, or if it is not in line with the previous trend of measurements, try to find an explanation. For instance, there may be an obvious change of the control that would explain the deviation. All such explanations should be documented in the measurement notes. If a satisfactory explanation cannot be found, then make a check measurement."

While early techniques for collecting and computing ADCP discharge measurements may have made it impractical to obtain a final discharge before processing the measurement in the office, advancements in technology now allow for efficient processing of ADCP measurements in the field. However, many ADCP measurements are still being processed at the office, often days after the measurement was made. This delay may result in missing a critical data-quality issue that can only be resolved at the site.

Processing an ADCP Measurement On-Site

USGS policy requires that all discharge measurements be computed on-site to obtain, as nearly as possible, the final discharge, and that the discharge should be plotted on or compared with the applicable discharge rating before leaving the site. In order to do this, all of the following steps must be completed prior to leaving the measurement site:

1. **Verify Compass Calibrations and Accuracy** - Valid compass headings are critical for loop moving-bed tests and when using global positioning system (GPS) for reference. Appropriate calibration routines must be performed as close to the measurement cross section as possible. An accurate compass calibration requires the entire deployment, everything moving with the ADCP, be rotated during the calibration. It is not acceptable to rotate the ADCP in the mount beside a manned boat without rotating the manned boat. For a manned boat with a tethered boat attached, both the manned boat and tethered boat need to be rotated together. It is possible to have a calibration that is "good", but the heading be adversely affected by something in the cross section, resulting in invalid or biased compass readings. Watch for compass issues while collecting data. Indications of compass errors include: a) heading difference warning reported by LC or equivalent manufacturers software, b) loop ends significantly downstream of starting location, c) shiptrack for bottom track (BT) is downstream of shiptrack for VTG or GGA references, or d) large variations in transect discharges when using GPS references (GGA or VTG), which are not apparent when using BT reference. If potential compass issues are observed, try recalibrating in a different location and/or changing the measurement location.
2. **Perform / Evaluate Moving-Bed Tests** – Evaluate moving bed tests in SMBA (stationary moving-bed tests), LC (loop moving-bed tests), or versions of these utilities that have been integrated into the manufacturers software. If a moving bed is found, either GPS should be used as reference, or the bottom track discharge corrected appropriately using the techniques in SMBA or LC. GPS should be used in moving-bed conditions whenever accurate and reliable GGA or VTG data can be collected. The validity of the loop moving-bed test is dependent on continuous bottom track and accurate compass headings, especially when the boat is changing directions or in areas where moving bed is more likely. Therefore, if there is significant invalid bottom track or the compass is inaccurate, as indicated by warning messages in LC, either repeat the loop until reliable results are obtained or perform a stationary moving-bed test.
3. **Evaluate GPS** – When using an external GPS, verify data output are correct. This includes: a) differentially-corrected GGA NEMA strings with 5-decimal minute precision for latitude and longitude, b) VTG NEMA strings with 2 decimal precision for speed, c) a GPS update rate of 5Hz or greater when possible (see baud rate recommendations at http://hydroacoustics.usgs.gov/movingboat/pdfs/HydroacousticsUpdate-GPSBaudRates.pdf), d) no lag/latency between GPS data and ADCP data (drive course changing directions, ensuring GPS/BT change directions at same time in shiptrack plot), d) ensure that any positional filters in the GPS receiver are turned off, and e) verify the correct magnetic variation (declination) is entered into the software.
4. **Check for Air Entrainment** – Review SNR or Intensity profile plots (ideally during data collection), looking for differences in individual beam intensities that increase with water velocity or turbulence. If this occurs the hydrographer should a) increase ADCP depth, b) take steps to minimize pitch/roll during data collection, and/or c) locate another cross-section.

5. **Select the Proper Reference** - The appropriate ADCP reference should be determined as either bottom track, GGA GPS, VTG GPS, or moving bed corrected (LC or SMBA) bottom track. Note: SonTek RiverSurveyor Live software has the ability to substitute references (called "Composite Track") when the selected reference is invalid. When using RiverSurveyor Live, check for any reference substitutions, making sure the alternate reference used is valid. If GPS data are substituted for bottom track, it is important to have a compass calibration with accurate headings and the correct magnetic declination entered, just as if you were using GPS as the reference.
6. **Examine Distribution of Errors** – Examine contour plots for the distribution of invalid or missing data. If a significant amount of data are invalid or missing in one portion of a transect, that transect should not be included in the computation of discharge. Additional transects may be needed to meet the minimum measurement exposure time requirement of 720 seconds and maintain an even number of transects with reciprocal courses (OSW Technical Memorandum 2011.08). Any replacement transects should be made in the same direction as the discarded transect. The rationale for discarding any transect should be documented.
7. **Evaluate Edge Discharges** – Verify that edge discharges computed in the ADCP software are reasonable for the site. If an individual edge discharge is more than 5% of the total discharge, an alternate method of measuring/estimating the discharge should be used to check the edge discharge. An alternate method could include measuring and/or estimating multiple point velocities and depths in the edge and computing a discharge for the edge using the midsection method. If the edge discharge measured with the alternate method agrees with the ADCP software edge discharge, the ADCP software edge discharge should be used. If the check discharge does not agree with the ADCP software edge discharge, the more accurate of the two discharges, based on the hydrographer's judgment, should be used. The alternate method must be documented with the measurement.
8. **Apply Thresholds and Data Screening** – Apply any thresholds and data screening needed to filter out obvious erroneous data that may affect the final discharge.
9. **Evaluate Extrapolation Methods** – Verify that the extrapolation methods used for the top and bottom discharges are valid using the extrap program. The same extrapolation method should be used for all transects in a measurement.

While there are many situations when it may be beneficial to use a PDA or mobile phone software for ADCP measurement data collection, all of the above items cannot be completed on the currently available handheld (PDA/mobile phone) software. At the field site, hydrographers must move the measurement to a laptop after data collection to process the measurement, review the measurement, and obtain a final discharge. The final discharge should then be compared with the rated discharge and a determination made as to whether a check measurement is necessary.

When a number of consecutive measurements are made during a site visit, such as making continuous measurements over a tidal cycle, it may not be possible to obtain a final discharge to compare with rated discharge on-site. However, as much as practical, the items listed above should be completed to avoid measurements that contain critical data-quality issues.

ADCP Check Measurements

Check measurements are a critical quality assurance component in rating development and verification. If the discharge measurement does not verify: a) a defined segment of the rating curve by 5 percent (or other percentage specified in the Water Science Center Surface Water QA Plan), b) the trend of departures shown by recent measurements (including when the deviation from the trend is a sudden return to the rating), or c) an obvious and documented change in control conditions, the hydrographer is expected to make a second discharge measurement to check the original measurement.

When making a check measurement, change as much as is practical about the measurement while still maintaining the overall quality of the measurement. Ideally a different ADCP or Price meter will be used. However, using a different instrument is not always possible or practical. Other potential changes for the check measurement include: a) measurement method (moving boat or mid-section), b) cross section, c) power (batteries), d) ADCP depth, e) ADCP configuration, and f) operator. Make the check measurement as close in time and gage height to the original measurement as possible. If an ADCP is used for both the original and check measurement, the complete ADCP measurement procedure must be repeated, including: diagnostic tests, compass calibration, moving-bed test, and ADCP configuration. During rapidly changing flow, it may not be possible to complete a check measurement in the same segment of the rating. However, multiple measurements should still be made to help verify trends in the departure over the changing conditions.

Policies in this memo clarify and expand on those documented in Techniques and Methods Book 3-Section A22 “Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat”. Water Science Centers should verify that their Surface Water QA Plan is in agreement with the policies contained in this memorandum. Questions concerning these policies should be directed to the Mike Rehmel (msrehmel@usgs.gov) or the OSW Hydroacoustics Work Group (hawg@simon.er.usgs.gov).

Robert R. Mason*//signed//*

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