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April 23, 2009

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2009.04

SUBJECT: Application of FlowTracker firmware and software mounting correction factor for potential bias

The purpose of this memorandum is to establish policy regarding the application of a mounting correction factor for potential bias from wading rod mounts for SonTek/YSI[1] FlowTrackers used for measuring velocity and discharge. The mounting correction factor is available in firmware version 3.7 and software version 2.30. The addition of the mounting correction factor for potential bias is the only modification in this firmware and software that will affect field users. Upgrading to this new firmware and software is optional for U.S. Geological Survey (USGS) users, although new FlowTrackers will come standard with this firmware and software.

Policy for use of the Mounting Correction Factor

A potential bias of 1 to 2 percent was identified in the x-velocity component (streamwise component) during tests conducted using a FlowTracker in a tow tank with a standard wading rod and offset mount. SonTek/YSI has released new versions of firmware (3.7) and software (2.30) for the FlowTracker to allow a setting called "mounting correction" that may be used to adjust the measured x-velocity component for flow disturbance in the sample volume caused by the mounting bracket and wading rod. After careful investigation and analysis, the policy of the Office of Surface Water (OSW) is that the "mounting correction" must NOT be applied because follow-up USGS field comparisons, flowing water numerical simulations, and lab comparisons in flowing water did not indicate a consistent bias of this magnitude for expected field applications.

Summary of Supporting Investigations

SonTek/YSI alerted the OSW that they had identified a bias in velocity measurements collected in a tow tank in Switzerland. Their investigation showed a negative bias of 1 to 2 percent from flow disturbance caused by the mounting bracket (round-S, flat-S, and flat-J) and the standard top-setting wading rod for conditions with the flow aligned with the FlowTracker. Subsequently the OSW, in cooperation with SonTek/YSI, completed (1) additional testing at the Hydrologic Instrumentation Facility (HIF) in both the jet tank and tow tank, and (2) simulated the flow field around the instrument, mounts, and wading rod using a 3-dimensional numerical model.

[1] Any use of trade, product, or firm names in this document is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Tests conducted in the HIF tow tank (moving instrument in still water) indicated biases of -1.6 percent, -1.6 percent, and -1.7 percent for the Flat-J, Flat-S, and Round-S brackets, respectively, which are consistent with those reported by SonTek/YSI. However, the bias was reduced to -0.6 percent for the Flat-J bracket in the turbulent flow of the jet tank which is more representative of flowing water field conditions. Numerical simulations of the HIF tow tank mount and the Flat-J bracket on a wading rod confirmed the observations from the HIF tow tank and jet tank to within 0.2 percent and provided further evidence that the bias caused by the mounting bracket and wading rod was about 1 percent less in turbulent flowing water than in tow tank tests with a moving instrument in still water. In addition, the effect of flow angles investigated in the tow-tank tests conducted at the HIF showed that the bias changed with flow angle through a range of about -0.7 to -2.5 percent depending on flow angle (30 to -30 degrees).

Pierce (1941) showed that in field measurements the hydrographer's presence in the stream holding the wading rod caused the measured velocity to vary from about +3 percent to -4 percent depending on the site conditions and position of the hydrographer. Pierce's analyses were done with Price AA current meters. The OSW investigated the effect of the hydrographer in the stream on FlowTracker measurements. Numerical simulations using two cylinders (representing the legs of a hydrographer) located at the recommended location for the hydrographer (Pierce, 1941; Rantz, 1982) resulted in a positive bias of approximately +2 percent in FlowTracker measurements.

Rehmel (2007) published a comparison of 55 measurements of discharge made with a FlowTracker to those measured with Price AA and pygmy meters. He found no statistical difference between FlowTracker measurements and Price AA/pygmy measurements, with a mean difference for all 55 measurement comparisons of -0.1percent.

Therefore, based on the research and measurement comparisons completed to date, ***the OSW policy is that the velocity bias correction feature of the new FlowTracker firmware and software <u>not</u> be used at this time*** because the bias caused by the flow disturbance of the mounting bracket and wading rod:

a) varies with flow angle,
b) is expected to be less than 1 percent in turbulent flowing water typical of our field measurements,
c) is less than the potential bias caused by the position of the hydrographer in the stream, and
d) was not evident in 55 comparison field measurements.

One of the variables affecting the bias in the measured velocity is the position of the hydrographer in the stream. It is important that the hydrographer stand

> "…in a position that least affects the velocity of the water passing the current meter. That position is usually obtained by facing the bank so that the water flows against the side of

the leg. The wading rod is held at the tag line by the hydrographer who stands about 3 in (0.07 m) downstream from the tag line and 1.5 ft (0.46 m) from the wading rod." (Rantz, 1982, page 146).

Hydrographers are also encouraged to use the FlowTracker bubble level with an alignment rod available from the Hydrologic Instrumentation Facility to properly align the FlowTracker with the tagline. Misalignment of the FlowTracker with the tagline can also result in a biased velocity and discharge measurement.

Additional research is ongoing and it is OSW's intent that this work be documented in an appropriate peer-reviewed publication. Although not expected, if additional research indicates a need for a bias correction, additional guidance for that correction will be provided by the OSW.

If you have any questions or comments about this memo, please contact David Mueller (dmueller@usgs.gov) or the OSW Hydroacoustics Work Group (hawg@simon.er.usgs.gov).

/signed/

Stephen F. Blanchard
Chief, Office of Surface Water

References

Pierce, C. H., 1941, Preliminary report on position of the engineer in discharge measurements by wading: U.S. Geological Survey.

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

Rehmel, M. S., 2007, Application of acoustic Doppler velocimeters for streamflow measurements: Journal of Hydraulic Engineering, Vol. 133, No. 12, December, ASCE, Reston, Va., pp. 1433-1438.