Sontek RiverSurveyor Test Plan

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February 20, 2004

INTRODUCTION

Sontek/YSI has introduced new firmware and software for their RiverSurveyor product line. Firmware changes were made to add a shallow-water ping, which should allow data to be collected in shallow-water and closer to the transducer face in any depth. In addition, modifications were made to the bottom tracking technique and the number of default bottom pings. This change to the bottom-tracking algorithm was prompted by the results of earlier USGS testing and analysis. The latest firmware is version 8.8. Numerous changes to the RiverSurveyor software application have also been made in cooperation with the USGS. Sontek and beta testers in the USGS feel that RiverSurveyor version 4 is much more user-friendly and powerful than previous version. It has several important functions including but not limited to: (a) discharge summary output form, (b) discharge summary table, (c) customizable text windows, (d) more user-friendly setup routines, (e) integration of the compass calibration routine into RiverSurveyor, etc.

New and thorough testing of the RiverSurveyor product line is needed to verify the many new features that have been added. This includes testing of the software, hardware, and the resulting discharges. The development and implementation of this test plan **does not** mean that RiverSurveyor equipment cannot be used, however, during the use of the equipment the user should be careful to look for potential problems and, if possible, collect data and make comparisons that can be shared with the Office of Surface Water to help validate the current firmware and software releases.

RIVERSURVEYOR SOFTWARE

Many different types of comparisons will be needed to fully verify the function of the RiverSurveyor software.

1. **Replaying of Existing Data**. It is recommended that a sample of previously collected data be played back through this new version of RiverSurveyor and the discharges and other selected variables be compared to the results of previous versions. These data sets should include GPS and BT based discharges, unusual edge or profile extrapolation conditions, and instruments of different frequencies. During previous USGS testing and Sontek's continued development of RiverSurveyor some changes were made to the code that will change the value computed for some variables. Therefore these changes should be accounted for in comparing discharges or other variables computed with prior version of RiverSurveyor.

    i. The method for computing discharge, using GPS, was changed in version 3.4.

ii. A correction to the discharges computed in the edge estimates was made in version 3.1
iii. A correction to the computed discharge for measurements where the speed of sound was recomputed due to a salinity change was made in version
iv. The bottom of profile cutoff location has been changed. The program was trimming the profile based on a three-beam depth average depth. The program now trims the profile based on the shallowest beam depth. This may change discharges in steep-banked small canals of about 1% between RS versions 3.5 and 4.2. Sontek observed on some occasions along the riverbanks there was a potential for signal inference in the bottom-cell (above the trim depth) of the profile. This would typically only occur when beam depths were significantly different.
v. The method for computing cross section area was changed several times during beta testing of version 4.

2. **Instrument Setup and Data Collection.** The software needs to be used to setup and collect data in the field. These data should include situations using GPS and an external depth sounder. This test may be combined with the comparison measurement test defined below. Document any problems, bugs, or suggestions for improving the user interface.

DISCHARGE COMPARISON MEASUREMENTS

Defining absolute truth in the field is difficult, if not impossible. However, our standard over the years has been a Price AA or Pygmy meter measurement made in accordance with the standards defined in Water-Supply Paper 2175. Due to unsteady flow a direct comparison may not be possible so we will define three types of comparisons that could be made in descending order of confidence. You must provide all the documentation to support the comparison with your submission of comparison data. All data must be collected using standard procedures defined in the attached document.

Conditions were measurements are needed are define as follows:

Water Velocity (ft/s)	Water Depth (ft)	Bed Condition
<0.5	< 3 ft	Gravel or smoother
0.5-1.5	< 3 ft	Gravel or smoother
<0.5	> 3 ft	Gravel or smoother
<0.5	> 3 ft	Rough bottom
0.5-1.5	> 3 ft	Gravel or smoother
0.5-1.5	> 3 ft	Rough bottom
> 1	> 3 ft	Soft bottom (mud, silt, organics)
> 1	> 3 ft	Hard bottom (bed rock, dense packed gravel)
> 1	> 3 ft	Sand bottom
> 1	> 3ft	Moving bed conditions

1. **Comparison to simultaneous cup meter measurement.** The most defensible comparison is made when the discharge is measured simultaneously with both a cup meter and an ADP. To minimize the effects of unsteady flow the cup meter and ADP measurements should start and stop at the same time. This may mean that many more than 4 ADP transects are collected. The comparison discharge should be based on the average of all ADP transects collected during the cup meter measurement.

2. **Comparison to a rating curve.** At locations where it can be demonstrated that the rating curve is accurate and does not change significantly, measurements can be compared to the rated discharge. For this situation, it is recommended that the rating curve be verified twice on the day of the comparison, once at the beginning of the comparison period and once at the end. Verification can be by a standard cup meter measurement or another accepted measurement technique. Individual comparison measurements can contain as few as four transects that fall within 5 percent of the mean of those 4 transects. By collecting more transects, statistics on the variability of a particular configuration can be computed more accurately.

3. **Comparison to other simultaneous acoustic measurements.** Where another instrument for measuring discharge can be used concurrently, these can be compared to the results using an ADP. These other instruments should already have adequate comparison data to a cup meter or rating to provide confidence in their measurements. Positional and other sources of bias should be evaluated to ensure that any differences in discharge are attributed to the difference in instruments not in how they were deployed. Individual comparison measurements can contain as few as four transects that fall within 5 percent of the mean of those 4 transects. By collecting more transects, statistics on the variability of a particular configuration can be computed more accurately.

BOTTOM TRACK EVALUATION

The objective of these bottom track tests are to verify the accuracy of the bottom tracking algorithms and to determine the limiting conditions in which they can be used. Some of the bottom-tracking tests use GPS as the comparison. The GPS used must have verifiable accuracy. It is recommended that the characteristics of the GPS unit used in such tests be documented by placing the GPS antenna on a tripod in a clear area, not effected by multi-path, and logging at least one hour of data (could use SonUtils or other terminal program for this). These data should be included with your comparison data. You must provide all the documentation to support the comparison with your submission of comparison data. All discharge data must be collected using standard procedures defined in the attached document.

1. **Comparison to GPS**. GPS positioning can be used as an external check of the ADP bottom tracking accuracy, provided the errors in GPS positioning are minimized. Errors in GPS positioning can be minimized by bottom tracking over long paths such that an error in GPS position at the beginning and end of

the path is less than 0.5% of the total distance. The recommended procedure is to traverse a course (~800 m) at a constant speed and compass heading (do not start recording until the boat is at the speed and heading that will be maintained during the entire course). The position of the GPS antenna on the boat and the location of the test path should minimize or eliminate any multi-path errors. Because RiverSurveyor is recording both bottom track and DGPS and compares the two, it is very important that bottom tracking is maintained during the entire path or the bottom tracking results will be too short. The ratio of distance measured by bottom tracking compared with GPS is the "D(BT)/D(GPS)" value in the GPS data window. Any deviation from unity multiplied by 100 is the percent difference between bottom track and GPS. Typically this value should be less than +/- 0.5%. This type of test should be completed over a variety of bottom types in order to verify the robustness and limitations of the bottom-tracking algorithm.

2. **Evaluation of bottom track limitations.** Sites with various bed material types and bank slopes are needed to fully evaluate the bottom modes (see table below). The objective is to determine the shallowest depths and maximum bottom variability for which bottom tracking will work. When testing on a slope, tests should be made moving up the slope and down the slope to determine the shallowest depth at which it can bottom track in each direction. It is possible that the instrument may track into shallower depths when coming from a deeper depth than when initialized in a shallow depth. The test should be conducted so that both the minimum depth that the instrument will track into and the minimum depth at which tracking is initialized is evaluated. You should start and stop the tests in the same location so that bottom track comparison can be made. Tracks should also be made into deep enough water that the bottom tracking will fail. This will identify the maximum expected range for the bottom tracking, for those site conditions.

3. **Stationary test.** The ADCP has random noise associated with bottom tracking, therefore, an instrument held in a fixed location will show small random movements based on bottom tracking. This test evaluates the random noise in the bottom tracking algorithms. This test should also be completed with different bed conditions (see table below). To complete this test, the instrument must be deployed in a fixed location. This could be a temporary mount on some fixed platform. It could be a boat securely anchored from the bow and two points on the stern. It is important to document the deployment and how much actual movement the deployment may have experienced. This test like a moving bed test should be conducted for no less than 10 minutes. A duration of 30-60 minutes would be preferred. Assuming the instrument did not move, the values to be compared would be the mean velocity computed from the ADP and the standard deviation associated with the mean.

4. **Comparison of ADP ver. 8.8 with ADP ver. 8.6:** Sontek has made improvements to their bottom tracking algorithms and are evaluating others. A

limited number of users willing to work closely with the Office of Surface Water and Sontek will complete some of the described tests using two different firmware versions and perhaps different configurations within the firmware.

The table below outlines tests that will help evaluate the capabilities and robustness of the bottom tracking algorithms. No priority has been assigned to the tests and hopefully contributions from various users in different parts of the country will allow us to cover the full range of conditions.

Test No.	Type	Depth	Bed Material	Terrain Variability or Slope
1	GPS Comparison Measurements (1,4)		Mud / Silt	Smooth
2			Sand	Smooth
3			Sand	Dunes, Moderate changes
4			Gravel	Moderate changes
5			Gravel	Rapid changes
6			Cobble/Boulders	Moderate changes
7			Cobble/Boulders	Rapid changes
8	Bottom Track Capability (2,4) and Stationary Tests (3,4)	< 2 ft	Mud / Silt	Mild Slope
9			Mud / Silt	Steep Slope
10			Sand	Mild Slope
11			Sand	Steep Slope
12			Gravel	Mild Slope
13			Gravel	Steep Slope
14			Cobble/Boulders	Mild Slope
15			Cobble/Boulders	Steep Slope
16		Any	Mud / Silt	Smooth
17			Sand	Smooth
18			Sand	Dunes, Moderate changes
19			Gravel	Moderate changes
20			Gravel	Rapid changes
21			Cobble/Boulders	Moderate changes
22			Cobble/Boulders	Rapid changes
23			Any	Wood debris on bottom

SITE CONDITIONS

The site conditions should be completely documented, for completeness and to facilitate use of these data by others. Video or digital pictures are encouraged. The flow, bed conditions, weather, mounts, boats, and other equipment should be documented. If necessary use a tape recorder to ensure detailed notes and then transcribe them back in the office.

SUBMITTING DATA

Data submitted for the comparisons described herein should be sent via FedEx or a note to dmueller@usgs.gov with information as where the data can be downloaded. This submission should include all raw data, supporting information used to make the comparison, documentation of any deviation from standard procedures, and documentation of site conditions. Please do not email large data sets without prior notification and approval.

FedEx address:

David Mueller
U.S. Geological Survey
9818 Bluegrass Parkway
Louisville, KY 40299
(502) 493-1935
dmueller@usgs.gov

Standard Procedures for Collection of Discharge Data

- Follow all OSW recommended procedures for making a discharge measurement except as noted in test plan.
- Use standard USGS Acoustic Profiler Discharge Measurement Notes (Form 9-275-I), if possible.
- Use RiverSurveyor 4.x
- If possible, collect 12 transects to get a better estimate of the instrument / river variability and to allow evaluation of 2, 4, 6, and 8 transect averages.
- Record air temperature and water temperature
- Document speed and direction of wind.
- Calibrate compasses prior to data collection
- Run the self-test prior to measurements. To run the self-test use Terminal program in SonUtils. After connecting and establishing communications with the ADP, open a log file. Then click on config, system, and setup icons. Finally type "test" at the command line at the bottom and hit enter. Close the log file and exit.
- Configure ADP using built-in automatic bin size computations or minimum bin sizes and recommended blank (3 MHz:15 cm minimum bin size and 20 cm blank and 1.5 MHz: 25 cm minimum bin size and 40 cm blank). Turn on shallow-water ping.
- Set time on PC and ADP.
- Accurately measure draft, particularly on shallow streams. Be sure to compensate for pitch or roll of the boat during this measurement. If a pressure sensor is used, be sure and zero it and check for reasonableness of the draft measurement.
- Locate a section with uniform flow, if possible.
- Document any observed reverse flow at the edges.
- Set starting and stopping edge to allow two good depth cells at each edge. If this is not possible, document why.
- Collect at least 2 profiles in a stationary position at the beginning and end of each transect.
- Use buoys to ensure consistent starting and stopping points, if possible. Measure distance to shore from each buoy.
- Always *measure* distance to shore for each transect, if buoys are not used.
- Maintain a boat speed equal to or less than the water speed, if at all practical. Document reasons for deviation.
- When possible, collect at least one and preferably 2 cup meter measurements. Where there is changing flow conditions, it will be important to identify which transects were collected during the cup meter measurement.