Comparing Apples and Oranges: Teledyne/RDI StreamPro ADCP and the OTT QLiner River Discharge Measurement System

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INTRODUCTION

Over the past few years, acoustic Doppler current profilers have been adapted for use in shallow water applications that include both velocity and discharge measurements. A special class of these instruments includes those that are autonomous and use wireless communication. The Teledyne/RDI StreamPro ADCP and the OTT QLiner are two such instruments and we have chosen to compare them on two fundamental water resources/hydraulics applications.

On the surface these two instruments are quite different although they are both touted as shallow water discharge measuring systems. The StreamPro is a 3-dimensional acoustic Doppler current profiler with bottom tracking while the QLiner features a 2-dimensional (3 beam) acoustic Doppler current profiler *without* bottom tracking. The major difference here is that the StreamPro can perform a discharge measurement quickly by continuously pulling the boat across the channel in question whereas the QLiner must employ a section-by-section approach (more similar to traditional current metering).

We compared the performance of these two systems on discharge measurements in a concrete-lined trapezoidal canal. In addition, we investigated and compared the velocity profile measurements of each system within this channel and along the centerline of a 4 ft-wide laboratory flume with steady flow. In the field discharge measurements, we used both the moving boat (continuous) and section-by-section with the StreamPro while the QLiner could only be used with the section-by-section method.

FIELD SITE TESTING

The field test site we chose was the Charles Hansen Feeder Canal, on the Colorado Big Thompson Project near Loveland, Colorado, just downstream from the Big Thompson siphon. The section properties include a concrete-lined trapezoidal section with a bottom width of 7 ft, side slopes of 1.25 to 1, a depth of 8.2 ft, and a lining thickness of 4 inches. We chose to do the measurements at an existing gauging station (HFCBBSCO), figure 1. Records show the discharge capacity at 550 ft^3/s, but this has been reduced in recent years because of several flow baffles installed in the canal bottom downstream from the gauging station used to create pools for fire water supply/storage. The trapezoidal section was chosen to insure a fair comparison of the two systems, feeling that due to the geometry of the respective profilers, a rectangular shaped channel could favor the QLiner. The StreamPro and the QLiner were operated simultaneously using a section-by-section method. In addition, a standard Price AA current meter measurement was also completed. The StreamPro was used to collect additional discharge data by the moving boat method slightly downstream from the gauging station using a tagline and an Ocean Science Cable Chimp, figure 2. An additional current meter transect and QLiner transect were measured at this same time for comparison.

Figure 1: Gauging station on the Hansen Feeder Canal where section-by-section measurements were made. Teledyne/RDI StreamPro on the right side, OTT QLiner on the left side, deployed from the current metering bridge.

Figure 2: StreamPro deployed on a tagline with an Ocean Science Cable Chimp (radio controlled cableway ROV) for taking moving boat discharge measurements.

SECTION-BY-SECTION DISCHARGE MEASUREMENTS

Discharge measurements by the StreamPro and QLiner along with a standard current meter gauging measurement were completed on the morning of May 10, 2007. Data were collected for 40 s at each position for each instrument. The time required to take a single current meter transect allowed us to collect 2 transects each with the StreamPro and QLiner. Data are shown in Table 1. The current meter transect was rated "good" and the measured discharge was 3.88-percent higher than the rated discharge. The two StreamPro measurements were an average of 8.34-percent less than the rated flow and the two QLiner measurements resulted in an average of 0.72-percent greater than the rating. The QLiner data were processed using the 1/6th power law, 90-percent of depth used for valid cells, immersion depth of 0.13 ft and a fixed width of 27.1 ft.

Table 1: Results of section-by-section comparative measurements for current meter, StreamPro, and QLiner.

Measurement Type	*Stage (ft)*	*Rated Discharge (ft^3/s)*	*Measured Discharge (ft^3/s)*	*Area (ft^2)*	*Mean Velocity (ft/s)*
Current Meter #1	6.16	484	502.76	138.49	3.63
StreamPro #1	6.16	484	449.17	130.36	3.45
StreamPro #2	6.16	484	438.11	131.0	3.34
QLiner #1	6.16	484	481.95	132.66	3.63
QLiner #2	6.16	484	493.0	135.50	3.64

MOVING BOAT MEASUREMENTS

Later that afternoon, several moving boat measurements were taken using the StreamPro. At the same general time these were completed, we repeated a current meter transect and a QLiner section-by-section measurement. Comparative data are shown in Table 2.

Table 2: Results showing StreamPro moving boat discharge measurements compared to current meter and Qliner measurements taken concurrently.

Measurement Type	*Stage (ft)*	*Rated Discharge (ft^3/s)*	*Measured Discharge (ft^3/s)*	*Area (ft^2)*	*Mean Velocity (ft/s)*
Current Meter #2	6.13	479	492.12	135.84	3.62
StreamPro #3 (IPAQ) n=14	6.13	479	469.11	136.77	3.43
StreamPro #3 (WinRiver II) n=12	6.13	479	464.36	137.94	3.36
QLiner #3	6.13	479	478.21	133.55	3.58

Once again this was deemed a good measurement for the current meter, resulting in a flow that was 2.74-percent above the rated discharge. The StreamPro averaged 2.09-percent lower than the rating and the QLiner measurement was 0.17-percent low. The two StreamPro measurements were slightly different in that one was collected using the hand-held pocket PC (IPAQ) and used 14 passes, while the second measurement was collected with a laptop running WinRiver II and used 12 passes. The StreamPro was moved across the canal using a ¼ inch tagline and the OceanScience Cable Chimp. The section-by-section parameters used by the QLiner and the current meter measurements remained unchanged for these tests.

OBSERVATIONS

Accurate discharge measurements are made up of an accurate flow area measurement along with an accurately determined mean velocity profile. A comparison of the cross section measurements taken by each method is shown in figure 3. Note that the StreamPro seems to have the most variability in this determination, especially near the transitions from the flat bottom section to the 1.25:1 side slopes. This is most likely caused by the Janus transducer configuration. The QLiner features a dedicated depth sounding transducer and so should be the most accurate at determining water cross section. The current meter depths measured were consistently greater than the acoustic devices, making us wonder if this may be due to an angle on the sounding caused by the high velocity flows or if the acoustic devices were just under predicting depth.

Figure 4 shows the horizontal distribution of the mean vertical velocities measured by each instrument for the section-by-section measurements performed. While all methods showed a similar trend in the mean profile, the QLiner profile appeared to have the greatest variability along the side slopes of the canal. The current meter profile was the most repeatable and the StreamPro profiles were also quite repeatable. The StreamPro collects data at a substantially faster rate than the QLiner, pinging at 40 Hz versus 3 Hz, so the increased variability in the mean velocity determination by the QLiner could likely be due to this reason alone. The interesting fact to note however is that the QLiner consistently performed better in the actual discharge determination as compared to the rated discharge than either the StreamPro or the individual current meter transects.

Comparison of individual velocity profile measurements was performed for a centerline location in the Hansen Feeder Canal, figure 5. Again, we can see increased variability in the QLiner data as compared to the StreamPro data. Beam 3 is included to provide more accurate determination of the velocity profile near the surface. One might describe the QLiner data a “noisy” as compared to the StreamPro – once again this could largely be due to the StreamPro utilizing over 10 times the individual measurements than processed by the QLiner.

Comparison of the profile data taken in our 4-ft laboratory flume showed similar trends with better agreement between the QLiner and StreamPro. The StreamPro is capable of much smaller cell sizes, and hence better resolution, figure 6.

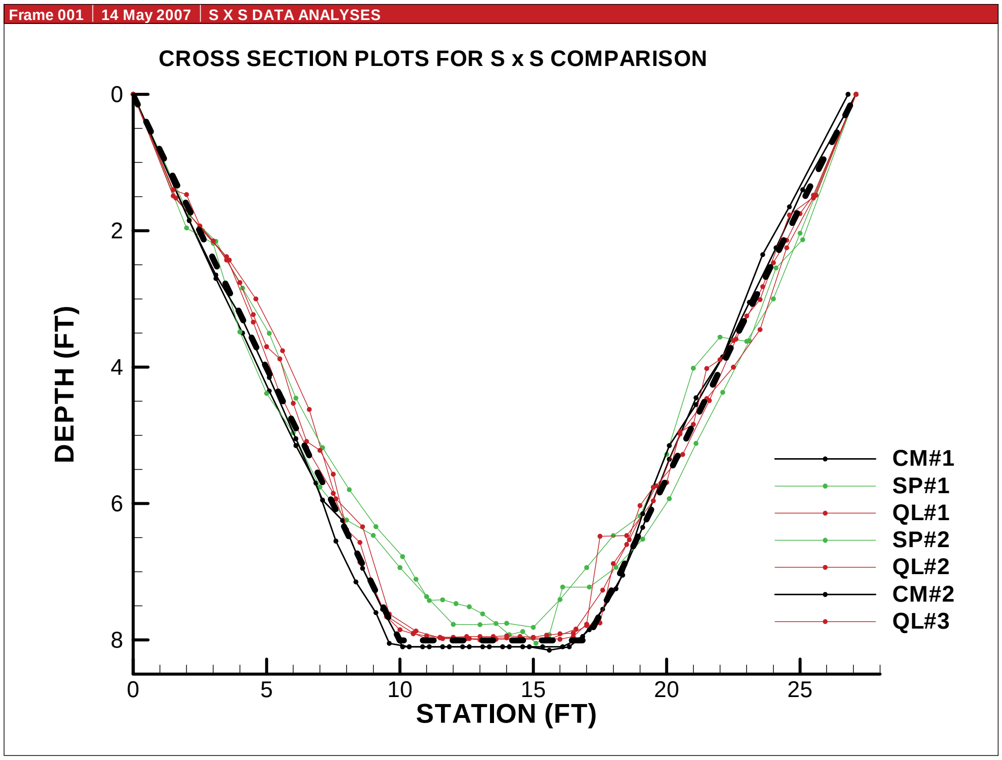

Figure 3: Comparison of the cross section measurements taken during the section-by-section measurements.

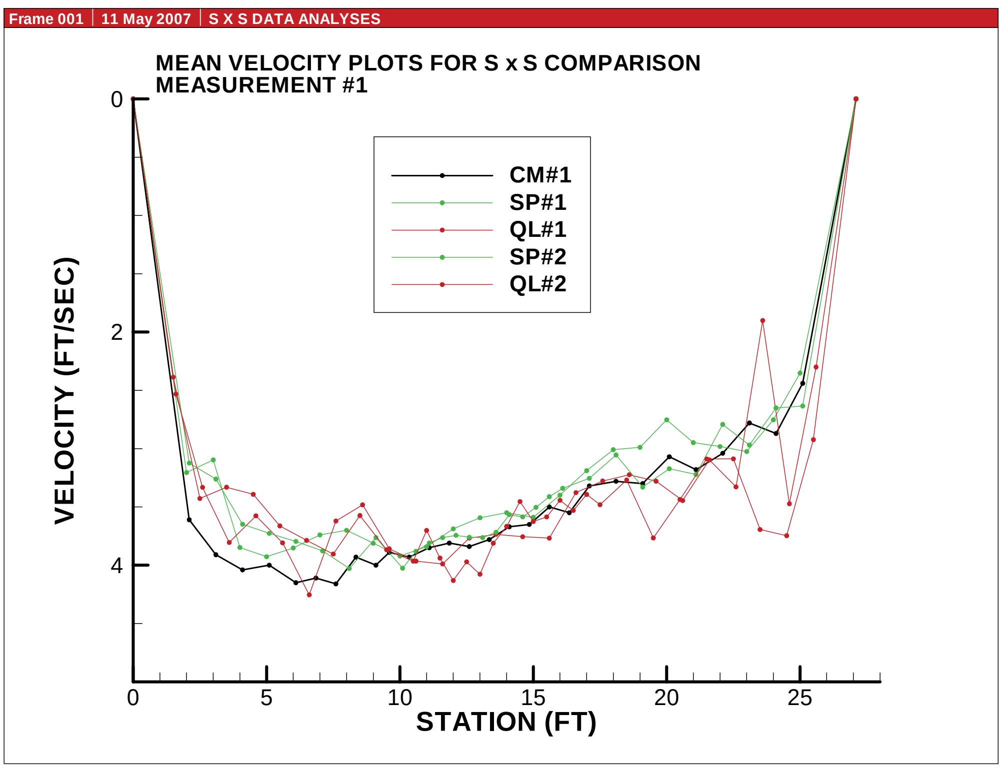

Figure 4: Comparison of the horizontal distribution of average vertical velocities for the different instruments in the section-by-section measurements.

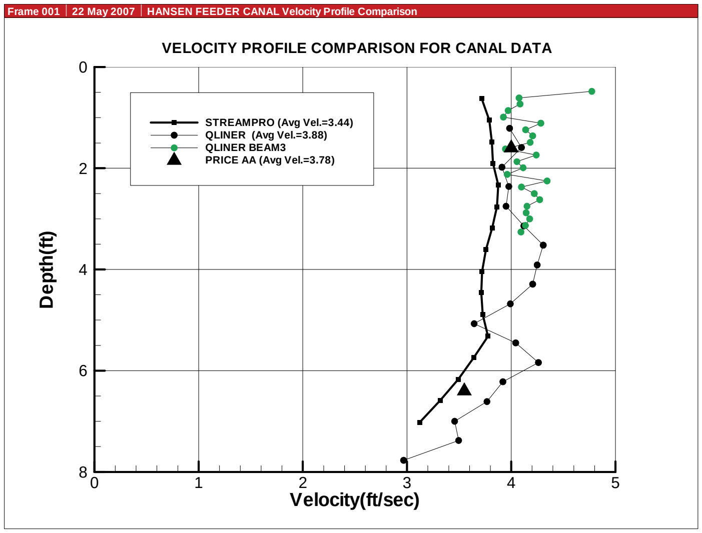

Figure 5: Centerline velocity profile (40 sec) for the Hansen Feeder Canal. Note StreamPro data is consistently lower than QLiner and Price AA values. Average values from the StreamPro and QLiner data are from numerical integration of the profiles.

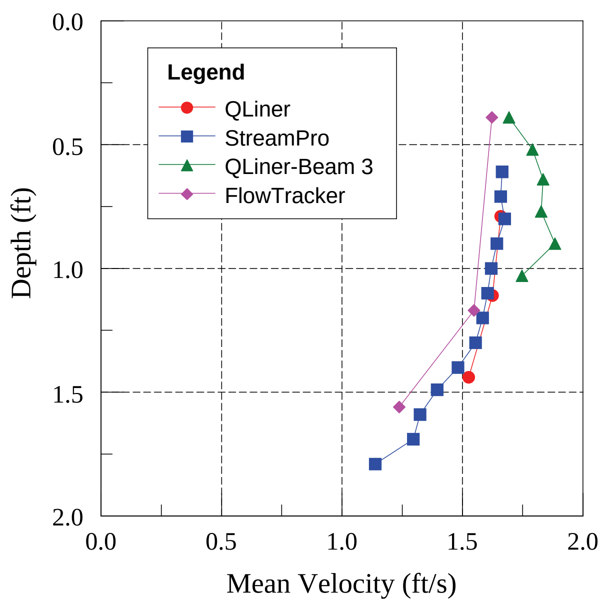

Figure 6: Centerline velocity profile in labaoratory 4 ft wide flume with steady flow. Comparison of Qliner, StreamPro and FlowTracker.

CONCLUSIONS

- The increased measurement frequency (pinging) by the StreamPro over the QLiner is most likely responsible for the cleaner (less noisy) velocity profiles.
- Since discharge is the product of area and velocity, each quantity is important in the accuracy of the final determination. It appears the StreamPro may measure the velocity more accurately while the QLiner does a better job with flow area.
- The StreamPro performed much better using the moving boat method rather than the section-by-section approach.
- The acoustic instruments proved to be as accurate (compared to the rated Q) and much less time consuming than the traditional Price AA current meter.