RD Instruments
Acoustic Doppler Solutions

ChannelMaster H-ADCP Application Note:

ChannelMaster 1200 kHz Horizontal ADCP Discharge Measurements at Check 13 on the Imperial Irrigation District West Highline Canal

SUMMARY: *ChannelMaster Horizontal ADCPs are ideal for making high accuracy, near real-time discharge measurements on canals, streams, and rivers. BroadBand ADCP technology, which provides the combination of fine horizontal resolution, fast sample rates, and low velocity noise, makes taking accurate discharge data at thirty second intervals possible. Measurements from the West Highline Canal at Check 13 illustrate the accuracy of the ChannelMaster for this application.*

Site: The West Highline Canal runs along the western boundary of the Imperial Irrigation District, in southeastern California. Check 13 is about 4 miles west of Westminster, CA. At this location, the canal is concrete lined with a trapezoidal cross-section having a base 3meters wide and walls with a nominal slope of 1:1.5. The flow at this location varies significantly during the day, due to it being near the end of the main canal along the western boundary of the irrigation system. The water elevation remains relatively steady since the measurement site is upstream of the check structure.

Equipment: a 1200 kHz ChannelMaster Horizontal ADCP measured horizontal velocity profiles across the irrigation channel. Since this was a temporary installation, a simple mounting plate was used that allowed the pitch and roll of the ChannelMaster to be adjusted to ensure that the acoustic beams are horizontal, so that both are in the same plane of the flow. The ChannelMaster was configured to use 25 cm (10 inch) cells and acquire 40 cells of data. Data was acquired using 200 water profiling pings and 3 vertical beam depth samples every 30 seconds. With this setup, the expected standard deviation for any individual cell is 0.95 cm/sec (.03 ft/sec) for the basic instrument noise.

An RD Instruments StreamPro ADCP Discharge Measurement System was used to measure the flow in the canal using a moving ADCP technique. For this canal, a typical StreamPro discharge measurement required about 2.5 minutes with an expected accuracy of ± 2%. The StreamPro not only provided quick accurate discharge measurement used to determine the velocity rating parameter but also was used to measure the hydrographic cross section of the canal, which is also needed to set the parameters to compute cross-sectional area from the ChannelMaster vertical acoustic stage sensor data, and then discharge from the area-velocity product.

Procedure: since the nominal canal dimensions were known ahead of time, when we arrived at the site we knew the approximate water depth was about 1.5 meters. The elevation of the mean velocity in a typical stream is about 60% of the elevation up from the bottom of the channel. So, we mounted the ChannelMaster and slid it down the canal bank so that the surface sensing vertical beam indicated that the ADCP was 0.5 meters below the surface. Then the pitch and roll angle of the mount were adjusted until they were both less than 1.0 degree. Using the signal intensity and correlation displays in WinHADCP, the software used to control and record data from the ChannelMaster, we determined that the first 16 cells of data were valid and not affected by the reflections from the far bank of the canal. The first 16 cells were then selected to be averaged to characterize the velocity of the canal.

During this time, we also set up a loop of light cable across the canal with which to pull the StreamPro back and forth to make discharge measurements periodically. A quick pass was made across the channel to determine the edge positions and to determine the depth at the middle of the channel. The StreamPro configuration was then adjusted to use 20 cells of 8cm.

For the next few hours, the ChannelMaster measured the velocity in the canal and the StreamPro was used to make several discharge measurements as the flow in the canal changed during the day.

Determining the rating coefficients: the StreamPro measures not only total discharge but from its data, the cross-sectional area is computed from the bottom tracking depth and velocity data. So, by dividing the discharge measured by the StreamPro by the corresponding cross-sectional area, the mean velocity is obtained of the entire canal. Since the ChannelMaster was outputting data every thirty seconds, we can then compared the mean channel velocity from the StreamPro to the corresponding data from the ChannelMaster. Since the StreamPro measurements required about 2.5 minutes, we average the five ChannelMaster readings with times just before and after the StreamPro measurements to remove the influence of temporal variability in the flow. These data are then fit with a linear regression to determine if the ChannelMaster's averaged horizontal velocity has a linear relation to the StreamPro mean velocity. The results are shown in Figure 1.

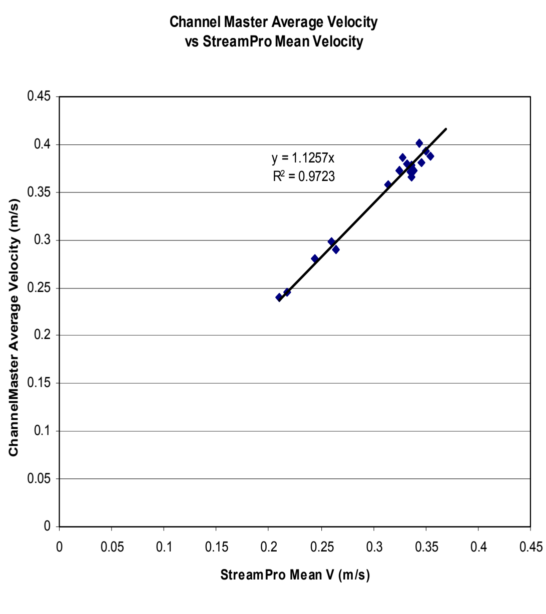

Figure 1: Channel Master velocity averaged over 16 cells vs StreamPro mean channel V

From this we determine that the linear regression fit is very good with an R2 of 0.97. We also find that

$$0.887 * V_{avg,\ CM} = V_{mean\ SP}$$

By comparing the depth of the canal measured by the StreamPro to the distance to the surface measured by the ChannelMaster's vertical beam, we find that the ChannelMaster was mounted 0.95 meters above the bottom of the canal. From the StreamPro bottom tracking data, we calculate the slope of the canal sides to be 0.59, and the width of the bottom to be 3.0 meters. So, since the canal is trapezoidal, then the area of the canal is

$$A = 3.0 * D + (0.59)^{-1} * D^2$$

Where D is the total depth of the canal which is also given by

$$D = h_{mounting} + h_{vb} = 0.95 + h_{vb}$$

Using this and the result for the relationship between range averaged ChannelMaster data and the mean channel velocity, then from the ChannelMaster data, the discharge is

$$Q_{CM} = \{3.0D + (0.59)^{-1} D^2\} * 0.887V_{avg,\ CM}$$

These parameters were then entered into WinHADCP software and the data acquired earlier were replayed to compute the discharge from the ChannelMaster data. This data and the discharges measured by the StreamPro are graphed in Figure 2.

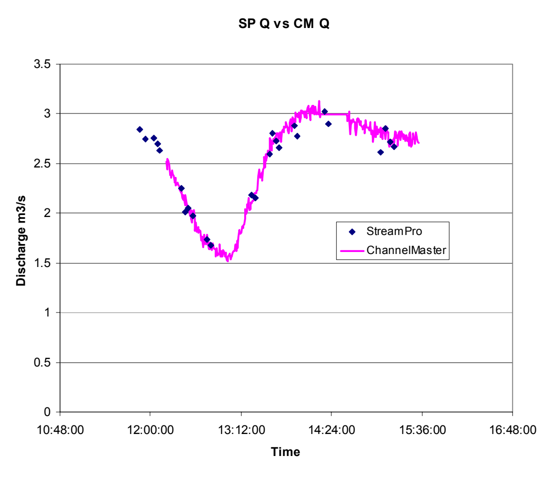

Figure 2: Discharge from ChannelMaster and discharge measured by StreamPro