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Mini Review

Measuring Flow in Flood Channels with Multi-Functional Flume System Network

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Introduction

Understanding flow in flood channels is an essential part of watershed management. The flood flow affects downstream flood control, land development, and watershed risk management. There are various flow measurement structures which are used in open channels such as, Partial-Flume [1]. Sharp-Crested and Broad-Crested Weirs [2], but these devices are not suitable in flood channels because of the following characteristics of the flood channels.

Large range of flow, changing from very small flow rate to very large flow rate (Figure 1). This characteristic makes it hard to design a proper device, because if the flow measuring device is built for large flow, it will not function at low flow rates which are common in the beginning of the storm event. On the other hand, if the device is built for low flow rate, it will submerge and will not function at high flow rates.

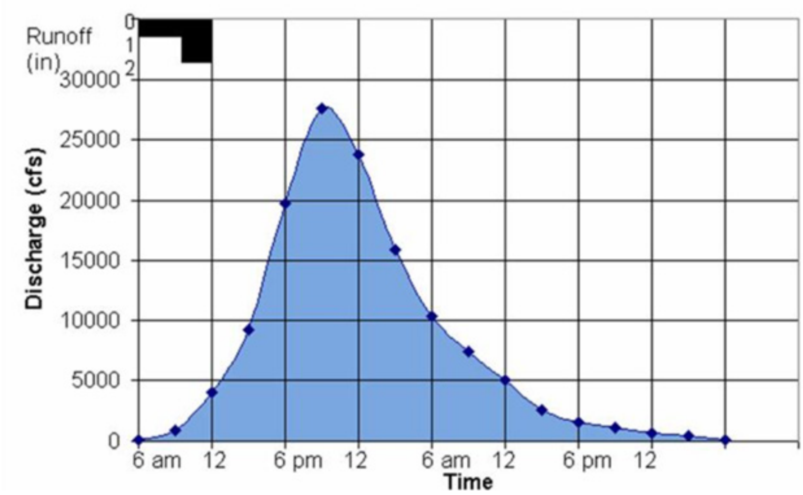

Figure 1: Typical discharge rate in a flood channel, Las Cruces, NEW Mexico.

The second issue is that flood channels typically carry large amount of sediments and debris which can plug up a flow measuring device and renders it useless. Because of these limitations, flow measuring devices are not installed in flood channels, and hydrologist and scientist are often forced to try to estimate flow in such channels using empirical equations.

Theoretical Foundation

Samani [3] and Samani et al. [4] introduced a cylindrical flow measuring device which can be used to measure flow in open channels. Figure 2 shows the top-view of a cylindrical flow measuring device installed in a rectangular channel. In such a channel, a contracting cylinder is split in half and each piece is installed on one side of the channel cross-section as shown in Figure 2. The cylinder contracts the flow cross-section and creates critical flow at the contraction. At this hydraulic condition, it becomes possible to measure discharge rate in the channel by measuring upstream depth at the junction of the half cylinder and the channel wall using a ruler as shown in Figure 2.

Note the location of the upstream head (H) measuring point shown by an arrow in Figure 2. Once the upstream head (Ha) is measured at the column (Figures 2 & 3), then the flow rate through the flume can be calculated using Eq. 2.

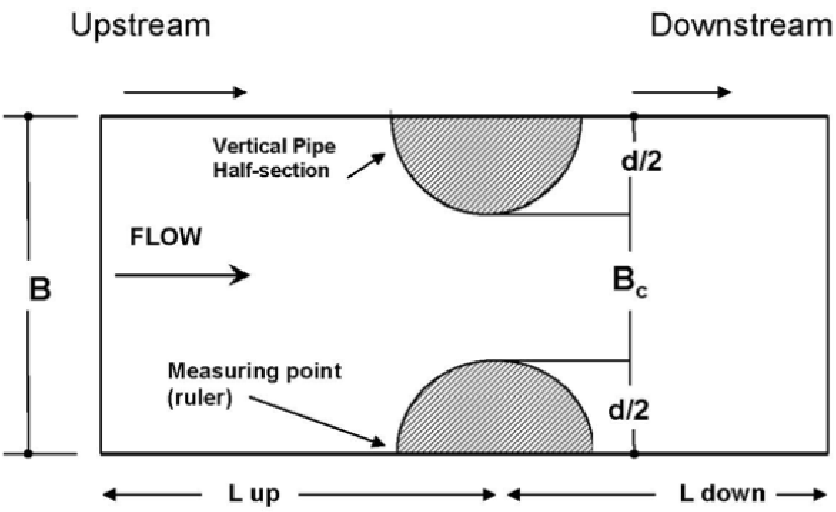

Figure 2: Schematic of a cylindrical flume installed in a rectangular channel.

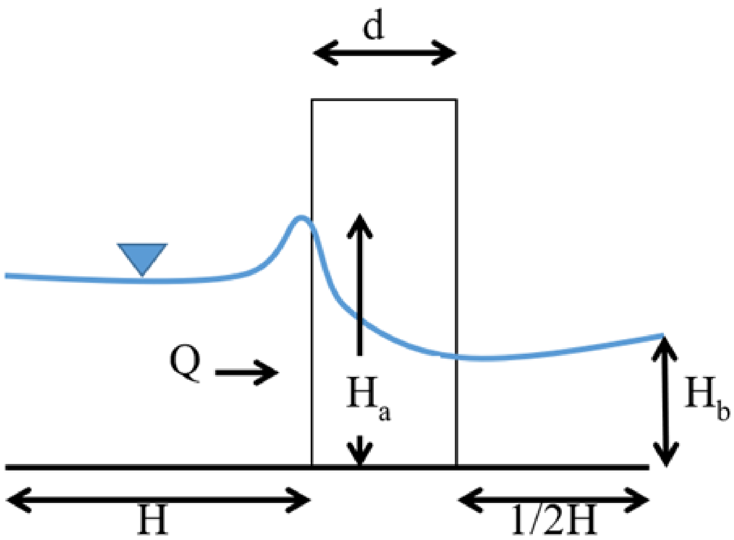

Figure 3: Vertical cross-section of a rectangular flume.

Equation 1 is the general equation of flow in such devices where" a" and "b" are Calibration parameters that depend on the channel characteristics. Equation 2 shows the coefficients (a and b) for the rectangular channel with cylindrical contraction as described in Figure 2. Samani [3] describe the ease of construction as well as the high accuracy of such a device.

A major advantage of such device (shown in Figure 2) is that the sediment/trash can easily flush through the narrow section without plugging the channel. The second advantage is that using the concept of cylindrical flumes, a multiplex system can be set up where a large range of flow in a typical flood channel can be measured while sedimentation and debries can be flushed through as the flume multiplex feature serves as sluice gate and flushes the sediments and trash through the central part of the system as shown in Figure 4.

$$Q = a(B_c^{2.5})(g^{0.5})(\frac{H}{B_c})^b \quad (1)$$

$$Q = 0.701 * B_c^{2.5} * g^{0.5} * (\frac{H}{B_c})^{1.59} \quad (2)$$

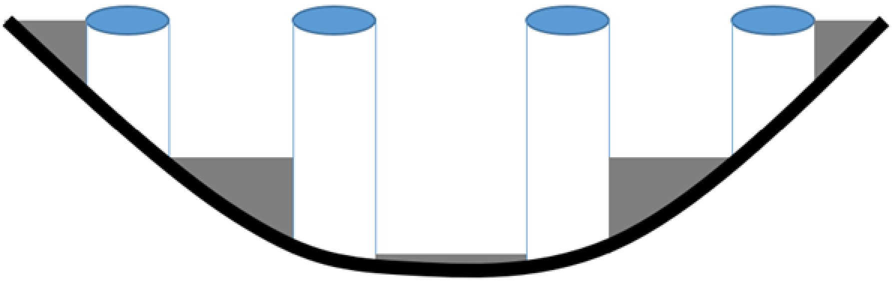

Figure 4: Multiplex cylindrical flume system installed in a flood channel.

In the multiplex flume system shown in Figure 4, the central part functions as a sluice gate while measuring small flow rates, while the side flumes in combination with the central flume can accommodate larger flow rates [5].

In the system shown in Figure 4, If the width of the central section is set at 0.5 meter, and the top width of the entire system is 5meter, then the narrow central section can measure flow rate as low as $0.01m^3/s$ while the entire system can measure flow rate as high as $120m^3/s$

Summary and Conclusion

A multiplex combined flow system is shown that can measure a large range of flow which is typical of flood channels using a single gage, while at the same time functions as a sluice gate and flush the sediments and suspended material through the channel. Such a system can easily accommodate the task of flow measurement in a typical flood channel.

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