FACT SHEET No. 39

Rangeland Watershed Program

U.C. Cooperative Extension and USDA Natural Resources Conservation Service

Monitoring Streamflow

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Hydrologists, stream ecologists, and watershed managers are often interested in estimating stream discharge. ***Discharge (q)*** is the flow rate of water passing a point on a stream at an instant in time. Discharge is expressed as a unit volume of water per unit of time, usually expressed as cubic feet per second (cfs). One cfs equals 7.5 gallons per second. ***Current velocity (v)*** is the speed at which water in the channel is moving expressed as feet per second (ft/s). ***Flow volume (Q)*** is estimated as discharge (q) multiplied by the time duration of interest [Q (ft) = q (ft^3/sec) * time (sec)].

Whether stream discharge is measured automatically at a flume or manually at a stream cross-section, there are two basic concepts which must be applied to monitor stream discharge. This paper will introduce the area-velocity and the stage-discharge concepts and their application. This is not a detailed description of how to monitor streamflow. Monitoring streamflow requires training.

Area-Velocity

The area-velocity concept allows one to estimate discharge as the area (A) of water (ft^2) within a stream channel cross-section multiplied by the current velocity (v) at which the water in the cross-section is traveling (ft/s).

$$q\ (ft^3/s) = A\ (ft^2) * v\ (ft/s)$$

Current velocity at the surface of the stream will be greater than at the bottom. Current velocity at the edge of the stream will be lower than at the middle of the stream. This is simply due to the resistance to flow presented by the stream channel.

Because current velocity will vary within the stream channel cross-section, a stream channel cross-section is often divided into portions and the area and current velocity within each portion of the stream cross-section determined individually.

Figure 1 illustrates the division of a stream channel cross-section into 5 portions and the estimation of area within each portion. The number of portions a cross-section should be divided into depends upon the characteristics of the cross-section, and the intended use of the information.

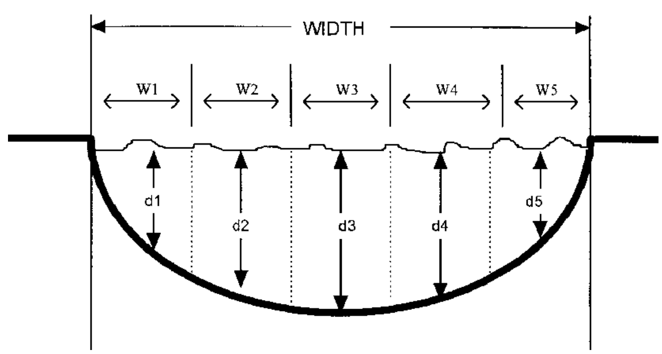

Figure 1

The more complex or irregular the cross-section and the greater the need for an accurate estimate, the more portions needed.

A current velocity can be used to estimate velocity within each portion of the cross-section. The reading of current velocity should be taken at 0.6 times the water depth from the top of the water column.

Stream discharge is simply the sum of the discharge in each portion of the cross-section.

$$q = A1*v1 + A2*v2 + A3*v3 + A4*v4 + A5*v5$$

or

$$q = w1*d1*v1 + w2*d2*v2 + w3*d3*v3 + w4*d4*v4 + w5*d5*v5$$

Often, a velocity meter is not available. In this case a float and stopwatch can be used to estimate average stream *profile* velocity. The average stream *profile* velocity is substituted for v1 though v5 in the calculation of discharge (i.e., v1 through v5 have the same value).

An orange makes a good float because it is submerged enough not to be affected by wind and it is easy to see in the water. Figure 2 illustrates the use of a float to estimate average stream *surface* velocity. The time of travel over a known distance is measured, and velocity is computed as distance divided by elapsed time. The stream reach the float is used in should be straight with uniform flow, and the distance should be such that the travel time is at least 20 seconds. The reach should be near the cross-section. The procedure should be repeated several times, and an average stream *surface* velocity calculated. The average stream *surface* velocity should then be multiplied by 0.85 to approximate the average stream *profile* velocity.

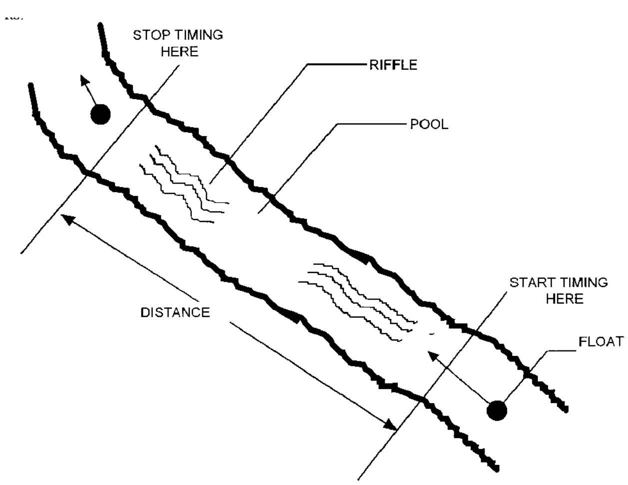

Figure 2

Stage-Discharge Relationship

The stage-discharge relationship is based upon the relationship between stream water depth (stage) and discharge at a flume or permanent cross-section. A stage discharge relationship is an equation which computes discharge from stage. Stage-discharge relationships have been calculated for most standard flumes and weirs, making discharge estimation at a flume simply a matter of monitoring stage and then calculating discharge.

Where discharge is to be monitored in a channel without a flume, the stage-discharge relationship must be established. The relationship will be different for every cross-section, and will change at a cross-section as the cross-section changes through time (aggrades or degrades).

The first step is to identify a permanent cross-section. The cross-section should be in a stable portion of the stream (i.e., little erosion or deposition). The cross-section should be easily assessable and should not be located in a flood plain or where flow might be affected by a downstream lake, pond, or estuary.

The second step is to install a stage staff or depth meter in the channel at the cross-section. One often sees stage staffs attached to the side of bridges or pilings. The stage staff must be fixed and permanent. Reference points should be identified in the event the stage staff moves during a flood event. The permanence of the stage staff and the stability of the cross-section are crucial for developing a meaningful stage-discharge relationship.

The next step is to repeatedly use the area-velocity method at the cross-section to estimate discharge over a wide a range of discharge levels as possible (low flow to flood flow). Stage must be recorded each time discharge is estimated. It is important that the observations represent a wide range of discharges, numerous readings of similar flow events are of limited value. When enough observations are made, a stage-discharge relationship (equation) can be developed to relate discharge at the cross-section to water depth at the cross-section. The number of observations needed to establish the stage-discharge relationship varies with each cross-section. Developing a stage-discharge relationship requires experience.

Once the stage-discharge relationship is developed, discharge can be estimated as often as desired simply by monitoring the water level at the cross-section over time. One must be careful when extrapolating beyond the range of discharge used to develop the stage-discharge relationship (equation).

Although the stage-discharge method may seem complex, it can be accomplished with sufficient training. The initial effort exerted in developing the stage-discharge relationship (equation) is worthwhile if one is interested in monitoring discharge at fairly frequent intervals. Once the discharge relationship is established, it must be checked periodically to insure it has not changed due to changes in the stream channel cross-section (erosion or deposition).

Monitoring stream discharge does require training and an initial investment of time. Anyone monitoring discharge should have a clear objective in mind before expending time and energy monitoring discharge.