FIELD PROCEDURE: DATA SHEET 5, STREAM FLOW

EQUIPMENT

stop watch
float (i.e., ball)
2 tape measures or string
Data Sheet 5, "Flow"
yardstick

WHAT?

To calculate flow, you will need to measure the velocity of the water and the cross sectional area of the stream's channel.

The procedure outlined is a simple method requiring inexpensive equipment. Rather than measuring velocity with a $1000 flow meter, you will use a float (ball).

While the float method serves more as an estimation of flow, it is a tried and true method. It may even work even better than a meter under very low flow conditions. With proper quality assurance your results can be accurate and useful.

In addition to measuring flow, keep track of storm events, especially those events that occur in the week preceding your flow measurement. At a minimum, you should keep track of the amount of precipitation that falls and the time that elapsed between the last storm and your flow measurement.

WHERE?

You will need a section of the stream reach that is as straight and uniform in width as possible (channelized sections of streams work well for this exercise). The section you choose should be free of turbulence, eddies, slack backwater areas, and obstacles such as boulders and woody debris.

Because it is often difficult to find a section of stream that is straight and without turbulence, eddies, or backwater areas, your flow measurement will be an estimate. Make sure you are consistent and careful with your methods. Remember to not send the float down only the fastest path within the stream channel; this will skew your results. You need to estimate the range of velocities across the stream.

The section you choose should also be shallow enough for you to wade across safely. In general, the length of the section should be about three times the width; however, do not sacrifice the other conditions listed above if this is not possible. A ten foot or even shorter distance will work.

If the stream is culverted for a short distance within the reach, check to see if a float will flow freely through the culvert without interruption or turbulence. If so, we recommend you use the culvert for measuring flow. Because culverts have very uniform dimensions, you will encounter less variability and be able to take measurements quickly and easily.

Mark the locations of the flow sites in the field and document these locations on your data sheet and in the Quality Assurance Plan to ensure that you come back to the same place every time you measure flow.

WHEN?

Because flow is so variable, we recommend that you measure it at least once per month. In order to obtain a comprehensive picture of the stream's flow throughout the year, take a flow measurement on approximately the same day each month.

You may consider evaluating the effect of storm events on the flow of the stream. This is more labor intensive than monthly observations, because for each storm, you will have to take flow readings at regular time intervals from the beginning of the storm until some time after it ends. However, it may be important information to gather if you are concerned about increased runoff volumes resulting from development in the watershed.

HOW?

Velocity

You will need at least two people, and best three, for this exercise.

1. Measure the length (distance) of the stream section you have chosen for your flow measurement and record it on Data Sheet 5, Flow. Mark the start and finish lines in some manner (a tape measure or string, held across the stream perpendicular to the direction of flow, works well).

2. Person #1 wades in the stream at the upstream starting line, float in hand. Person #2 wades in the stream at the downstream finish line. Person #3, if available, stands on the bank next to the finish line, stopwatch and clipboard in hand. If you have only 2 people, the one at the finish line (#2) holds the stopwatch.

3. Person #1 drops the float on the surface, upstream from the starting line. As the float passes the starting line, person #1 yells "go" and person #2 starts the stopwatch. (It is more accurate to start the float this way than trying to drop it exactly at the starting line.)

4. When the float crosses the finish line, person #2 stops the stopwatch, catches the float, and records the time, or gets person #3 to help out.

5. Discard any trials in which the float gets caught in debris, rocks, or eddies.

6. On Data Sheet 5, record the time in seconds that it took for the float to travel the measured distance.

7. Because the velocity of the water varies across the width of the stream, you need to repeat this process several times, sending the float down different flow paths. Starting at one side of the stream, send the float down progressively farther from the bank, at one or two foot intervals until you reach the other side. This way you will be able to sample the full range of velocities that occur across the width of the stream. We recommend ten float trials to get a velocity measurement representative of the stream.

8. Record all the time values on Data Sheet 5. Calculate the average float time by dividing the sum of the time values by the number of float trials.

9. To calculate the average velocity, divide the distance value by the average float time value. Your result is the average surface velocity.

10. Because the velocity of a stream varies from the surface to the bottom, adjust your result to reflect the overall average velocity of the stream. Multiply your average surface velocity value by a correction factor of 0.8 to convert surface velocity of average flow velocity. This adjusted value is called the corrected average velocity. Record your result on the data sheet.

CROSS SECTION AREA

This section outlines two methods for measuring and calculating cross sectional area. The first method is more accurate for streams wider than three feet, but requires that you take depth measurements in one (or two) foot intervals across the width of the stream. If it is too difficult to do this on the stream, or if the stream is only a few feet wide, method 11 should work better for you.

If you have surveyed the cross section profile at the same site and on the same day as your flow measurement, you can save yourself a little time by using data from your profile survey. The sum of the wetted stream depth measurements you took at one foot intervals equals the cross sectional area of the wetted stream at the point surveyed. Find this value, and then use Method I to find the cross sectional area at two more points along the length of the channel you used for the velocity float trials. Use these three values to calculate the average cross sectional area of that section of the channel.

If you used a culvert to measure velocity, simply use method II to calculate the cross sectional area of the culvert. You need not find an average (assuming the culvert is of uniform size from beginning to end).

Method 1 - For Streams More than Three Feet Wide

1. Stretch a tape measure across the stream at the starting point of your velocity float trials. The tape measure should be perpendicular to stream flow and just above the surface of the water. The first person holds the "O" point on the tape measure even with one wetted edge. A second person on the opposite bank holds the tape measure level, taut, and even with the other wetted edge. A third person stands on the bank with Data Sheet 5 and records information.

2. A fourth person, stadia rod in hand, starts six inches from wetted edge and moves along the tape measure at one foot intervals. The stadia rod is used to measure the depth of the water (the vertical distance from the water surface to the stream bottom) at the mid-point of each one foot interval. (Thus, the first and last measurements are made 6 inches from the wetted edges.) The in-stream person calls out these measurements to the person on the bank, who records them on Data Sheet 5.

   Note: If the stream is wider than 20 feet, measure depths at two-foot intervals.

3. If measured at one-foot intervals, each depth is roughly equivalent to the area of a one-foot-wide section of the wetted stream. Thus the sum of these areas (or depths) is the total cross-sectional area of the wetted stream at the point measured. The mid-point depth is used because it is a better approximation of the area of the one-foot-wide section than the depth at the beginning or end of the section.

4. Sum the depths and record the result for Cross Section 1 on Data Sheet 5. If you measured depths at two foot intervals, multiply the sum of the depths by two to calculate cross sectional area.

5. Your result is the cross sectional area of the wetted stream at the starting line of your velocity float trials. In order to find the average cross sectional area of the whole length of the channel used for the float trials, you'll need to repeat steps 1-4 at two more points. Use the finish line and a point in the middle of the section. This is especially important if the area of the channel varies along the length used for the float trials.

6. Take the three cross sectional area values and average them to find average cross sectional area. Record the result on Data Sheet 5.

Method 2 - For Streams Three Feet Wide or Less

1. Stretch a tape measure across the stream at the starting point of the channel you used for the velocity float trials. Record the width of the stream at this point. (The width is the distance from one wetted edge to the other).

2. Use a stadia rod to measure the depth of the water in three places along the tape measure. One depth measurement should be at the midpoint of the stream; the other two should be at points equidistant from the midpoint to the wetted edges.

3. Use Data Sheet 5 to calculate the average depth of the starting point. Then calculate the cross sectional area of the starting point by multiplying the width by the average depth.

4. Repeat this process at two other points along the length of the channel used for the float trials. Use the finish line and a point in the middle of the stretch. Calculate the cross sectional area for these two other points.

5. Use Data sheet 5 to calculate the average cross sectional area for the whole channel used for the float trials.

Calculating Flow

Now it is possible to calculate the flow with the information you have gathered. Multiply the corrected average velocity by the average cross sectional area and record your flow value on Data Sheet 5.

A note on units: Most studies in the United States measure flow in cubic feet per second (CFS). If you want to compare your measurements easily with other studies, measure your depths in feet (cross sectional area in square feet) and your velocity in feet per second. This will give you flow in cubic feet per second. You'll want to use cubic meters per second in most countries outside the United States.

A Short Cut-Measuring Flow from a Pipe

Here is a short and simple way to measure flow from small streams or pipes. This method can be used when there are low flows and all the water can be directed into a container. Simply time how long it takes your container to fill. That is your flow.

1. Use a bucket of known volume (5 gallons is common) or use a one gallon milk jug to determine your bucket's volume by counting the number of gallons needed to fill it to a given point.

2. To convert gallons to cubic feet, divide the number of gallons by 7.48. (There are 7.48 gallons in one cubic foot.)

3. Position the bucket below the outfall of the culvert so that all of the water flowing out is caught by the bucket. Time how many seconds it takes for the bucket to fill completely with water.

4. The flow equals the volume of the bucket divided by the time it took to fill (flow = volume/time). Your answer should be in cubic feet per second.

Monitoring Storm Events

It is important to keep track of storm events when monitoring flow, because flow is so dependent on precipitation. Each time you measure flow, note how long it's been since it's rained and the approximate number of inches that fell in the last rainfall. If you can, monitor rainfall for at least one week prior to your flow measurement.

You can obtain precipitation and other weather information from your local weather service. However, to obtain data that is more specific to the microclimate of the stream, use your own rain gauge. They are inexpensive and easy to use, they just require regular attention. It is best if you can check your gauge every day when it rains.