

Streamflow: Flow Speaks Volumes

Why are we concerned?

Streamflow, or discharge, is the volume of water moving past a cross-section of a stream over a set period of time. It is usually measured in cubic feet per second (cfs). Streamflow is affected by the amount of water within a watershed, increasing with rainstorms or snowmelt, and decreasing during dry periods. Flow is also important because it defines the shape, size and course of the stream. It is integral not only to water quality, but also to habitat. Food sources, spawning areas and migration paths of fish and other wildlife are all affected and defined by streamflow and velocity. Velocity and flow together determine the kinds of organisms that can live in the stream (some need fast-flowing areas; others need quiet, low-velocity pools). Different kinds of vegetation require different flows and velocities, too.

Streamflow is affected by both forces of nature and by humans. *(continued on page 2)*

Time Needed: Equipment Needed:

30 minutes



When to Measure:

At least monthly, May-October.

- Tape measure
- Yardstick or marked D-frame net pole
- Surveying flags/flagging
- Float (please use a tennis ball with a small amount of water in it)
- Net (Can use D-frame net to catch the float)
- Stopwatch
- Calculator
- Form to record data
- Pencil
- Hip boots or waders
- String (optional)
- Stakes (optional)

DEFINITION OF TERMS

Discharge: Another term for streamflow, or the volume of water moving past a designated point over a set period of time.

Flow Regime: The pattern of streamflow over time, including increases with stormwater runoff inputs and decreases to a base-flow level during dry periods.

Impervious Surface: A surface that does not allow water (e.g., rain) to pass through (infiltrate).

Rating Curve: A graphical representation of the relationship between the stage height and the discharge (flow).

Run: An area of a stream that has swift water flow and is slightly deeper than a riffle (a run will be about knee/thigh deep).

Stage Height: Height of the water in a stream above a baseline.

Watershed: An area of land that drains to a main water body.

In undeveloped watersheds, soil type, vegetation, and slope all play a role in how fast and how much water reaches a stream. In watersheds with high human impacts, water flow might be depleted by withdrawals for irrigation, domestic or industrial purposes. Dams used for electric power generation may affect flow, particularly during periods of peak need when streamflow is held back and later released in a surge. Drastically altering landscapes in a watershed, such as with development, can also

change *flow regimes*, causing faster runoff with storm events and higher peak flows due to increased areas of *impervious surface*. These altered flows can negatively affect an entire ecosystem by upsetting habitats and organisms dependent on natural flow rates.

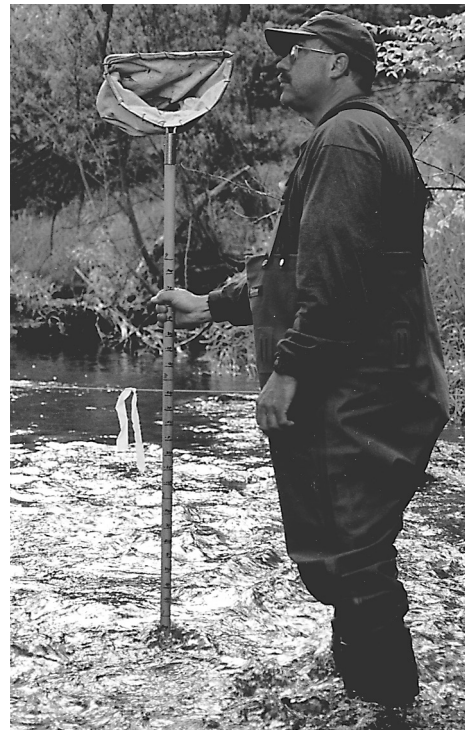
Tracking streamflow measurements over a period of time can give us baseline information about the stream's natural flow rate.

Safety considerations

You will need to enter the stream channel to make width and depth measurements and to calculate velocity. Be aware of stream velocity, water depth, and bottom conditions at your stream-monitoring site. Do not attempt to measure streamflow if water velocity appears to be fast enough to knock you down when you are working in the stream. If you are unsure of water depth across the width of the stream, be sure to proceed with caution as you move across the stream, or choose an alternate point from which to measure streamflow.

Determining Streamflow (Area x Velocity = Flow)

The method you are going to use in determining streamflow is known as a velocity-area approach. The task is to find out the volume of water in a 20-ft. (at least) section of stream by determining both the stream's velocity and the area of the stream section. You will first measure the width of the stream, and then measure water depth at a number of locations across the width to find the average depth at your monitoring site. Then by multiplying the average depth by the width, you can determine the average cross-sectional area (ft²) of the stream. Water velocity (ft/sec) is determined simply by measuring the number of seconds it takes a float to travel along the length of stream you are studying. Since water velocity varies at different depths, (surface water moves more quickly than subsurface water because water moving against rough bottom surfaces is slowed down by friction) you will need to multiply velocity by a correction factor to adjust your measurement to account for the effect of friction. The actual equation you will use to determine flow is this: Flow=Area x Corrected Velocity. This method was developed and adapted from several sources (see bibliography). Alternative methods that may be better for your monitoring site are featured in the sidebar below.



Streamflow Monitoring Methods: Professional and Home-Made

The type of monitoring station used by professionals depends on the conditions at the site including size, slope, accessibility, and sedimentation of the stream. Flow can also be measured at spillways, dams, and culverts or by using a weir or flume, which are man-made structures within a stream that provide a fixed stage-flow relation. Another method, using a home-made combination staff/crest gage, allows volunteer monitors to measure the water level (stage) both at the time of inspection and at the highest level reached since last inspected. This tool is made of PVC pipe, granulated cork and other materials. For more information, including how to make your own, visit:

www.epa.gov/owow/monitoring/volunteer/newsletter/volmon07no2.pdf

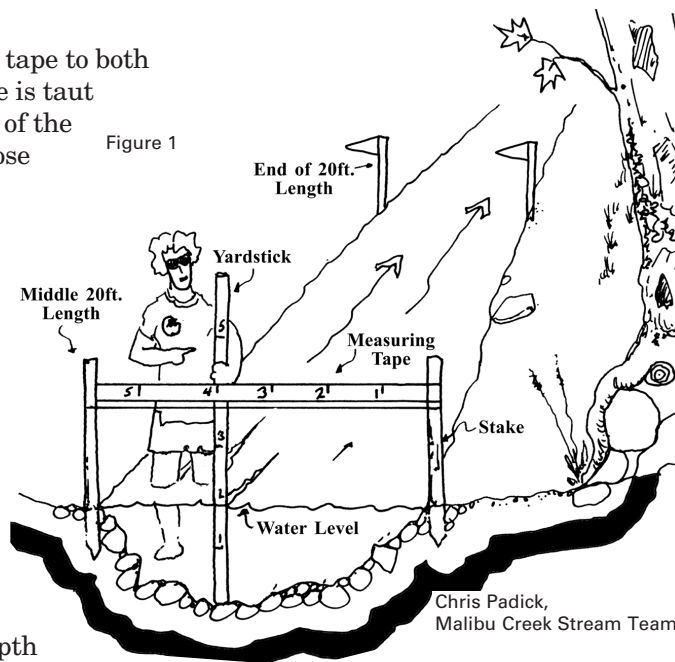
Measuring and Calculating Streamflow

Site location

1. At your monitoring site, locate a straight section of stream that is at least 20 feet in length and has a uniform width. The water should be at least 6 inches deep, and have some movement. Unobstructed runs or riffles are ideal sites to choose.
2. Measure 20 feet along the length of your chosen stream segment with your measuring tape and mark both the up and downstream ends of the section with flagging.

Width and depth measurements

3. Working with a partner, measure stream width (wetted edge to wetted edge) by extending a measuring tape across the stream at the midway point of your marked stream segment. Record the width in feet on your recording form. (Using a tape measure graduated in tenths of feet will make calculations easier.)
4. Secure the measuring tape to both shores so that the tape is taut and above the surface of the water. You might choose to attach the tape or a length of string to two stakes secured on opposite banks to create a transect line across the stream if it is impractical to secure the tape using shoreline vegetation. (Figure 1)
5. Using your yardstick or pre-marked (in tenths of feet) D-frame net pole, measure the water depth (ft) at one-foot intervals across the stream where you measured width (and secured the measuring tape). Be sure to measure depth in tenths of feet, not in inches (See conversion chart from inches to tenths of feet on data recording form). Record depth measurements (ft) on the recording form. If your stream is greater than 20 feet wide, measure depth in 20 equal intervals across the stream.



across the stream, in both slower and faster areas, will help to ensure the closest approximation to the stream's true velocity. This in turn will make your flow calculations more accurate. However, be sure your tennis ball travels freely downstream (during every float trial) without catching in slack water areas of the stream. For narrower streams (less than 10 feet), you can conduct only three float trials to assess velocity.

6. Position the person who will release the tennis ball upstream from the upper flag. Position the timekeeper on the stream bank (or out of the main flow path) at the downstream flag with the stopwatch. Position the person who will catch the floating tennis ball downstream from the timekeeper (Note: Unless velocity is very fast, the timekeeper should be able to catch the tennis ball float with a net after they have finished timing its run down the stream).

7. The float-releaser will gently drop the float into the stream a few feet upstream from the upper flag, and will alert the timekeeper to begin timing as the float passes the upstream flag (the float should have time to get up to speed by the time it passes the upper flag into the marked length of stream). If the float gets stuck on a log, rock or other obstruction, it should be released from the starting point again.
8. The timekeeper should stop the stopwatch as the float passes the downstream flag and retrieve the float using the net.

9. Record the float time for the first trial on the recording form.
10. Repeat steps 7-9 for each of the remaining float time trials in different sections of the stream. Record the float time (seconds) for each trial on the recording form.

Determine the correction factor

To account for the effects of friction with the stream bottom, select the correction factor that best describes the bottom of your stream:

- a. Correction factor for rough or loose rocks, coarse gravel or weeds: 0.8
- b. Correction factor for smooth mud, sand or bedrock: 0.9

Velocity measurement

Velocity will be measured by tracking the time it takes a floating tennis ball to move the marked 20-foot length of stream. You will time the floating tennis ball (in seconds) a total of four times, at different locations across the stream. Repeating your measurements

Determining streamflow

The DNR SWIMS online database will calculate streamflow for you when you enter your measured depths, width, assessed length, velocity float times, and chosen correction factor. If you are curious about the answer while in the field, follow steps in the next section to calculate streamflow on your own.

Calculating streamflow

11. To determine the average depth at the site, first find the sum of your depth measurements. Then divide the sum of the depths by the number of depth measurements (intervals) you made.
12. Next, multiply your average depth by the stream width. This is the average cross-sectional area (ft²) of the stream.
13. Determine the average float time by first determining the sum of float times measured. Then divide the sum of the times by the number of float time measurements taken.
14. Divide the length of your stream segment (e.g., 20 feet) by the average float time (seconds) to determine the average surface velocity at the site.
15. Multiply your correction factor by the average velocity measurement.
16. Multiply the average cross-sectional area (ft²) by the corrected average surface velocity (ft/sec) to determine streamflow.

Overestimation of the float method

In 2011-2012 a number of WAV monitors assisted with a WAV study to compare this method of determining streamflow to results obtained using a flow meter. The great news is that a consistent relationship was found between the two methods from very small (<1 cfs) to large (about 125 cfs) streams. Unfortunately, results suggested that this float method overestimates by about 24% on average. The SWIMS online database will automatically correct results using an equation derived from the study, but those carrying out field calculations should remember to reduce their final result by about a quarter.

Bibliography:

We reviewed and adapted information and methods from Missouri Stream Team Program, the WI DNR, the EPA Volunteer Stream Monitoring Methods Manual (EPA 841-B-97-003), the Nohr Network of Monitors, the Washington Co. (WI) Waterways Program, Hoosier Riverwatch, Project SEARCH, and California's Nonpoint Source Pollution Control Program as well as other technical information.

©2010 University of Wisconsin. DNR PUB WT-755. This publication is part of a seven-series set, "Water Action Volunteers- Volunteer Monitoring Factsheet Series" and is available from the Water Action Volunteers Coordinator at 608/264-8948.

Water Action Volunteers is a cooperative program between the University of Wisconsin-Extension and the Wisconsin Department of Natural Resources. For more information, contact the Water Action Volunteers Coordinator at 608/264-8948.

What is a Staff Gage?



A staff gage is a tool that is often used in conjunction with other methods to determine streamflow. It looks like a large ruler placed vertically within a stream in a position least likely to catch floating debris, and that will be stable during high water flows and the winter freeze. Staff gages are calibrated in tenths of feet and allow a monitor to read and record the stage height (the height of water in the stream at a certain level) any time a monitor has the opportunity to visit the stream site. Staff gages are often placed at the stream's edge on a bridge abutment. WAV monitors may choose to place a staff gage at their monitoring site. You may need a permit to do this, however. Contact your local DNR Service Center for more information on permits.

If a staff gage is installed, monitors can simply record the water level on the staff gage without measuring flow.

This method will provide added detail when assessing other parameters. However, scores cannot be compared between sites because each reading is germane only to that site.

Monitors may also choose to install a staff gage at their monitoring site and then, at a number of different water levels, record the stage height and determine the flow in the stream by following methods provided in this fact sheet. This type of monitoring is similar to what professionals do to determine a *rating curve* for a stream discharge monitoring station. The rating curve will reveal the stream's unique relationship between flow and stage height. Eventually, a monitor could determine streamflow simply by reading the stage height on the staff gage and looking at the site's rating curve to see what the flow is at that stage height. Caution must be used with this method since weeds, ice, or other factors can cause ponding of the stream water or movement of the staff gage over time, thus affecting rating curve results.