Measuring streamflow using the float method
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**Abstract:**
Streamflow, the amount of water flowing in a creek, stream, or river at a certain point in time, is critical to people and the environment. Knowing the amount of flowing water is important for numerous water resources, ecological, and engineering applications including flood forecasting, ecosystem health, environmental flows assessment, infrastructure design, and water supply management used for drinking water, electricity production, manufacturing, and irrigation.

In this lesson, students will learn how to measure and calculate streamflow in the field using the velocity-area method. In the velocity-area method, streamflow is determined by multiplying stream velocity, the speed of water flowing in a stream channel, by the cross-sectional area of the stream channel that the water is flowing. Velocity is measured using the float method, a simple, low tech approach where the time it takes a "float" (e.g., small orange) to move a measured distance downstream. The cross-sectional area of the stream channel where water is flowing, called the effective stream channel, is determined using a survey that measures the width and depth of the effective channel using a line tape and yard stick, ruler, or stadia rod.

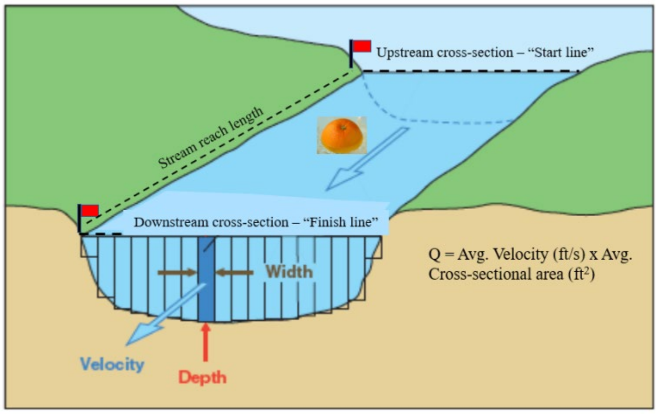
**Keywords**: River Field Studies Network; streamflow estimation; float method; direct streamflow measurements

**Instructor Notes**:

1. Target audience – This lesson is geared towards undergraduate students in lower or upper division courses or graduate student courses that include topics of water resources and management, environmental sciences, hydrology, stream ecology, design, and planning. Prior knowledge of the water cycle is not necessary although a brief explanation of the stores and fluxes of water ([USGS The Water Cycle]) could be helpful.

2. Summary of lesson – Streamflow, also known as discharge and denoted by $Q$, is the amount of water flowing in a creek, stream, or river at a point in time and is critical to people and the environment. In the United States, streamflow is usually expressed in *cubic feet per second*, $ft^3/s$ or *cfs*. A helpful way to visualize a cubic foot of water is a basketball which has volume approximately equal to one cubic foot. A streamflow of 50 $ft^3/s$ for example, would look like 50 basketballs floating past the observer every second.

   In this lesson, students will learn how to measure streamflow using the velocity-area method, $Q\ (length^3/time) = velocity$ (length/time) *x cross-sectional area* ($\text{length}^2$) (Figure 1). *Velocity*, the rate that water in a stream channel is moving downstream, will be measured using the float method. The float method is a simple, low tech approach that consists of measuring the time it takes a float (e.g., small orange) to travel the distance ("stream reach length") from an upstream cross-section to a downstream cross-section. *Area* is the cross-sectional area of where water is flowing. Students will survey stream cross-sections and calculate area by multiplying the average stream channel width by average stream channel depth.



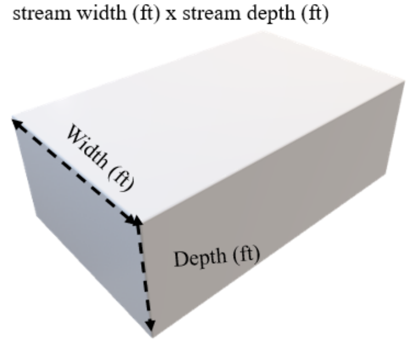



Figure 1. Left – Conceptual layout for estimating streamflow using the velocity-area method (Adapted from the USGS). Right – Determination of stream cross-sectional area by multiplying average stream width x average stream depth.

This lesson is comprised of three parts:

Part 1 – Stream cross-sectional area survey
Part 2 – Velocity measurements and streamflow calculation
Part 3 – Reflection/discussion and optional written report

An optional starting activity prior to Part 1 could be the *Field sketching, geomorphic data, and the power of perspective* lesson also located on Qubes. This lesson uses hypothesis generation and field sketching as data collection, offering students the opportunity to *"see and focus on different aspects of the landscape"*, namely geomorphic and hydrologic characteristics that affect stream velocity and streamflow. By comparing and discussing field sketches with other students, students are given the opportunity to "*see the way that disciplinary learning informs their perspective*".

3. Approach to engagement –
   a) Reflection – Streamflow plays a sometimes obvious but more frequently, invisible, role in our lives and livelihoods. Prior to starting experiential learning in the field and to pique student's interests, instructors should ask students to reflect on how streamflow affects their lives and livelihoods and the environment. For example, have students experienced a flood, felt the force of moving water from the safety of a whitewater raft, or tried to cross a creek? Another opportunity for reflection is at the end of the activity where students revisit hypotheses posed earlier on in the activity and reflect on how their understanding of streamflow has changed.

   b) Discussion – Students can also be asked to discuss a scenario where understanding how much water is flowing in a stream or river can help answer a question or solve a problem around community, ecosystem, or economic health. Discussions should take place at the beginning to set the context for experiential learning.

c) Experiential learning – Students will engage in lesson content and meet learning outcomes by conducting field measurements of velocity and stream channel cross-sectional area; sketching; recording measurements and solving for streamflow using the velocity-area method. During this portion of the lesson, instructors should prompt students to note and record observations on stream channel and bank characteristics that influence streamflow such as channel substrate (e.g., cobble, rocks, boulders), vegetation, or woody debris.

4. Learning Outcomes – By the end of this activity, students will be able to
   - LO1: Discern basic hydrologic and geomorphic stream characteristics important to streamflow (channel depth, channel width, and calculation of cross-sectional area).
   - LO2: Measure stream channel width and depth and calculate cross-sectional area using a stream survey
   - LO3: Measure streamflow velocity using the float method
   - LO4: Calculate streamflow using the velocity-area equation

5. Assessment of Learning Outcomes – After the lesson, students will be able to
   - ALO1: Hypothesizes how deep the water is and what influences stream velocity and streamflow.
   - ALO2: Measures stream channel depth and width and calculates cross-sectional area.
   - ALO3: Hypothesizes how fast the water is moving; explains how different streamflow characteristics affect stream velocity and streamflow.
   - ALO4: Estimates streamflow; reflects on results of stream survey; lab report; and reflection on how their perceptions and understanding changed from before the activity to afterwards.

6. Logistics and materials – Flowing water can be dangerous; strong currents, debris, and uneven streambeds pose significant hazards. If the water is above the student's knees or flowing too fast, do not let students get into the water. Animal waste, agricultural runoff (pesticides, herbicides, etc.), industrial wastes, and sewage leaks can be hazardous to participants. It is important to know about potential upstream contaminants reaching the stream *prior* to field lesson. If you find a stream with any of the above contaminants, a class must use additional safety precautions before entering the stream, if at all, including avoiding direct skin contact (e.g., use rubber boots, waders, gloves) and wash hand and other exposed skin after the activity is completed. Instructors should at a minimum provide hand sanitizer and students should wear protective boots, gloves, and goggles when necessary.

   This lesson, therefore, is best suited for a wadable stream with sufficient water quality so students can remain safe and enjoy interacting with the river environment. The lesson is best suited for small groups of 3 to 4 students (e.g., 1 student located at upstream 'start line' location who initiates experiment by dropping float into stream; 1 student at downstream location who catches float after it passes 'finish line'; 1 student who measures the time it takes the float to travel downstream; 1-2 students who record measurements in datasheets) but also can be done with a minimum of 2 students.

7. Field Activity Timeline

| Activity | Time | Instructor Responsibilities | Student Responsibilities | Notes |
|---|---|---|---|---|
| Introduction | 20 min | Site orientation, review learning objectives, explain expectations, review safety, identify groups | Assembles in groups, brief introductions | |
| Activity orientation | 15 min | Review activity procedures, orientation to equipment, guidance on site identification | Follows procedure in activity document; procures equipment | 3-4 students/groups |
| Part 1 - Selection, layout, and survey of stream channel cross-sections | 30 min | Continuous visitation to groups, redirects/correct activities, answers questions | Work in small groups to complete Part 1 | Students could rotate among different roles |
| Part 2 - Velocity measurements and streamflow calculation | 30 min | Continuous visitation to groups, redirects/correct activities, answers questions | Continue in small groups to complete Part 2 | Students could rotate among different roles |
| Part 3 - Reflection/discussion | 20 min | Reassembles groups, leads discussion of results and reflection, assemble and inventory of field gear & materials, ensures site cleanliness | Complete reflection and participate in group discussions, police equipment and trash | Be sure to collect all items and trash |
| Optional written report | 5 min | Reminds students of report expectation | Student complete work outside of class | |

8. <u>Required materials</u> per group include
    - Preferably 2, 100-foot reel tapes to measure horizontal and downstream distances of the stream channel at upstream and downstream locations.
    - Yard stick, ruler, or stadia rod to measure water level and stream channel depth.
    - 3 floating objects with neutral buoyancy such as a small orange, half-filled plastic bottle, or film canister.
    - 4 pins flags to mark the left and right stream banks for an upstream and downstream cross-section.
    - 4 landscaping nails, rebar, or sticks to anchor the reel tape across each channel.
    - Stopwatch to measure the time it takes the float to travel downstream.
    - Datasheets to sketch stream reach and record measurements.
    - Calculator to solve for streamflow using the velocity-area method.

9. <u>Further references for instructor and students</u> –
    - Learn more about streamflow measurements, approaches, and technology at the USGS Water Science School – How Streamflow is Measured.
    - Learn more about the float method at Measuring the Flow of a Stream | The Float Method video tutorial developed by the Arizona Department of Environmental Quality (ADEQ).

10. <u>Connection to other Qube lessons</u> – This lesson can be used independently, in conjunction with, or as an extension to the following Qubes lessons:

- Geography and embodied perceptions - a pathway to reanimating rivers through lived experiences.
- What Shapes Our River Environment?
- Field sketching, geomorphic data, and the power of perspective