Discharge

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Measuring Velocity Overview

A working knowledge of flow meter operation, as well as the limitations of operation, must be attained prior to the use of this type of equipment. The operation of these meters must follow the instructions provided by the manufacturer in the user manual.

The number of measurements taken at each vertical is dependent upon the depth of the stream. Follow these guidelines when determining the number of measurements to make:

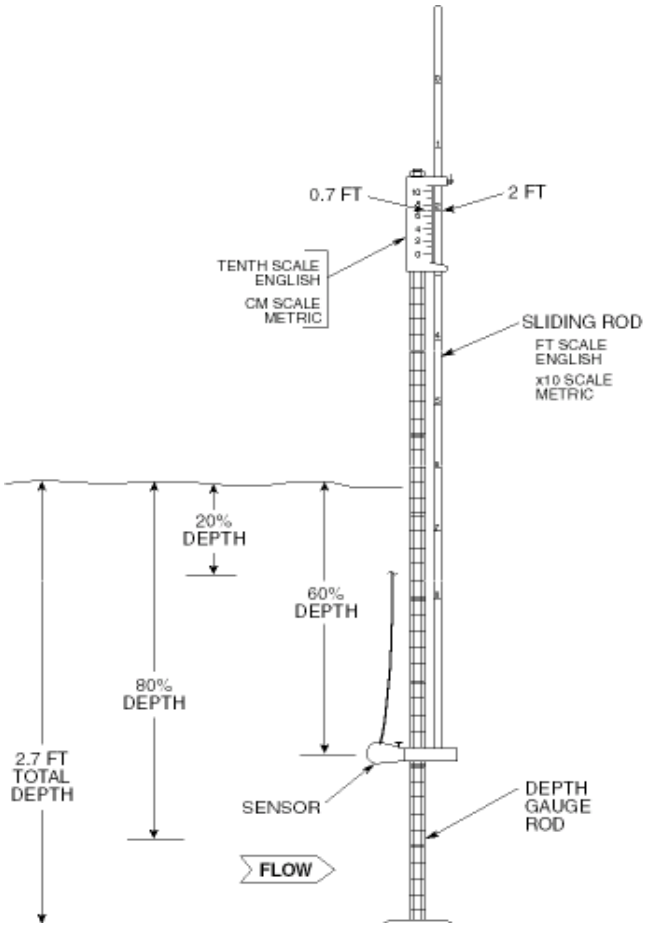
Depths of ≤ 2.5 feet
When water depth is ≤ 2.5 feet, discharge is measured at 0.6 of the depth below the water's surface at each vertical, referred to as the 0.6-depth method (Rantz et al., 1982). A standard top-setting wading rod will automatically adjust the probe to the 0.4-depth position up from the streambed.

Depths of ≥ 2.5 feet
When water depth is ≥ 2.5 feet, discharge is measured at 0.2 and 0.8 of the total depth below the water's surface at each vertical, referred to as the two-point method (Rantz et al., 1982). For example, if the stream depth is 3 feet at a particular station, one should take a velocity measurement at 0.6' and another at 2.4'. An average of these two readings will be used as the average velocity for the vertical.

A standard top-setting wading rod can be adapted to this method by following these instructions:

- To set the rod at the 0.2-depth, position the setting rod at half the water depth.

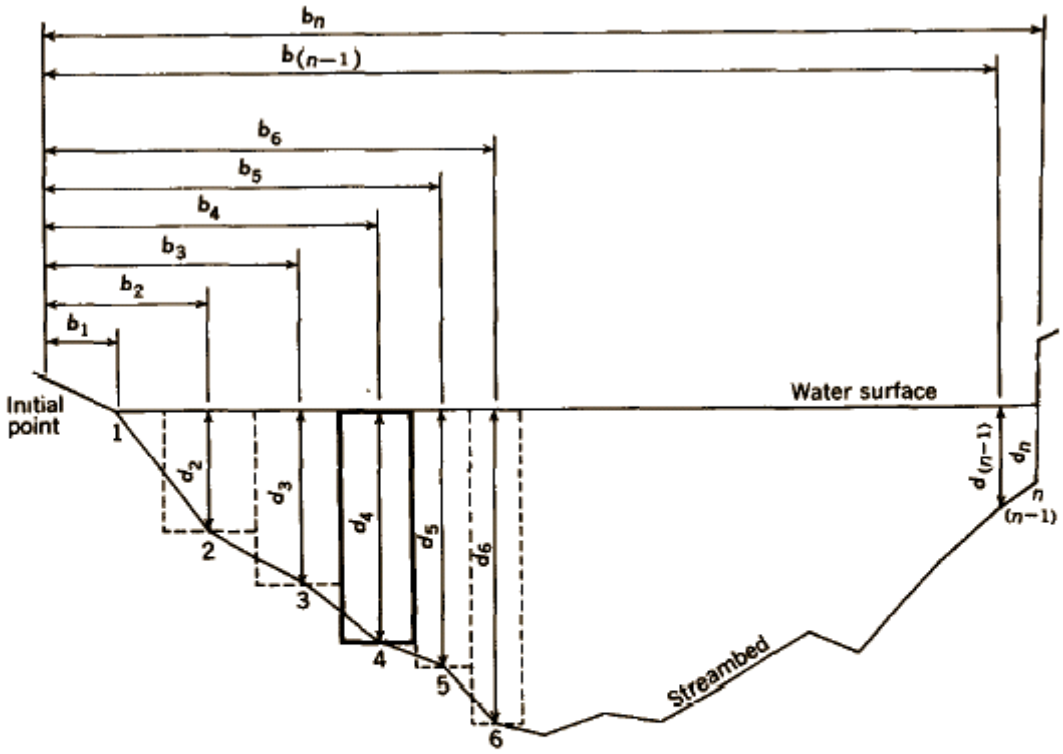
- To set the rod at the 0.8-depth, position the setting rod at twice the water depth.



The wading rod should be held perpendicular to the water's surface and the instrument should be parallel to the stream flow. The individual making the measurements should stand at least 1.5 feet away from the wading rod and 3 inches downstream of the tagline in a way that alters the stream flow as little as possible (Rantz et al., 1982). Rocks, logs, or other obstructions should not be moved during the measurement process as this may cause the stream flow to change in an area of the stream where velocity has already been measured. Once the process of measuring velocity has begun, the stream should not be altered further.

Record the location of the starting edge on the field data sheet (LEW or REW). If the starting edge has a water depth, record this. No velocity measurements should be made at the starting or ending edges. Facing upstream, place the wading rod behind the tape measure at the first vertical and record the location and stream depth. Velocity readings should be averaged over a time period of 25s – 45s, depending on in-stream conditions.

Once the stream velocity has been measured and recorded at the first vertical, continue measuring water velocity at each vertical, making sure that the appropriate number of measurements are being taken based on water depth (0.6-depth method vs. two-point method). Continue until you have reached the end of the cross-section. Record the location and depth of the ending edge.



EXPLANATION

1, 2, 3 ..... n	Observation verticals
$b_1, b_2, b_3, \ldots . b_n$	Distance, in feet or meters, from the initial point to the observation vertical
$d_1, d_2, d_3, \ldots . d_n$	Depth of water, in feet or meters, at the observation vertical
Dashed lines	Boundaries of subsections; one heavily outlined is discussed in text

Measuring Velocity Instructions

1. Select a Cross-section for velocity measurements. The following site characteristics for cross-section locations are critical for accurate discharge measurements (from Rantz et al., 1982 unless otherwise cited):

    - The site lies within a straight reach of stream and flowlines are parallel to each other. Avoid sites directly below sharp bends.
    - Flow is relatively uniform and free from eddies, slack water, and excessive turbulence.
    - The streambed is free from large obstructions, such as boulders and aquatic vegetation.
    - Water velocity is >0.5 ft/s.
    - Water depths >0.5 ft are preferred but a minimum depth of >0.1 ft is required.
    - The flow is perpendicular to the tagline at all points (SonTek/YSI, Inc., 2007)

2. Stretch a tape between the endpoints of your channel cross-section. Divide the distance between the water's edges by 25 (at least) to set the interval for metering (e.g., the water surface is 22 feet across; 22 / 25 = an interval of 0.88 feet, which can be rounded to 0.9). The vertical measurements (depth and velocity) will be taken at the midpoint of each interval. ***Space the verticals so no subsection has more than 10 percent of the total discharge***.

3. Record the starting edge (LEW or REW) in the first cell under the "Station" column (See Example Discharge Form). The actual location of the edge in relation to the tagline should be recorded. For example, if the starting edge occurs at 2.5' on the tagline, the starting edge will be recorded as 2.5.

4. Record the starting edge depth in the first cell under the "Depth" column and the velocity in the first cell under the "Velocity", if these exist at the starting edge. If there are no depth and velocity, record a 0 in these cells. The starting edge is considered the first midpoint; the width for this record will be half an interval, since only half the interval is in the stream.

5. Proceed to the first vertical at which velocity will be measured. Each subsequent vertical (midpoint) can be found by adding the interval length to the current position (e.g. 2.5, 3.4 [=*2.5 + 0.9*], 4.3 [=*3.4+0.9*], 5.2, 6.1, 7.0 etc). Record the depth, velocity and interval width.

6. If using the 0.6 method, fill out only one row per vertical. If using the two-point method, fill out two rows for each station and designate the measurement point in parenthesis next to the station. For example, if the two-point method was used at station 5, one row would contain the station name of "5 (0.2)" and the next row would contain the station name of "5 (0.8)". Record the depth and velocity for both points in the appropriate cells.

7. Continue until you have completed the final velocity measurement. Record the ending edge (LEW or REW) as well as the depth and velocity, if these exist.

Calculating Discharge

1. When the velocity measurement is complete, calculate the total discharge (Q). The mid-section method is currently recommended by the U.S. Geological Survey.

2. Using the mid-section method, compute the area (a_n = mid-point depth x interval length) of each subsection.

3. Next, multiply the subsectional area (a_n) by the mean velocity (Vn) for the subsection to get the Sub-section discharge (Qn). If only one velocity measurement was taken at 0.6 depth, it is the mean velocity (Vn). If two measurements (v_1 and v_2) were taken at 0.2 and 0.8 depth, compute the mean value.

4. To compute the discharge for each subsection, use the equation:

$$Q_n = a_n V_n$$

where

Q_n = discharge for subsection n,

a_n = area of subsection n, and

V_n = mean velocity for subsection n.

The calculation repeats this process for each subsection, as shown below:
$Q_1=a_1 V_1$, $Q_2=a_2 V_2$, $Q_3=a_3 V_3$, $Q_4=a_4 V_4$, and so on. ..

The subsection products are then added to get total discharge (Q):
$Q_1 = Q_1 + Q_2 + Q_3 + Q_4 + Q_5,$ and so on...

Thus, total discharge (Q) equals the sum of all discharges (aV) , as stated earlier in the basic equation:

$$\mathbf{Q = (aV) .}$$

References:

Kentucky Division of Water (KDOW). 2010. Measuring Stream Discharge Standard Operating Procedure. Kentucky Department for Environmental Protection, Division of Water, Frankfort, Kentucky.

Stream Discharge Measurement Sheet

Site ID #: _____
Name and Location: _____
Date:_____Crew: _____

State:_____ County: _____
Weather: _____
Cross-section Location: _____ Width:_____
Meter: _____

Station	Cell Width	Water Depth	Area (Width x Depth)	Run Length (Secs)	Velocity 1 (fs)	Velocity 2 Use with 2pt method	Average Velocity Use with 2pt method (0.2+0.8)/2	Discharge (Q) (Area x Velocity) (cfs)
2 (LEW)	0.5	0	0		0			0
3	1.0	1.0	1.0		0.2			0.20
4	1.0	1.0	1.0		0.2			0.20
5 (0.2)	1.0	2.5	2.5		0.15 (0.2)	0.20 (0.8)	0.175	0.4375
6 (0.2)	1.0	2.8	2.8		0.20 (0.2)	0.25 (0.8)	0.225	0.63
7	1.0	2.0	2		0.25			0.50
8	1.0	2.0	2		0.25			0.50
9	1.0	1.8	1.8		0.30			0.54
10	1.0	1.8	1.8		0.30			0.54
11	1.0	1.5	1.5		0.20			0.30
12	1.0	1.5	1.5		0.20			0.30
13	1.0	1.0	1.0		0.18			0.18
14	1.0	1.0	1.0		0.18			0.18
15	1.0	1.0	1.0		0.10			0.10
16	1.0	1.0	1.0		0.05			0.05
17	0.5	0	0		0			0

Total Discharge (Q): **4.658** CFS (add all discharge measurements)

Comments:

Stream Discharge Measurement Sheet

Site ID #: _____
Name and Location: _____
Date:_____Crew: _____

State:_____ County: _____
Weather: _____
Cross-section Location: _____
Meter: _____

Station	Cell Width	Water Depth	Area (Width x Depth)	Run Length (Secs)	Velocity 1 (fs)	Velocity 2 Use with 2pt method	Average Velocity Use with 2pt method (0.2+0.8)/2	Discharge (Q) (Area x Velocity) (cfs)

Total Discharge (Q): _____ CFS (add all discharge measurements)

Comments:

Stream Discharge Measurement Sheet

Site ID #: _____
Name and Location: _____
Date:_____Crew: _____

State:_____ County: _____
Weather: _____
Cross-section Location: _____
Meter: _____

Station	Cell Width	Water Depth	Area (Width x Depth)	Run Length (Secs)	Velocity 1 (fs)	Velocity 2 Use with 2pt method	Average Velocity Use with 2pt method (0.2+0.8)/2	Discharge (Q) (Area x Velocity) (cfs)

Total Discharge (Q): _____ CFS (add all discharge measurements)

Comments:

Stream Discharge Measurement Sheet

Site ID #: _____
Name and Location: _____
Date:_____Crew: _____

State:_____ County: _____
Weather: _____
Cross-section Location: _____
Meter: _____

Station	Cell Width	Water Depth	Area (Width x Depth)	Run Length (Secs)	Velocity 1 (fs)	Velocity 2 Use with 2pt method	Average Velocity Use with 2pt method (0.2+0.8)/2	Discharge (Q) (Area x Velocity) (cfs)

Total Discharge (Q): _____ CFS (add all discharge measurements)

Comments:

Stream Discharge Measurement Sheet

Site ID #: _____
Name and Location: _____
Date:_____Crew: _____

State:_____ County: _____
Weather: _____
Cross-section Location: _____
Meter: _____

Station	Cell Width	Water Depth	Area (Width x Depth)	Run Length (Secs)	Velocity 1 (fs)	Velocity 2 Use with 2pt method	Average Velocity Use with 2pt method (0.2+0.8)/2	Discharge (Q) (Area x Velocity) (cfs)

Total Discharge (Q): _____ CFS (add all discharge measurements)

Comments: