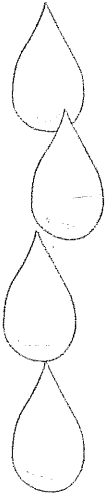


# Estimating Water Flow Rates

W.L. Trimmer



Increasing competition for water resources has made water conservation a high priority. Measuring the flow rate of water is the first step to good water management. All water right holders in the State of Oregon must be able to measure the flow rate of the water being diverted.

If a flow meter, flume, or weir isn't available, there are several methods available to estimate flow rate that you can do with available tools like stopwatches, rulers, and buckets.

The usual unit measuring flow rate for irrigation water rights is a cubic foot per second (cfs). This is water flowing through a cross-sectional area of 1 ft<sup>2</sup> at a velocity of 1 foot per second, and it's sometimes called a second-foot.

A common diversion rate in eastern Oregon might be 1 cfs/40 acres. Here are some handy conversions (see page 4 for others): 1 cfs is about 450 gallons per minute; 1 cfs is about 1 acre-inch per hour; 1 cfs is about 2 acre-feet per day.

Propeller flow meters, weirs, and flumes provide the most accurate measures of flow rate, but in many instances you must make an estimate without them. Here are four methods to estimate irrigation diversions.

## Method 1 Discharge from a pipe

If water can freely drop from a pipe, you can estimate the flow rate by measuring length with nothing more than a carpenter's rule. When the pipe is flowing full, place the rule as shown in Figure 1 and measure a horizontal distance when the vertical drop  $Y = 13$  inches.

Find the proper pipe size in Table 1, and the discharge is in gallons per minute (gpm). If the pipe isn't level, use a plumb bob to measure the vertical drop  $Y$ .

**Example 1.** An 8-inch-diameter pipe is flowing full, and the horizontal distance  $X$  is measured to be 20 inches. From Table 1, the flow rate is 1,005 gpm.

If the pipe is flowing only partially full, find the ratio of the unfilled portion of pipe to the diameter of the pipe to estimate flow rate in gallons per minute, as shown in Table 2.

**Example 2.** A 10-inch-diameter pipe is flowing only partially full. The measured distance  $U$  is 2 inches. The ratio  $U \div D$  in Table 2 is  $2 \div 10 = 0.2$ . The flow rate is 825 gpm.

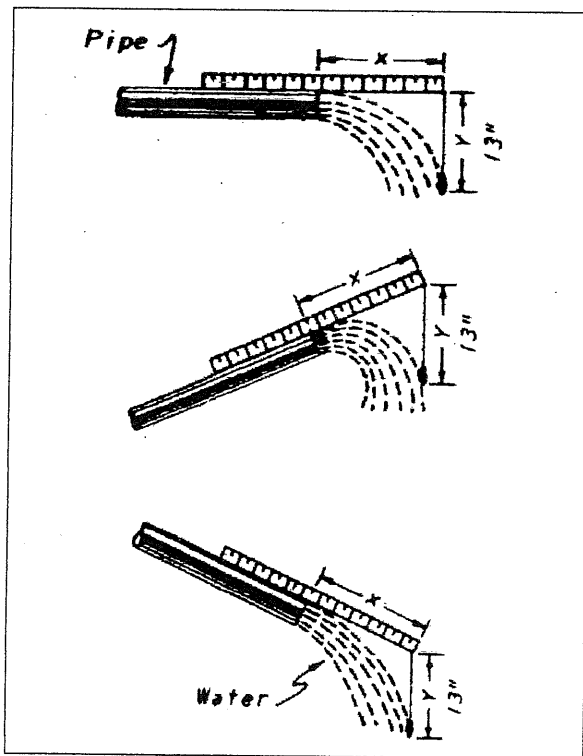


Figure 1.—Measuring horizontal distance ( $X$ ) of a pipe flowing full with vertical drop  $Y=13$ ".

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## Method 2

### Average cross section

The flow rate in a stream or channel can be measured as shown in Figure 2 by timing a float.

Measure off a 50- to 100-foot section of the stream. Flow rate is equal to the cross-sectional area times the velocity. Multiply the average cross-sectional area times the average stream velocity in fps to get the rate of flow in cfs.

Estimating the cross-sectional area is the hard part. A simple way to do it is to measure the bottom width of the channel and the top width, then average the two. Multiply this average times the depth of the water.

Measure the widths and depths in fractions of feet (for example, 1 foot 6 inches = 1.5 feet).

**Example 3.** A ditch is 10 feet wide at the top and about 6 feet across the bottom; the water is 3 feet deep. A float traveled 100 feet in 33 seconds. This is our basic formula:

$$\text{Flow rate} = \text{area} \times \text{velocity} \times \text{roughness factor}$$

We'll use four steps to get our answer:

#### Step 1—Area

$$= \text{average width} \times \text{average depth}$$

$$= \frac{(10 + 6)}{2} \times 3 = 24 \text{ ft}^2$$

#### Step 2—Velocity

$$= \text{distance divided by time}$$

$$= \frac{100}{33} = 3 \text{ feet per second}$$

#### Step 3—Roughness factor

$$= 0.8 \text{ (because the water near the edge moves slower than the float)}$$

#### Step 4—Flow rate

$$= \text{area} \times \text{velocity} \times \text{roughness factor}$$

$$= 24 \text{ ft}^2 \times 3 \text{ feet per second} \times 0.8$$

$$= 58 \text{ ft}^3 \text{ per second (rounded off)}$$

This method is the least accurate of the four we're discussing, and it can usually measure water in a natural stream only within  $\pm 20$  percent. A concrete channel can be measured to  $\pm 10$  percent accuracy.

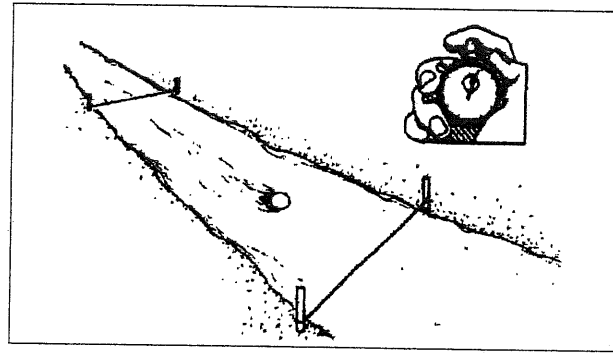


Figure 2.—Measuring the flow rate in a stream or channel by timing a float.

## Method 3

### Timed volume

Depending on your type of system, use a bucket and a stopwatch to measure flow. As shown in Figure 3 for a siphon tube, time a 1- to 5-gallon bucket as it's filled to get the discharge in gpm. You can use a flexible rubber hose on a sprinkler.

**Example 4.** A hose is placed over the nozzle of a sprinkler and water is caught in a 5-gallon bucket. A stopwatch found the time to fill the bucket was 47 seconds.

$$\begin{aligned} \text{Flow rate} &= \text{volume} / \text{time} \\ &= \frac{5 \text{ gallons}}{47 \text{ seconds}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \\ &= 6.4 \text{ gpm} \end{aligned}$$

Multiply the number of tubes or sprinklers by the flow rate of an individual tube or sprinkler to get the total. You can use the rule of thumb (450 gpm = 1 cfs) to convert to the proper units.

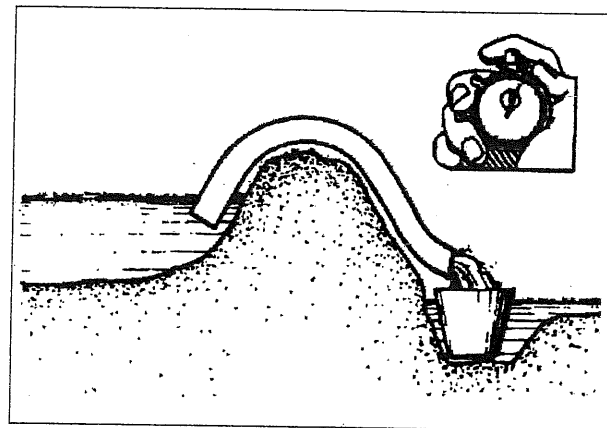


Figure 3.—Timing a bucket as it's filled to get the discharge in gpm.

Table 3.—Capacities (gallons per minute) of certain diameter nozzles.

Pressure (psi)	Nozzle size (in inches)							
	3/32	1/8	9/64	5/32	11/64	3/16	13/64	7/32
35	1.50	2.70	3.40	4.16	5.02	5.97	7.08	8.26
40	1.60	2.90	3.63	4.45	5.37	6.41	7.60	8.87
45	1.70	3.20	3.84	4.72	5.70	6.81	8.07	9.41
50	1.80	3.10	4.04	4.98	6.01	7.18	8.49	9.88
55	1.90	3.30	4.22	5.22	6.30	7.51	8.87	10.30

### Method 4

#### Pressure and nozzle size

A way to estimate diversions pumped into a sprinkler system is to measure the pressure of a few sprinklers as shown in Figure 4. Find the nozzle size stamped on the side of the nozzle and use Table 3 to find the flow rate.

**Example 5.** The sprinkler in example 4 is marked as a  $\frac{3}{16}$ -inch diameter nozzle, and a Pitot pressure gauge reads 40 psi. From Table 3, the flow rate is 6.41 gpm. There are 30 sprinklers, so the total flow rate is 190 gpm.

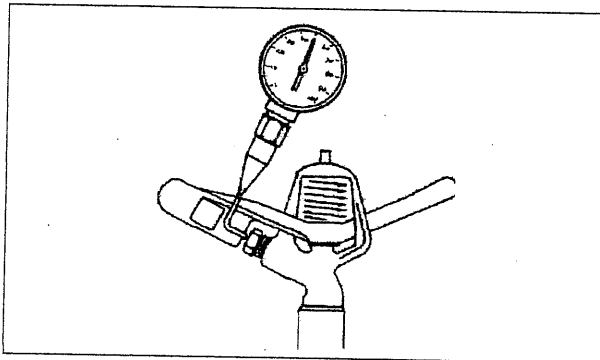


Figure 4.—Check pressure at sprinklers when they're in operation by inserting a Pitot tube into the stream spraying from the nozzle. Read the highest pressure indicated.

Try to measure several sprinklers near the center of the field. The pressure differences caused by friction loss down the laterals and around the field and elevation changes, plus nozzle wear, limit the accuracy of this method to about  $\pm 10$  percent.

Flow control nozzles and nozzles meant for low pressure with orifices that aren't round create some difficulties. Use the bucket and stopwatch method in this case. If you're using a center pivot, find out if your dealer can provide you with a chart of flow rates vs. the pivot pressure for your machine.

#### List of equivalents

1 acre-foot	=	325,851 gallons
1 acre-foot	=	43,560 cubic feet
0.001 acre-foot	=	325.9 gallons
1 acre-inch	=	27,154 gallons
1 acre-inch	=	3,360 cubic feet
1 cubic foot	=	7.48 gallons
1 cubic foot	=	0.0283 cubic meters
450 gallons/minute	=	1 acre-inch in 1 hour
1 gallon/minute	=	0.06309 liter/second

Extension Service, Oregon State University, Corvallis, O.E. Smith, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.



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