



Water Measurement Units and Conversion Factors

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Irrigation water management begins with knowing the quantity of water available. The purpose of this publication is to provide basic information on water measurement units and convenient conversion factors. Sometimes one will want to know only the volume of water used; while, at other times one will want to know the rate of flow. Conversion factors simplify changing from one unit of measurement to another.

Water Measurement Units

There are two conditions under which water is measured—water at rest and water in motion. Water at rest is measured in units of volume. Water in motion is measured in units of flow—unit of volume for a convenient time unit. It is important that the difference between a unit of volume and a unit of flow be kept in mind.

Volume Units

Water at rest; i.e., ponds, lakes, reservoirs, and in the soil, is measured in units of volume — gallon, cubic foot, acre-inch, and acre-foot.

Cubic Foot - The volume of water that would be held in a container one foot wide by one foot long by one foot deep.

Acre-Inch - The volume of water that would cover one acre (43,560 square feet) one inch deep.

Acre-Foot - The volume of water that would cover one acre one foot deep.

Flow Units

Water in motion; i.e., flowing in streams, canals, pipelines, and ditches, is measured in units of volume per unit of time—gallons per minute (gpm), cubic feet per second (cfs), acre-inches per hour and acre feet per day. Cubic feet per second, sometimes written second-feet (sec. ft. or cusec) is most commonly used for measuring flow of irrigation water moving by gravity from streams and reservoirs. Gallons per minute is most commonly used for measuring flow from pumps.

Cubic foot per second - The quantity of water equivalent to a stream one foot wide by one foot deep flowing with a velocity of one foot per second.

Gallon per minute - The quantity of water equivalent to a stream which will fill a gallon measure once each minute of time.

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A flow of one cubic foot per second is approximately equal to either 450 gallons per minute, one acre-inch per hour, or two acre-feet per day (24 hours).

List of Equivalents

The following equivalents are useful for converting from one unit to another and for calculating volumes from flow units.

Volume Units

One gallon
= 231 cubic inches
= 0.13368 cubic foot weighs approximately 8.33 pounds

One cubic foot

= 1,728 cubic inches
= 7.481 gallons (7.5 for ordinary calculations) weighs 62.4 pounds (62.5 for ordinary calculations)

One acre-inch

= 3,630 cubic feet
= 27,154 gallons (27,200 for ordinary calculations)
= $\frac{1}{12}$ acre-foot weighs approximately 113.1 tons

One acre-foot

= 43,560 cubic feet
= 325,851 gallons
= 12 acre-inches weighs approximately 1,357 tons

Rate of Flow Units

One gallon per minute

= 0.00223 (approximately $\frac{1}{450}$) cubic foot per second
= 0.00221 acre-inch per hour
= 0.00442 acre-foot per (24 hour) day
= 1 acre-inch in 452.6 hours (450 for ordinary calculations)
= 1 acre-foot in 226.3 days

One cubic foot per second

= 448.83 gallons per minute (450 for ordinary calculations)
= 1 acre-inch in 1 hour and 30 seconds (1 hour for ordinary calculations)
= 1 acre-foot in 12 hours and 6 minutes (12 hours for ordinary calculations)
= 1.984 acre-feet per (24 hours) day (2 acre-feet for ordinary calculations)

Conversion Table for units of flow.

Units	Cubic Feet Per Second	Gallons Per Minute	Million Gallons Per Day	Acre-Inches Per 24 Hours	Acre-Feet Per 24 Hours
Cubic Feet Per Second	1.0	448.8	0.646	23.8	1.984
Gallons Per Minute	0.00223	1.0	0.00144	0.053	0.00442
Million Gallons Per Day	1.547	694.4	1.0	36.84	3.07
Acre-Inches Per 24 Hours	0.042	18.86	0.0271	1.0	0.0833
Acre-Feet Per 24 Hours	0.504	226.3	0.3259	12.0	1.0

Million gallons per day (mgd)

- = 694.4 gallons per minute (695 for ordinary calculations)
- = 1.547 cubic feet per second (1.5 for ordinary calculations)

Using Conversion Table

To use the above conversion table, first locate the know unit of measurement in the left hand column headed "Units." Next, moving to the right, select the appropriate conversion factor listed under the vertical column with the heading of the desired unit of measurement.

Example No. 1: A well yielding 750 gallons per minute will supply how many acre-inches in 24 hours?

- Step 1:** Locate the line labeled "Gallons Per Minute" in the left-hand column labeled "Units."
- Step 2:** Move to the right along the "Gallons Per Minute" line and read 0.053 under the column headed "Acre-Inches Per 24 Hours."
- Step 3:** 750 x 0.053 = 39.75. The 750 gpm well will yield 39.75 acre-inches in 24 hours.

Example No. 2: How many cubic feet per second are required to make a 4 inch gross application on 40 acres of land in 72 hours?

- Step 1:** 40 acres x 4" = 160 acre-inches gross application. The conversion table shows factors for converting acre-inches per 24 hours to cubic feet per second. 72 hours ÷ 24 hours = 3 days. 160 ÷ 3 = 53.33 acre-inch per 24 hours.
- Step 2:** Locate the line labeled "Acre-Inches Per 24 Hours" in the left-hand column labeled "Units."
- Step 3:** Move to the right and under the vertical column labeled "Cubic Feet Per Second" read 0.042.
- Step 4:** 53.33 x 0.042 = 2.23986. It will require approximately 2 1/4 cfs to apply 4" of water on 40 acres in 72 hours.

Conversion Formulas

The following formulas are handy for computing the approximate depth of water applied to a field.

$$\frac{\text{Cubic feet per second} \times \text{hours}}{\text{acres}} = \text{acre-inches per acre, or average depth in inches.}$$

$$\frac{\text{Gallons per minute} \times \text{hours}}{450 \times \text{acres}} = \text{acre-inches per acre, or average depth in inches.}$$

Example: What average depth of water would be applied to an 80 acre field if a farmer pumped 750 gpm for 8 days (pumping 24 hours a day)?

Solution:

$$\frac{\text{Gallons per minute} \times \text{hours}}{450 \times \text{acres}} = \text{average depth in inches.}$$

$$\frac{750 \text{ gpm} \times 8 \text{ days} \times 24 \text{ hours/day}}{450 \times 80} = 4 \text{ inches average depth.}$$

Irrigation water management does begin with knowing how much water available and involves some arithmetic. The most common mistake when working with water measurement units is to accidentally substitute one flow unit or volume unit for another without proper conversion. Usually the final answer appears obviously wrong; however, this is not always true. When checking your arithmetic, also check the measurement unit to see they are correct.

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