

IRRIGATION MANAGEMENT

S E R I E S

Useful Conversions and Formulas

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Water Measurement

- 1 cubic foot = 7.48 gallons = 62.4 pounds of water
- 1 acre-foot = 43,560 cubic feet = 325,851 gallons = 12 acre-inches
- 1 acre-inch = 27,154 gallons
- 1 acre-foot is the volume of water that would cover 1 acre of land 1 foot deep
- 1 acre-inch per hour = 450 gallons per minute (gpm)
= 1 cubic foot per second (cfs)
- 1 cubic meter = 1,000 liters = 264 gallons
- 1 gallon = 128 ounces = 3,785 milliliters
- 1 ounce = 29.56 milliliters
- 1 liter = 1.06 quarts

Pressure

- 1 pound per square inch (psi) = 2.31 feet of water = 6.9 kpa (kilopascal)
= 0.0703 kilogram per square centimeter (kg/cm²)
= 0.704 meters of water

A column of water 2.31 feet deep exerts a pressure of 1 psi at the bottom of the column.

Total dynamic head (TDH) = pumping lift + elevation change + friction loss + irrigation system operating pressure

Area/Length/Weight/Yield

- 1 acre = 0.405 hectare (ha) = 43,560 feet²
- 1 hectare = 2.47 acres
- 1 mile = 5,280 feet = 1.61 kilometers
- 1 foot = 0.305 meter (m)
- 1 meter = 3.28 feet
- 1 inch = 2.54 centimeters
- 1 pound = 454 grams
- 1 kilogram per hectare (kg/ha) = 1 metric ton/ha (MT/ha)
= 0.0149 bushel (60 pounds) per acre

Temperature

$$^{\circ}\text{F} = 1.8 (^{\circ}\text{C}) + 32$$

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$$

$^{\circ}\text{C}$	-40	-20	0	20	37	60	80	100
$^{\circ}\text{F}$	-40	0	32	80	98.6	160	212	
			(water freezes)		(body temperature)			(water boils)

Horsepower

1 horsepower = 0.746 kilowatts (kw) = 33,000 foot-pounds per minute

Water horsepower (WHP) is the power required to lift a given quantity of water against a given total dynamic head.

$\text{WHP} = (Q \times H) \div 3960$, where Q = flow rate in GPM and H = total dynamic head in feet

Brake horsepower (BHP) is the required power input to the pump.

$\text{BHP} = \text{WHP} / \text{E}$, where E = pump efficiency

Power unit horsepower

Electric power units: approximate name plate horsepower = $\text{BHP} \div 0.9$

Internal combustion units:

Must derate 20 percent for continuous duty (= 80 percent efficiency)

5 percent for right-angle drive (= 95 percent efficiency)

3 percent for each 1,000 feet above sea level (= 91 percent for 3,000 feet)

1 percent for each 10° above 60°F (= 96 percent for 100°F)

Approximate engine horsepower required = $\text{BHP} \div \text{deratings}$

= $\text{BHP} \div (0.80 \times 0.95 \times 0.91 \times 0.96)$

Nebraska Performance Criteria (NPC)

Energy source	WHp-hours per unit of fuel
Diesel	12.5 WHp-hrs per gallon
Propane	6.89 WHp-hrs per gallon
Natural gas:	
925 BTU/ft ³	61.7 WHp-hrs per 1,000 ft ³ (MCF)
1,000 BTU/ft ³	66.7 WHp-hrs per 1,000 ft ³ (MCF)
Electric	0.885 WHp-hrs per kilowatt-hour

Water Application

$$D = Q \times T \div A \text{ or } T = D \times A \div Q$$

D = average application depth (inches)

Q = flow rate (acre-inches per hour)

T = time of application (hours)

A = area irrigated (acres)

Acreage covered by rectangular set:

$$\text{acres} = \frac{\text{no. of rows} \times \text{row width} \times \text{length of run}}{43,560 \text{ feet}^2/\text{acre}}$$

(measure width and length in feet)

Acreage covered by center pivot:

$$\text{acres} = \frac{(\text{radius}^* \text{ of wetted area})^2 \times 3.14}{43,560 \text{ ft}^2/\text{acre}}$$

(measure radius in feet)

* Radius is the distance from the pivot point to the end of the area wetted by the system.

Nozzle discharge:

$$\text{Flow rate (gpm)} = 29.7 \times D^2 \times \sqrt{P}$$

D = diameter of nozzles (inches)

P = pressure (psi)

Net irrigation = gross irrigation \times system efficiency

Irrigation Delivery Rate* per Acre (gpm/acre)

Net irrigation

application ----- System efficiency (percent) -----
(inches/day) 50 60 70 80 90 100

----- gpm/acre -----

0.10	3.77	3.14	2.69	2.36	2.10	1.89
0.15	5.66	4.71	4.04	3.54	3.14	2.83
0.20	7.54	6.29	5.39	4.71	4.19	3.77
0.25	9.43	7.86	6.73	5.89	5.24	4.71
0.30	11.31	9.43	8.08	7.07	6.29	5.66
0.35	13.20	11.00	9.43	8.25	7.33	6.60
0.40	15.09	12.57	10.78	9.43	8.38	7.54
0.45	16.97	14.14	12.12	10.61	9.43	8.49
0.50	18.86	15.71	13.47	11.79	10.48	9.43

Field delivery rate = gpm/acre \times acres irrigated

Plastic Pipe Friction Loss (psi loss per 100 feet of pipe) for C = 150

Pipe size (inches)	Flow rate (gpm)-----					
	10	25	50	75	100	150
	----- psi loss per 100 feet -----					
1½	0.26	1.40	5.50	—	—	—
2	0.09	0.52	1.90	4.10	—	—
2½	0.03	0.17	0.65	1.35	2.40	5.00
3	—	0.07	0.26	0.38	0.95	2.05
4	—	0.01	0.06	0.14	0.24	0.50

Pipe size (inches)	Flow rate (gpm)-----					
	200	400	600	800	1000	1200
	----- psi loss per 100 feet -----					
4	0.85	3.20	—	—	—	—
6	0.12	0.42	0.93	1.60	2.40	3.40
8	0.03	0.11	0.22	0.38	0.60	0.85
10	—	0.04	0.08	0.16	0.19	0.28
12	—	—	0.03	0.06	0.08	0.11

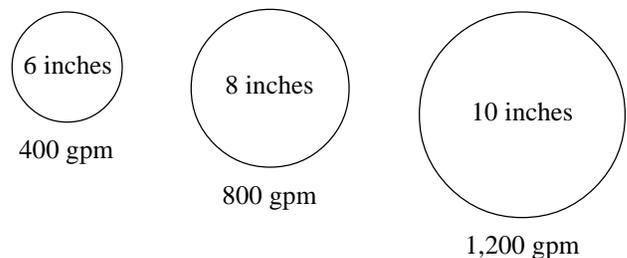
Economical Pipe Size Selection (flow in gpm)

Size (inches)	Aluminum *	Plastic *
	----- gpm -----	
4	200	275
6	450	620
8	800	1,100
10	1,250	1,720
12	1,800	2,480

* Aluminum pipe velocity limited to 5 ft/sec. Plastic pipe velocity limited to 7 ft/sec.

Maximum Economical Pipe-flow Capacities

A rule of thumb for coupled and gated pipe:



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