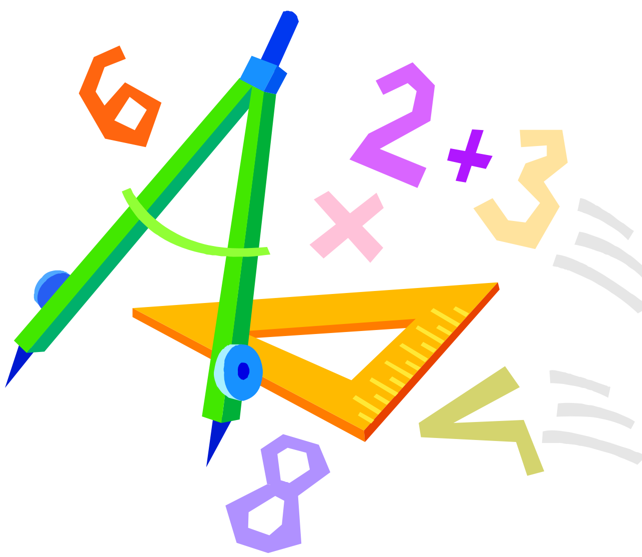
Collection Systems Mathematical Formulas

First Edition



Fleming Training Center

Murfreesboro, TN

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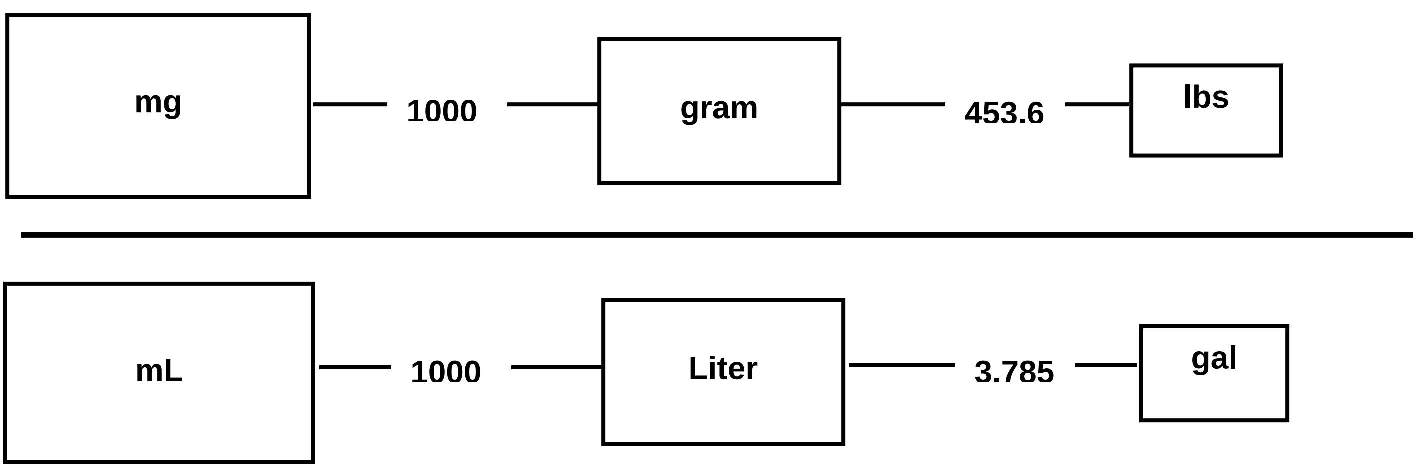
Conversion Factors

1 acre	=	43,560 ft^2
1 foot of head	=	0.433 psi
1 psi	=	2.31 feet of head
1 yd^3	=	27 ft^3
1 gal	=	3.785 Liters
1 gallon of water	=	8.34 lbs
1 cubic foot of water	=	7.48 gallons
1 lb	=	453.6 grams
1 mile	=	5280 feet
1%	=	10,000 $^{mg}/_{L}$

Converting $^{mg}/_{mL}$ to $^{lb}/_{gal}$



To use this diagram: First, find the box that coincides with the beginning units (i.e. mg/mL). Then, find the box that coincides with the desired ending units (i.e. lbs/gal). The numbers between the starting point and ending point are the conversion factors. When moving from a smaller box to a larger box, multiply by the factor between them. When moving from a larger box to a smaller box, divide by the factor between them. For final number, divide top number by bottom number.

Area

Rectangle: Area, ft^2 = (length, ft)(width, ft)

Circle: Area, ft^2 = $(0.785)(\text{Diameter, ft})^2$

Triangle: Area, ft^2 = (0.5)(base, ft)(height, ft)

Volume

Rectangle: Volume, ft^3 = (length, ft)(width, ft)(depth, ft)

Cylinder: Volume, ft^3 = $(0.785)(\text{Diameter, ft})^2(\text{depth or length, ft})$

Cone: Volume, ft^3 = $\frac{(0.785)(\text{Diameter, ft})^2(\text{height, ft})}{3}$

Volume, gallons = $(\text{volume, ft}^3)(7.48\ ^{gal}/_{cu.ft.})$

Temperature

$°C = {}^5/_9(°F – 32)$

$°F = {}^9/_5\ (°C) + 32$

Flow

Q = AV

Q = (Area)(Velocity)

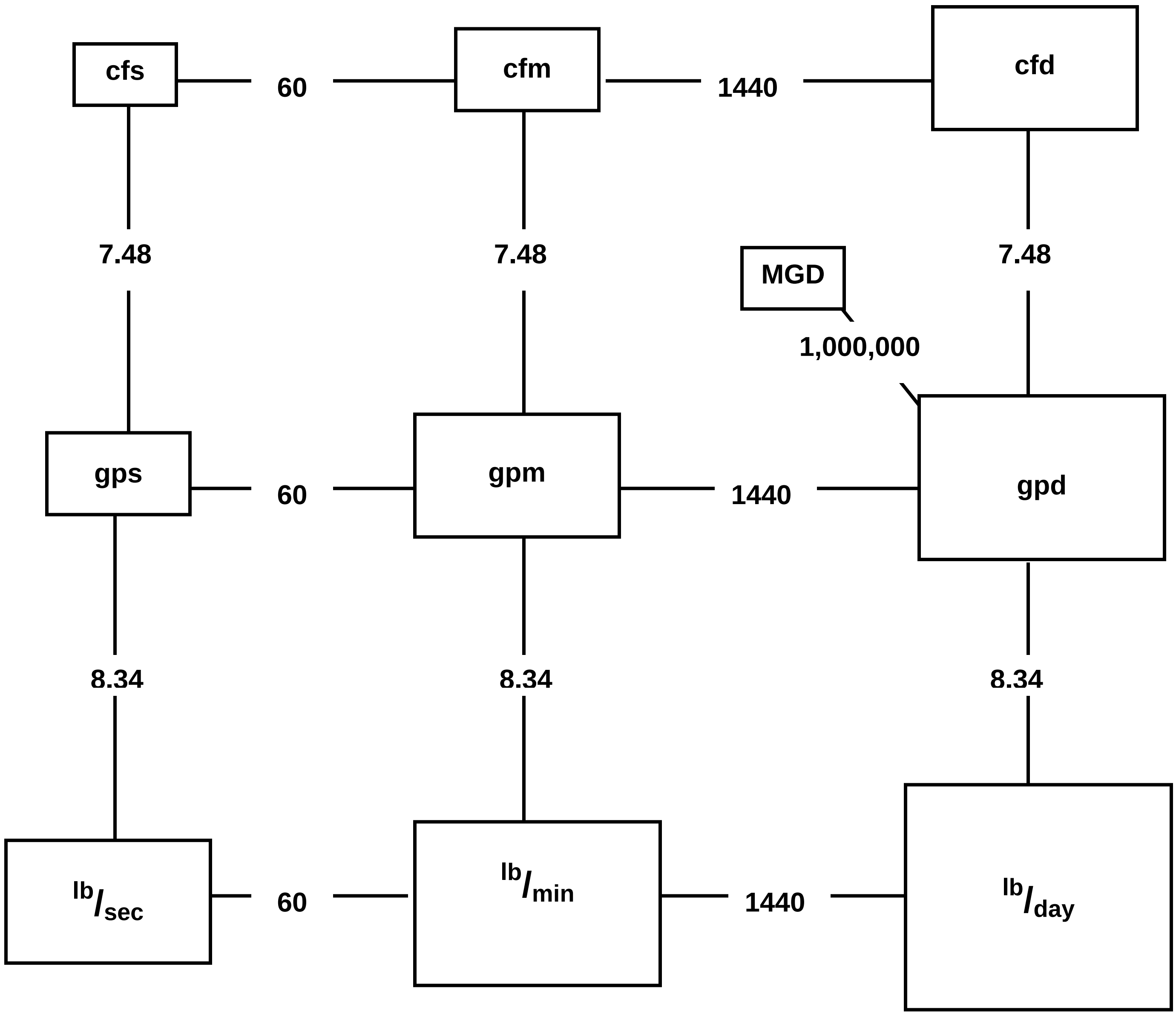
Q (channel), cfs = (width, ft)(depth, ft)(Velocity, fps)

Q (pipeline), cfs = $(0.785)(\text{Diameter, ft})^2(\text{Velocity, fps})$

Velocity, fps = $\frac{\text{Distance, ft}}{\text{Time, sec}}$

Average Flow, MGD = $\frac{\text{sum of daily flows, MGD}}{\text{Number of daily flows}}$

Flow Conversions



cfs	=	cubic feet per second	gps	=	gallons per second
cfm	=	cubic feet per minute	gpm	=	gallons per minute
cfd	=	cubic feet per day	gpd	=	gallons per day

To use this diagram: First, find the box that coincides with the beginning units (i.e. gpm). Then, find the box that coincides with the desired ending units (i.e. cfs). The numbers between the starting point and ending point are the conversion factors. When moving from a smaller box to a larger box, multiply by the factor between them. When moving from a larger box to a smaller box, divide by the factor between them.

Dosage

Dosage, $^{mg}/_L$ = $\frac{(^{grams}/_{min})(1{,}000\ ^{mg}/_{gram})}{(\text{flow, gpm})(3.785\ ^{L}/_{gal})}$

Dosage, $^{mg}/_L$ = $\frac{\text{chemical feed, } ^{lbs}/_{day}}{(\text{flow, MGD})(8.34\ ^{lbs}/_{gal})}$

Pounds

Chemical Feed, lbs = $(\text{dose, } ^{mg}/_L)(\text{volume, MG})(8.34\ ^{lbs}/_{gal})$

Chemical Feed, lbs = $\frac{(\text{dose, } ^{mg}/_L)(\text{volume, MG})(8.34\ ^{lbs}/_{gal})}{\%\text{ chemical purity, expressed as decimal}}$

Feed Rate, $^{lbs}/_{day}$ = $(\text{dose, } ^{mg}/_L)(\text{flow, MGD})(8.34\ ^{lbs}/_{gal})$

Feed Rate, $^{lbs}/_{day}$ = $\frac{(\text{dose, } ^{mg}/_L)(\text{flow, MGD})(8.34\ ^{lbs}/_{gal})}{\%\text{ chemical purity, expressed as decimal}}$

Feed Rate, $^{lbs}/_{day}$ = $\frac{(\text{conc., } ^{mg}/_L)(\text{vol. pumped, mL})(1440\ ^{min}/_{day})}{(\text{time pumped, min})(1000\ ^{mL}/_L)(1000\ ^{mg}/_{gram})(453.6\ ^{gram}/_{lb})}$

Power

1 Horsepower = 746 watts or 0.746 kilowatts

Power, watts = (volts)(amps)

Amps, single-phase = $\frac{(746)(\text{horsepower})}{(\text{volts})(\%\text{ efficiency, as decimal})(\text{power factor})}$

Amps, three-phase = $\frac{(746)(\text{horsepower})}{(1.732)(\text{volts})(\%\text{ efficiency, as decimal})(\text{power factor})}$

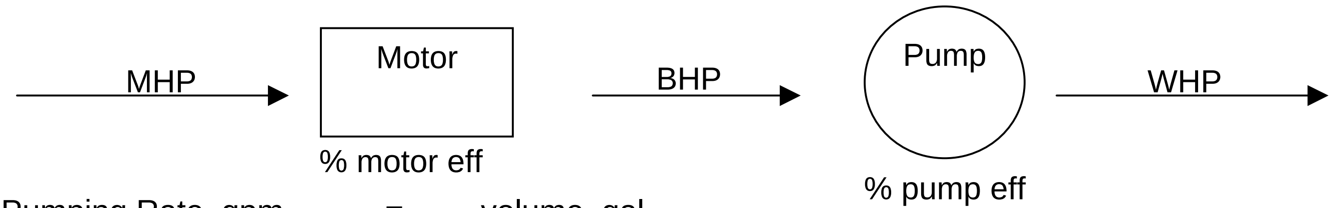
Horsepower = $\frac{(\text{volts})(\text{amps})}{746}$

Kilowatts, single-phase = $\frac{(\text{volts})(\text{amps})(\text{power factor})}{1000}$

Kilowatts, three-phase = $\frac{(\text{volts})(\text{amps})(\text{power factor})(1.732)}{1000}$

Power Factor = $\frac{\text{watts}}{(\text{volts})(\text{amps})}$

Pumps



$$\text{Pumping Rate, gpm} = \frac{\text{volume, gal}}{\text{time, min}}$$

$$\text{Pumping Rate, gpm} = \frac{(\text{length, ft})(\text{width, ft})(\text{depth, ft})(7.48\ \text{gal/ft}^3)}{\text{time, min}}$$

$$\text{Pumping Rate, gpm} = \frac{(0.785)(\text{Diameter, ft})^2(\text{depth, ft})(7.48\ \text{gal/ft}^3)}{\text{time, min}}$$

$$\text{Time to fill, min} = \frac{\text{tank volume, gal}}{\text{flow rate, gpm}}$$

$$\text{Water hp} = \frac{(\text{flow, gpm})(\text{head, ft})}{3960}$$

$$\text{Brake hp} = \frac{(\text{flow, gpm})(\text{head, ft})}{(3960)(\text{\%pump efficiency, as decimal})}$$

$$\text{Motor hp} = \frac{(\text{flow, gpm})(\text{head, ft})}{(3960)(\text{\%pump efficiency, as decimal})(\text{\%motor efficiency, as decimal})}$$

$$\text{Brake hp} = \frac{\text{water hp}}{\text{\%pump efficiency, as decimal}}$$

$$\text{Motor hp} = \frac{\text{brake hp}}{\text{\%motor efficiency, as decimal}}$$

$$\text{\% Motor Efficiency} = \frac{\text{brake hp}}{\text{motor hp}} \times 100\%$$

$$\text{\% Pump Efficiency} = \frac{\text{water hp}}{\text{brake hp}} \times 100\%$$

$$\text{\% Efficiency} = \frac{\text{hp output}}{\text{hp supplied}} \times 100\%$$

$$\text{\% Efficiency, overall} = \frac{\text{water hp}}{\text{motor hp}} \times 100\%$$

$$\text{Wire-to-water Efficiency, \%} = (\text{\% pump eff., as decimal})(\text{\% motor eff., as decimal})(100\%)$$

Pumps, cont

Static Head, ft = suction lift, ft + discharge head, ft

Static Head, ft = discharge head, ft – suction head, ft

Friction Loss, ft = (0.1)(static head, ft) *****use this formula in absence of other data*****

Total Dynamic Head, ft = static head, ft + friction losses, ft

Cost, $^{\$}/_{hr}$ = (motor hp)(0.746 kW/hp)(cost, $^{\$}/_{kW\text{-}hr}$)

Metric Conversions

Primary Unit

mega (M)	. .	kilo (k)	hecto (h)	deka (da)	no prefix	deci (d)	centi (c)	milli (m)	. .	micro (µ)
1,000,000		1,000	100	10	1	$^{1}/_{10}$	$^{1}/_{100}$	$^{1}/_{1,000}$		$^{1}/_{1,000,000}$

↓

meter – linear measurement
liter – volume measurement
gram – weight measurement

Chlorination

Chlorine Dose, $^{mg}/_{L}$ = chlorine demand, $^{mg}/_{L}$ + chlorine residual, $^{mg}/_{L}$

HTH, lbs = $\dfrac{(\text{\% conc. hypo, as decimal})(\text{hypochlorite, gal})(8.34\ ^{lbs}/_{gal})}{\text{\% available HTH, as decimal}}$

Bleach, $^{gal}/_{day}$ = $\dfrac{(\text{dose, }^{mg}/_{L})(\text{flow, MGD})}{(\text{\% available, as decimal})}$

$(c_1)(v_1) = (c_2)(v_2)$

where: *c = concentration*
v = volume

Time/Slope

$$\text{Average Time, sec} = \frac{(t_1 + t_2)}{2}$$

$$\text{Slope, } {}^{ft}/_{ft} = \frac{\text{vertical drop,ft}}{\text{distance,ft}}$$

$$\text{Slope, \%} = \text{Slope, } {}^{ft}/_{ft} \times 100\%$$

Sewer Leak Test

$$\text{Leakage, gal} = (0.785)(\text{Manhole Diameter, ft})^2(\text{Water Drop, ft})(7.48\ {}^{gal}/_{ft^3})$$

$$\text{Leakage, } {}^{gal}/_{day} = \frac{(\text{Leakage, gal})(24\ {}^{hr}/_{day})}{\text{Time, hr}}$$

$$\text{Leakage, } {}^{gal}/\text{day}/_{inch} = \frac{(\text{Leakage, } {}^{gal}/_{day})}{\text{Sewer Diameter (inch)}}$$

$$\text{Leakage, gal/day/inch/mile} = \frac{(\text{Leakage, } {}^{gpd}/_{inch})(5280\ {}^{ft}/_{mile})}{\text{Pipe Length, ft}}$$

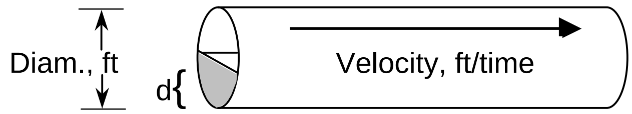
$$\text{Blower Capacity, } {}^{cu.ft.}/_{min} = \frac{(0.785)(\text{Manhole Diameter, ft})^2(\text{Manhole depth, ft})}{\text{Air Change, min}}$$

Excavation/Paving and Maps/Blueprints

$$\text{Paving, cu.yd.} = \frac{(\text{Length,ft})(\text{Width, ft})(\text{Depth, ft})}{27\ {}^{cu.ft.}/_{cu.yd.}}$$

$$\text{Map Scale: } \frac{\text{1 inch}}{\text{Measured Distance, in}} = \frac{\text{Scale, ft}}{\text{Actual Distance, ft}}$$

Flow, Partially Full Pipe



$$Q_{cfs} = \underbrace{A}_{} \quad \underbrace{V_{fps}}_{}$$

$$Q_{cfs} = (\text{factor from } {}^{d}/_{D} \text{ table})(D, \text{ft})^2 \quad (\text{fps})$$

depth/Diameter Table							
0.01	0.0013	0.26	0.1623	0.51	0.4027	0.76	0.6404
0.02	0.0037	0.27	0.1711	0.52	0.4127	0.77	0.6489
0.03	0.0069	0.28	0.1800	0.53	0.4227	0.78	0.6573
0.04	0.0105	0.29	0.1890	0.54	0.4327	0.79	0.6655
0.05	0.0147	0.30	0.1982	0.55	0.4426	0.80	0.6736
0.06	0.0192	0.31	0.2074	0.56	0.4526	0.81	0.6813
0.07	0.0242	0.32	0.2167	0.57	0.4625	0.82	0.6893
0.08	0.0294	0.33	0.2260	0.58	0.4724	0.83	0.6969
0.09	0.0350	0.34	0.2355	0.59	0.4822	0.84	0.7043
0.10	0.0409	0.35	0.2450	0.60	0.4920	0.85	0.7115
0.11	0.0470	0.36	0.2546	0.61	0.5018	0.86	0.7186
0.12	0.0534	0.37	0.2642	0.62	0.5118	0.87	0.7254
0.13	0.0600	0.38	0.2739	0.63	0.5212	0.88	0.7320
0.14	0.0668	0.39	0.2836	0.64	0.5308	0.89	0.7384
0.15	0.0739	0.40	0.2934	0.65	0.5404	0.90	0.7445
0.16	0.0811	0.41	0.3032	0.66	0.5499	0.91	0.7504
0.17	0.0885	0.42	0.3130	0.67	0.5594	0.92	0.7560
0.18	0.0961	0.43	0.3229	0.68	0.5687	0.93	0.7612
0.19	0.1039	0.44	0.3328	0.69	0.5780	0.94	0.7662
0.20	0.1118	0.45	0.3428	0.70	0.5872	0.95	0.7707
0.21	0.1199	0.46	0.3527	0.71	0.5964	0.96	0.7749
0.22	0.1281	0.47	0.3627	0.72	0.6054	0.97	0.7785
0.23	0.1365	0.48	0.3727	0.73	0.6143	0.98	0.7816
0.24	0.1449	0.49	0.3827	0.74	0.6231	0.99	0.7841
0.25	0.1535	0.50	0.3927	0.75	0.6318	1.00	0.7854