

TN

Department of
**Environment &
Conservation**



Tennessee Operator Certification Formula Manual

Wastewater Treatment Formulas & Conversions

Prepared by the Fleming Training Center

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About This Manual

This publication is provided by the Tennessee Department of Environment and Conservation (TDEC), Division of Water Resources (DWR), as an official resource for examinees participating in the State of Tennessee's operator certification program. It may be used during certification exams and is intended to support operators in understanding and applying essential mathematical formulas and conversions in the field.

This manual was collaboratively developed and reviewed by:

- **Fleming Training Center (FTC)** – content development and formatting
- **Water Professionals International (WPI)** – foundational formula reference materials
- **Tennessee Association of Utility Districts (TAUD)** – editorial review and industry input

This resource is intended to reflect Tennessee's commitment to operator preparedness and professional excellence. While based on national standards, the formatting and presentation have been tailored to meet the needs of Tennessee operators and exam settings.

Document Revision History

<u>Revision</u>	<u>Date</u>	<u>Brief Summary of Change</u>
0	10/2025	Initial Issue
1	1/2026	Note added to Solids Loading Rate

Wastewater Treatment Formulas & Conversions

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Wastewater Treatment Formulas & Conversions

Circumference and Perimeter

Circumference of a Circle = $(3.14)(\text{Diameter})$

Perimeter, ft = $(2)(\text{Length, ft}) + (2)(\text{Width, ft})$

Area

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

Area of a Circle, $\text{ft}^2 = (3.14)(\text{Radius, ft})^2$

Area of a Rectangle*, $\text{ft}^2 = (\text{Length, ft})(\text{Width, ft})$

Area of a Right Triangle*, $\text{ft}^2 = \frac{[(\text{Base, ft})(\text{Height, ft})]}{2}$

Lateral Surface Area of a Cone, $\text{ft}^2 = (3.14)(\text{Radius, ft}) \left(\sqrt{(\text{Radius, ft})^2 + (\text{Height, ft})^2} \right)$

Total Surface Area of a Cone, $\text{ft}^2 = (3.14)(\text{Radius, ft}) \left(\text{Radius, ft} + \sqrt{(\text{Radius, ft})^2 + (\text{Height, ft})^2} \right)$

Total Exterior Surface Area of a Cylinder, $\text{ft}^2 =$

$$\left(\text{end \#1 SA, ft}^2 \right) + \left(\text{end \#2 SA, ft}^2 \right) + [(3.14)(\text{Diameter, ft})(\text{Height, ft})]$$

Where SA = Surface Area of a Circle

Volume

Volume of a Cone*, $\text{ft}^3 = (1/3)(0.785)(\text{Diameter, ft})^2(\text{Height, ft})$

Volume of a Cylinder*, $\text{ft}^3 = (0.785)(\text{Diameter, ft})^2(\text{Height, ft})$

Volume of a Rectangular Tank*, $\text{ft}^3 = (\text{Length, ft})(\text{Width, ft})(\text{Height, ft})$

Volume of a Wedge, $\text{ft}^3 = \frac{(\text{Length, ft})(\text{Width, ft})(\text{Depth, ft})}{2}$

Volume, gallons = $\left(\text{Volume, ft}^3 \right) \left(7.48 \text{ gal/ft}^3 \right)$

*Pie Wheel Format for this equation is available at the end of this document

Wastewater Treatment Formulas & Conversions

Velocity and Flow

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

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3/\text{sec}}{\text{Area, ft}^2}$$

$$\text{Flow}^*, \text{ft}^3/\text{sec} = (\text{Area, ft}^2)(\text{Velocity, ft/sec})$$

$$\text{Flow Through a Channel, ft}^3/\text{sec} = (\text{Width, ft})(\text{Depth, ft})(\text{Velocity, ft/sec})$$

$$\text{Flow Through a Full Pipe, ft}^3/\text{sec} = (0.785)(\text{Diameter, ft})^2(\text{Velocity, ft/sec})$$

$$\text{Daily Flow, gal/day/capita} = \frac{\text{Water Used, gpd}}{\text{Number of People Served, capita}}$$

Pounds (Feed Rate)

$$\text{Mass}^*, \text{lb} = (\text{Concentration, mg/L})(\text{Volume, MG})(8.34 \text{ lb/gal})$$

$$\text{Mass, lb} = \frac{(\text{Concentration, mg/L})(\text{Volume, MG})(8.34 \text{ lb/gal})}{\text{Chemical Purity, \% as a decimal}}$$

$$\text{Loading Rate}^*, \text{lb/day} = (\text{Concentration, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{Feed Rate, lb/day} = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Chemical Purity, \% as a decimal}}$$

Dosage

$$\text{Dosage, mg/L} = \frac{(\text{Feed Rate, lb/day})}{(\text{Flow, MGD})(8.34 \text{ lb/gal})}$$

$$\text{Dosage, mg/L} = \frac{(\text{Feed Rate, lb/day})(\text{Chemical Purity, \% as a decimal})}{(\text{Flow, MGD})(8.34 \text{ lb/gal})}$$

$$\text{Dosage, mg/L} = \frac{(\text{Feed Mass, lb})(\text{Chemical Purity, \% as a decimal})}{(\text{Volume, MG})(8.34 \text{ lb/gal})}$$

$$\text{Dosage, mg/L} = \frac{(\text{Feed Rate, g/min})(1000 \text{ mg/g})}{(\text{Flow, gpm})(3.785 \text{ L/gal})}$$

*Pie Wheel Format for this equation is available at the end of this document

Wastewater Treatment Formulas & Conversions

Power

$$\text{Amps} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Amps (Single-Phase)} = \frac{(746 \text{ watts/HP})(\text{Horsepower})}{(\text{Volts})(\text{Efficiency, \% as a decimal})(\text{Power Factor})}$$

$$\text{Amps (Three-Phase)} = \frac{(746 \text{ watts/HP})(\text{Horsepower})}{(1.732)(\text{Volts})(\text{Efficiency, \% as a decimal})(\text{Power Factor})}$$

$$\text{Electromotive Force}^*, \text{ volts} = (\text{Current, amps})(\text{Resistance, ohms})$$

$$\text{Force}^*, \text{ lbs} = (\text{Pressure, psi})(\text{Area, in}^2)$$

$$\text{Horsepower} = \frac{(\text{Volts})(\text{Amps})}{(746 \text{ watts/HP})}$$

$$\text{Power, watts (AC Circuit)} = (\text{Volts})(\text{Amps})(\text{Power Factor})$$

$$\text{Power, watts (DC Circuit)} = (\text{Volts})(\text{Amps})$$

$$\text{Power Factor} = \frac{\text{Watts}}{(\text{Volts})(\text{Amps})}$$

$$\text{Cost, \$/hour} = (\text{Motor Horsepower, hp})(0.746 \text{ kW/hp})(\text{Cost, \$/kW-hr})$$

Pumps and Motors

$$\text{Cycle Time, min} = \frac{\text{Storage Volume, gal}}{(\text{Pump Capacity, gpm} - \text{Wet Well Inflow, gpm})}$$

$$\text{Time to Fill, min} = \frac{\text{Tank Volume, gal}}{\text{Flow Rate, gal/min}}$$

Pumping Rate

$$\text{Pumping Rate, gpm} = \frac{\text{Volume, gal}}{\text{Time, min}}$$

$$\text{Pumping Rate of a Rectangular Tank, gpm} = \frac{(\text{Length, ft})(\text{Width, ft})(\text{Depth, ft})(7.48 \text{ gal/ft}^3)}{\text{Time, min}}$$

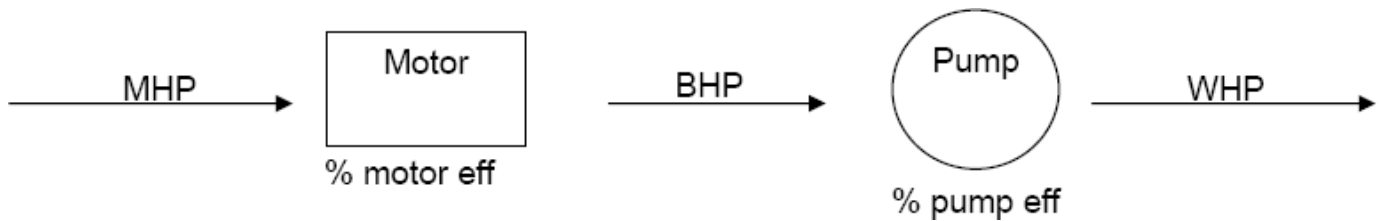
$$\text{Pumping Rate of a Cylindrical Tank, gpm} = \frac{(0.785)(\text{Diameter, ft})^2(\text{Depth, ft})(7.48 \text{ gal/ft}^3)}{\text{Time, min}}$$

$$\text{Pumping Rate of a Conical Tank, gpm} = \frac{(1/3)(0.785)(\text{Diameter, ft})^2(\text{Depth, ft})(7.48 \text{ gal/ft}^3)}{\text{Time, min}}$$

*Pie Wheel Format for this equation is available at the end of this document

Wastewater Treatment Formulas & Conversions

Pumps and Motors (continued)



Horsepower

$$\text{Water Horsepower, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)}$$

$$\text{Brake Horsepower, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Pump Efficiency, \% as a decimal})}$$

$$\text{Brake Horsepower, hp} = \frac{\text{Water Horsepower, hp}}{\text{Pump Efficiency, \% as a decimal}}$$

$$\text{Motor Horsepower, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Pump Efficiency, \% as a decimal})(\text{Motor Efficiency, \% as a decimal})}$$

$$\text{Motor Horsepower, hp} = \frac{\text{Water Horsepower, hp}}{(\text{Pump Efficiency, \% as a decimal})(\text{Motor Efficiency, \% as a decimal})}$$

$$\text{Motor Horsepower, hp} = \frac{\text{Brake Horsepower, hp}}{\text{Motor Efficiency, \% as a decimal}}$$

Efficiency

$$\text{Efficiency, \%} = \frac{\text{Horsepower Output, hp}}{\text{Horsepower Supplied, hp}} \times 100\%$$

$$\text{Motor Efficiency, \%} = \frac{\text{Brake Horsepower, hp}}{\text{Motor Horsepower, hp}} \times 100\%$$

$$\text{Pump Efficiency, \%} = \frac{\text{Water Horsepower, hp}}{\text{Brake Horsepower, hp}} \times 100\%$$

$$\text{Wire-to-Water Efficiency, \%} = (\text{Pump Efficiency, \% as a decimal})(\text{Motor Efficiency, \% as a decimal})(100\%)$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{\text{Water Horsepower, hp}}{\text{Motor Horsepower, hp}} \times 100\%$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{(\text{Flow, gpm})(\text{Total Dynamic Head, ft})(0.746 \text{ kW/hp})}{(3,960)(\text{Electrical Demand, kW})} \times 100\%$$

Wastewater Treatment Formulas & Conversions

Preliminary Treatment

$$\text{Grit Removal, ft}^3/\text{MG} = \frac{\text{Grit Volume, ft}^3}{\text{Flow, MG}}$$

$$\text{Screenings Pit Capacity, days} = \frac{\text{Pit Volume, ft}^3}{\text{Screenings Removed, ft}^3/\text{day}}$$

$$\text{Screenings Removed, ft}^3/\text{day} = \frac{\text{Screenings removed, ft}^3}{\text{Time, day}}$$

$$\text{Screenings Removed, ft}^3/\text{MG} = \frac{\text{Screenings removed, ft}^3}{\text{Flow, MG}}$$

Attached Growth Systems

$$\text{BOD Removed, lb/day} = (\text{BOD removed, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{Efficiency, \%} = \frac{(\text{In-Out})}{\text{In}} \times 100\%$$

$$\text{Hydraulic Loading Rate, gpd/ft}^2 = \frac{\text{Flow Rate, gpd}}{\text{Surface Area, ft}^2}$$

$$\text{Hydraulic Loading Rate, gpd/ft}^2 = \frac{(\text{Primary Effluent Flow, gpd} + \text{Recirculated Flow, gpd})}{\text{Surface Area, ft}^2}$$

$$\text{Organic Loading Rate-RBC, lb SBOD}_5/\text{day}/1,000 \text{ ft}^2 = \frac{\text{Organic Load, lb SBOD}_5/\text{day}}{\text{Surface Area of Media, 1,000 ft}^2}$$

$$\text{Suspended Solids Removed, lb/day} = (\text{Suspended Solids Removed, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{Organic Loading Rate-Trickling Filter, lb BOD}_5/\text{day}/1,000\text{ft}^3 = \frac{\text{Organic Load, lb BOD}_5/\text{day}}{\text{Volume of Media, 1,000 ft}^3}$$

$$\text{Volume of Media, 1000 ft}^3 = \frac{(0.785)(\text{Filter Diameter, ft})^2(\text{Media Depth, ft})}{1,000}$$

$$\text{Recirculation Ratio - Trickling Filter} = \frac{\text{Recirculated Flow, MGD}}{\text{Primary Effluent Flow, MGD}}$$

$$\text{Surface of the Media, 1000 ft}^2 = \frac{(0.785)(\text{Filter Diameter, ft})^2}{1,000}$$

Wastewater Treatment Formulas & Conversions

Ponds/Lagoons

$$\text{BOD Loading, lb/day} = (\text{BOD, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{BOD Removal Efficiency, \%} = \left(\frac{\text{BOD Removed, mg/L}}{\text{Total BOD, mg/L}} \right) \times 100\%$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible.}$$

$$\text{Flow, ac-ft/day} = \frac{\text{Flow, gpd}}{(7.48 \text{ gal/ft}^3)(43,560 \text{ ft}^2/\text{ac})}$$

$$\text{Hydraulic Loading Rate, inches/day} = \left(\frac{\text{Flow, ac-ft/day}}{\text{Pond Area, acres}} \right) \times 12 \text{ in/ft}$$

$$\text{Organic Loading Rate, lb/day/acre} = \frac{\text{Influent BOD, lb/day}}{\text{Pond Area, acres}}$$

$$\text{Population Loading, persons/acre} = \frac{\text{Population Served, persons}}{\text{Pond Area, acres}}$$

$$\text{Pond Area, acre} = \frac{(\text{Pond Length, ft})(\text{Pond Width, ft})}{43,560 \text{ ft}^2/\text{acre}}$$

$$\text{Pond Volume, ac-ft} = \frac{(\text{Pond Length, ft})(\text{Pond Width, ft})(\text{Pond Depth, ft})}{43,560 \text{ ft}^2/\text{acre}}$$

$$\text{Pond Volume, ac-ft} = (\text{Pond Area, acres})(\text{Pond Depth, ft})$$

$$\text{Pond Volume, gal} = (\text{Volume, ac-ft})(43,560 \text{ ft}^2/\text{ac})(7.48 \text{ gal/ft}^3)$$

$$\text{Population Equivalent, Organic} = \frac{(\text{BOD, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{0.17 \text{ lb BOD/day/person}}$$

Activated Sludge

$$\text{BOD Loading, lb/day} = (\text{BOD, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{COD Loading, lb/day} = (\text{COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{MLSS, lb} = (\text{MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lb/gal})$$

$$\text{MLVSS, lb} = (\text{MLSS, mg/L})(\text{Aerator Vol., MG})(8.34 \text{ lb/gal})(\text{Volatile Solids, \% exp. as a decimal})$$

Wastewater Treatment Formulas & Conversions

Activated Sludge (continued)

Food to Microorganisms (F/M) Ratio

$$F/M \text{ Ratio} = \frac{\text{BOD}_5 \text{ or COD, lb/day}}{\text{MLVSS, lb}}$$

$$F/M \text{ Ratio} = \frac{\text{BOD or COD, lb/day}}{(\text{MLSS, lb})(\text{Volatile Solids, \% as a decimal})}$$

$$F/M \text{ Ratio} = \frac{(\text{BOD or COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{(\text{MLVSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lb/gal})}$$

$$F/M \text{ Ratio} = \frac{(\text{BOD or COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{(\text{MLSS, mg/L})(\text{Volatile Solids, \% as a decimal})(\text{Aerator Volume, MG})(8.34 \text{ lb/gal})}$$

$$\text{Desired MLVSS, lb} = \frac{\text{BOD or COD, lb/day}}{\text{Desired F/M Ratio}}$$

$$\text{Desired MLSS, lb} = \frac{\text{Desired MLVSS, lb}}{\text{Volatile Solids, \% as a decimal}}$$

Mean Cell Residence Time (MCRT) or Solids Retention Time (SRT)

$$\text{Actual MLSS, lb} = (\text{Actual MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lb/gal})$$

$$\text{MCRT, days} = \frac{\text{Suspended Solids in Systems, lbs}}{\text{Suspended Solids Leaving Systems, lb/day}}$$

$$\text{MCRT, days} = \frac{(\text{Aeration Tank TSS, lb} + \text{Clarifier TSS, lb})}{(\text{TSS Wasted, lb/day} + \text{Effluent TSS, lb/day})}$$

$$\text{MCRT, days (No CCSS provided)} =$$

$$\frac{(\text{MLSS, mg/L})(\text{Aerator Volume, MG} + \text{Final Clarifier Volume, MG})(8.34 \text{ lb/gal})}{(\text{WAS SS, mg/L})(\text{WAS Flow, MGD})(8.34 \text{ lb/gal}) + (\text{S.E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lb/gal})}$$

$$\text{MCRT, days} =$$

$$\frac{(\text{MLSS, mg/L})(\text{Aerator Vol, MG})(8.34 \text{ lb/gal}) + (\text{CCSS, mg/L})(\text{Final Clarifier Vol, MG})(8.34 \text{ lb/gal})}{(\text{WAS SS, mg/L})(\text{WAS Flow, MGD})(8.34 \text{ lb/gal}) + (\text{S.E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lb/gal})}$$

$$\text{SRT, days} = \frac{(\text{Aeration Tank TSS, lbs})}{(\text{TSS Wasted, lb/day} + \text{Effluent TSS, lb/day})}$$

$$\text{SRT, days} = \frac{(\text{MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lb/gal})}{(\text{WAS SS, mg/L})(\text{WAS Flow, MGD})(8.34 \text{ lb/gal}) + (\text{S.E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lb/gal})}$$

Wastewater Treatment Formulas & Conversions

Activated Sludge (continued)

Waste Activated Sludge (WAS)

Amount to Be Wasted, lbs = Actual MLSS, lbs – Desired MLSS, lbs

$$\text{MLSS, gal to waste} = \frac{\text{MLSS, lbs to waste}}{(\text{RAS Concentration, mg/L})(8.34 \text{ lb/gal})} \times 1,000,000$$

$$\text{Time to Waste Sludge, min} = \frac{\text{MLSS, gal to waste}}{\text{Waste Sludge Pump Capacity, gpm}}$$

WAS, lb/day =

$$\left(\frac{(\text{MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \frac{\text{lb}}{\text{gal}})}{\text{MCRT, days}} \right) - (\text{S.E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lb/gal})$$

Return Activated Sludge (RAS)

$$\text{RAS Flow, \%} = \frac{\text{Settled Sludge Volume, mL}}{(1000 \text{ mL} - \text{Settled Sludge Volume, mL})} \times 100\%$$

$$\text{RAS Flow, \%} = \frac{\text{RAS Flow, MGD}}{\text{Influent Flow, MGD}} \times 100\%$$

$$\text{RAS Flow, gal/day} = (\text{RAS Flow, \% as a decimal})(\text{Flow, gpd})$$

$$\text{RAS Flow, gal/day} = \frac{(\text{Aerator Influent Flow, gpd})(\text{MLSS, mg/L})}{(\text{RAS Concentration, mg/L} - \text{MLSS, mg/L})}$$

$$\text{RAS Concentration, mg/L} = \frac{1,000,000}{\text{Sludge Volume Index}}$$

*SVI formula found in
Laboratory Calculations.*

$$\text{Return Rate, \%} = \left(\frac{\text{Return Flow Rate}}{\text{Influent Flow Rate}} \right) \times 100\%$$

$$\text{Return Sludge Rate–Solids Balance, MGD} = \frac{(\text{MLSS, mg/L})(\text{Flow Rate, MGD})}{(\text{RAS Suspended Solids, mg/L} - \text{MLSS, mg/L})}$$

Wastewater Treatment Formulas & Conversions

Sedimentation

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible.}$$

$$\text{Detention Time, hr} = \frac{(\text{Volume, gal})(24 \text{ hr/day})}{\text{Flow, gpd}}$$

$$\text{BOD Removed, lb/day} = (\text{BOD removed, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{Removal Efficiency, \%} = \left[\frac{(\text{In-Out})}{\text{In}} \right] \times 100\%$$

$$\text{Solids Loading Rate, lb/day/ft}^2 = \frac{\text{Solids Applied, lb/day}}{\text{Surface Area, ft}^2} \quad \text{May include RAS Flow.}$$

$$\text{Surface Loading Rate or Surface Overflow Rate, gpd/ft}^2 = \frac{\text{Flow, gpd}}{\text{Surface Area, ft}^2}$$

$$\text{Suspended Solids Removed, lb/day} = (\text{SS Removed, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})$$

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$\text{Weir Length (Circular Basin), ft} = (3.14)(\text{Diameter, ft})$$

$$\text{Weir Length (Rectangular Basin), ft} = (2)(\text{Length, ft}) + (2)(\text{Width, ft})$$

Chlorination

$$\text{Chlorine Dose, mg/L} = \text{Chlorine Demand, mg/L} + \text{Chlorine Residual, mg/L}$$

$$\text{Chlorine Demand, mg/L} = \text{Chlorine Dose, mg/L} - \text{Chlorine Residual, mg/L}$$

$$\text{Dosage, mg/L} = \frac{(\text{Feed Rate, lb/day})(\text{Chemical Purity, \% as a decimal})}{(\text{Flow, MGD})(8.34 \text{ lb/gal})}$$

$$\text{Dosage (bleach), mg/L} = \frac{(\text{Bleach Fed, gal/day})(\text{Available Chlorine, \% as a decimal})}{\text{Flow, MGD}}$$

$$\text{Feed Rate*}, \text{ lb/day} = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Available Chlorine, \% as a decimal}}$$

$$\text{Feed Rate (bleach), gal/day} = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})}{\text{Available Chlorine, \% as a decimal}}$$

$$\text{Bleach Dilution Volume, gal} = \frac{(\text{Desired Available Chlorine, \% as a decimal})(\text{Desired Volume, gal})}{\text{Bleach Available Chlorine, \% as a decimal}}$$

$$\text{HTH Solution Mix, lb} = \frac{(\text{Desired Available Chlorine, \% as a decimal})(\text{Desired Volume, gal})(8.34 \text{ lb/gal})}{\text{HTH Available Chlorine, \% as a decimal}}$$

*Pie Wheel Format for this equation is available at the end of this document

Wastewater Treatment Formulas & Conversions

Chemical Feeders

$$\text{Chemical, lbs} = \frac{(\text{Water Volume, gal})(8.34 \text{ lb/gal})(\text{Desired Concentration, \%})}{(100\% - \text{desired concentration, \%})}$$

All concentrations (%) should be entered in decimal form.

$$\text{Chemical Feed Pump Setting, \% stroke} = \frac{\text{Desired flow}}{\text{Maximum flow}} \times 100\%$$

$$\text{Chemical Feed Pump Setting, mL/min} =$$

$$\frac{(\text{Flow, MGD})(\text{Dose, mg/L})(3.785 \text{ L/gal})(1,000,000 \text{ gal/MG})}{(\text{Chemical Density, mg/mL})(\text{Active Chemical, \% as a decimal})(1440 \text{ min/day})}$$

$$\text{Dosage, mg/L} = \frac{(\text{Feed Rate, lb/day})(\text{Chemical Purity, \% as decimal})}{(\text{Flow, MGD})(8.34 \text{ lb/gal})}$$

$$\text{Feed Rate, lb/day} = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Chemical Purity, \% as a decimal}}$$

$$\text{Percent Strength by weight, \%} = \frac{\text{Weight of chemical, lbs}}{(\text{Weight of water, lbs} + \text{Weight of chemical, lbs})} \times 100\%$$

$$\text{Solution Feeder Setting, gpd} = \frac{(\text{Dose, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Solution Concentration, lb/gal}}$$

$$\text{Water Volume, gal} = \frac{(\text{Chemical, lbs})(100\% - \text{Desired Concentration, \%})}{(\text{Desired Concentration, \%})(8.34 \text{ lb/gal})}$$

Solids Treatment

Sludge Production and Thickening

$$\text{Hydraulic Loading Rate, gpd/ft}^2 = \frac{\text{Total Flow, gal/day}}{\text{Area, ft}^2}$$

$$\text{Solids Concentration, \%} = \left(\frac{\text{Solids Loading Rate, lbs/day}}{\text{Sludge Production Rate, lb/day}} \right) \times 100\%$$

$$\text{Solids Loading Rate, lb/day} = (\text{Sludge Feed Rate, gpd})(8.34 \text{ lb/gal})(\text{Solids Conc., \% as a decimal})$$

$$\text{Solids Loading Rate, lb/day/ft}^2 = \frac{\text{Solids Loading Rate, lb/day}}{\text{Surface Area, ft}^2}$$

$$\text{Sludge Production Rate, lb/day} = \frac{\text{Solids Loading Rate, lb/day}}{\text{Solids Concentration, \% as a decimal}}$$

$$\text{Sludge Detention Time, days} = \frac{\text{Sludge Blanket Volume, gal}}{\text{Sludge Pumping Rate, gal/day}}$$

$$\text{Sludge Blanket Volume, gal} = (0.785)(\text{Diameter, ft})^2(\text{Sludge Blanket Depth, ft})(7.48 \text{ gal/ft}^3)$$

Wastewater Treatment Formulas & Conversions

Solids Treatment (continued)

Sludge Digestion

$$\text{Digester Gas Production, ft}^3/\text{lb VS Destroyed} = \frac{\text{Gas Produced, ft}^3}{\text{Volatile Solids Destroyed, lbs}}$$

$$\text{Digester Gas Production, ft}^3/\text{lb VS Destroyed} = \frac{\text{Gas Produced, ft}^3/\text{day}}{(\text{VS to Digester, lb/day})(\text{VS Reduction, \% as decimal})}$$

$$\text{Digester Loading, lbs/day/ft}^3 = \frac{(\text{Sludge Loading Rate, lb/day})(\text{Solids Conc, \% as decimal})(\text{VS Conc, \% as decimal})}{(0.785)(\text{Diameter, ft})^2(\text{Water Depth, ft})}$$

$$\text{Digestion Time, days} = \frac{\text{Digester Volume, gal}}{\text{Sludge Flow Rate, gpd}}$$

$$\text{Lime or Caustic, lbs} = (\text{Lime or Caustic Dose, mg/L})(\text{Digester Volume, MG})(8.34 \text{ lb/gal})$$

$$\text{Seed Sludge Concentration, \%} = \left(\frac{\text{Seed Sludge Volume, gal}}{\text{Total Digester Capacity, gal}} \right) \times 100\%$$

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, g})(1,000,000)}{\text{Sample Volume, mL}}$$

$$\text{Solids Added, lbs} = (\text{Flow, gpd})(8.34 \text{ lb/gal})(\text{Total Solids Concentration, \% as a decimal})$$

$$\text{Volatile Acids, lbs} = (\text{Volatile Acids Concentration, mg/L})(\text{Digester Volume, MG})(8.34 \text{ lb/gal})$$

Note: Volatile Acids, lbs = Lime Required, lbs

$$\text{Volatile Acids/Alkalinity Ratio} = \frac{\text{Volatile Acids Concentration, mg/L}}{\text{Total Alkalinity, mg/L as CaCO}_3}$$

$$\text{Volatile Solids, \%} = \frac{\text{Volatile Solids, mg/L}}{\text{Total Solids, mg/L}} \times 100\%$$

$$\text{Volatile Solids, \%} = \left(\frac{(\text{Dry Solids, g} - \text{Fixed Solids, g})}{\text{Dry Solids, g}} \right) \times 100\%$$

$$\text{Volatile Solids Concentration, \%} = \left(\frac{\text{Volatile Solids Feed Rate, lb/day}}{\text{Total Solids Feed Rate, lb/day}} \right) \times 100\%$$

$$\text{Volatile Solids Destroyed, lb/day/ft}^3 = \frac{\text{Volatile Solids Destroyed, lb/day}}{\text{Digester Volume, ft}^3}$$

$$\text{Volatile Solids Destroyed, lb/day/ft}^3 = \frac{(\text{Sludge Feed, gpd})(8.34 \text{ lb/gal})(\text{Solids Conc., \% as decimal})(\text{VS Conc, \% as decimal})(\text{VS Reduced, \% as decimal})}{(0.785)(\text{Diameter, ft})^2(\text{Depth, ft})}$$

$$\text{Volatile Solids Feed Rate, lb/day} = (\text{TS Feed Rate, lb/day})(\text{VS Concentration, \% as a decimal})$$

Wastewater Treatment Formulas & Conversions

Solids Treatment (continued)

Volatile Solids Feed Rate, lb/day =

$$(\text{Sludge Feed Rate, lb/day})(\text{Solids Conc., \% as a decimal})(\text{VS Conc., \% as a decimal})$$

$$\text{Volatile Solids Reduction, \%} = \left(\frac{\text{Volatile Solids Reduced, lbs}}{\text{Total Volatile Solids Entering, lbs}} \right) \times 100\%$$

$$\text{Volatile Solids Reduction, \%} = \left(\frac{\text{VS in-VS out}}{\text{VS in}-(\text{VS in} \times \text{VS out})} \right) \times 100\%$$

All information (in and out) must be in decimal form.

Centrifuge Dewatering

$$\text{Solids Capture, \% (Centrifuges)} = \left(\frac{\text{Cake TS, \%}}{\text{Feed Sludge TS, \%}} \right) \times \left(\frac{(\text{Feed Sludge TS, \%}-\text{Centrate TSS, \%})}{(\text{Cake TS, \%}-\text{Centrate TSS, \%})} \right) \times 100\%$$

All solids concentrations (%) should be entered in decimal form.

Filter Press Dewatering (Plate-and-Frame)

$$\text{Solids Loading Rate, lb/hr} = (\text{Sludge Feed Rate, gal/hr})(8.34 \text{ lb/gal})(\text{Solids Conc., \% as a decimal})$$

$$\text{Solids Loading Rate, lb/hr/ft}^2 = \frac{\text{Solids Loading Rate, lb/hr}}{\text{Plate Area, ft}^2}$$

Hydraulic Belt Press Dewatering

$$\text{Loading Rate, gpm/ft} = \frac{\text{Total Flow, gal/min}}{\text{Belt Width, ft}}$$

$$\text{Sludge Feed Rate, lb/hr} = \frac{\text{Sludge To Be Dewatered, lb/day}}{\text{Operating Time, hr/day}}$$

Vacuum Filter Dewatering

$$\text{Filter Loading Rate, lb/hr/ft}^2 = \frac{\text{Solids to Filter, lb/hr}}{\text{Surface Area, ft}^2}$$

$$\text{Filter Loading Rate, lb/hr/ft}^2 = \frac{\left(\frac{\text{Solids to Filter, lb/day}}{\text{Filter Operations, hr/day}} \right)}{(3.14)(\text{Diameter, ft})(\text{Width, ft})}$$

Sand Drying Beds

$$\text{Total Sludge Applied, gal} = (\text{Length, ft})(\text{Width, ft})(\text{Depth, ft})(7.48 \text{ gal/ft}^3)$$

Wastewater Treatment Formulas & Conversions

Laboratory Calculations

$$\text{Alkalinity, mg/L as CaCO}_3 = \frac{(\text{Titrant Volume, mL})(\text{Acid Normality})(50,000)}{\text{Sample Volume, mL}}$$

$$\text{Composite Sample Single Portion} = \frac{(\text{Instantaneous Flow})(\text{Total Sample Volume})}{(\text{Number of Portions})(\text{Average Flow})}$$

$$\text{Hardness, mg/L as CaCO}_3 = \frac{(\text{Titrant Volume, mL})(1,000)}{\text{Sample Volume, mL}} \quad \text{Only when the titration factor is 1.00 of EDTA}$$

Activated Sludge

$$\text{Sludge Density Index (SDI)} = \frac{100}{\text{SVI}}$$

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

$$\text{SSC, mg/L} = \left(\frac{\text{Initial Settleometer Volume, mL}}{\text{SSV}_{30}} \right) \times \text{MLSS, mg/L}$$

$$\text{SVI, mL/gram} = \frac{(\text{Settleable Solids Volume, mL/L})(1,000)}{\text{MLSS, mg/L}}$$

$$\text{SVI, mL/gram} = \frac{(\text{Settleable Solids Conc., \% as a decimal})(1,000,000)}{\text{MLSS, mg/L}}$$

Bacteriological Sampling

$$\text{Average (arithmetic mean)} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

$$\text{Average (geometric mean)} = [(x_1)(x_2)(x_3)(x_4)\dots(x_n)]^{1/n} \quad \text{The } n\text{th root of the product of } n$$

$$\text{\#CFU/100 mL} = \frac{(\text{\# of Colonies on Plate})(100)}{\text{Sample Volume, mL}}$$

Biochemical Oxygen Demand (BOD)

Utilize bottle volume provided if different than 300 mL.

$$\text{Biochemical Oxygen Demand (seeded), mg/L} = \frac{[(\text{Initial DO, mg/L} - \text{Final DO, mg/L} - \text{Seed Correction, mg/L})(300 \text{ mL})]}{\text{Sample Volume, mL}}$$

$$\text{Biochemical Oxygen Demand, mg/L (seeded)} = \frac{[(\text{Initial DO, mg/L} - \text{Final DO, mg/L}) - (\text{Initial Seed Control DO} - \text{Final Seed Control DO})] \left(\frac{\text{Seed in Sample, \% as a decimal}}{\text{Seed in Control, \% as a decimal}} \right)}{(\text{Sample Concentration, \% as a decimal})}$$

$$\text{Biochemical Oxygen Demand, mg/L (unseeded)} = \frac{(\text{Initial DO in Sample, mg/L} - \text{Final DO in Sample, mg/L})}{\text{Sample Concentration, \% as a decimal}}$$

$$\text{Biochemical Oxygen Demand (unseeded), mg/L} = \frac{[(\text{Initial DO, mg/L} - \text{Final DO, mg/L})(300 \text{ mL})]}{\text{Sample Volume, mL}}$$

Utilize bottle volume provided if different than 300 mL.

Wastewater Treatment Formulas & Conversions

Laboratory Calculations (continued)

Chemistry

$$\text{Concentration} = \frac{\text{Concentration, lb/gal}}{\text{Density, lb/gal}} \times 100\%$$

$$\text{Milliequivalent} = (\text{mL})(\text{Normality})$$

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

$$\text{Normality} = \frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$$

$$\text{Number of Equivalent Weights} = \frac{\text{Total Weight}}{\text{Equivalent Weight}}$$

$$\text{Number of Moles} = \frac{\text{Total Weight}}{\text{Molecular Weight}}$$

$$\text{Percent Strength, \% (by weight)} = \frac{\text{Weight of Chemical, lb}}{(\text{Weight of Water, lb} + \text{Weight of Chemical, lb})} \times 100\%$$

$$\text{Specific Gravity} = \frac{\text{Density of substance, lb/gal}}{8.34 \text{ lb/gal}}$$

$$\text{Three Normal Equation} = (C_1 \times V_1) + (C_2 \times V_2) = (C_3 \times V_3)$$

Where C = Concentration or Normality
and V = Volume

$$\text{Two Normal Equation (Dilution)} = (C_1 \times V_1) = (C_2 \times V_2)$$

Units must match

Oxygen Uptake Rate (OUR)

$$\text{Oxygen Uptake Rate or Oxygen Consumption Rate, mg/L/min} = \frac{\text{Oxygen Usage, mg/L}}{\text{Time, min}}$$

$$\text{Oxygen Uptake Rate, mg/L/hr} = \left[\frac{(\text{Starting DO, mg/L} - \text{Ending DO, mg/L})}{\text{Elapsed Time, min}} \right] \times 60 \text{ min/hr}$$

$$\text{Specific Oxygen Uptake Rate or Respiration Rate, (mg of O}_2\text{/g)/hr} = \frac{(\text{OUR, mg/L/min})(60 \text{ min})}{(\text{MLVSS, g/L})(1 \text{ hour})}$$

Solids

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, g})(1,000,000)}{\text{Sample Volume, mL}}$$

Where A = filter and residue in grams

$$\text{Suspended Solids, mg/L} = \frac{(A - B)(1,000,000)}{\text{Sample Volume, mL}}$$

and B = weight of clean, dry filter in grams

$$\text{Solids, mg/L (Fixed, Volatile, or Total)} = \frac{(A - B)(1,000,000)}{\text{Sample Volume, mL}}$$

Where A = weight of dish + dried sample (grams)
and B = weight of clean, dry dish

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

Wastewater Treatment Formulas & Conversions

Laboratory Calculations (continued)

$$\text{Total Solids, \%} = \left[\frac{(\text{Dried weight, g} - \text{Tare weight, g})}{(\text{Wet weight, g} - \text{Tare weight, g})} \right] \times 100\%$$

$$\text{Volatile Solids, \%} = \frac{\text{Volatile Solids, mg/L}}{\text{Total Solids, mg/L}} \times 100\%$$

$$\text{Volatile Solids, \%} = \left(\frac{(\text{Dry Solids, g} - \text{Fixed Solids, g})}{\text{Dry Solids, g}} \right) \times 100\%$$

Temperature

$$\text{Temperature, } ^\circ\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

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

Filtration

$$\text{Filter Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$$

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, gpm/ft}^2)(12 \text{ in/ft})}{7.48 \text{ gal/ft}^3}$$

$$\text{Filter Drop Test Velocity, ft/min} = \frac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$$

$$\text{Filter Loading Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$$

$$\text{Filter Yield, lb/hr/ft}^2 = \frac{(\text{Solids Loading, lb/day})(\text{Recovery, \% as decimal})}{(\text{Filter Operation, hr/day})(\text{Area, ft}^2)}$$

$$\text{Backwash Water Volume, gal} = (\text{Backwash Rate, gpm/ft}^2)(\text{Backwash Time, min})(\text{Filter Area, ft}^2)$$

$$\text{Backwash Water, \%} = \frac{\text{Backwash Water, gal}}{\text{Water Filtered, gal}} \times 100\%$$

Wastewater Treatment Formulas & Conversions

Collection Systems Calculations

$$\text{Volume of a Cylinder Segment, ft}^3 = \left[(1.33)(\text{Height, ft})^2 \sqrt{\left(\frac{\text{Diameter, ft}}{\text{Height, ft}} - 0.608 \right)} \right] (\text{Length, ft})$$

Flow Through a Partially Full Pipe , ft³/sec =

$$\left[(1.33)(\text{Height, ft})^2 \sqrt{\left(\frac{\text{Diameter, ft}}{\text{Height, ft}} - 0.608 \right)} \right] (\text{Velocity, ft/sec})$$

$$\text{Leakage, gpd} = \frac{\text{Volume, gal}}{\text{Time, days}}$$

$$\text{Slope, \%} = \frac{\text{Drop or Rise, ft}}{\text{Distance, ft}} \times 100\%$$

Wastewater Treatment Formulas & Conversions

Common Abbreviations

ac-ft = acre-feet	MGD = million gallons per day
atm = atmospheres	mi = mile
BOD ₅ = biochemical oxygen demand	min = minutes
°C = Celsius	mL = milliliters
CBOD ₅ = carbonaceous biochemical oxygen demand	MLSS = mixed liquor suspended solids
CCSS = clarifier core suspended solids	MLVSS = mixed liquor volatile suspended solids
cfs = cubic feet per second	OCR = oxygen consumption rate
cm = centimeters	OLR = organic loading rate
COD = chemical oxygen demand	OUR = oxygen uptake rate
DO = dissolved oxygen	PE = population equivalent
EMF = electromotive force	ppb = parts per billion
°F = Fahrenheit	ppm = parts per million
F/M Ratio = food to microorganism ratio	psi = pounds per square inch
ft = feet	Q = flow
ft lb = foot-pound	RAS = return activated sludge
g = grams	RBC = rotating biological contactor
gal = gallons	RPM = revolutions per minute
gfd = gallons flux per day	SBOD ₅ = soluble BOD
gpcd = gallons per capita per day	SDI = sludge density index
gpd = gallons per day	sec = second
gpg = grains per gallon	SLR = solids loading rate
gpm = gallons per minute	SOUR = specific oxygen uptake rate
HLR = hydraulic loading rate	SRT = solids retention time
hp = horsepower	SS = settleable solids
hr = hours	SSC = settled sludge concentration
in = inches	SSV ₃₀ = settled sludge volume 30 minute
kg = kilograms	SVI = sludge volume index
km = kilometers	TOC = total organic carbon
kPa = kilopascals	TS = total solids
kW = kilowatts	TSS = total suspended solids
kWh = kilowatt-hours	VS = volatile solids
L = liter	VSS = volatile suspended solids
lb = pounds	W = watts
m = meters	WAS = waste activated sludge
MCRT = mean cell residence time	WOR = weir overflow rate
MG = million gallons	yd = yards
mg = milligrams	yr = year

Wastewater Treatment Formulas & Conversions

Unit Conversion Factors

Linear

1 ft = 0.305 m
 1 ft = 12 in
 1 in = 2.54 cm
 1 yd = 3 ft
 1 mi = 5,280 ft

Area

1 ac = 43,560 ft²
 1 ac = 0.405 Hectare
 1 m² = 1.19 yd²
 1 ft² = 144 in²
 1 Hectare = 2.47 ac
 π or pi = 3.14

Volume

1 ac-ft = 43,560 ft³
 1 ac-ft = 325,828.8 gal
 1 ft³ = 7.48 gal
 1 L = 0.2642 gal
 1 L = 1,000 mL
 1 gal = 231 in³
 1 gal = 0.1337 ft³
 1 gal = 3.785 L
 1 MG = 1,000,000 gal
 1 m³ = 264 gal
 1 yd³ = 27 ft³

Flow

1 cfs = 0.6463 MGD
 1 cfs = 448.8 gpm
 1 MGD = 694.44 gpm
 1 MGD = 1.55 cfs

Weight and Mass

1 ft³ of water = 62.4 lb
 1 g = 1,000 mg
 1 gal of water = 8.34 lb
 1 kg = 1,000 g
 1 kg = 2.2 lbs
 1 lb = 0.454 kg
 1 lb = 453.6 g
 1 metric ton = 2,205 lb
 1 mg/L = 0.0584 gpg
 1 gpg = 17.118 mg/L
 1 ton = 2,000 lb
 1% = 10,000 mg/L

Pressure and Head

1 atm = 33.9 ft of water
 1 atm = 14.7 psi
 1 ft of water = 0.433 psi
 1 psi = 2.31 ft of water

Power

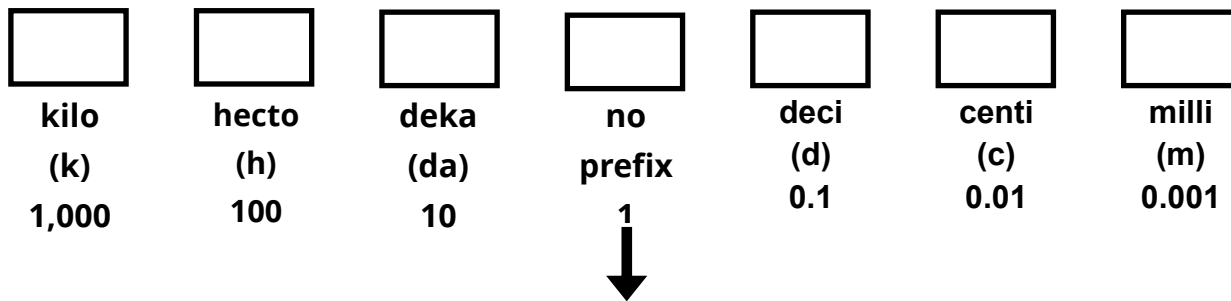
1 hp = 0.746 kW
 1 hp = 746 W
 1 hp = 33,000 ft•lb/min
 1 kW = 1,000 W

Population Equivalent

PE, hydraulic = 100 gal/person/day
 PE, organic = 0.17 BOD/person/day

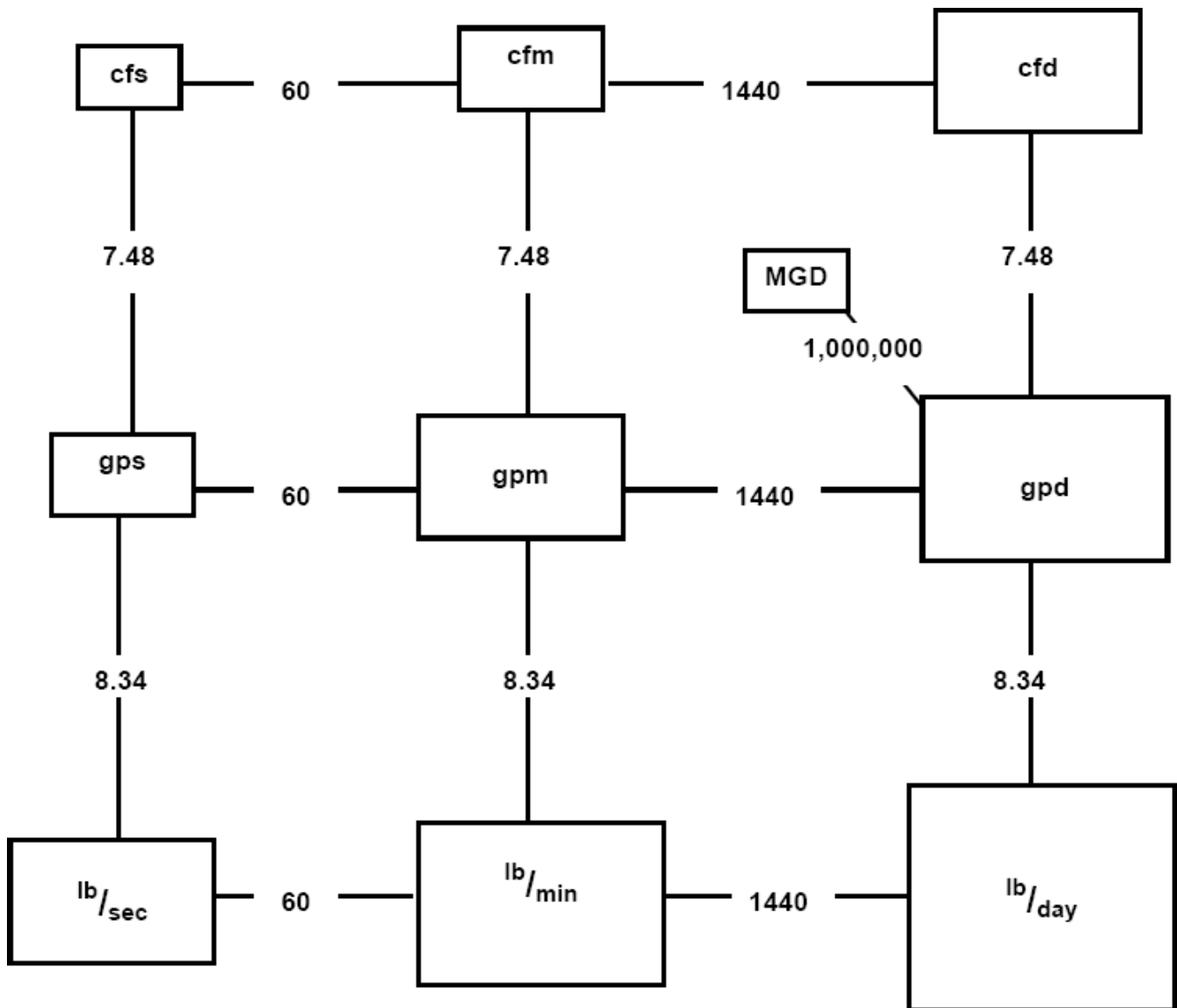
Metric Conversion Chart

Primary Unit



meter (m) - linear measurement
liter (L) - volume measurement
gram (g) - weight measurement

Flow Conversion Chart



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.

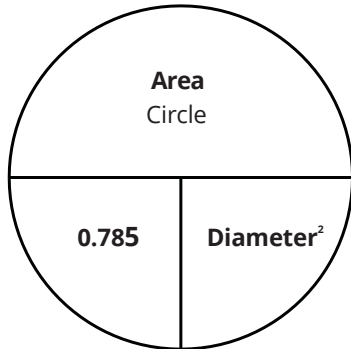
When moving from a **larger box to a smaller box, divide** by the factor between them

Wastewater Treatment Formulas & Conversions

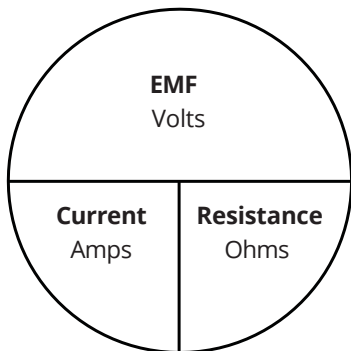
Pie Wheels

- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.
- Given units must match the units shown in the pie wheel.
- When US and metric units or values differ, the metric is shown in parentheses, e.g. (m²).

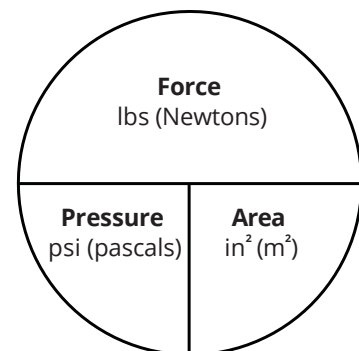
Area of Circle



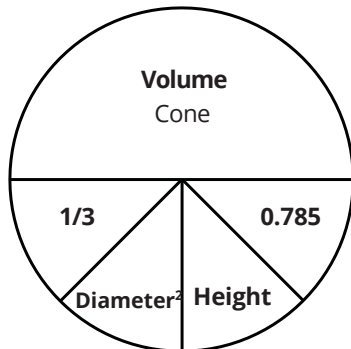
Electromotive Force (EMF), Volts



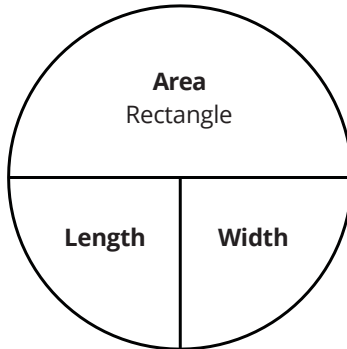
Force, lbs (Newtons)



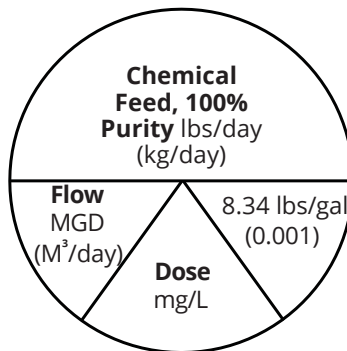
Volume of Cone



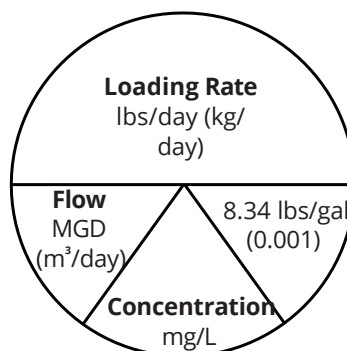
Area of Rectangle



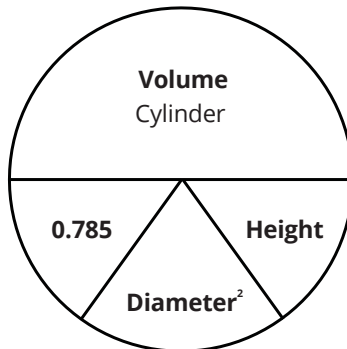
Feed Rate, lbs/day (kg/day)



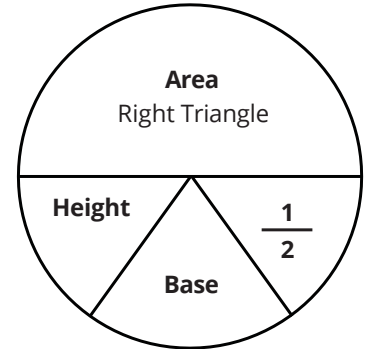
Loading Rate, lbs/day (kg/day)



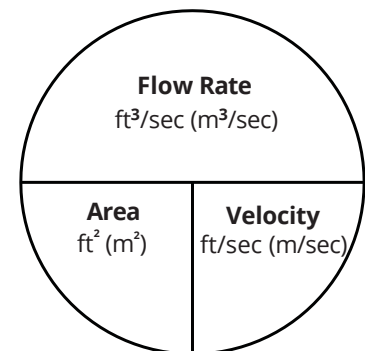
Volume of Cylinder



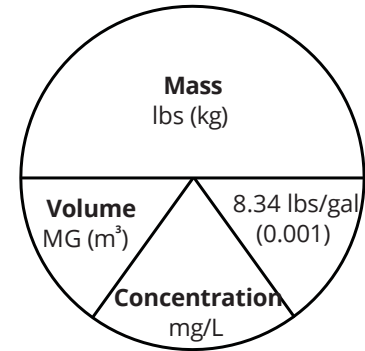
Area of Right Triangle



Flow Rate, ft³/sec (m³/sec)



Mass, lbs (kg)



Volume of Rectangular Tank

