FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Wastewater Treatment Formulas/Conversion Table

12 in = 1 ft	27 cu. ft. = 1 cu. yd.	1,000 mg = 1 gm
3 ft = 1 yd	7.48 gal= 1 cu. ft.	1,000 gm = 1 kg
5,280 ft = 1 mi	8.34 lbs= 1 gal	1,000 ml = 1 liter
43,560 sq. ft.= 1 acre	62.4 lbs= 1 cu. ft.	454 gm = 1 lb.
43,560 cu. ft.= 1 acre-ft	2.31 ft water = 1 psi	10,000 mg/L = 1%
325,829 gal = 1 acre-ft	0.433 psi = 1 ft water	1 mg/l = 1ppm
60 sec = 1 min	1 Hp= 0.746 kW	1 kg = 2.2 lbs.
60 min = 1 hour	1 Hp = 33,000 ft lbs/min	1 MGD = 695 gpm
1,440 min = 1 day	1 kW = 1,000 W	1 MGD = 1.549 cfs

L = Length B = Base W = Width H = Height R = Radius D = Diameter π = 3.14

Activated Sludge

$$\text{Change, WAS Rate, MGD} = \frac{\text{(Current Solids Inventory, lbs.) - (Desired Solids Inventory, lbs.)}}{\text{(WAS, mg/L) (8.34 lbs./gal)}}$$

$$\text{Food to Microorganism Ratio (F/M)} = \frac{\text{(Influent CBOD, mg/L) (Plant Flow, MGD) (8.34 lbs/gal)}}{\text{(Aeration Tank Cap., MG) (MLVSS, mg/L) (8.34 lbs/gal)}}$$

$$\text{Mean Cell Residence Time (MCRT), days} = \frac{\text{Solids Inventory, lbs.}}{\text{(Effluent Solids, lbs/day) + (WAS, lbs/day)}}$$

Solids Inventory, lbs. = (Aeration Tank Cap., MG) (MLSS, mg/L) (8.34 lbs/gal)

WAS, lbs/day = (Waste Sludge Flow, MGD) (Waste Conc., mg/L) (8.34 lbs/gal)

Effluent Solids, lbs/day = (Plant Flow, MGD) (Effluent TSS, mg/L) (8.34 lbs/gal)

$$\text{WAS, lbs/day to Waste} = \left(\frac{\text{Solids Inventory, lbs.}}{\text{Target MCRT, days}} \right) - \text{Effluent Solids, lbs/day}$$

$$\text{WAS Flow Rate, MGD} = \frac{\text{WAS, lbs/day to Waste}}{\text{(WAS, mg/L) (8.34 lbs/gal)}}$$

$$\text{Return Sludge (RAS) Rate, MGD} = \frac{\text{(Settleable Solids, ml) (Plant Flow, MGD)}}{\text{(1,000 ml/L) - (Settleable Solids, ml)}}$$

$$\text{Sludge Age, days} = \frac{\text{Solids Inventory, lbs}}{\text{Inf. Solids Added, lbs/day}}$$

$$\text{Sludge Volume Index (SVI), ml/g} = \frac{\text{30 minute settleability, ml}}{\text{MLSS, mg/L}} \times 1{,}000 \text{ mg/g}$$

Area, Circumference, and Volume

Area (A), sq. ft.

Circle, $A = \pi \times R^2$ *or* $A = 0.785 \times D^2$

Cylinder, (outside surface area): $A = [(2 \times 0.785 \times D^2) + (\pi \times D \times H)]$ *or* $[(2 \times \pi \times R^2) + (\pi \times D \times H)]$

Rectangle, $A = L \times W$

Circumference, linear ft.

Circle, $ft = \pi \times D$

Rectangle, $ft = (2 \times L) + (2 \times W)$

Volume (V), cu. ft.

Cylinder, $V = \pi \times R^2 \times H$ *or* $V = 0.785 \times D^2 \times H$

Rectangle, $V = L \times W \times H$

$$\text{Average (Arithmetic Mean)} = \frac{\text{Sum of All Terms or Measurements}}{\text{Number of Terms or Measurements}}$$

$$\text{Annual Running Average} = \frac{\text{Sum of All Averages}}{\text{Number of Averages}}$$

Chemical Feed

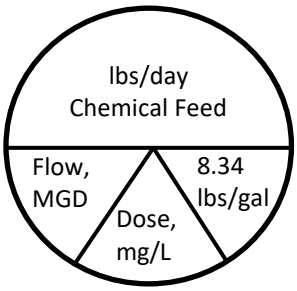
Chemical solution, lbs/gal = (solution, as a decimal) (8.34 lbs/gal)

$$\text{Feed Pump Flow, gpd} = \frac{\text{Chemical Feed, lbs/day}}{\text{Chemical Solution, lbs/gal}}$$

$$\text{Feed Pump Stroke Setting, \%} = \frac{\text{Desired Flow Rate, gpd}}{\text{Maximum Feed Rate, gpd}} \times 100\%$$

Feed Rate

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



Using the Davidson Pie Chart

- To find the quantity above the horizontal line: Multiply the 3 pie wedges below the line together. Next, divide by the % purity as a decimal (i.e., 65% = 0.65).
- To solve for one of the pie wedges below the horizontal line: Divide the 2 bottom pie wedges into the quantity of lbs above the horizontal line. Next, multiply by the % purity as a decimal (i.e., 65% = 0.65).
- The given units must match the units shown in the pie wheel.

Detention Time

$$\text{Detention Time, days} = \frac{\text{Tank Volume, gallons}}{\text{Flow Rate, gal/day}}$$

Note: for detention time in hours, multiply by 24 hrs/day
For detention time in minutes, multiply by 1,440 min/day

Disinfection

Chlorine Demand, mg/L = Chlorine Dosage, mg/L – Chlorine Residual, mg/L

Chlorine Dosage, mg/L = Chlorine Demand, mg/L + Chlorine Residual, mg/L

Chlorine Residual, mg/L = Chlorine Dosage, mg/L – Chlorine Demand, mg/L

Horsepower & Force

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

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

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

Upward Force, lbs = (62.4 lbs/cu. ft.) (ground water height over tank bottom, ft) (tank bottom area, ft²)

Side Wall Force, lbs = (31.2 lbs/cu.ft.) (height, ft) (length, ft)

$$\text{Motor Horsepower, Hp} = \frac{\text{(Power to electric motor, kW) (Motor efficiency as decimal)}}{0.746\ \text{kW/Hp}}$$

$$\text{Pump System Efficiency, \%} = \frac{\text{Water horsepower, WHP}}{\text{Motor horsepower, Hp}} \times 100\%$$

Kilowatt, hrs/day = (Motor horsepower, Hp) (Motor run time, hrs/day) (0.746 Kw/Hp)

Energy Cost, $/day = (Kilowatt, hrs/day) (Energy cost, $/kWh)

Total Dynamic Head, ft = Static head, ft + Friction losses, ft

Static Head, ft = Suction lift, ft + Discharge head, ft

Laboratory Procedures & Measurements

RDD = dried residue + dish + disc (filter), grams
Tare weight (DD) = dish + disc (filter), grams
FDD = fired residue + dish + disc (filter), grams
1 M = 1,000,000

$$\text{Total Suspended Solids (TSS), mg/L} = \frac{\text{(RDD - Tare Weight)}}{\text{Sample volume, ml}} \times 1\text{ M}$$

$$\text{Volatile Suspended Solids (VSS), mg/L} = \frac{\text{(RDD - FDD)}}{\text{Sample volume, ml}} \times 1\text{ M}$$

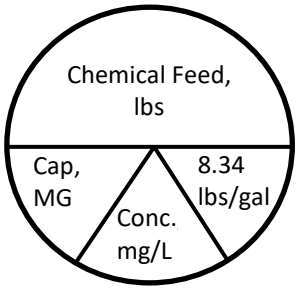
$$\text{Volatile Suspended Solids (VSS), \%} = \frac{\text{Volatile Suspended Solids, mg/L}}{\text{Total Suspended Solids, mg/L}} \times 100\%$$

MLVSS, mg/L = (MLSS, mg/L) (VSS % as decimal)

Parts per Million (ppm) & Pounds (lbs)

$$\text{PPM (mg/L)} = \frac{\text{Pounds of Chemical}}{\text{(MG } \textit{or}\text{ MGD) (8.34 lbs/gal)}}$$

Lbs. = (Capacity, MG) (Concentration, mg/L) (8.34 lbs/gal)



Sedimentation & Loadings

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

$$\text{Solids Loading Rate, lbs/day/ft}^2 = \frac{\text{Solids applied, lbs/day}}{\text{Surface area, ft}^2}$$

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

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

$$\text{Trickling Filter Organic Loading, lbs CBOD/day/1,000 ft}^3 = \frac{\text{CBOD applied, lbs/day}}{\text{Media volume, as 1,000 ft}^3\text{ units}}$$

Sludge Digestion

Dry Solids, lbs = (Raw sludge, gal) (raw sludge, % solids) (8.34 lbs/gal)

$$\text{Seed Sludge, lbs. volatile solids (VS)} = \frac{\text{VS pumped, lbs VS/day}}{\text{Loading factor, lbs VS/day/lb VS in digester}}$$

$$\text{Seed Sludge, gal} = \frac{\text{Seed sludge, lbs volatile solids}}{\text{(seed sludge, lbs/gal) (solids \%, as decimal) (VS, as decimal)}}$$

Lime Required, lbs. = (sludge volume, MG) (Volatile acids, mg/L) (8.34 lbs/gal)

$$\text{Volatile Solids Reduction, \%} = \frac{\text{(In - Out)}}{\text{In - (In x Out)}} \times 100\ \%$$

$$\text{Volatile Solids Destroyed, lbs/day/ft}^3 = \frac{\text{(VS added, lbs/day) (VS reduction, \%)}}{\text{Digester volume, ft}^3}$$

$$\text{Gas Production, ft}^3\text{/lb Volatile Solids} = \frac{\text{Gas produced, cu ft/day}}{\text{VS destroyed, lbs/day}}$$

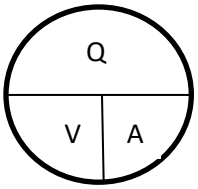
Temperature Conversions

$$\text{Degrees Celsius, }^oC = (^oF - 32)\ (0.555) \quad \textit{or} \quad \frac{(^oF - 32)}{1.8}$$

Degrees Fahrenheit, $^oF = (^oC \times 1.8) + 32$

Velocities & Flow Rates

$$\text{Velocity, fps} = \frac{\text{Flow Rate, cfs}}{\text{Area, sq ft}} \quad \textit{or} \quad \frac{\text{Distance, ft}}{\text{Time, seconds}}$$



Where:
Q = flow rate, cfs
V = velocity, fps
A = area, ft^2

Flow Rate, cfs = (Area, sq. ft.) (Velocity, ft/sec) *or* Q = V x A

Flow Rate, gpm = (Area, sq. ft.) (Velocity, ft/sec) (7.48 gal/cu ft) (60 sec/min) *or* Q = V x A x 7.48 x 60

Abbreviations:

BOD	Biochemical Oxygen Demand	mg	Milligrams
cfs	Cubic feet per second	mg/L	Milligrams per liter
CBOD	Carbonaceous Biochemical Oxygen Demand	MG	Million gallons
DO	Dissolved oxygen	MGD	Million gallons per day
ft	Feet	mL	Milliliter
fps	Feet per second	MLSS	Mixed liquor suspended solids
gm	Grams	MLVSS	Mixed liquor volatile suspended solids
gpd	Gallons per day	PPM	Parts per million
gpm	Gallons per minute	psi	Pounds per square inch
gph	Gallons per hour	Q	Flow
hp	Horsepower	RAS	Return Activated Sludge
in	Inch	SS	Settleable solids
kg	Kilogram	TSS	Total suspended solids
kW	Kilowatt	VS	Volatile solids
kWh	Kilowatt-hour	W	Watt
lbs	Pounds	WAS	Waste Activated Sludge
Lbs/day	Pounds per day		