Working Math

Formulas, Units, Conversions

- This presentation has been adapted from “Math for Subsurface Operators” given at the North Carolina Subsurface Operator School

- Math will be used to
  - Determine a flow rate for a facility
  - Determine the minimum length of line needed for a drainfield
  - Calculate the minimum dose volume required

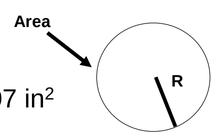
Basic Equations

- Area of a circle
  - $\pi \times r^2$
- Area of a rectangle
  - L x w
- Volume of a cylinder
  - $L \times \pi \times r^2$
- Volume of rectangle
  - L x w x h

Equations

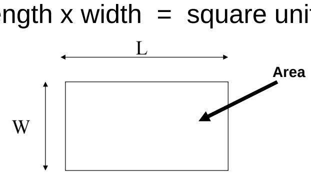
Area of a circle = πr^2 or 3.14 x radius x radius

The area of a circle with a 3” diameter is
3.14 x (1.5 in x 1.5 in) = 7.07 in^2



Equations

Area of a rectangle or square =
Length x width = square units



Converting Units

- A drainfield is 4 **ft** wide and 102 **in** long
- What is the area of the drainfield?

102 in ÷ 12 in/ft = 8.5 ft
4 ft x 8.5 ft = 34 ft^2

OR

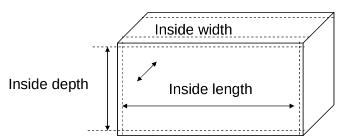
48 in x 102 in = 4896 in^2
4896 in^2 ÷ 144 in^2/ft^2 = 34 ft^2

Equations

Volume of a rectangular tank:

length x width x depth = $units^3$

8 ft x 4 ft x 5 ft = 160 ft^3



Conversion factor

To convert cubic feet to gallons

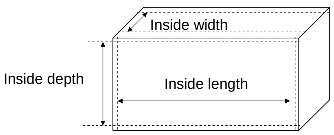
- 1 cubic foot = 7.48 gallons

Equations

Volume of a rectangular tank:

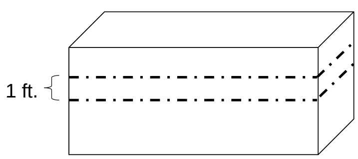
$$8 \text{ ft} \times 4 \text{ ft} \times 5 \text{ ft} = 160 \text{ ft}^3$$

$$160 \cancel{\text{ft}^3} \times 7.48 \text{ gal}/\cancel{\text{ft}^3} = 1197 \text{ gallons}$$



Determining Gallons per Inch

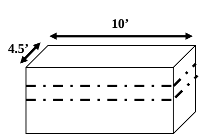
$$L\,(\cancel{\text{ft}}) \times W\,(\cancel{\text{ft}}) \times \frac{1\ \cancel{\text{ft}}}{12 \text{ in.}} \times \frac{7.48 \text{ gal}}{\cancel{\text{ft}^3}} = \frac{\text{gal}}{\text{in.}}$$



Example: A tank is 10 feet long and 4.5 feet wide – How many gallons are there per inch of liquid depth?

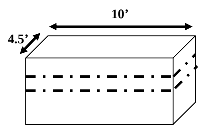
$$10 \text{ ft.} \times 4.5 \text{ ft.} \times 1 \text{ ft.} = 45 \text{ ft}^3$$

$$45 \cancel{\text{ft}^3} \times \frac{7.48 \text{ gal}}{\cancel{\text{ft}^3}} = 336.6 \text{ gal.}$$



Example: A tank is 10 feet long and 4.5 feet wide – How many gallons are there per inch of liquid depth?

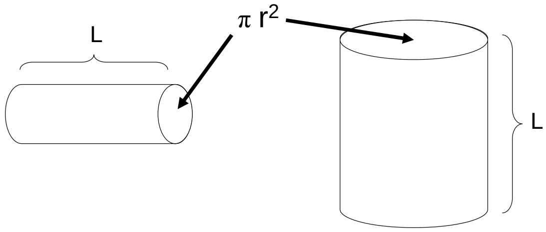
$$\frac{336.6\ \text{gal.}}{12\ \text{in.}} = 28.05\ \frac{\text{gal.}}{\text{in.}}$$



Equations

- Volume of a cylinder (e.g., a tank or pipe):

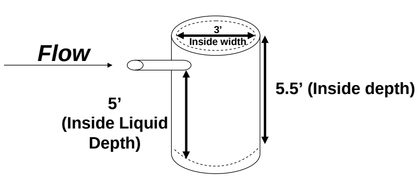
πr^2 x length



- Operating volume (ft^3) of a cylindrical pump tank:

πr^2 x length (or depth)

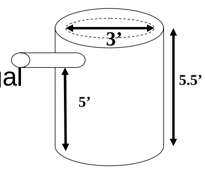
(**3.14 x 1.5 ft x 1.5 ft**) x 5 ft = 35.3 ft^3



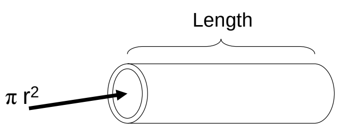
- Operating volume (gal) of a cylindrical pump tank:

$$\text{Volume (ft}^3\text{)} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = \text{gallons}$$

$$35.3 \cancel{\text{ft}^3} \times \frac{7.48 \text{ gal}}{\cancel{\text{ft}^3}} = 264.04 \text{ gal}$$



- Volume of a pipe can be calculated the same way:



$$\pi r^2 \times \text{length} \times 7.48 \text{ gal/cu ft}$$

Pipeline Volume

(Gallons per 100 feet)

	PVC Rigid Pipe		PVC Flexible Pressure Pipe		
Nominal Size (inches)	**Schedule 40**	**Schedule 80**	**SDR 26 (160 psi)**	**SDR 21 (200 psi)**	**Corrugated tubing**
¾	2.8	2.2			
1	4.5	3.7	5.8	5.5	
1 ¼	7.8	6.7	9.6	9.2	
1 ½	10.6	9.2	12.6	12.1	
2	17.4	15.3	19.6	18.8	
3	38.4	34.3	42.6	40.9	
4	66.1	59.7	70.4	67.7	65.3
6	150	135	153	147	147

Units of Measure and Calculations

Calculating percent

First, divide one number into another:

A ÷ B = quotient

The quotient expresses how many times a quantity is contained in another.

A = 20 ; B = 30

20 ÷ 30 = 0.67

So, A is: 0.67 the size of B

Calculating percent

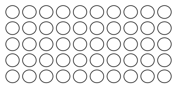
When we multiply the quotient by 100 we obtain how many times a number is contained in 100 of another (percent).

Using the same example:

0.67 x 100 = 67

So, A is: **67%** the size of B

Calculating percent



There are 50 dots shown above and 20 of them are black. What percent of the dots are black?

Divide # black by total 20 ÷ 50 = 0.4
Convert to percent 0.4 x 100 = 40%

Calculating percent solids in a septic tank

- Liquid depth = 60”
- Scum depth = 6”
- Sludge depth = 18”

Add amount of scum and sludge 18”+ 6” = 24”

Divide by tank liquid depth 24” ÷ 60” = 0.4

Convert to percent 0.4 x 100 = 40 %

Units

Pressure: Force applied to a unit area. Expressed in:

– **pounds per square foot (psf)**
A tank lid designed to support 150 psf.

– **pounds per square inch (psi)**
60 psi pressure of water in a force main

– **Feet of head**
An alternative expression of water pressure
psi x 2.31 = Head (ft)

Units

- **Concentration**
  - –Milligrams per liter (mg/L)
  - –Parts per Million (ppm)
  - –A system may have a requirement for the effluent not to exceed 10 mg/L (or ppm) of nitrate nitrogen.

% Reduction in concentration

is a reflection of the treatment efficiency of a system component.

$$\% \text{ reduction} = \frac{\text{influent} - \text{effluent}}{\text{influent}} \times 100$$

% Reduction in Concentration

- The influent concentration to a sand filter is 300 ppm BOD. The effluent concentration is 30 ppm BOD. What is the % reduction in concentration?

$$\% \text{ reduction} = \frac{\text{influent} - \text{effluent}}{\text{influent}} \times 100$$

$$\% \text{ reduction} = \frac{300 - 30}{300} \times 100 = 90\%$$

Units

Flow rate is volume per unit time

- –Gallons per minute (gpm)
- –Gallons per day (gpd)
- –Cubic feet per sec (cfs)

Flow Velocity

- Flow velocity is distance per unit time
  - –Feet per sec (fps)
- The minimum flow rate should be at least 2 fps for good scour
- The equation to calculate the minimum flow rate in a pipe of known diameter is:

4.896 x [pipe diameter (in)]^2 = gpm required

Flow rate in gallons per minute to achieve a flow velocity of 2 feet per second in rigid PVC pipe

Schedule 40 PVC		Schedule 80 PVC	
Nominal Dia. (inches)	Flow Rate (gpm)	Nominal Dia. (inches)	Flow Rate (gpm)
1	5.4	1	4.5
1 ¼	9.3	1 ¼	8.0
1 ½	14.2	1 ½	12.4
2	20.9	2	18.4
2 1/2	29.8	2 1/2	26.4
3	46.1	3	41.2
4	79.4	4	71.7
6	180	6	162.5

- **Pump Delivery Rate (PDR):** the rate at which wastewater is pumped to the drainfield or treatment unit in gallons per minute **(gpm)**

$$PDR = \frac{\text{gallons of water pumped (gal)}}{\text{pump run time (min)}}$$

$$\frac{\text{40 gallons}}{\text{5 minutes}} = \text{8 gal/min}$$

- **Hydraulic loading rate**: the amount of wastewater applied per day to a given area of trench bottom or sand filter surface expressed as:

gallons per day per square foot

or

gpd / ft^2

Calculate the Hydraulic Loading Rate to a sand filter surface, given:

3 Bedroom home: 360 gpd

Sand Filter is 18' x 10'

$$HLR = \frac{\text{gal. applied per day (gpd)}}{\text{area } (ft^2)}$$

$$= \frac{\text{360 gpd}}{180\ ft^2} = 2.0\ \frac{\text{gpd}}{ft^2}$$

Example

An LPP Drainfield is 20’ x 90’ or 1800 ft^2.

How many gallons per day can be dosed to the drainfield without exceeding the permit limit of 0.2 gpd / ft^2?

Design flow in gpd

$$\text{HLR} = \frac{\text{(gpd)}}{\text{area (ft}^2)}$$

$$\text{area (ft}^2) \times \text{HLR} = \frac{\text{(gpd)}}{\cancel{\text{area (ft}^2)}} \times \cancel{\text{area (ft}^2)}$$

$$\text{area (ft}^2) \times \text{HLR} = \text{gpd}$$

An LPP Drainfield is 30’ x 90’ or 2700 ft^2.

How many gallons per day can be dosed to the drainfield without exceeding the permit limit of 0.2 gpd / ft^2 ?

$$\text{area (ft}^2) \times \text{HLR} = \text{gpd}$$

$$2700\ \cancel{\text{ft}^2} \times \frac{0.2\ \text{gpd}}{\cancel{\text{ft}^2}} = 540\ \text{gpd}$$

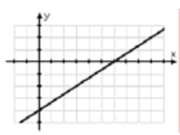
Slope

Slope correction is the process of determining, based on soil depth, amount of slope, system type, and trench width requirements if there is enough suitable soil to install a system

Slope

Slope is the ratio of the rise to the run (or the change in height over the length of the area)

The rise is 4 units and the run is 6 units from our graph, so the slope is 67%.



Slope Correction

Minimum soil depth = trench depth needed + (trench width x slope)

MSD = TD + (TW x S)
MSD – minimum soil depth
TD – trench depth
TW – trench width
S – percent slope

Slope Correction

To install a conventional gravel trench on a 30% slope, what is the minimum soil depth needed?

MSD = TD + (TW x S)
TD – 30 inches minimum
TW – 36 inches
S – 0.3

MSD = 30 in + (36 in x 0.3) = 41 in