

## Mathematics For Wastewater Operators

The understanding of the mathematics of wastewater treatment is an important tool for all wastewater system operators. This chapter covers most of the major categories of math calculations that are important to know for both certification and daily operations of wastewater systems. The examples range from basic problems like flows, velocities and detention times, that might appear on a Grade 1 or 2 exam, to more complex problems that could be found on a Grade 3 or 4 exam. The advanced levels will also have more problems related to wastewater treatment processes like F:M ratios and MCRT problems.

### FLOW

The amount of water moving through the system can be measured in one of three different units. They are gpm (gallons per minute), mgd (millions of gallons per day), and cfs (cubic feet per second). The conversions are listed below.

$$\begin{array}{l} \text{mgd} \times 700 = \text{gpm} \qquad \frac{\text{gpm}}{700} = \text{mgd} \\ \text{cfs} \times 449 = \text{gpm} \qquad \frac{\text{gpm}}{449} = \text{cfs} \end{array}$$

Examples:

1. A system averages 2.0 mgd. How many gallons per minute is the daily average?

A. Convert mgd to gpm  
 $2.0 \text{ mgd} \times 700 = \mathbf{1400 \text{ gpm}}$

2. A pipeline has a carrying capacity of 3 cfs. What is the flow in gpm?

A. Convert cfs to gpm  
 $3 \text{ cfs} \times 449 = \mathbf{1347 \text{ gpm}}$

3. A lift station pumps 350 gpm. How many mgd will it pump?

A. Convert gpm to mgd  
 $\frac{350 \text{ gpm}}{700} = \mathbf{0.5 \text{ mgd}}$

### AREAS

In order to calculate volumes of circular tanks and velocities in pipes, the area of the circle must first be determined. There are two basic formulae used to calculate the area of a circle.

$$\begin{array}{l} \text{Area} = 3.1416 \times r^2 \qquad \text{Area} = d^2 \times 0.785 \\ r = \text{radius} \qquad \qquad \qquad d = \text{diameter} \end{array}$$

Examples:

1. A sedimentation basin is 60 feet in diameter. What is the surface area of the tank?

A. Calculate the area  
 $3.1416 \times 30' \times 30' = \mathbf{2830 \text{ square feet}}$   
 $60' \times 60' \times 0.785 = \mathbf{2830 \text{ square feet}}$

2. A pipeline has diameter of 12 inches. What is the area of the pipe?

A. Calculate the area

$$3.1416 \times 6'' \times 6'' = \mathbf{113 \text{ square inches}}$$

$$12'' \times 12'' \times 0.785 = \mathbf{113 \text{ square inches}}$$

## VOLUMES

The volume of a rectangular tank can be determined by multiplying the length, height, and width together.

$$\text{Volume of rectangular tank (ft}^3\text{)} = L' \times H' \times W'$$

Example:

1. A sedimentation basin is 60' long by 40' wide and 10' deep. What is the volume of the tank in cubic feet?

A. Calculate the volume

$$60' \times 40' \times 10' = \mathbf{24,000 \text{ cubic feet (ft}^3\text{)}}$$

The volume of a circular tank can be determined by multiplying the area of the by the height (or depth) of the tank.

$$\text{Volume of circular tank (ft}^3\text{)} = 3.1416 \times r^2 \times H'$$

Or

$$\text{Volume of circular tank (ft}^3\text{)} = d^2 \times 0.785 \times H'$$

Example:

1. A sedimentation basin is 60'in diameter and 12' deep. What is the volume of the tank?

A. Calculate the volume

$$3.1416 \times 30' \times 30' \times 12' = \mathbf{33,900 \text{ cubic feet (ft}^3\text{)}}$$

$$\text{or } 60' \times 60' \times 0.785 \times 12' = \mathbf{33,900 \text{ cubic feet (ft}^3\text{)}}$$

## VOLUMES IN GALLONS

It is often necessary to calculate a volume of a tank or pipe in gallons rather than cubic feet. In most cases the volume must be calculated in cubic feet and then converted into gallons. This is determined by multiplying cubic feet by 7.48.

$$\text{Cubic feet} \times 7.48 = \text{gallons}$$

Example:

1. A sedimentation basin is 60' long by 40' wide and 10' deep. What is the volume of the tank in cubic feet?

A. Calculate the volume

$$60' \times 40' \times 10' = 24,000 \text{ ft}^3$$

B. Convert cubic feet to gallons

$$24,000 \text{ ft}^3 \times 7.48 = \mathbf{179,500 \text{ gallons}}$$

2. A circular tank has a diameter of 40 feet and is 10 feet deep. How many gallons will it hold?

A. Calculate the volume

$$3.1416 \times 20' \times 20' \times 10' = 12,600 \text{ ft}^3$$

B. Convert cubic feet to gallons

$$12,600 \text{ ft}^3 \times 7.48 = \mathbf{94,200 \text{ gallons}}$$

## DETENTION TIME

Detention time is the length of time in minutes or hours for one gallon of water to pass through a tank. To calculate detention time, the capacity of a tank in gallons is divided by the flow in gallons per minute (gpm) or gallons per day (gpd). If gpm is used, the answer will be in minutes and must be divided by 60 minutes to get hours. If gpd is used, the answer will be in days and must be multiplied by 24 hours. The detention time formula can also be used to calculate how long it will take to fill a tank.

Examples:

1. A 50,000 gallon tank receives 250,000 gpd flow. What is the detention time in hours?

A. Find detention time in days

$$\frac{50,000 \text{ gal.}}{250,000 \text{ gal/day}} = 0.2 \text{ days}$$

B. Change days to hours

$$0.2 \text{ days} \times 24 \text{ hrs/day} = \mathbf{4.8 \text{ hours}}$$

2. A tank is 60' x 80' x 10' and the flow is 2.0 mgd? What is the detention time in hours?

A. Find Volume in cubic feet

$$60' \times 80' \times 10' = 48,000 \text{ cu.ft.}$$

B. Change cubic feet to gallons

$$48,000 \text{ cu.ft.} \times 7.48 \text{ gal/cu.ft.} = 359,000 \text{ gal.}$$

C. Change mgd to gal/day

$$2.0 \text{ mgd} = 2,000,000 \text{ gal/day}$$

D. Find D.T. in days

$$\frac{359,000 \text{ gal.}}{2,000,000 \text{ gal/day}} = 0.18 \text{ days}$$

E. Change days to hours

$$0.18 \text{ days} \times 24 \text{ hrs/day} = \mathbf{4.3 \text{ hours}}$$

3. A tank is 100' in diameter and 12 feet deep. If the flow into the tank is 2500 gpm, how many hours will it take to fill the tank?

A. Calculate the volume in cubic feet

$$3.1416 \times 50' \times 50' \times 22' = 94,300 \text{ ft}^3$$

or  $100' \times 100' \times 0.785 \times 22' = 94,300 \text{ ft}^3$

B. Change cubic feet to gallons

$$94,300 \text{ ft}^3 \times 7.48 = 705,000 \text{ gallons}$$

C. Calculate how long until full (detention time)

$$\frac{705,000 \text{ gal}}{2500 \text{ gpm}} = 282 \text{ minutes}$$

$$2500 \text{ gpm}$$

E. Change minutes to hours

$$\frac{282 \text{ min}}{60 \text{ min/hr}} = \mathbf{4.7 \text{ hours}}$$

$$60 \text{ min/hr}$$

## DOSAGE

Chemical dosages are measured in ppm (parts per million) or mg/L (milligrams per liter.) Parts per million (ppm) is always a comparison of weight (pounds per million pounds). One pound of chemical added to one million pounds of water would be a dosage of 1 ppm. Since each gallon of water weighs 8.34 pounds, one million gallons of water weighs 8.34 million pounds and would require 8.34 pounds of chemical to obtain a dosage of 1 ppm. A milligram per liter (mg/L) is the metric term for a dosage equal to ppm.

$$1 \text{ gallon} = 8.34 \text{ lbs.}$$

$$1 \text{ ppm} = 1 \text{ mg/L}$$

The number of pounds of chemical needed to achieve a certain dosage can be determined by multiplying the ppm by the number of millions of gallons treated and then by 8.34 lbs/gal. The amount of water to be treated must always be in terms of millions of gallons (mgd).

$$\text{mg/L} \times \text{mgd} \times 8.34 = \text{pounds per day}$$

Examples:

1. How many lbs/day of chlorine are needed to provide a dosage of 2.2 mg/L in 800,000 gal/day?

A. Change gal/day to mgd

$$800,000 \text{ gpd} = 0.8 \text{ mgd}$$

B. Calculate lbs/day

$$2.2 \text{ mg/L} \times 0.8 \text{ mgd} \times 8.34 = \mathbf{14.7 \text{ lbs/day}}$$

If HTH is used, instead of chlorine gas, only 65-70% of each pound will be chlorine. Therefore, the amount of HTH must be calculated by dividing the pounds of chlorine needed by 0.65 or 0.70.

2. A tank is 44' in diameter and 22' high and is dosed with 50 ppm of chlorine. How many pound of 70% HTH is needed?

- A. Find the volume of the tank in cubic feet  
 $22' \times 22' \times 3.1416 \times 22' = 33,450 \text{ cu.ft.}$
- B. Change cu.ft. to gallons  
 $33,450 \times 7.48 = 250,000 \text{ gallons}$
- C. Change gallons to mgd  
 $250,000 \text{ gallons} = 0.250 \text{ mgd}$
- D. Find lbs of chlorine  
 $50 \text{ ppm} \times 0.25 \text{ mg} \times 8.34 = 104.25 \text{ lbs of chlorine}$
- E. Change percent available to a decimal equivalent  
 $70\% = 0.70$
- F. Find lbs of HTH  

$$\frac{104.25 \text{ lbs Cl}}{0.70} = \mathbf{149 \text{ lbs of HTH}}$$

## VELOCITIES

The flow in a channel can be determined if the velocity and channel dimensions are known. The area of the channel flow is multiplied by the velocity (fps) determine the flow in cubic feet per second (cfs).

Examples:

1. A channel 4 feet wide has water flowing 2 feet deep. The velocity is 5.0 fps. What is the flow in cfs?

- A. Find area of the channel in sq ft  
 $4 \times 2 = 8 \text{ sq.ft.}$
- B. Find the flow in cfs  
 $5.0 \text{ fps} \times 8 \text{ sq.ft.} = \mathbf{40 \text{ cfs}}$

3. A channel 3.2 feet wide has water flowing 18 inches deep. The velocity is 2.8 fps. What is the flow in cfs?

- A. Convert inches to feet  

$$\frac{18}{12} = 1.5 \text{ ft}$$
- B. Find the area of the channel.  
 $3.2 \times 1.5 = 4.8 \text{ sq ft}$
- C. Find the flow in cfs.  
 $2.8 \text{ fps} \times 4.8 \text{ sq ft} = 13.4 \text{ cfs}$

## PROCESS REMOVAL EFFICIENCY

The removal efficiency of a process can be determined by taking the influent strength and subtracting the effluent strength then dividing that number by the influent strength. The decimal value is multiplied by 100 to convert to a percentage.

$$\frac{\text{BOD (in)} - \text{BOD (out)} \times 100}{\text{BOD (in)}} = \text{Percent Removal}$$

Examples:

1. The influent BOD of a trickling filter is 120 mg/L. The effluent BOD is 20 mg/L. What is the removal efficiency for BOD?

A. Find the removal efficiency

$$\frac{120 - 20 \times 100}{120} = \mathbf{83.3\%}$$

2. A primary clarifier has an influent SS of 250 mg/L. The effluent SS is 90 mg/L. What is the SS removal efficiency?

A. Find the removal efficiency

$$\frac{250 - 90 \times 100}{250} = \mathbf{64\%}$$

3. A plant has an influent BOD of 215 mg/L. The plant effluent BOD is 5 mg/L. What is the BOD removal efficiency for the plant?

A. Find the removal efficiency

$$\frac{215 - 5 \times 100}{215} = \mathbf{97.7\%}$$

## PROCESS LOADING CALCULATIONS

The organic loading rates for secondary processes like lagoons and trickling filters can be calculated using the dosage formula to determine the total number of pounds of BOD and dividing it by the unit area or volume (acres for lagoons, 1,000 ft<sup>3</sup> for trickling filters.).

Examples:

1. A 10 acre lagoon receives an average flow of 0.2 mgd and a BOD of 120 mg/L. What is the organic loading in lbs/day /acre?

A. Find the pounds of BOD per day

$$120 \times 0.2 \times 8.34 = 200 \text{ lbs/day}$$

B. Find the pounds per acre

$$\frac{200 \text{ lbs/day}}{10 \text{ acres}} = \mathbf{20 \text{ lbs/day/acre}}$$

2. A trickling filter is 80 feet in diameter and 6 feet deep. The BOD is 60 mg/L and the flow is 0.6 mgd. What is the organic loading rate in lbs per day per 1,000 ft<sup>3</sup>?
- Find pounds of BOD per day  
 $60 \times 0.6 \times 8.34 = 300 \text{ lbs/day}$
  - Find the volume of the filter in cubic feet  
 $40 \times 40 \times 3.1416 \times 6 = 30,200 \text{ cubic feet}$
  - Change cubic feet to thousands of cubic feet  
 $30,200 = 30.2 \text{ thousand cubic feet}$
  - Find the loading rate  

$$\frac{300 \text{ lbs/day}}{30.2} = \mathbf{10 \text{ lbs/day/1000 cubic feet}}$$

## F:M RATIO

The food-to-microorganism ratio is used to determine how much food (BOD) is available for every pound of microorganisms (bugs). To calculate the F:M ratio, divide the pounds of food (BOD loading) by the pounds of bugs under aeration (MLVSS). It requires working two dosage problems and dividing the results.

Examples:

- A 150,000 gallon aeration tank receives an average flow of 1.2 mgd and a BOD of 100 mg/L. The MLVSS is 3000 mg/L. What is the F:M ratio?
  - Find the pounds of BOD per day  
 $100 \times 1.2 \times 8.34 = 1000 \text{ lbs/day}$
  - Find the pounds of MLVSS  
 $3000 \times 0.15 \times 8.34 = 3750 \text{ lbs of MLVSS}$
  - Find F:M ratio  

$$\frac{1000 \text{ lbs/day}}{3750 \text{ lbs MLVSS}} = \mathbf{0.27}$$
- An aeration basin is 40' x 20' x 15' deep. The influent BOD is 80 and the flow is 1.1 mgd. The MLVSS is 2400 mg/L. What is the F:M ratio?
  - Find pounds of BOD per day  
 $80 \times 1.1 \times 8.34 = 734 \text{ lbs/day}$
  - Find the volume of the aeration basin in cubic feet  
 $40 \times 20 \times 15 = 12,000 \text{ cubic feet}$
  - Change cubic feet to gallons  
 $12,000 \times 7.48 = 90,000 \text{ gallons or } 0.09 \text{ mg}$
  - Find the pounds of MLVSS  
 $2400 \times 0.09 \times 8.34 = 1800 \text{ lbs of MLVSS}$
  - Find F:M ratio  

$$\frac{734 \text{ lbs/day}}{1800 \text{ lbs MLVSS}} = \mathbf{0.41}$$

## SLUDGE VOLUME INDEX (SVI)

The sludge volume index uses the settleometer test results to determine the relative density of the settled sludge in milliliters per gram of settled solids. It is determined by multiplying the results from a 1-liter settleometer test in milliliters by 1000 and dividing by the MLSS (mg/L).

$$\frac{\text{Settleometer (ml)} \times 1000}{\text{MLSS (mg/L)}} = \text{SVI}$$

Examples:

1. The settleometer results were 280 ml and the MLSS is 2350 mg/L. What's the SVI?

A. Find the Sludge Volume Index

$$\frac{280 \text{ ml} \times 1000}{2350 \text{ mg/L}} = \mathbf{119 \text{ SVI}}$$

2. The settleometer results were 260 ml and the MLSS is 3000 mg/L. What's the SVI?

A. Find the Sludge Volume Index

$$\frac{260 \text{ ml} \times 1000}{3000 \text{ mg/L}} = \mathbf{87 \text{ SVI}}$$

## MEAN CELL RESIDENCE TIME (MCRT) OR SLUDGE AGE

Mean cell residence time (MCRT), also known as sludge age, is a determination of the average length of time activated sludge stays in the system before it's wasted or it leaves over the effluent weirs. It is determined by calculating the pounds of MLSS in the aeration basin and dividing it by the total pounds of SS that are wasted and in the effluent each day.

$$\frac{\text{Lbs of SS in Aeration}}{\text{Lbs of SS wasted/day} + \text{lbs of SS effluent/day}} = \text{Days MCRT}$$

Examples:

1. An aeration basin is 650,000 gallons and the flow is 2.8 mgd. The MLSS is 2600 mg/L. The WAS flow is 15,000 gpd and WAS SS is 6,000 mg/L. The effluent SS is 8 mg/L. What is the MCRT in days?

A. Find the pounds of MLSS in aeration

$$2600 \text{ mg/L} \times 0.65 \text{ mg} \times 8.34 = 14,100 \text{ lbs}$$

B. Find the pounds of SS in the WAS

$$6,000 \text{ mg/L} \times 0.015 \times 8.34 = 751 \text{ lbs/day}$$

C. Find the pounds of SS in the effluent

$$8 \text{ mg/L} \times 2.8 \text{ mgd} \times 8.34 = 187 \text{ lbs/day}$$

D. Find the MCRT

$$\frac{14,100 \text{ lbs}}{751 + 187} = \frac{14,100}{938} = \mathbf{15 \text{ day MCRT}}$$

2. An aeration basin is 28,000 gallons and the flow is 150,000 gpd. The MLSS is 3400 mg/L. The WAS flow is 2000 gpd and WAS SS is 7,500 mg/L. The effluent SS is 6 mg/L. What is the MCRT in days?
- A. Find the pounds of MLSS in aeration  
 $3400 \text{ mg/L} \times 0.028 \text{ mg} \times 8.34 = 794 \text{ lbs}$
- B. Find the pounds of SS in the WAS  
 $7,500 \text{ mg/L} \times 0.002 \times 8.34 = 125 \text{ lbs/day}$
- C. Find the pounds of SS in the effluent  
 $6 \text{ mg/L} \times 0.15 \text{ mgd} \times 8.34 = 7.5 \text{ lbs/day}$
- D. Find the MCRT  

$$\frac{794 \text{ lbs}}{125 + 7.5} = \frac{749}{132.5} = \mathbf{6 \text{ day MCRT}}$$

## WIRE-TO-WATER CALCULATIONS

The term wire-to-water refers to the conversion of electrical horsepower to water horsepower. The motor takes electrical energy and converts it into mechanical energy. The pump turns mechanical energy into hydraulic energy. The electrical energy is measured as motor horsepower (MHP.) The mechanical energy is measured as brake horsepower (BHP.) And the hydraulic energy is measured as water horsepower (WHP.)

Horsepower is measured by lifting a weight a given distance in a specific time period. One horsepower is the amount of energy required to produce 33,000 ft-lbs of work per minute. That means that lifting 33,000 pounds one foot in one minute or lifting one pound 33,000 feet in the air in one minute would both require one horsepower worth of energy.

When water is pumped, performance is measured in flow (gallons/minute) and pressure (feet of head). If you multiply gallons per minute and feet of head the resulting units would be gallon-feet per minute. Multiply gallon-feet per minute by 8.34 pounds/gallon and the units become foot-pounds (of water) per minute. This can now be converted to water horsepower by dividing by 33,000 ft-lbs/min per horsepower.

$$\frac{\text{Gpm} \times 8.34 \times \text{Feet of Head}}{33,000 \text{ ft-lbs/min/Hp}} = \text{Water Horsepower (WHP)}$$

This equation can be further simplified to:

$$\frac{\text{Gpm} \times \text{Feet of Head}}{3960} = \text{Water Horsepower (WHP)}$$

Brake horsepower is the amount of energy that must go into the pump to produce the required WHP. Losses due to friction and heat in the pump reduce the pump's efficiency and require more energy in than goes out. If a pump is 80% efficient, it requires 10 BHP to generate 8 WHP.

$$\text{BrakeHp} = \frac{\text{WaterHp}}{\text{Pump Efficiency}}$$

Motor horsepower is the amount of electrical energy that must go into the motor to produce the required BHp. Losses due to friction and heat in the motor reduce the motor's efficiency and require more energy in than goes out. If a motor is 88% efficient, it requires 10 BHp to generate 8.8 BHp

$$\text{MotorHp} = \frac{\text{BrakeHp}}{\text{Motor Eff}}$$

OR

$$\text{MotorHp} = \frac{\text{WaterHp}}{\text{Motor Eff} \times \text{Pump Eff}}$$

Motor horsepower can be converted into kilowatts by multiplying by 0.746 Kw/Hp. Kilowatt-hours can be determined by multiplying kilowatts by run time in hours.

$$\text{MotorHp} \times 0.746 \text{ Kw/Hp} \times \text{Hours} = \text{Kw-Hours of electricity}$$

The following example has seven problems that relate to wire-to-water calculations. Each problem will take the calculation one step further. It is intended to show how the steps are linked, not to represent an example of a set of exam questions. An actual exam question would possibly require the calculation of Water horsepower (Problems 1-3) or calculation of cost of operation (Problems 1-7)

Pump Data: 6 Feet - Negative Suction Head  
 96 Feet - Discharge Head  
 17 Feet - Friction Loss  
 400 gpm - Flow  
 Motor Efficiency - 90%  
 Pump Efficiency - 80%

1. What is the static head on the pump?

$$96 \text{ ft} + 6 \text{ ft} = \mathbf{102 \text{ ft}}$$

2. What is the total dynamic head?

$$96 \text{ ft} + 6 \text{ ft} + 17 \text{ ft} = \mathbf{119 \text{ ft TDH}}$$

3. What is the Water Horsepower that the pump delivers?

$$\frac{400 \text{ gpm} \times 119 \text{ ft}}{3960} = \mathbf{12 \text{ WHp}}$$

4. What is the Brake Horsepower?

A. Change 80% to a decimal

$$80\% = 0.80$$

B. Find Brake Horsepower

$$\frac{12 \text{ Whp}}{0.80 \text{ Pump Eff}} = \mathbf{15 \text{ BHp}}$$

5. What is the Motor Horsepower?

A. Change 90% to a decimal

$$90\% = 0.90$$

B. Find Motor Horsepower

$$\frac{15 \text{ BHp}}{0.90 \text{ Motor Eff}} = \mathbf{16.7 \text{ MHp}}$$

6. How many Kilowatts of electricity does the motor require?

$$16.7 \text{ MHp} \times 0.746 \text{ Kw/HP} = \mathbf{12.5 \text{ Kw}}$$

7. If the pump runs 13 hours a day and electric rates are \$0.09/Kw-Hour, How much does it cost to run the pump for a month (30 days)?

A. Find Kw-Hours per day

$$12.5 \text{ Kw} \times 13 \text{ hours/day} = 162 \text{ Kw-Hours/day}$$

B. Find cost per day

$$162 \text{ Kw-Hours} \times \$0.09/\text{KwHour} = \$14.58/\text{day}$$

C. Find cost for the month

$$14.58/\text{day} \times 30 \text{ days/month} = \mathbf{\$437.40/\text{month}}$$

### BASIC SAMPLE PROBLEMS

- The daily average flow at the plant is 2.8 mgd. What is the average flow in gpm?
  - 1730 gpm
  - 1850 gpm
  - 1960 gpm
  - 2120 gpm
- The flow through a clarifier is 490 gpm. What is the flow in mgd?
  - 0.5 mgd
  - 0.7 mgd
  - 1.2 mgd
  - 1.6 mgd
- A tank is 20' x 60' by 15' deep. What is the volume in gallons?
  - 115,000 gallons
  - 128,000 gallons
  - 135,000 gallons
  - 154,000 gallons
- A tank is 60' in diameter and 22' deep. How many gallons will it hold?
  - 465,000 gallons
  - 528,000 gallons
  - 640,000 gallons
  - 710,000 gallons
- A dosage of 2.4 mg/L of chlorine gas is added to 3.8 mgd. How many pounds per day of chlorine are needed?
  - 68 lbs/day
  - 76 lbs/day
  - 82 lbs/day
  - 88 lbs/day
- The influent BOD is 235 mg/L and the effluent BOD is 10 mg/L. What is the BOD removal efficiency for the plant?
  - 82 %
  - 88 %
  - 90%
  - 96%
- A 17-acre lagoon receives a flow of 220,000 gpd with an influent BOD of 186 mg/L. What is the organic loading rate?
  - 10 lbs/acre/day
  - 12.5 lbs/acre/day
  - 20 lbs/acre/day
  - 32 lbs/acre/day
- A 820,000 gallon clarifier has an influent flow of 6.7 mgd. What is the detention time in hours?
  - 0.8 hours
  - 1.6 hours
  - 2.5 hours
  - 2.9 hours

### ADVANCED SAMPLE PROBLEMS

- The settleometer reading after 30 minutes was 340 ml. The MLSS is 2850 mg/L. What is the SVI?
  - 87
  - 119
  - 136
  - 210

2. A clarifier is 82' in diameter and 12 deep high. The flow is 3600 gpm. What is the detention time in hours?
- 1.8 hours
  - 2.2 hours
  - 2.6 hours
  - 3.1 hours
3. A tank is 120' x 50' x 14' deep. The flow is 2.8 mgd. What is the detention time in hours?
- 3.8 hours
  - 4.4 hours
  - 5.4 hours
  - 6.2 hours
4. A trickling filter is 60 feet in diameter and 7 feet deep. The flow is 0.8 mgd and the BOD in the filter influent is 110 mg/L. What is the organic loading rate in lbs/day/1000 cu.ft?
- 37 lbs/day/1000 cuft
  - 42 lbs/day/1000 cuft
  - 56 lbs/day/1000 cuft
  - 60 lbs/day/1000 cuft
5. The plant flow is 3.6 mgd. The aeration basin influent BOD is 80 mg/L. The basin is 750,000 gallons. The MLVSS is 2350 mg/L. What is the F:M ratio?
- 0.12
  - 0.16
  - 0.23
  - 0.34
6. The plant flow is 1.8 mgd. The MLSS is 4000 mg/L. The aeration basin is 300,000 gallons. The WAS rate is 7,000 gpd and the WAS SS is 8,000 mg/L. The effluent SS is 8 mg/L. What is the MCRT?
- 12 days
  - 17 days
  - 21 days
  - 24 days
7. Pump Data:  
 18 Feet - Positive Suction Head  
 158 Feet - Discharge Head  
 26 Feet - Friction Loss  
 1200 gpm - Flow  
 Motor Efficiency - 86%  
 Pump Efficiency - 78%
- What is the motor horsepower?
- 60 MHP
  - 65 MHP
  - 70 MHP
  - 75 MHP
8. Pump Data:  
 20 Feet - Positive Suction Head  
 185 Feet - Discharge Head  
 18 Feet - Friction Loss  
 300 gpm - Flow  
 Motor Efficiency - 90%  
 Pump Efficiency - 80%  
 Kw-Hour Cost = \$0.11/Kw-Hr  
 Average Run Time – 6 Hours/day
- What is the cost to run the pump for 30days?
- \$245.08
  - \$284.34
  - \$410.50
  - \$463.82