ADVANCED WASTEWATER MATH

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Math Problem Solving Strategy

1. Read the question carefully and underline what they are asking you to find.

2. Write down the formula you need to solve the problem. Look in the front of the test booklet if necessary.

3. Fill in everything you know. Sometimes filling in what you know might require you to find something else first like area or volume.

4. Check your units! Make sure they are correct for the formula and agree with each other.

5. Convert units where needed.

6. Put the new units into the formula.

7. Solve.

8. Check the units of your answer. Are they what the question asked for?

9. Convert units if necessary.

1. Find the solids retention time for an aerobic digester that is 100 feet long by 40 feet wide by 12 feet deep. The digester is full and the solids in the digester are 2% total solids. The digester is decanted daily at a rate of 2,000 gallons per day. The decant liquid contains 400 mg/L of solids on average. Solids are removed from the digester for ultimate disposal at a rate of 4000 gallons per day.

2. An anaerobic digester is maintained at 95 degrees Fahrenheit. If the SRT is 40 days, how many degree days are the biosolids digested?

3. MLSS is pumped to an aerobic digester. The MLSS is 3,000 mg/L and contains 80% volatile suspended solids. The digester contains solids at 1.82% total solids. Biosolids withdrawn from the digester are 67% volatile solids. What was the percent VSS reduction through the digestion process?

4. An activated sludge process has three aeration basins. Each basin is 100 feet long, 35 feet wide, and 12 feet deep. The MLSS concentration is 2800 mg/L. There are two clarifiers. Each clarifier is 35 feet in diameter and 12 feet deep. A clarifier core sample indicates that the solids concentration in the clarifier is equivalent to 500 mg/L. If the RAS/WAS concentration is 6,000 mg/L, find the WAS pumping rate in gallons per day to maintain a sludge age of 15 days.

5. If the WAS pump in problem #5 only operates for 15 minutes out of each hour, what should the pump rate be in gpm?

6. A water plant is fed by two wells. Water from the first well has an arsenic concentration of 60 ug/L. Water from the second well has an arsenic concentration of 3 ug/L. If the total water production desired is 60,000 gpd, what is the maximum pumping rate that can be allowed for the first well if the arsenic concentration in the finished water needs to be 25 ug/L or less?

7. The liquid train for a 4.0 mgd WWTP consists of screening, grit removal, primary clarification, activated sludge, secondary clarifiers, and disinfection. The influent contains 350 mg/L of BOD. If the primary clarifiers remove 47% of the BOD, what is the load to the secondary process?

8. If the treatment plant in problem #7 has two aeration basins with a combined volume of 1.25 mgd, what should the MLSS concentration be to maintain an F:M ratio of 0.10?

9. A WWTP produces 240 dry tons of biosolids per year. The biosolids are land applied to a quarter section (160 acres). Lab results indicate that the concentration of Cadmium in the biosolids is 22 mg/kg. What is the annual cadmium loading rate to the site? Express your answer as lbs Cd/acre.

10. Estimate the sludge pumping time in minutes per day for a primary sludge pump removing 100 gpm of sludge at 5% total solids from a primary tank receiving a flow of 5.0 mgd. Primary influent contains 200 mg/L of TSS and the primary effluent contains 70 mg/L of TSS.

11. Calculate the volatile solids loading rate in lbs/day/cf for a conical bottomed, cylindrical anaerobic digester receiving 13,000 gpd of sludge that is 5% solids. Assume the solids are 75% volatile. The digester is 40 feet in diameter. The cylindrical portion of the digester has a liquid depth of 25 feet. The cone is 10 feet deep at its deepest point.

12. Find the motor horsepower for a pump discharging 5.0 mgd against a total head of 15 feet. Assume that the pump is 70 percent efficient and the motor is 90 percent efficient.

13. A belt filter press receives a feed sludge at 3% total solids and produces a cake that is 20% total solids. If the influent flow rate to the press is 50 gpm, what will the volume of cake produced be if the press runs for 8 hours?

· 14. A treatment plant has 4 grit basins operated in parallel. Each grit basin is 2.5 feet wide, 2 feet deep, and 10 feet long. The influent flow is 4.0 mgd. What is the minimum number of grit basins that should be in service to maintain a velocity less than 1.0 fps?

15. A single-piston reciprocating pump has a 6-inch diameter piston and a 12-inch stroke. The pump makes 22 strokes per minute. What is the pumping rate in gpm?

16. A 25 hp pump is used to dewater a lake. If the pump runs for 8 hours a day, seven days a week, how much will is cost to run the pump for six weeks? Assume energy costs of $0.07 per kilowatt hour.

17. How many gallons of sodium hypchlorite (bleach) is required to obtain a residual of 100 mg/L in a well? The casing diameter is 18-inches and the length of the water filled casing is 180 feet. Sodium hypochlorite contains 5.25% available chlorine. Assume a demand of 15 mg/L.

ᐧ 18. A treatment plant uses sulfur dioxide to dechlorinate effluent. An operator needs to adjust the sulfonator so that the dosing concentration is 1.5 mg/L more than the chlorine residual. Based on the following information, what should the sulfonator feed rate be in pounds per day? Design flow = 5 mgd, Chlorine dosage rate = 4 mg/L, Chlorine residual = 0.9 mg/L.

19. A 2.5 mgd activated sludge process has two aeration basins. Each basin is 150 feet long, 55 feet wide, and 12 feet deep. The MLSS concentration is 3500 mg/L. There are two clarifiers. Each clarifier is 45 feet in diameter and 15 feet deep. A clarifier core sample indicates that the solids concentration in the clarifier is equivalent to 500 mg/L. The final effluent TSS is 25 mg/L. If the RAS/WAS concentration is 7,500 mg/L, find the WAS pumping rate in gallons per day to maintain a sludge age of 18 days.

20. For the plant in problem #19, assume an influent BOD concentration of 300 mg/L. If the desired F:M ratio is 0.20, should wasting be increased or decreased?

21. Wastewater influent contains 30 mg/L of ammonia, 250 mg/L of BOD and TSS, and 280 mg/L of alkalinity. If the final effluent contains 1 mg/L of ammonia and 12 mg/L of nitrate, what is the theoretical concentration of alkalinity?

22. A treatment plant aeration basin holds 2 million gallons. If the influent flow is 8 mgd and the BOD concentration is 350 mg/L, what is the space loading? Express your answer as pounds of BOD per 1000 cf.

23. A lift station has a 12-inch shut off valve located outside to isolate the force main for repairs. The water pressure inside the line is 75 psi. Find the amount of force in tons exerted on the valve if the lift station pumps start while it is in the closed position.

24. MLSS is pumped to an anaerobic digester. The MLSS is 3,000 mg/L and contains 83% volatile suspended solids. The digester contains solids at 2.3% total solids. Biosolids withdrawn from the digester are 67% volatile solids. What was the percent VSS reduction through the digestion process?

25. Given the following information, find the solids loading rate to the secondary clarifier.
    MLSS = 2500 mg/L   Influent Flow = 2 mgd
    RAS = 6000 mg/L   RAS = 70% of influent flow
    Secondary clarifier is 65 feet in diameter and 12 feet deep.

26. A small treatment plant has decided to accept septic waste. The plant currently receives about 0.8 mgd of flow with an influent ammonia concentration of 35 mg/L. If the treatment plant accepts 3 loads of septic waste per day at 3,000 gallons each, what will the new influent ammonia concentration become? Assume an ammonia concentration of 450 mg/L.

27. Ferric chloride is added to precipitate phosphorus in the clarifier wet well. The ferric chloride is delivered as a concentrated solution at 47% ferric chloride. The desired dose in the floc well is 30 mg/L. If the influent flow to the clarifier is 80,000 gpm, find the chemical dose rate in gallons per day.

28. Liquid alum contains 642.3 milligrams of aluminum per milliliter of solution. Jar tests indicate that the best alum dose for phosphorus removal is 9 mg/L. Determine the setting on the liquid alum feeder in ml/min when the plant flow is 3.2 mgd.

29. An anaerobic digester is in start-up mode. The digester is 40 feet in diameter and 25 feet tall. The digester is equipped with a boiler capable of putting out 140,000 BTUs per hour. If the current digester temperature is 70 degrees Fahrenheit and the desired operating temperature is 95 degrees Fahrenheit, how many hours will the boiler run? Assume the digester contents have a specific gravity of 1.12.

30. A treatment plant has one aeration basin and one clarifier. The aeration basin holds 300,000 gallons and the clarifier holds 60,000 gallons. The MLSS concentration is 2500 mg/L, the RAS and WAS concentrations are 7,000 mg/L, and the clarifier core concentration is 600 mg/L. Find the SRT if the WAS pump operates continuously at 10 gpm.

31. An operator needs to collect a composite effluent sample for permit compliance. They collect a total of four grab samples at 8:00 am, 10:00 am, noon, and 2:00 pm. The average daily flow for the facility is 1.5 mgd. The desired composite sample volume is 2 liters. If the instantaneous flow at noon is 1.75 mgd, what will the aliquot size be, in milliliters, for that time?

32. A treatment plant headworks wet well is filling at a rate of 60 gpm. The influent pump is capable of discharging 500 gpm. The wet well is 10 feet deep and 15 feet in diameter. What is the pump cycle time in minutes?

33. A treatment plant does not have flow monitoring on their Return Activated Sludge line. The operator wants to know what the percent RAS rate is relative to the influent flow. Calculate the RAS rate given the following information: MLSS concentration is 2500 mg/L, influent flow is 4.0 mgd, RAS concentration is 7,000 mg/L, WAS concentration is 7,200 mg/L, WAS pump rate is 60 gpm.

34. Calculate the Sludge Volume Index (SVI) for two different operating conditions. In situation one, the MLSS concentration is 3,000 mg/L and the settled sludge volume after 30 minutes (SSV30) is 250 mL. In situation two, the MLSS concentration is 8,000 mg/L and the SSV30 is 980 mL.

35. Find the surface overflow rate for a secondary clarifier that is 120 feet in diameter when the influent flow is 120 gpm.

1. $SRT = \dfrac{\text{Solids in Digester}}{\text{Solids Leaving}}$ $1\% = 10,000 \; mg/L$

$Volume = L \times W \times H$

$Volume = (100 \; ft)(40 \; ft)(12 ft)$

$Volume = 48,000 \; cf$

$$48000 \; cf \left| \frac{7.48 \, gal}{1 \, cf} \right| \frac{1 \, MG}{1000000 \, gal} = 0.359 \; mg$$

$lbs \; in \; Digester = (mg/L)(Q, mgd)(8.34)$

$\qquad = (20,000 \; mg/L)(0.359 \; mg)(8.34)$

$\qquad = 59,881.2 \; lbs$

$lbs \; in \; Decant = (mg/L)(Q, mgd)(8.34)$

$\qquad = (400 \; mg/L)(0.002 \; mgd)(8.34)$

$\qquad = 6.67 \; lbs$

$lbs \; for \; Disposal = (mg/L)(Q, mgd)(8.34)$

$\qquad = (20,000 \; mg/L)(0.004 \; mgd)(8.34)$

$\qquad = 667.2 \; lbs$

$SRT = \dfrac{lbs \; in \; digester}{lbs \; leaving}$

$SRT = \dfrac{59881.2 \; lbs}{667.2 \, lbs + 6.67 \, lbs}$

$SRT = 88.9 \; DAYS$

2. DEGREE DAYS = $(°C \times SRT, days)$

$$°F = \frac{9}{5}°C + 32$$
$$95°F = \frac{9}{5}°C + 32$$
$$95°F - 32 = \frac{9}{5}°C + 32 - 32$$
$$63° = \frac{9}{5}°C$$
$$\frac{5}{9}(63°) = \left[\frac{9}{5}°C\right]\frac{5}{9}$$
$$35 = °C$$

* could also
convert $\frac{9}{5}$ to 1.8

DEGREE DAYS = $(°C \times SRT)$
$= (35°C \times 40\ days)$
$= 1400$

3. % VSS REDUCTION $= \left[\dfrac{IN - OUT}{IN - (IN)(OUT)}\right] * 100$

% VSS REDUCTION $= \left[\dfrac{0.8 - 0.67}{0.8 - (0.8)(0.67)}\right] * 100$

% VSS REDUCTION $= \left[\dfrac{0.13}{0.8 - 0.536}\right] * 100$

% VSS REDUCTION $= \left[\dfrac{0.13}{0.264}\right] * 100$

% VSS REDUCTION $= 49.2$

4. $MCRT = \dfrac{\text{lbs MLSS in system}}{\text{lbs MLSS leaving system}}$

a. Volume A-basins = $L \times W \times H$

$= (100 \text{ ft} \times 35 \text{ ft} \times 12 \text{ ft})$

$= 42,000$ cf

multiply by 3 for three basins = 126,000 cf total

$\dfrac{126,000 \text{ cf}}{} \left| \dfrac{7.48 \text{ gal}}{1 \text{ cf}} \right| \dfrac{1 \text{ MG}}{1000000 \text{ gal}} = 0.942 \text{ mg}$

b. Volume Clarifiers = $0.785 d^2 h$

$= (0.785 \times 35 \text{ ft})^2 (12 \text{ ft})$

$= 11539.5 \text{ ft}^3$

multiply by 2 for two clarifiers = 23,079 cf total

$\dfrac{23,079 \text{ cf}}{} \left| \dfrac{7.48 \text{ gal}}{1 \text{ cf}} \right| \dfrac{1 \text{ MG}}{1000000 \text{ gal}} = 0.173 \text{ mg}$

c. lbs in A-basin = $(\text{mg/L})(\text{mg})(8.34)$

$= (2800 \text{ mg/L} \times 0.942 \text{ mg} \times 8.34)$

$= 21,997.5$ lbs

d. lbs in Clarifiers = $(\text{mg/L})(\text{mg})(8.34)$

$= (500 \text{ mg/L} \times 0.173 \text{ mg})(8.34)$

$= 721.4$ lbs

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e.
$$mCRT = \frac{lbs\ A\text{-}basin + lbs\ Clarifier}{lbs\ WAS + lbs\ Effluent}$$

$$15\ days = \frac{21,997.5\ lbs + 721.4\ lbs}{lbs\ WAS + \emptyset}$$

— we assume zero since we don't know

$$15\ days = \frac{22718.9\ lbs}{lbs\ WAS}$$

$$1514.6 = lbs\ WAS$$

f.
$$lbs\ WAS = (mg/L)(mgd)(8.34)$$
$$1514.6\ lbs = (6000\ mg/L)(mgd)(8.34)$$

$$\frac{1514.6\ lbs}{(6000\ mg/L)(8.34)} = mgd$$

$$0.00303 = mgd$$

g.
$$\frac{0.00303\ mg}{day} \left| \frac{1000000\ gal}{1\ mg} \right| = \boxed{30,268\ gal/day}$$

A review of the steps
 a + b find volumes of basin + clarifiers in gallons
 c + d ~~can~~ find lbs of MLSS in basins + clarifiers
 e find lbs of WAS
 f back out mg of WAS
 g convert units

5. If the pump runs 15 minutes of every hour, the pump rate should be 4 times the average daily rate.

$$\frac{30,268 \text{ gal}}{\text{day}} \left| \frac{1 \text{ day}}{1440 \text{ min}} \right| = 21 \frac{\text{gal}}{\text{min}} \text{ average}$$

$$21 \text{ gpm} \times 4 = 84 \text{ gpm}$$

6. basic formula is
$$C_1 V_1 + C_2 V_2 = C_3 V_3$$
we can only solve equations with 1 unknown, so we have to turn V_2 into something that looks like V_1

We know that $V_1 + V_2 = V_3$
$$50,000 \qquad V_2 = V_3 - V_1$$

$$C_1 V_1 + C_2 V_2 = C_3 V_3$$
$$C_1 V_1 + C_2 (V_3 - V_1) = C_3 V_3$$
$$(60 \mu g/L)(V_1) + (3 \mu g/L)(60,000 \text{ gpd} - V_1) = (25 \mu g/L)(60,000)$$
$$60 V_1 + 180,000 - 3 V_1 = 1,500,000$$
$$57 V_1 + 180,000 = 1,500,000$$
$$57 V_1 = 1,320,000$$
$$V_1 = 23,158 \text{ gpd}$$

WELL 1 = 23,158 gpd
WELL 2 = 36,842 gpd

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7.
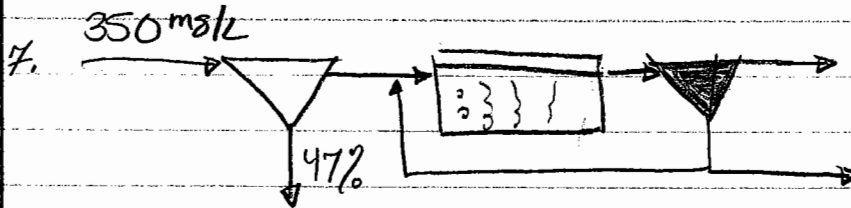
$$100\% - 47\% = 53\%$$

$$(350 \text{ mg/L})(0.53) = 185.5 \text{ mg/L to a-basin}$$

$$\text{lbs/day} = (\text{mg/L})(\text{mgd})(8.34)$$
$$\text{lbs/day} = (185.5 \text{ mg/L})(4.0 \text{ mgd})(8.34)$$
$$\text{lbs/day} = 6,188$$

8. $$\frac{F}{m} = \frac{\text{lbs BOD}}{\text{lbs MLSS}}$$

$$0.10 = \frac{6,188 \text{ lbs BOD}}{\text{lbs MLSS}}$$

$$(0.10 \times \text{lbs MLSS}) = 6,188 \text{ lbs BOD}$$
$$\text{lbs MLSS} = 61,880$$

$$\text{lbs MLSS} = (\text{mg/L})(\text{mgd})(8.34)$$
$$61,880 = (\text{mg/L})(1.25 \text{ mgd})(8.34)$$

$$\frac{61,880}{(1.25)(8.34)} = \text{mg/L}$$

$$5,935 = \text{mg/L}$$

YIKES!

9. a complicated unit conversion

$$\frac{240 \text{ tons}}{160 \text{ acres}} \left| \frac{2000 \text{ lbs biosolids}}{1 \text{ ton biosolids}} \right| \frac{1 \text{ kg biosolids}}{2.2 \text{ lbs biosolids}} \right| \frac{22 \text{ mg Cd}}{1 \text{ kg biosolids}} = 30,000 \frac{\text{mg Cd}}{\text{acre}}$$

then

$$\frac{30,000 \text{ mg Cd}}{\text{acre}} \left| \frac{1 \text{ g}}{1000 \text{ mg}} \right| \frac{1 \text{ kg}}{1000 \text{ g}} \right| \frac{2.2 \text{ lbs}}{1 \text{ kg}} = 0.066 \frac{\text{lbs Cd}}{\text{acre}}$$

10.

5 msd
200 mg/L   → 70 mg/L

100 gpm
5% solids
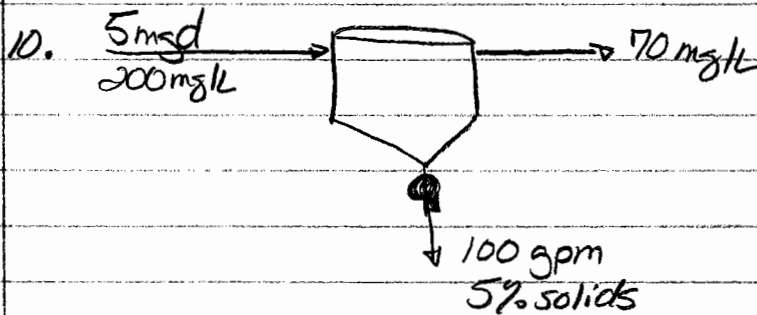
find lbs of solids going to bottom of clarifier

$$lbs = (mg/L)(mgd)(8.34)$$
$$lbs = (200 - 70)(5 \text{ mgd})(8.34)$$
$$lbs = (130)(5)(8.34)$$
$$lbs = 5,421$$

now find total gallons to pump
$$lbs = (mg/L)(mgd)(8.34)$$
$$5,421 = (50,000 \text{ mg/L})(mgd)(8.34)$$
$$0.013 = mgd$$

↳ SAME AS 13,000 gpd

Pump rate is 100 gpm

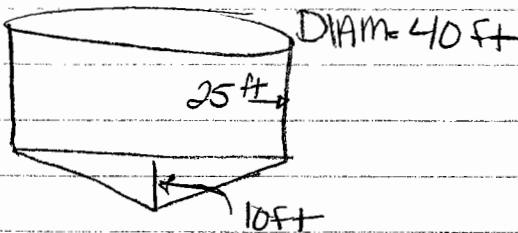$$\frac{13,000 \text{ gallons total}}{100 \text{ gpm}} = 130 \text{ minutes}$$

$$130 \text{ minutes} \left| \frac{1 \text{ hr}}{60 \text{ min}} \right| = \boxed{\begin{array}{c} 2.17 \text{ hours} \\ \text{OR} \\ 2 \text{ hrs } 10 \text{ minutes} \end{array}}$$

11. lbs = (mg/L)(mgd)(8.34)

lbs VSS = (50,000 mg/L)(0.75)(0.013 mgd)(8.34)

lbs VSS = 4065.75

this turns lbs solids into lbs VSS

DIAM = 40 ft

25 ft

10 ft

$$V_{CYLINDER} = 0.785 d^2 h$$
$$= (0.785)(40 ft)^2 (25 ft)$$
$$= 31,400 \text{ cf}$$

$$V_{CONE} = \frac{0.785 d^2 h}{3}$$
$$= \frac{(0.785)(40')^2 (10')}{3}$$
$$= 4187 \text{ cf}$$

$$V_{TOTAL} = V_{CYLINDER} + V_{CONE}$$

$$V_{TOTAL} = 31,400 \text{ cf} + 4,187 \text{ cf}$$

$$V_{TOTAL} = 35,581 \text{ cf}$$

lbs VSS = 406.6

V_{TOTAL} = 35,587 cf

VSS Loading = $\dfrac{4065.75 \, lbs}{35,587 \, cf}$

= 0.11 lbs VSS/cf   pretty typical
for an anaerobic
digester

12. Pump formula only works with gpm.
Convert

$\dfrac{5.0 \, mg}{day} \left| \dfrac{1000000 \, gal}{1 \, mg} \right| \dfrac{1 \, day}{1440 \, min} \left| = 3472 \dfrac{gal}{min} \right.$

$HP_{MOTOR} = \dfrac{(gpm)(head, ft)}{(3960)(E_p)(E_m)}$

$HP_{MOTOR} = \dfrac{(3472 \, gpm)(15 \, ft)}{(3960)(0.70)(0.90)}$

$HP_{MOTOR} = 20.88$

13. $\dfrac{50 \text{ gal}}{\text{min}} \Big| \dfrac{60 \text{ min}}{1 \text{ hr}} \Big| = 3{,}000 \dfrac{\text{gal}}{\text{hr}}$

eight hours gives $(8)(3{,}000) = 24{,}000$ gallons going into belt press

$$C_1 V_1 = C_2 V_2$$

$$(3\%)(24{,}000 \text{ gal}) = (20\%)(V_2)$$

$$\dfrac{(3\%)(24{,}000 \text{ gal})}{20\%} = V_2$$

$$3{,}600 \text{ gal} = V_2$$

$3{,}600 \text{ gal} = 481 \text{ cf} = 17.8$ cubic yards

14. The easiest way to do this problem is to find the velocity if all the flow goes through 1 basin

$4.0 \dfrac{\text{mg}}{\text{day}} \Big| \dfrac{1000000 \text{ gal}}{1 \text{ mg}} \Big| \dfrac{1 \text{ cf}}{7.48 \text{ gal}} \Big| \dfrac{1 \text{ day}}{1440 \text{ min}} \Big| \dfrac{1 \text{ min}}{60 \text{ sec}} \Big| = 6.19 \dfrac{\text{cf}}{\text{s}}$

$\text{velocity} = \dfrac{\text{flow}}{\text{area}}$

$\text{velocity} = \dfrac{6.19 \text{ cfs}}{(2.5 \text{ ft})(2 \text{ ft})}$ ← Note: area is the cross section of the basin

$\text{velocity} = 1.23 \text{ ft/s}$

therefore ∴ 2 basins needed

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15. 6 inches = 0.5 ft ⎫ convert because
12 inches = 1.0 ft ⎬ square inches aren't
⎭ useful

find volume per stroke

$V = 0.785 \, d^2 h$
$V = (0.785)(0.5 \, ft)^2 (1.0 \, ft)$
$V = 0.19625 \, ft^3$

$$\frac{0.19625 \, cf}{stroke} \, \Big| \, \frac{22 \, strokes}{1 \, min} \, \Big| \, \frac{7.48 \, gal}{1 \, cf} \, \Big| = \frac{32.3 \, gal}{min}$$

16. find hours of run time
8 hrs/day × 7 day/week = 56 hours/week

6 weeks × 56 hrs/week = 336 hours

$$\frac{25 \, HP}{} \, \Big| \, \frac{0.746 \, kw}{1 \, HP} \, \Big| \, \frac{\$0.07}{1 \, kwh} \, \Big| \, \frac{336 \, hrs}{} \, \Big| = \$438.65$$

17. We will use the ppd formula to find out how much bleach we need. First, we need volume in mg.

18 inches = 1.5 ft $V = 0.785 \, d^2 h$
$V = (0.785)(1.5 \, ft)^2 (180 \, ft)$
$V = 317.925 \, cf$

$$\frac{317.925 \, cf}{} \, \Big| \, \frac{7.48 \, gal}{1 \, cf} \, \Big| \, \frac{1 \, MG}{1000000 \, gal} \, \Big| = 0.0024 \, MG$$

$$ppd = \frac{(mg/L)(MG)(8.34)}{\% \, Purity}$$

$$ppd = \frac{(100 + 15 \, mg/L)(0.0024 \, mg)(8.34)}{0.0525}$$

$$ppd_{BLEACH} = 43.8$$

they asked for gallons

$$43.8 \, ppd \, bleach \, \left| \, \frac{1 \, gal}{8.34 \, lbs} \, \right| = 5.25 \, gallons$$

18. Chlorine residual = 0.9 mg/L

Sulfonator dose = Chlorine Residual + 1.5 mg/L

$$= 0.9 + 1.5 \, mg/L$$
$$= 2.4 \, mg/L$$

$$ppd = (mg/L)(mgd)(8.34)$$
$$ppd = (2.4 \, mg/L)(5 \, mgd)(8.34)$$
$$ppd = 100$$

19. $V_{BASIN} = L \times W \times H$

$V_{BASIN} = (150\,ft)(55\,ft)(12\,ft)$

$V_{BASIN} = 99000\,ft^3$

2 BASINS, SO $2 \times 99,000 = 198,000\,cf$

$$\frac{198,000\,cf}{} \left| \frac{7.48\,gal}{1\,cf} \right| \frac{1\,MG}{1000000\,gal} = 1.48\,mg$$

$lbs\ A\text{-}basin = (mg/L)(MG)(8.34)$

$lbs\ A\text{-}basin = (3500\,mg/L)(1.48\,mg)(8.34)$

$lbs\ A\text{-}basin = 43,201$

$V_{CLARIFIER} = 0.785\,d^2 h$

$V_{CLARIFIER} = (0.785)(45\,ft)^2(15\,ft)$

$V_{CLARIFIER} = 23,844\,ft^3$

2 CLARIFIERS, SO $2 \times 23,844 = 47,688\,cf$

$$\frac{47,688\,cf}{} \left| \frac{7.48\,gal}{1\,cf} \right| \frac{1\,MG}{1000000\,gal} = 0.357\,mg$$

$lbs\ CLARIFIER = (mg/L)(MG)(8.34)$

$lbs\ CLARIFIER = (500\,mg/L)(0.357\,mg)(8.34)$

$lbs\ CLARIFIER = 1488.69$

$\qquad\qquad\quad = 1489\,lbs$

Since MLVSS was not available,
just use MLSS. The MLVSS/MLSS
ratio for a given facility tends to be
fairly constant.

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$$MCRT = \frac{lbs\ A\text{-}Basin + lbs\ Clarifier}{lbs\ WAS}$$

$$18\ days = \frac{43,201\ lbs + 1489\ lbs}{lbs\ WAS}$$

$$18\ days = \frac{44690\ lbs}{lbs\ WAS}$$

$$(18\ days \times lbs\ WAS) = 44690\ lbs$$
$$lbs\ WAS = 2482.78$$

now, back out the volume of WAS
from the lbs formula

$$lbs\ WAS = (mg/L)(MGD)(8.34)$$
$$2482.78\ lbs = (7,500\ mg/L)(MG)(8.34)$$

$$\frac{2482.78}{(7500)(8.34)} = MGD$$
$$0.03969 = MGD$$

which is $39,692\ \dfrac{gallons}{day}$

20. $lbs\ BOD = (mg/L)(MGD)(8.34)$
     $lbs\ BOD = (300\ mg/L)(2.5\ mgd)(8.34)$
     $lbs\ BOD = 6255$

have   43,201 lbs MLSS in Basin
           6255 lbs BOD

$$\frac{F}{m} = \frac{lbs\ BOD}{lbs\ MLSS}$$

$$\frac{F}{m} = \frac{6255\ lbs\ BOD}{43201\ lbs\ MLSS}$$

$$\frac{F}{m} = 0.14$$

If we want an $\frac{F}{m}$ of 0.2, we need
less MLSS in the basin

SO ∘ ∘ ∘ ∘   INCREASE wasting

21. Nitrification consumes 7.14 mg/L of
alkalinity for every mg/L of ammonia

        30 mg/L IN — 1 mg/L OUT = 29 mg/L
                                     nitrified

        USED = (29 mg/L)(7.14 mg/L) = 207.06 mg/L Alkalinity

Denitrification produces 3.57 mg/L
of ~~alkali~~ alkalinity for every mg/L of nitrate

turned into nitrogen gas
        29 mg/L NO₃ made — 12 mg/L EFF = 17 mg/L
                                            Denitrified

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$$\text{alkalinity produced} = \left(17\,{}^{mg}/_L\,NO_3\right)\left(3.57\,{}^{mg}/_L\right)$$
$$\text{alkalinity produced} = 60.7\ mg/L$$

$$\text{INFLUENT ALKALINITY} = 280\ {}^{mg}/_L$$
$$\text{CONSUMED} = -207.1\ {}^{mg}/_L$$
$$\text{PRODUCED} = +60.7\ {}^{mg}/_L$$

$$\text{EFFLUENT ALKALINITY} = 133.6\ {}^{mg}/_L$$

22. $$\text{SPACE LOADING} = \dfrac{lbs\ BOD}{1000\ cf}$$

$$\dfrac{2\,mg}{}\Bigg|\dfrac{1000000\,gal}{1\,mg}\Bigg|\dfrac{1\,cf}{7.48\,gal}\Bigg| = 267{,}380\ cf$$
$$or$$
$$267.38 \times 1000\ cf$$

$$lbs\ BOD = (mg/L)(MGD)(8.34)$$
$$lbs\ BOD = (350\ mg/L)(8\ mgd)(8.34)$$
$$lbs\ BOD = 23{,}352$$

$$\text{SPACE LOADING} = \dfrac{lbs\ BOD}{1000\ cf}$$
$$= \dfrac{23{,}352\ lbs\ BOD}{267.38 \times 1000\ cf}$$
$$= 87\ lbs\,BOD/_{1000\,cf}/day$$

NORMAL RANGE IS
 5 - 15   for extended aeration
 20 - 40   for conventional system

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23. FORCE = PRESSURE × AREA

force is one of the only times we'll use square inches for area.

$$AREA = 0.785 d^2$$
$$= (0.785)(12 \text{ inches})^2$$
$$= 113 \text{ in}^2$$

$$FORCE = PRESSURE \times AREA$$
$$= (75 \text{ lbs/in}^2)(113 \text{ in}^2)$$
$$= 8475 \text{ lbs}$$

$$\frac{8475 \text{ lbs}}{} \left| \frac{1 \text{ ton}}{2000 \text{ lbs}} \right| = 4.2 \text{ tons of force}$$

24. $$\% VSS = \left[\frac{In - Out}{In - (In)(Out)} \right] * 100$$

$$\% VSS = \left[\frac{0.83 - 0.67}{0.83 - (0.83)(0.67)} \right] * 100$$

$$\% VSS = \left[\frac{0.16}{0.83 - 0.5561} \right] * 100$$

$$\% VSS = 58.4$$

25. The clarifier actually has 2 influent flows
   — the influent wastewater
   — the RAS

both flows push solids (MLSS) out of the a-basin

lbs MLSS $= (Q_{INF} + Q_{RAS})(MLSS \; mg/L)(8.34)$

lbs MLSS to Clarifier $= (2 mGD + 1.4 mGD)(2500 \; mg/L)(8.34)$

$= 70,890 \; lbs/day$

Area of Clarifier $= 0.785 d^2$
$= (0.785)(65 ft)^2$
$= 3316.6 \; ft^2$

solids load $= \dfrac{lbs \; MLSS \; to \; clarifier}{clarifier \; area}$

$= \dfrac{70,890 \; lbs/day}{3316.6 ft^2}$

$= 21.4 \; lbs/ft^2 \cdot day$

26. $(3,000 \text{ gallons})(3) = 9,000 \text{ gallons}$
             $= 0.009 \text{ MG}$

$C_1V_1 + C_2V_2 = C_3V_3$
$(35 \text{ mg/L})(0.8 \text{ mgd}) + (450 \text{ mg/L})(0.009 \text{ MG}) = (0.809 \text{ MG})(C_3)$
       $28 + 4.05 = (0.809 \text{ MG})(C_3)$
          $32.05 = (0.809 \text{ MG})(C_3)$
          $39.6 \text{ mg/L} = C_3$

27. $47\% \left| \dfrac{10,000 \text{ mg/L}}{1\%} \right| = 470,000 \text{ mg/L}$

$\dfrac{80,000 \text{ gal}}{\text{min}} \left| \dfrac{1440 \text{ min}}{1 \text{ day}} \right| = 115,200,000 \dfrac{\text{gal}}{\text{day}}$

$C_1V_1 = C_2V_2$
$(470,000 \text{ mg/L})(V_1) = (30 \text{ mg/L})(115,200,000 \text{ gal/d})$
       $V_1 = \dfrac{(30 \times 115\,200\,000)}{470\,000}$

       $V_1 = 7,353 \text{ gal/day}$

              OR

            5.1 gpm

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28. there is a special formula for this problem AND the certification exam gives it to us in the front of the test booklet

$$\text{Feed Pump } \frac{ml}{min} = \frac{(MGD)(mg/L)(3.785\,L/gal)(1,000,000\,gal/MG)}{(liquid\ mg/ml)(24\,hr/d)(60\,min/hr)}$$

$$\text{Feed Pump, } \frac{ml}{min} = \frac{(3.2\,mgd)(9\,mg/L)(3.785\,L/gal)(1,000,000\,gal/mg)}{(642.3\,mg/ml)(24\,hr/d)(60\,min/hr)}$$

$$\text{Feed Pump } \frac{ml}{min} = 117.9$$

29. 1 BTU is the amount of energy required to raise the temperature of 1 pound of water by 1°F

$$Volume = 0.785 \, d^2 h$$
$$Volume = (0.785 \times 40ft)^2 (25 \, ft)$$
$$Volume = 31,400 \, cf$$

$$\frac{31,400 \, cf}{} \left| \frac{7.48 gal}{1 \, cf} \right| \frac{8.34 \, lbs}{1 \, gal} \left| 1.12 \, \overset{specific}{grav} \right| = 2,193,892 \, lbs$$

the specific gravity makes the sludge weigh more than water

$$\begin{array}{r} 95°F \\ -70°F \\ \hline 25°F \end{array} \text{ temp. Increase}$$

BTU's Needed = (lbs water)(°F)
= (2,193,892 lbs)(25°F)
= 54847300 BTU's

BOILER DOES 140,000 BTU/hr

$$\frac{54847300 \, BTU}{} \left| \frac{1 \, hr}{140,000 \, BTU} \right| = 391 \, hours$$

30. SRT does not include the solids in
    the clarifier

LBS MLSS = $(^{mg}/_L)(mg)(8.34)$
LBS MLSS = $(2500^{mg}/_L)(0.3\ mg)(8.34)$
LBS MLSS = 6,255 lbs

$$\frac{10\ gallons}{min} \left|\ \frac{1440\ min}{1\ day}\ \right|\ \frac{1\ mg}{1000000\ gal}\ \right| = 0.0144\ mgd$$

LBS WAS = $(^{mg}/_L)(mgd)(8.34)$
LBS WAS = $(7,000^{mg}/_L)(0.0144\ mgd)(8.34)$
LBL WAS = 840.67

$$SRT = \frac{lbs\ in\ system}{lbs\ leaving} = \frac{6,255\ lbs}{840.67\ lb/d} = \boxed{7.44\ days}$$

31. COMPOSITE PORTION = $\dfrac{(INSTANT\ FLOW)(TOTAL\ VOLUME)}{(\#PORTIONS)(AVERAGE\ FLOW)}$

    COMPOSITE PORTION = $\dfrac{(1.75\ mgd)(2,000\ mL)}{(4)(1.5\ mgd)}$

    COMPOSITE PORTION = 583 mL

32. CYCLE TIME, MIN = $\dfrac{Storage\ Volume,\ gal}{Pump,\ gpm\ -\ Inflow,\ gpm}$

    need to find volume in gallons

32. $Volume = 0.785 \, d^2 h$

$Volume = (0.785 \times 15 \, ft)^2 (10 \, ft)$

$Volume = 1,766 \, cf$

$$\frac{1,766 \, cf \mid 7.48 \, gal}{\mid 1 \, cf} = 13,209.68 \, gallons$$

$cycle \, time_{min} = \dfrac{storage \, volume, \, gal}{Pump, \, gpm - Inflow, \, gpm}$

$= \dfrac{13,209.68 \, gallons}{500 \, gpm - 60 \, gpm}$

$= \dfrac{13,209.68 \, gal}{440 \, gpm}$

$= 30 \, minutes$

33. $RAS \, Rate = \dfrac{(MLSS \times Flow)}{RAS - MLSS}$

$RAS \, RATE = \dfrac{(2500 \, mg/L \times 4.0 \, mgd)}{(7,000 \, mg/L - 2500 \, mg/L)}$

$RAS \, RATE = \dfrac{10,000}{4,500}$

$RAS \, RATE = 2.22 \, mgd$ about 56% return rate

34. $SVI = \dfrac{SSV_{30} \times 1,000 \, mg/g}{MLSS, \, mg/L}$

$SVI = \dfrac{(250 \, mL \times 1,000 \, mg/g)}{3,000 \, mg/L}$

$SVI = 83 \, mL/gram$

31 PART 2 $SVI = \dfrac{(SSV_{30} \times 1000^{m/g})}{MLSS, mg/L}$

$SVI = \dfrac{(980 mL)(1000)}{8,000 \, mg/L}$

$SVI = 123 \, mL/g$

is this sludge really settling well?
Nope — SVI formula results are
meaningless at high solids concentrations

35. $SOR = \dfrac{gallons \ per \ day}{square \ feet}$

$AREA = 0.785 d^2$
$AREA = (0.785)(120 ft)^2$
$AREA = 11304 \ sf$

$\dfrac{120 \ gal}{min} \bigg| \dfrac{1440 min}{1 \ day} \bigg| = 172,800 \ \dfrac{gal}{day}$

$SOR = \dfrac{172,800 \ gpd}{11304 \ sf}$

$SOR = 15.3 \ gpd/sf$