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Process I

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1.

We first assume all the particles is under laminar flow condition and use Re parameter to readjusts the equation due to different flow type, then

$$Re = \frac{\rho v_s d_p}{\mu} \quad \text{and} \quad v_s = \frac{g(\rho_p - \rho_w)d_p^2}{18\mu}$$

where Re = Reynolds number, dimensionless

μ = dynamic viscosity, $N \cdot s/m^2$ or $kg/m \cdot s = 1.307 \times 10^{-3}\ kg/m \cdot s$

Then, in terms of different Re (Clark, 1996), readjusts our equation to fit different conditions

$$Cd = \frac{Re}{24}\ (Re < 2) = \frac{18.5}{Re^{0.6}}\ (2 < Re < 500) \ = 0.44\ (500 < Re < 2 \times 10^5)$$

$$v_{re} = \sqrt{\frac{4g(\rho_p - \rho_w)d_p}{3C_d\rho_w}} \quad \text{and}\ Re_{re} = \frac{\rho v_s d_p}{\mu}$$

Make a table:

Particle	Re(laminar flow)	Actual Flow Type	Re_{re}	v_{re}
A	0.07	Laminar Flow	0.04	0.002
B	2.01	Turbulent Flow	1.94	0.005
C	0.43	Laminar Flow	0.42	0.002
D	1.72	Laminar Flow	1.07	0.015
E	2.07	Turbulent Flow	1.56	0.013

* detailed calculation process by Matlab programming

2.

$$v_s = \frac{b}{t} = \frac{b}{a/V_f} = \frac{0.6}{4/0.2} = 0.03\ m/s$$

Where

$a = 4m, b = 0.6m, c = 0.9m$
$V_f = 20cm/s = 0.2m/s$

Then

$$OR = \frac{a}{c/v_s} = \frac{4}{0.9/0.03} = 0.13\ m/s$$

$$OR = 0.13\frac{m}{s} \times \frac{60s}{min} \times \frac{7.48\ gallons}{ft^3} \times \frac{3.28\ ft}{1m} = 191.4\ gpm/ft^2$$

$$L_{re} = \tau \times V_f = \frac{c}{V_s} \times V_f = 6\ m$$

3.

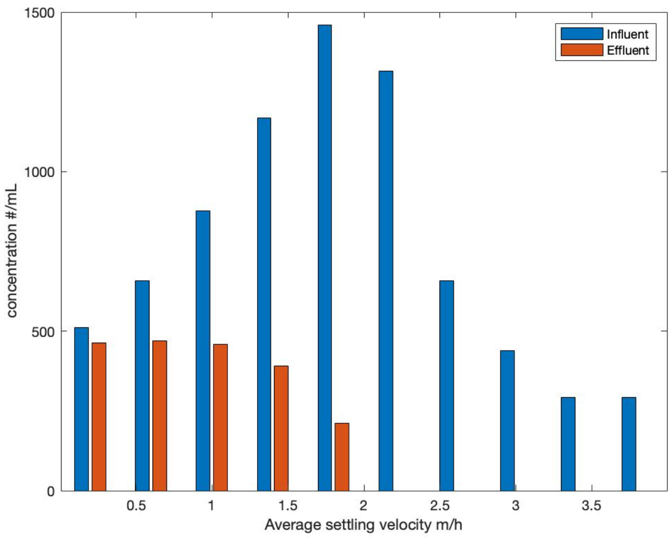
$$OR = \frac{h_o}{\tau} = \frac{h_oQ}{h_oA} = \frac{Q}{A} = 50.47\ m/d$$

$$Removal\ efficiency\ = \frac{\Sigma N_i^0 \times (1 - \frac{v_i}{OR})}{N}$$

where N is the total particles amount and vi is the average settling velocity

Settling Velocity	Average Velocity	Number of Influent	Fraction of Removed	Number of Removed	Number in Effluent
0 - 0.4	0.2	511	0.10	49	462
0.4-0.8	0.6	657	0.29	187	470
0.8-1.2	1.0	876	0.48	417	459
1.2-1.6	1.4	1168	0.67	778	390
1.6-2.0	1.8	1460	0.86	1250	210
2.0-2.4	2.2	1314	1.00	1314	0
2.4-2.8	2.6	657	1.00	657	0
2.8-3.2	3.0	438	1.00	438	0
3.2-3.6	3.4	292	1.00	292	0
3.6-4.0	3.8	292	1.00	292	0

* detailed calculation process by Matlab programming



$$Removal\ efficiency\ = \frac{\Sigma N_i^0 \times (1 - \frac{v_i}{OR})}{N} = 74\,\%$$

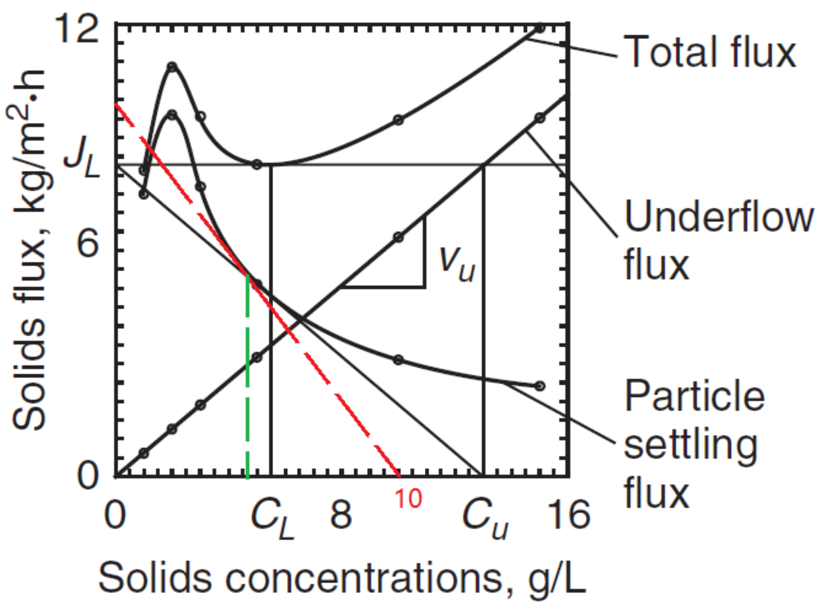
4.

Influent flow rate = 3000 m3 / h

Influent solid concentration = 500 mg / L

Underflow solid concentration = 10000mg / L

Determine J_L and C_L. From the data plotted on Fig. 10-8b and an underflow solids concentration of C_u = 10000 mg/L, the gravity flux is determined by drawing a line from the x axis at a solids concentration of 10,000 mg/L to the y axis such that it is tangent to the solids flux curve and intersects the y axis. The point at which the line intersects the y axis is the limiting gravity flux and is equal to 9.90 kg/m^2 · h. The value for C_L can also be determined by drawing a vertical line from the tangent point to the x axis and is equal to 4600 mg/L.



Then

$$J_L = 9.9\ kg/m_2{\cdot}h$$

$$C_L = 4600\ mg/L$$

$$Q_u = \frac{Q_i C_i}{C_u} = \frac{3000m^3/h \times 500mg/L}{10000mg/L} = 150m^3/h$$

5.

Determine the number of basins: Two basins would satisfy the mini- mum requirement for maintenance purposes.According to the small flow in the requirement, two basins will be selected.

SIZE: The basin width will be governed by the by the standard size of sludge removal equipment. The standard maximum width of the chain-and-flight sludge collector is 6 m, so basin widths in increments of 3 m will be considered, starting with 6 m. Water depths from 3 to 5 m are appropriate, according to the design criteria listed in Table 10-4. As previously mentioned, deeper basins are recommended over shallower basins, so a depth of 4 m will be selected.

Determine the basin area: I assume The water is coagulated with alum and the alum floc was measured to have a settling velocity of 2.2 m/h at 10°C (50°F). The dynamic viscosity of water at 10°C is 0.00131 kg/m s and the density of water is 999.7 kg/m3.

$$A = \frac{Q}{v_c} = \frac{0.1736m^3/s}{2.2m/h \times \frac{1h}{3600s}} = 284.1m^2$$

$$ratio = \frac{A}{2 \times 3m} \times \frac{1}{3m} = 4.0$$

The length-to-width ratio is greater than the minimum recommendation of 4:1 to 5:1.

Check the various design parameters listed in Table 10-4

$$Q_{max} = \frac{(6 \times A \times 4) \times 2\ basins}{OR \times \frac{1h}{3600s}} = 21.82\ h$$

6.

Countercurrent settlers

$$\frac{V_s}{V_{f\theta}} = \frac{d}{L_p cos\theta + d sin\theta}$$

Where V_s is settling velocity

d is the distance between two parallel pates = 50mm

θ = inclination angle of plates from horizon = 60

L_p = length of plate = 2m

$V_{f\theta}$ = fluid velocity in channel

Then

$$\frac{Q}{A sin\theta} = V_{f\theta} = \frac{d}{V_s(L_p cos\theta + d sin\theta)}$$

Thus

$$A = \frac{Qd}{sin\theta V_s(L_p cos\theta + d sin\theta)} = 52.71\ m^2$$

(II)

$$A_{cover} = \frac{h}{sin\theta} \times \frac{A}{\frac{d}{sin\theta}} =$$

7.

Assume temperature is 15 C

$$H_{YC} = K_C \times e^{-\frac{\Delta H^o_{dis}}{RT}} = 46$$

$$C_{fl} = \frac{Y}{H_{YC}} = 26.63\ mg/L \qquad \text{and} \qquad C_r = C_{fl} \times \frac{P}{P_0} = 170.83 \text{ mg/L}$$

$Y =$ the density of air at 15 C and 1 atm = 1225 mg / L
$H_{YC} =$ the value of the dimensionless Henry's constant at 15 C and 1 atm
$P =$ operating pressure = 650 KP
$P_0 = 101.325\ KPa$ = standard air pressure
$C_r =$ mass concentration of air in recycle flow, mg/L
$C_{fl} =$ mass concentration of air in floc tank effluent

$$C_b = \frac{e(C_r - C_{fl})r - k}{1 + r} = 9.61\ mg/L$$

$C_b =$ mass concentration of air released, mg/L
$e =$ efficiency factor, dimensionless = 0.9
$r =$ mg/L recycle ratio, dimensionless = 0.08
$k =$ factor to account for air deficit in incoming flocculated water = 0

$$\Phi_b = \frac{C_b}{\rho_{air}} = 7847\ ppm \qquad \text{and} \qquad N_b = \frac{10^{12} \times 6\Phi_b}{\pi d_b^3} = 5.6 \times 10^5 \text{ bubbles/mL}$$

$\rho_{air} = 1225\ mg/L$
$d_b =$ the mean bubble diameter = $30\mu m$
$N_p =$ floc particle concentration = 1000 particles / mL

$$\frac{N_b}{N_p} = \frac{5.6 \times 10^5}{1000} = 560$$

Because the ratio of bubbles to particles is high, there is a lot of opportunity for particle collision and attachment