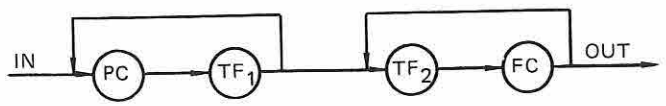
ent's line back up. The subdivision is in a flood plain and the sewer lines are very flat and cannot be steepened. The rim on the manhole cannot be raised. (a) Give two solutions to this problem. (b) Sketch a plan view showing what your solutions would look like.

2. A high-rate, two-stage trickle filter system processes 5.2 MGD of sewage with a 5-day BOD of 320 mg/l. The effluent is to have a 5-day BOD of 28 mg/l, within a ± 20 mg/l range. (a) What is the final BOD of the effluent? (b) Determine the required filter size (diameters). Both filters have the same size.

hydraulic load to filter: 32 mgad including recycle
30% BOD removal in primary clarifier
filter depth: 5 feet for both filters
Use NRC standards.



3. A town has a current population of 10,000 and is expected to double in size in 15 years. The town has plans to deposit its solid waste in a 30-acre landfill that will be used as a park in 20 years. (a) Describe the general requirements for a sanitary landfill. (b) What factors should be considered in selecting a site? (c) If the average person generates 5 pounds of solid waste per day, how long will it take to produce a 6-foot lift? Hint: The town continues to grow after 15 years.

4. A town of 10,000 people has selected a 50 acre site to deposit its solid waste. The minimum side borders are 50 feet. The maximum trench depth is ± 20 feet. There is a minimum requirement of 10 feet of earth cover for the lift. (a) What is the service life of the disposal site? (b) What is the daily annual solid waste volume? (c) What is the volumetric capacity of the disposal site? (d) Discuss the environmental considerations relating to traffic, pollution, aesthetics, and other factors.

5. A town of 10,000 people has its own primary treatment plant. (a) What mass of total solids (in pounds per day) should the treatment plant expect? (b) If the town is 4 miles from the treatment plant and 400 feet above it in elevation, what size pipe should be used between the town and the plant?

6. A small community has a projected flow of 1 MGD. Incoming wastewater has the following properties:

BOD of 250 mg/l
grit specific gravity of 2.65
total suspended solids of 400 mg/l

The community wishes to have a wastewater treatment system consisting of an aerated grit chamber, primary clarification, two trickling filters, and a secondary clarifier. The final effluent is to have a final BOD of 30 mg/l. The recirculation ratio of the system is 100%. (a) Size the aerated grit chamber. (b) Determine the air requirements for grit chamber in order to capture 95% of the grit. (c) Size the primary clarifier. (d) Size the trickling filters in acre-feet. (e) Size the secondary clarifier.

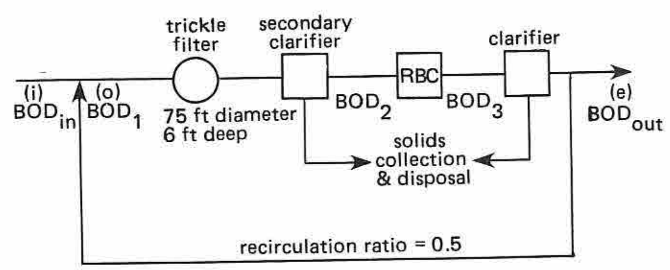
7. Wastewater enters the recirculating biological contactor (RBC) treatment process shown with 250 mg/l BOD at the rate of 1.5 MGD. The RBC removes a fraction of the incoming BOD.

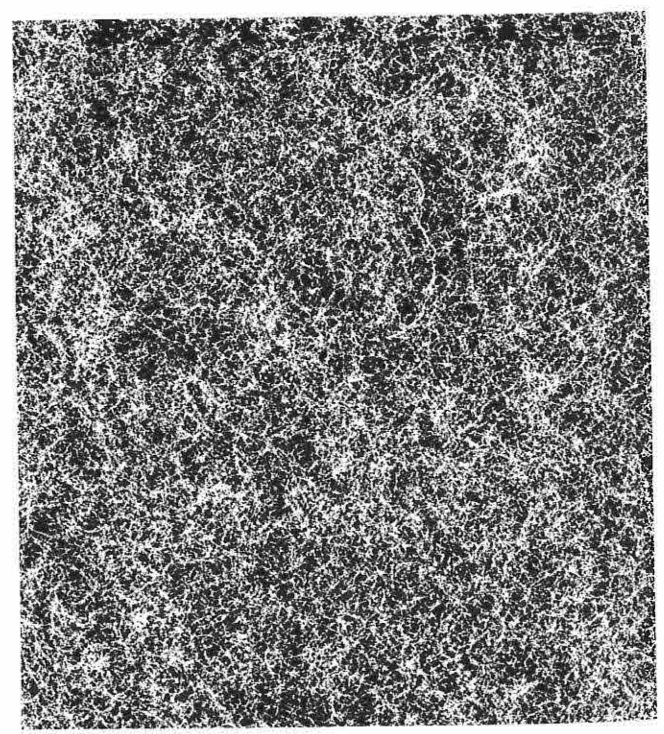
Fraction BOD removal in RBC (expressed as a decimal) $= \dfrac{1}{\left[1 + \frac{kA}{Q}\right]^3}$

$$k = 2.45\ \frac{\text{gpd}}{\text{ft}^2}$$

Q does not include recirculation

(a) Find the area of the RBC such that BOD_{out} is 30 mg/l. (b) Find the recirculation ratio such that the BOD_{out} is 30 mg/l. Keep the RBC area the same as in (a). (c) Find the sludge volume produced from the clarifiers if the yield is 0.4 lbs/lb BOD removed. S.G. of raw sludge – 1.0. (d) What is the organic loading to the RBC under the flow scheme outlined in part (a)?





9 SOILS

Nomenclature

A	area	various
c	cohesion	psf
C_c	compression index	–
C_u	uniformity coefficient	–
C_z	coefficient of curvature	–
CBR	California bearing ratio	–
D	diameter	mm
e	void ratio	–
F	percent passing through the sieve, or shape factor	–, various
G_H	hydraulic gradient	–
h	head	cm
I_d	density index	–
I_g	group index	–
I_l	liquidity index	–
I_p	plasticity index	–
k	coefficient of permeability	cm/sec
L	flow path length	cm
n	porosity	–
N	number of blows	–
p	pressure	psi
P	load	lbf
PPS	percent pore space	–
Q	flow quantity	cm^3/sec
r	radius	various
R	overconsolidation ratio, or Hveem's resistance	–, –
s	degree of saturation	–
S	strength	psi
SG	specific gravity[1]	–
t	time	seconds
v	velocity	cm/sec
V	volume	cm^3
w	water content	–
W	weight	grams
w_l	liquid limit	–
w_p	plastic limit	–

Symbols

ϵ	strain	–
ρ	mass density	g/cm^3 or lbm/ft^3
γ	specific weight	lbf/ft^3
σ	normal stress	psi
ϕ	angle of internal friction	degrees
τ	shear stress	psf
θ	angle of principal stress plane	

Subscripts

A	axial
B	borrow
c	compressive
d	dry
eq	equilibrium
f	final
F	fill
g	air
i	ith component, or initial
n	unconfined
o	consolidated
R	radial
s	soil
sat	saturated
t	total
u	ultimate
uc	ultimate compressive
us	ultimate shear
v	void or volumetric
w	water
z	zero air voids

1 CONVERSIONS

multiply	by	to obtain
centimeters	0.3937	inches
centimeters squared	0.155	square inches
cubic yards	27	cubic feet
cubic yards	202.2	gallons
dynes	EE–5	newtons
cubic feet	7.48	gallons
cubic feet	0.03704	cubic yards

[1] As a peculiarity of soils engineering, the specific gravity is usually given the symbol *G*, as opposed to this book which uses *SG* throughout.