WASTEWATER OPERATOR EXAM RESOURCE BOOKLET

ENVIRONMENTAL TRAINING CENTER

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Summary of Formulas

Length

Length of Clarifier Weir **or** Circumference of a Circle	(3.14) x (Diameter)

Area

Answer in square units (i.e. square feet or square inches)

Rectangle	(Length) x (Width)
Triangle	$\frac{\text{(Base) x (Height)}}{2}$
Circle	(0.785) x (Diameter^2)
Cylinder (Wall)	(3.14) x (Diameter) x (Height)
Cylinder (Total Area)	2 (3.14) (Radius)^2 + 3.14 (Diameter) (Height)
Sphere	3.14 (Diameter)^2

Volume

Answer in cubic units (i.e. cubic feet or cubic inches)

Rectangle (Cube)	(Length) x (Width) x (Height)
Cylinder	(0.785) x (Diameter^2) x (Height)
Sphere	0.524 (Diameter)^3

Concentration (Universal Loading Equation)

Lbs/day = (mg/L) x (8.34) x (Flow, MGD)

Velocity

$$\text{Velocity, ft./sec.} = \frac{\text{Distance Traveled, ft.}}{\text{Time, sec.}} \quad \textbf{Or} \quad \frac{\text{Flow Rate, cu. ft./sec.}}{\text{Cross-Sectional Area, sq. ft.}}$$

Sedimentation Tanks and Clarifiers

Detention Time, hrs. = $\frac{\text{(Tank Volume, cu. ft.) x (7.5 gal/cu. ft.) x (24 hr./day)}}{\text{Flow, gpd}}$

Surface Loading Rate, gpd/sq. ft. = $\frac{\text{Flow, gpd}}{\text{Area, sq. ft.}}$

Weir Overflow Rate, gpd/ft. = $\frac{\text{Flow, gpd}}{\text{Length of Weir, ft.}}$

Trickling Filters

Hydraulic Loading, gpd/sq. ft. = $\frac{\text{Flow, gpd}}{\text{Surface Area, sq. ft.}}$

Organic Loading, $\frac{\text{1lbs. BOD/day}}{\text{1,000 cu. ft.}} = \frac{\text{BOD Applied, lbs./day}}{\text{Volume of Media, cu. ft.} \div 1{,}000}$

Activated Sludge

Solids in Aerator, lbs. = (MLSS, mg/L) x (Tank Vol., MG) x (8.34 lbs./gal)

Aerator Loading, lbs. BOD/day = (Primary Clar. Effl. BOD, mg/L) x (Flow, MGD) x (8.34 lbs./gal)

Sludge Volume Index (SVI) = $\frac{\text{(30-Minute Setteable Solids, \%) x (10,000)}}{\text{MLSS, mg/L}}$ **Or**

$\frac{\text{30 Minute Setteable Solids, grams}}{\text{100 ml}}$

Sludge Density Index (SDI) = $\frac{100}{\text{SVI}}$

Sludge Age, days = $\frac{\text{(MLSS, mg/L) x (Tank Vol., MG) x (8.34 lbs./gal)}}{\text{(SS in Primary Effl, mg/L) x (Flow, MGD) x (8.34 lbs./gal)}}$

OR $\frac{\text{Mixed Liquor Solids, lbs., **OR** Solids in Aerator, lbs.}}{\text{Primary Effluent Solids, lbs./day}}$

Waste Sludge Pumping Rate MGD = $\frac{\text{Solids to be Wasted (lbs./day)}}{\text{(Return Sludge Suspended Solids, mg/L) x (8.34)}}$

Activated Sludge (cont.)

Mean Cell Residence Time (MCRT) = $\dfrac{\text{(MLSS, mg/L) (Aeration Tank Volume, MG) (8.34 lbs./gal)}}{\text{(WAS, mg/L) (WAS Rate, MGD) (8.34 lbs./gal) + (Effluent TSS, mg/L) (Effluent Rate, MGD) (8.34 lbs./gal)}}$

Sludge Digestion

CO_2 in Digester Gas % = $\dfrac{\text{(Total Volume, mL – Gas Remaining, mL)}}{\text{Total Volume, mL}}$ x 100%

Reduction of Volatile Matter, % = $\dfrac{\text{(In – Out) x (100%)}}{\text{In – (In x Out)}}$ *All information (In and Out) must be in decimal form*

Digester Loading, lb VM/day/cu. ft. = $\dfrac{\text{Volatile Matter Added, lbs./day}}{\text{Digester Volume, cu. ft.}}$

Ponds

Pond Area, Acres = $\dfrac{\text{(Avg. Length, ft) x (Avg. Width, ft)}}{43{,}560\ \text{ft}^2\ /\ \text{acre}}$

Pond Volume, ac-ft = (Area, Acres) (Depth, ft)

Flow Rate, ac-ft/day = $\dfrac{\text{Flow (total gallons/day)}}{\text{325,829 (gallons/ac-ft)}}$

Detention Time, days = $\dfrac{\text{Pond Volume, ac-ft}}{\text{Flow Rate, ac-ft/day}}$

Hydraulic Loading, in/day = $\dfrac{\text{Depth of Pond, inches}}{\text{Detention Time, days}}$

Organic Loading, lbs. BOD/day/ac = $\dfrac{\text{(BOD, mg/L) x (Flow, MGD) x (8.34 lbs./gal)}}{\text{Area, acre}}$

Chlorination

Chlorine Demand, mg/L = (Chlorine Dose, mg/L) – (Chlorine Residual, mg/L)

Chlorine Feed Rate, lbs/day = (Dose, mg/L) (Flow, MGD) (8.34 lb/gal)

Chlorination (cont.)

Chlorine Substitute, lbs./day = $\frac{\text{Chlorine Feed Rate (lbs./day)}}{\text{\% Available Chlorine of Substitute}}$

Laboratory Results

DO Saturation, % = $\frac{\text{DO of Sample, mg/L x 100\%}}{\text{DO at 100\% Saturation mg/L}}$

Manual Composite, mL = Hourly Flow (MG) x 100

Weight of Volatile Solids = (Weight of Dish + Dry Solids, gms) – (Weight of Dish + Ash)

Volatile Solids % = $\frac{\text{Weight of Volatile Solids, gms}}{\text{Weight of Total Solids, gms}}$ (100)

Total Suspended Solids, mg/L = $\frac{\text{Weight of Solids, mg x 1,000 ml/L}}{\text{Sample Volume, mL}}$

Fixed Suspended Solids, mg/L = $\frac{\text{Weight of Fixed Solids, mg x 1,000 ml/L}}{\text{Sample Volume, mL}}$

% Fixed Suspended Solids = $\frac{\text{Weight of Fixed Solids, mg}}{\text{Weight Total, mg}}$ (100)

Efficiency of Plant or Treatment Process

Efficiency, % = $\left(\frac{\text{In – Out}}{\text{In}} \right)$ (100)

Pumps

Water, HP = $\frac{\text{(Flow, gpm) x (H. ft.)}}{3960}$

Brake, HP = $\frac{\text{(Flow, gpm) (H, ft.)}}{(3960)\ (E_p)}$

Motor, HP = $\frac{\text{(Flow, gpm) (H, ft.)}}{(3960)\ (E_p)\ (E_m)}$

Work (ft-lb) = (weight, lbs.) (height, ft.)

Pumps (cont.)

Power (ft-lb)/(sec) $= \frac{\text{Work (ft-lb)}}{\text{Time (sec)}}$

Note: 3960 Constant $= \frac{\text{1 HP or 33,000 ft lbs./min.}}{\text{8.34 lbs./gal.}}$

Land Treatment Systems

Hydraulic Loading Rate, ins/day $= \frac{\text{Flow, gpd}}{\text{(27,154 gal/acre-in) (acres used)}}$

Note: 27,154 gallons = 1 inch of water over 1 acre – 1 acre-inch

Nutrient Loading Rate, lbs./day = (Flow, MGD) (Nutrient Concentration, mg/L) (8.34 lbs./gal.)

Loading, lbs./month = (Quantity, lbs./day) (Days sprayed)

Loading, lbs./acre $= \frac{\text{Lbs./month}}{\text{Acres Used}}$

Average Daily Flow, MGD $= \frac{\text{Total Monthly Flow, MG}}{\text{Days Sprayed}}$

Weight of Volatile Solids = (Weight of Dish + Dry Solids, gms) – (Weight of dish + Ash, gms)

Available Nitrogen Content of Sludge, lbs./ton = Available NH_4 – N, lbs./ton + Available NO_3 – N, lbs./ton + Available Organic N, lbs./ton

Agronomic Loading Rate, tons/acre $= \frac{\text{Amount of Sludge N Needed, lbs./acre}}{\text{Available N, lbs./ton}}$

Annual Pollutant Loading Rate, lbs./acre/year = (Sludge pollutant content, lbs./ton) (Agronomic loading rate, tons/acre/year)

Allowable accumulation period for a heavy metal, years $= \frac{\text{Cumulative limit, lbs./acre}}{\text{Annual Pollutant Loading Rate, lbs./acre/year}}$

Conversion Tables

The American and English weights and measures referred to in this book are alike except for the gallon. The United States gallon is employed. The United States billion, which equals 1,000 million, is also employed.

LENGTH				
MILES	**YARDS**	**FEET**	**INCHES**	**CENTIMETERS**
1	1,760	5,280	-	-
-	1	3	36	91.44
-	-	1	12	30.48
-	-	-	1	2.540

1 m = 100 cm = 3.281 ft = 39.37 in

AREA				
SQUARE MILES	**ACRES**	**SQUARE FEET**	**SQUARE INCHES**	**SQUARE CENTIMETERS**
1	640	-	-	-
-	1	43,560	-	-
-	-	1	144	929.0
-	-	-	1	6.452

1 sq m = 10.76 sq ft

VOLUME				
CUBIC FEET	**IMPERIAL GALLONS**	**U.S. GALLONS**	**CUBIC INCHES**	**LITERS**
1	6.23	7.481	1728	28.32
-	1	1.2	277.4	4.536
-	-	1	231	3.785
-	-	-	57.75	0.946
-	-	-	61.02	1

1 cu m = 35.31 cu ft = 264.2 gal

1 Imperial (UK) gal. weighs 10 lbs.
1 cu. ft. of water weighs 62.43 lbs.
1 cu. m. = 10^3 and weighs 1,000 kg

1 US gal. weighs 8.34 lbs.
1 cu. m. weighs 2,285 lbs.
325,829 gal. = 1 acre-ft.

VELOCITY				
MILES PER HOUR	**FEET PER SECOND**	**INCHES PER MINUTE**	**CENTIMETERS PER SECOND**	**KILOMETERS PER HOUR**
1	1.467	1056	-	1.609
-	1	720	30.48	-
-	-	1	0.423	-

TIME			
DAYS	**HOURS**	**MINUTES**	**SECONDS**
1	24	1,440	86,400
-	1	60	3,600
-	-	1	60

WEIGHT				
TONS	**POUNDS**	**GRAMS**	**GRAINS**	**METRIC TONS**
1	2,000	-	-	0.9078
-	1	454	7,000	-
-	-	1	15.43	-

1 long ton = 2,240 lbs.
1 ppm = 1 mg/L = 8.34 lbs per MG
Lbs/treatment unit = (mg/L) (volume, MG) (8.34 lbs./gal)

DISCHARGE		
CUBIT FEET PER SECOND	**MILLION GALLONS DAILY**	**GALLONS PER MINUTE**
1	0.6463	448.8
1.547	1	694.4

1 in per hour per acre = 1.008 cfs
1 cu m/sec = 22.83 MGD = 35.32 cfs

PRESSURE		
POUNDS PER SQUARE INCH	**FEET OF WATER**	**INCHES OF MERCURY**
1	2.307	2.036
0.4333	1	0.8825
0.4912	1.133	1

1 atm = 14.70 psia = 29.92 in. Hg = 33.93 ft water = 76.0 cm Hg

POWER			
KILOWATTS	**HORSEPOWER**	**FOOT-POUNDS PER SECOND**	**KILOGRAM-METERS PER SECOND**
1	1.341	737.6	102.0
0.7457	1	550	76.04

WORK AND ENERGY		
KILOWATT HOURS	**HORSEPOWER HOURS**	**BRITISH THERMAL UNITS**
1	1.341	3412
0.7457	1	2544

TEMPERATURE

$$\text{Degree Fahrenheit} = 32 + (1.8 \times {}^{o}\text{C})$$

$$\text{Degree Centigrade} = \frac{({}^{o}\text{F} - 32)}{1.8}$$

0	5	10	15	20	25	30	35	40	45	50	55	60	C
32	41	50	59	68	77	86	95	104	115	122	131	140	F

DENSITY OF WATER

1 gram/cm^3 = 62.43 lbs./cu. ft.
1 gal. = 8.34 lbs.

Tables in this section were taken from Water and Wastewater Engineering, Volume 1, Water Supply and Wastewater Removal, by G.M. Fair, J.C. Geyer, and D.A. Okun, John Wiley & Sons, Inc., New York, 1966. k Price $19.95. The tables are also found in Volume 2, Water Purification and Wastewater Treatment and Disposal, 1968. Price $22.00.

Abbreviations

BOD	biochemical oxygen demand
CBOD	carbonaceous biochemical oxygen demand
cfs	cubic feet per second
COD	chemical oxygen demand
DO	dissolved oxygen
ft	feet
g	grams
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
in	inches
kW	kilowatt
lbs	pounds
MCRT	mean cell residence time
mg	milligrams
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solid
OCR	oxygen consumption rate
ORP	oxygen reduction potential
OUR	oxygen uptake rate
PE	population equivalent
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
Q	flow
RAS	return activated sludge
RBC	rotating biological contactor
SDI	sludge density index
SS	suspended solids
SSV_{30}	settled sludge volume 30 minutes
SVI	sludge volume index
TOC	total organic carbon
TS	total solids
TSS	total suspended solids
TTHM	total trihalomethanes
VS	volatile solids
WAS	waste activated sludge

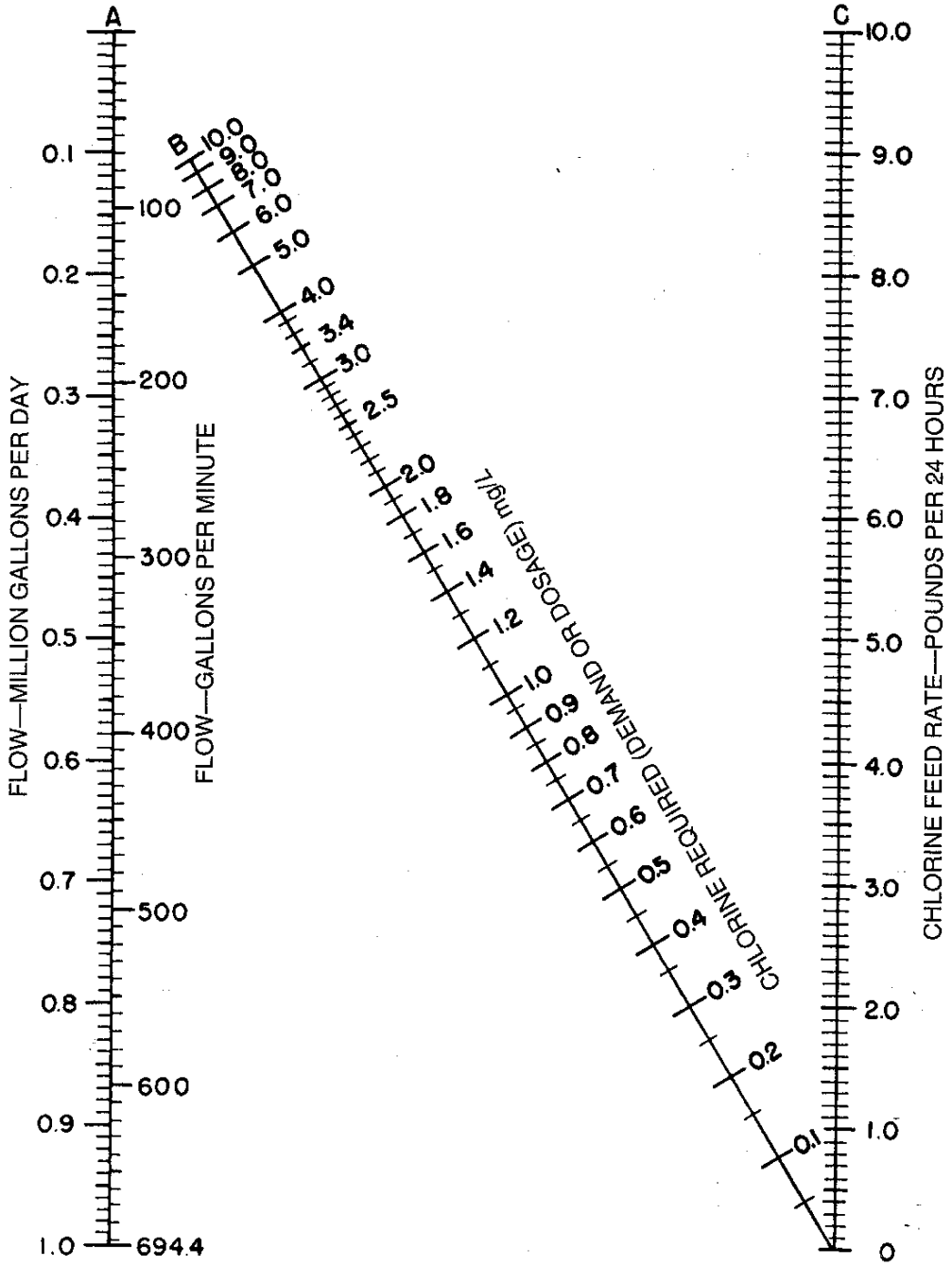

Fig. 10.4 Chlorination control nomogram

(Source: *WPCF MOP No. 11*, 1968)

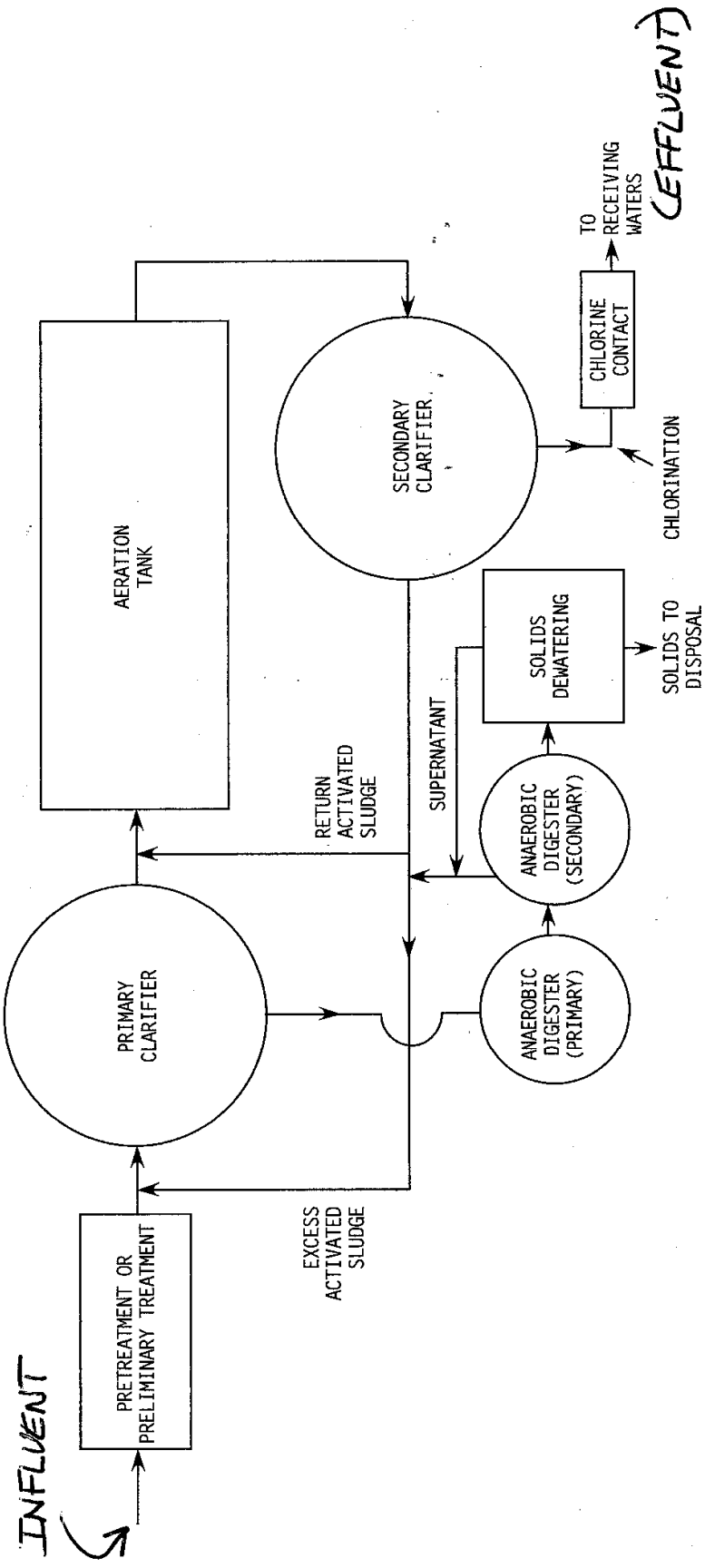

Fig. 8.4 Plan layout of a typical activated sludge plant

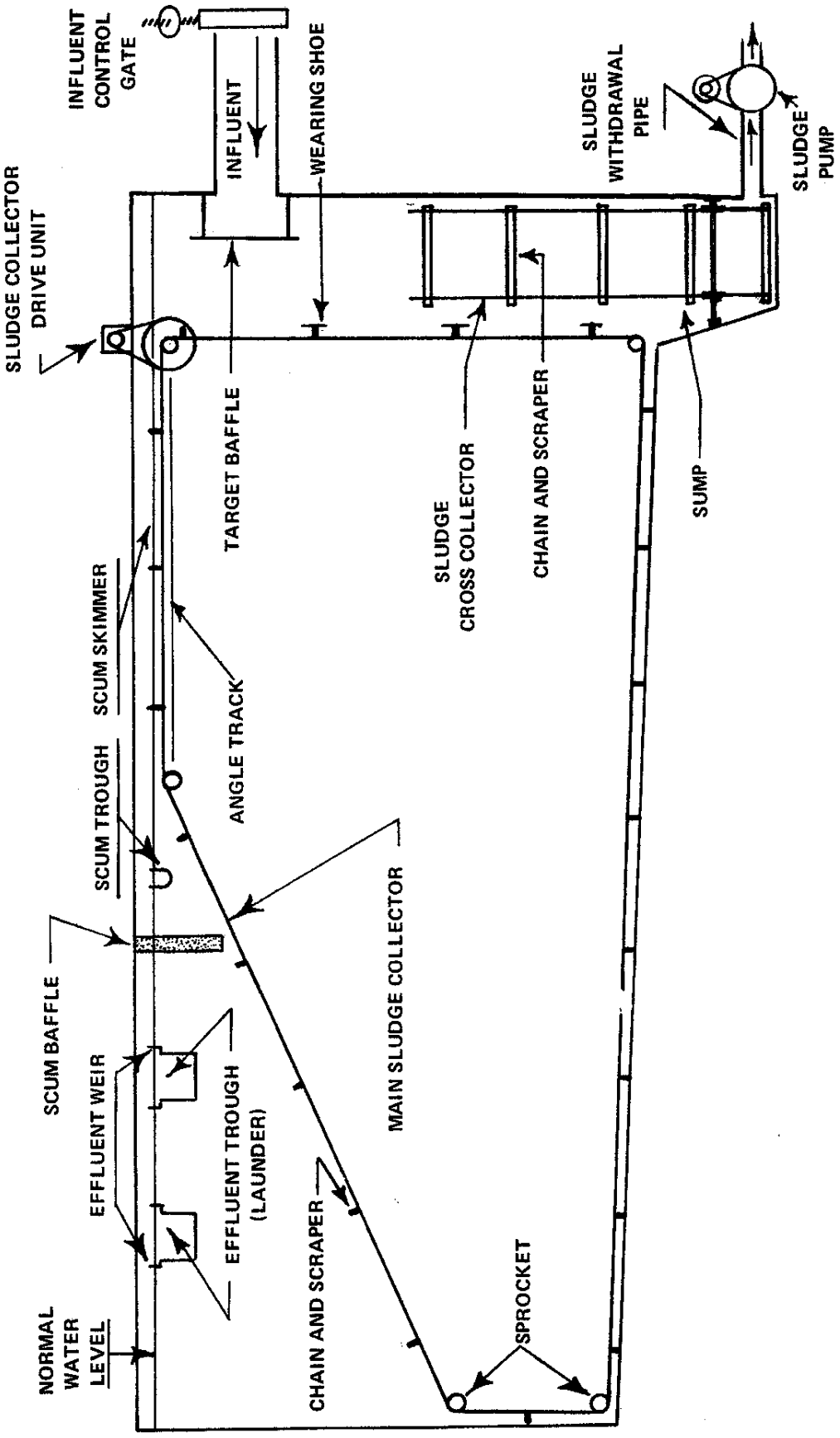

Fig. 5.3 Side-view section of a rectangular sedimentation basin

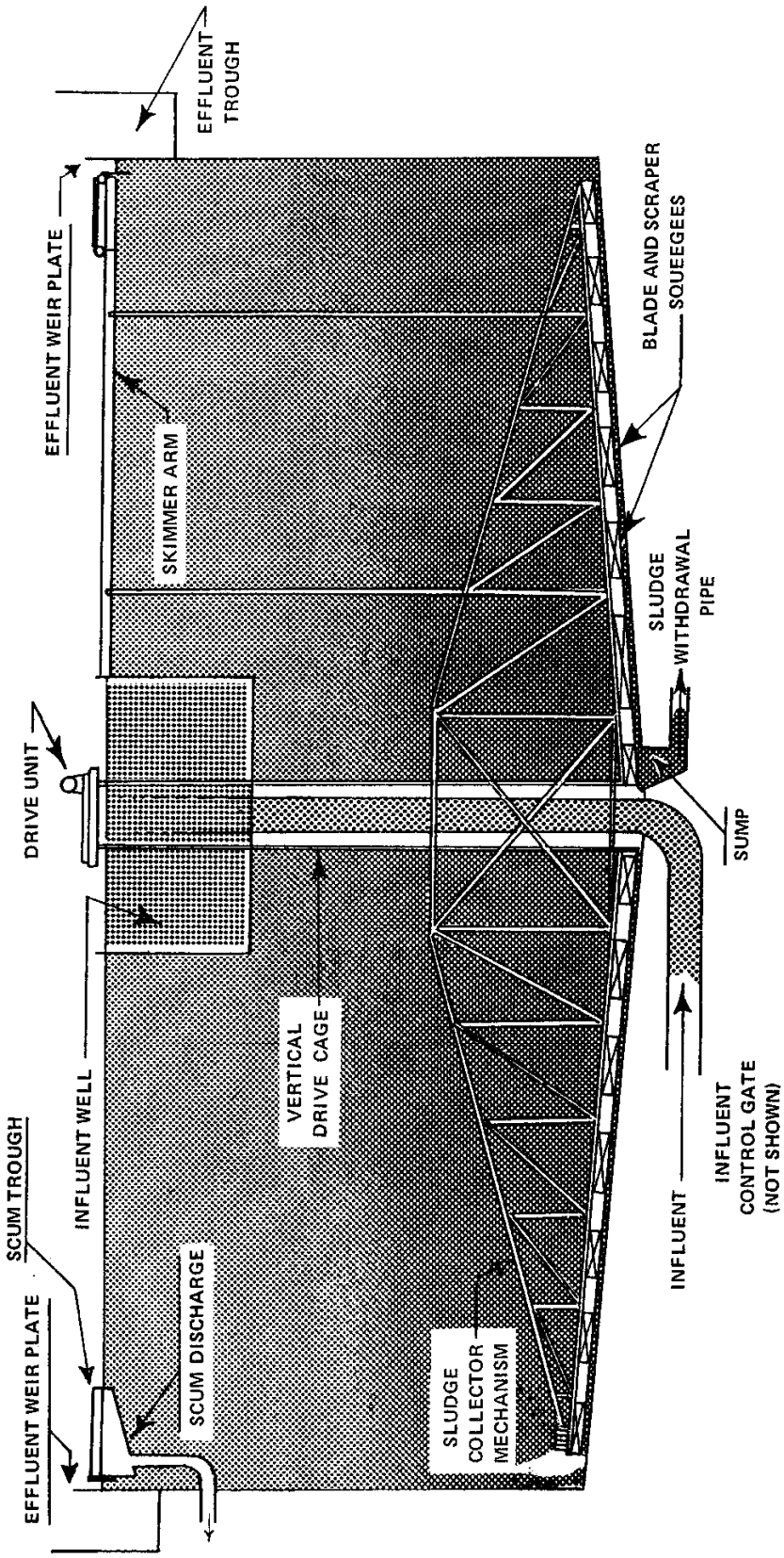

Fig. 5.4 Side-view section of a circular clarifier with blades and scraper squeegees