PRIMARY TREATMENT

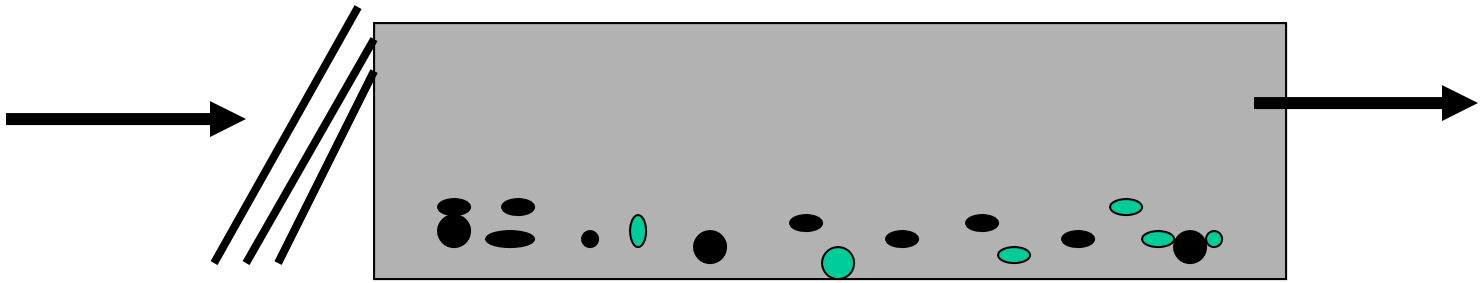
- REMOVES SETTLEABLE and FLOATABLE SOLIDS

- LARGELY A PHYSICAL PROCESS

A PHYSICAL PROCESS DEPENDS ON …

- PARTICLE SIZE, SHAPE
- PARTICLE WEIGHT (DENSITY)

REMEMBER…



HEAVY, INORGANIC MATERIAL REMOVED IN GRIT CHAMBER (BY REDUCING THE VELOCITY)

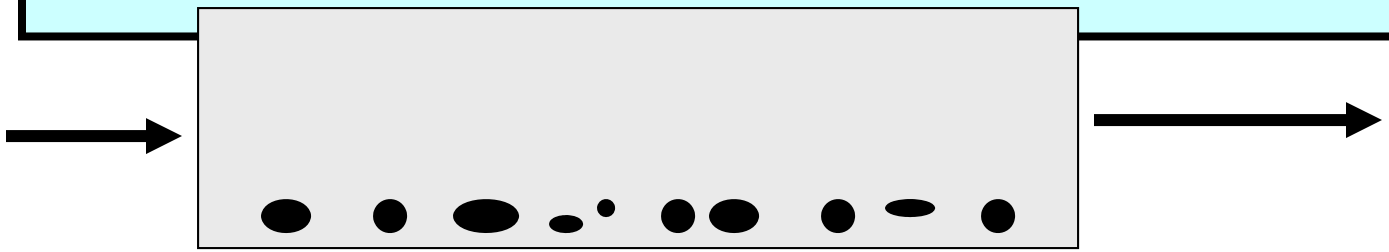
IF THE VELOCITY IS FURTHER REDUCED…

- ORGANIC SOLIDS WILL SETTLE OUT
- THE VELOCITY OF FLOW IN A SETTLING BASIN = 2 ft/min

RECALL…

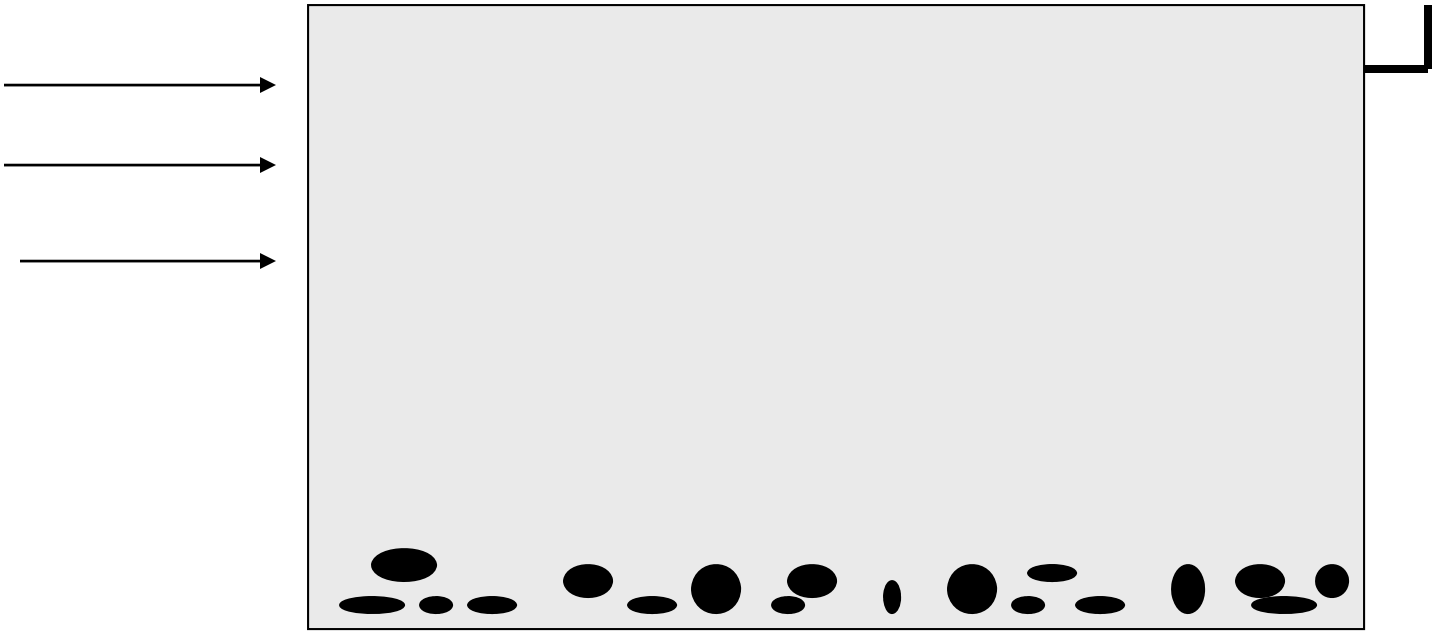
SEWER: 2 fps = 120 ft/min

(NO SETTLING)



GRIT CHAMBER: 1 fps = 60 ft/min

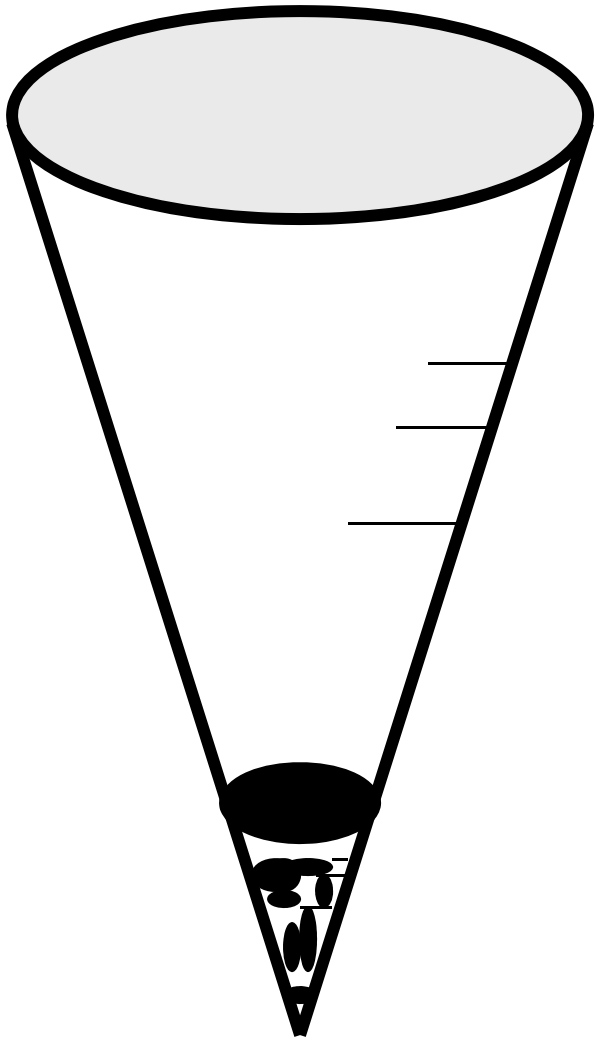
(HEAVY INORGANICS SETTLE OUT)



SETTLING BASIN

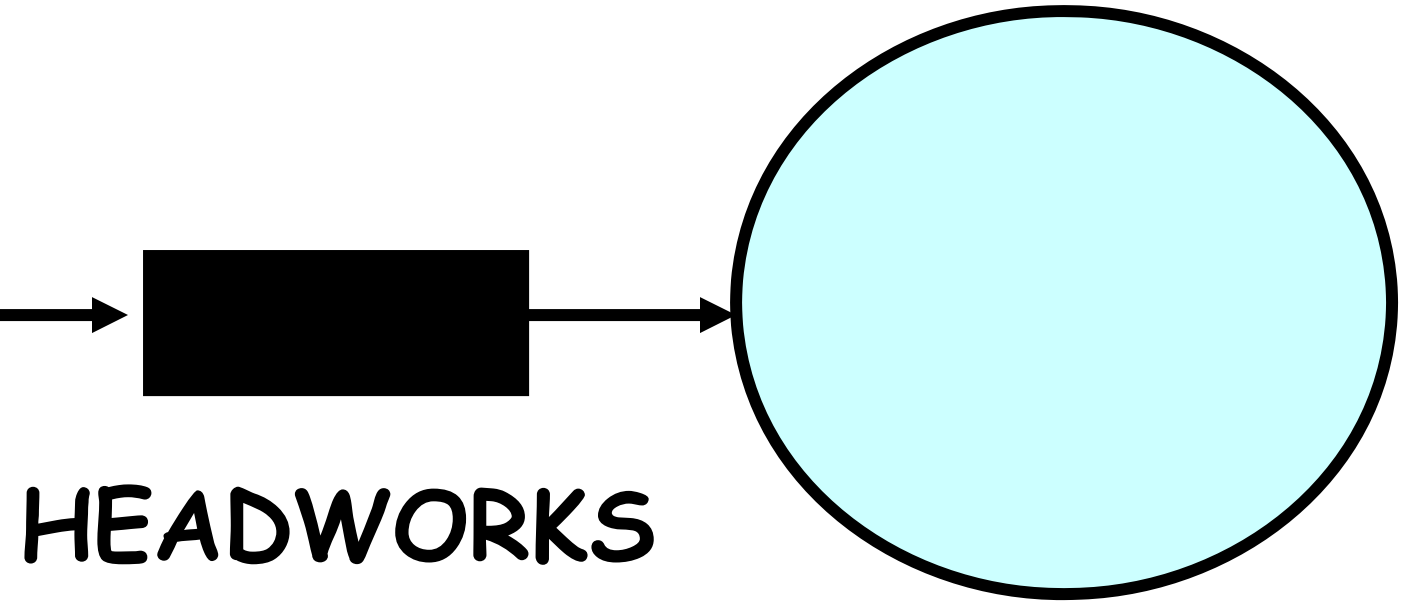
VELOCITY = 2 ft/min

(REMOVES SETTLEABLE SOLIDS)



RECALL THE IMHOFF CONE?

...TO MEASURE SETTLEABLE SOLIDS

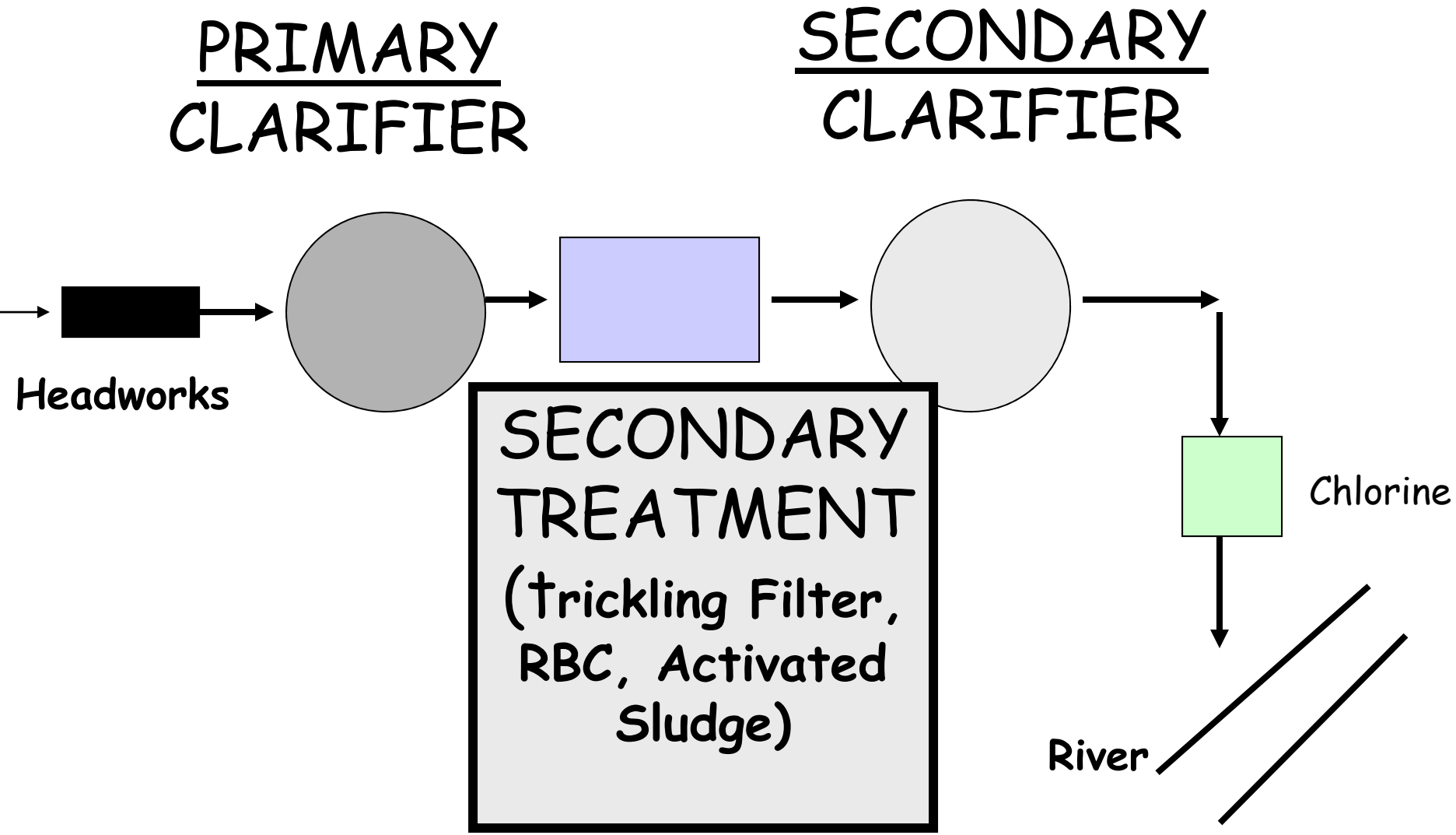


HEADWORKS

PRIMARY
CLARIFIER

ALSO CALLED "PRIMARY…

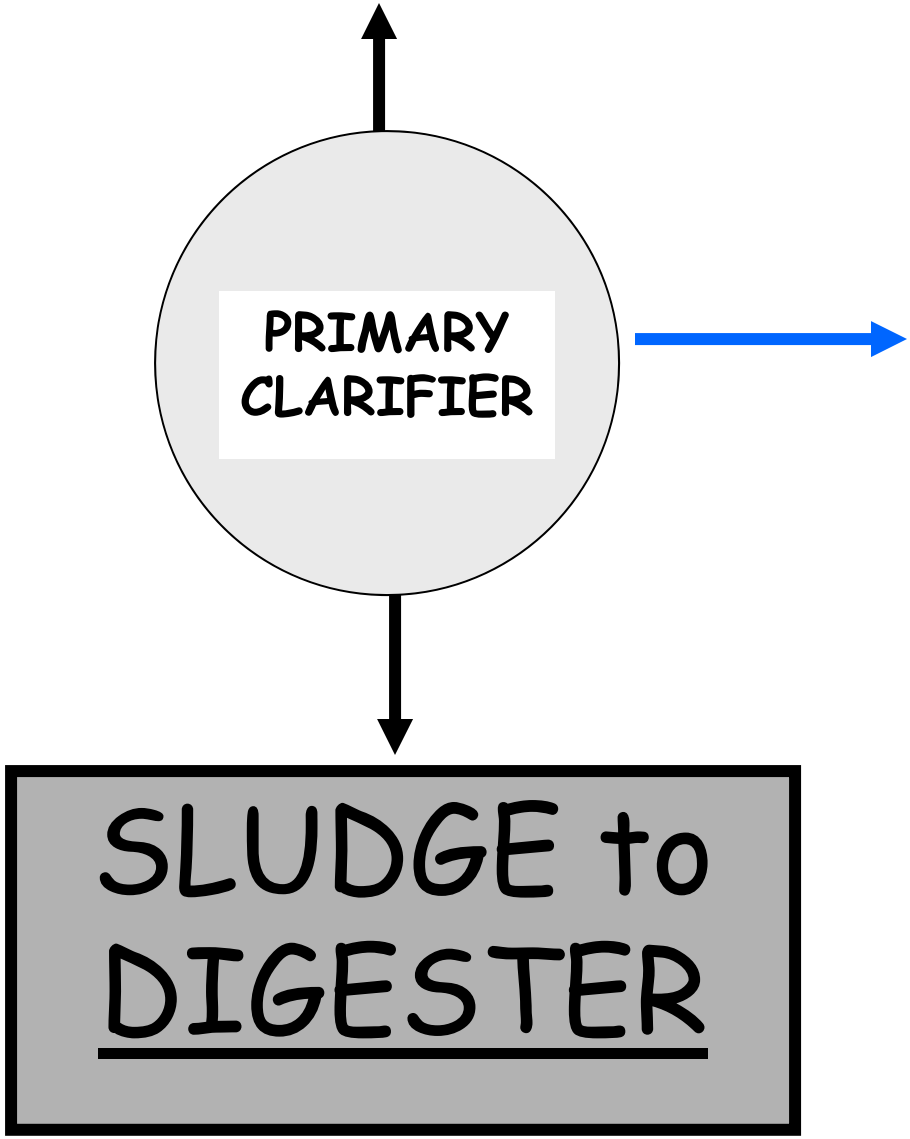
- SEDIMENTATION TANK or BASIN
- SETTLING TANK or BASIN


PRIMARY CLARIFIER
SECONDARY CLARIFIER
Headworks
SECONDARY TREATMENT
(trickling Filter, RBC, Activated Sludge)
Chlorine
River

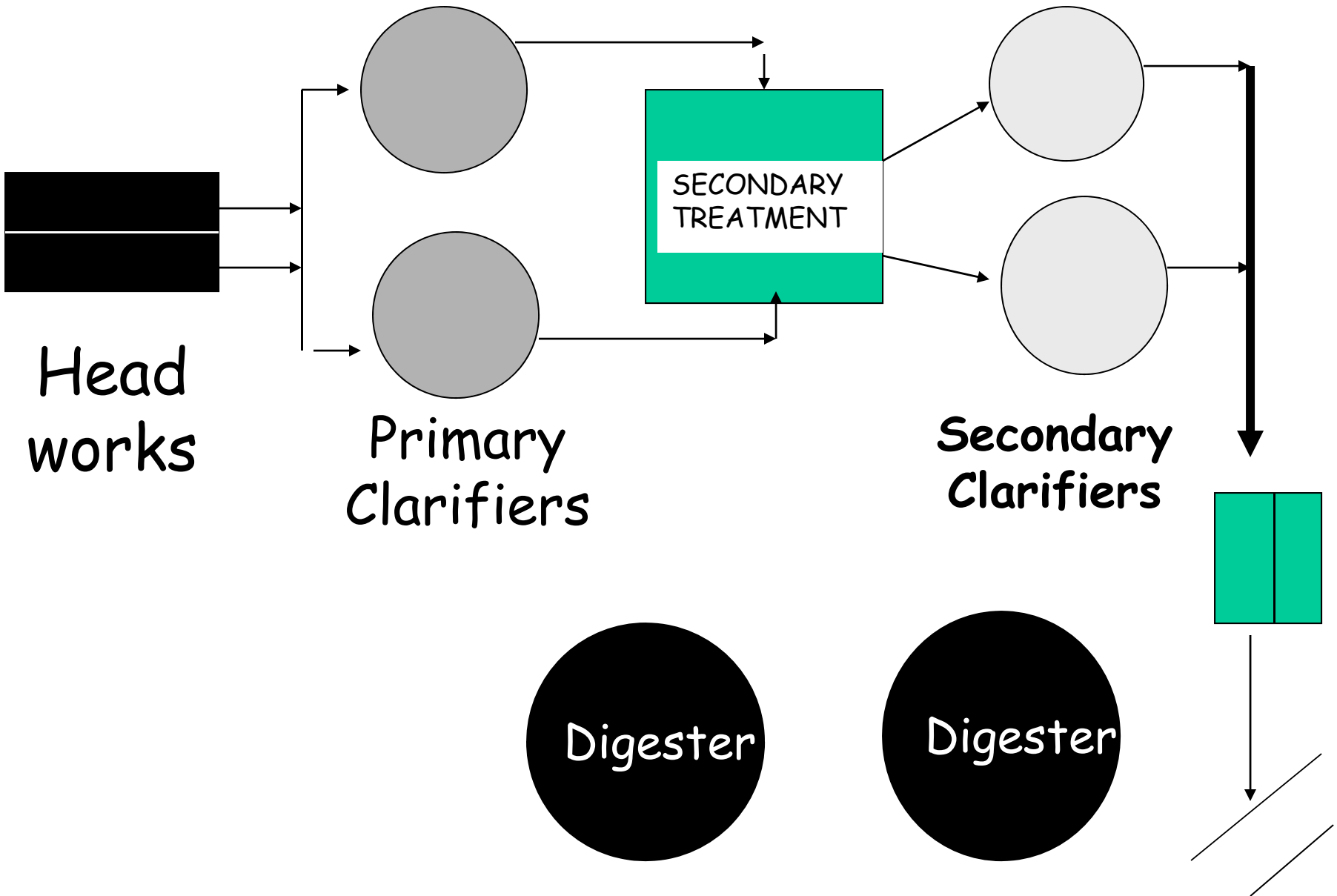
3 things come out of a primary clarifier…

- SETTLED EFFLUENT
- FLOATABLE "SCUM"
- SLUDGE

BURY THE SCUM



BACK-UP UNITS FOR FLEXIBILITY



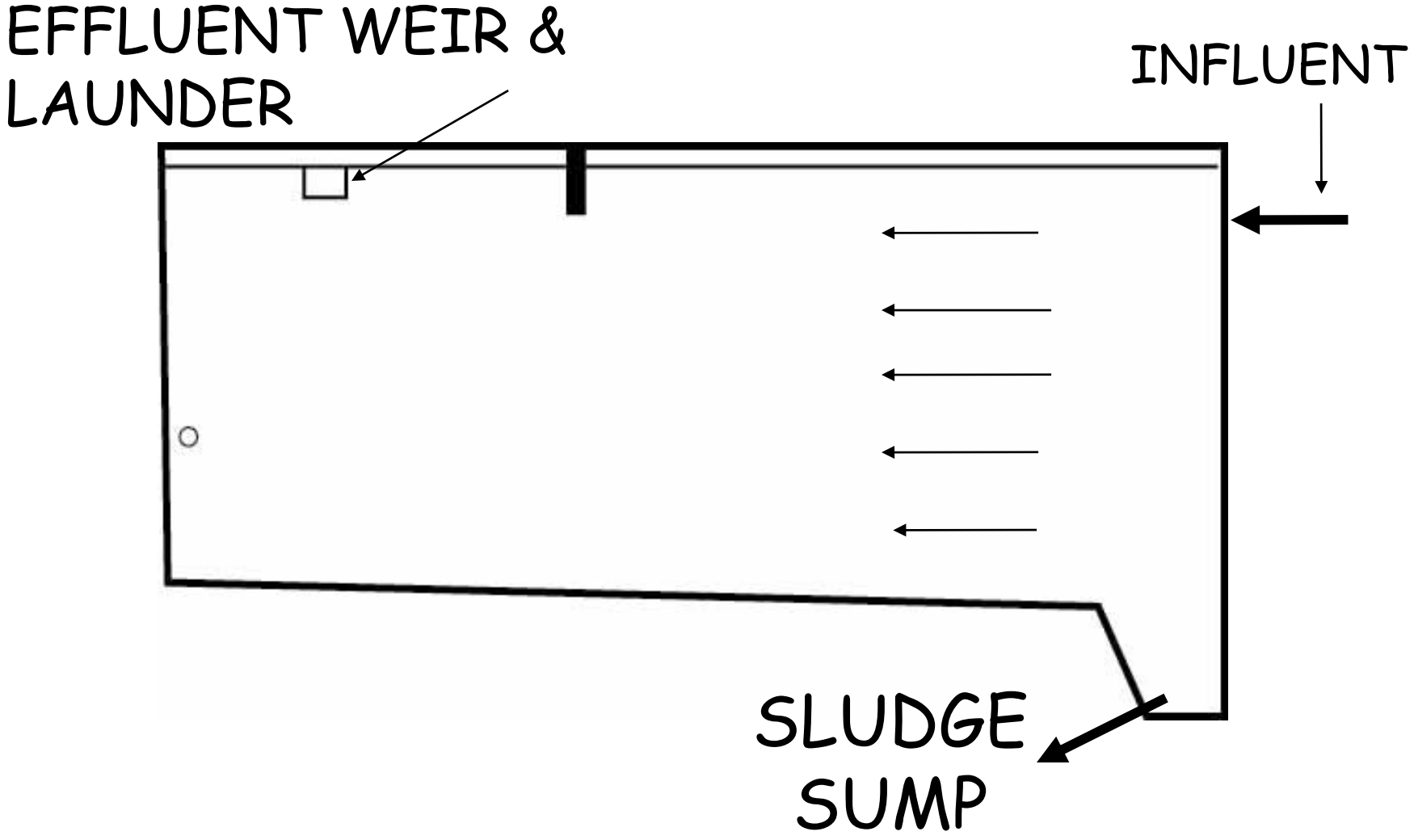
TYPES OF CLARIFIERS

- HORIZONTAL
- CIRCULAR

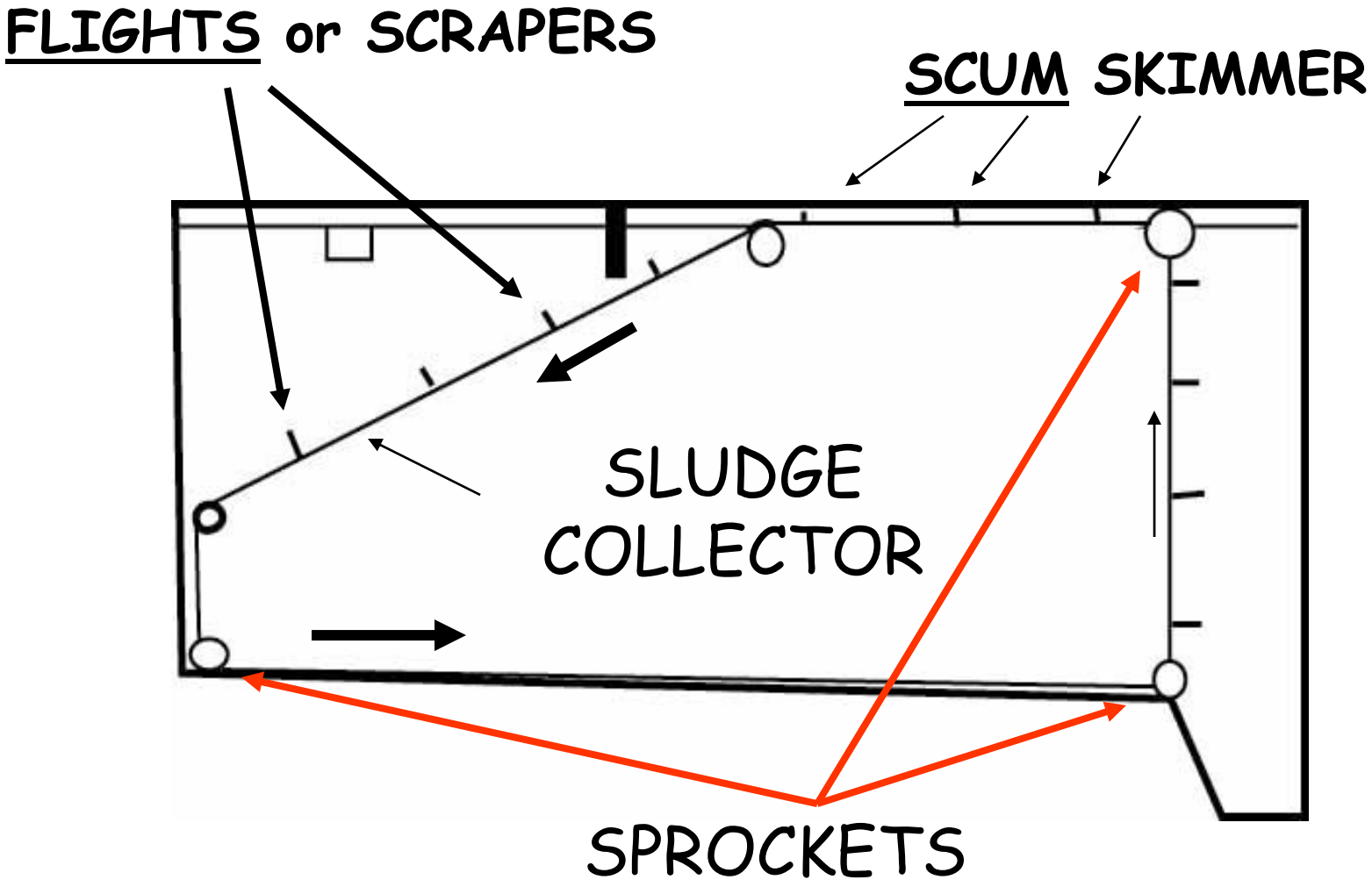
HORIZONTAL CLARIFIERS

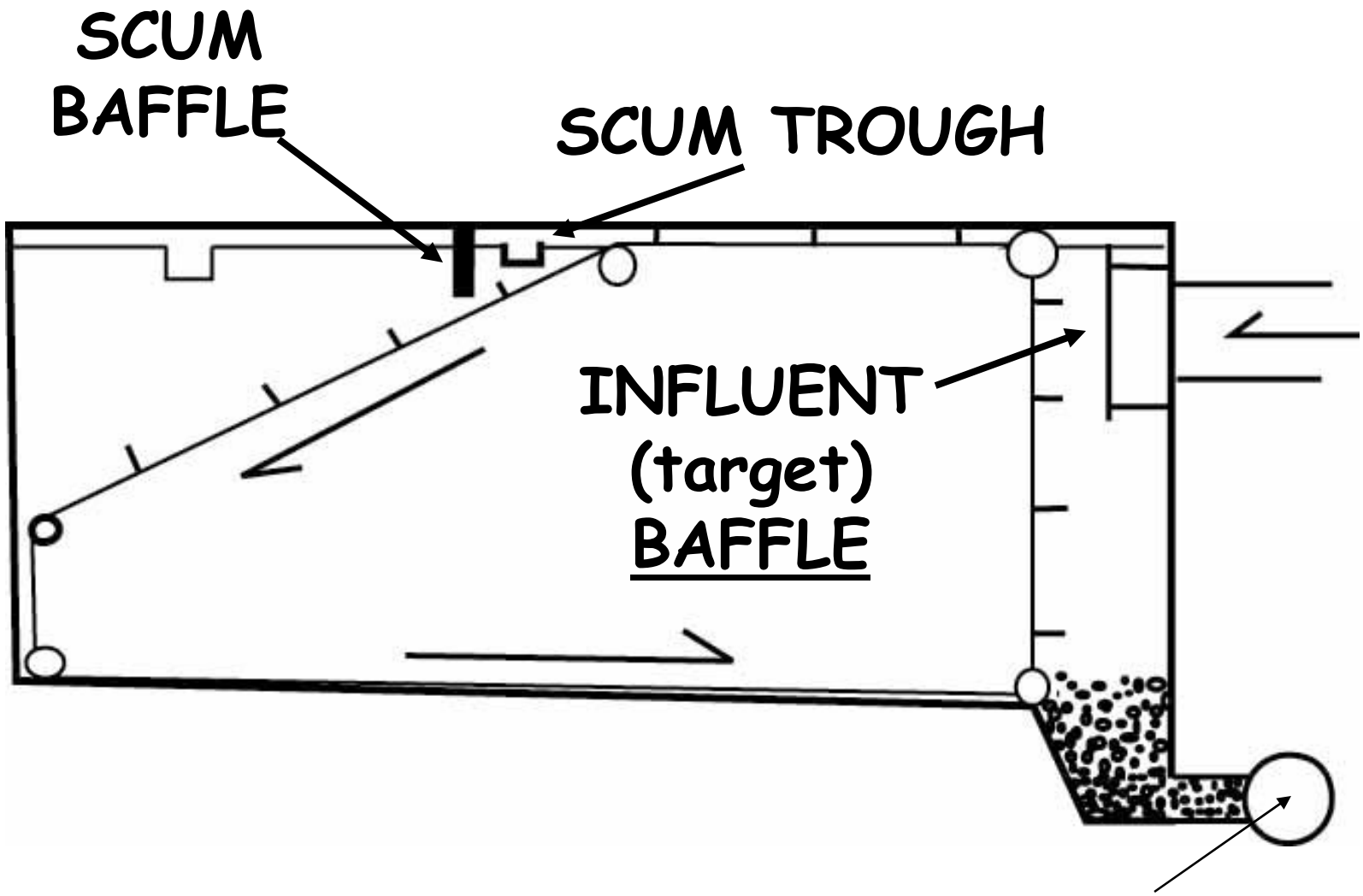
- GENERALLY THE OLDER UNITS
- BUILT WHERE SPACE IS LIMITED
- MAY BE 100 - 200 FEET LONG

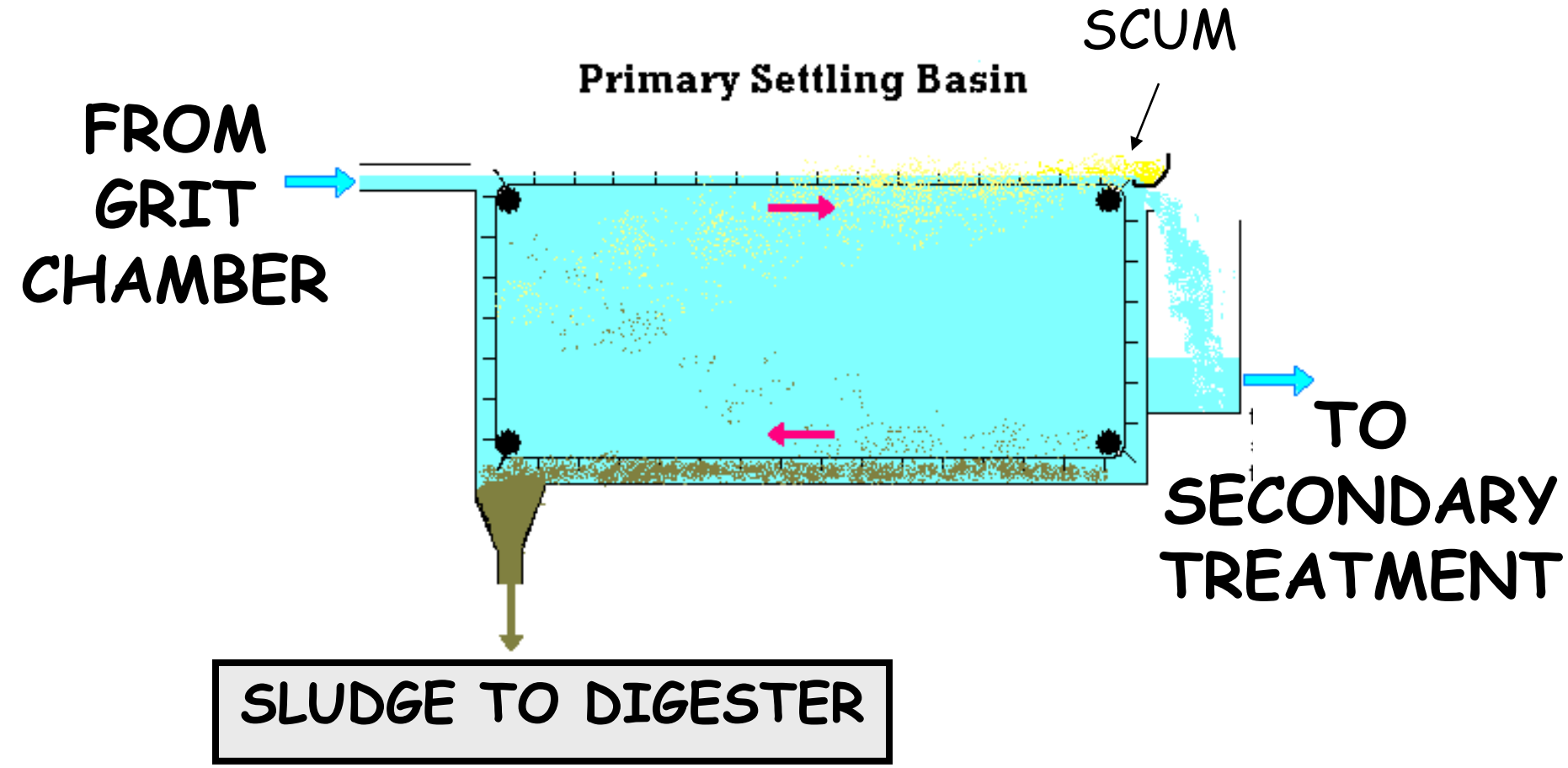
HORIZONTAL CLARIFIERS



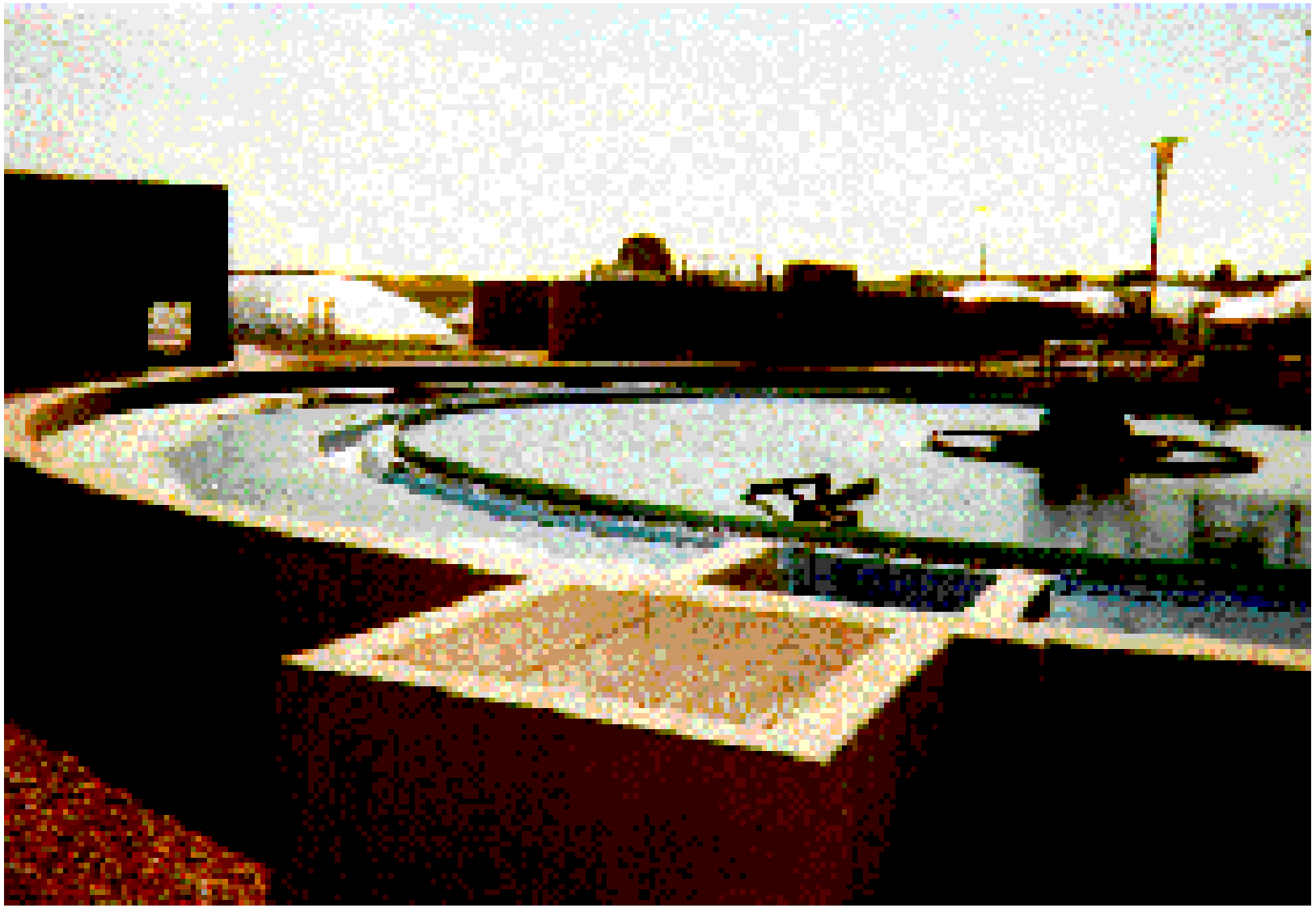
HORIZONTAL CLARIFIER



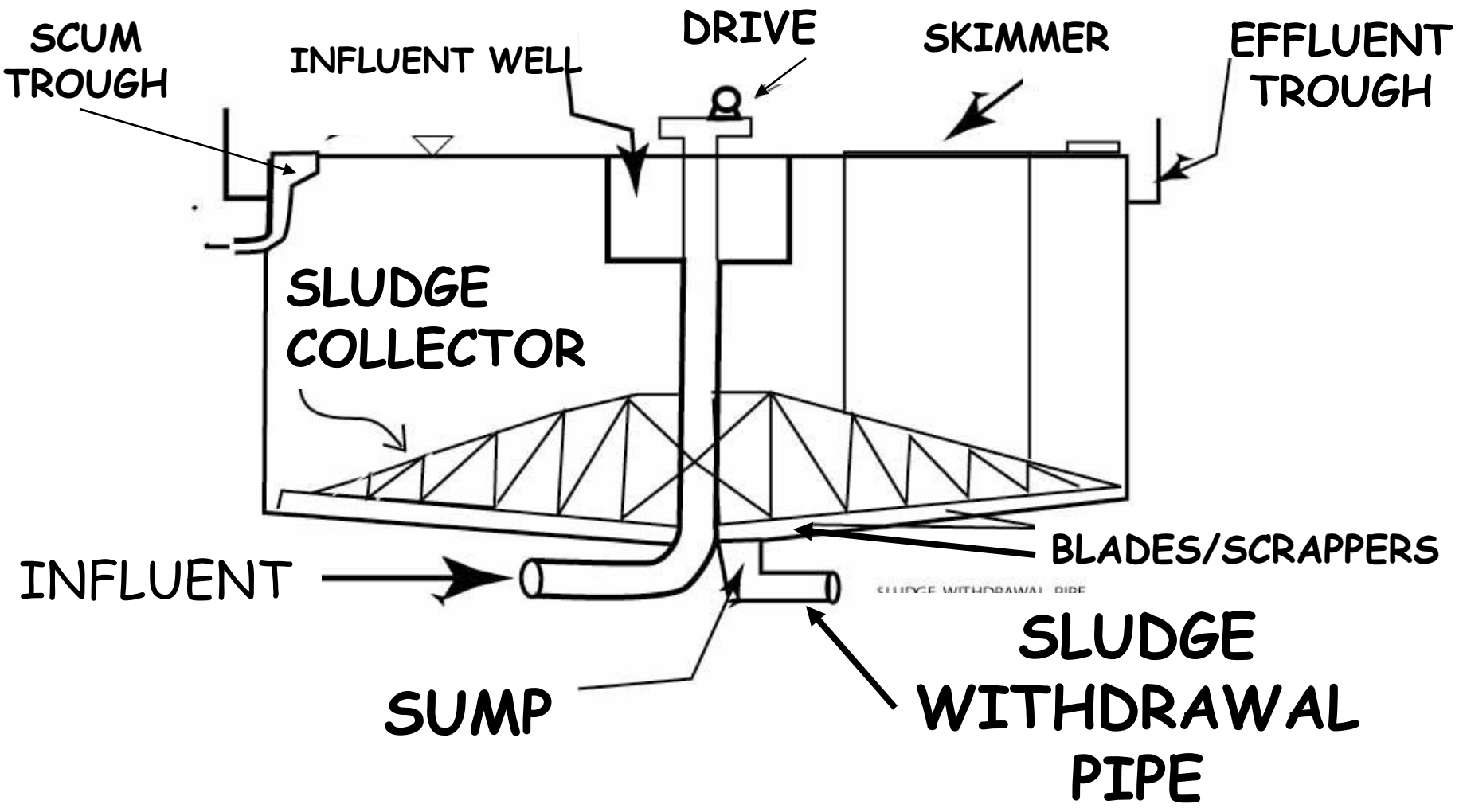

SCUM
BAFFLE
SCUM TROUGH
INFLUENT
(target)
BAFFLE
SLUDGE PUMP

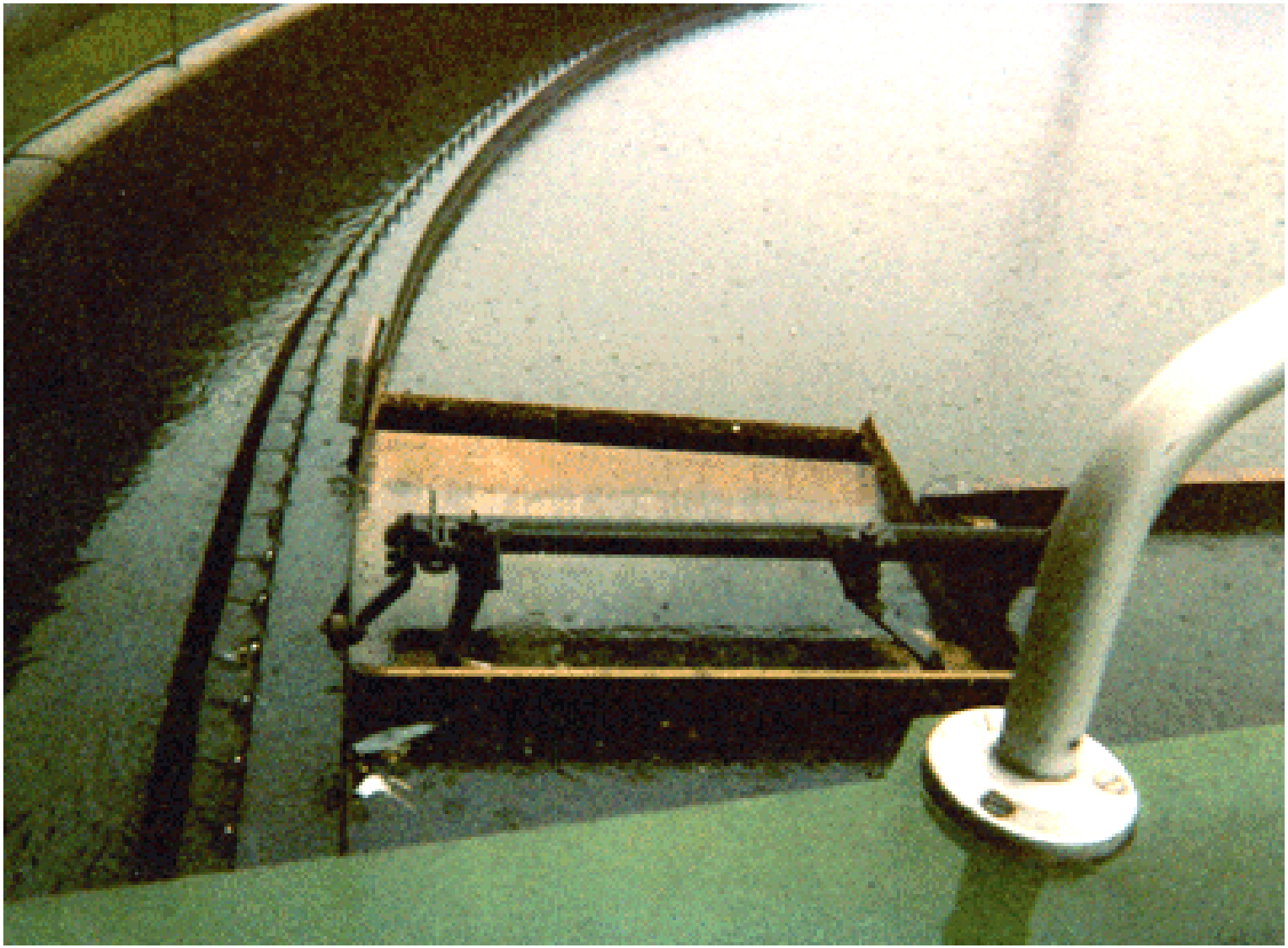

Primary Settling Basin
SCUM
FROM GRIT CHAMBER
TO SECONDARY TREATMENT
SLUDGE TO DIGESTER

CIRCULAR CLARIFIERS



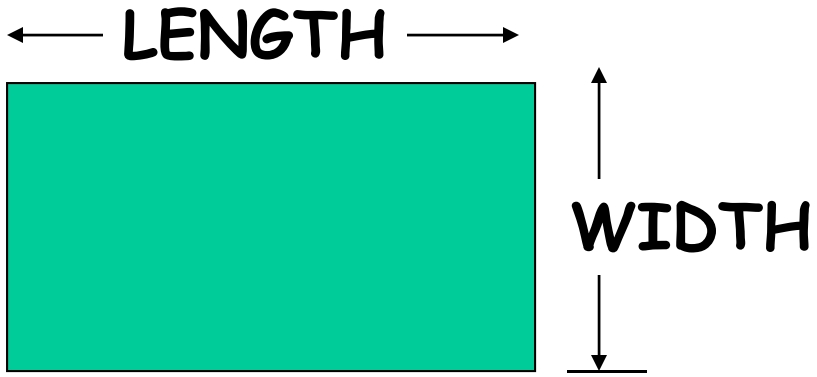
CIRCULAR CLARIFIERS





SCUM REMOVAL

REVIEW OF ARITHMETIC

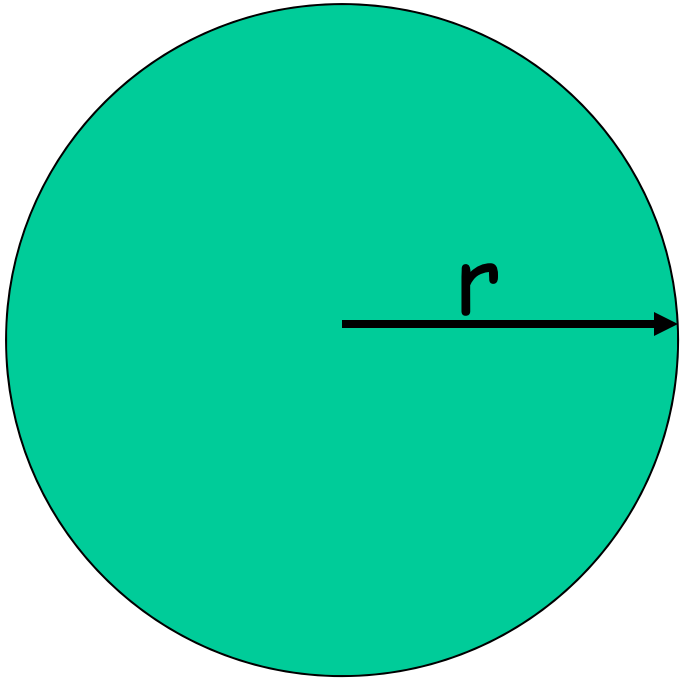


SURFACE AREA = LENGTH x WIDTH

EXAMPLE: WHAT IS THE SURFACE AREA of a 45 ft x 26 ft Tank?

Surface Area = 45' x 26' = 1170 sq-ft

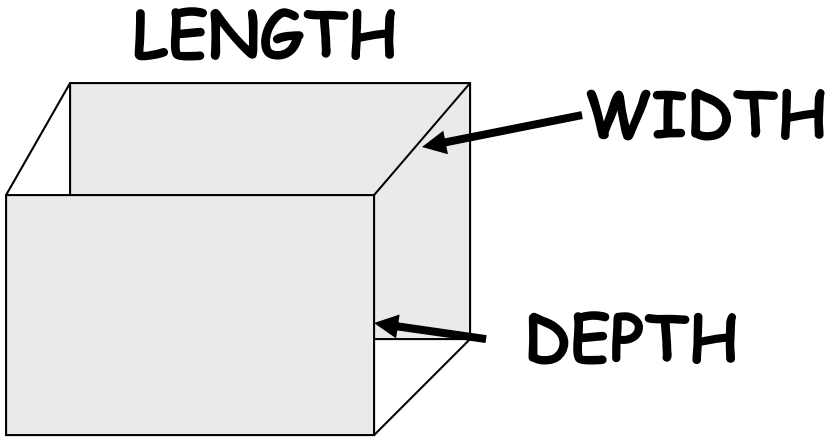
REVIEW OF ARITHMETIC



SURFACE AREA OF a CIRCLE = πr^2

Or, $0.7854 \times D^2$

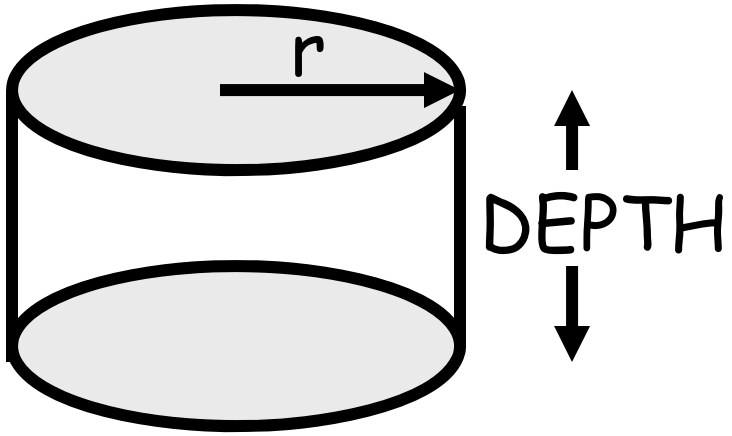
Example: What is the surface area of a circular tank that is 65' in diameter: SA = 0.7854 x 4225 = 3317 sq-ft



VOLUME = LENGTH x WIDTH x DEPTH

EXAMPLE: WHAT IS THE VOLUME OF A TANK THAT IS 45' LONG, 22' WIDE, AND 12' DEEP?

VOL = 45'x22'x 12' = 11,880 cu-ft



VOLUME = πr^2 x depth

Or; 0.7854 D^2 x depth

EXAMPLE: WHAT IS THE VOLUME of a 45' CIRCULAR TANK with a WATER DEPTH OF 12'?

VOLUME = 0.7854 x 45^2 x 12 =

<u>19,076</u> cu-ft

REMEMBER…

- 1 GALLON OF WATER WEIGHTS 8.34 POUNDS

- 1 CUBIC FOOT HOLDS

  7.48 GALLONS

MORE ARITHMETIC…

WHAT IS THE VOLUME in **GALLONS** of a TANK THAT HOLDS 19,076 cu-ft of WATER?

VOL = 19,076 cu-ft x 7.48 gal/cu-ft = **143,070 gallons**

FOLLOW-UP PROBLEM:

HOW MANY GALLONS DOES A 30' DIAMETER, 9' DEEP TANK HOLD?

VOL = 0.7854 D^2 x depth = 0.7854 x 900 x 9 = 6358 cu-ft

VOL, gal = 6358 cu-ft x 7.48 gal/cu-ft

= 47,685 gallons

CLARIFIER OPERATION

THREE IMPORTANT FACTORS:

1. DETENTION TIME

The time it takes for water to flow through the tank

DT = TANK VOL/ FLOW

EXAMPLE: VOLUME = 65,000 gal; FLOW = 550 gal/min then; DT=65,000/550 =118 min (1.9 hr)

2. SURFACE LOADING

SURFACE LOADING = FLOW, gal/day DIVIDED BY THE SURFACE AREA, sq ft

EXAMPLE: Flow = 790,000 gal/day; 20'x60' clarifier; surface area of clarifier =1200 sq ft; SURFACE LOADING=790,000/1200 = 658 gal/sq-ft

3. WEIR OVERFLOW RATE

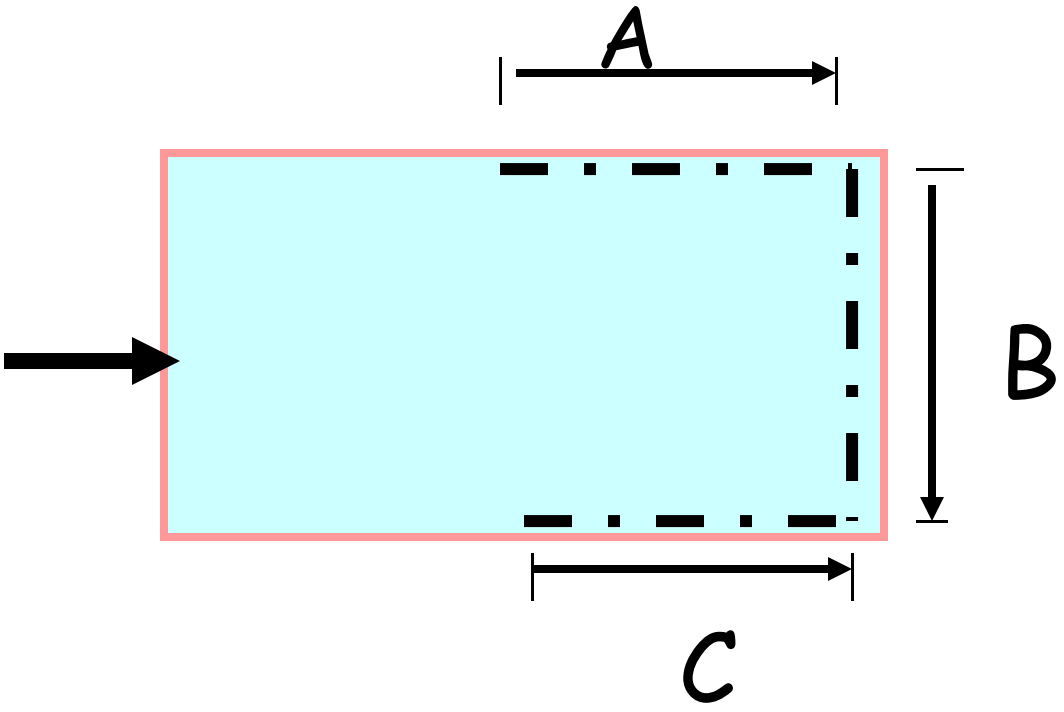
WOR = **FLOW**, gal/day/ **weir length**, ft

EXAMPLE: WHAT IS THE WEIR OVERFLOW RATE IN A TANK HAVING **80' OF WEIR LENGTH** THAT **RECEIVES 790,000 GPD?**

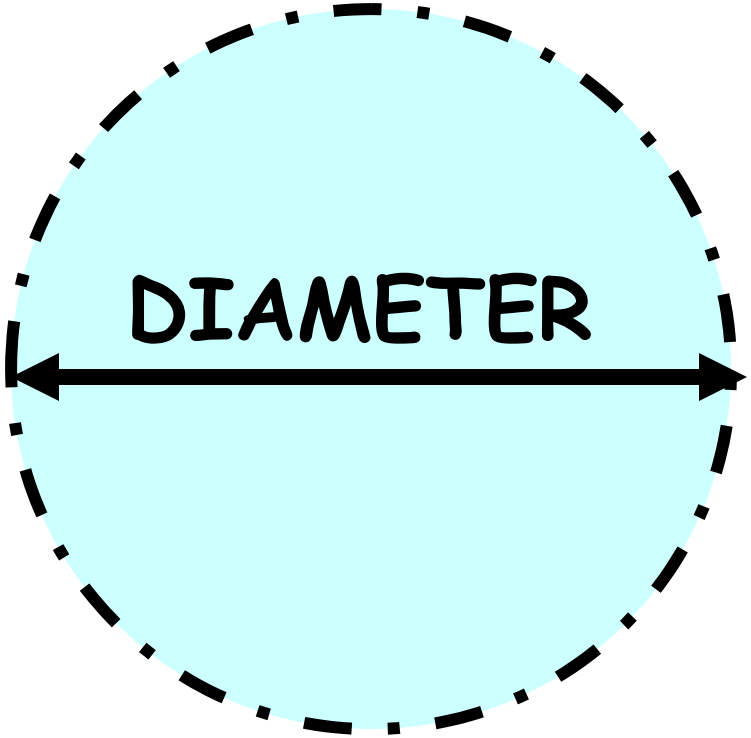
WOR = 790,000 gpd/80 ft = 9875 gpd/ft

EFFLUENT WEIR

WEIR LENGTHS



Weir Length = A + B + C



WEIR LENGTH on a CIRCULAR BASIN

$$= \underline{\pi D}$$

CLARIFIER OPERATING RANGES

	PRIMARY	SECONDARY
DETENTION TIME, hr	2-3	2-3
Weir overflow rate, gpd/ft	10,000-20,000	5,000-15,000
Surface loading, gpd/ft^2	300-1,200	300-1,200

DETERMINING EFFICIENCIES

$$\% \text{ EFFICIENCY} = \frac{(\text{IN} - \text{OUT})}{\text{IN}} \times 100\%$$

EXAMPLE: Given an **influent** conc. of suspended solids = **220 mg/L**, and an **effluent** conc. of suspended solids = **8 mg/L**, what is the efficiency of the clarifier?

$$\% \text{ Efficiency} = \frac{(220 - 8)}{220} \times 100\%$$

$$= 96\%$$

TYPICAL CLARIFIER EFFICIENCIES

PARAMETER	% EFF	Avg
Settleable Solids	90-99	97
Suspended Solids	40-60	50
Total Solids	10-15	10
BOD	20-50	35
Bacteria	25-75	50
pH	no change	

CLARIFIER EFFICIENCY IS AFFECTED BY…

- TYPES OF SOLIDS (industrial? Sewage?)
- **Wastewater freshness (fresh settles better)**
- **Hydraulic loading (actual flow vs design flow)**

CLARIFIER EFFICIENCY, con't

- Sludge withdrawal rate (may be leaving it in tank too long)

- Return solids may be difficult to settle

INDICATORS OF POOR SETTLING

- FLOATING SLUDGE (aka SLUDGE BULKING)
- LOTS OF SCUM
- LOSS OF SOLIDS OVER WEIRS

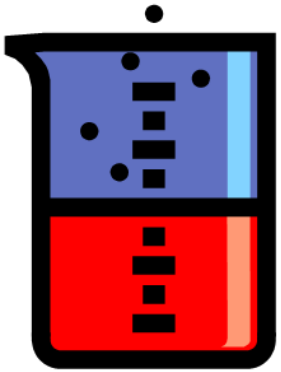
INDICATORS OF POOR SETTLING

- LOW pH + ODORS

- DEEP SLUDGE BLANKET BUT THIN SLUDGE

SETTLING EFFICIENCY

- BASED ON COMPOSITE SAMPLE



COLLECT A SAMPLE EVERY 2-4 HRS FOR 24 HRS

EFFICIENCY = (IN-OUT)/IN x 100%

SLUDGE "BULKING"

"LIGHT, NON-SETTLING SLUDGE THAT OCCURS IN SECONDARY CLARIFIER BECAUSE OF…

GASIFICATION; INSUFFICIENT SLUDGE REMOVAL; DAMAGED OR TURNED-OFF SLUDGE COLLECTOR; SLUDGE BLANKET TOO DEEP; TOXIC SPILL, (see text)

SLUDGE REMOVAL

- FREQUENCY: 0.5 -24 hrs

- GOOD PRIMARY SLUDGE CONTAINS 4-8% TOTAL SOLIDS

"DRAWING" SLUDGE

- SHOULD BE SLOW TO MINIMIZE WATER CONTENT
- LISTEN TO THE PUMP
- OBSERVE SLUDGE DENSITY GAGE READINGS, SIGHT GLASSES,...

KNOW AND RESPECT THE COMMON GASSES:

$\underline{H_2S}$, Cl_2, CO_2, $\underline{CH_4}$

READ SAFETY SECTION 5.5 in your text

LOOK, LISTEN, SMELL, & THINK

PRIMARY FUNCTION

GRIT CHAMBER: TO REMOVE HEAVY INORGANICS

CLARIFIER: TO REMOVE ORGANIC SETTLEABLE & FLOATABLE SOLIDS

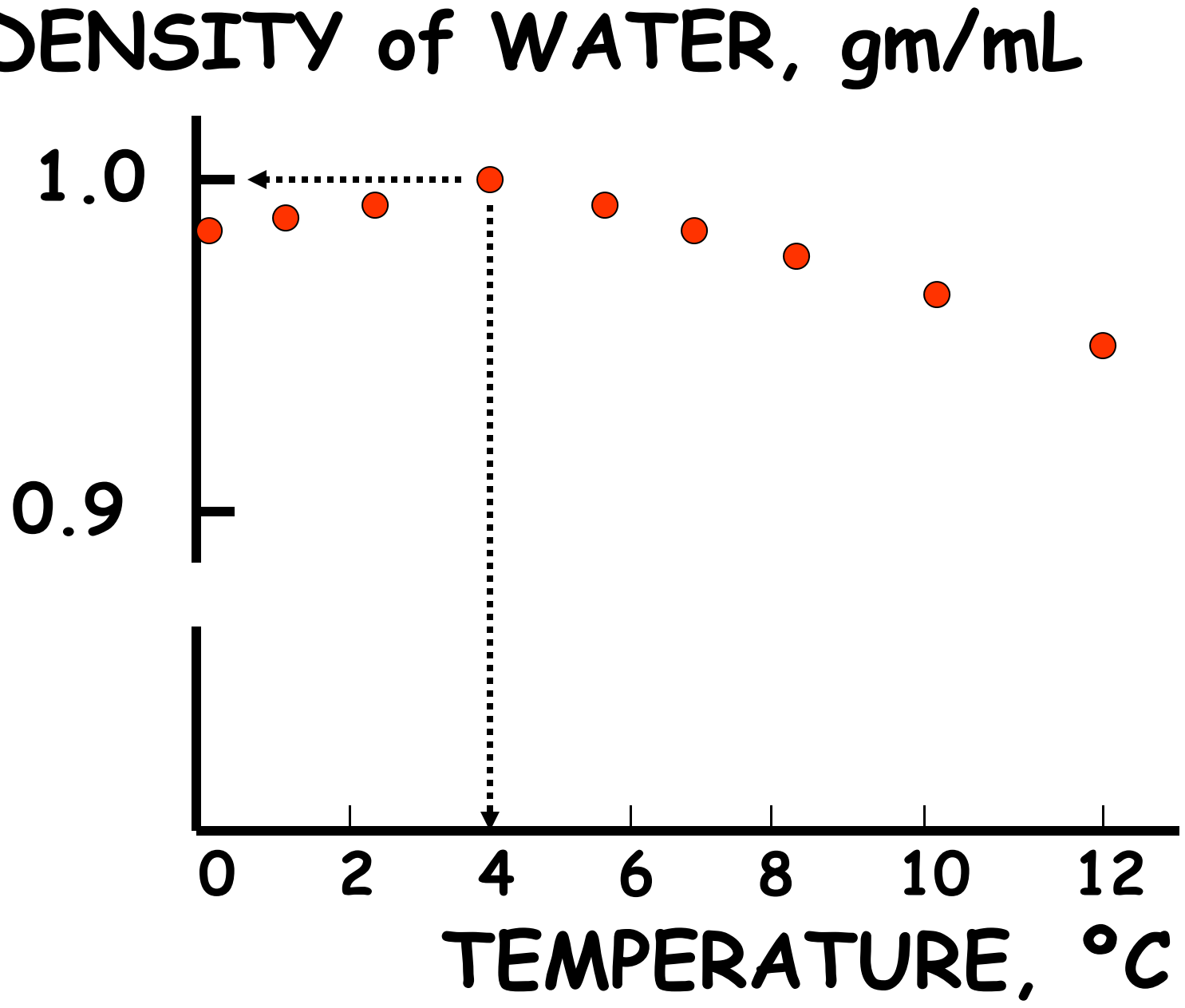
FACTORS AFFECTING SETTLING

- ORGANICS ARE NOT MUCH HEAVIER THAN WATER- SLOW TO SETTLE

1. TEMPERATURE: SETTLING RATE INCREASES WITH INCREASED TEMPERATURES

WATER IS UNIQUE

H_2O IS MOST DENSE @ 4°C, THEN DENSITY DECREASES


DENSITY of WATER, gm/mL
1.0
0.9
0
2
4
6
8
10
12
TEMPERATURE, °C

SO WHAT??

ALL OTHER LIQUIDS BECOME MORE DENSE AS TEMPERATURE DROPS

IT IS WATER'S UNIQUE BEHAVIOR THAT ALLOWS US TO INHABIT EARTH!!

THIS IS WHY ICE FLOATS

OTHERWISE, LAKES WOULD FREEZE SOLID AND NEVER THAW!

FACTORS AFFECTING SETTLING

- TEMPERATURE

- (WOULD YOU EXPECT BETTER SETTLING IN THE SUMMER OR WINTER?)

FACTORS AFFECTING SETTLING

2. SHORT CIRCUITS AND DEAD SPOTS

ENGINEERS TRY TO DESIGN TANKS WITH UNIFORM FLOW ACROSS THE BASIN USING BAFFLES, PORTS, AND PLATES

SHORT CIRCUITS con't

MAY BE CAUSED BY TURBULENCE or DENSITY LAYERS (SALT or TEMPERATURE)

CAUSES REDUCED DETENTION TIME OR AREAS SUBJECT TO SEPTIC CONDITIONS

FACTORS AFFECTING SETTLING

3. DETENTION TIME:

TOO SHORT= SOLIDS IN EFFLUENT

DESIGNED FOR 2-3 HOURS OF D.T.

D.T.= VOL/ FLOW RATE

(ACTUAL WITH DYES, TRACERS)

FACTORS AFFECTING SETTLING

4. WEIR OVERFLOW RATE

- WASTEWATER EFFLUENT FLOWS OVER WEIRS INTO LAUNDERS
- THE LENGTH OF THE WEIR IS IMPORTANT TO PREVENT SHORT CIRCUITING OR HIGH VELOCITIES NEAR THE WEIR

WEIR OVERFLOW RATE

- AMOUNT OF WASTEWATER THAT FLOWS OVER 1 LINEAL FOOT OF WEIR/DAY
- RECOMMEND 10,000-20,000 GPD/FT IN PRIMARY, LESS IN SECONDARY CLARIFIER

WEIR OVERFLOW RATE

GIVEN: A 60' DIAMETER CIRCULAR CLARIFIER, 15' DEEP, RECEIVES 2.5 MGD. WHAT IS THE DETENTION TIME AND THE WEIR OVERFLOW RATE?

$VOL = [0.7854(60)^2 \times 15]\ ft^3 \times 7.48\ gal/ft^3$

$= \underline{317{,}925}$ gallons

WEIR LENGTH $= \pi D = 3.14 \times 60 = \underline{188'}$

DETENTION TIME & WEIR OVERFLOW RATE

D.T.= 317,925 gal/2,500,000 gal/day =0.13 day x 24 hrs/day = 3.1 hours

W.O.R = 2,500,000 gal/day/188 ft

= 13,298 gal/day/ft of weir

WHAT IS THE SURFACE LOADING FOR THIS SITUATION?

SURFACE LOADING =FLOW/SURFACE AREA

= 2,500,000 gal/day / 0.7854 x $(60)^2$ = <u>653</u> gpd/ft^2

(WITHIN THE RANGE OF 300 to 1200 gpd / ft^2)

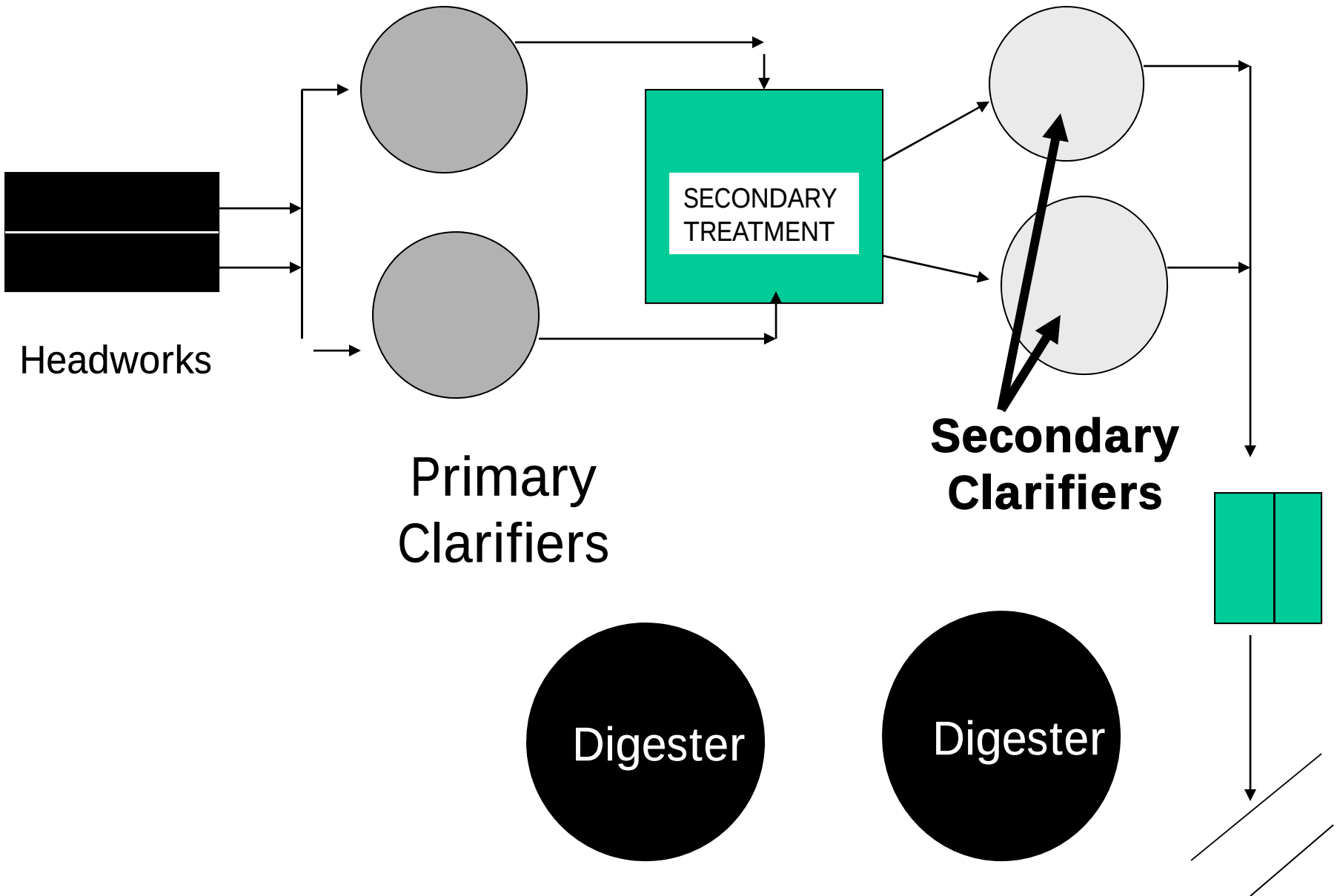
THE REAL PROOF OF PERFORMANCE IS IN THE LABORATORY RESULTS

OTHER FACTORS…

- TOXIC WASTES FROM INDUSTRIAL SPILLS, DUMPS

- SEPTIC OVERLOAD (RV DUMPS, PORTA-POTTY DUMPS, STORM FLOWS, HYDRAULIC OVERLOADS)

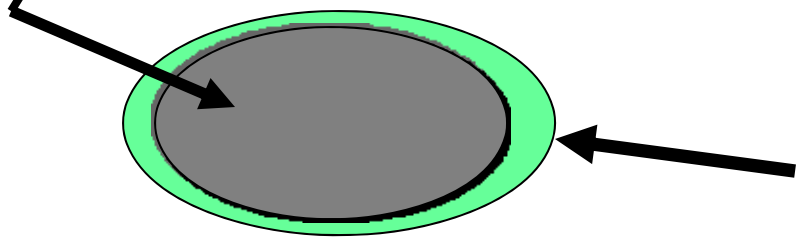
SECONDARY CLARIFIERS



A TRICKLING FILTER CREATES SETTLEABLE SOLIDS FROM SUSPENDED AND DISSOLVED SOLIDS

TRICKLING FILTER

ROCK (OR PLASTIC)



HUMUS

HUMUS (SLOUGHING BIOMASS) GOES TO THE SECONDARY CLARIFIER

TRICKLING FILTER CLARIFIER

- HUMUS IS HIGH IN BOD AND MUST BE REMOVED

- EXPECT TO PUMP 30-40% MORE SLUDGE FROM A SECONDARY CLARIFIER (THAN A PRIMARY CLARIFIER)

TRICKLING FILTER CLARIFIER

- DESIGNED MUCH LIKE PRIMARY CLARIFIERS
- DETENTION TIME: 2-3 hours
- WEIR OVERFLOW RATE: 5,000-15,000 GPD/FT
- SURFACE LOADING: 300-1200 gpd/ft^2

TRICKLING FILTER CLARIFIER SLUDGE

- LOOKS DIFFERENT THAN THE SLUDGE FROM THE PRIMARY CLARIFIER

- DARKER (but not gray or black)
- "FLUFFY" MATERIAL WITH LITTLE or NO ODOR
- MAY BE SENT BACK TO PRIMARY CLARIFIER or TO THE DIGESTER

ACTIVATED SLUDGE CLARIFIERS

NOTE: SOME ACTIVATED SLUDGE PLANTS DO NOT HAVE PRIMARY CLARIFIERS—ONLY SECONDARY

- DESIGNED TO HANDLE LARGE VOLUMES OF SLUDGE

- REQUIRE MORE OPERATOR ATTENTION (HIGHER CERTIFICATION LEVEL FOR ACTIVATED SLUDGE THAN a TRICKLING FILTER)

ACTIVATED SLUDGE CLARIFIERS ARE DESIGNED FOR…

- **DETENTION TIME: 2 – 3 hours**
- **SURFACE LOADING: 300-1200 gpd/ft²**
- **WEIR OVERFLOW RATE: 5,000 – 15,000 GPD/FT**
- **SOLIDS LOADING: 24-30 lbs/day/ft²**

SOLIDS LOADING RATE

- USEFUL FOR ACTIVATED SLUDGE SECONDARY CLARIFIERS

- INDICATES THE AMOUNT OF SOLIDS THAT CAN BE REMOVED DAILY FOR EACH SQ-FT OF SURFACE AREA

SOLIDS LOADING RATE

SLR=lbs of SOLIDS/day / ft^2

$$lbs/day = C \times Q \times 8.34$$

Where: C = Suspended Solids concentration in ppm; Q = flow in millions of gallons/day, and 8.34 is lbs/gallon

TYPICAL RANGE=12 -30 #/day/ft^2

ACTIVATED SLUDGE CLARIFIER DESIGN:

DETENTION TIME: 2-3 HOURS

SURFACE LOADING: 300-1200 gpd/ft^2

WEIR OVERFLOW RATE: 5000 - 15000 gpd/ft^2

SOLIDS LOADING: 12 - 30 $lbs/day/ft^2$

SLUDGE REMOVAL IN ACTIVATED SLUDGE SECONDARY CLARIFIERS

DIFFERS FROM PRIMARY CLARIFIER OPERATION BECAUSE SLUDGE WITHDRAWAL IS CONTINUOUS

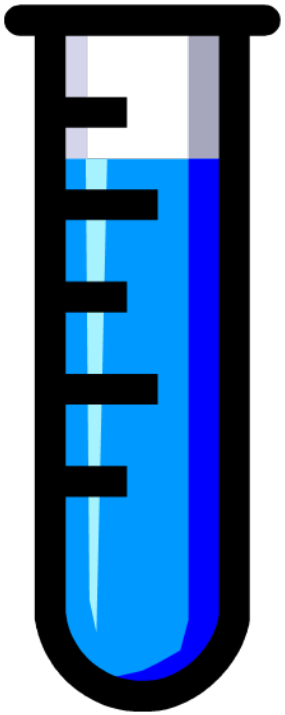
SUCTION-LIFT CLARIFIER

SLUDGE VOLUME INDEX (SVI)

- A GOOD OPERATING TEST FOR SLUDGE CONSISTENCY

- RELATES THE SETTLEABLE SOLIDS TO THE SUSPENDED SOLIDS

SLUDGE VOLUME INDEX TEST



- 1 Liter of mixed liquor, settled for 30 minutes

- ON SAME BATCH, RUN SUSPENDED SOLIDS

SVI, mL/gm =SETTLEABLE SOLIDS/ SUSPENDED SOLIDS

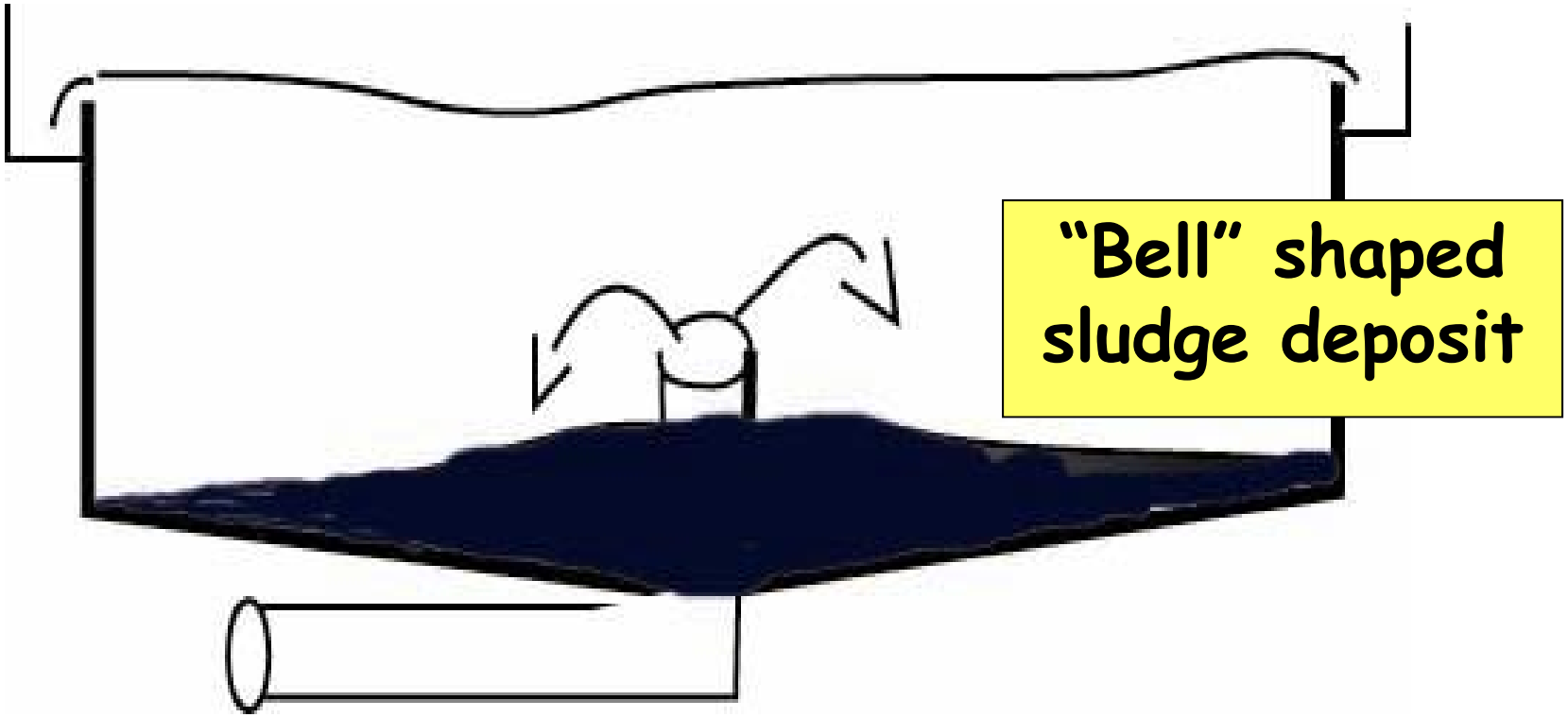
SVI EXAMPLE

FROM A SAMPLE OF MIXED LIQUOR YOU DETERMINE:

SETTLEABLE SOLIDS = 610 mL/L
SUSPENDED SOLIDS = 5580 mg/L

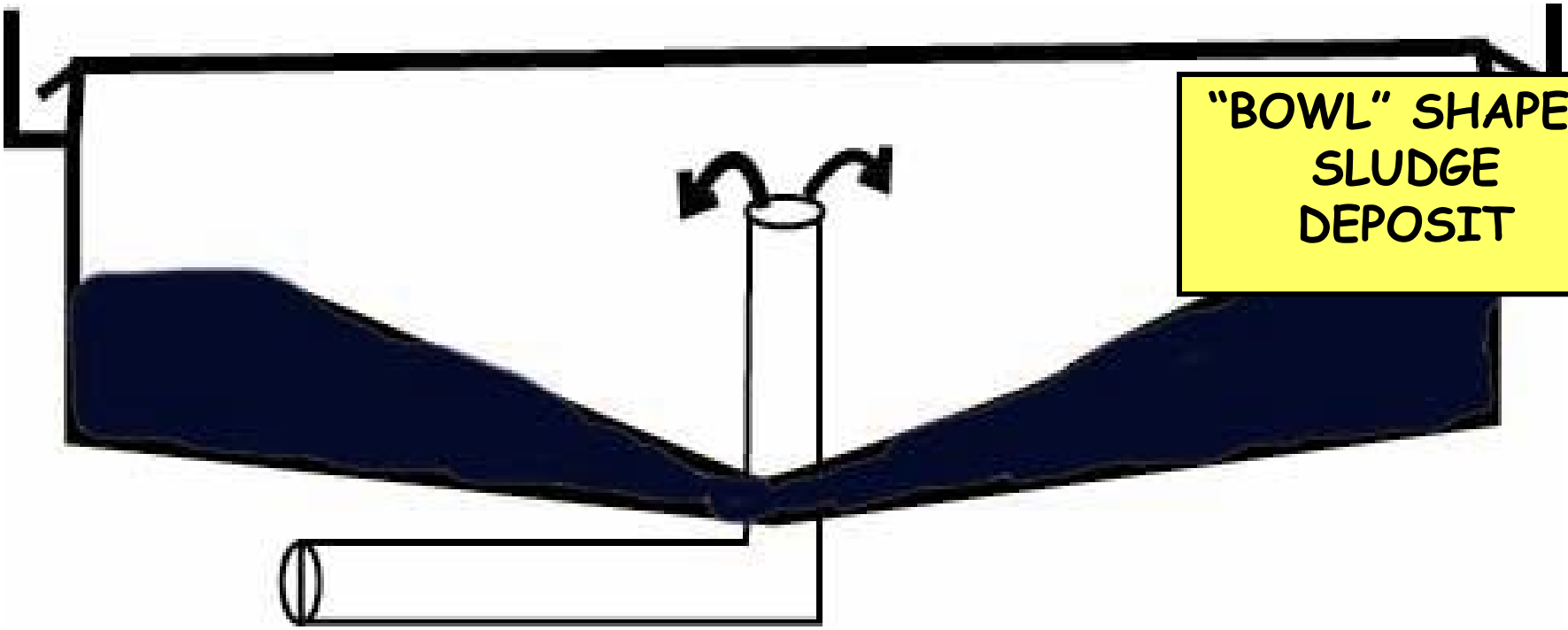
SVI = 610 ml/L / 5580 mg/L x 1000 mg/gm = 109 mL/gm

SIGNIFICANCE OF SVI



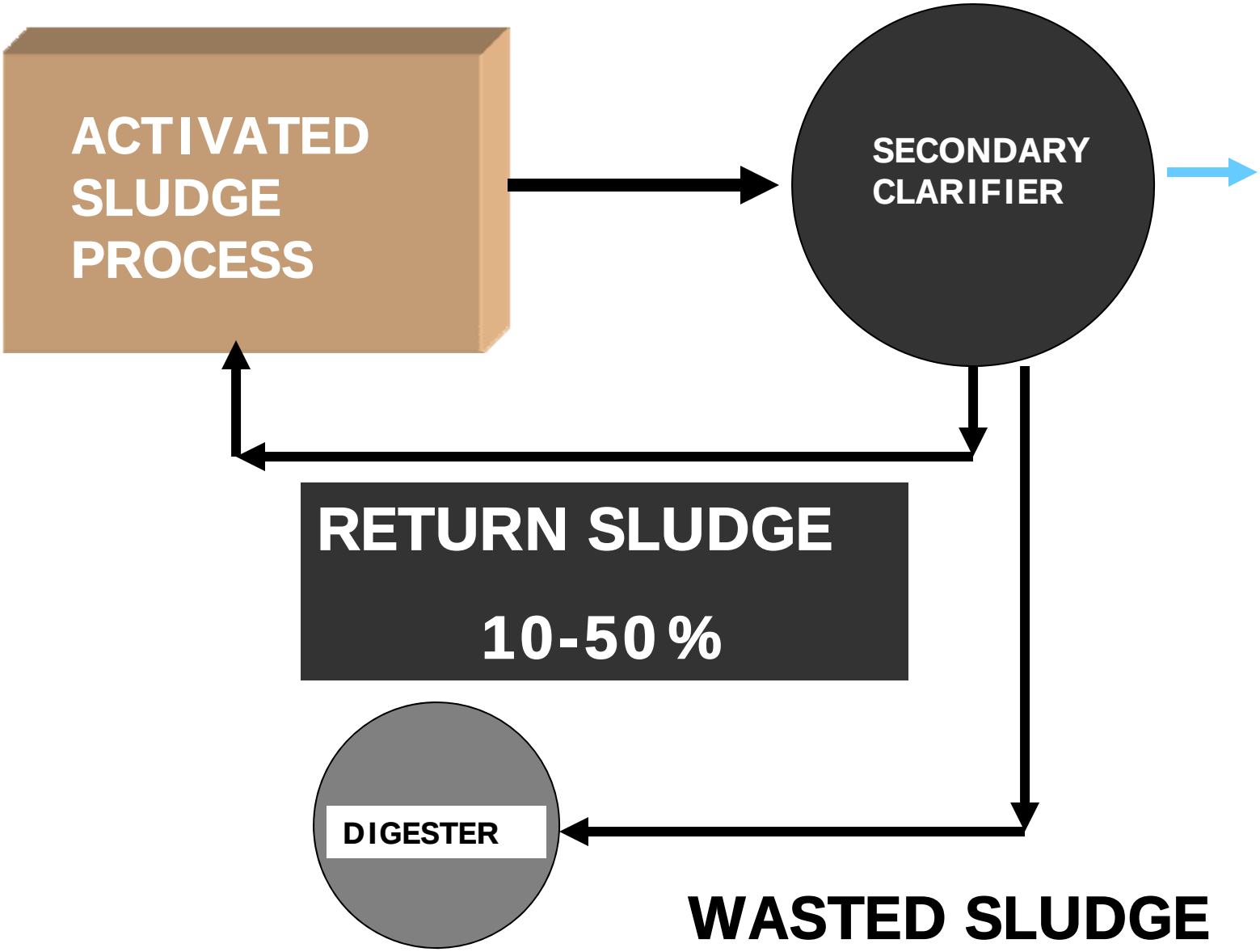
SVI ~ 100 mL/gm

SIGNIFICANCE OF SVI



SVI ~ 500 mL/gm

MORE EFFICIENT TO PUMP SLUDGE FROM CENTER OF CLARIFIER


ACTIVATED SLUDGE PROCESS
SECONDARY CLARIFIER
RETURN SLUDGE
10-50 %
DIGESTER
WASTED SLUDGE
3 - 4.5 %

IN THE CLARIFER, THE OPERATOR MUST MONITOR…

- SLUDGE BLANKET
- EFFLUENT SUSPENDED SOLIDS
- RETURN SLUDGE FLOWS

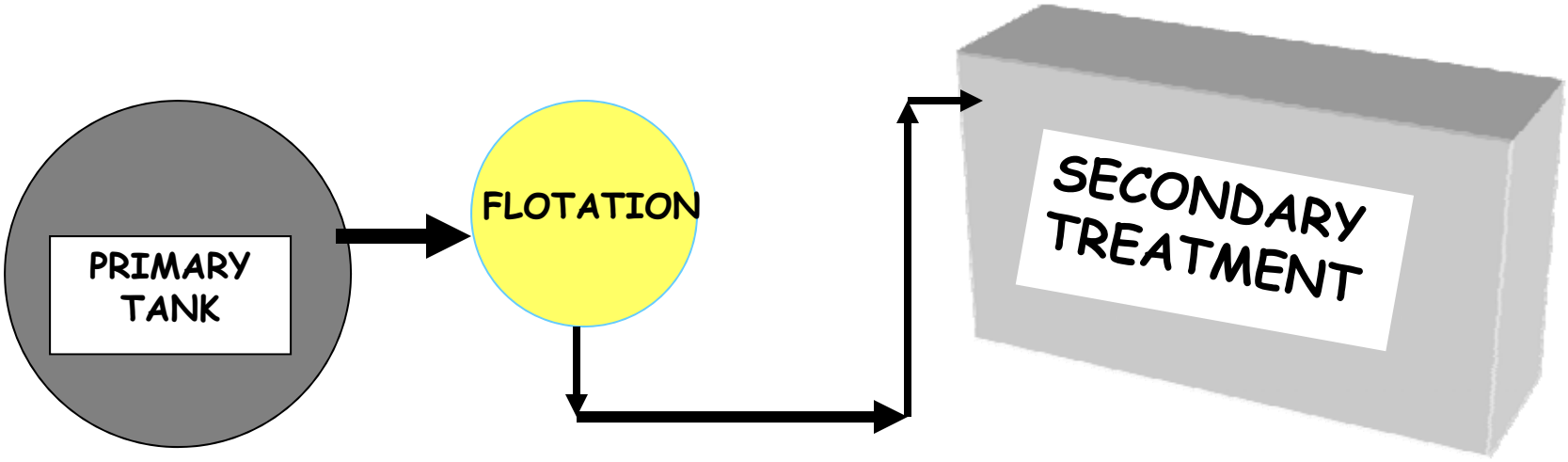
OPERATOR MUST MONITOR THE CLARIFIER EFFLUENT FOR…

- TURBIDITY
- DISSOLVED OXYGEN (O_2)
- pH, BOD, AMMONIA NITROGEN (NH_3)

WASTEWATER CONTAINS SOME SOLIDS THAT WILL NEITHER SINK NOR FLOAT!

- COLLOIDS = FINELY DIVIDED DISPERSED SOLIDS
- EMULSIONS =LIQUIDS THAT WILL NOT DISSOLVE IN EACH OTHER (GREASE, FATS, OIL in WATER)

FLOATATION PROCESS



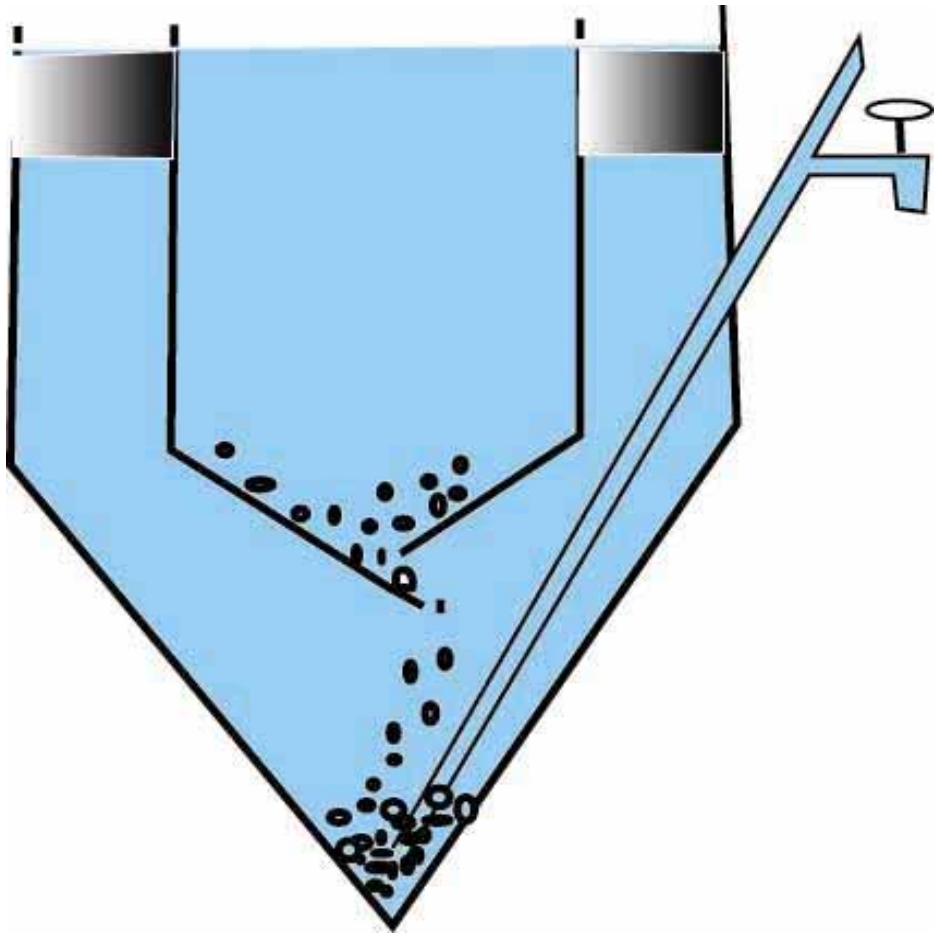
AIR IS PUMPED INTO THE WASTEWATER THEN REMOVED BY VACUUM OR RELEASED UNDER PRESSURE TO REMOVE COLLOIDS and EMULSIONS

FLOTATION IS NOT WIDELY USED WITH MUNICIPAL WASTEWATER TREATMENT

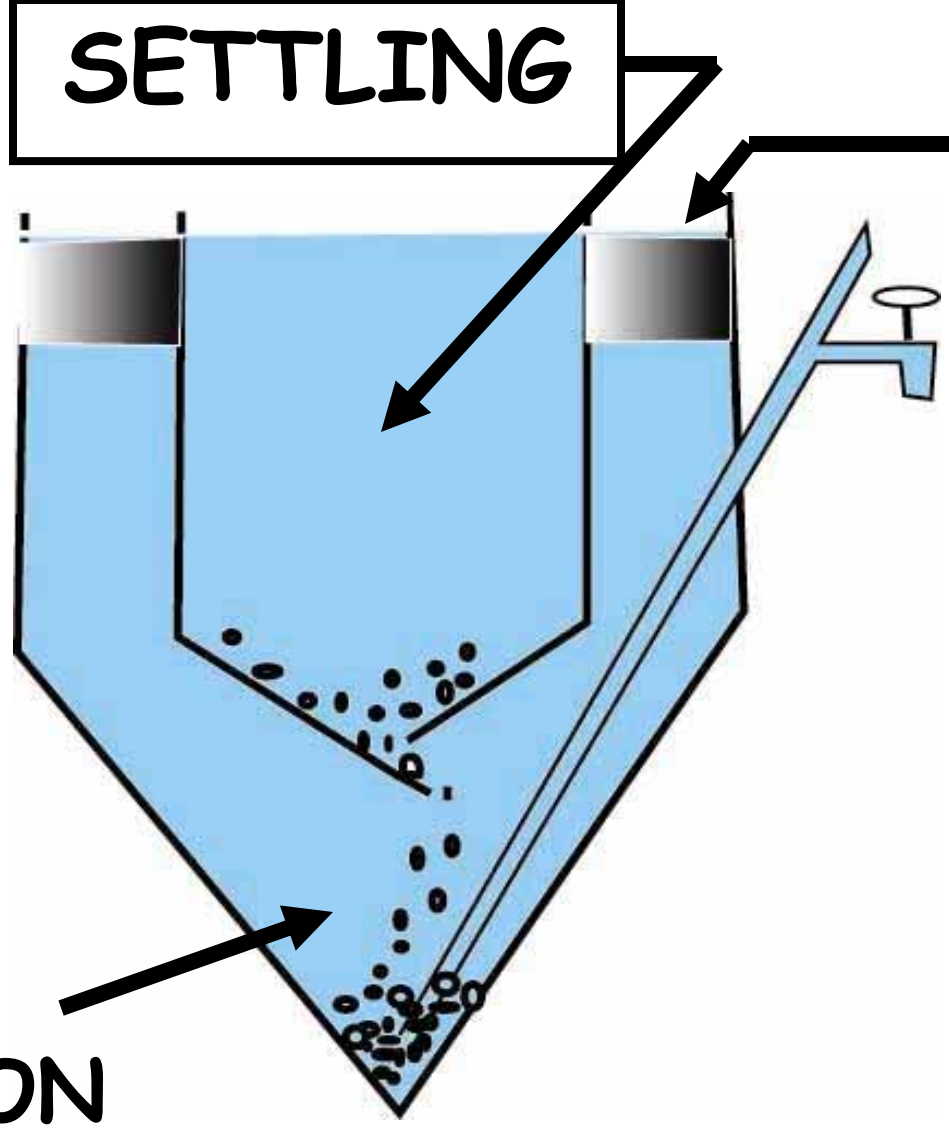
COMBINED SETTLING AND DIGESTION UNITS

- USUALLY CONSIDERED "PACKAGED TREATMENT PLANTS" BECAUSE THEY ARE FACTORY-BUILT AND SHIPPED TO THE SITE AS A PACKAGE

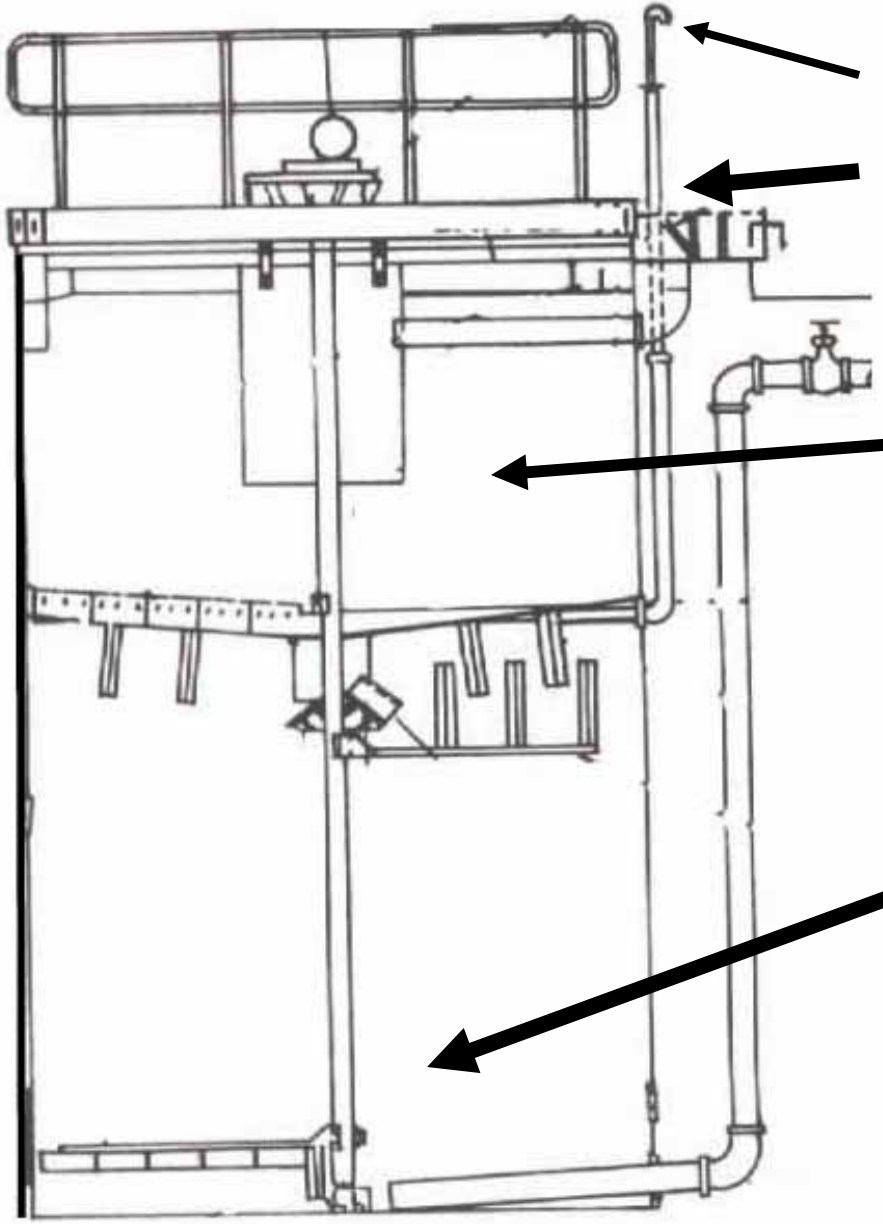
COMBINED SETTLING/DIGESTION



THESE UNITS ARE ALL COPIED FROM THE IMHOFF TANK



IMHOFF TANK



CLARIGESTER™