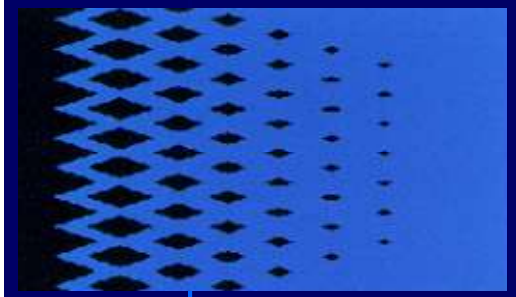

29th National Engineers Week Conference,Albany Marriott, Wolf Road, Albany, NY 12233

Training Seminar, February 5 & 6, 2009

Chemical and Biochemical Technologies for Environmental Infrastructure Sustainability

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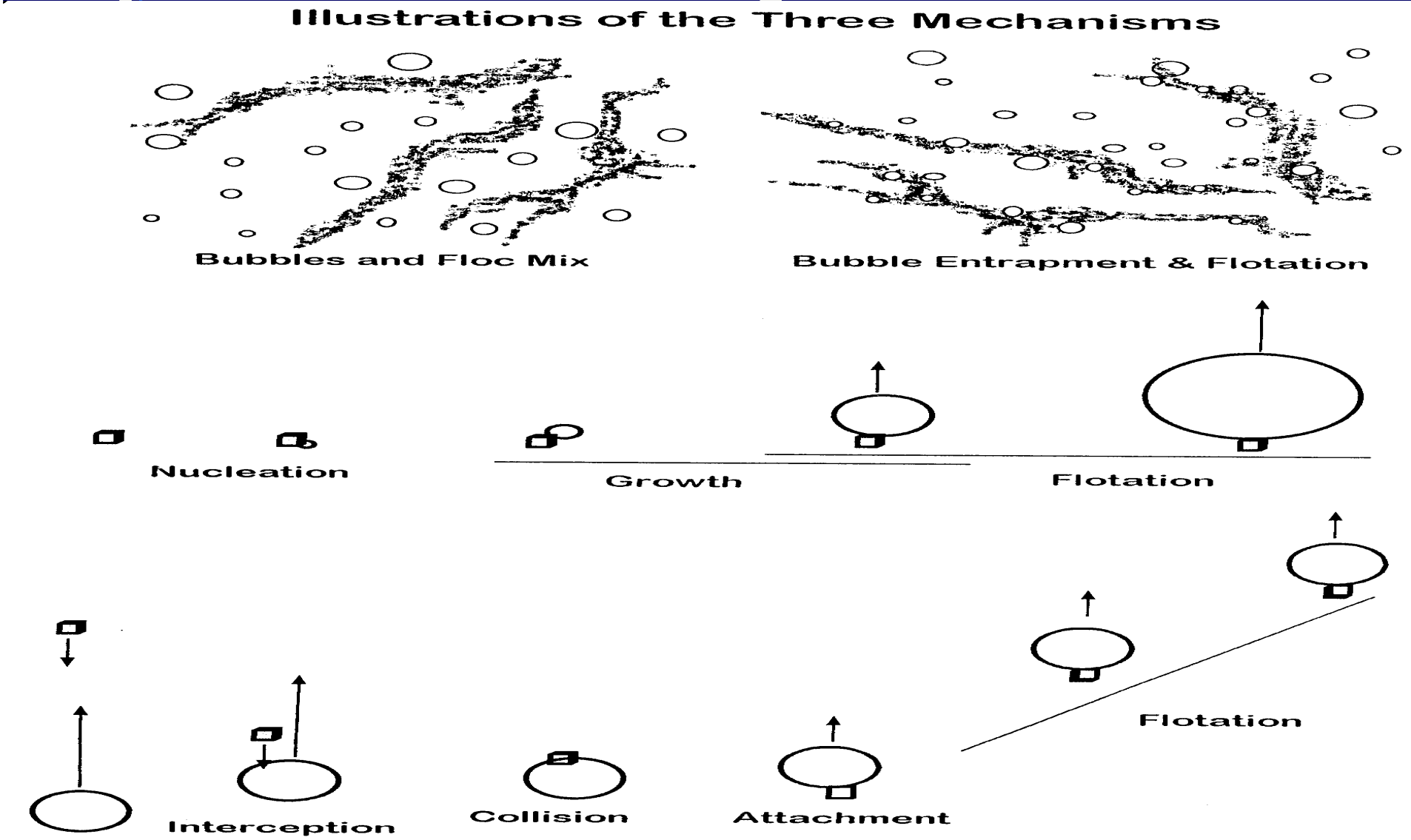
How can I separate various pollutants cost-effectively ?

Solution : Flotation Separation Technologies

- Plain Gravity Flotation (Oil/Wax)
- Dissolved Air (Gas) Flotation (Laminar Flow; Fine Bubbles;)
- Dispersed (Induced) Air Flotation (Turbulent Flow; Coarse Bubbles)
- Vacuum Flotation
- Electroflotation (H2, O2, Cl2 Bubbles)
- Biological Flotation (N2, CO2 Bubbles)

How does water-solids separation actually work?



Solution: Chemical Addition, Mixing, Precipitation & Coagulation

- Chemical Addition & Mixing
- Chemical Precipitation
  - Solute A + Solute B = insoluble flocs
- Chemical Coagulation:
  - Formation of chemical flocs that adsorb, entrap, or bring suspended matter together

    (Soluble Al → aluminum hydroxide flocs)
  - Opposite charge neutralization; particles are destabilized and form visible pin flocs
  - Collector adjustment (hydrophobic nature)

Flocculation

- Flocculation:
  - Enlargement of pinfloc to speed separation
  - Occurs via addition of long chain polymer
  - Polymer actually grabs onto several pinflocs and pulls material together

Why can flotation separation rate be so high? How does it work?

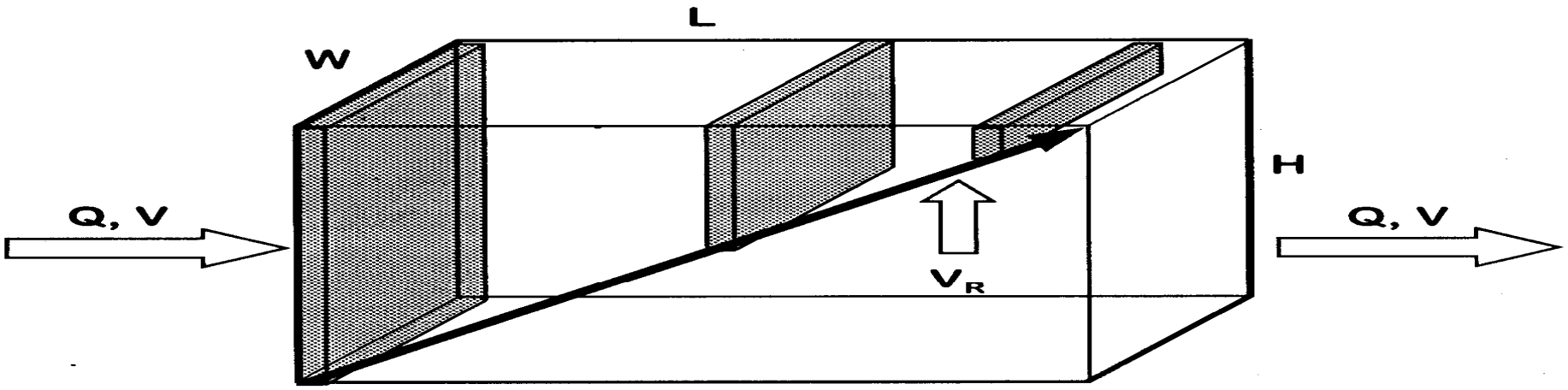
- Chemical addition, mixing, chemical precipitation and coagulation
- Flocculation – Formation of stable flocs
- Flotation Clarification:
  - Generation of gas bubbles (air, nitrogen, carbon dioxide, ozone, oxygen, hydrogen, chlorine)
  - Flotation (bubble) separation of insoluble particles from a aqueous suspension
  - Collection, harvest or disposal of floats
  - Discharge of clarified clear effluent from bottom

Water-Solids Separation by Flotation

Before Flotation

After Flotation

Solution: Flotation Hydraulic Loading Calculations



Q is the flow rate (m^3/ min)

V (Flow Velocity) = m / min = Q / WH

V_R = Rise Velocity

T (Time of rise from bottom to top) = H / V_R

L (Length water travels in Time T) = V T

= QT / WH

T = LWH / Q = H / V_R

V_R = Q / LW LW is the surface area

» A_P (Surface Loading)

$Q = V_R \cdot A_P$

V_R (m^3 / min / m^2)

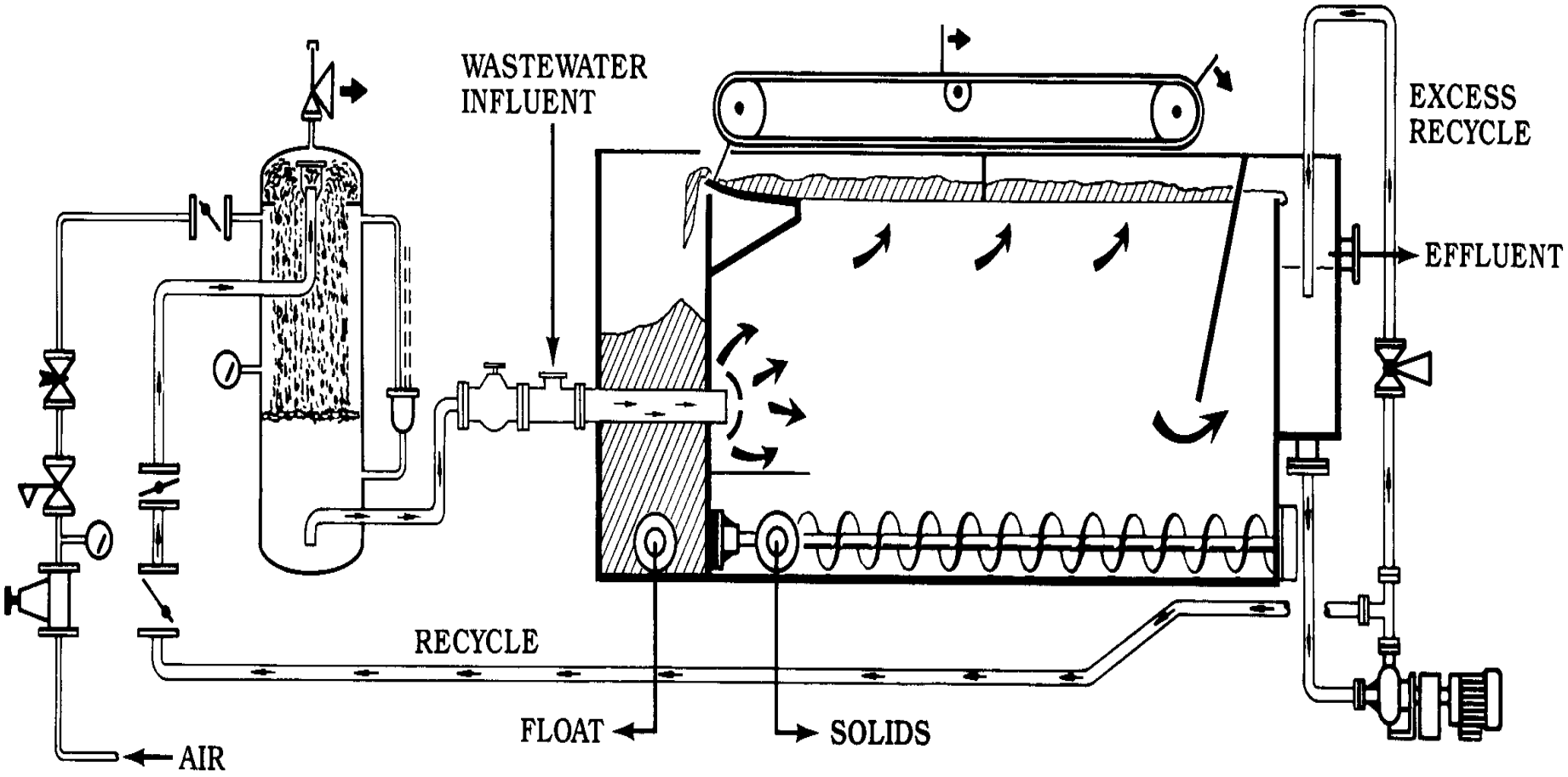
What are the practical flotation applications ?

- Potable water treatment
- Industrial water purification
- Industrial effluent treatment
- Municipal sewage & sludge treatment
- Ore mining
- Groundwater decontamination
- De-inking waste paper pulp
- Algae harvesting and lake restoration
- Separating plastics from shredded solid wastes

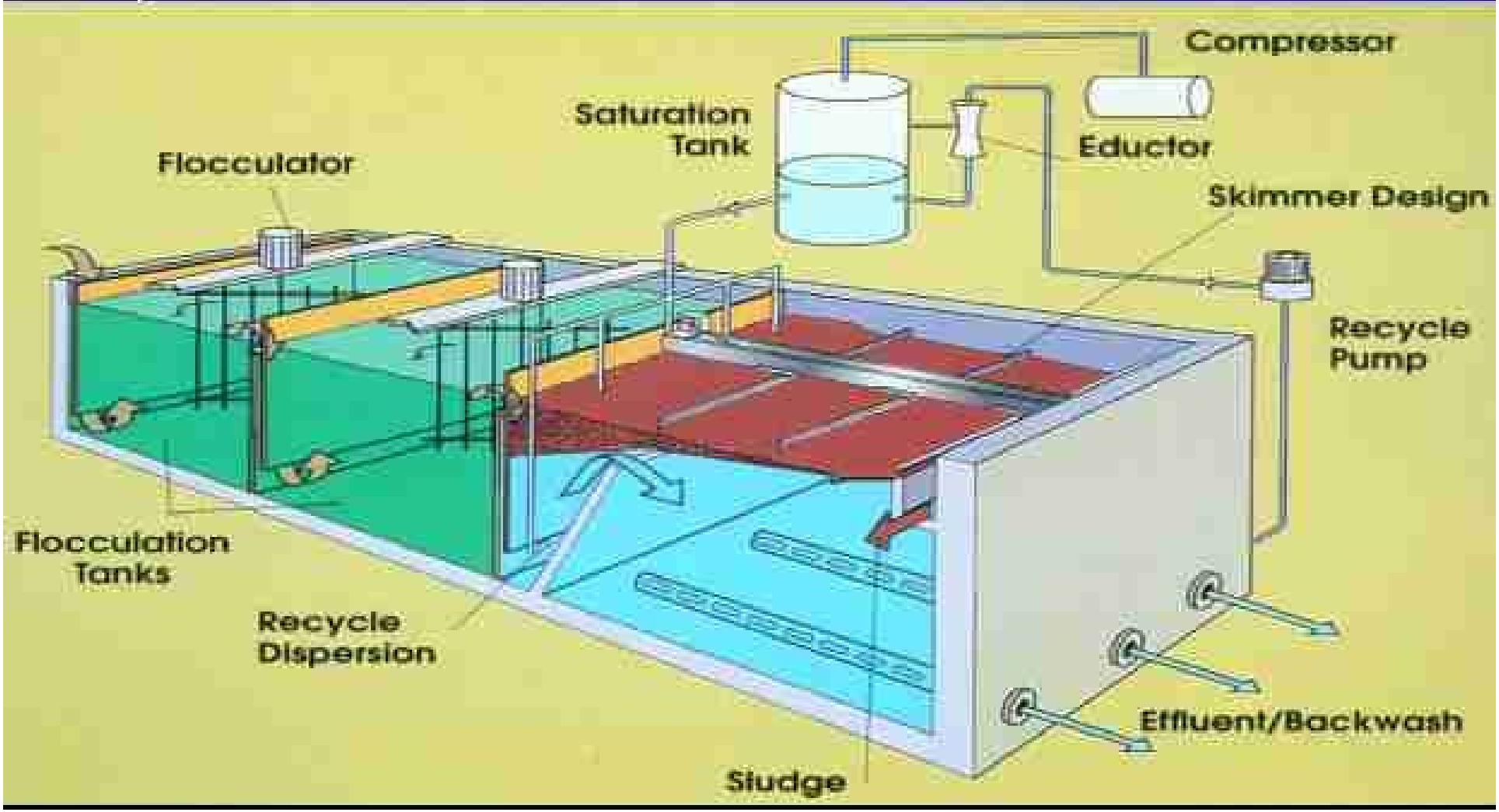
Rectangular Dissolved Air Flotation (DAF)

- Chemical addition, mixing, coagulation-flocculation
- Flotation
- Flotation effluent discharge
- Float discharge

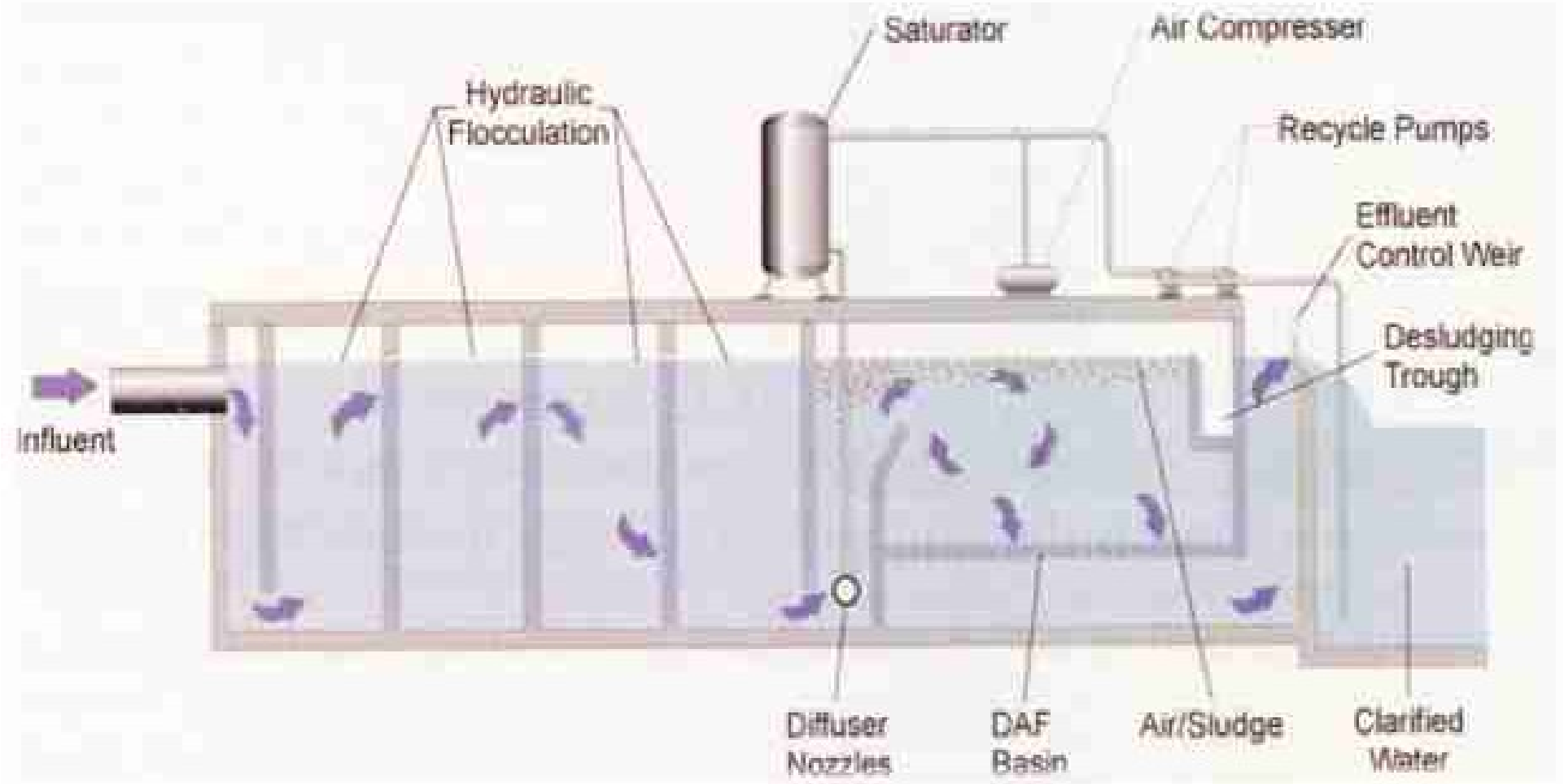
Multiple-Solutions, such as: Rectangular Dissolved Air Flotation (DAF) – Waterlink Separation Inc, Lake Bluff, Illinois



Rectangular Dissolved Air Flotation (DAF) – Waterlink Separation Inc, Lake Bluff, Illinois



Rectangular Dissolved Air Flotation (DAF) – West Nyack-NY potable water plant (30 MGD)



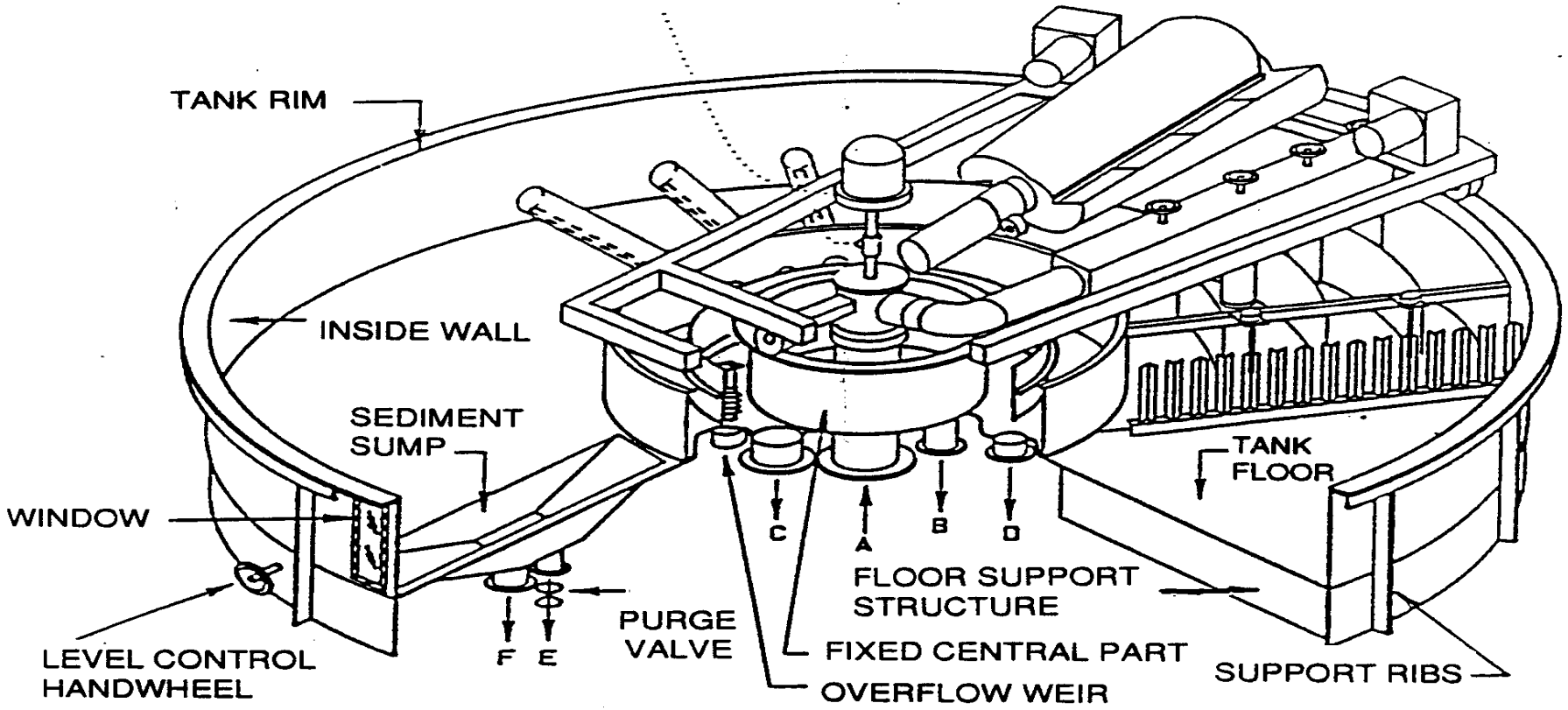
Rectangular Dissolved Air Flotation (DAF) – West Nyack-NY potable water plant (30 MGD)

Circular Dissolved Air Flotation (DAF) – Krofta Engineering Corp., Mass.

55-ft Diameter; 7290 GPM.

Petrochemical Wastewater Treatment

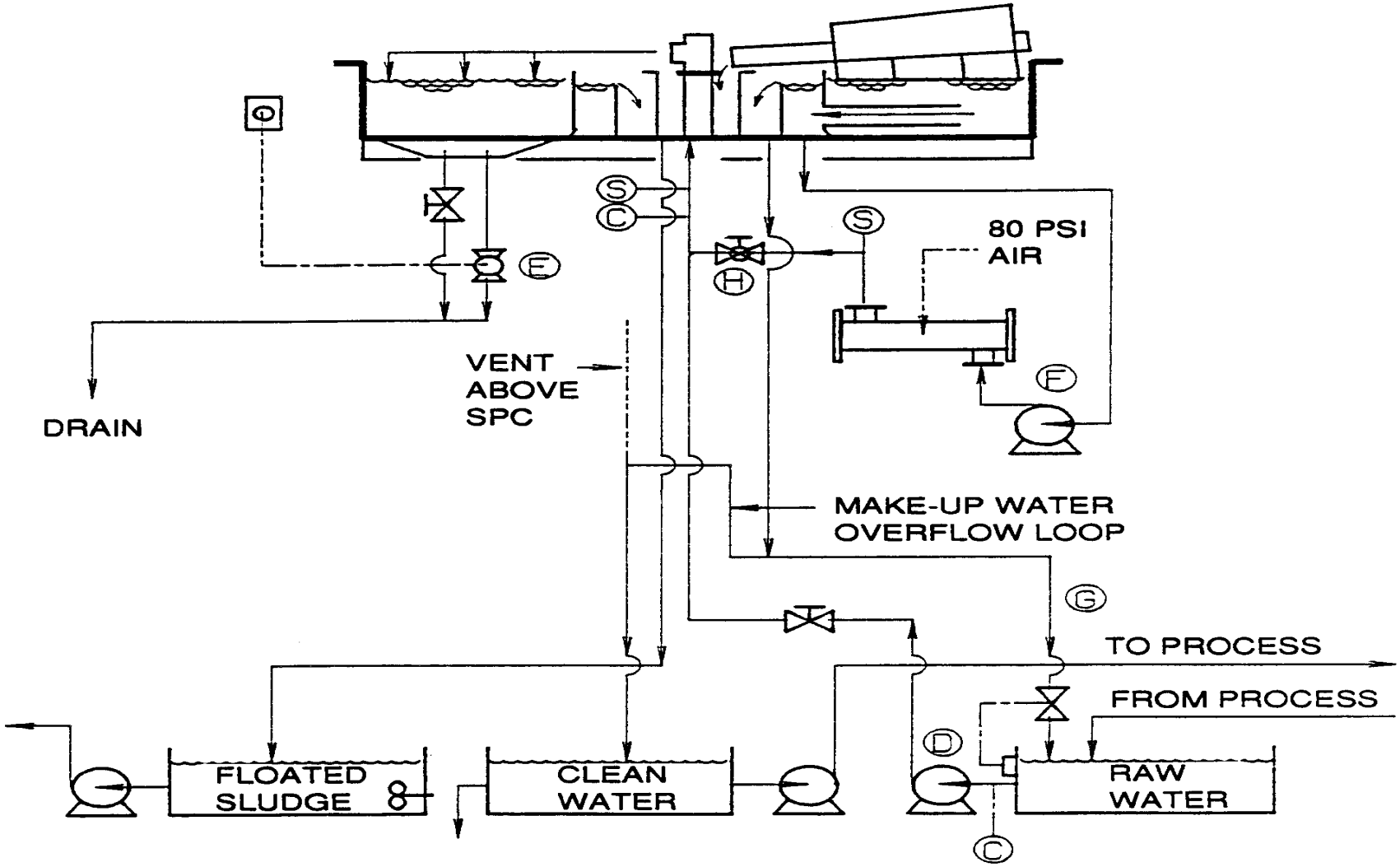
What is the “zero velocity concept of a Circular Dissolved Air Flotation (DAF) ? – Krofta Engineering Corp., Mass.



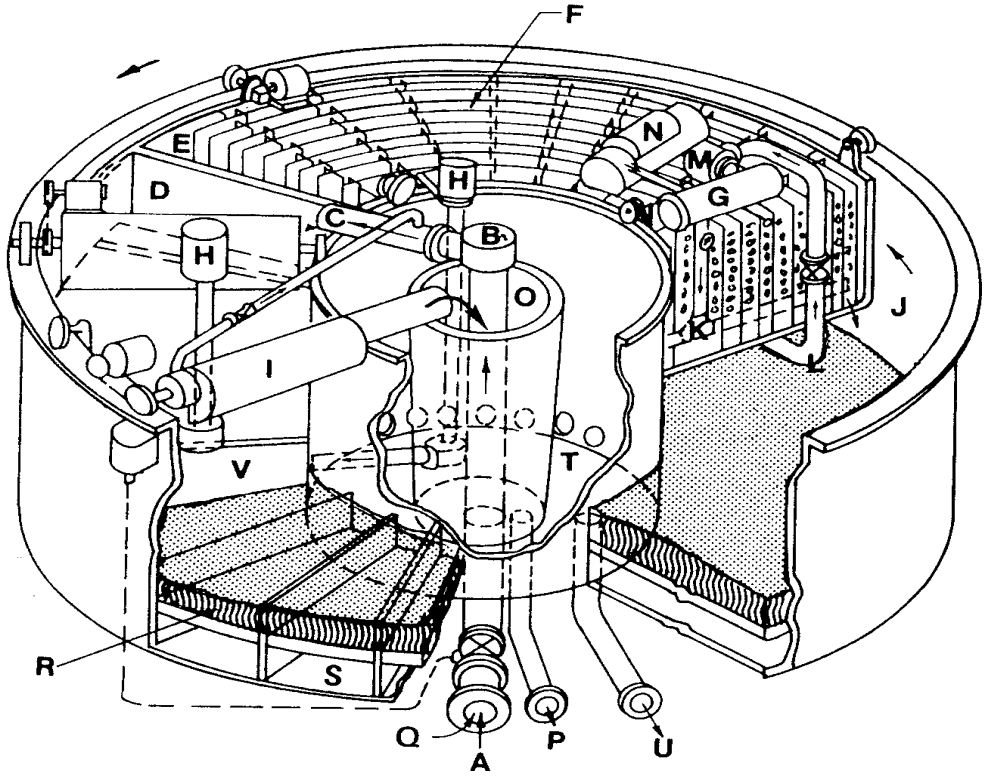
PIPE CONNECTIONS

A - Unclarified Water Inlet
B - Floated Sludge Outlet
C - Clarified Water Outlet
D - Recycle Outlet
E - Purge
F - Drain

Solution: Circular Dissolved Air Flotation (DAF) – Krofta Engineering Corp., Mass.

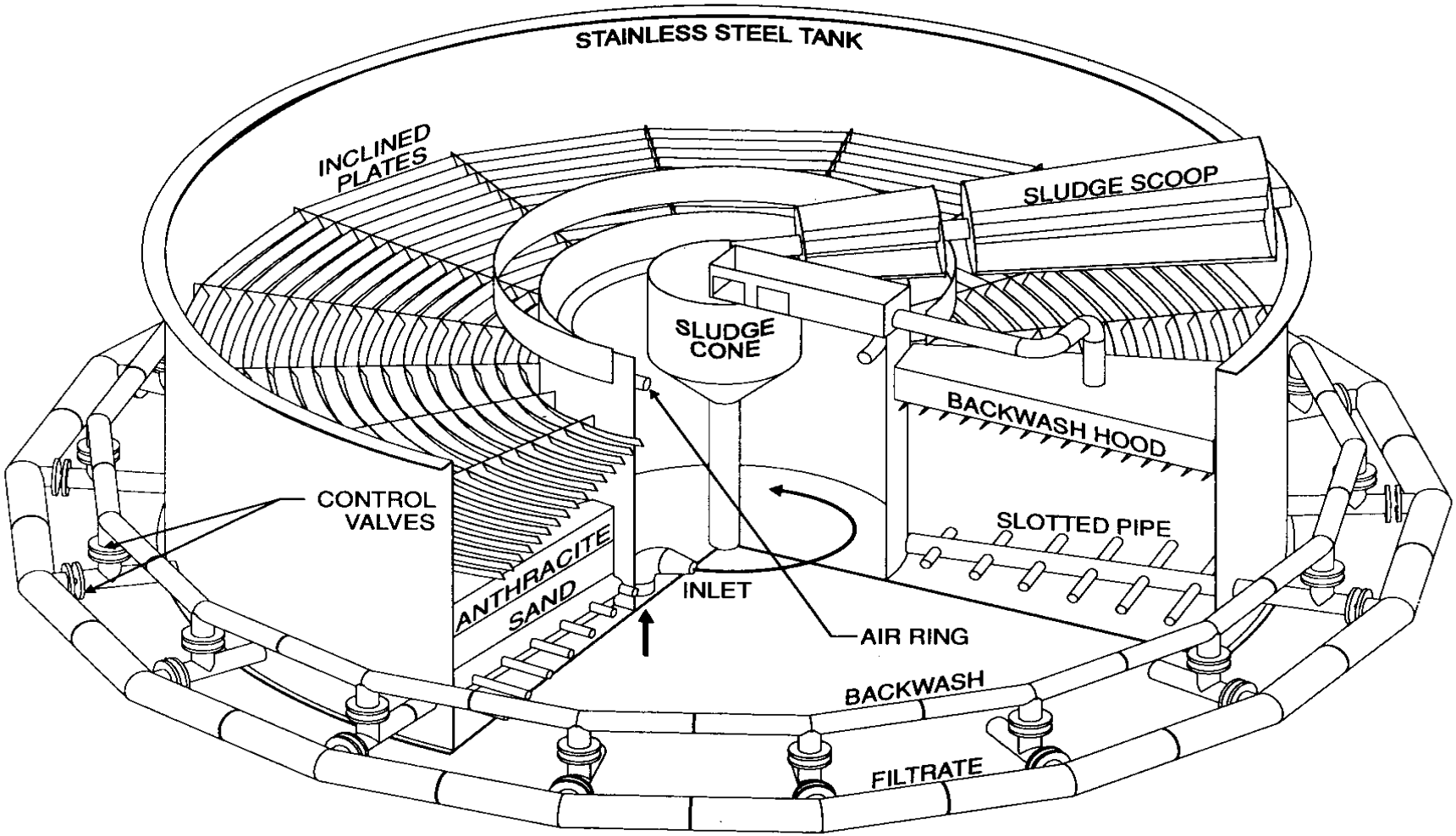


(1) 1st USA 1-MGD Lenox-MA potable water plant (DAFF) built in 1981;
(2) Once world's largest 37.5-MGD Pittsfield-MA potable water plant (DAFF) built in 1986

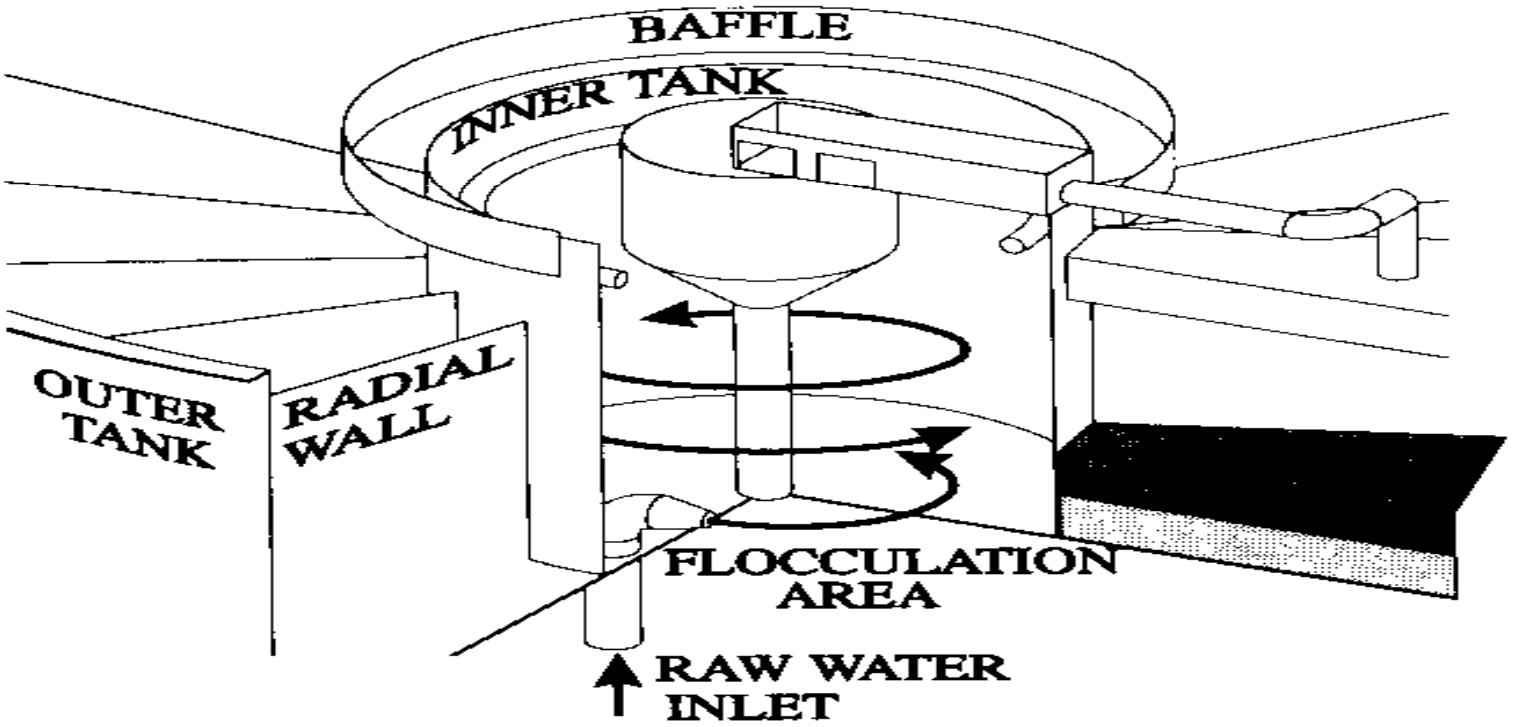


A — RAW WATER INLET
B — HYDRAULIC JOINT
C — INLET DISTRIBUTOR
D — RAPID MIXING
E — MOVING SECTION
F — STATIC HYDRAULIC FLOCCULATOR
G — AIR DISSOLVING TUBE
H — BACKWASH PUMPS
I — SPIRAL SCOOP
J — FLOTATION TANK
K — DISSOLVED AIR ADDITION
L — BOTTOM CARRIAGE
M — PRESSURE PUMP
N — AIR COMPRESSOR
O — CENTER SLUDGE COLLECTOR
P — SLUDGE OUTLET
Q — CHEMICAL ADDITION
R — SAND FILTER BEDS
S — INDIVIDUAL CLEAR WELLS
T — CENTER CLEAR WELL
U — CLEAR EFFLUENT OUTLET
V — TRAVELING HOOD

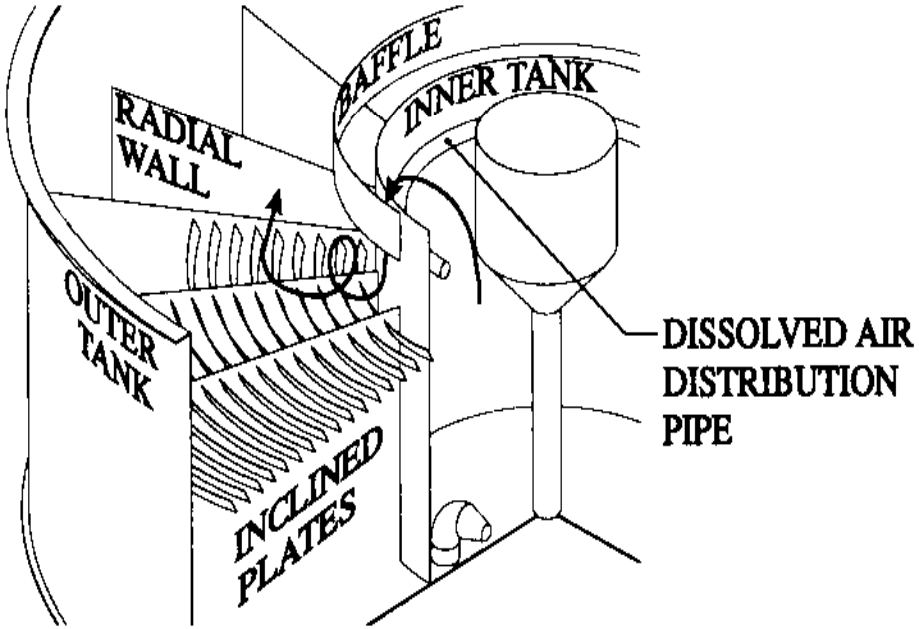
How does a new generation circular package plant work? – DAFF (Lenox-MA & Lee-MA)

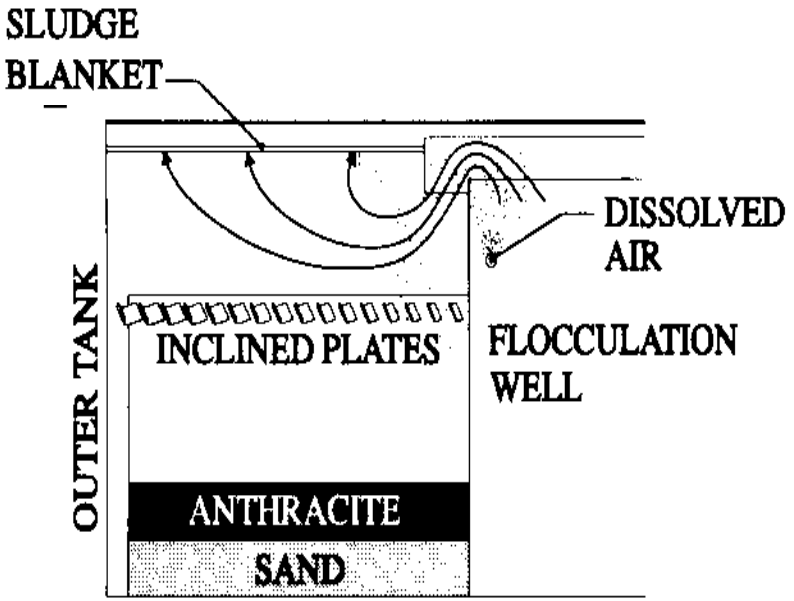


Solution: Circular Flotation-Filtration Plant – Coagulation & Flocculation

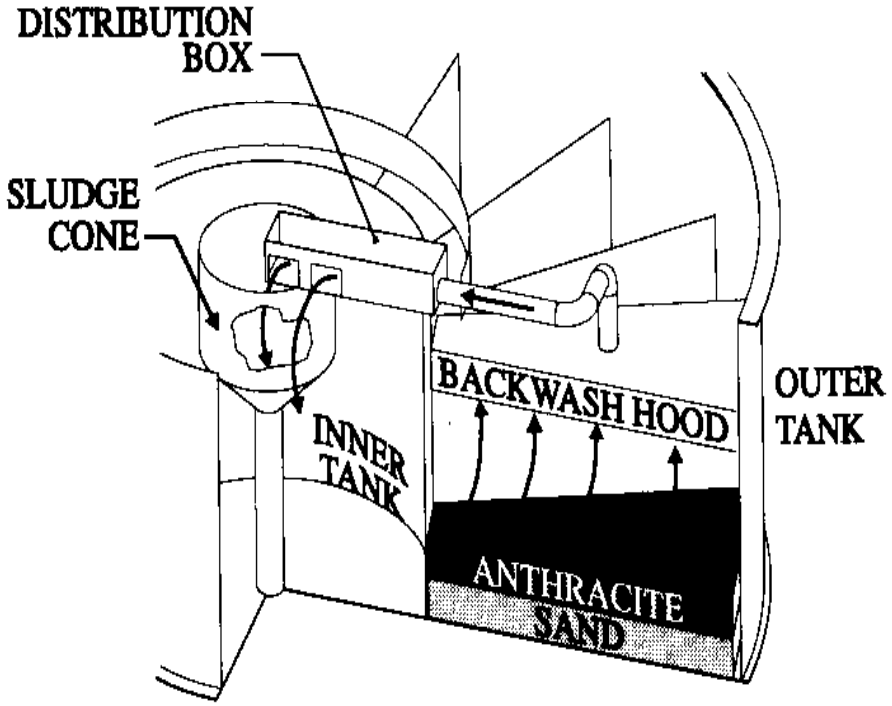


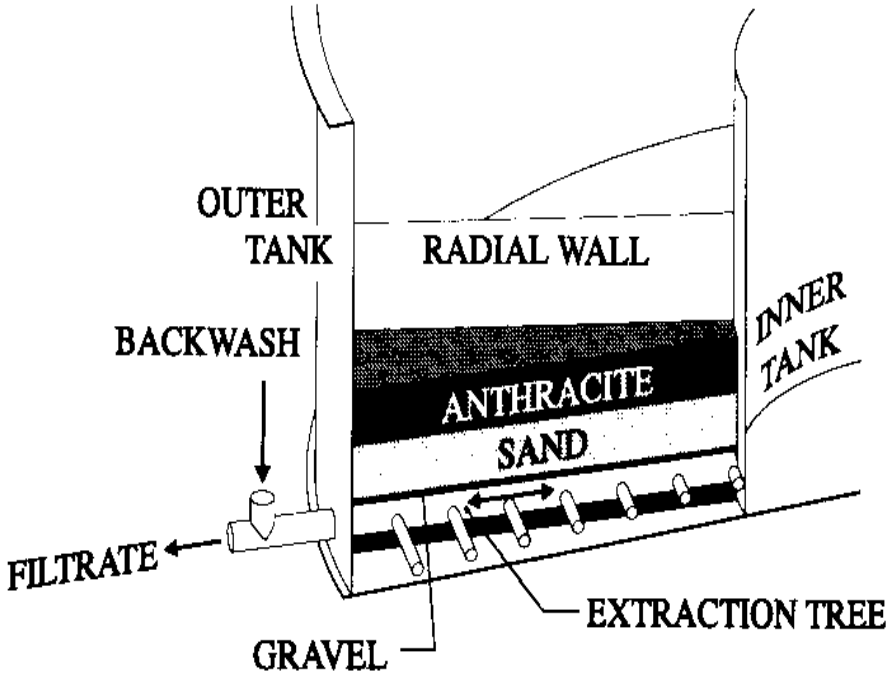
Solution: Circular Flotation-Filtration Plant – Dissolved Air Flotation



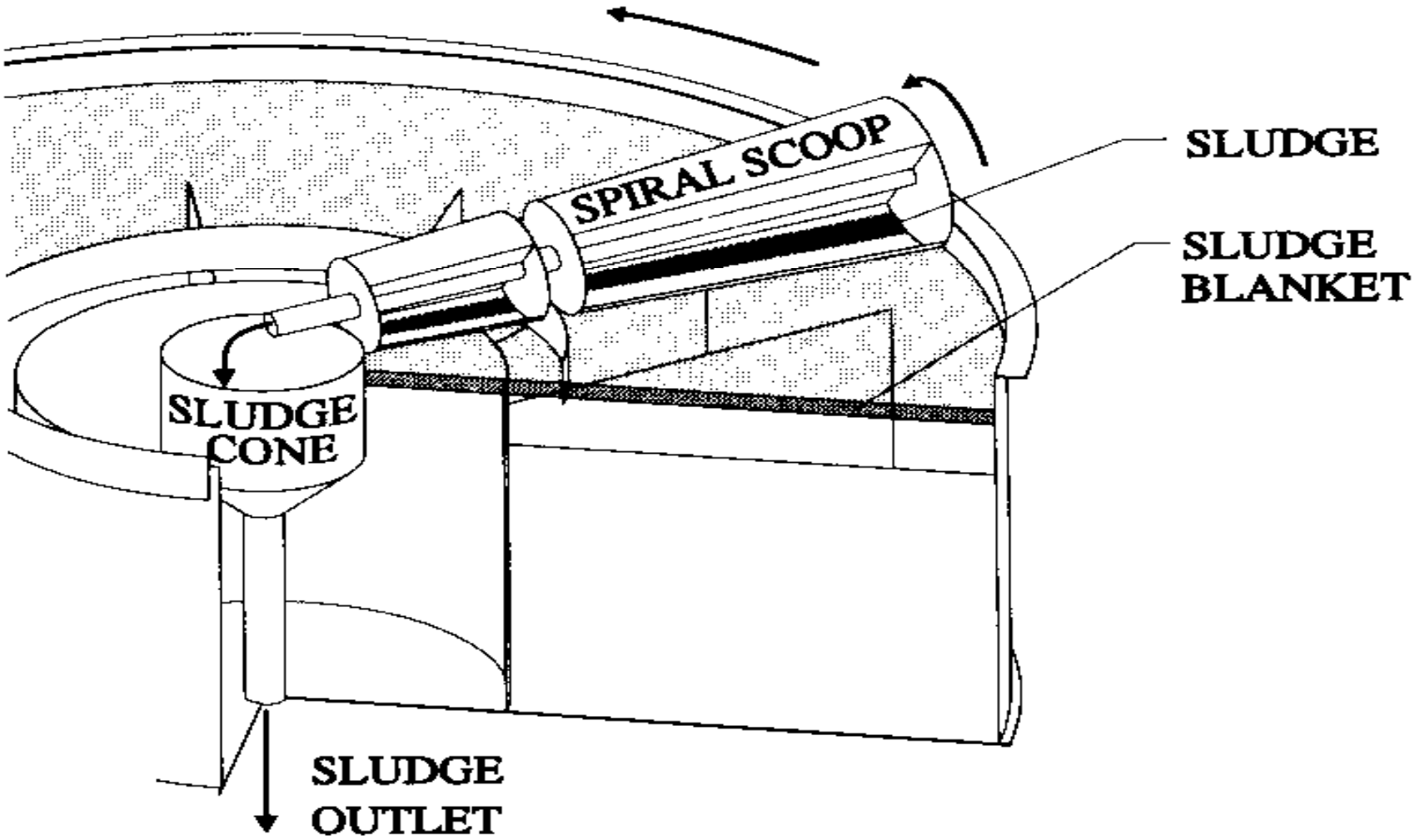


Solution: Circular Flotation-Filtration Plant – Automatic Backwash Filtration

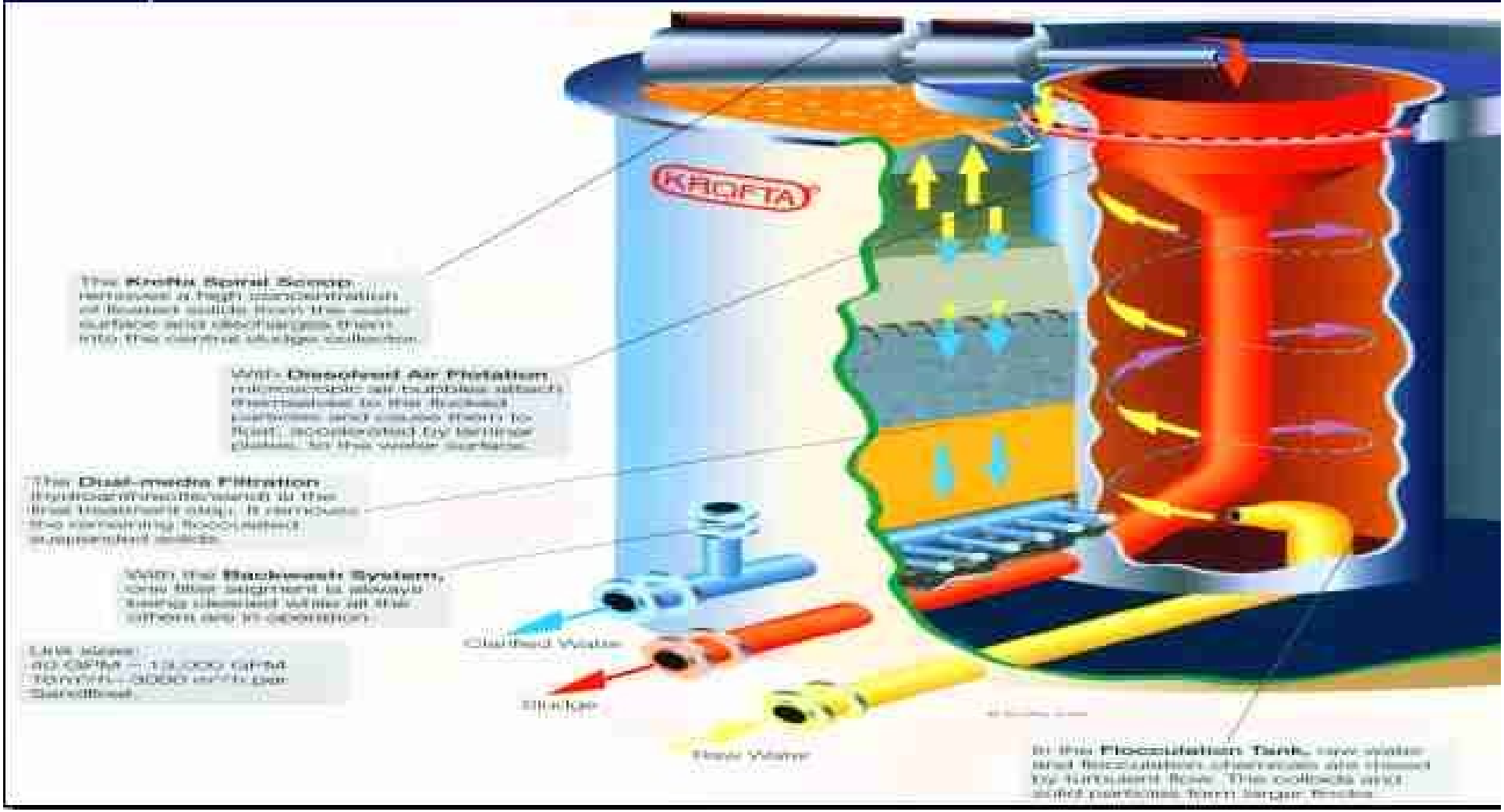




Solution: Circular Flotation-Filtration Plant – Sludge Collection & Discharge

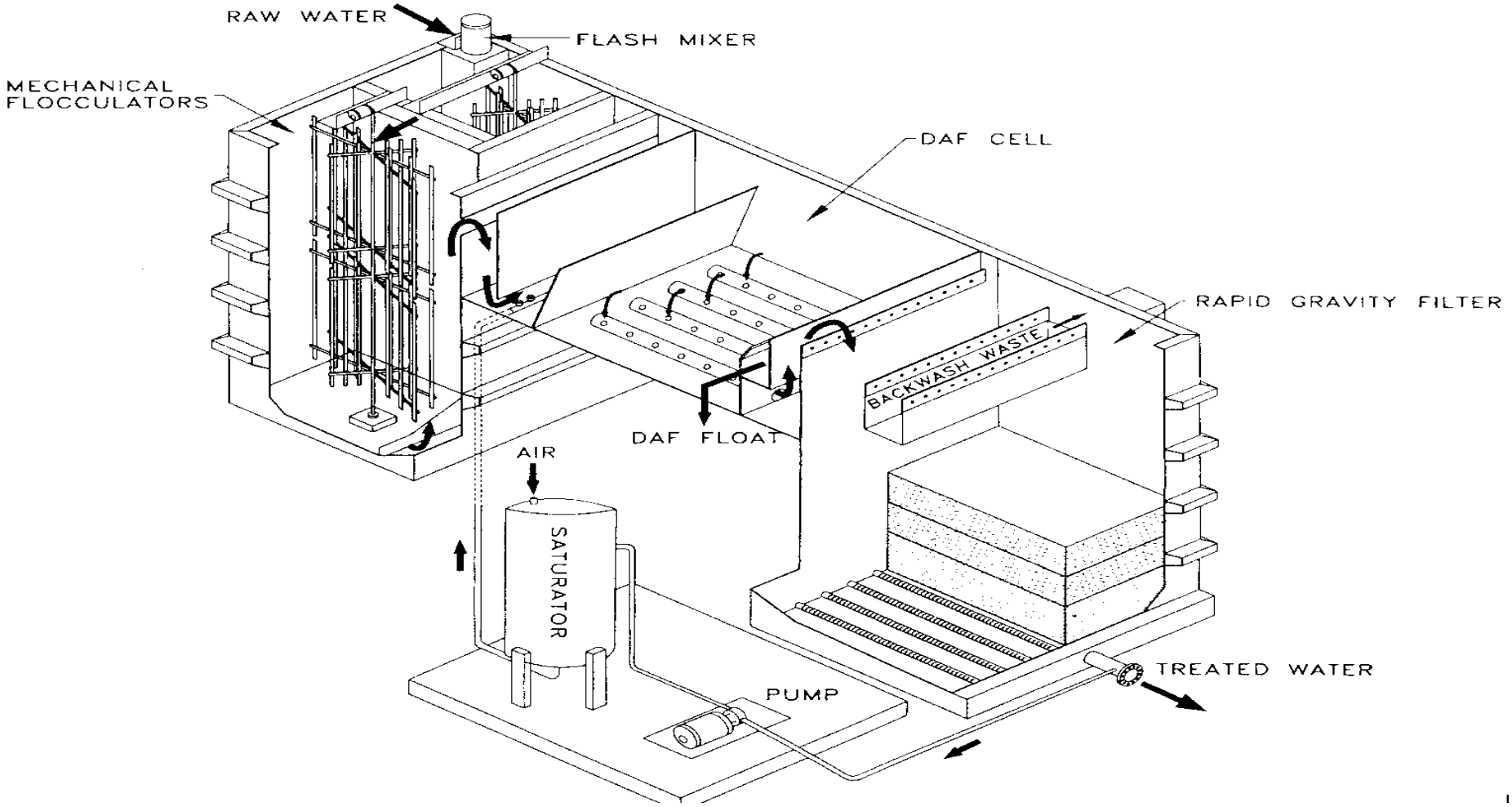


Circular Flotation-Filtration Plant (DAFF)
Krofta Engineering Corporation, Mass.

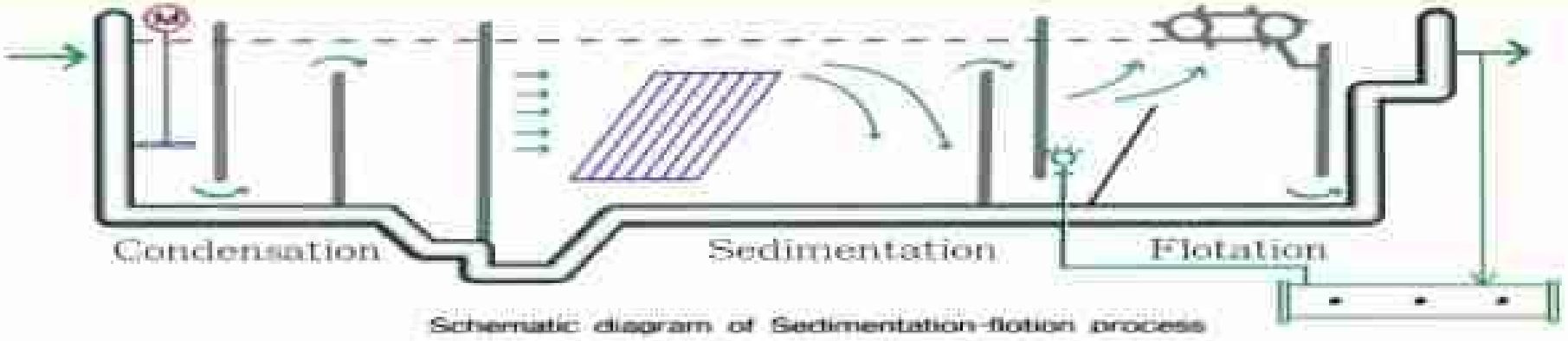


37.5-MGD Pittsfield Water Treatment Plant, Mass. -- 1986

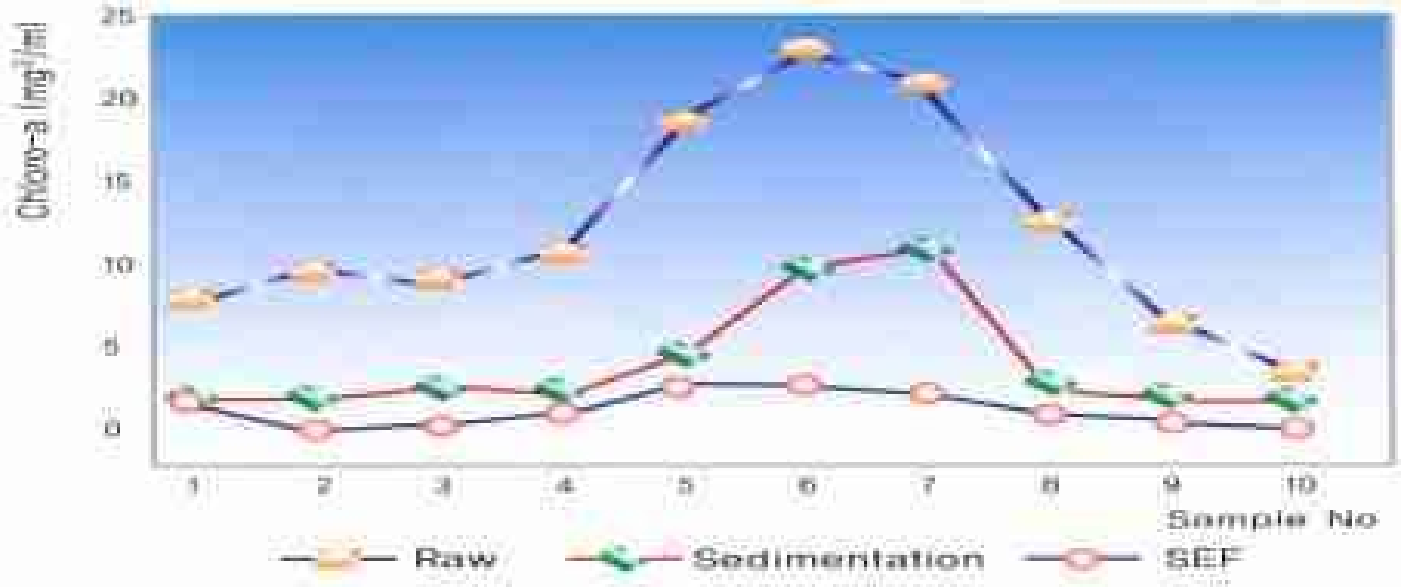
Rectangular Flotation-Filtration Package Plant (DAFF) – Clearwater Group, Black Diamond, Washington



Rectangular Sedimentation & Flotation, Seoul, Korea; Algae Separation

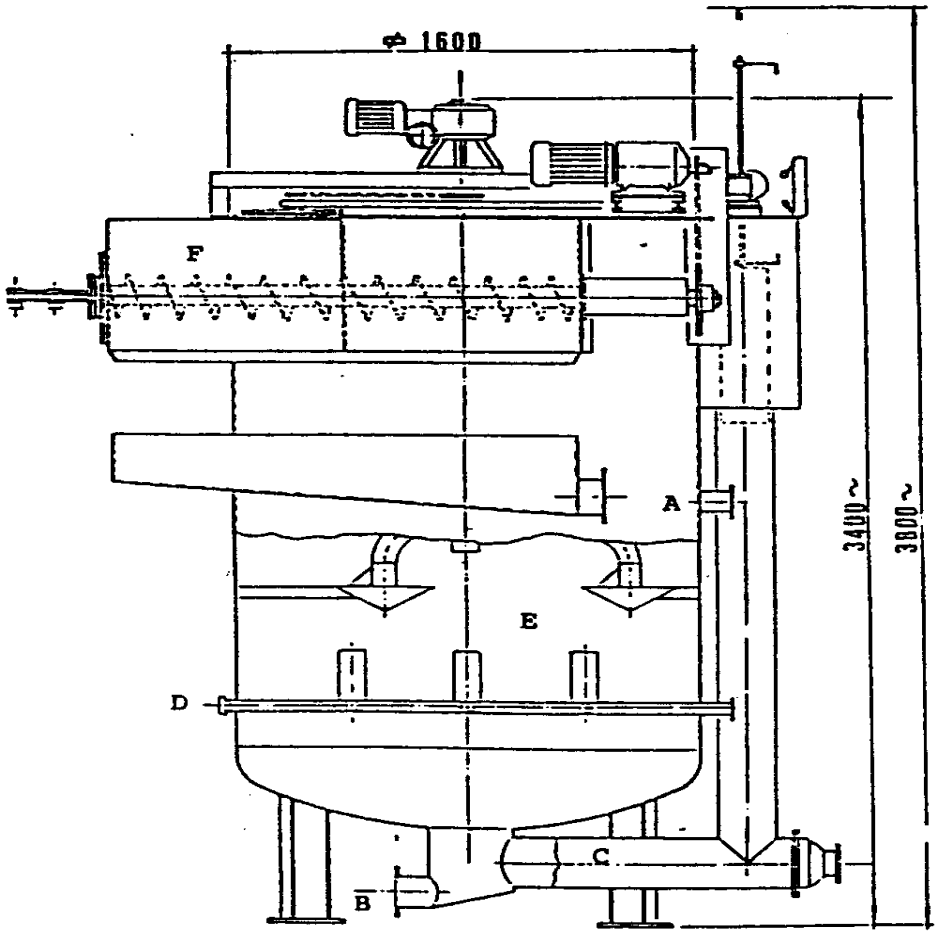


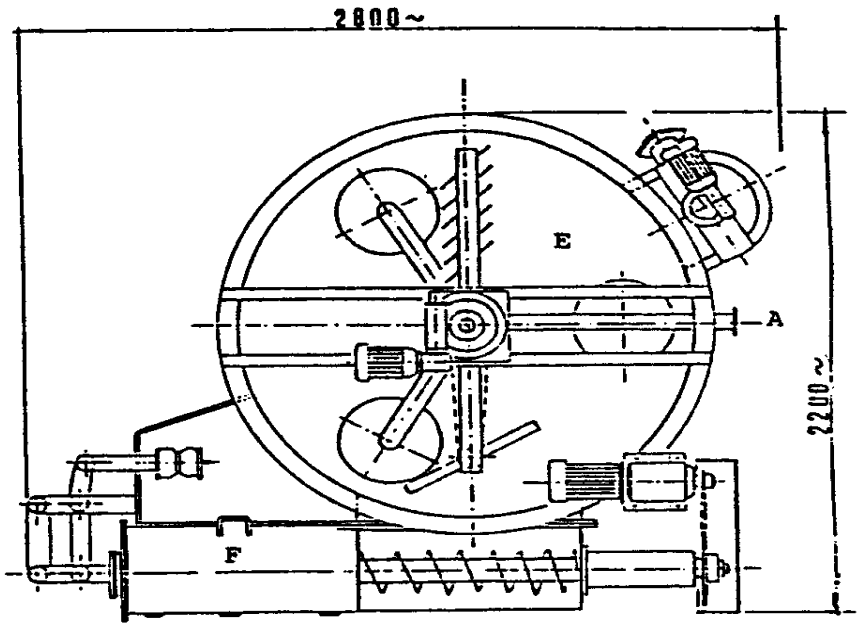
Schematic diagram of Sedimentation-flotion process



Chlorophy ll -a removal by Sedimentation - SEF process

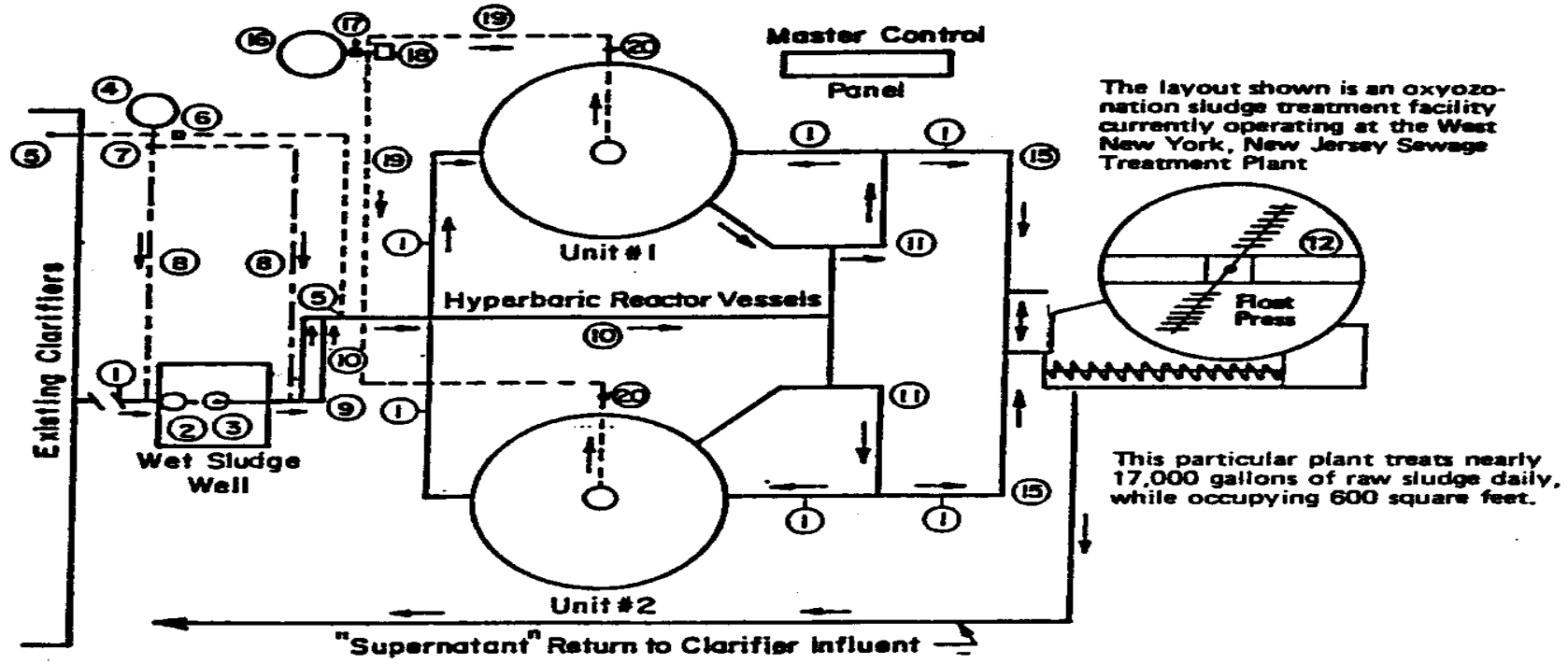
Combined Flotation-Screwpress Process for Sludge Thickening





A. Influent Feeding Pipe
B. Emptying Pipe
C. Pipe for Recycle Suction
D. Pressurized Water Pipe
E. Dissolved Air Flotation Thickener
F. Sludge Screw Press

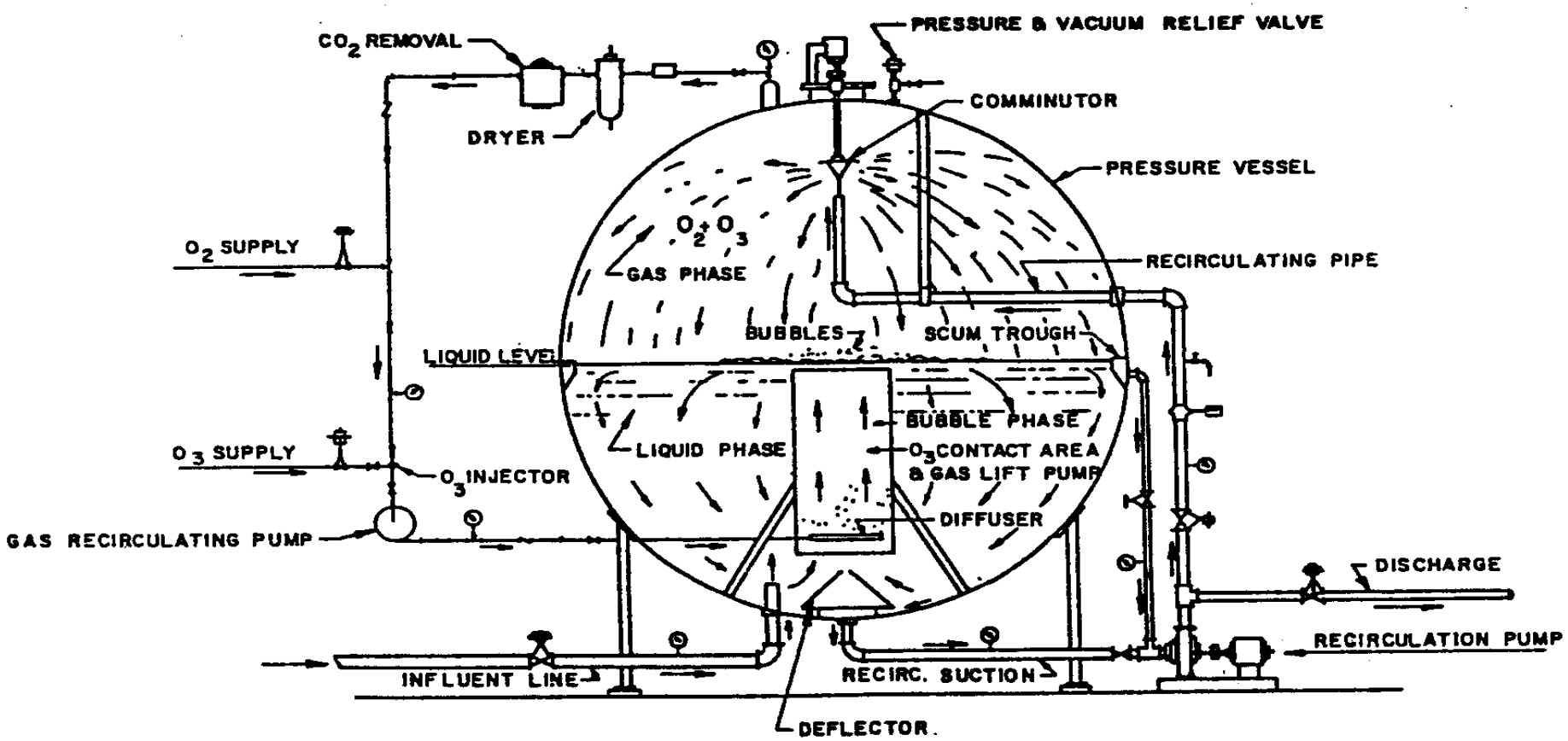
What are theory and principles of Ozonation-Oxygenation Flotation (Oxyozosynthesis) System ?



LEGEND

1 Pinch Type Flow Control Valve
2 Sludge Grinder
3 Mixer
4 Chemical Solution Storage Tank
5 PH Probe
6 PH Control Device
7 Chemical Solution Feed Pump
8 Chemical Feed Lines
9 Variable Speed Progressive Cavity Pump
10 Influent Pump
11 Progressive Cavity Recilculation Pump
12 Float Press
15 Auxiliary Sludge Removal
16 Oxygen Storage Tank
17 Oxygen Supply Control Device
18 Ozone Generator
19 0_2 and 0_3 Feed Line
20 Gas Recilculation and Gas Feed Line

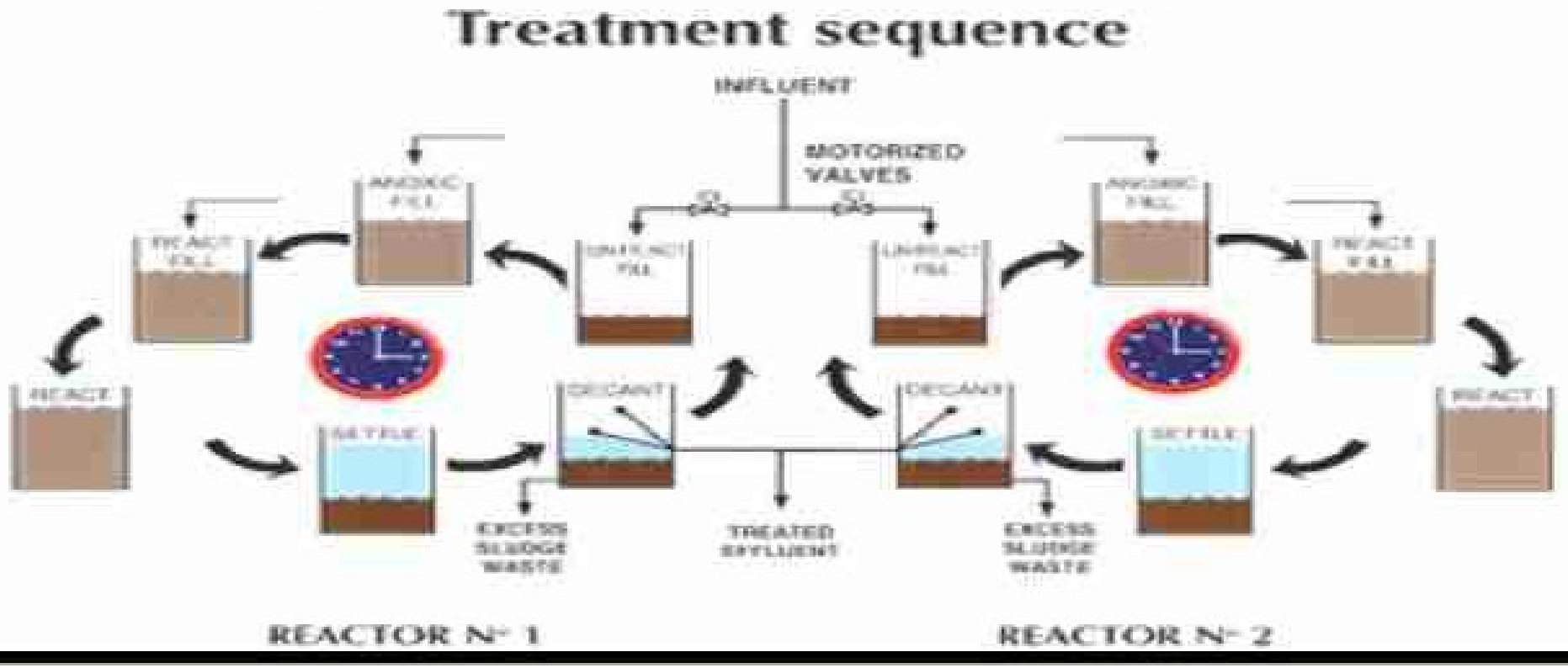
Solution: Ozonation-Oxygenation (Hyperbaric) Reactor



HYPERBARIC REACTOR VESSEL

Sequencing Batch Reactor (SBR)- Flotation or Sedimentation Biological or Physicochemical

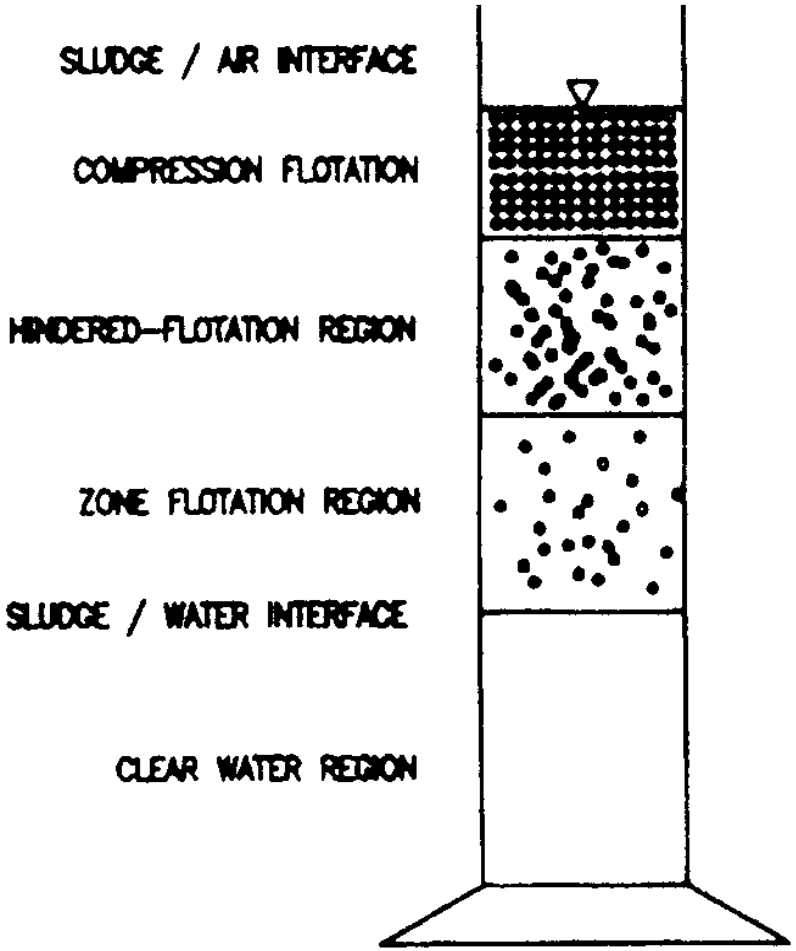
SBR A CONTINUOUS PROCESS "IN BATCH"

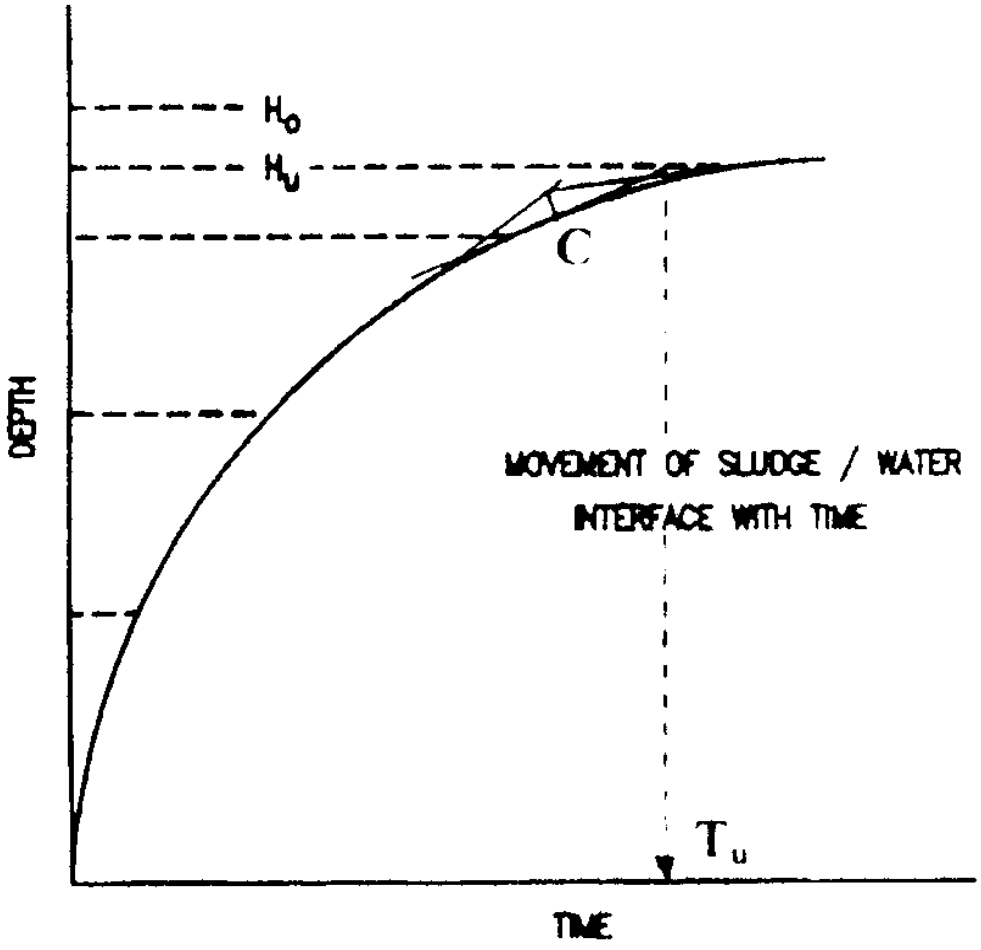


Flotation System Improvements

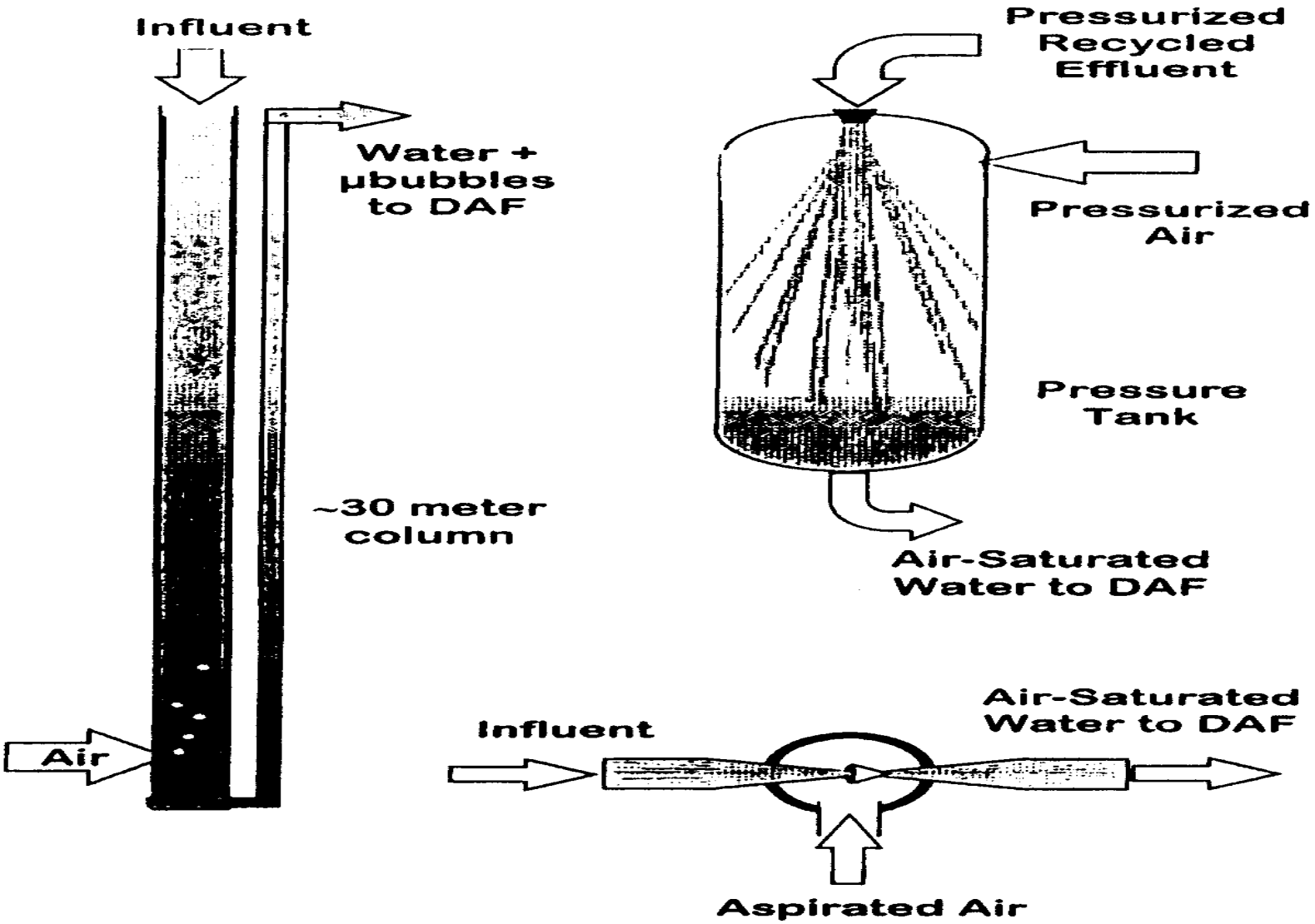
- Flotation Reactor Improvement
- Improved Sludge Thickening
- Improved Secondary DAF Clarification
- Improved Primary DAF Clarification
- Both Primary and Secondary Clarification
- Primary, Secondary and Tertiary Clarification
- Combined Chemical and Biological Treatment

Improved Flotation Reactors

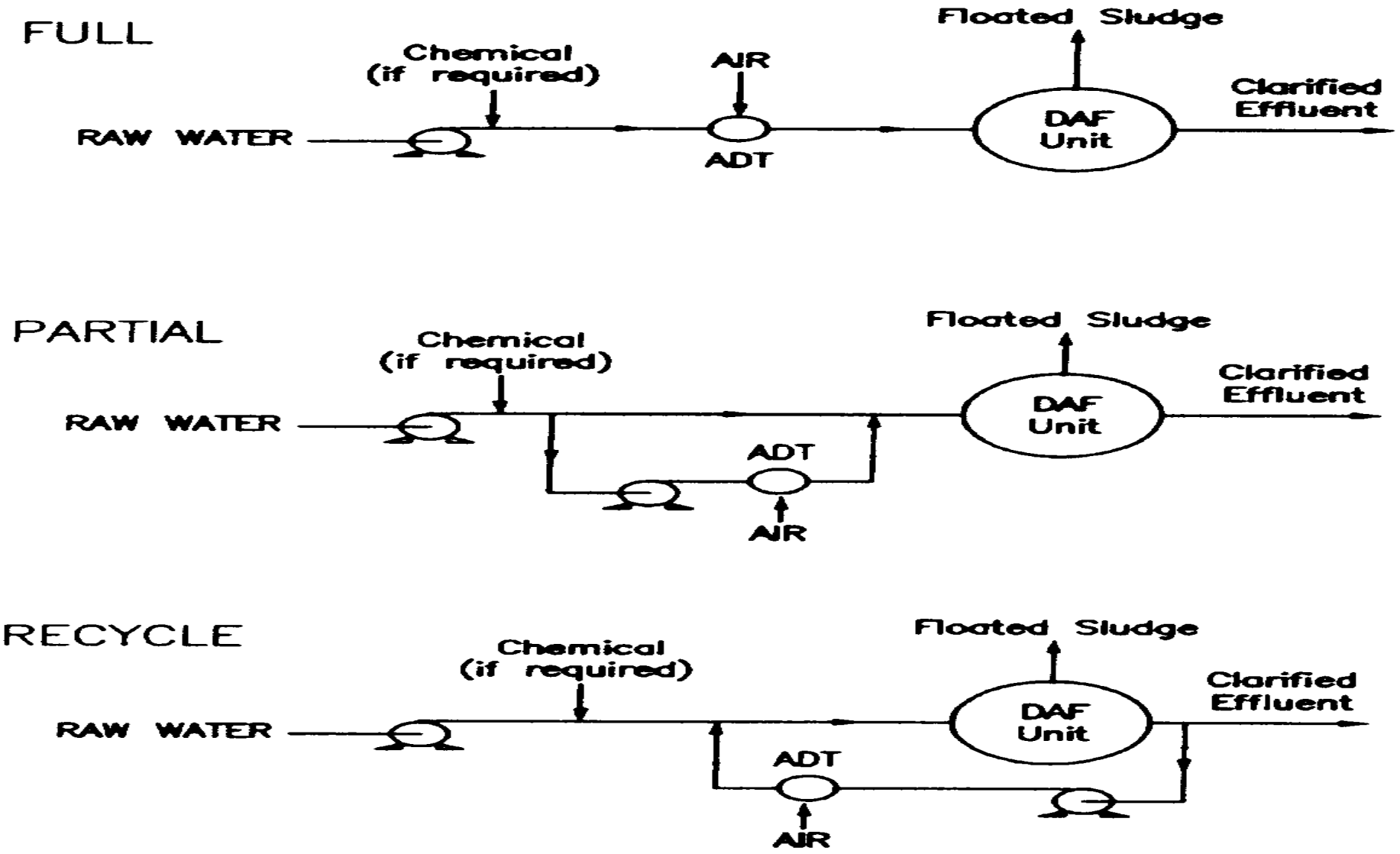




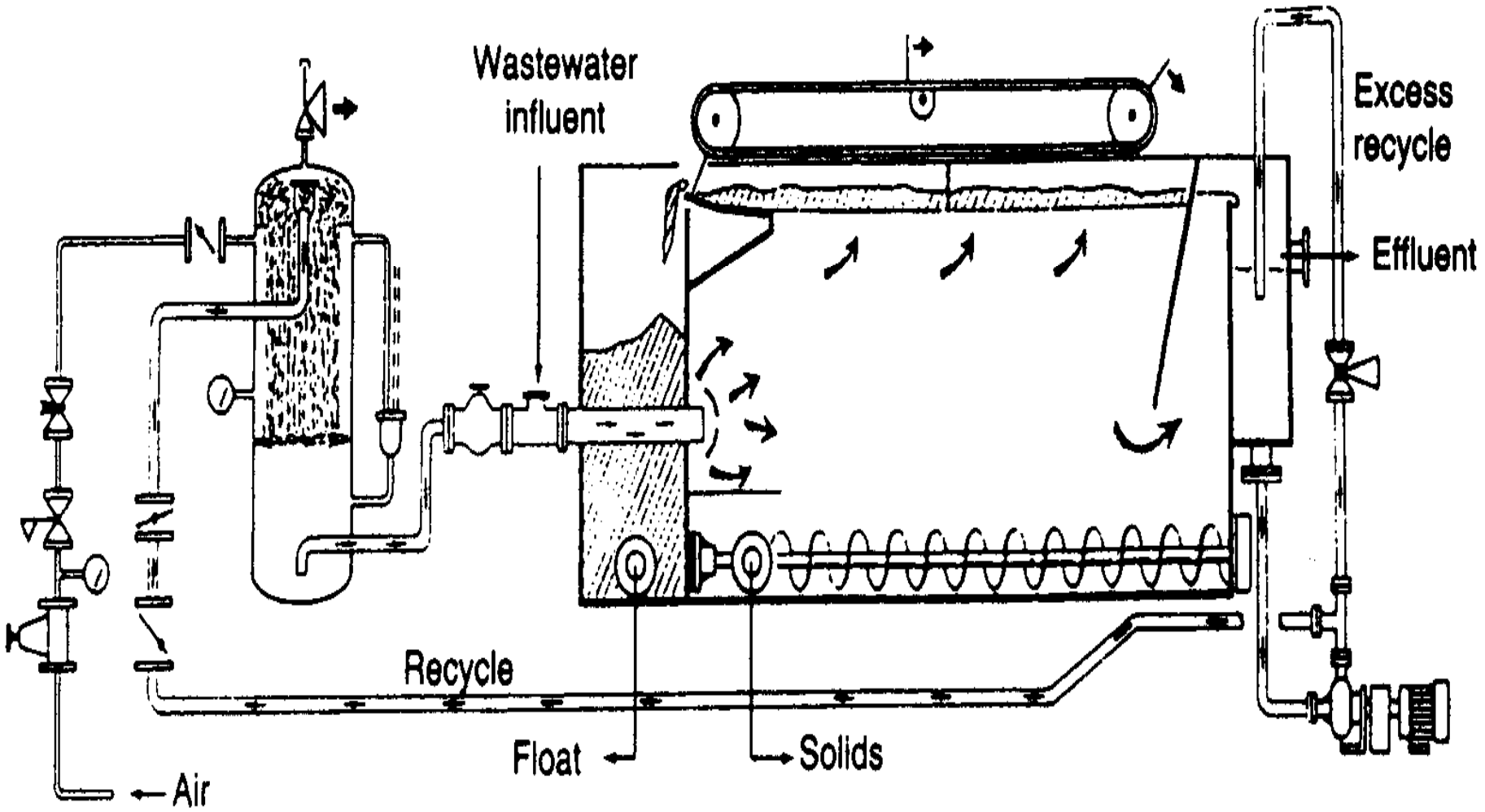
Improved Gas Dissolving



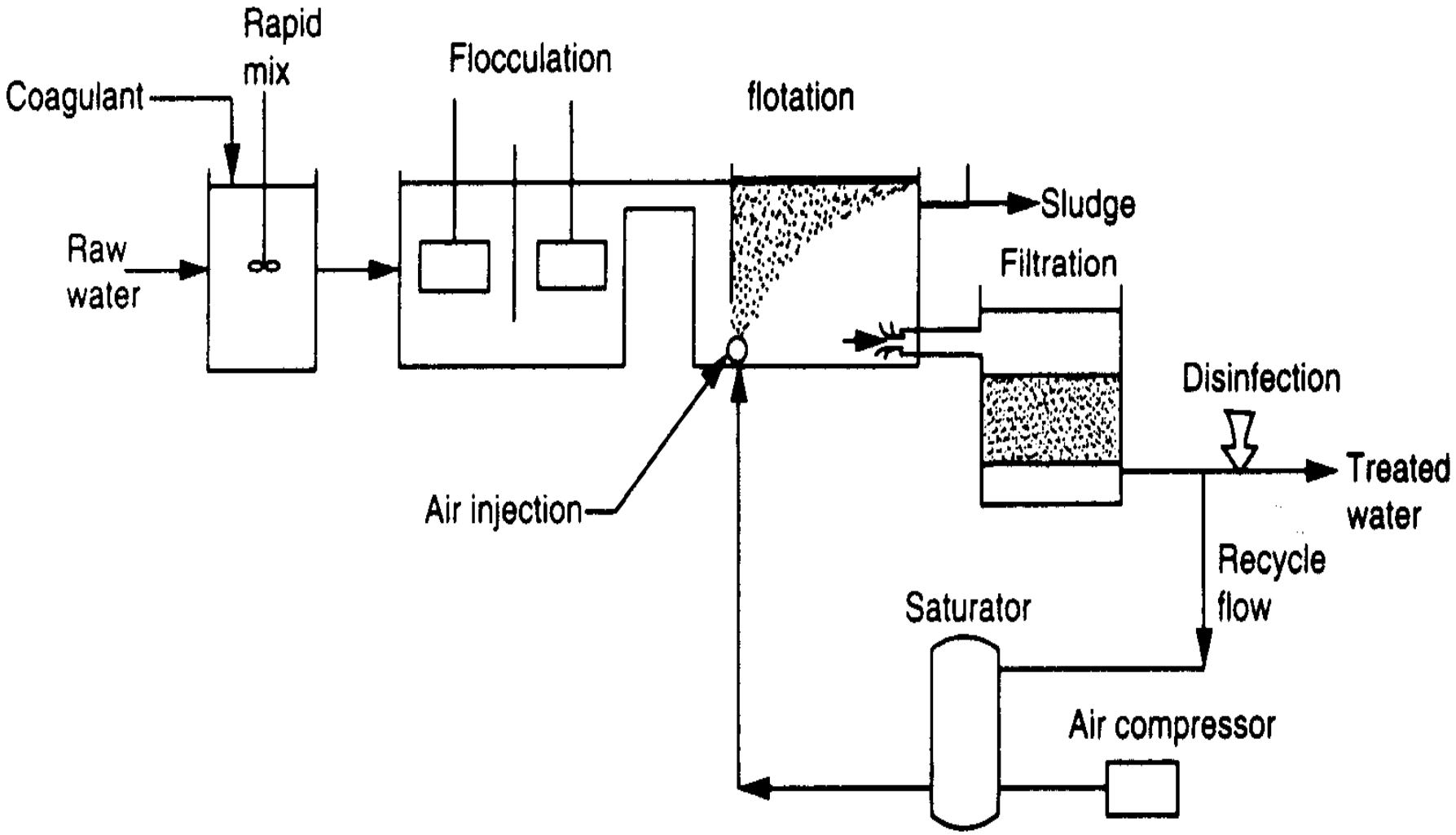
What are the improved optional modes ?



Solution-Example: Package Flotation Clarifier

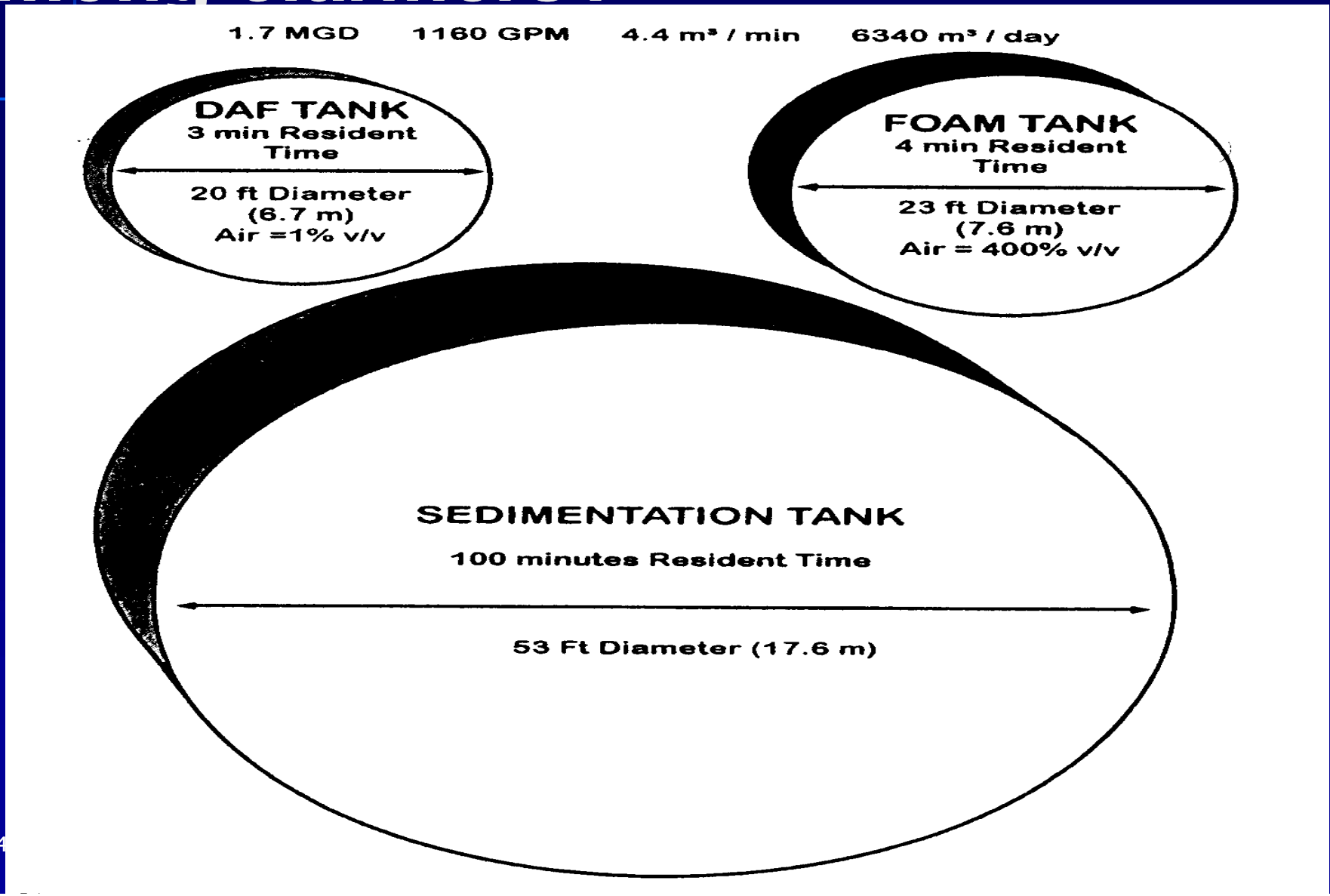


Complete Flotation WWT System

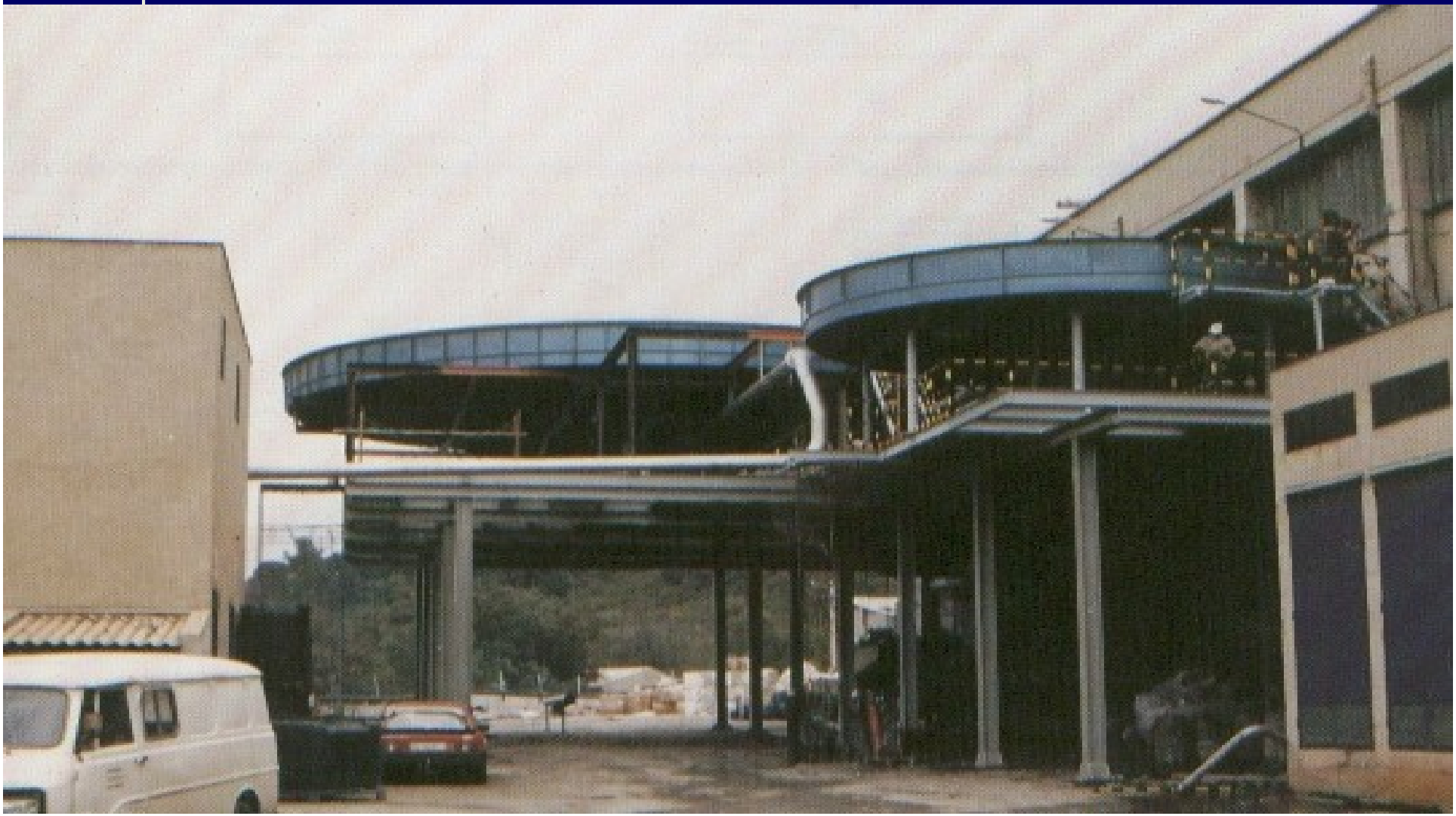


Complete Flotation Clarifier versus Sedimentation Clarifier

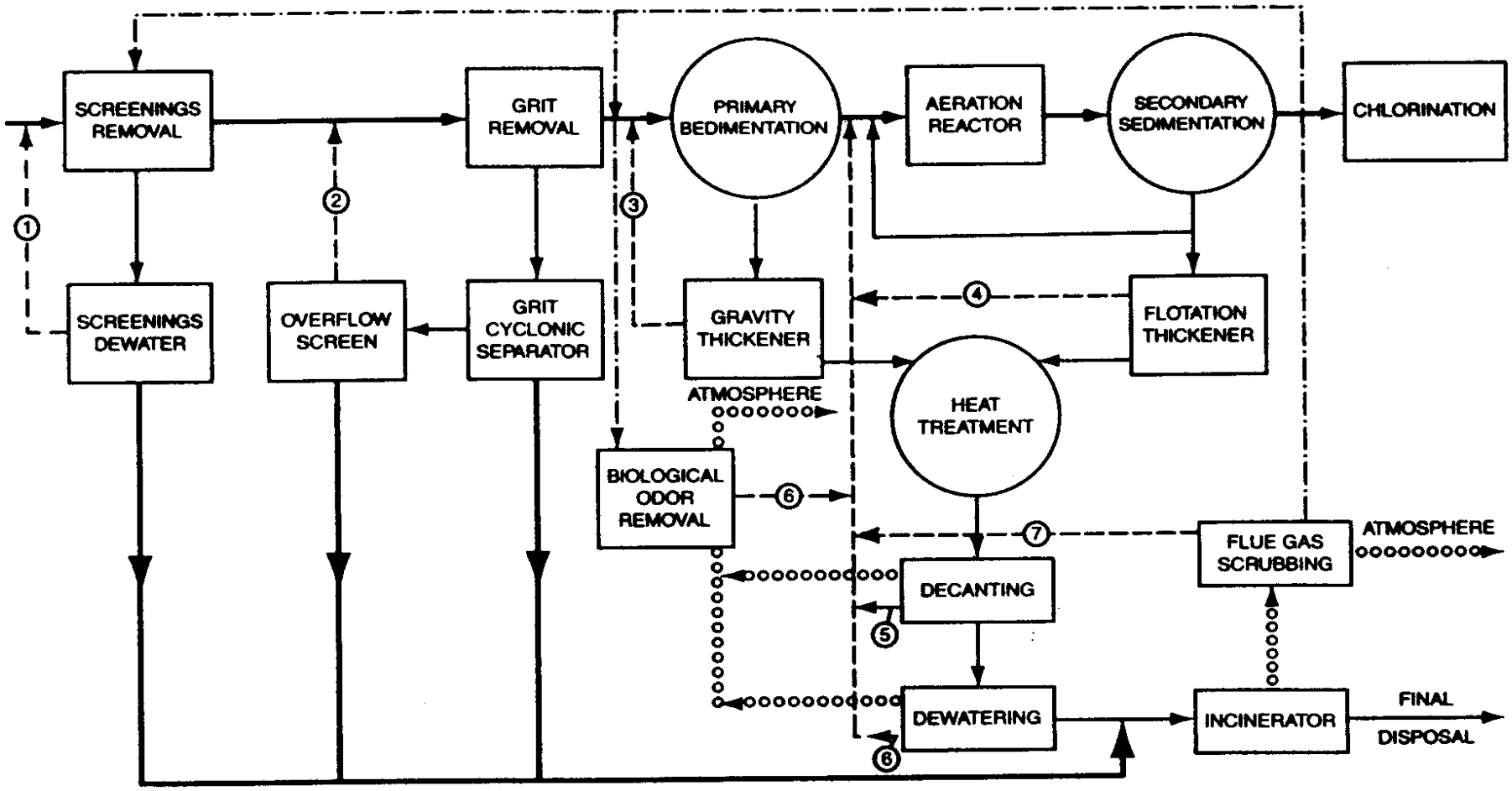
What is the footprint comparisons among clarifiers?



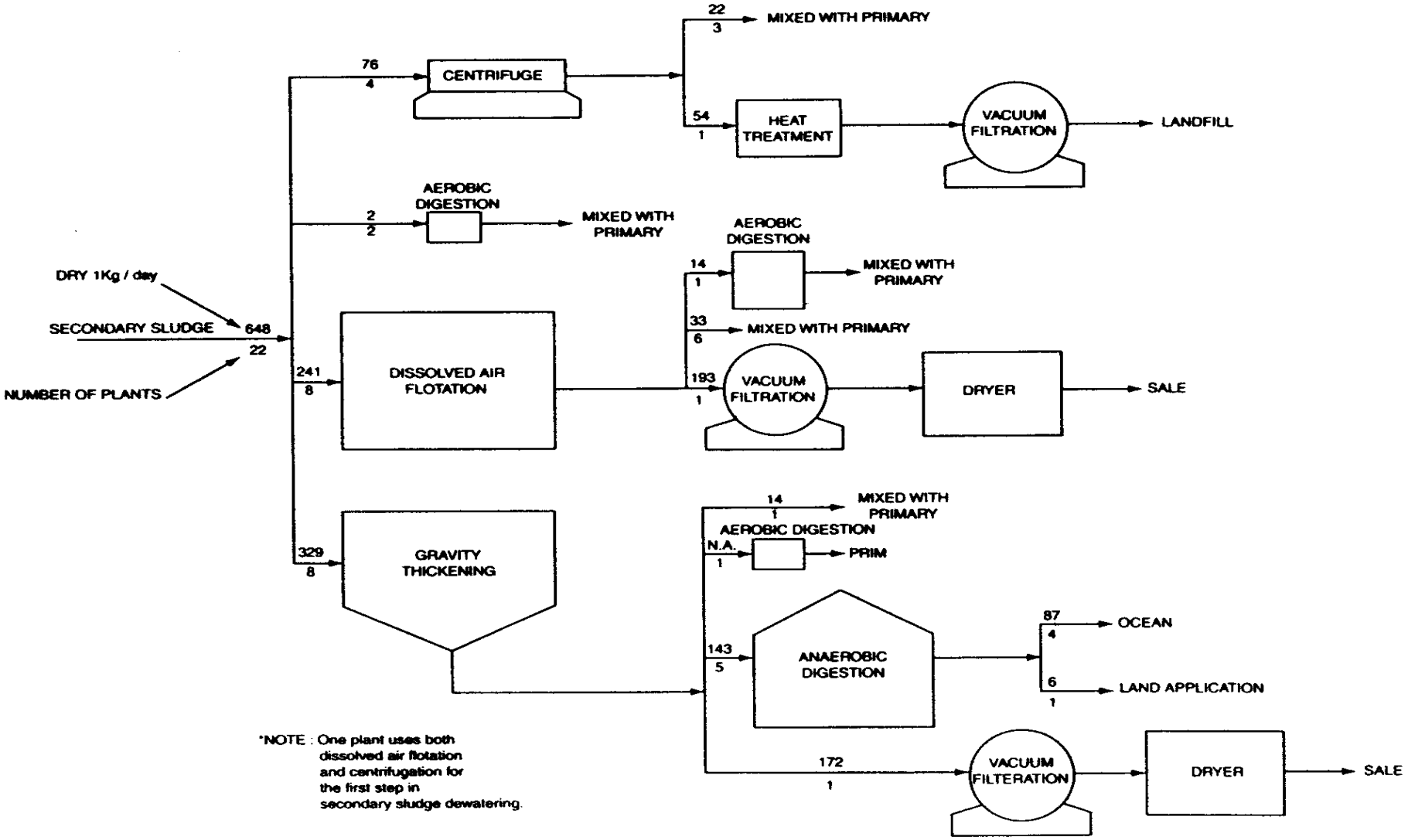
Solution: Almost Zero Footprint



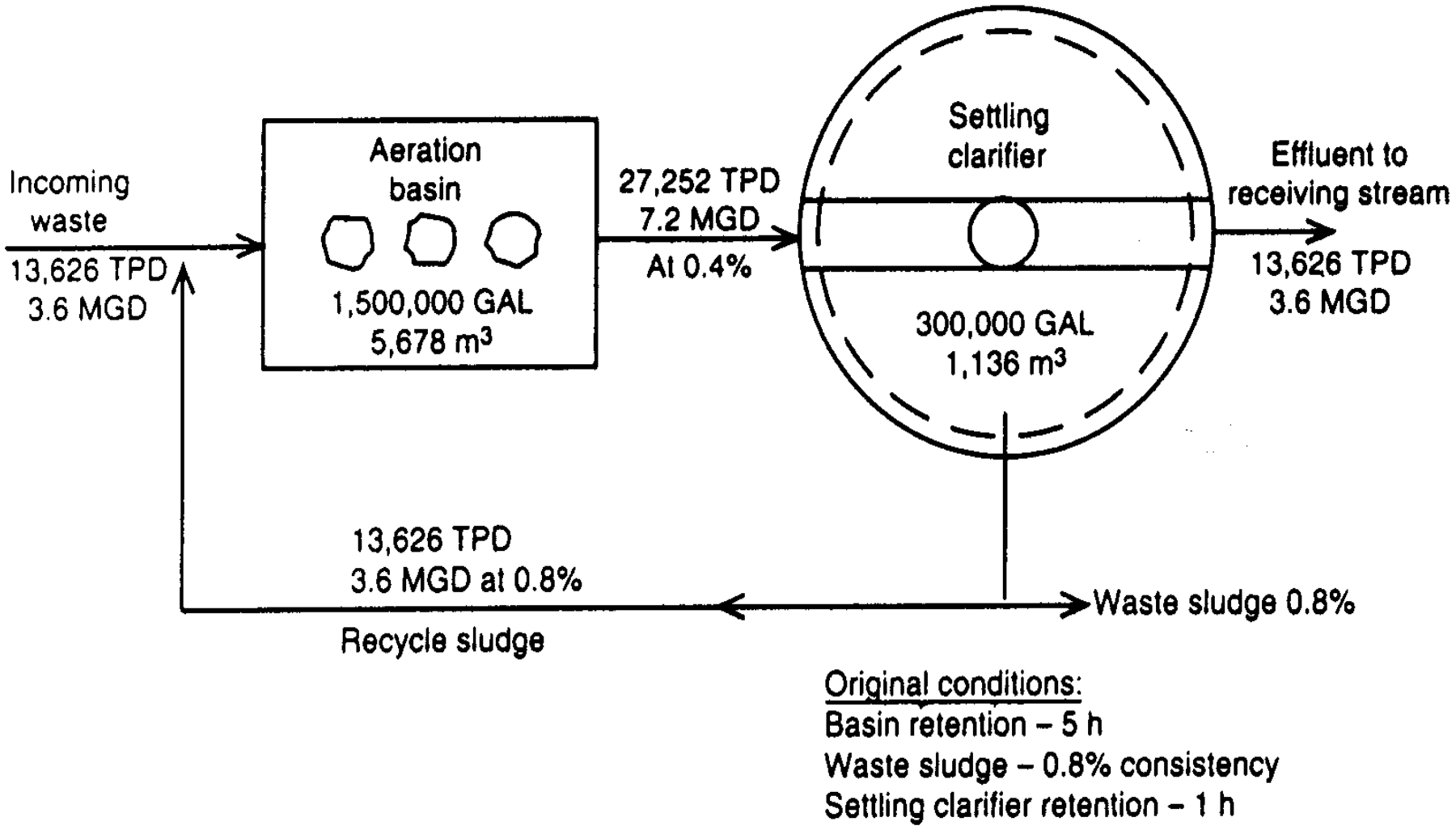
Traditional DAF Application -- Sludge Thickening --



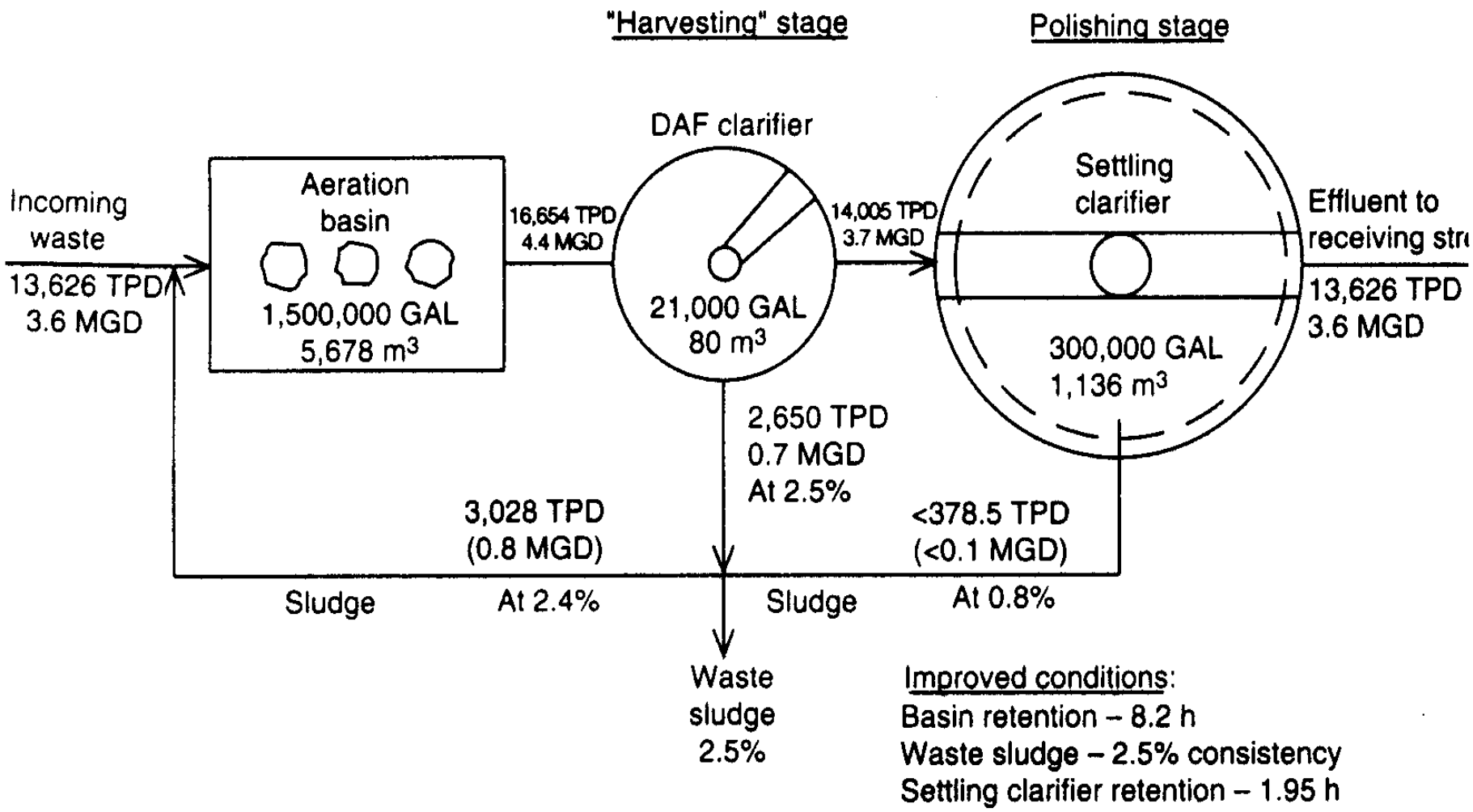
Improved Sludge Treatment
Source: USEPA



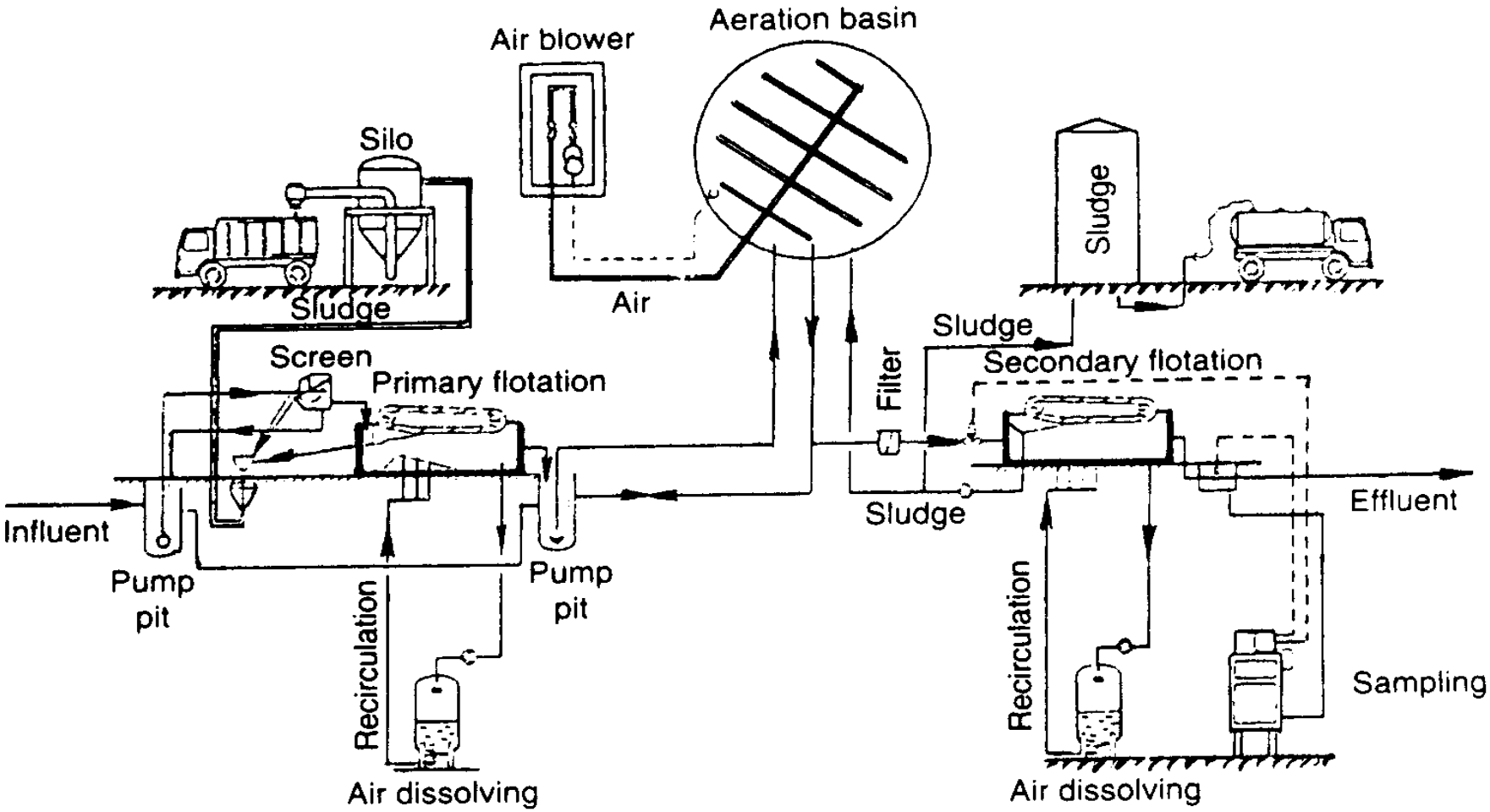
How can a troubled secondary clarification be corrected?



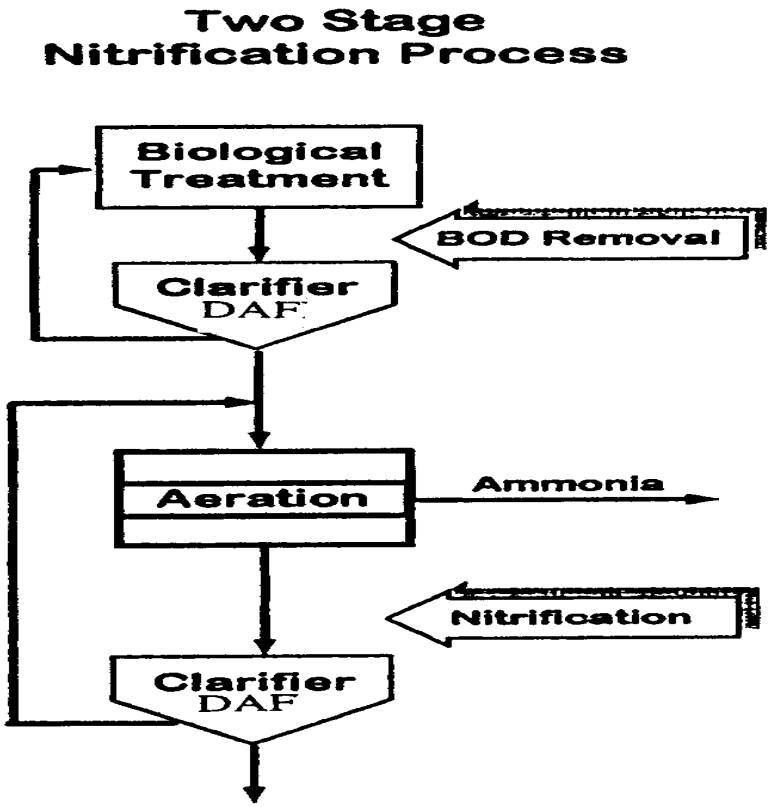
Solution: Improved Secondary Clarification

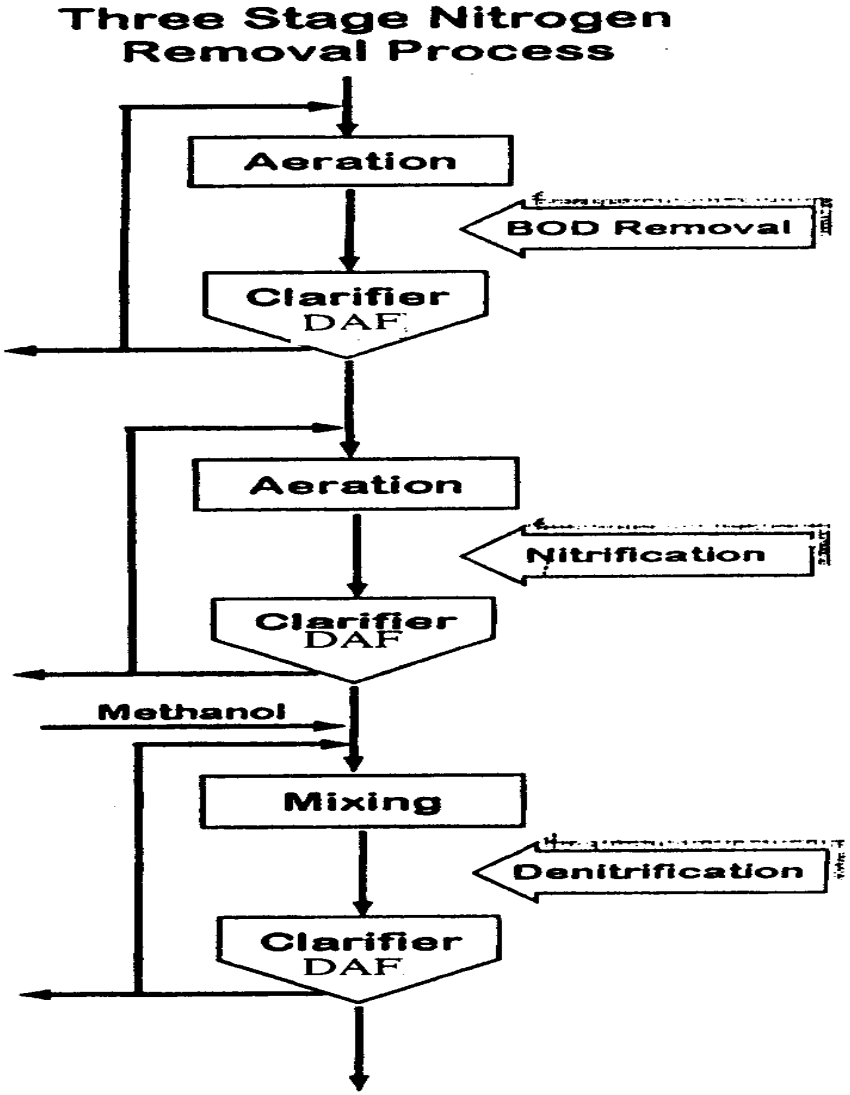


Solution: Both Primary & Secondary Flotation – Dairy WWT

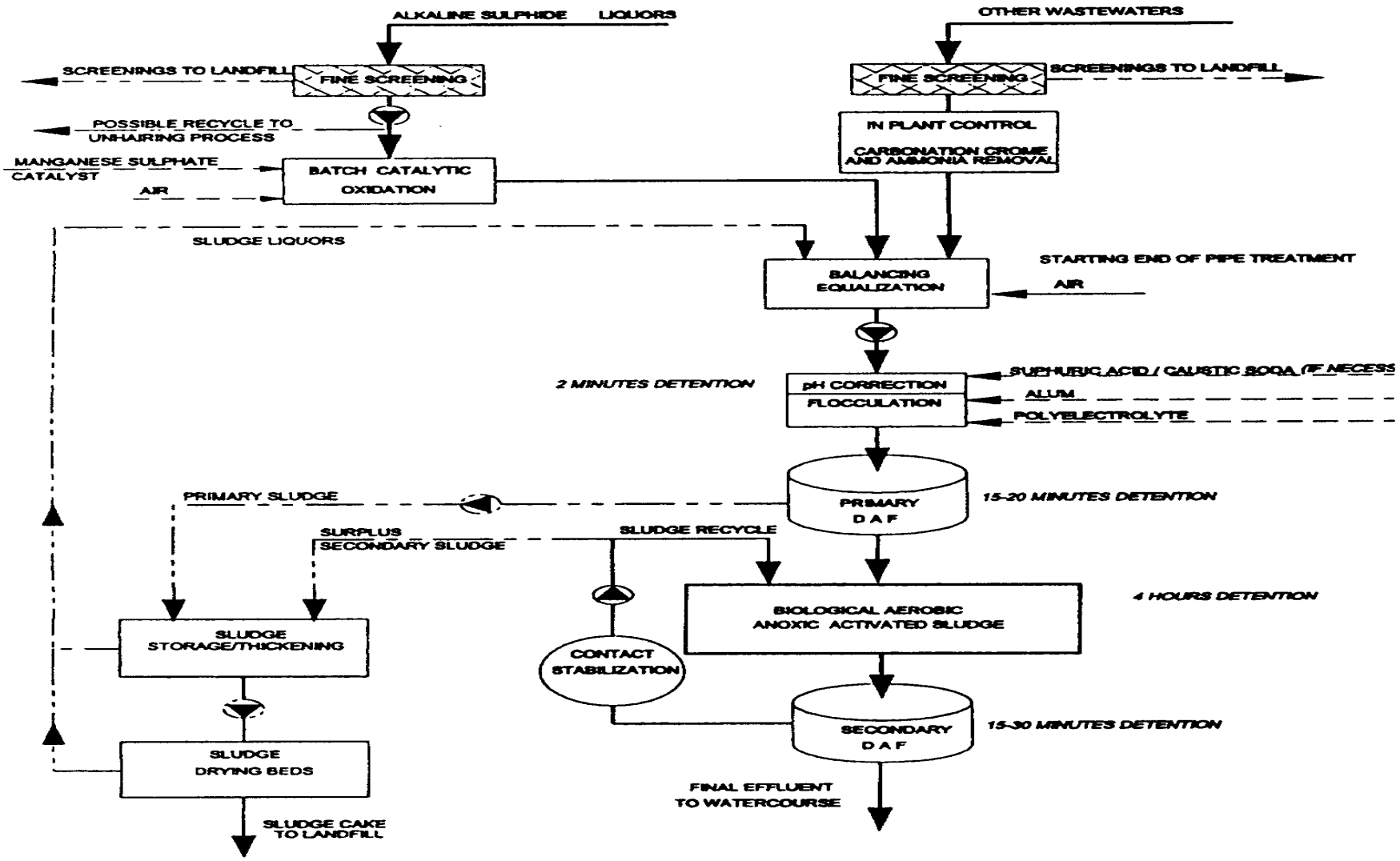


Solution: Improved Nitrification and Denitrification Processes

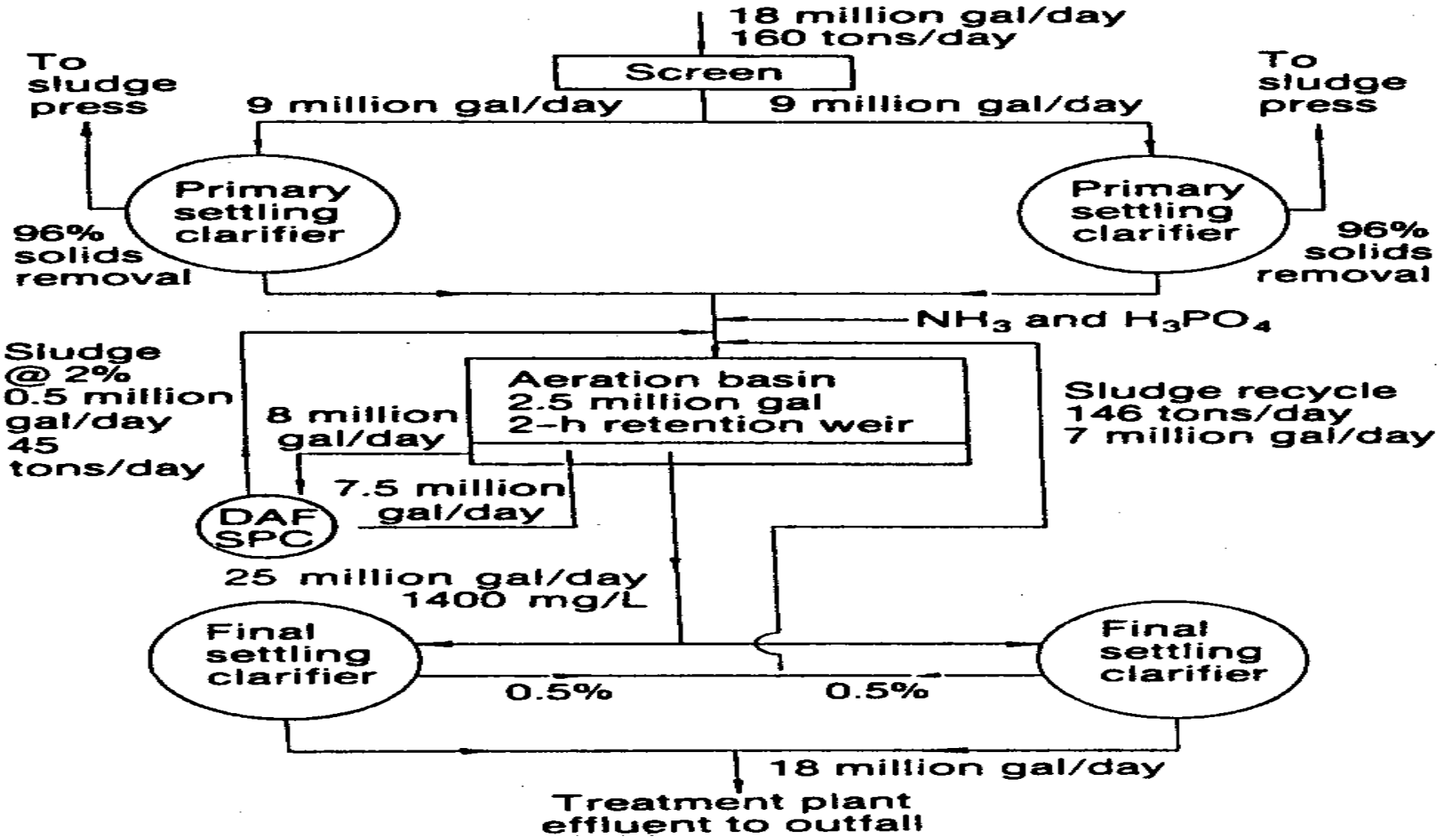




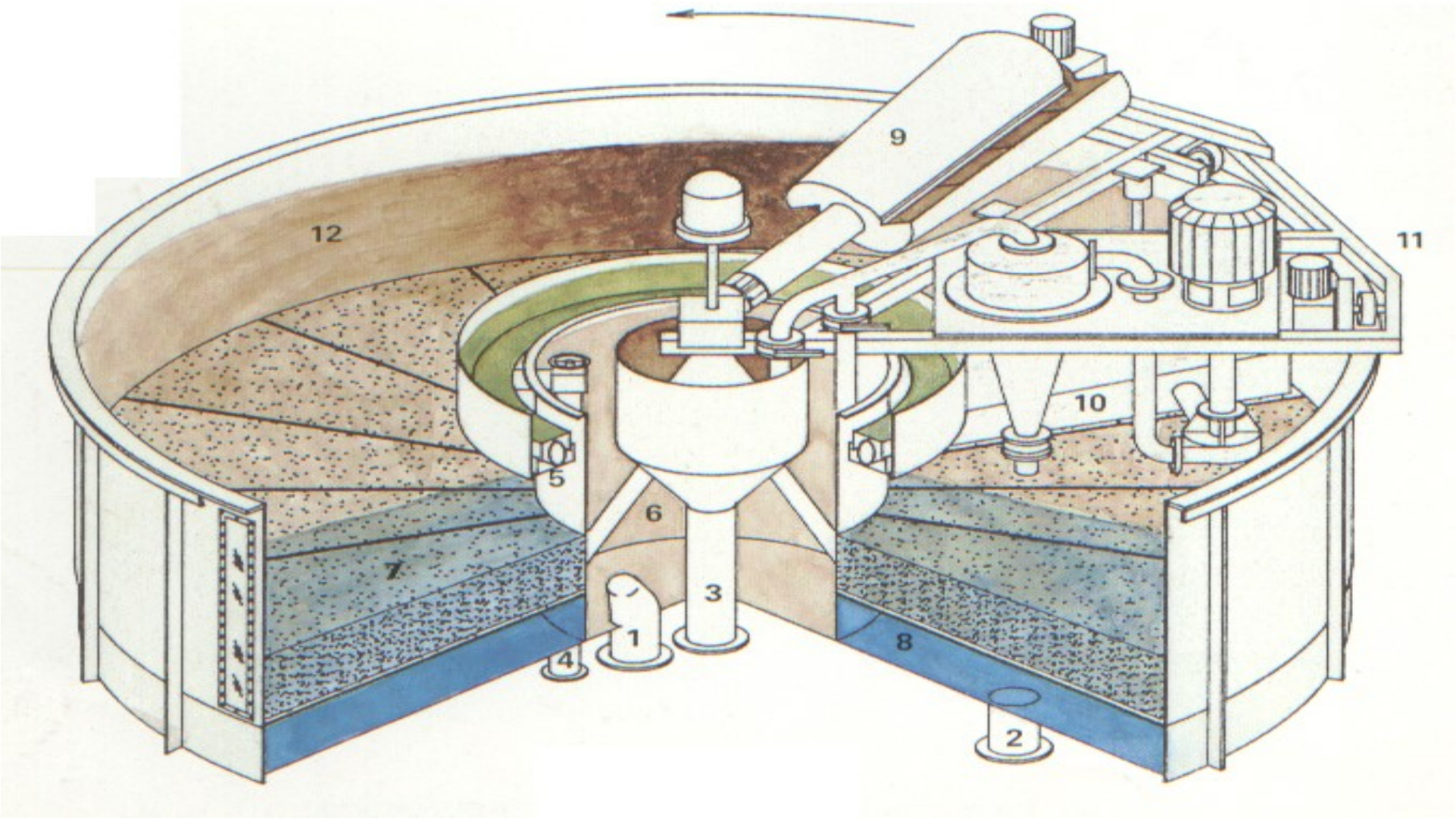
Chemical-Biological Treatment of Tannery Wastewaters



Solution: Champion International Corp (Paper Mill) WWT Improvement



Tertiary DAF-Filtration Clarifier

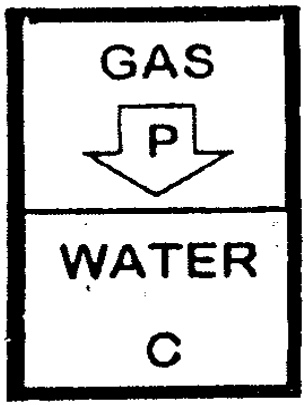


USEPA DAF Performance Data

Control Technology Summary for Dissolved Air Flotation

Pollutant	Effluent concentration		% Removal
	Range	Median	
Classical pollutants (mg/L)			
BOD (5-d)	140–1000	250	68
COD	18–3200	1200	66
TSS	18–740	82	88
Total phosphorus	<0.05–12	0.66	98
Total phenols(a)	>0.001–23	0.66	12
Oil and grease	16–220	84	79
Toxic pollutants (µg/L)			
Antimony	ND–2300	20	76
Arsenic	ND–18	<10	45
Xylene	ND–1000	200	97
Cadmium	BDL–<72	BDL	98[a]
Chromium	2–620	200	52
Copper	5–960	180	75
Cyanide	<10–2300	54	10
Lead	ND–1000	70	98
Mercury	BDL–2	BDL	75
Nickel	ND–270	41	73
Selenium	BDL–8.5	2	NM
Silver	BDL–66	19	45
Zinc	ND–53000	200	89
Bis(2-etHylhexyl) phthalate	30–1100	100	72
Butyl benzyl phthalate	ND–42	ND	>99
Carbon tetrachloride	BDL–210	36	75
Chloroform	ND–24	9	58
Dichlorobromomethane		ND	>99
Di-*N*-butyl phthalate	ND–300	20	97
Diethyl phthalate		ND	>99
Di-*N*-octyl phthalate	ND–33	11	78
N-nitrosodiphenylamine		620	66
2,4-Dimethylphenol	ND–28	14	>99
Pentachlorophenol	5–30	13	19
Phenol	9–2400	71	57
Dichlorobenzene	18–260	140	76
Ethylbenzene	ND–970	44	65
Toluene	ND–2100	580	39
Naphthalene	ND–840	96	77
Anthracene/phenanthrene	0.2–600	10	81

How can the greenhouse gas be utilized in treating industrial effluents?



P = Pressure of the the gas

Note: 1 atm = 1.01 Bar = 14.7 psi

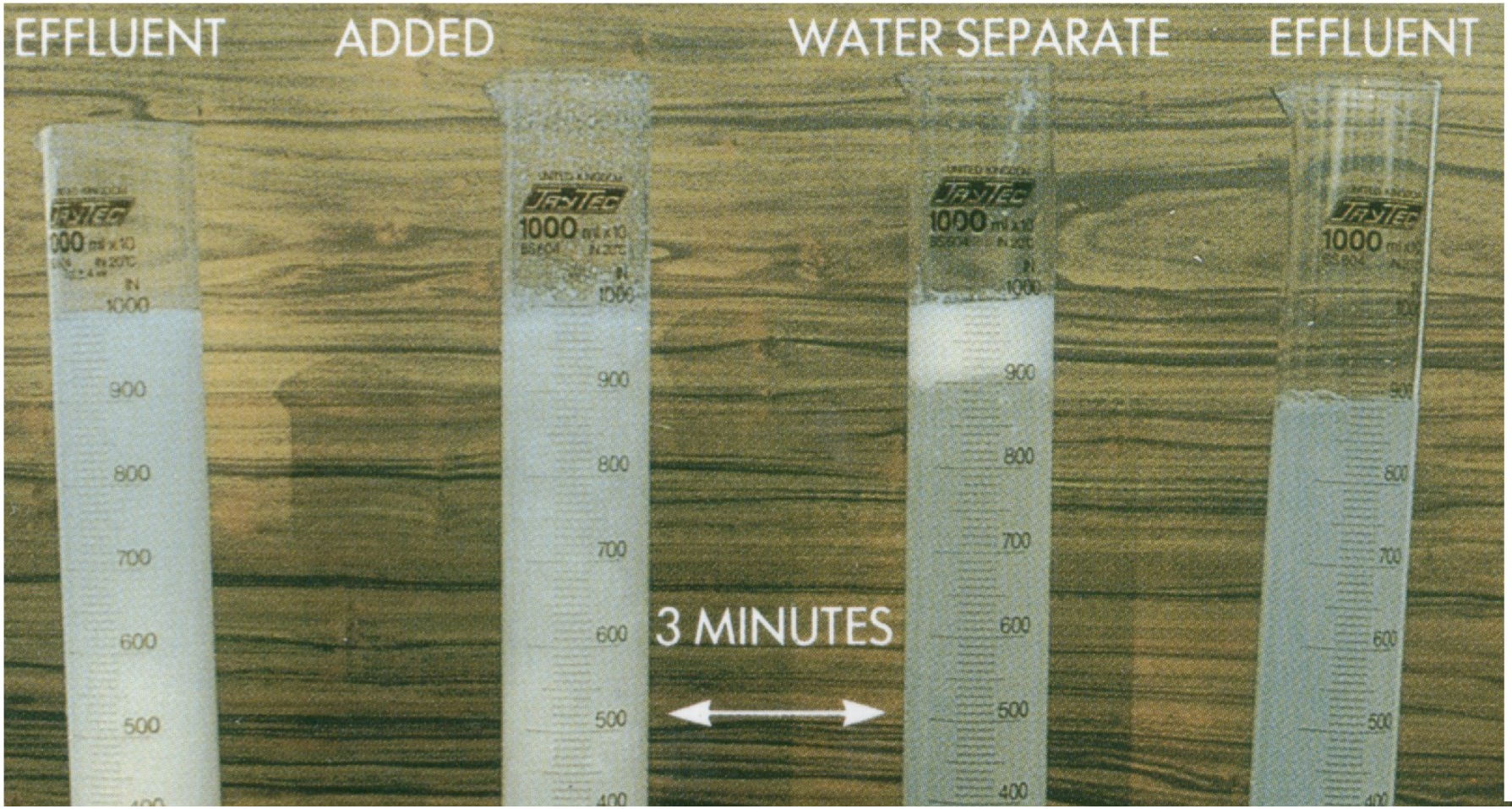
C = Concentration of the gas in a saturated solution

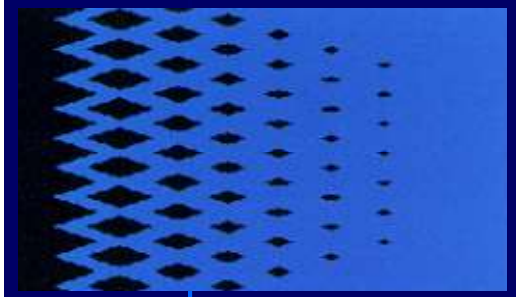
mL(STP) / 100 mL water = % v/v gas / water

Solubilities of some gasses, P = 1 atm

Temp °C	Air	Oxygen	Nitrogen	Hydrogen	CO_2
4	2.63	4.40	2.14	0.206	14.7
20	1.87	3.10	1.54	0.182	8.78
50	1.30	2.09	1.09	0.161	4.36

Solution: Carbon Dioxide Flotation of Dairy Factory Effluent





29th National Engineers Week Conference,Albany Marriott, Wolf Road, Albany, NY 12233
Training Seminar, February 5 & 6, 2009

Chemical and Biochemical Technologies for Environmental Infrastructure Sustainability

- Conference Speakers:
- Lawrence K. Wang, PE, PhD, DEE
- and Mu-Hao S. Wang, PE, PhD, DEE

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