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Chapter 5 : **Wastewater Treatment**

5.1. Introduction

5.2 Mechanical Treatment



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5.1 Introduction

Objectives:

- Remove pollutants from wastewater
- Compliance with law
- Conditioning and disposal or recycling of sludge (organic and inorganic residual material)
- Fulfillment of tasks has to be done economically and reliably

WWT is expected to avoid or minimize environmental degradation or impairment of health.

The choice of a treatment or pre-treatment technology depends on the water constituents:

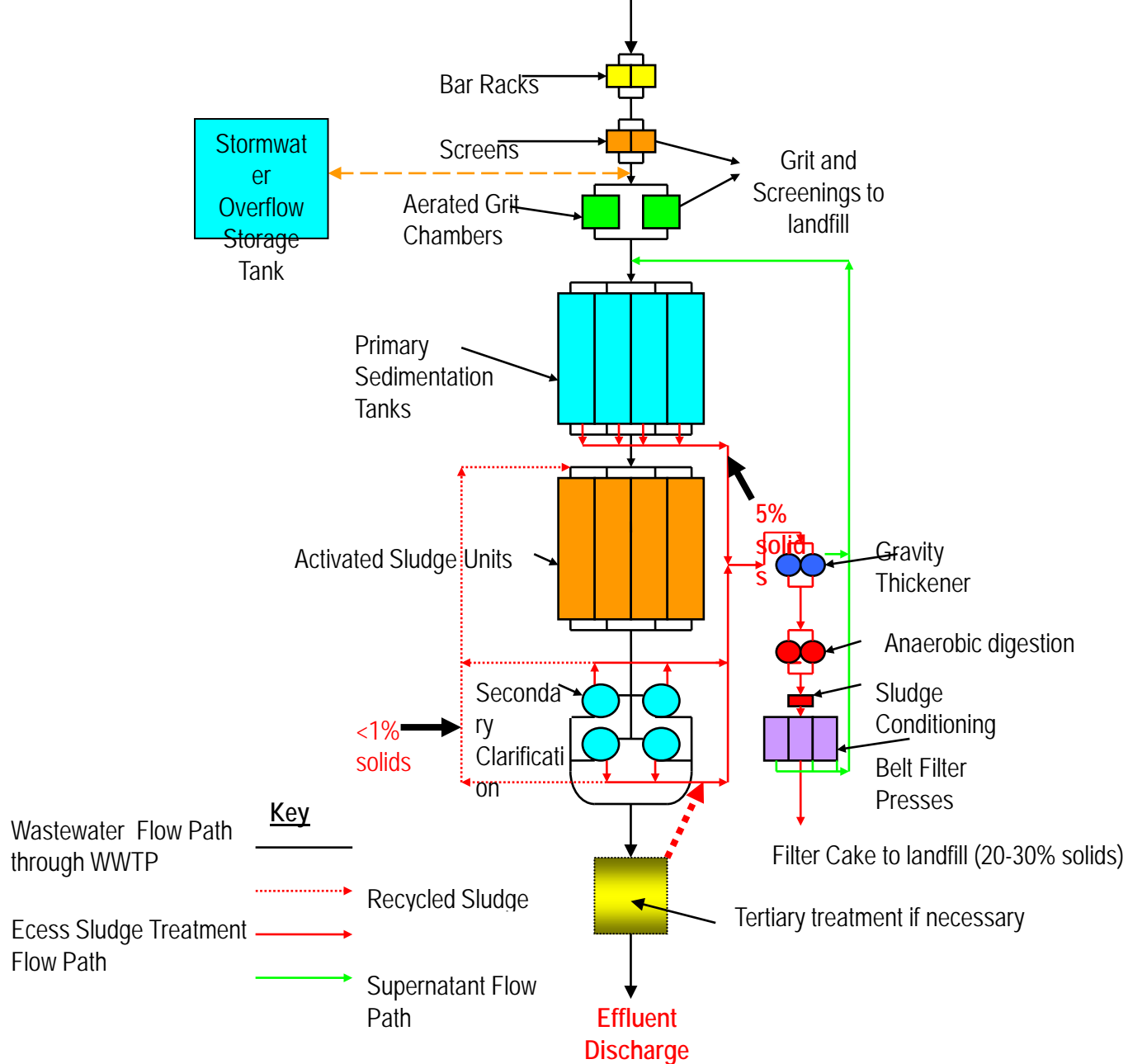
- Size
- Dissolved/suspended
- Organic/inorganic
- Biodegradable/non biodegradable
- Toxic/non toxic

Treatment technologies:

Mechanical	(primary)
Biological	(secondary)
Physical-chemical-biological	(tertiary, advanced)

Contaminant	Treatment Techniques
Suspended solids	<ul style="list-style-type: none"> - Coagulation/flocculation - Sedimentation - Flotation - Filtration
pH	<ul style="list-style-type: none"> - Neutralisation
Insoluble organics	<ul style="list-style-type: none"> - Separators
Biodegradable organics	<ul style="list-style-type: none"> - Aerobic - Anaerobic
Volatile organics	<ul style="list-style-type: none"> - Air stripping - Steam stripping - Distillation - Activated carbon - Evaporation
Metals	<ul style="list-style-type: none"> - Chemical coagulation - Ion exchange
Ammonia	<ul style="list-style-type: none"> - Ammonia stripping
Nutrients (N)	<ul style="list-style-type: none"> - Suspended-growth nitrification and denitrification variations - Fixed-film nitrification and denitrification variations - Ion exchange - Breakpoint chlorination - Natural systems

Nutrients (P)	<ul style="list-style-type: none"> - Metal-salt addition - Lime coagulation - Biological phosphorus removal - Biological-chemical phosphorus removal
Nutrients (N+P)	<ul style="list-style-type: none"> - Biological removal
Refractory organics	<ul style="list-style-type: none"> - Carbon adsorption - Ozonation - Supercritical water oxidation - Wet air/oxygen oxidation - Chemical oxidation
Dissolved organic solids	<ul style="list-style-type: none"> - Ion exchange - Membranes - Carbon adsorption



Scheme of WWTP

Mechanical treatment

Preliminary

Screens, sieves

Grit chamber

Grease separator

Primary: sedimentation, flotation

Biological treatment

Biological reactor (attached or suspended growth, e.g. AS, TF)

Secondary clarifier

Return sludge (only in case of AS)

Sludge treatment

Thickener (dewatering)

Digester (Biogas)

Sludge container

Recycling / Disposal

Advanced water treatment (AWT)

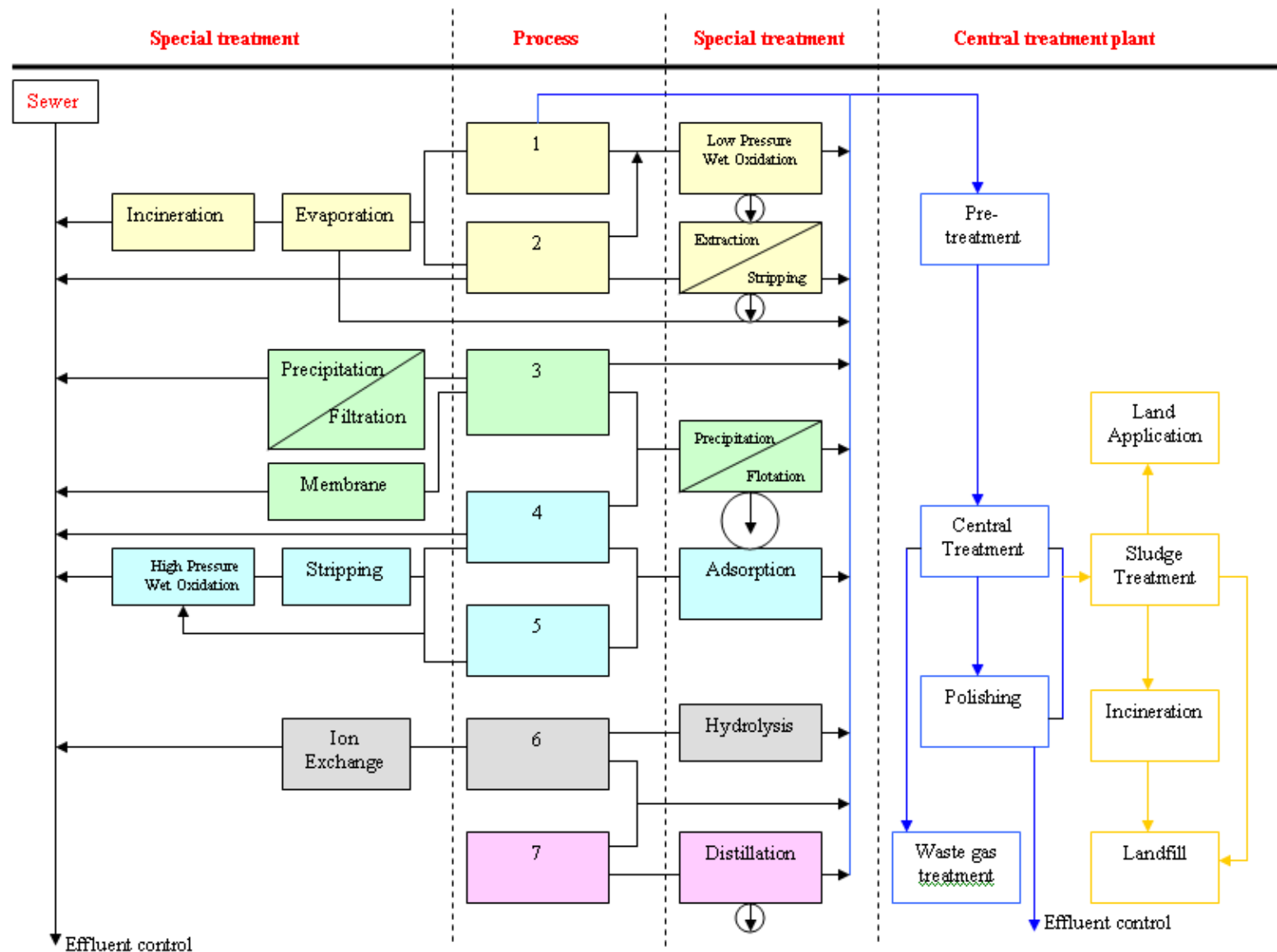
Physical

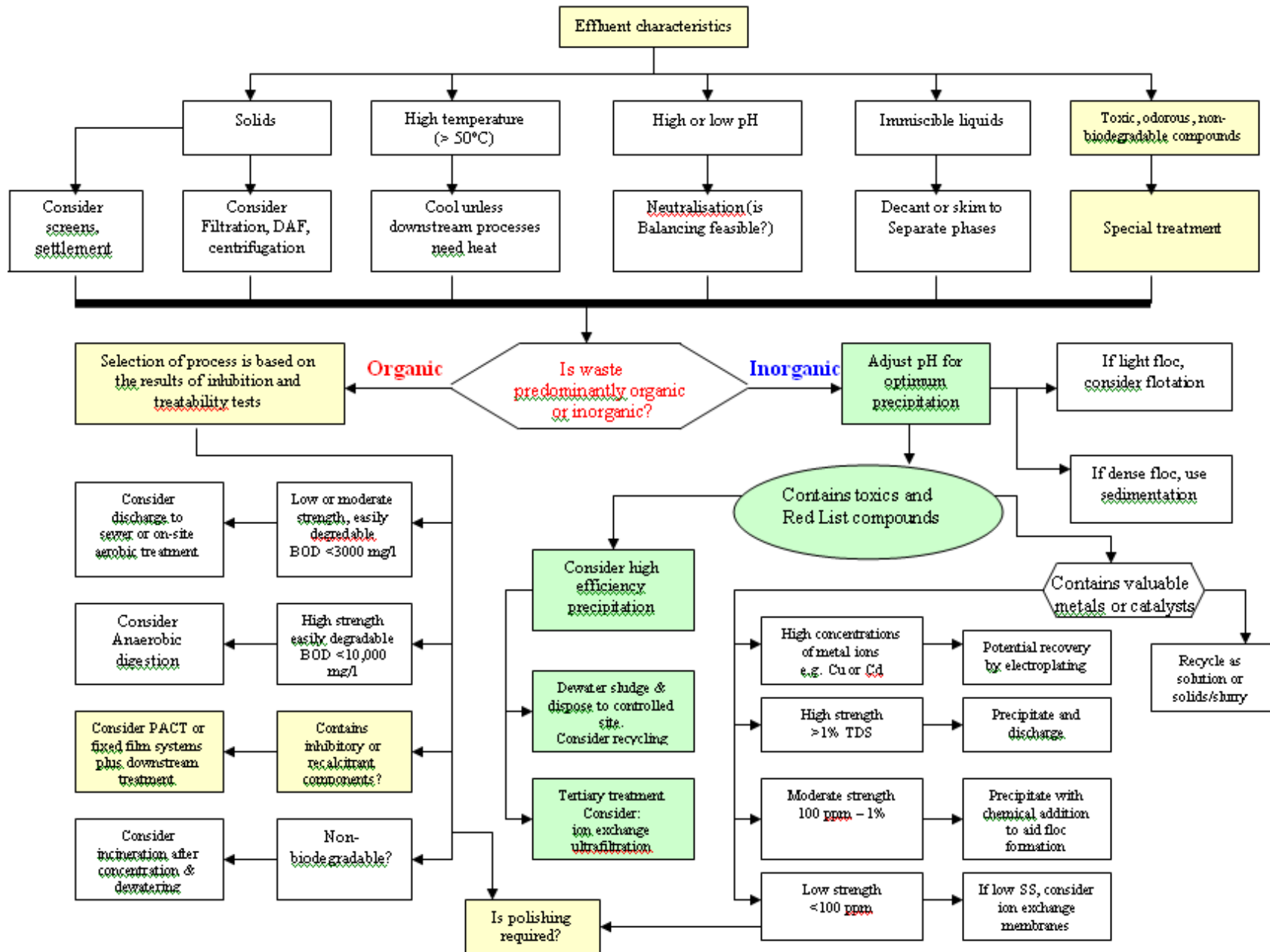
Chemical

Biological

Disinfection

Potential Special and Pre-treatment Techniques For Wastewater





5.2. Mechanical Wastewater Treatment

Total pollutant load of wastewater consist of a certain percentage (30 to 40 % in domestic water) undissolved matter.

As biological treatment is energy intensive and sensible, the mechanical pre-treatment has to reduce the load inflow to the biological treatment.

Need For Pre-treatment

- Protect downstream units
- Avoid blockages
- Prevent grit accumulation in reactors (digesters etc)
- Flow measurement
- Particle size reduction
- Removal of floating matter, especially if only treatment process
 - plastic, grease, faeces etc
- Odour control needed
- Improvement in downstream treatment process efficiency

Pre-treatment Units Used

- Screens
 - at stormwater overflow or at pumping station in sewer
 - at treatment plant inlet
- Grit removal
 - sand,silt,metal etc
- Flotation
 - grease
- Aeration
- Flow measurement (usually venturi meter)

5.2.1 Screens & Sieves

Screens

Usually the screening system is the very first stage of treatment at every conventional WWTP.

Screens are divided into:

Finest screening	spacings	< 8 mm
Fine screening	spacings	8 to 20 mm
Coarse screening	spacings	20 to 100 mm

- Clearance of the screen is done automatically and usually triggered by a certain difference of water level.
- The cleaning device is driven with chains, ropes or hydraulic systems.

- Screenings amounts up to 3 to 15 l / P*y
- By compressing (incl. dewatering) the volume of screenings can be reduced to about 50 to 30 %.
- Screenings are collected in containers and finally disposed of at landfills.

Despite the very simple principle, screens require a professional planning and construction and are very intensive in service.

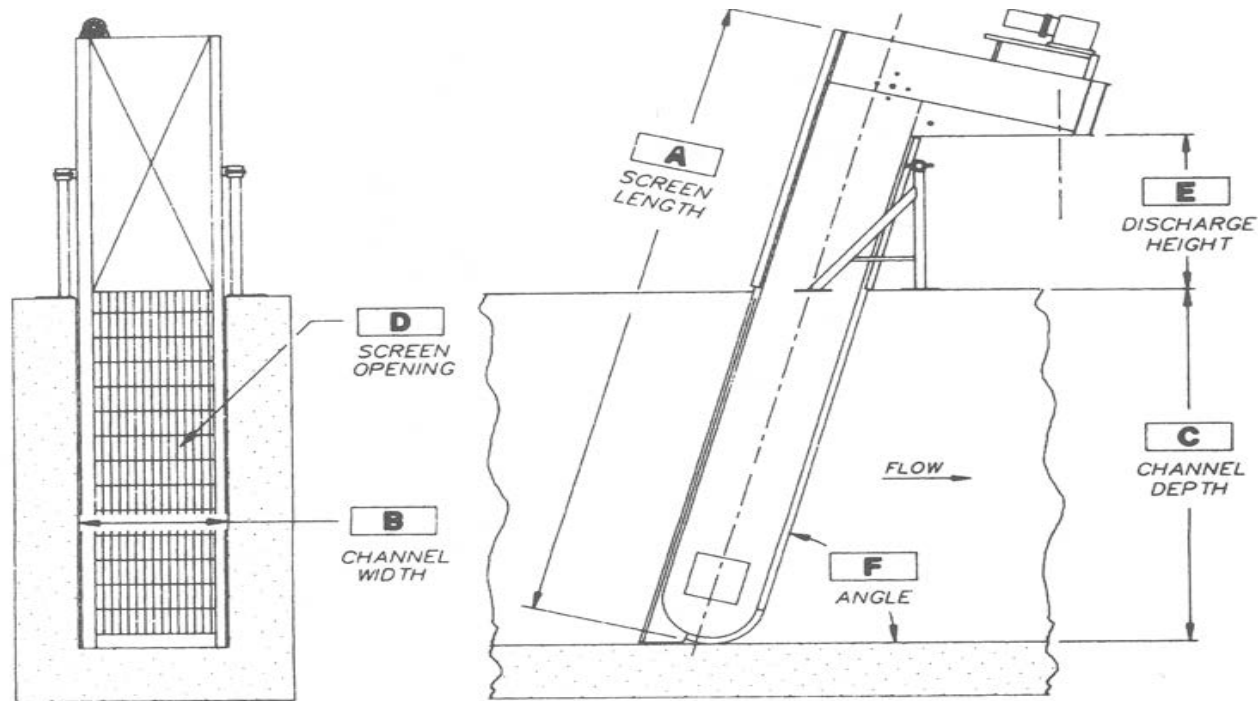
Sieves

Raising requirements induce the demand for new separation techniques, with better performance than fine or finest screening. The use of sieves with spacings of e.g. 1 mm gets more important. As this screening contains a lot of biodegradable matter, screening plant might be equipped with a washer, to remove organic matter

Advantages:

- Removal of coarse matter and fibres
- Reduction of settleable matter
- Positive effect on sludge conditioning processes
- Reduction or even substitution of primary settlement.

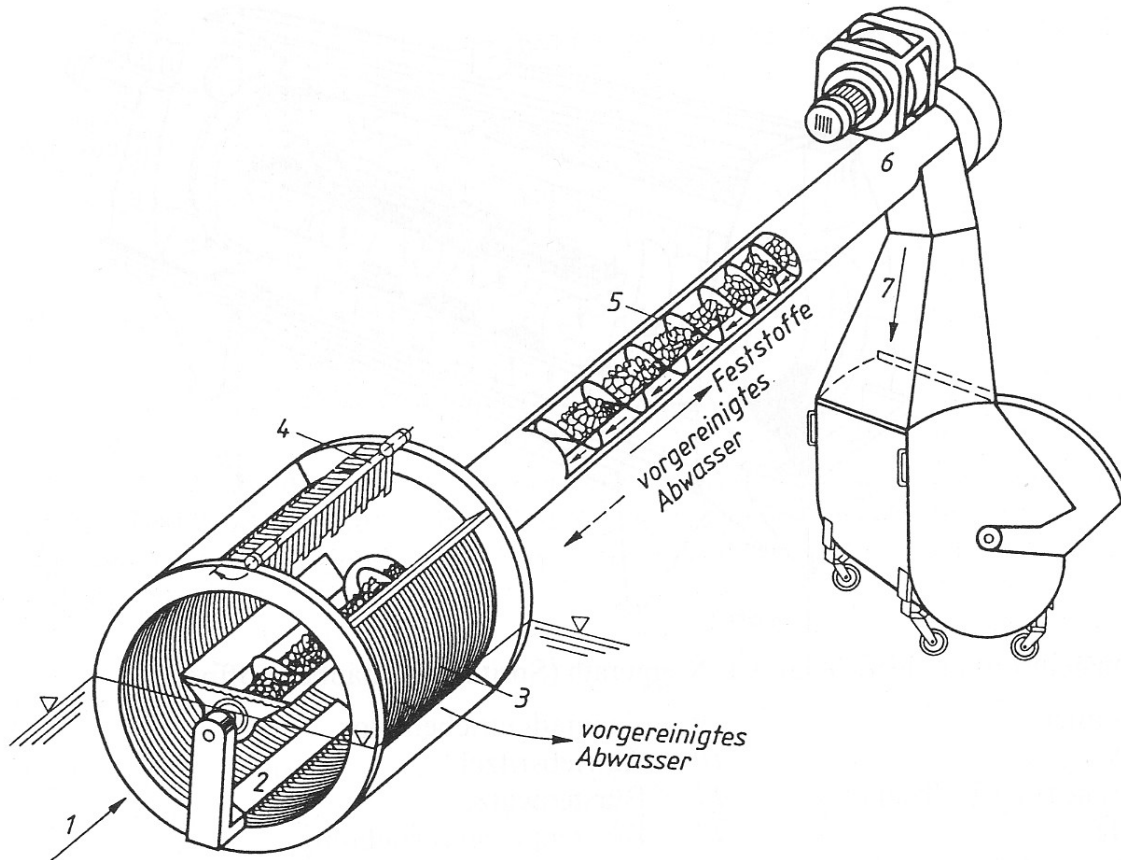
Examples



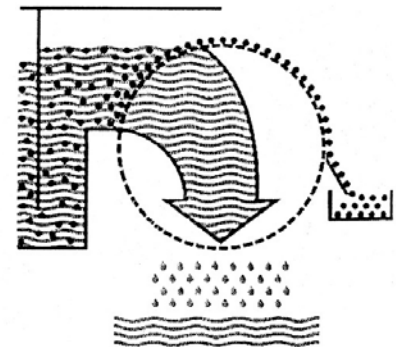
Screen with
automatic
screenings
remover

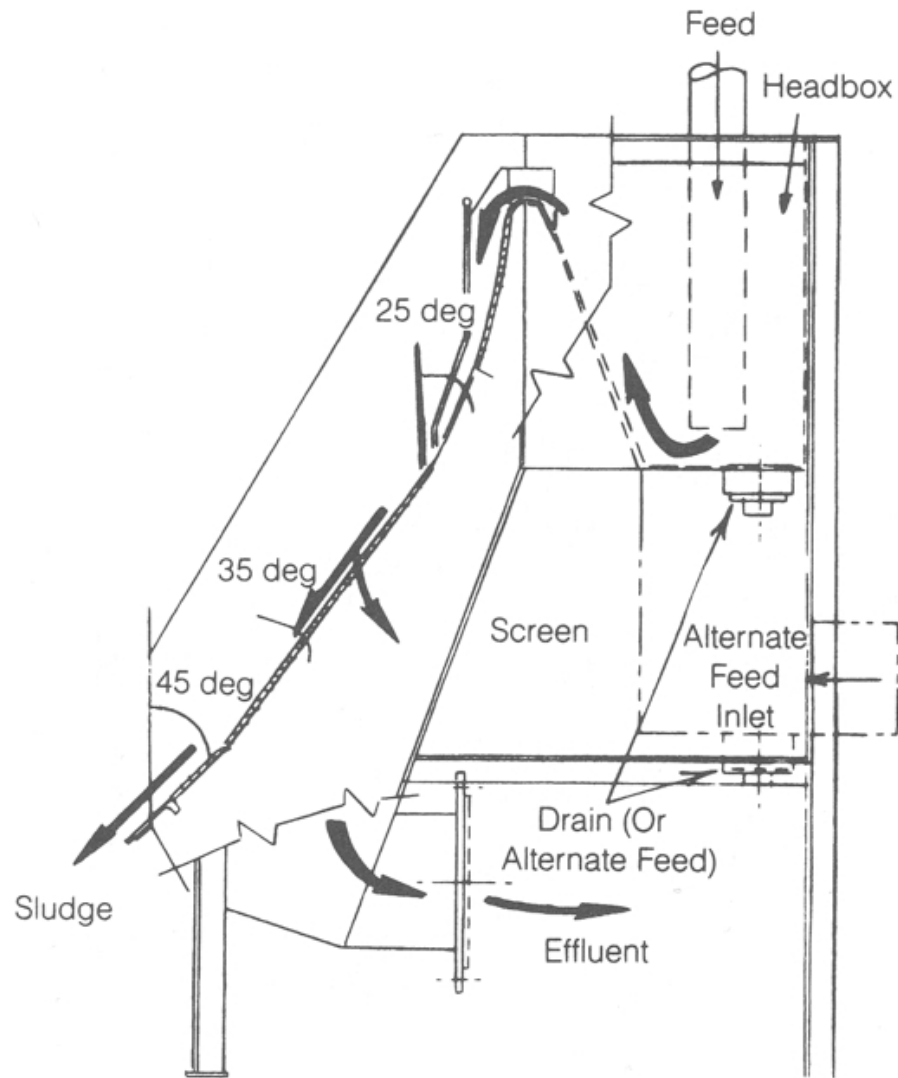
$A = 8' \text{ to } 25'$ $C = 2' \text{ to } 16'$ $E = 3' \text{ to } 5'$
 $B = 12'' \text{ to } 120''$ $D = 3/16'' \text{ to } 3/4''$ $F = 60 \text{ to } 80 \text{ degrees}$

Continuous self-cleaning screen (in. \times 24.5 = mm; ft \times 0.3048 = m).

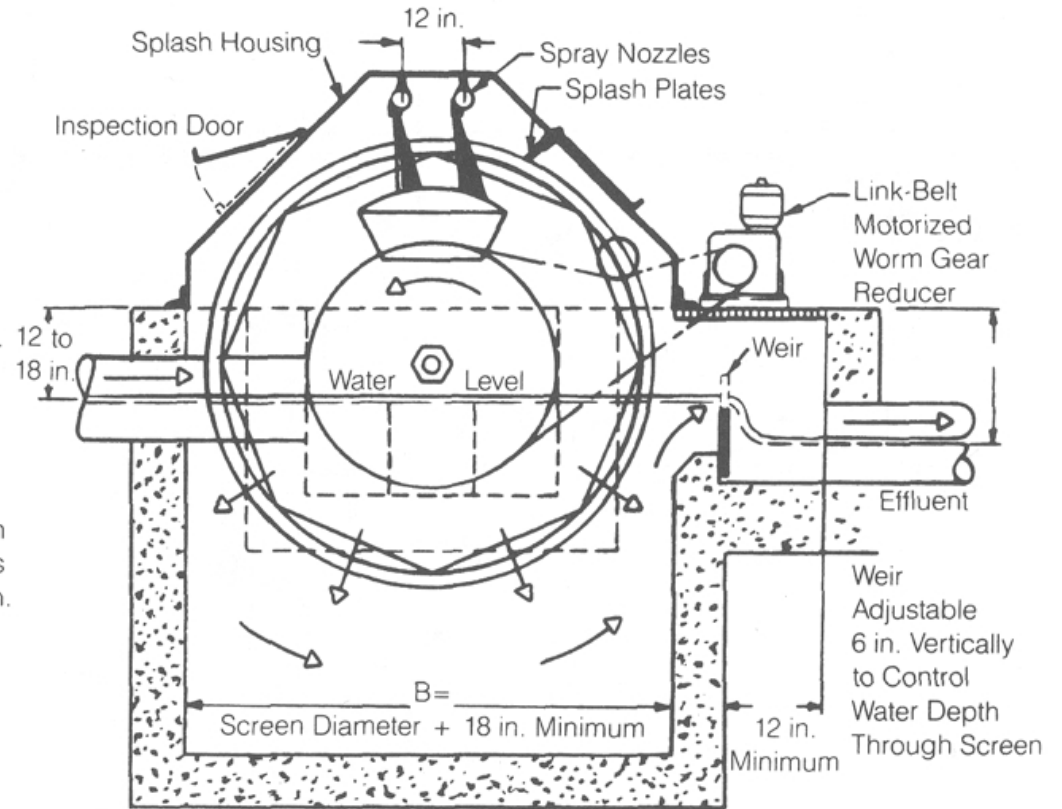
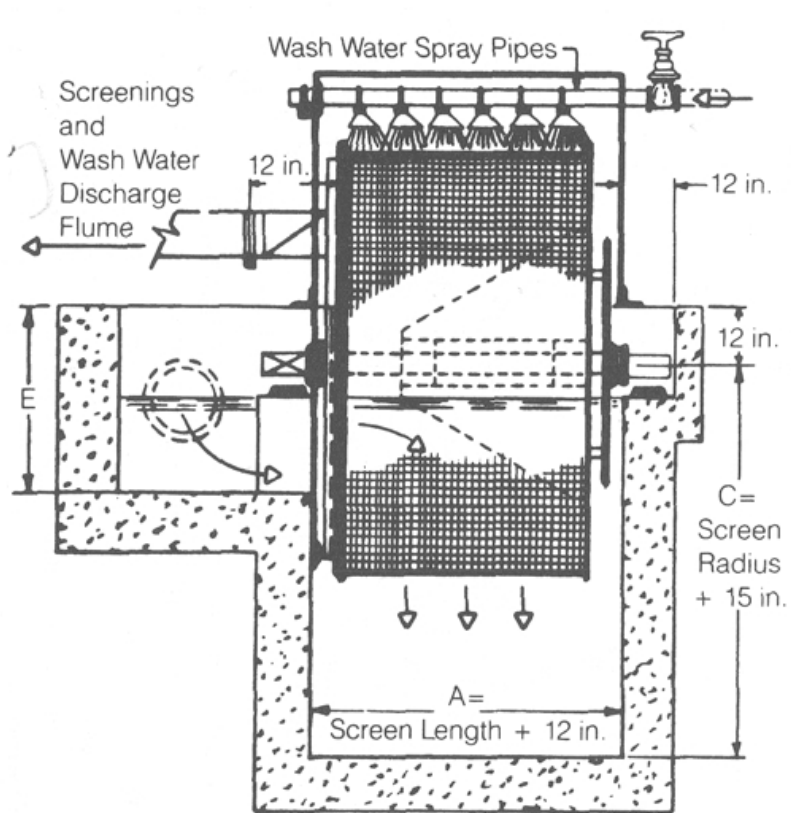


Rotary sieve
with screenings
remover and
screenings
press





Inclined, self-cleaning static screen.



Rotary drum screen (in. \times 25.4 = mm).

5.2.2 Sedimentation

- Objectives:
 - To remove readily settleable and floating solids
 - 50-65% SS reduction
 - 25-40% BOD₅ reduction
- Provided at most treatment plants except:
 - waste stabilisation ponds
 - extended aeration plants
- Continuous flow
- Equal flow distribution important
- Sludge removal:
 - continuous or intermittent

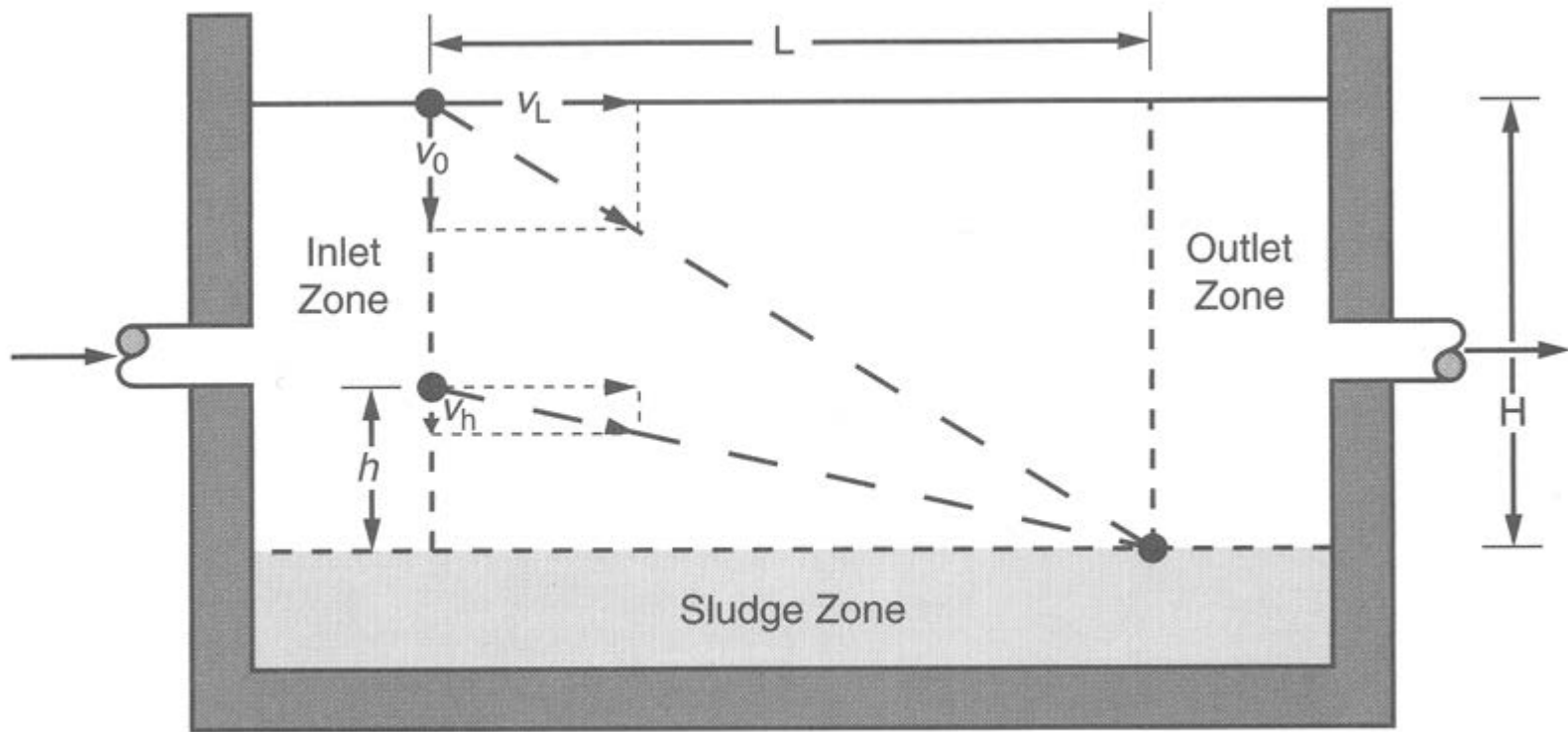
5.2.2.1 Primary Clarifier (settlement)

- Reduction of flow velocity enables settleable matter to sink to the bottom.
- Settlement is granted when the sinking time of a certain particle is shorter than the flow time through the clarifier.

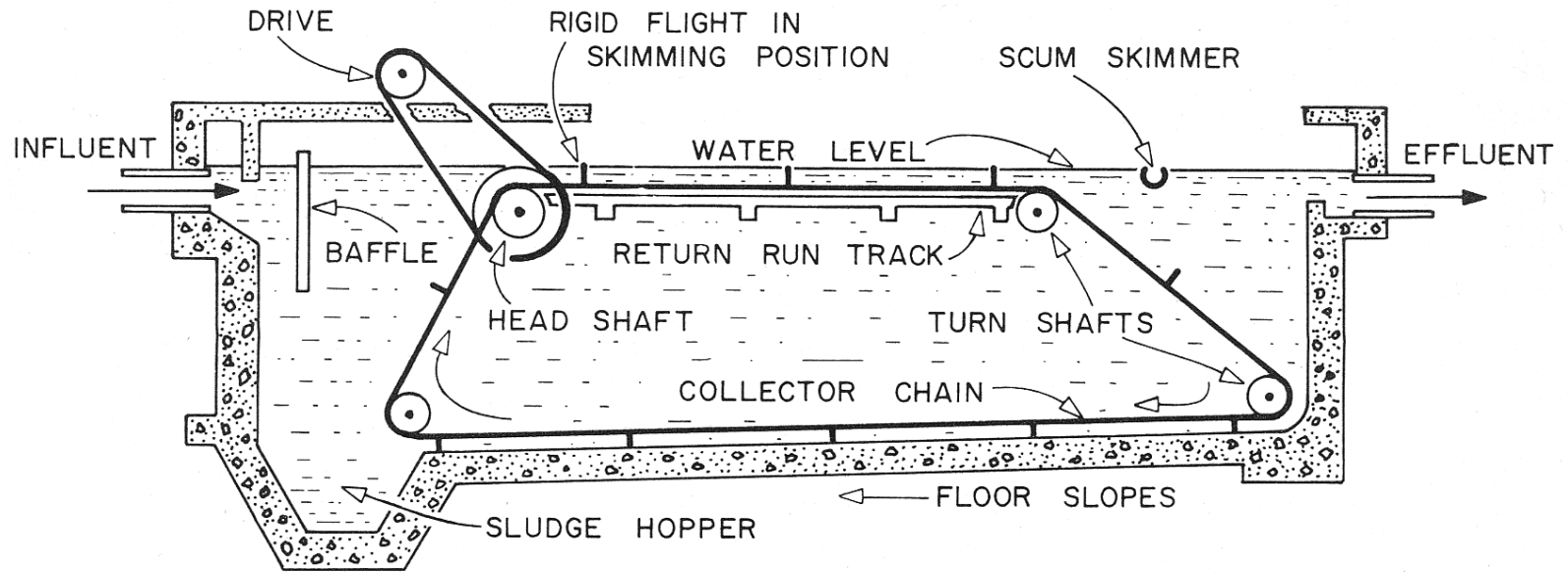
Selection of flow velocity, basin design and addition of substances (flocculant) determines the particle fraction removed.

Because of different particle shapes and other influencing factors the actual sinking velocity is much lower than the theoretical estimation.

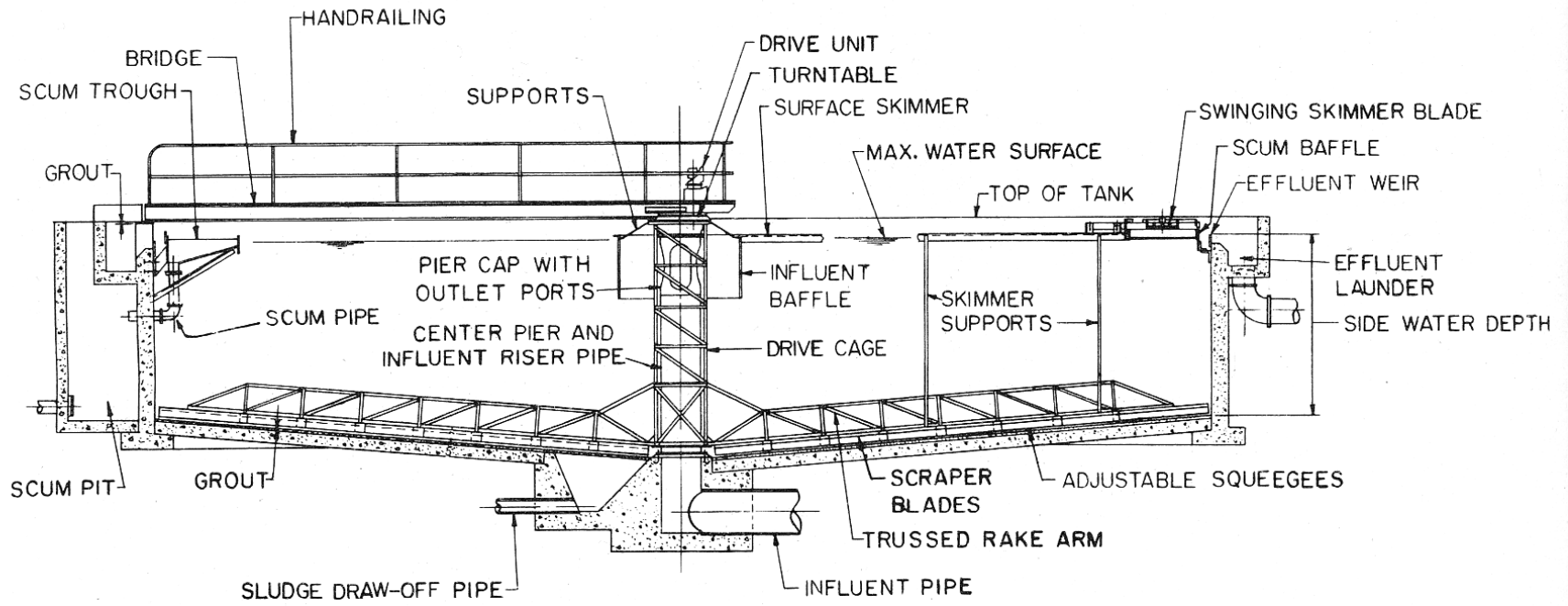
For design of a clarifier, practical experience is absolute necessary.



Zones of an ideal settling tank.

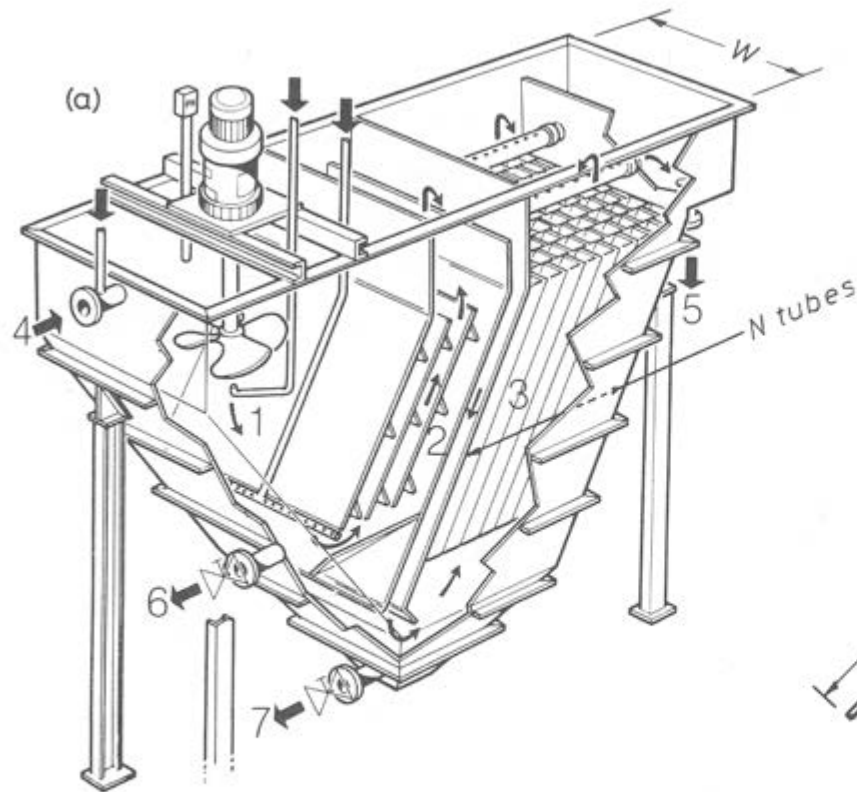


Single rectangular tank for primary sedimentation.

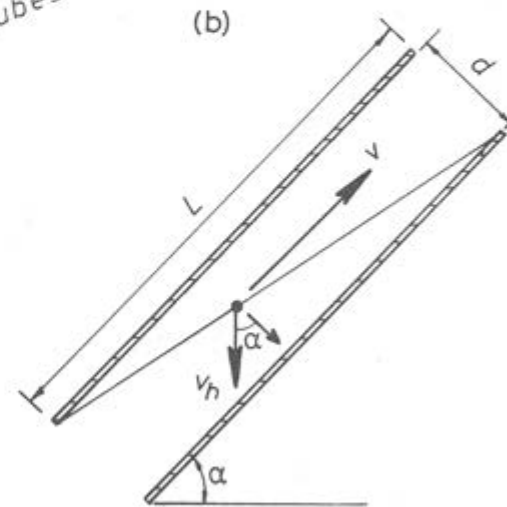


Circular sedimentation tank section.

5.2.2.2 Lamella separator (tilted-plate separator)



Parallel, steeply inclined plates, about 50 mm apart, increase the settling efficiency by reducing the settling distance



(a) Sedipacunit plate settler, reproduced by courtesy of Dégremont [15]. 1, Mixer; 2, flocculator; 3, settling zone; 4, raw water inlet; 5, treated water outlet; 6 and 7, drain. (b) Plate or tube settlement.

5.2.2.3 Light density separation

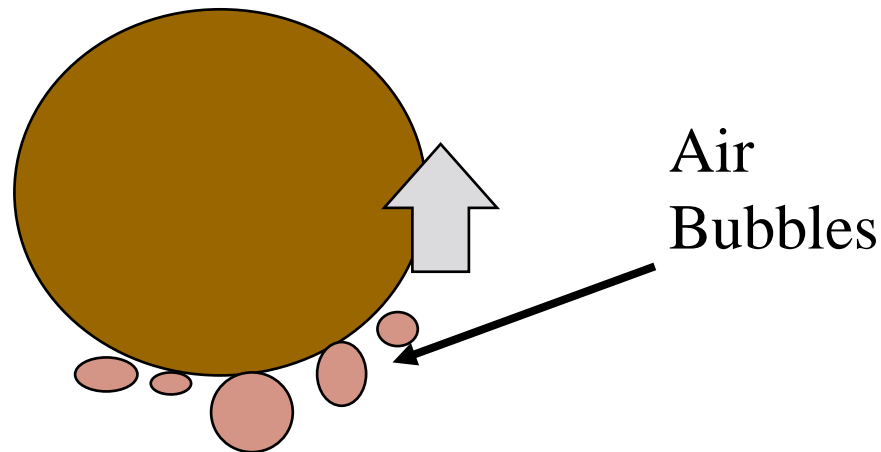
- Light density matters are all substances (solid or liquid) with a lower density than water.
- E.g. grease (from kitchen, food industry, butchery) and light liquid (petrol and other fuels)
- Light density matters are usually removed “ front of pipe” = at the wastewater origin.

Municipal WWT has to remove light density matters from diffuse (non-point) sources like households.

Average daily grease discharge: 1 l / 1000 P

Flotation

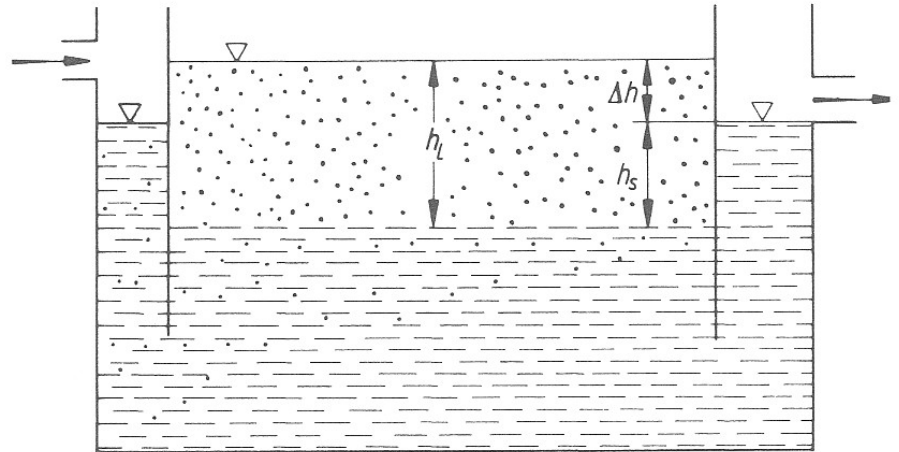
- Grease, fat and oil removal
 - originally at some domestic plants
 - mainly for industry and hotels
 - mainly emulsified by detergents
- Basic principle
 - reduce apparent specific gravity by attachment of gas to particles
 - most efficient is to attain very small bubbles



Flotation

... is used to separate suspended particles that wouldn't settle or float on its own because of very small size or density similar to water.

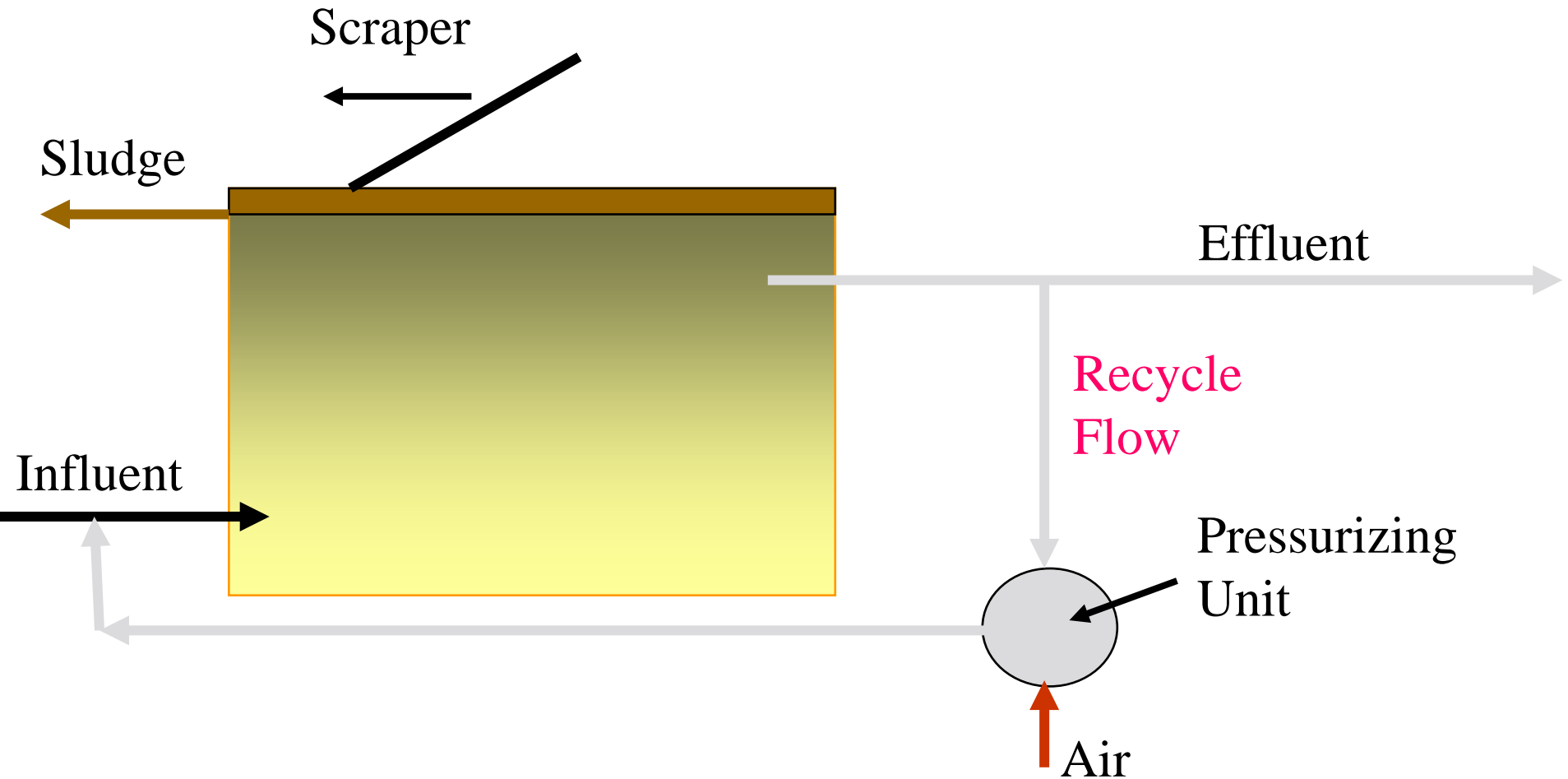
By dispersion of fine air bubbles, which stick to the suspended particles by adhesion, the particles are lifted to the surface and can be removed from there.



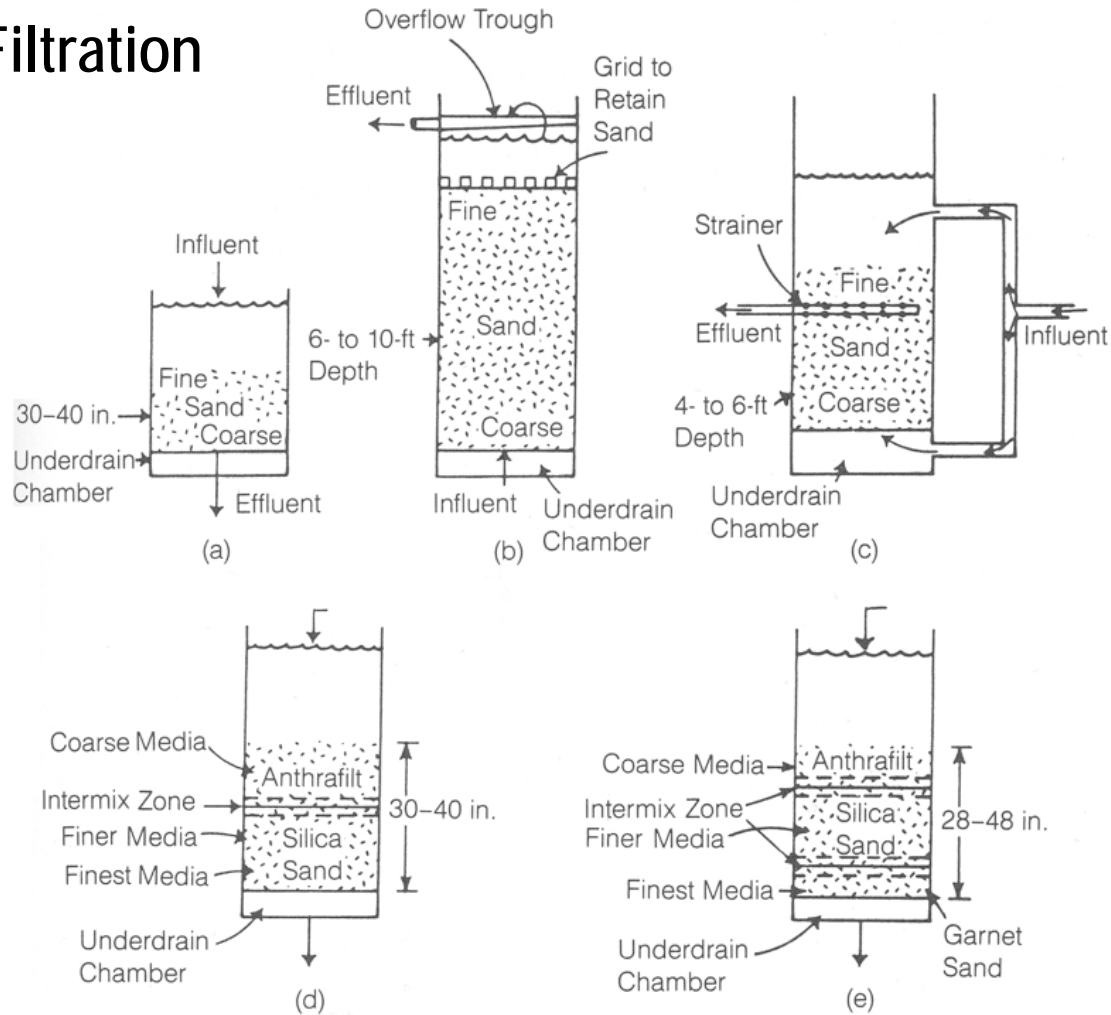
-  *leichtere Flüssigkeit L*
-  *schwerere Flüssigkeit s*

Principal of light liquid separation

Dissolved Air Flotation (DAF)



5.2.2.4 Filtration



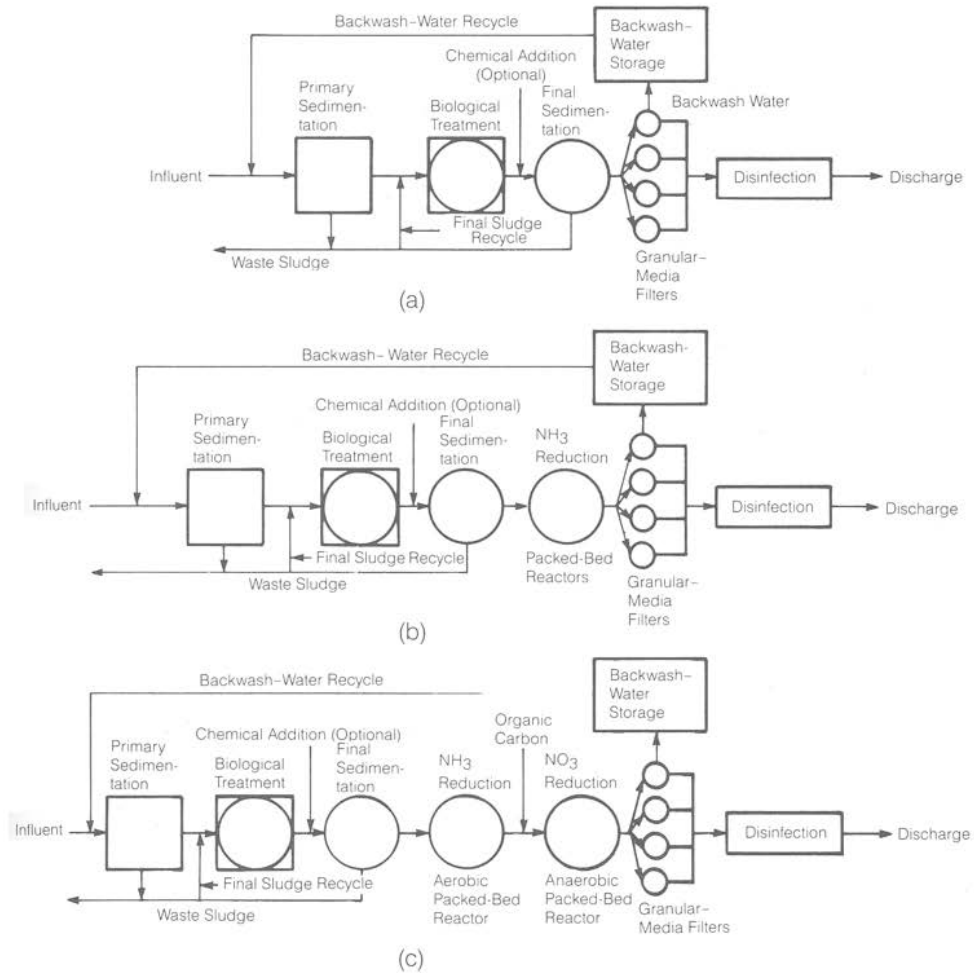
Filter configurations: (a) single-medium conventional, (b) single-medium upflow, (c) single-medium biflow, (d) dual-media conventional, and (e) mixed-media conventional (ft × 0.304 8 = m; in. × 25.4 = mm).¹

Media characteristics for dual-media and multimedia filters.

Characteristics ^{a,b}	Values	
	Range	Typical
Dual media		
Anthracite		
Depth, mm	300-600	450
Effective size, mm	0.8-2.0	1.2
Uniformity coefficient	1.3-1.8	1.6
Sand		
Depth, mm	150-300	300
Effective size, mm	0.4-0.8	0.55
Uniformity coefficient	1.2-1.6	1.5
Filtration rate, L/m ² ·min	80-400	200
Multimedia		
Anthracite (top layer of quad-media filter)		
Depth, mm	200-400	200
Effective size, mm	1.3-2.0	1.6
Uniformity coefficient	1.5-1.8	1.6
Anthracite (second layer of quad-media filter)		
Depth, mm	100-400	200
Effective size, mm	1.0-1.6	1.2
Uniformity coefficient	1.5-1.8	1.6
Anthracite (top layer of trimedia filter)		
Depth, mm	200-500	400
Effective size, mm	1.0-2.0	1.4
Uniformity coefficient	1.4-1.8	1.6
Sand		
Depth, mm	200-400	250
Effective size, mm	0.4-0.8	0.5
Uniformity coefficient	1.3-1.8	1.6
Garnet or ilmenite		
Depth, mm	50-150	100
Effective size, mm	0.2-0.6	0.3
Uniformity coefficient	1.5-1.8	1.6
Filtration rate, L/m ² ·min	80-400	200

^a mm × 0.039 37 = in.

^b L/m²·min × 0.024 5 = gpm/sq ft.



Granular-media filters following (a) biological secondary treatment, (b) biological secondary treatment plus tertiary treatment for ammonia reduction, and (c) biological secondary and biological tertiary treatment for ammonia and nitrate reduction. Phosphorus levels may be reduced by chemical addition to solids contact units located ahead of the granular-media filters.

