Solids Handling (Part 1): Separation, Thickening, Dewatering

Thursday, July 23, 2026
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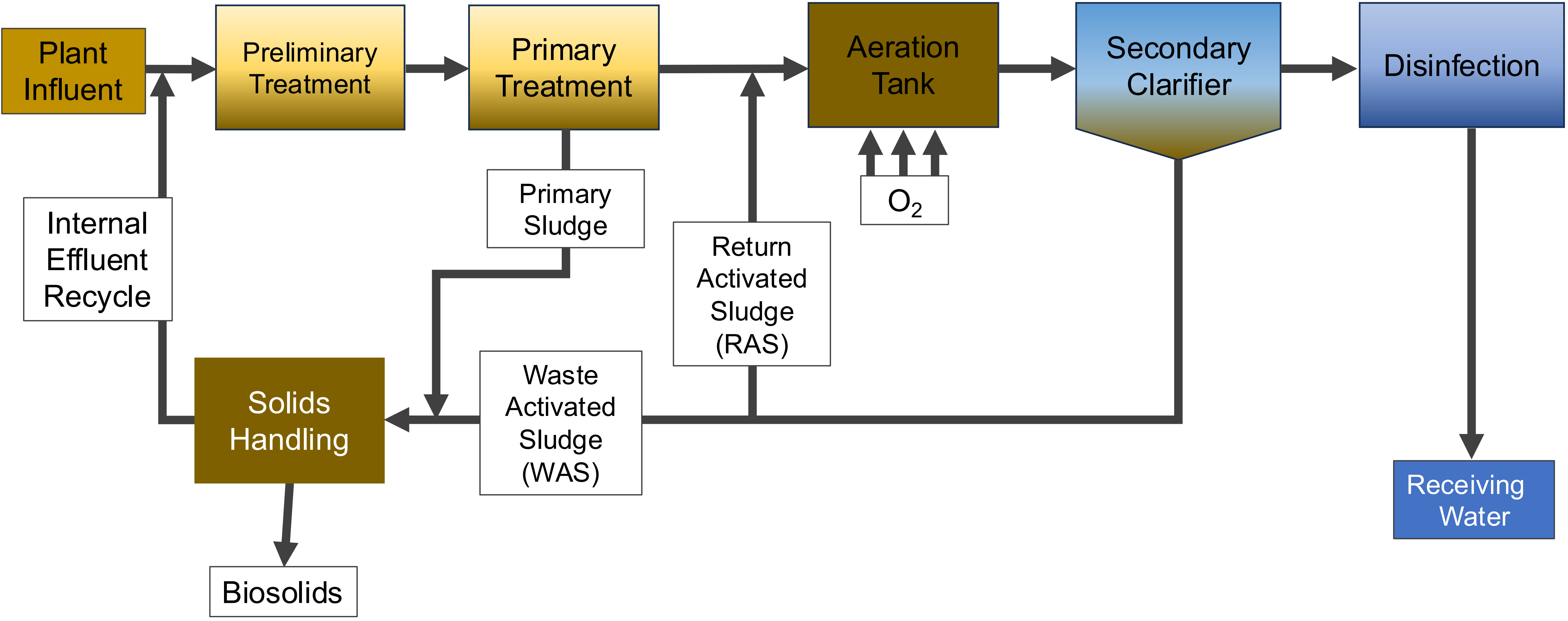
SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

This program is made possible under a cooperative agreement with US EPA.

Some Review

How we got to this point, and what we’re covering today…

Wastewater Flow Schematic



Preliminary Treatment

Screenings and Grit

Coarse Screenings

Fine Screenings

Grit Removal

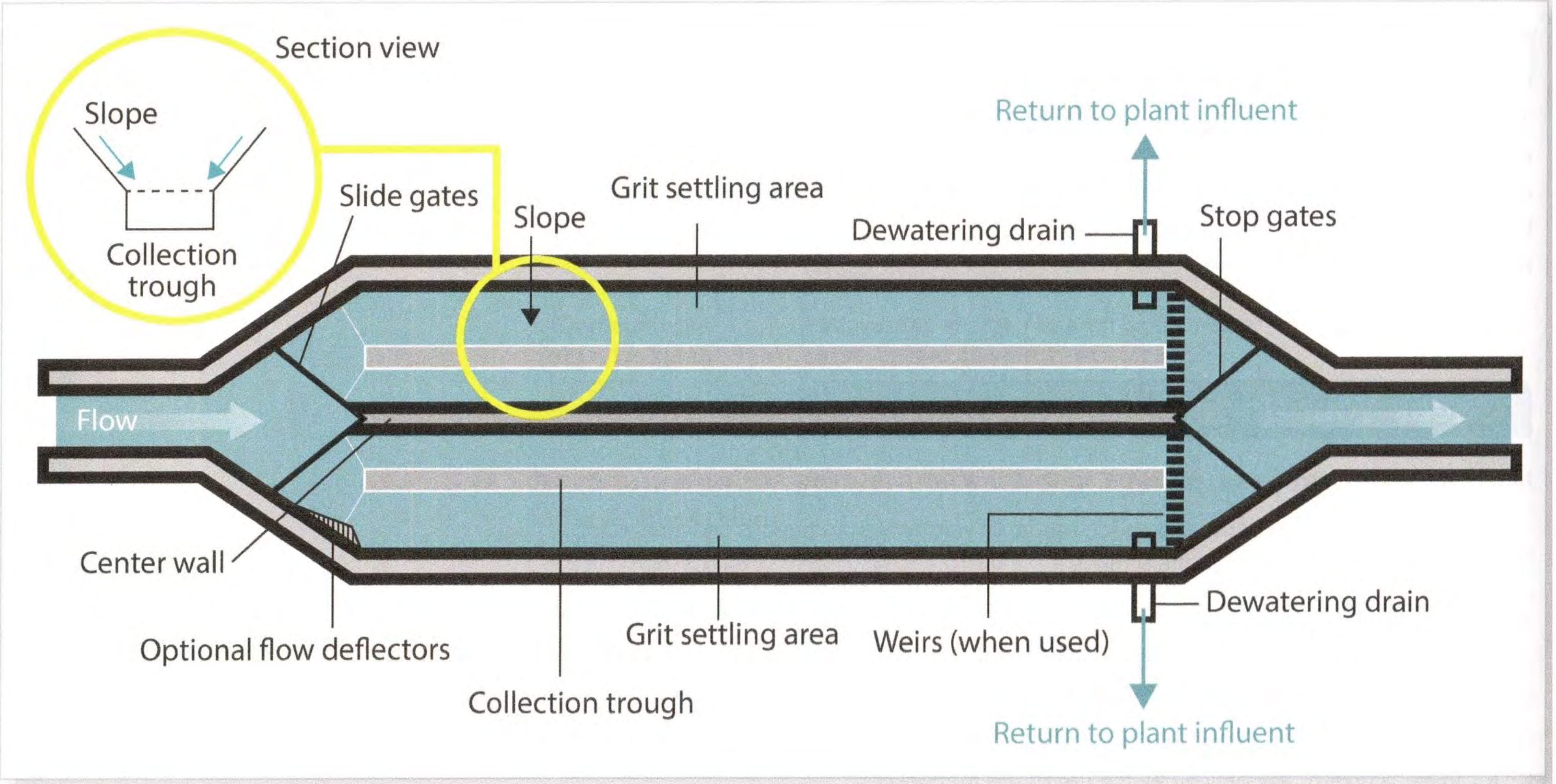
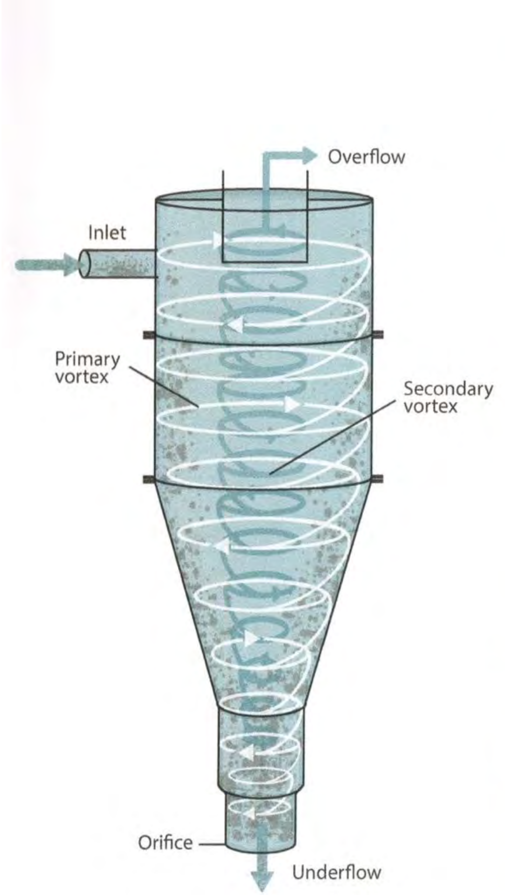
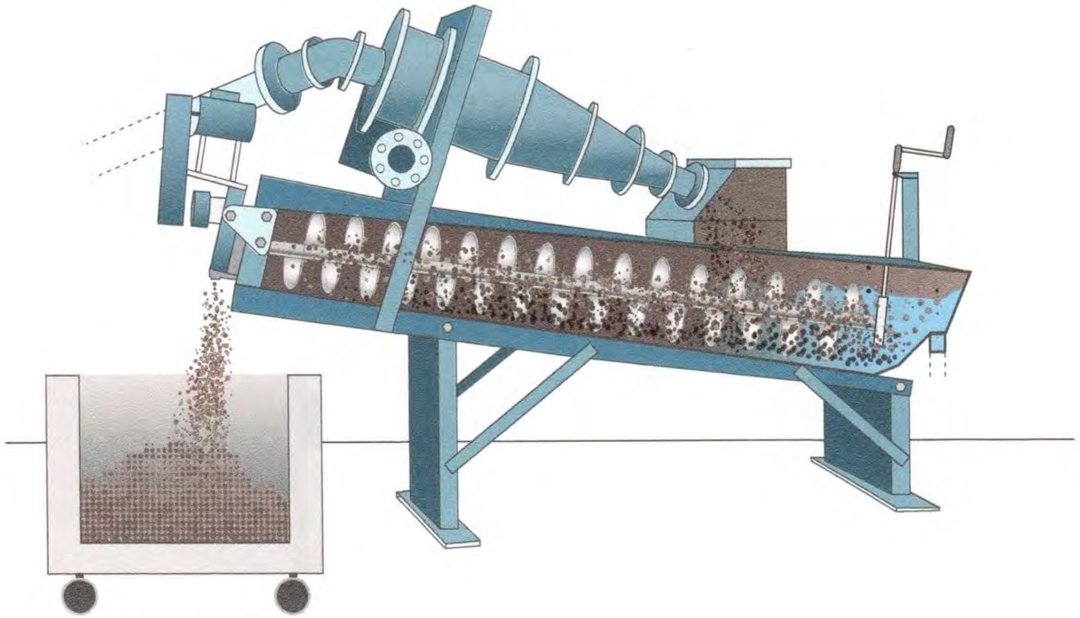


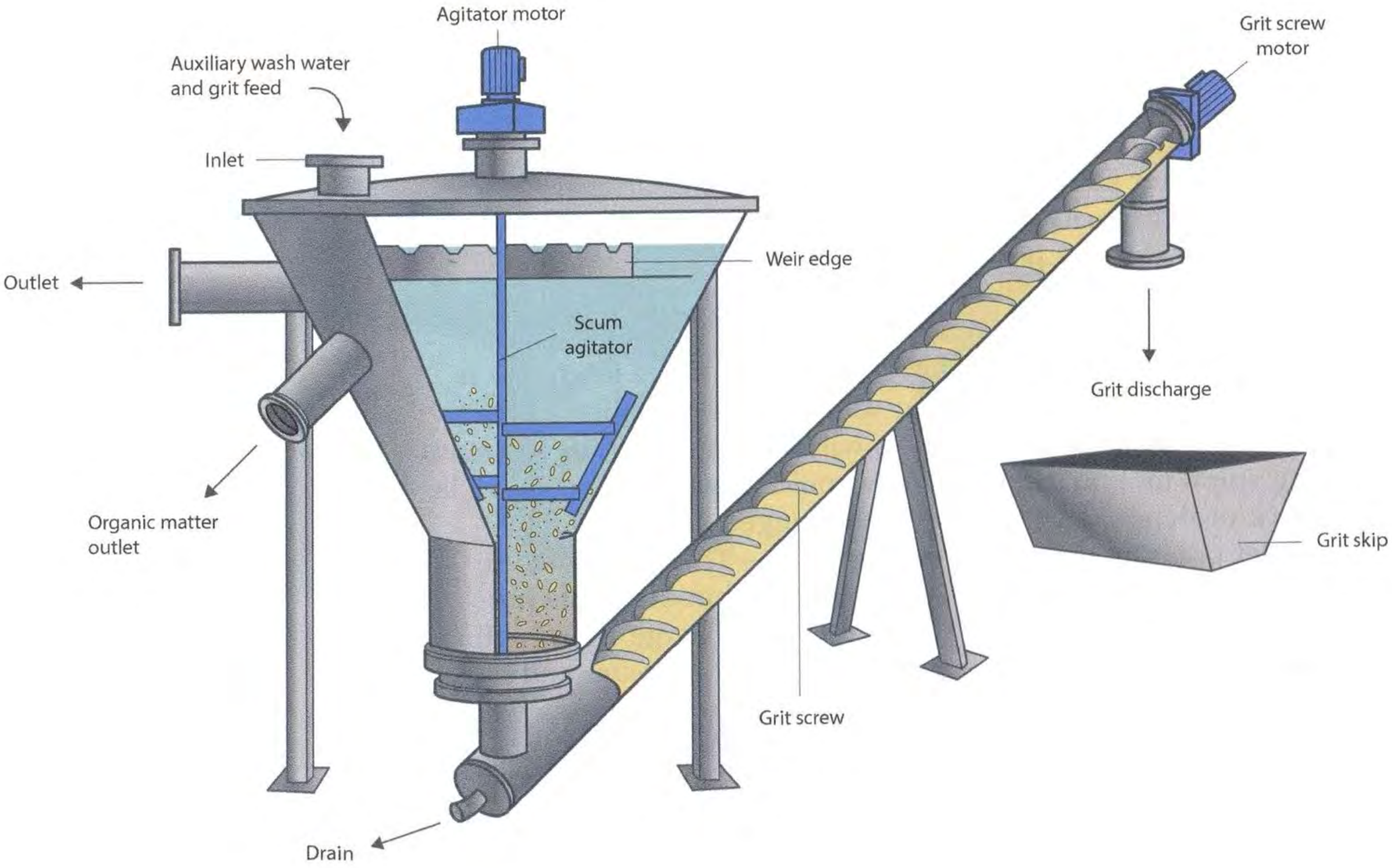
Figure 3.16 Grit channel

Removal Devices: Cyclone Separator





Grit Washing and Disposal (Classifiers)



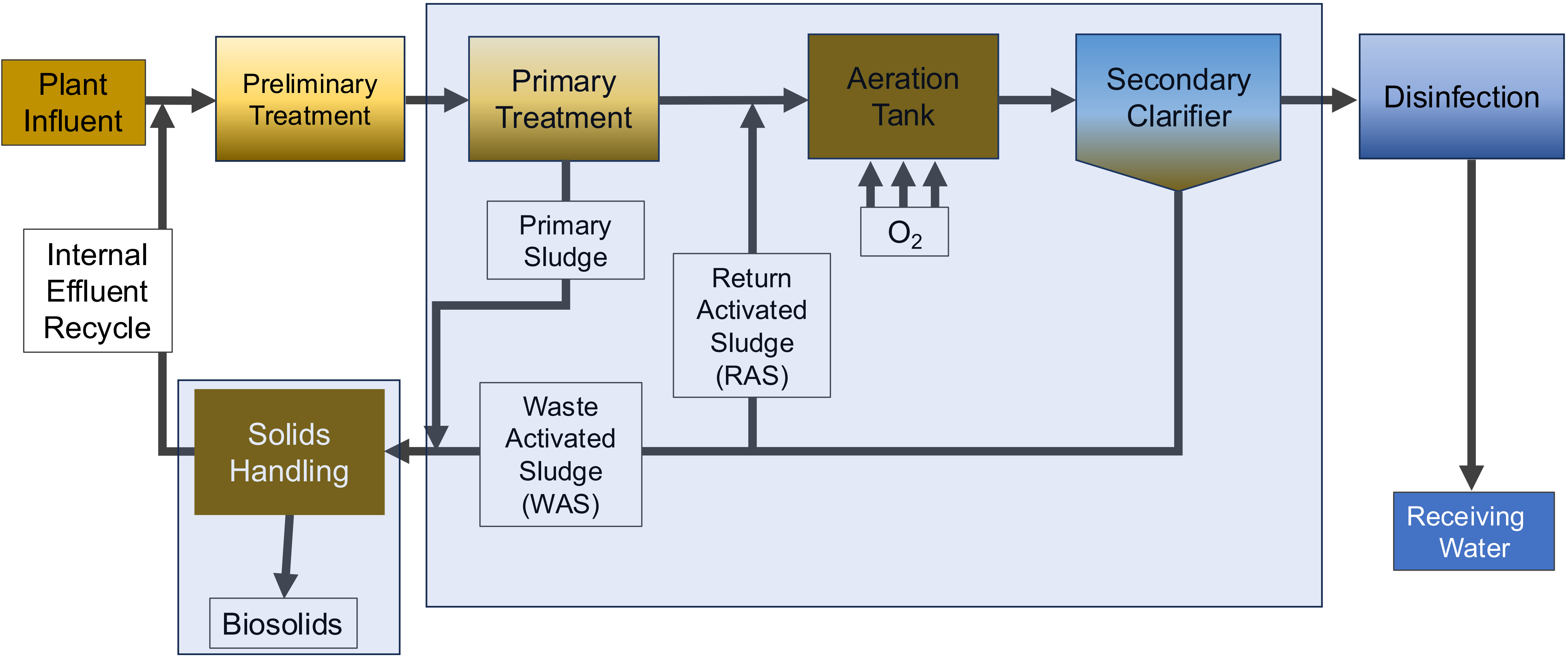
These aren’t the solids we’re looking for…

Grit and Screenings Handling

Biosolids Sources

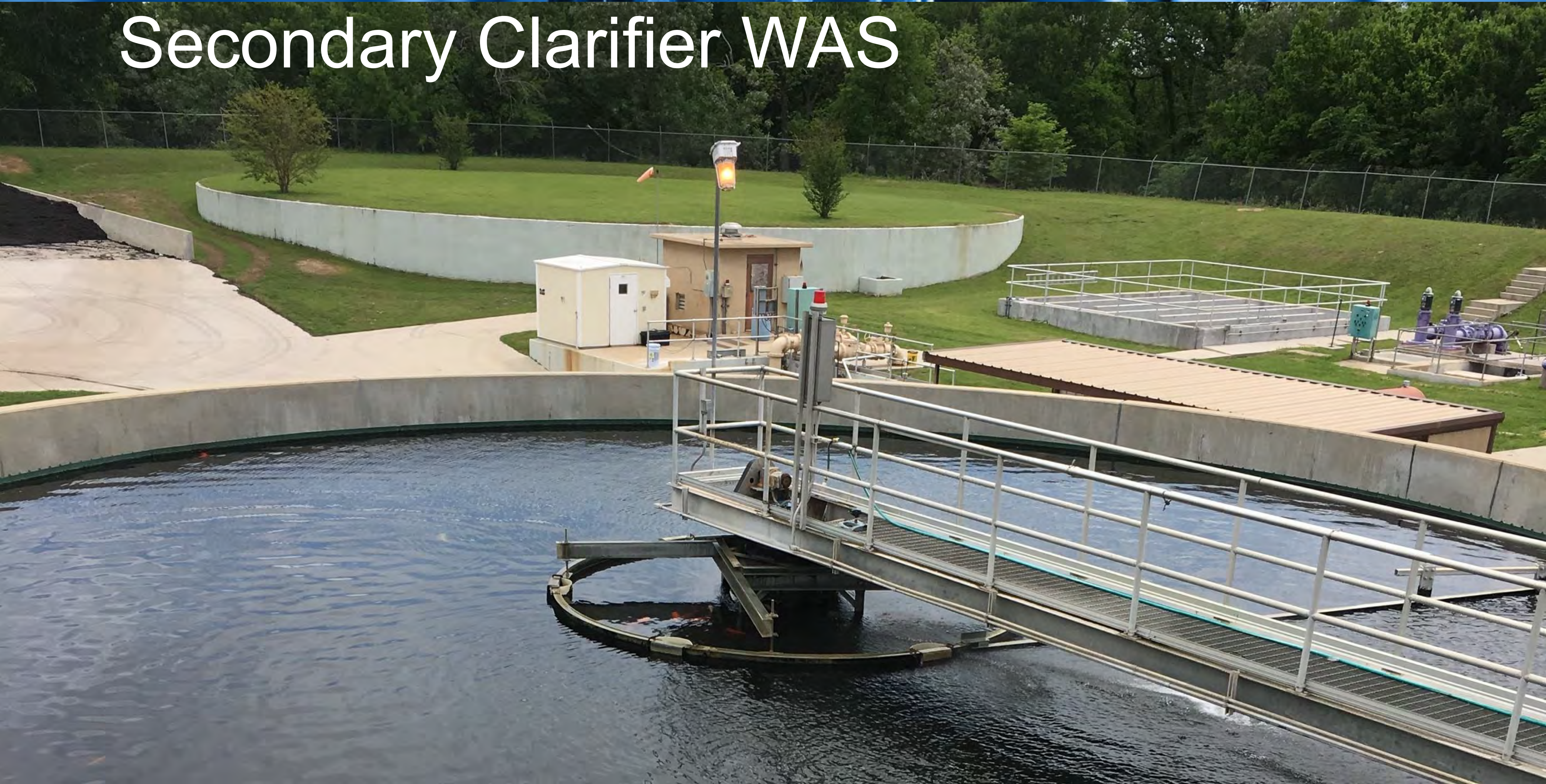
Here comes the sludge …

Wastewater Flow Schematic



Primary Clarifier Sludge

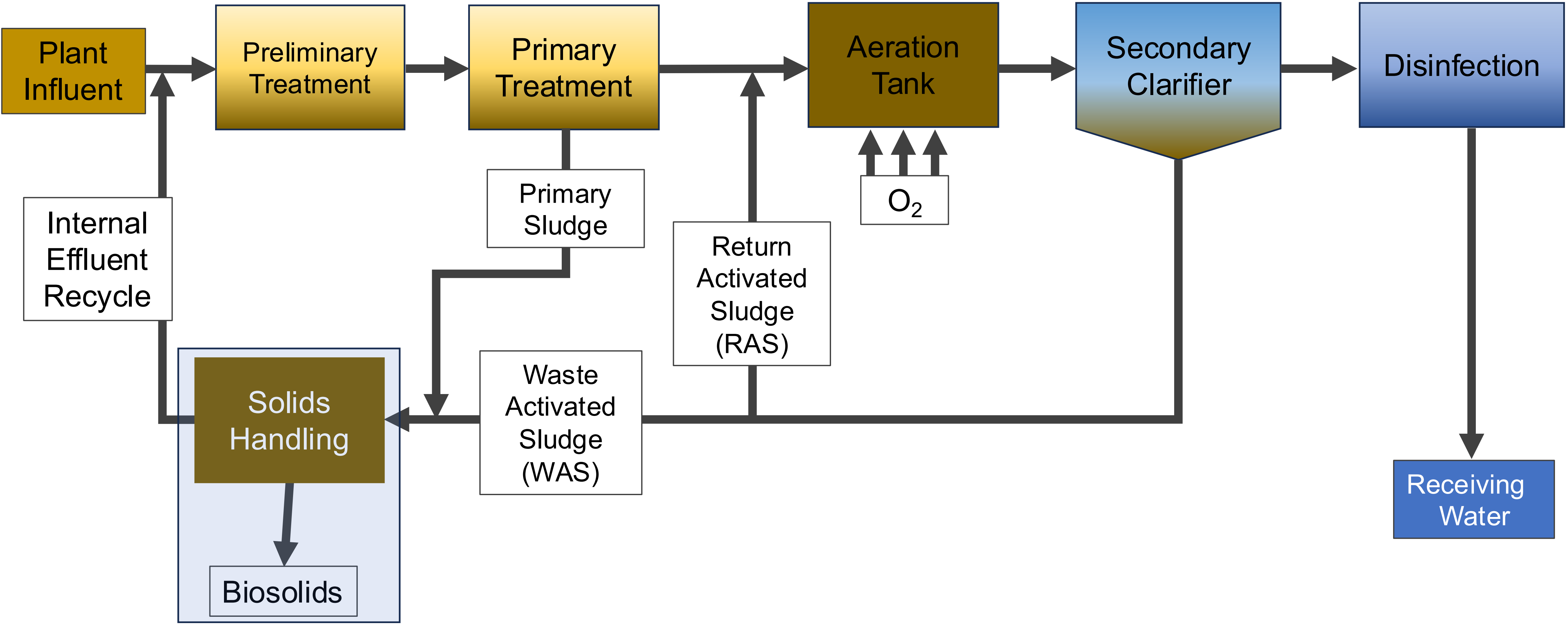
Secondary Clarifier WAS



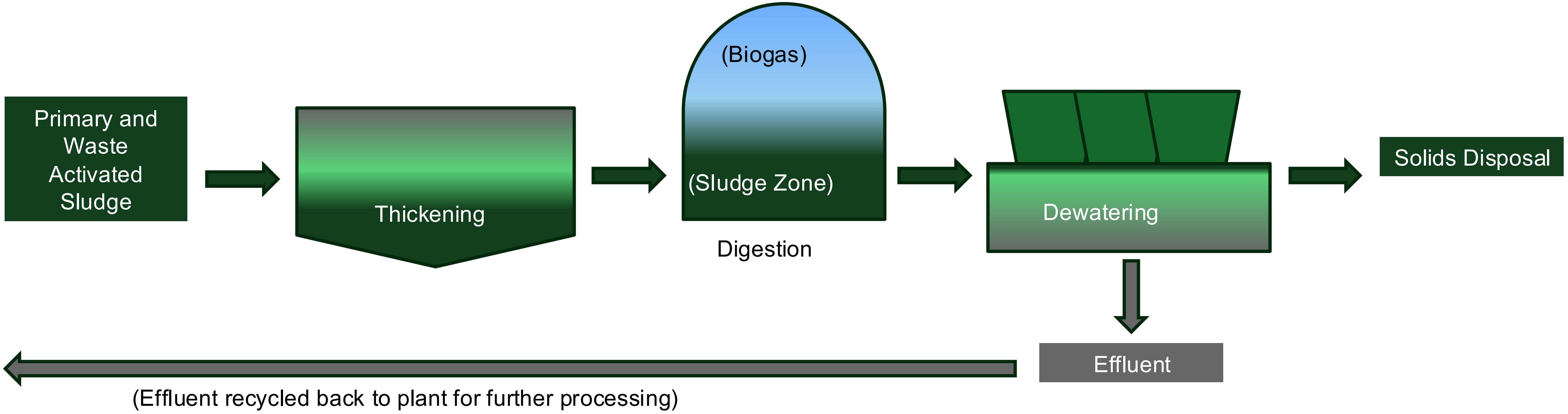
Solids Handling

Overview

Wastewater Flow Schematic



Solids Handling Stages



Solids Handling Stages

Thickening – reducing the sludge volume

Digestion - breaking down the sludge with micro-organisms

De-Watering – removing the water from the solids

Disposal or Reuse – the end of the line

Solids Handling Stages

Digestion - breaking down the sludge with micro-organisms

Disposal or Reuse – the end of the line

Thickening

(It’s just what it sounds like)

Why is thickening necessary?

Primary Sludge

Typically, contains 95-97 % water, 3 to 5% solids.

Every pound of primary sludge is suspended in between 20 and 30 pounds of water

Secondary Sludge

Secondary sludge typically varies between 2% and less than 1% solids

Every pound of secondary sludge is suspended in between 50 to 150 pounds of water

If you didn’t remove water, your digestion equipment would have to be **la**rger.

Advantages

Improved digester performance

Construction cost savings: smaller sludge volume = smaller required digestion facilities

Reduction in heating costs: digesters may need heating, the smaller they are, the cheaper that is

Let’s do some math together:

If your primary clarifier produces 3,000 gallons of sludge per day with a solids concentration of 3%, what’s the weight of the solids produced per day?

Water = 8.34 lbs/gal

$$Dry\ Sludge\ Solids\ \left(\frac{lbs}{day}\right) = Sludge\ volume\ \left(\frac{gal}{day}\right) \times\ 8.34\,\frac{lbs}{gal}\ \times\ \frac{\%\ solids}{100\%}$$

$$Dry\ Sludge\ Solids\ \left(\frac{lbs}{day}\right) = 3{,}000\left(\frac{\cancel{gal}}{day}\right) \times\ 8.34\,\frac{lbs}{\cancel{gal}}\ \times\ \frac{\cancel{3\%}}{\cancel{100\%}}$$

$$Dry\ Sludge\ Solids\ \left(\frac{lbs}{day}\right) = 750.6\left(\frac{lb}{day}\right)$$

Let's do some math together:

What would the volume of sludge be if you increased the solids concentration from your primary clarifier to 5%

Water = 8.34 lbs/gal

Dry Sludge Solids = 750.6 lbs/day

$$Dry\ Sludge\ Solids\ \left(\frac{lbs}{day}\right) = Sludge\ volume\ \left(\frac{gal}{day}\right) \times\ 8.34\,\frac{lbs}{gal}\ \times\ \frac{\%\ solids}{100\%}$$

$$750.6\left(\frac{lbs}{day}\right) = Sludge\ volume\left(\frac{gal}{day}\right) \times\ [8.34\,\frac{lbs}{gal}\ \times\ \frac{5\%}{100\%}]$$

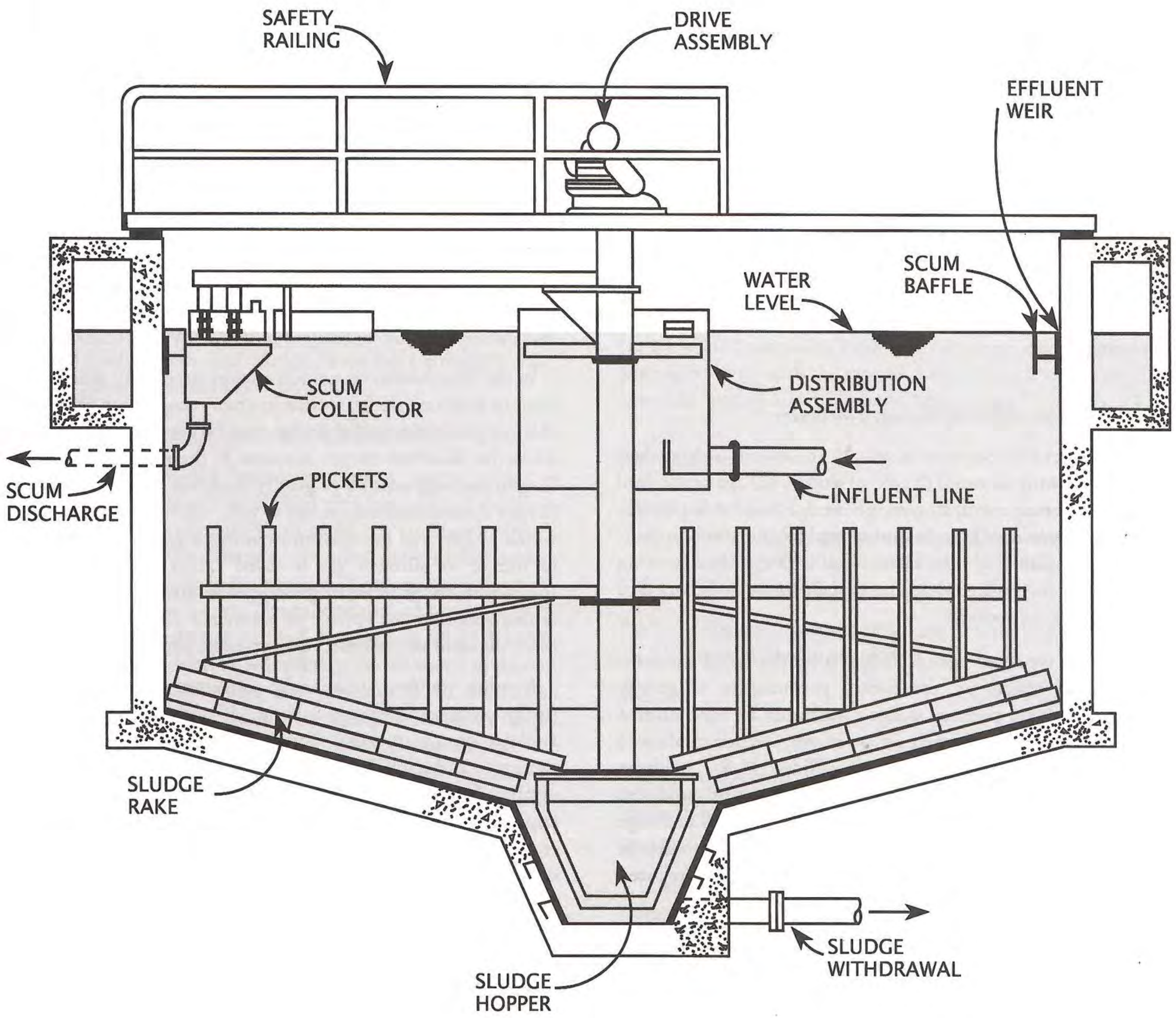
$$Sludge\ volume\left(\frac{gal}{day}\right) = \frac{750.6\ lbs/day}{8.34\frac{lbs}{gal} \times \frac{5\%}{100\%}}$$

$$Sludge\ volume\left(\frac{gal}{day}\right) = 1800\,\frac{gal}{day}$$

Gravity Thickeners

Does this look kind of familiar?

It's a sedimentation process.



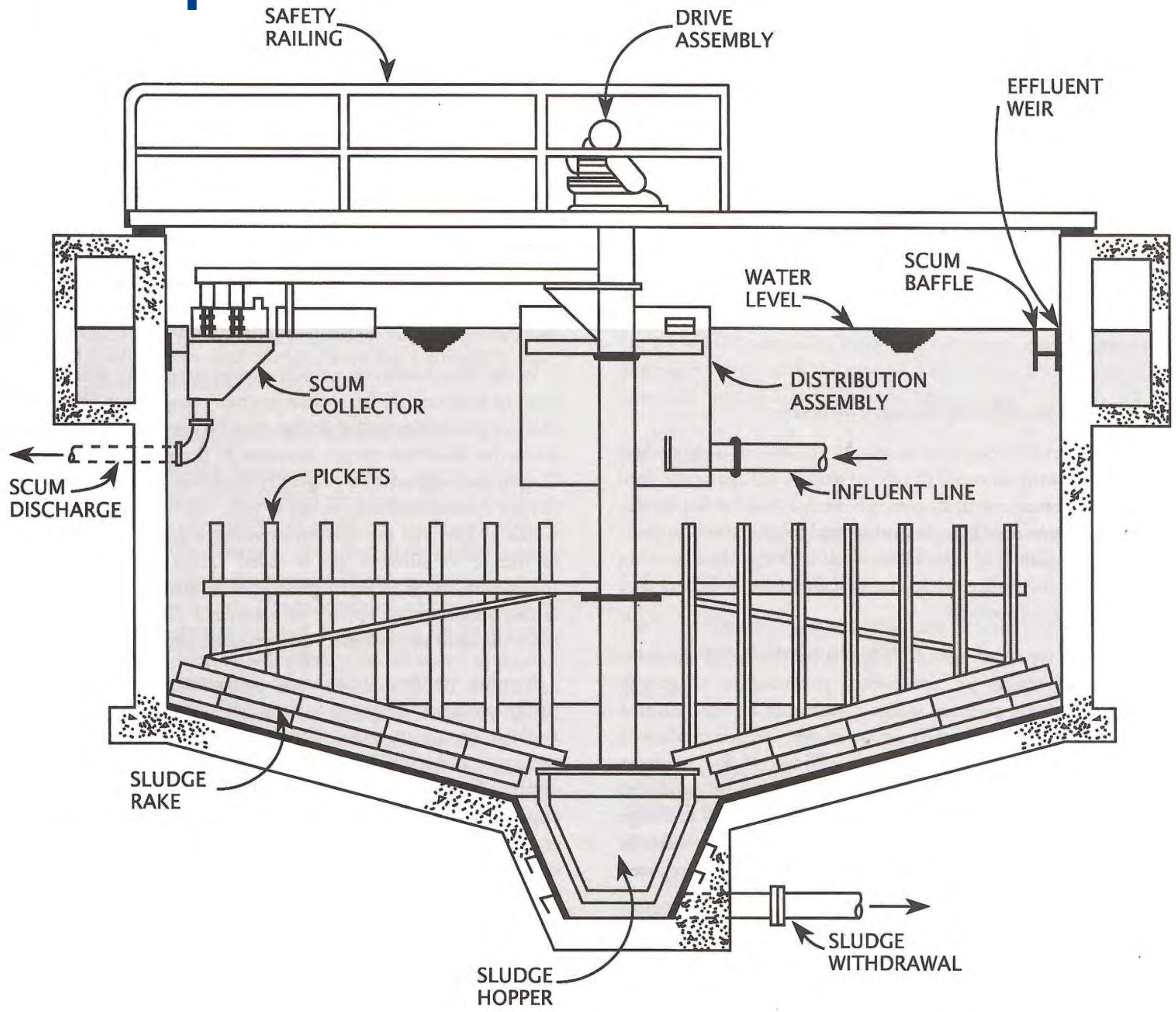
Sedimentation


Analogous to snowfall

Look at a snowglobe

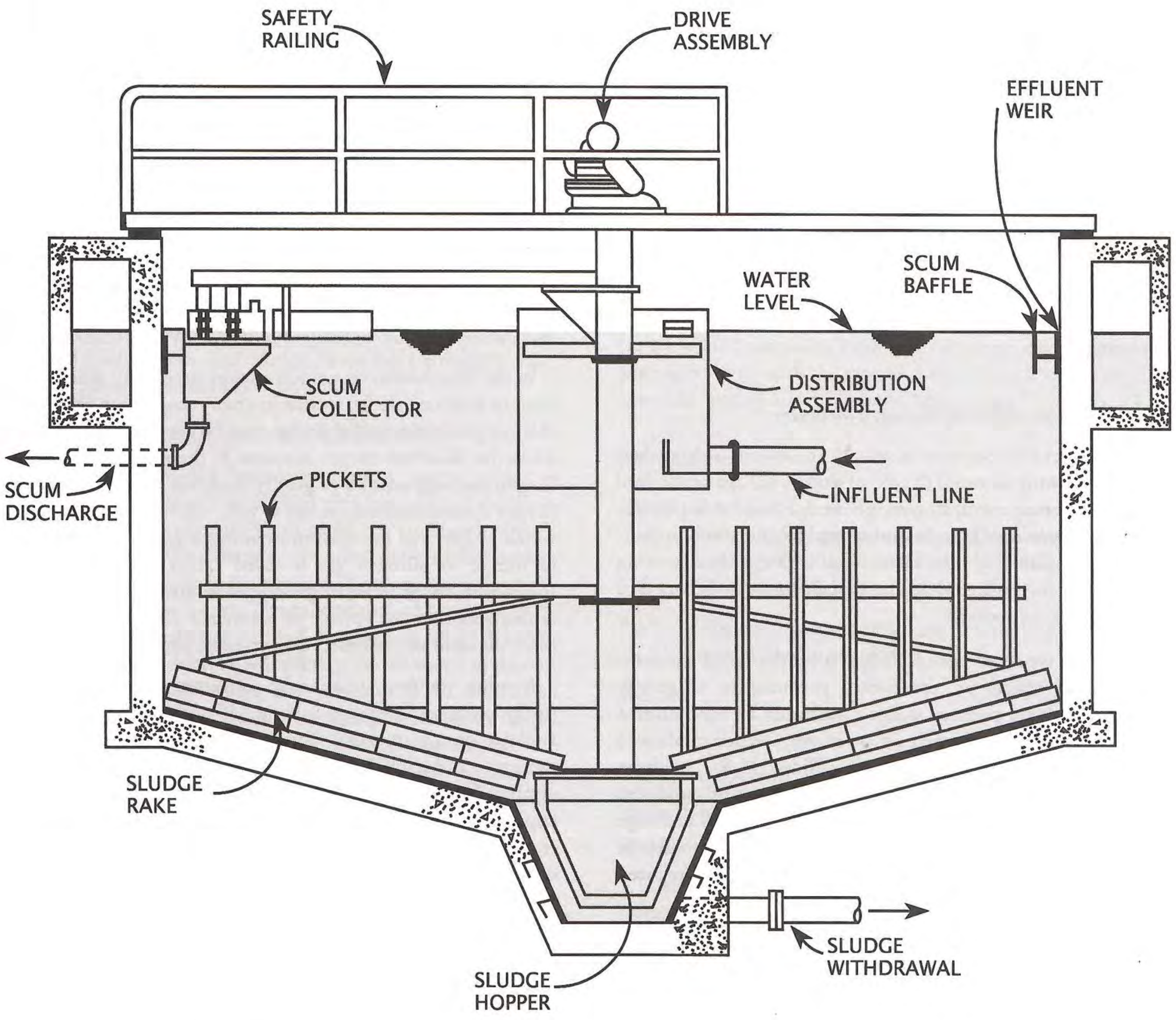
Gravity Thickener Components

1. Inlet and distribution assembly
2. Sludge rake
3. Pickets
4. Overflow weir
5. Scum removal equipment



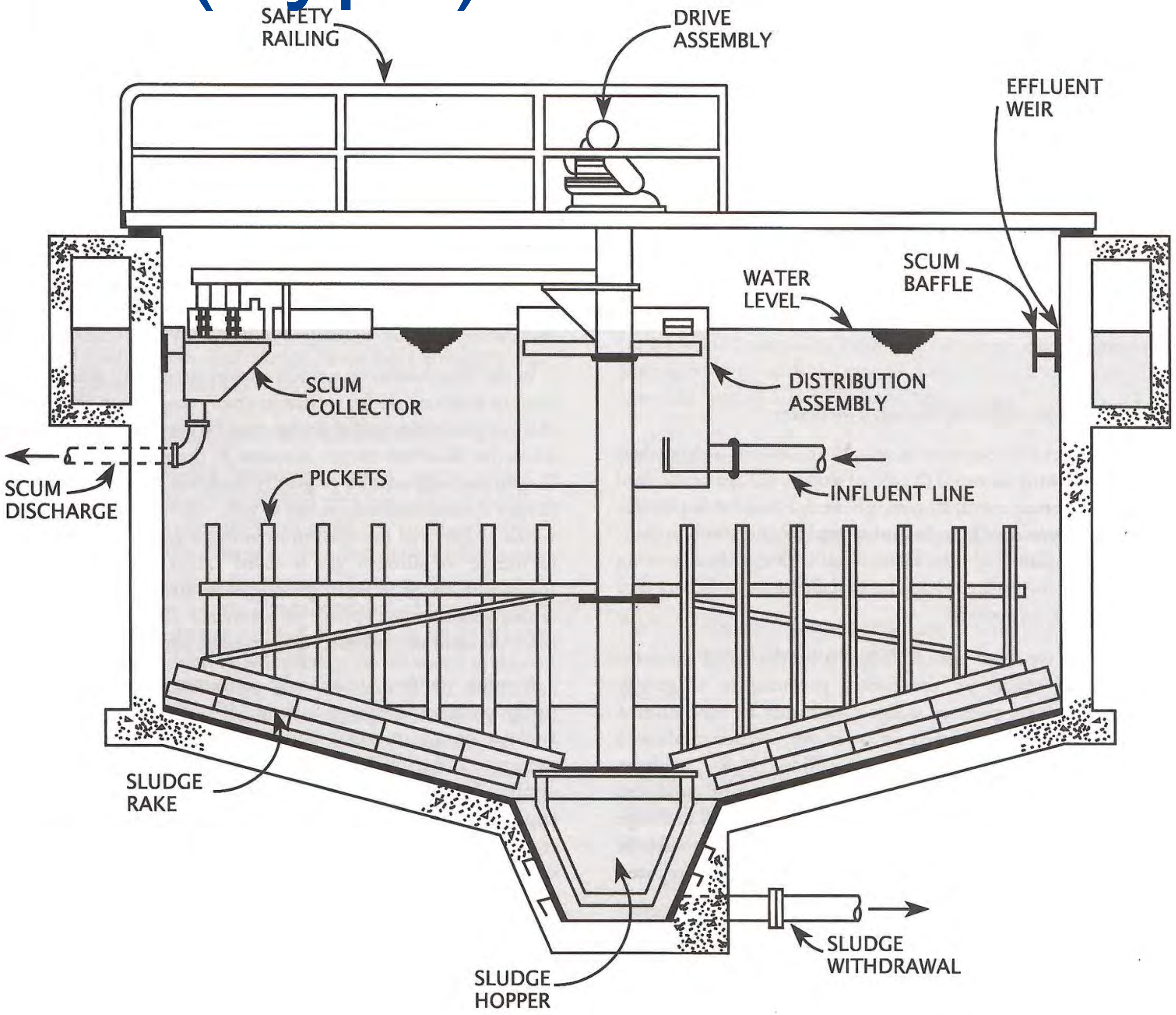
Operational Factors

1. Sludge type
2. Age of feed sludge
3. Sludge temperature
4. Sludge blanket depth
5. Solids and hydraulic detention time
6. Solids and hydraulic loading



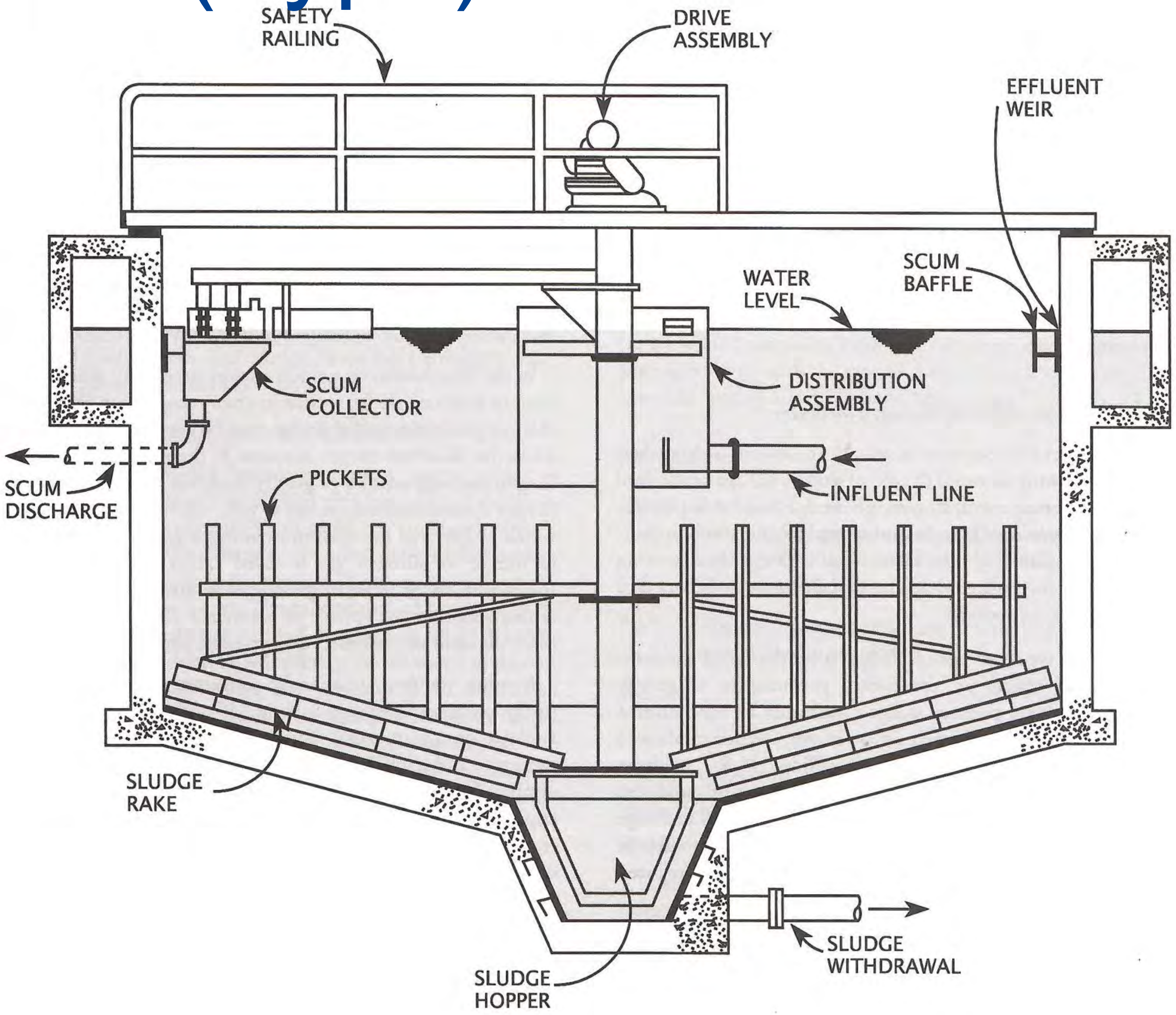
Sludge Characteristics (Type)

1. Gravity thickening works best with primary sludge
2. Fresh sludge can be concentrated to the highest degree
3. Septic sludge can result in gasification (CO_2, CH_4 H_2S)



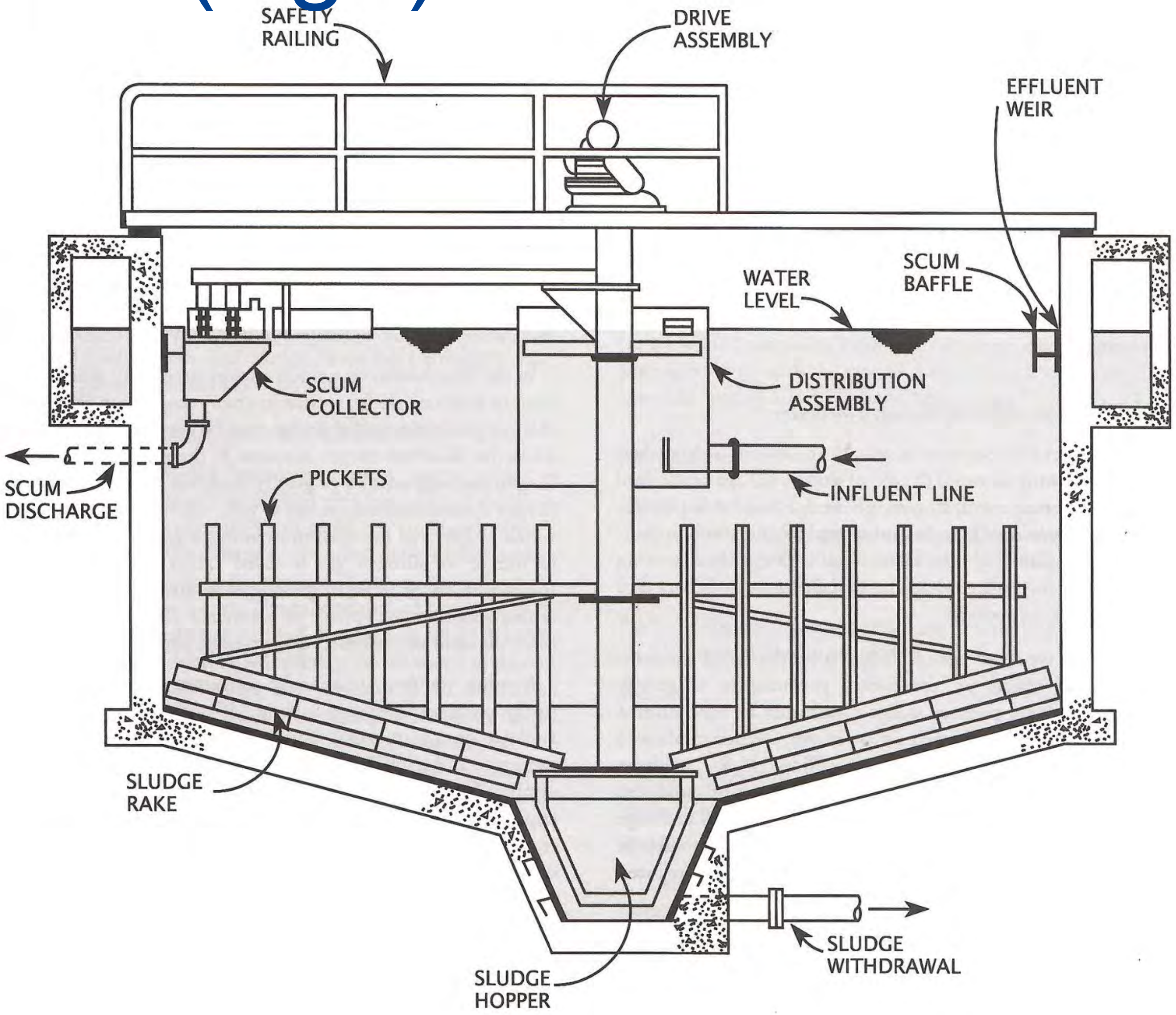
Sludge Characteristics (Type)

1. Secondary sludge is less dense & settles slower
2. Biosolids are 85-90% water (bound in the cells)
3. Solids are typically finer than primary solids



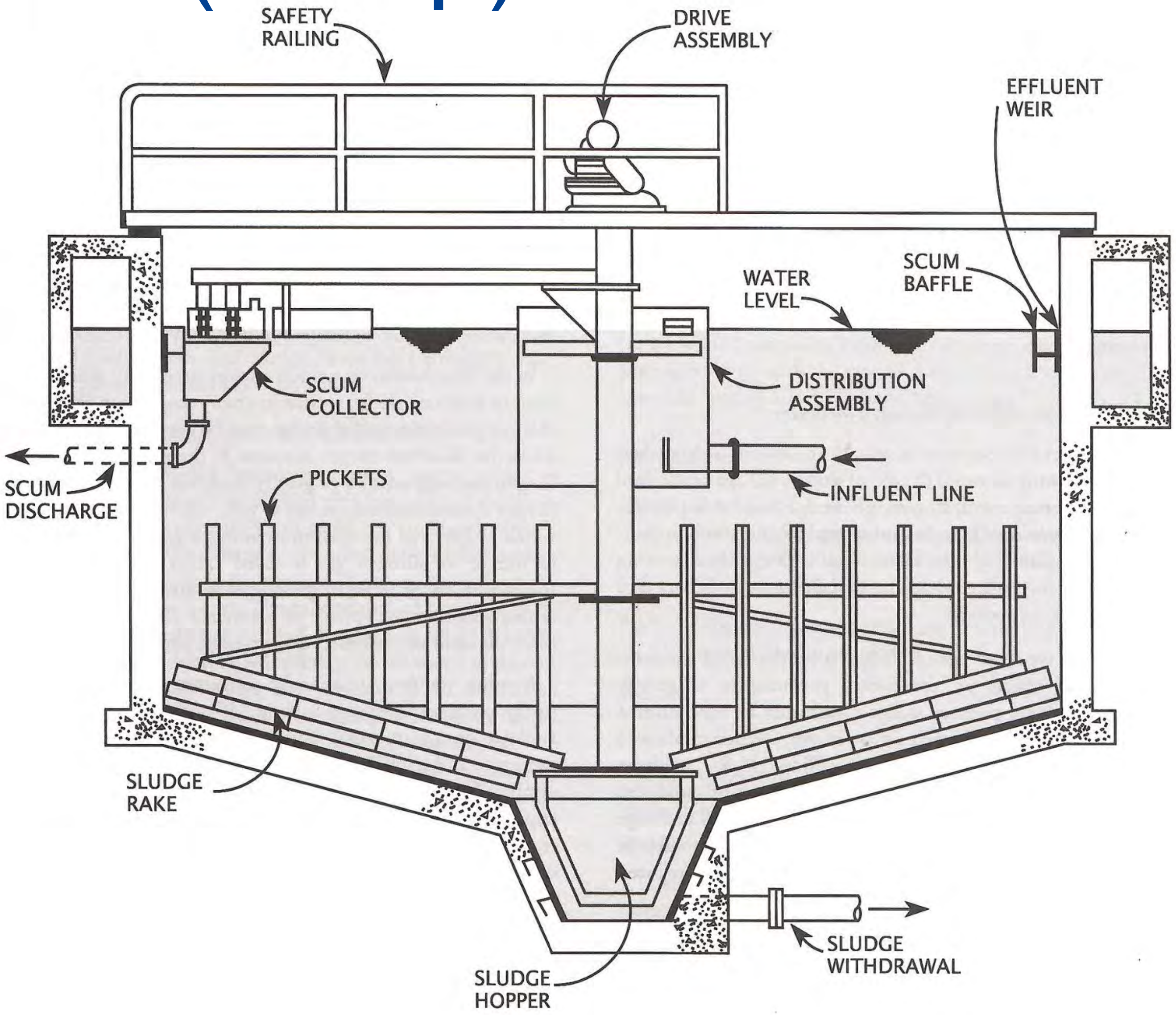
Sludge Characteristics (Age)

1. If sludge is held too long dissolved O_2 may be depleted
2. Denitrification can result creating nitrogen gas (gasification)
3. Filamentous organism growth can decrease settleability of sludge



Sludge Characteristics (Temp)

1. As sludge temperature increases so does biological activity
2. Gasification and sludge rising increases
3. Sludge removal rates tend to increase in summer and decrease in winter



Gravity Thickener Op Guidelines

Sludge Type	Solids Loading (lbs/day/ft^2)	Thickened Sludge %
Separate		
• Primary Sludge	20 - 30	8 - 10
• Activated Sludge	5 - 8	2 - 4
• Trickling Filter	8 - 10	7 - 9
Combined		
• Primary & Activated Sludge	6 - 12	4 - 9
• Primary & Trickling Filter	10 - 20	7 - 9

Gravity Thickener Op Guidelines

Sludge Type	Hydraulic Loading Rate (GPD/ft^2)
• Primary Sludge	400 - 800
• Activated Sludge	100 - 200
• Combined Primary & Activated Sludge	150 - 300

Hydraulic loading rates may be achieved by blending secondary effluent with the sludge entering the thickener.

Higher flows of fresh liquid will help prevent septic conditions and odors from developing

Poll Question

Gravity Thickener Op Guidelines

Sludge detention time can be controlled by varying the sludge blanket depth

The S/V (sludge/volume) ratio – or ratio of sludge blanket volume divided by the volume of sludge pumped from thickener – is typically between 0.5 and 2.o days

$$\frac{S}{V}\,ratio\,(days) = \frac{Sludge\ Blanket\ Volume\ (gal)}{Volume\ of\ Sludge\ pumped\ (\frac{gal}{day})}$$

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If more sludge enters than leaves, the blanket volume will INCREASE
If more sludge leaves than enters the blanket volume will DECREASE

Poll Question

Calculate the S/V Ratio

$$\frac{S}{V}\ ratio\ (days) = \frac{Sludge\ Blanket\ Volume\ (gal)}{Volume\ of\ Sludge\ pumped\ (\frac{gal}{day})}$$

If:

- The sludge blanket volume is 28,200 gallons, and
- Sludge flow IN to the thickener is 100 GPM at 3% concentration
- Sludge flow OUT of the thickener is 40 GPM at 7% concentration

What is the S/V ratio?

$$\frac{S}{V}\ ratio\ (days) = \frac{28{,}200\ (gal)}{40\ gal/min\ \times\ 1440\ min/day)} = \frac{28{,}200\ gal}{57{,}600\ gal/day} = 0.5\ days$$

Calculate Thickener Solids Removal Efficiency

$$Efficiency\ (\%) = \frac{Influent\ SS, \left(\frac{mg}{L}\right) - Effluent\ SS\ \left(\frac{mg}{L}\right) \times\ 100\%}{Influent\ SS\ (\frac{mg}{L})}$$

If:

- Flow IN to the thickener is 30 GMP at 3% concentration (30,000 mg/L),
- Effluent flow OUT of the thickener is at 0.15% concentration (1,500 mg/L)

What is the Solids Removal Efficiency of the thickener?

$$Efficiency\ (\%) = \frac{30{,}000\frac{mg}{L} - 1{,}500\frac{mg}{L} \times\ 100\%}{30{,}000\frac{mg}{L}} = 95\%$$

Or $$Efficiency\ (\%) = \frac{3\ {-0.15} \times 100\%}{3} = 95\%$$

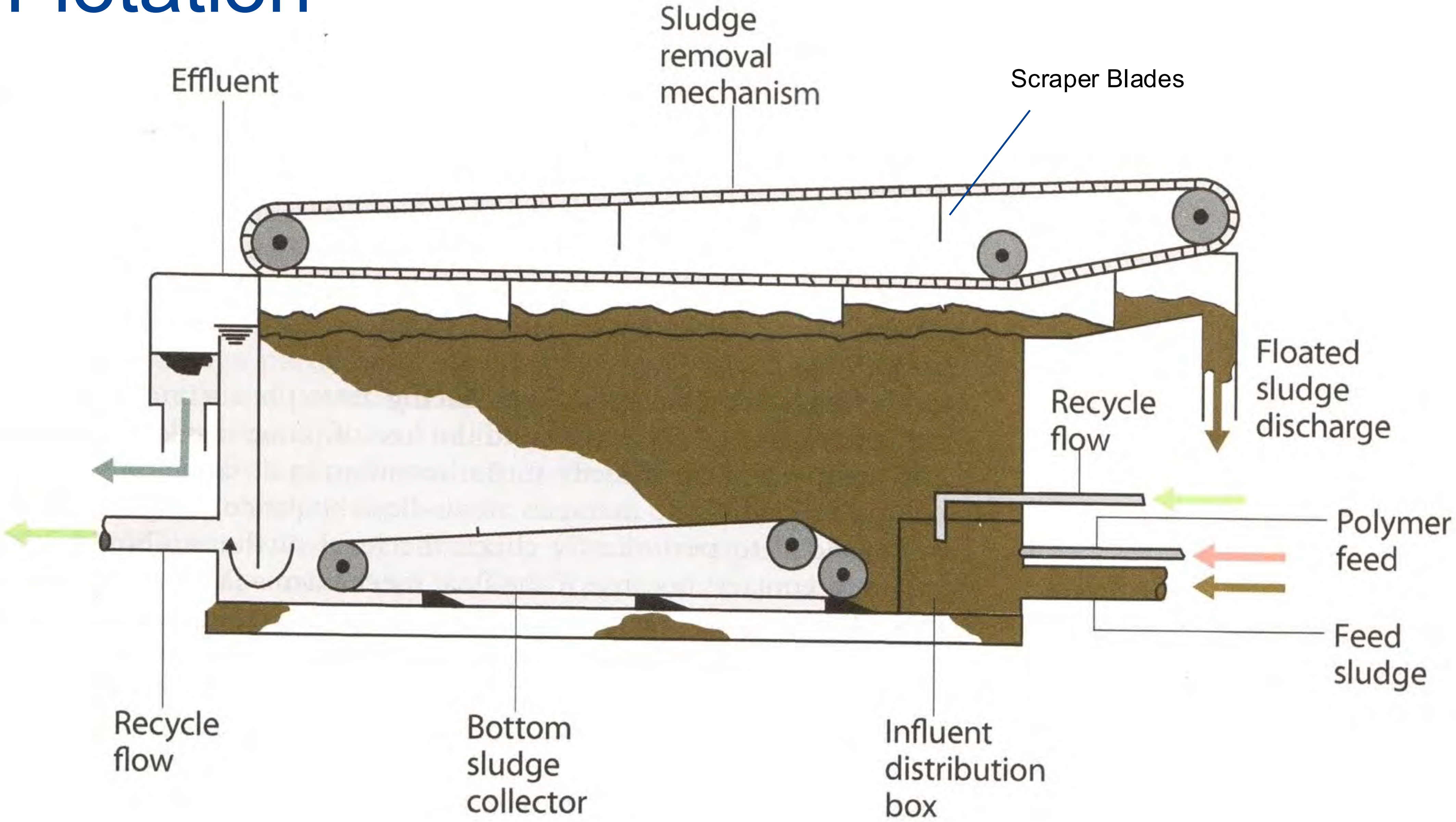
Other Thickening Methods

DAF, Centrifuges, Belts, Filtration, Drums

Flotation

Flotation

Flotation



Effluent
Sludge removal mechanism
Scraper Blades
Floated sludge discharge
Recycle flow
Polymer feed
Feed sludge
Recycle flow
Bottom sludge collector
Influent distribution box

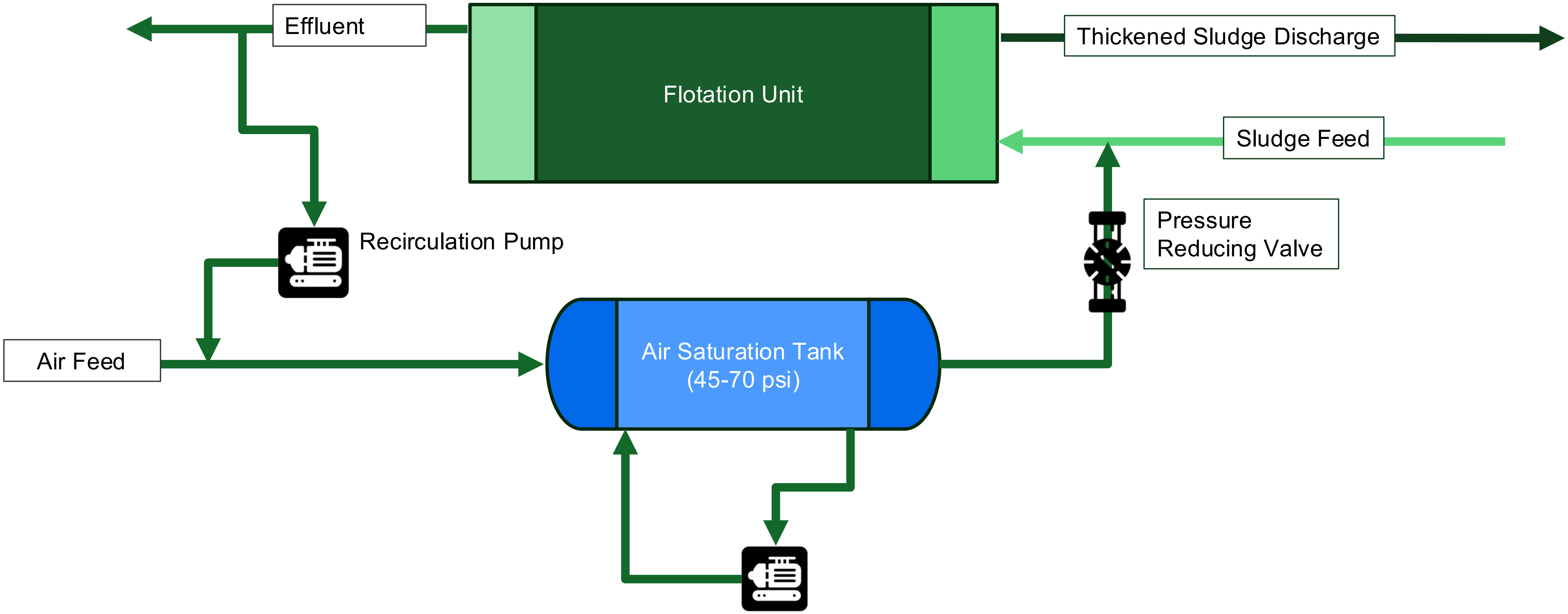
Four Flotation Methods

- Dispersed Air Flotation – Bubbles are generated by mixers or diffused aerators
- Biological Flotation – using gasses generated by biological activity to float solids
- Dissolved Air (Vacuum) Flotation – where the effluent is aerated at atmospheric pressure and released under vacuum
- Dissolved Air (Pressure) Flotation – where the effluent is aerated under pressure and released at atmospheric pressure

3 Pressure Flotation Methods

- Full-Flow Pressure Flotation – entire sludge influent flow is pressurized and released into DAF unit
- Partial-Flow Pressure Flotation – some of the sludge influent flow is pressurized and released into DAF unit and some sludge in released directly into the DAF unit without pressurization
- Recycle-Flow Pressure Flotation – part of the effluent flow, or other water flow source is recycled, pressurized and released into the DAF

Recycle Flow Schematic



Adapted from Figure 4.5, Operation of Wastewater Treatment Plants, Vol. 2, 8th Ed. Water Programs, Sacramento State, 2022

Source: H2DFlow – DAF: https://www.youtube.com/watch?v=OmSy_H0oaLE

Air to Solids Ratio

$$\frac{A}{S} = \frac{Air, lbs}{Solids, lbs}$$

Assume DAF Unit receives:

- 100 GPM of WAS at a concentration of 9,000 mg/L, and
- Air at 5 CFM (cubic feet per minute)

What's the A/S Ratio?

$$\frac{A}{S} = \frac{Air, lbs}{Solids, lbs} = \frac{5\ \frac{\cancel{ft^3}}{\cancel{min}} \times 0.075\ \frac{lbs}{\cancel{ft^3}}}{100\ \frac{\cancel{gal}}{\cancel{min}} \times 8.34\ \frac{lbs}{\cancel{gal}} \times \frac{0.9\cancel{\%}}{100\cancel{\%}}} = \frac{0.375\ lbs\ air}{7.5\ lbs\ solids} = 0.05\ \frac{lbs\ air}{lbs\ solids}$$

Operational Guidelines

	Without Polymer Addition	With Polymer Addition
Solids Loading (lbs/day/ft^2)	9.6 – 24	24 – 48
Hydraulic Loading (GPM/ft^2)	0.5 – 1.5	0.5 – 2.0
Recycle %	100 – 200	100 – 200
Air/Solids Ratio (lb/lb)	0.01 – 0.10	0.01 – 0.10
Minimum Influent Solids Concentration (mg/L)	5,000	5,000
Float Solids Concentration (%)	2 – 4	3 – 5
Solids Recovery (%)	50 – 90	90 – 98

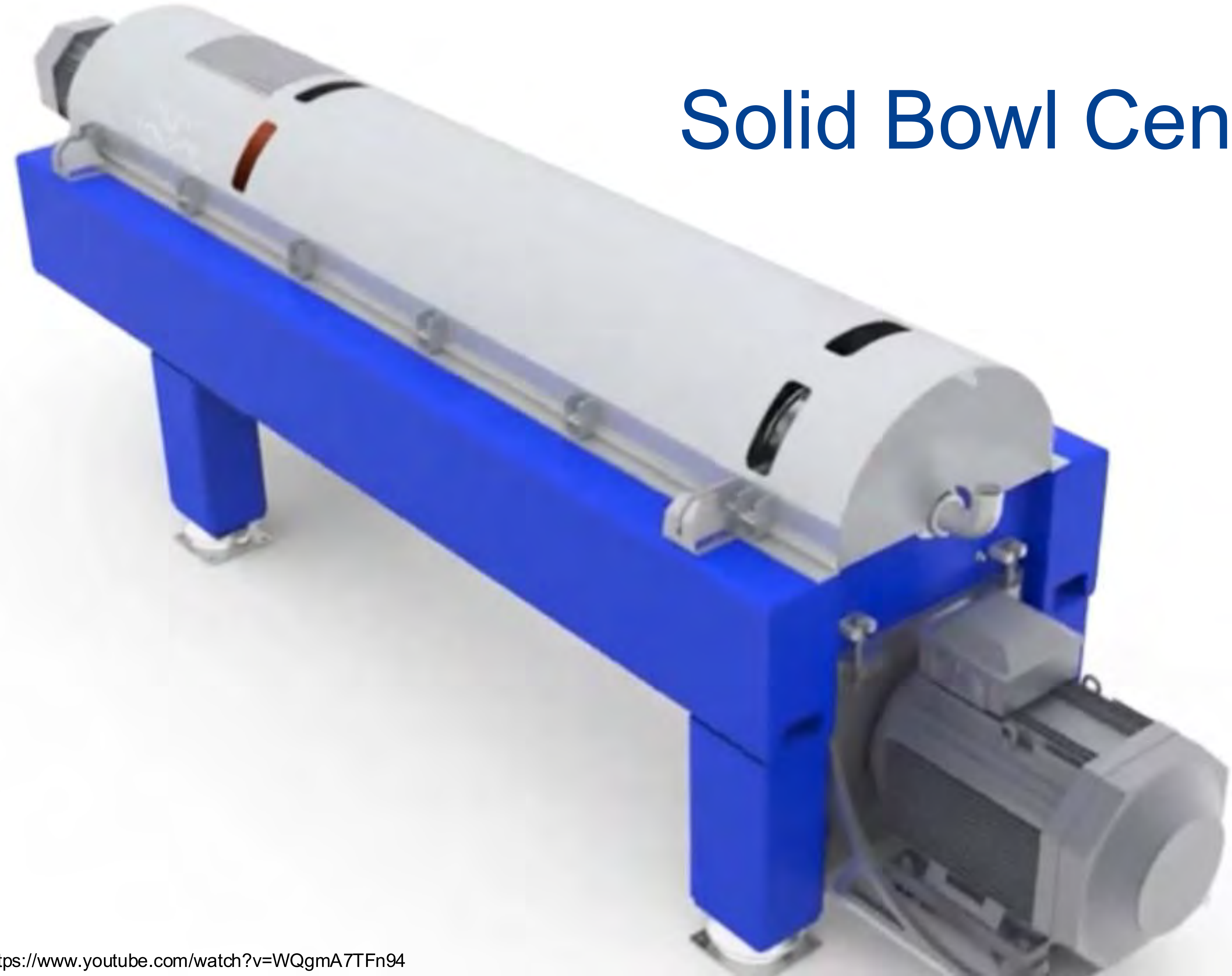
Some DAF Troubleshooting

Issue	Options
Float blanket too thick	Increase flight speed; check solids loading, lower flow rate if possible
Float blanket too thin	Decrease flight speed, check solids loading, increase flow rate if possible
Good effluent but thin float	A/S is too low, increase air input; check compressors
Poor effluent but thin float	Pressure may be too low or high Recycle pump may be inoperative Re-aeration pump may be inoperative Check chemical system Loading may be excessive

Centrifuges

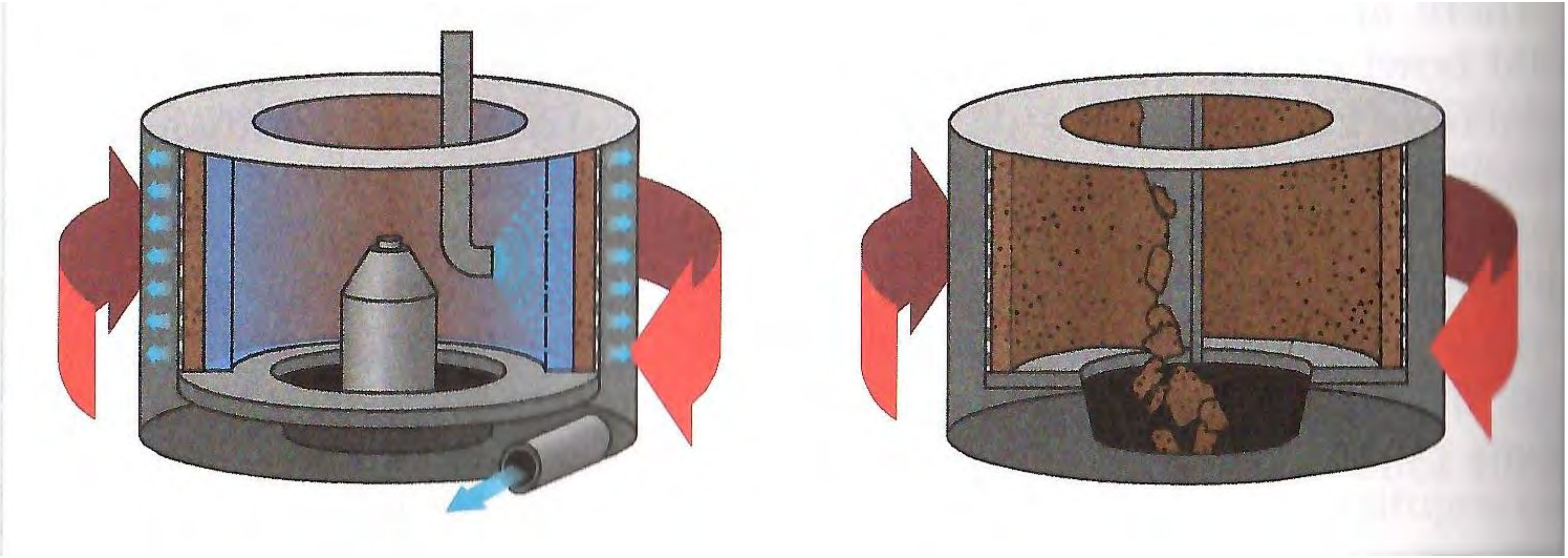
Centrifuges

Solid Bowl Centrifuge



Source: Alfa Laval, https://www.youtube.com/watch?v=WQgmA7TFn94

Basket Centrifuge



Source: Figure 4.8, Operation of Wastewater Treatment Plants, Vol. 2, 8th Ed. Water Programs, Sacramento State, 2022

Gravity Belt Thickeners

Source: Alfa Laval, https://www.youtube.com/watch?v=sAqKflyW_Uw

Drum Thickener

Source: Andritz Group, https://www.youtube.com/watch?v=M1CK-5ooOOM

Thickener Comparison

Method	Sludge Type	Use & Success
Gravity Thickener	Untreated Primary	Common, excellent results
	Untreated Primary & WAS	Often used, better for small plants
	WAS	Rare, poor solids concentration
Dissolved Air Flotation (DAF)	Untreated Primary & WAS	Limited use – results similar to gravity thickeners
	WAS	Common, but decreasing due to cost
Solid Bowl Centrifuge	WAS	Often used in medium to large plants, good results 4-6% solids concentration
Gravity Belt Thickener	WAS	Often used in medium to large plants, good results 3-6% solids concentration
Rotary Drum Thickener	WAS	Limited use, in medium to large plants, good results 5-9% solids concentration

Source: Table 13-18, Wastewater Engineering, Metcalf & Eddy, McGraw Hill, 2014

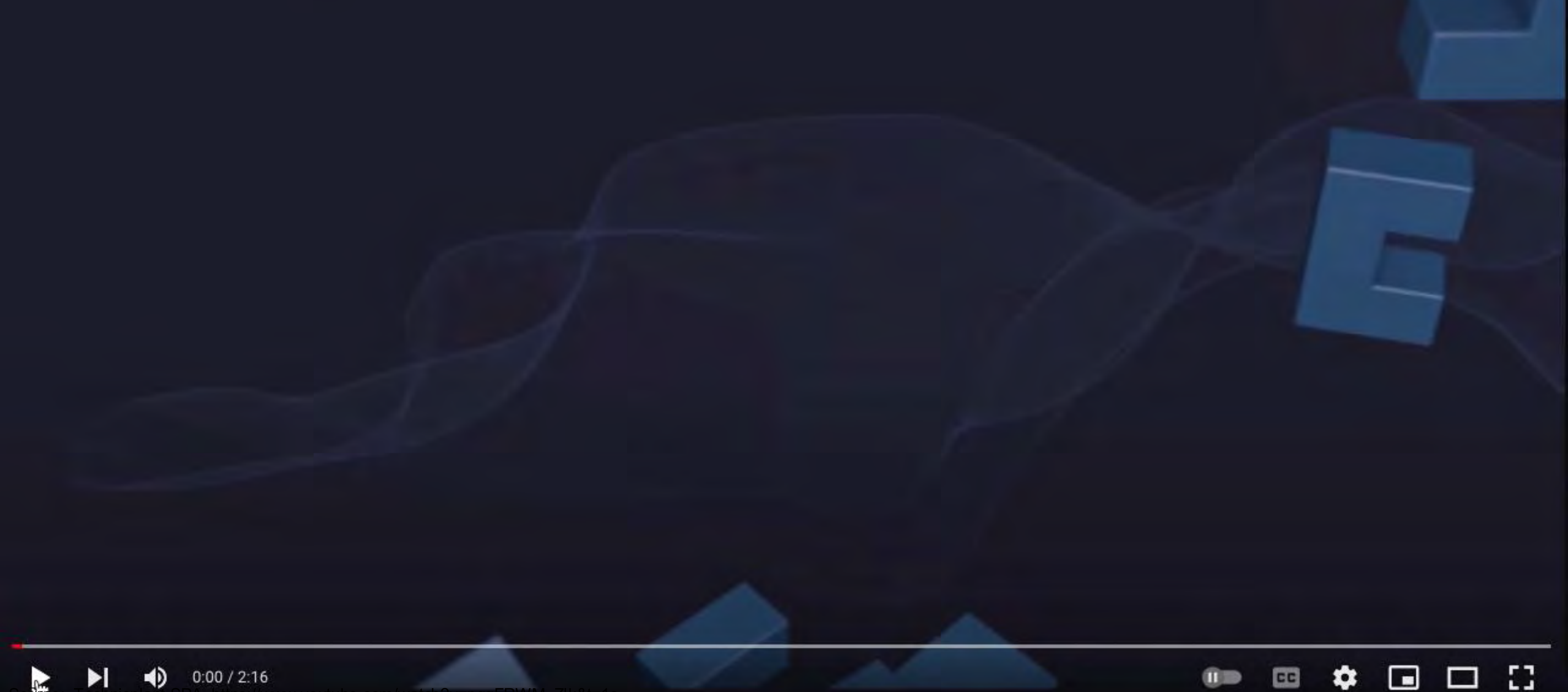
Digestion

The short version
(More on this in Part 2)

De-watering

More Volume Reduction – Filtration, Belts, Presses, Centrifuges

Drum Vacuum Filter



Source: Technicplant SPA, https://www.youtube.com/watch?v=pggFRWM_ZIk&t=1s

Belt Filter Press

Belt Filter Press

Belt Filter Press

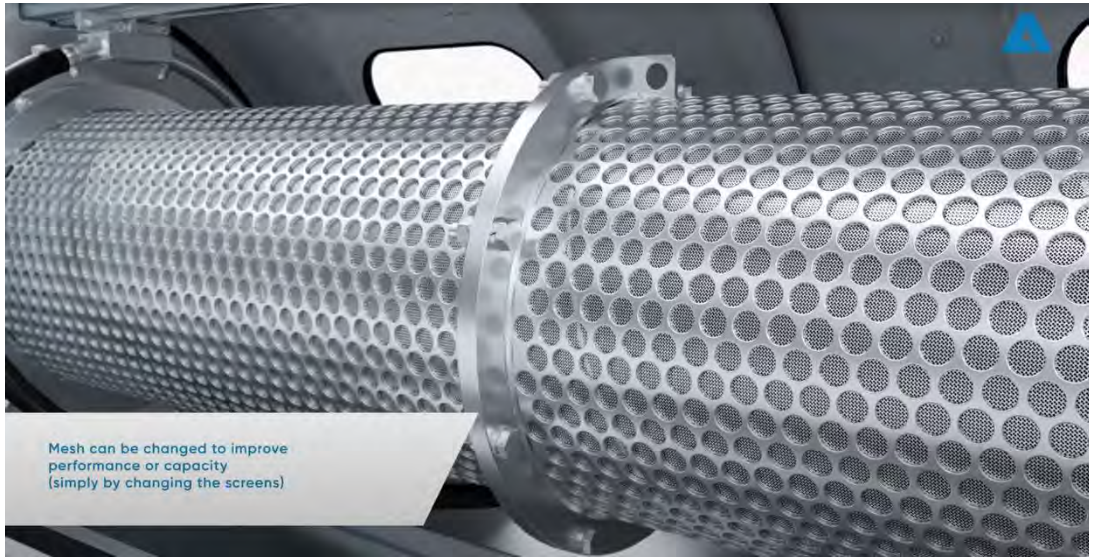
Belt Filter Press

Source: Alfa Laval, https://www.youtube.com/watch?v=eBbPIxkYfPI

Other Dewatering Presses

Screws & Rotary Mechanisms

Screw Presses



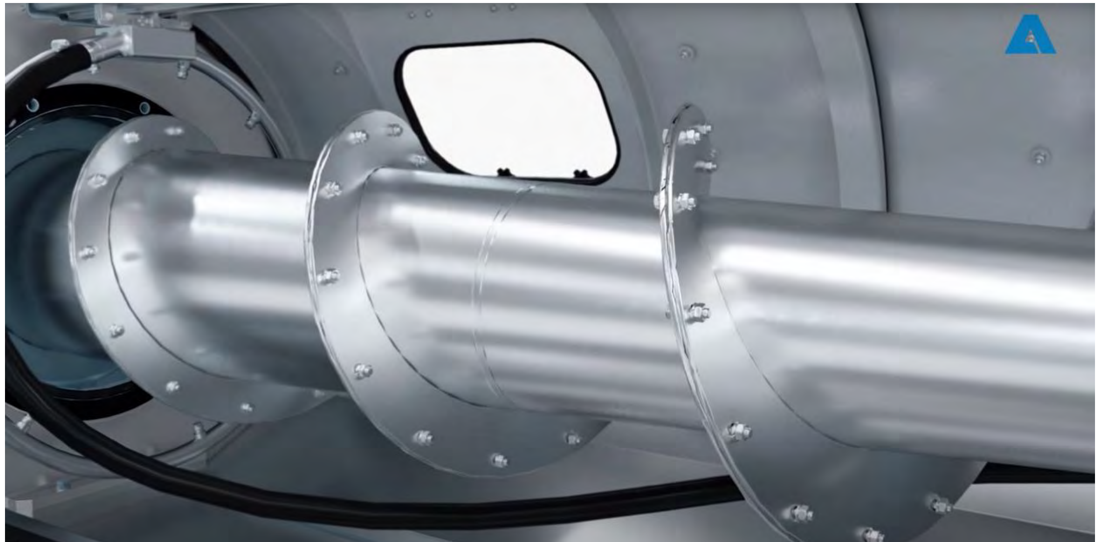


Image Source: Andritz: https://www.youtube.com/watch?v=6rEnmdwgtq8

Solid Bowl Centrifuge

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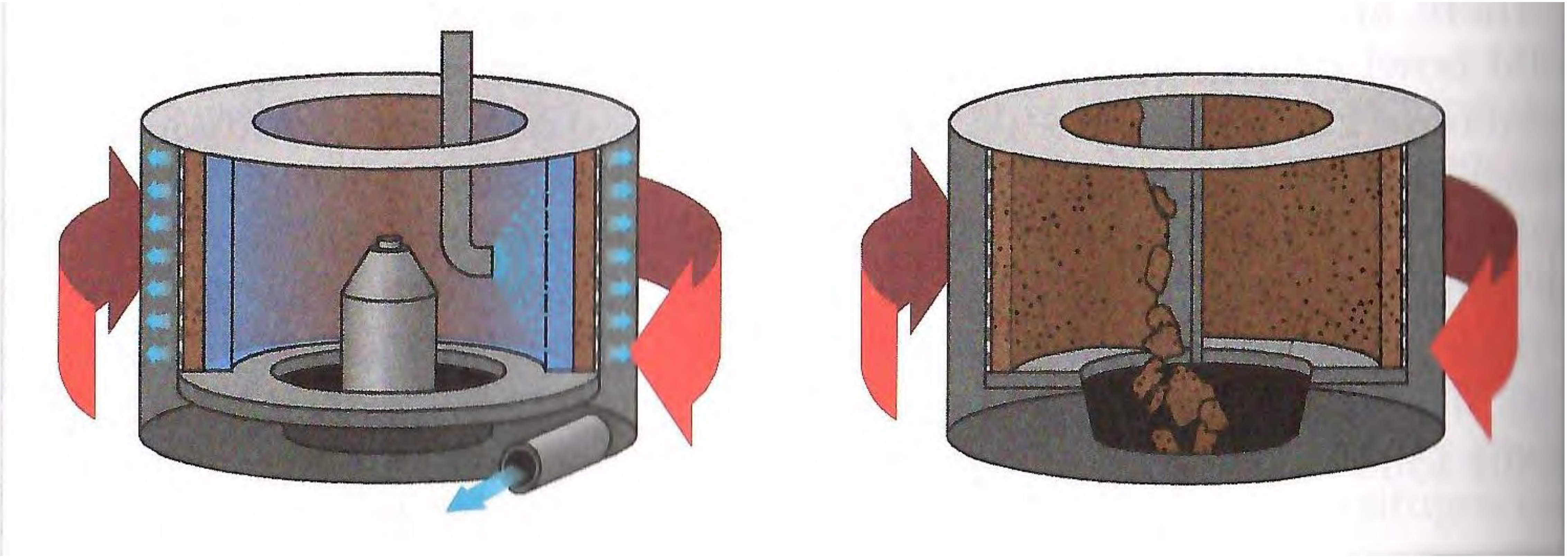
Basket Centrifuge



Source: Figure 4.8, Operation of Wastewater Treatment Plants, Vol. 2, 8th Ed. Water Programs, Sacramento State, 2022

Questions?

Contact Information

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