

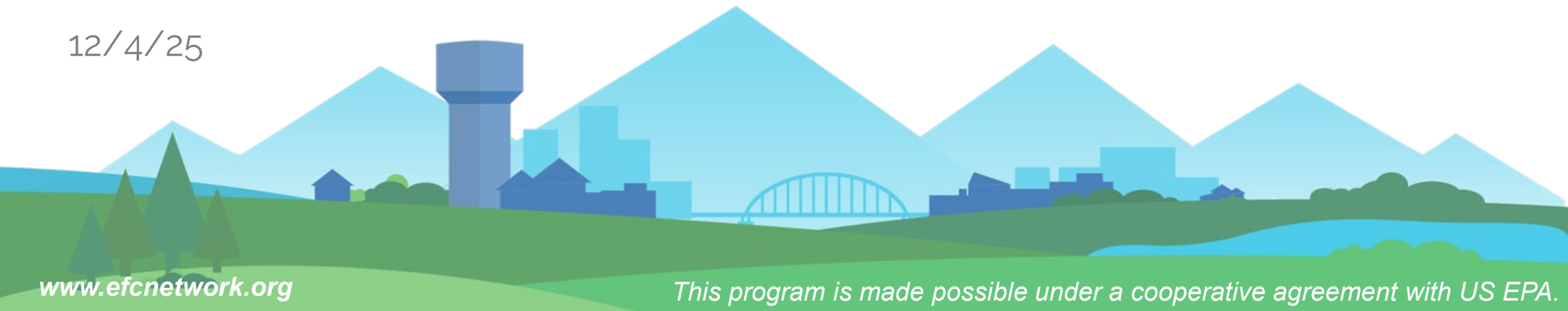


SOUTHWEST
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US Territories Water Operator Training Series

Session 12: Surface Water Treatment 1: Coagulation, Flocculation, Sedimentation

12/4/25



Tucker Colvin

Research Scientist

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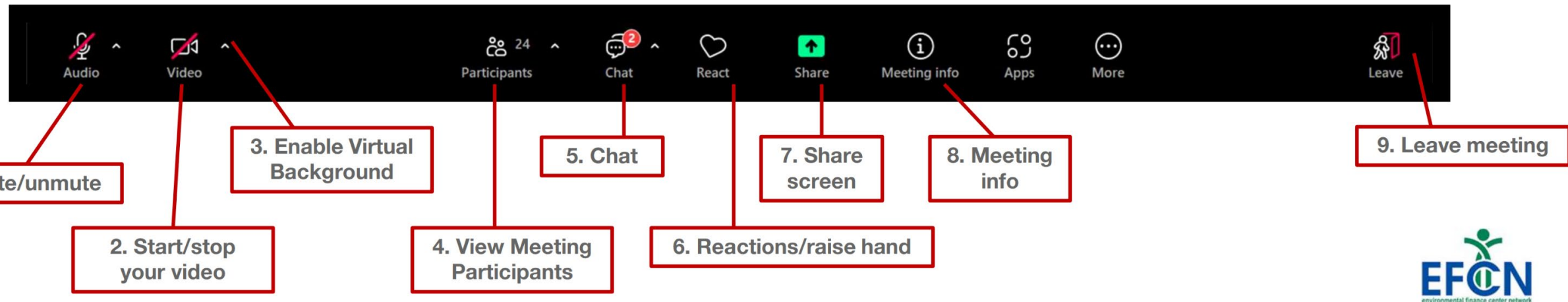
SCHOOL OF
ENGINEERING



This training series is funded by the US EPA

Attendee Meeting Controls

- Locate your control bar
- All attendees will see a black horizontal bar on their screen
- If your control bar is not visible, it may be hidden
 - Move your cursor to the screen's bottom (or top) to reveal this control bar.



Schedule for 2025:

Date	Topic
6/26/25	Program Overview, Test Format, Study & Test Tips
7/10/25	Drinking Water System Overview - (Source, Treatment, & Distribution)
7/24/25	Basic Operator Math (+, -, /, x, Exponents and basic algebra)
8/7/25	Applied Operator Math (e.g. Areas, Volume, Flow Rates, Detention Time, Pressure/Hydraulic Head)
8/21/25	Drinking Water Regulations
9/4/25	Source Water Characteristics
9/18/25	Surface Water Intake Components, Well Components, and O&M
10/2/25	Disinfection 1: Chloramines, UV, Chlorine Dioxide, Chlorine
10/16/25	Disinfection 2: Chlorine Disinfection Application for Sodium Hypochlorite and Gas Chlorine (including storage and safety)
10/30/25	Disinfection 3: Distribution System Application, Residual Measurement, Evaluation & Adjustment,
11/13/25	Disinfection 4: Chlorine Disinfection Math
12/4/25	Surface Water Treatment 1: Coagulation, Flocculation, Sedimentation (including chemistry, process controls, operations)
12/18/25	Surface Water Treatment 2: Filtration

Links to recordings and material are available on our website at <https://swefc.unm.edu/home/op-cert-trainings/>

Schedule for 2026:

Date	Topic
1/21/2026	Alternative Treatment Processes (e.g. fluoridation, ion exchange, RO...)
2/4/2026	Drinking Water Treatment Math & Concept Review
2/18/2026	Safety Program Basics (including personal safety, equipment safety, facility safety)
3/4/2026	Lead & Copper Rule, Corrosion Control
3/18/2026	Distribution Systems 1: Hydraulics, Pipe Types, Selection, Installation, and Water Quality
4/1/2026	Distribution Systems 2: Valves, Hydrants, Meters, and Service Connections
4/15/2026	Distribution Systems 3: Storage and Booster Pumping
4/29/2026	O&M: Pumps, Main, and Appurtenance Maintenance (including pressure monitoring, valve exercising, and flushing)
5/13/2026	O&M: Cross Connection Control
5/27/2026	O&M: Distribution System Math and Concept Review
6/10/2026	Sampling & Lab Procedures/Analysis/Interpretation
6/24/2026	Management Overview (including organization, communication, PR & record keeping)
7/8/2026	Drinking Water Practice Exam and Review

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Pacific Island Territories Operator Certification Trainings

This page is a repository of Wastewater and Drinking Water Operator Certification (Op Cert) Training Webinars offered by the SW EFC for systems in the Pacific Territories. Below you will find the **training webinar schedules (wastewater, then drinking water)** followed by a **training webinar recordings library**.

[Jump to Wastewater Trainings](#) ↓

[Jump to Drinking Water Trainings](#) ↓

Wastewater Training Schedule

Please note all times are local to CNMI and Guam. The times in American Samoa are one day earlier at 11 am.

Session	Date	Training Topic & Link to Recording (click to view)	Supporting Materials (click to download)
1	6/25/2025	Program Overview, Test Format, Study & Test Tips	PPT slides
2	7/9/2025	Treatment Overview	PPT slides
3	7/23/2025	WW Math Part 1 (Areas & Volumes)	PPT slides
4	8/6/2025	WW Math Part 2 (Flow Rates & Detention Times)	PPT slides
5	8/20/2025	Collection Systems – Gravity systems	PPT Slides

Sign in for every session to ensure you get credit for attending



**US Territories Water & Wastewater Operator Certification
Virtual Training Series Group Attendance Sheet**

Session Title: _____

Session Date: _____

Training Location: _____

Attendee Name	Attendee Signature	Arrival Time	Departure Time

I hereby certify that the individuals listed above attended the referenced training session.

Name: _____
Signature: _____
Title: _____
Date: _____

Please scan this sheet after each training session and email it to swefc@unm.edu with the subject line: "US Territories Op Cert Attendance Sheet"

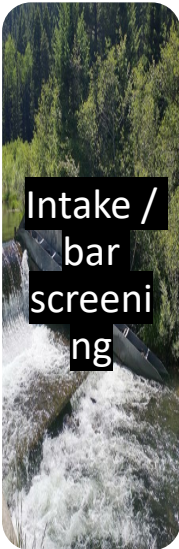
Surface Water Treatment 1: Coagulation, Flocculation, Sedimentation

Purpose of treatment

- Turbidity reduction
- Removal of suspended solids (TSS)
- Removal of dissolved solids (TDS)
- Removal or inactivation of organisms and viruses
- Alter water chemistry



Surface water treatment steps



Intake /
bar
screeni
ng



Grit
removal



Chemical
addition



Rapid
mix



Coagul
ation



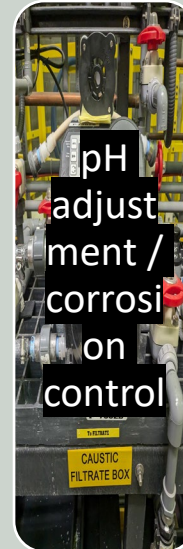
Floccul
ation



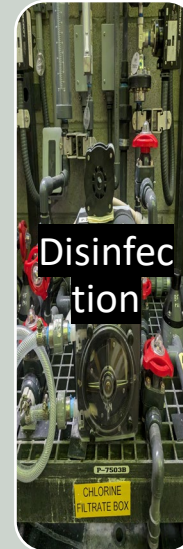
Sedime
ntation



Filtrati
on



pH
adjust
ment /
corrosi
on
control



Disinfec
tion



Fluorid
ation



Storage
/
distribu
tion

Pretreatment - chemical and physical process

Physical process – particle settling

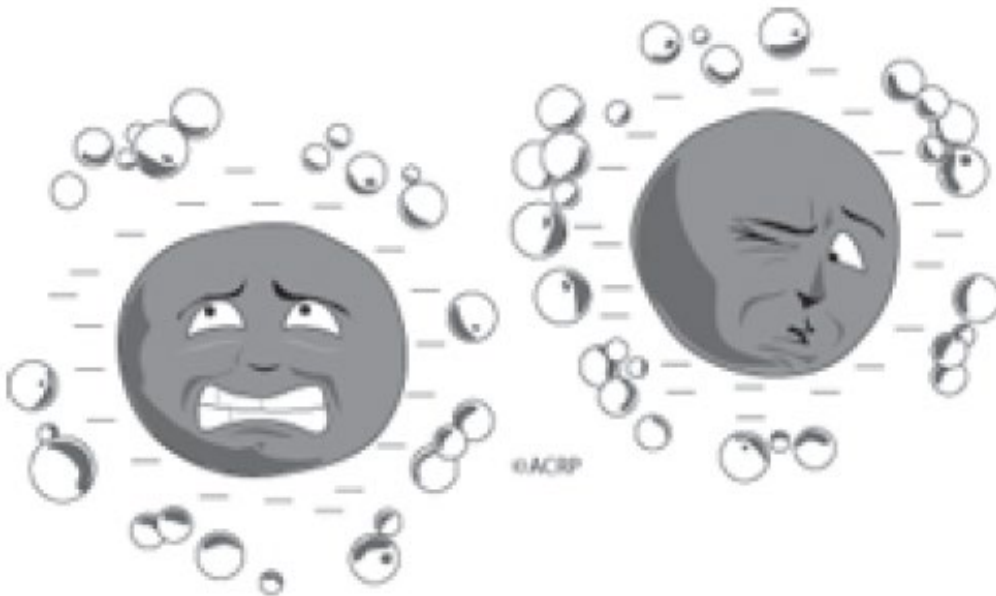
Particle Diameter mm	Representative Particle	Time Required to Settle in 1 ft. (0.3 m) Depth
<i>Settleable</i>		
10	Gravel	.03 sec
1	Coarse Sand	3 sec
0.1	Fine Sand	38 sec
0.01	Silt	33 min
<i>Considered Non-Settleable</i>		
0.001 (1 μ)	Bacteria	55 hours
0.0001	Color	230 days
0.00001	Collodial Particles	6.3 years
0.000001	Collodial Particles	63 years minimum

Chemical
process –
creating
particles to
settle

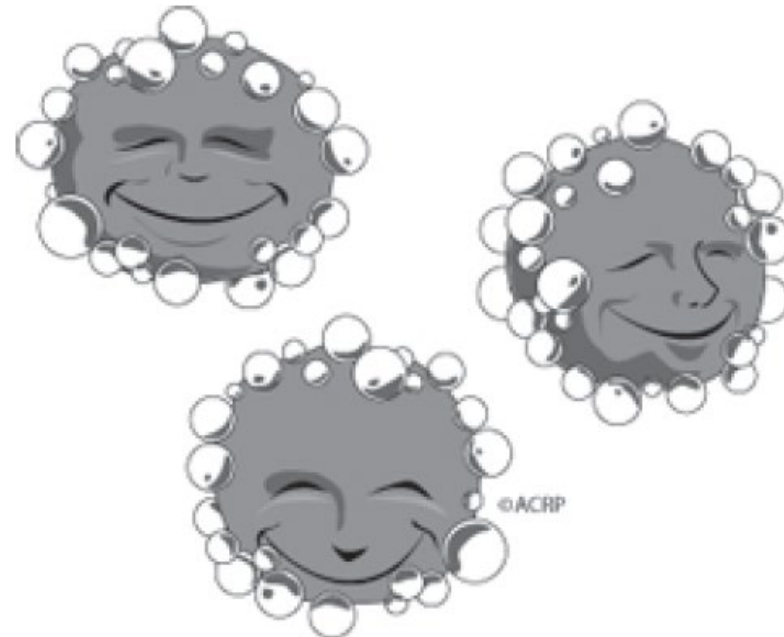
Colloids

- Do not settle quickly due to small size
- Charge overcomes force of gravity

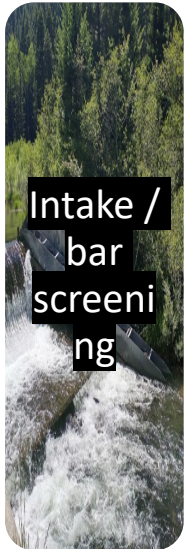
Hydrophobic (water fearing)



Hydrophilic (water loving)



Surface water treatment steps



Intake /
bar
screening



Grit
removal



Chemical
addition



Rapid
mix



Coagulation



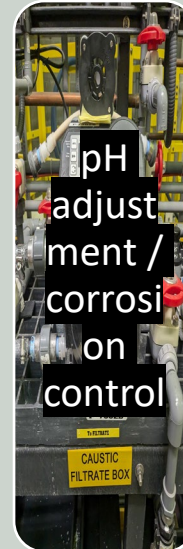
Flocculation



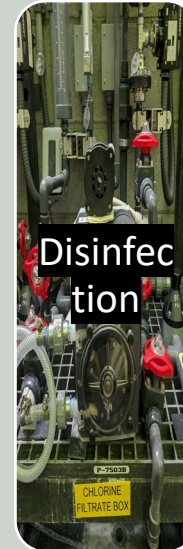
Sedimentation



Filtration



pH
adjustment /
corrosion
control



Disinfection



Fluoridation

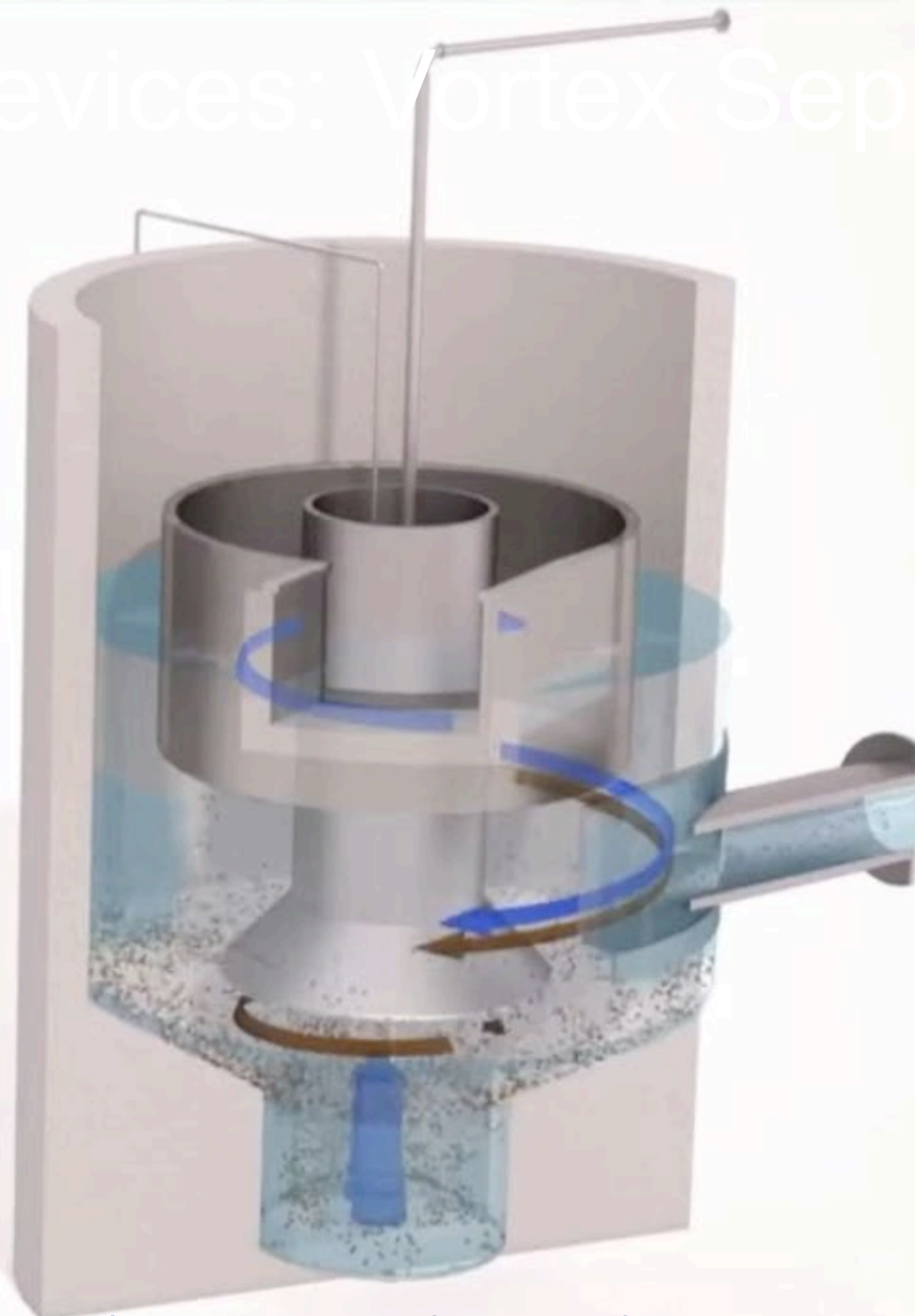


Storage
/
distribution

Influent / grit removal



Val Devices: Vortex Separator



Source: Grit King - <https://www.youtube.com/watch?v=v9Shzp4S1NU>

Water Pre-treatment Chemicals

- Oxidants
- pH adjustment
- Coagulants
- Adsorption



Water Pre-treatment Chemicals

Oxidizing agents
include

- Chlorine
- Ozone
- Aeration
- Hydrogen peroxide
- Sodium permanganate



Water Pre-treatment Chemicals

Oxidizing agents

- Precipitate out contaminants such as iron and manganese
- Decreased volatile organic compounds (VOCs), disinfection byproducts, hydrogen sulfide, carbon dioxide
- Can help with coagulation
- Neutralizes negative particle charges



Water Pre-treatment Chemicals

Coagulants

- *Alum*¹⁰ - Aluminum Sulfate $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$
- Sodium Aluminate - NaAlO_2
- Ferric Sulfate - $\text{Fe}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$
- Ferrous Sulfate - $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
- Ferric Chloride - FeCl_3
- Polymers



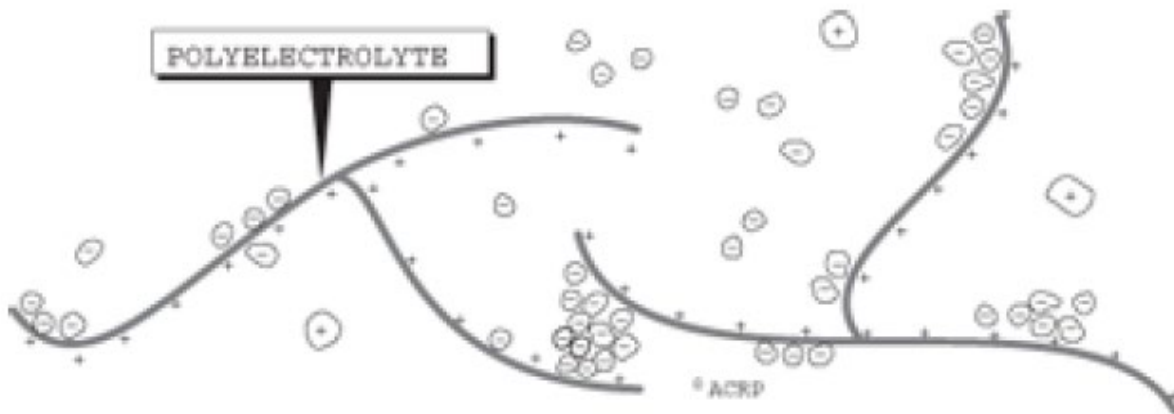
Coagulation

- Chemical process
- Sediment particles are mostly negatively charged and push away from each other
- Coagulant is positively charged and bonds to sediment to neutralize charge
- Microflocs are formed



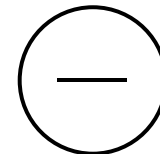
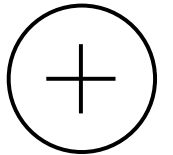
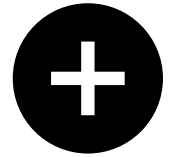
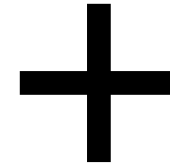
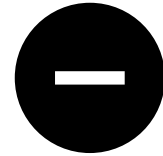
Coagulation and Polymers/Polyelectrolytes

- String-like chain molecules with charges along the string
- Aid in coagulation (sometimes as primary coagulant)
- Three types (type use depends on colloidal material)
 - Cationic polymers – positive charged
 - Anionic polymers – negative charged
 - Nonionic polymers – not charged



Factors that Affect Coagulation

- pH
- Alkalinity
- Turbidity
- Temperature
- Polymer type



Determining Chemical Dosage (jar test)



Feed Rate

The amount of chemical in pounds **or** gallons that you feed into a volume of water over a period of time.

pounds or gallons/day

$$\text{Feed Rate, lb/day}^* = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Purity, \% expressed as a decimal}}$$

Feed Rate Equation Parts

$$\text{Feed Rate, lb/day}^* = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Purity, \% expressed as a decimal}}$$

- Dosage, (mg/L) = The total amount of chemical solution fed into a volume of water.
- Flow (MGD) = The volume of water in Million Gallons per Day that you are feeding the chemical into.
- 8.34 lb/gal = The weight of water.
- Purity, % expressed as a decimal = Purity of the chemical that you are feeding into the water expressed as a decimal.

1) After doing a jar test, a 500K gpd water plant determined they want a dosage of 1.3 mg/L of their alum liquid solution with a 48% concentration. What is their lbs per day of alum solution usage?

$$\text{Feed Rate, lb/day}^* = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Purity, \% expressed as a decimal}}$$

$$\text{Feed Rate, lb/day} = \frac{(1.3 \text{ mg/L})(0.5 \text{ MGD})(8.34 \text{ lb/gal})}{0.48} =$$

$$\text{Feed Rate, lb/day} = \frac{(1.3 \text{ mg/L})(0.5 \text{ MGD})(8.34 \text{ lb/gal})}{0.48} =$$

$$\text{Feed Rate, lb/day} = \frac{(5.42 \text{ lb/day})}{0.48} = 11.3 \text{ lb/day}$$

- A) 5.42 lb/day
- B) 11.3 lb/day
- C) 86.9 lb/day
- D) 112.9 lb/day

Solubility of Salts and Water Treatment

- Salt = metal + other mineral
- Some salts soluble in water and some are not
- Most undesirable minerals in water are soluble salts
- Add chemicals and adjust pH to make soluble undesirables insoluble so can be removed

CHEMICAL NAMES AND SYMBOLS

METALS

Calcium – Ca
Magnesium – Mg
Manganese – Mn
Iron – Fe
Aluminum – Al
Sodium – Na
Copper – Cu

NON-METALS

Carbonate – CO_3
Bicarbonate – HCO_3
Hydroxide – OH
Sulphate – SO_4
Chloride – Cl

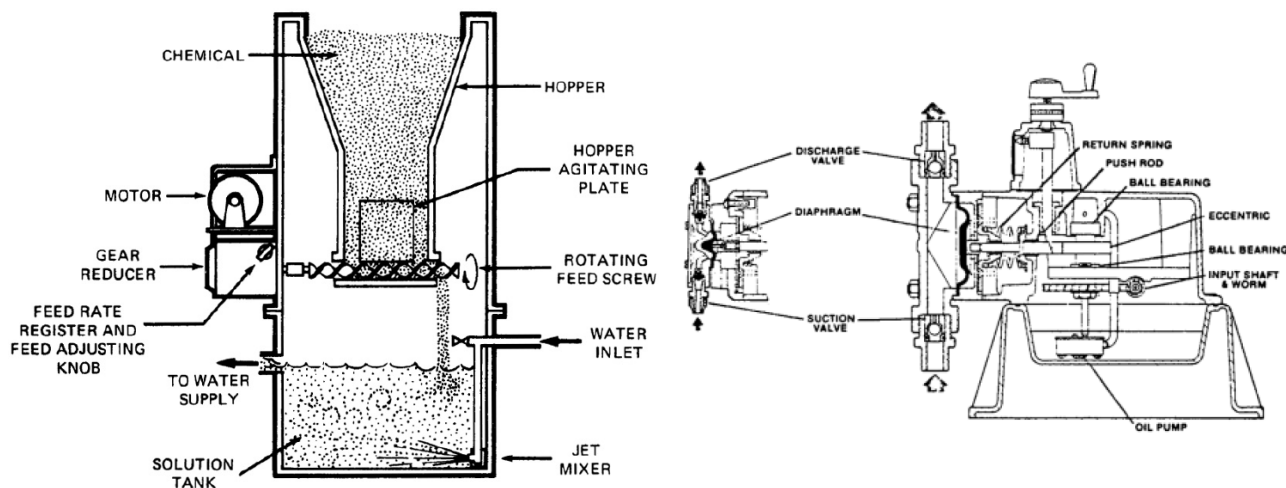
CHEMICAL COMPOUNDS

Calcium carbonate -
Magnesium hydroxide -
Aluminum sulphate -
Ferric (iron) chloride -
Copper Sulphate -

CaCO_3
 Mg(OH)_2
 $\text{Al}_2(\text{SO}_4)_3$
 FeCl_3
 Cu SO_4

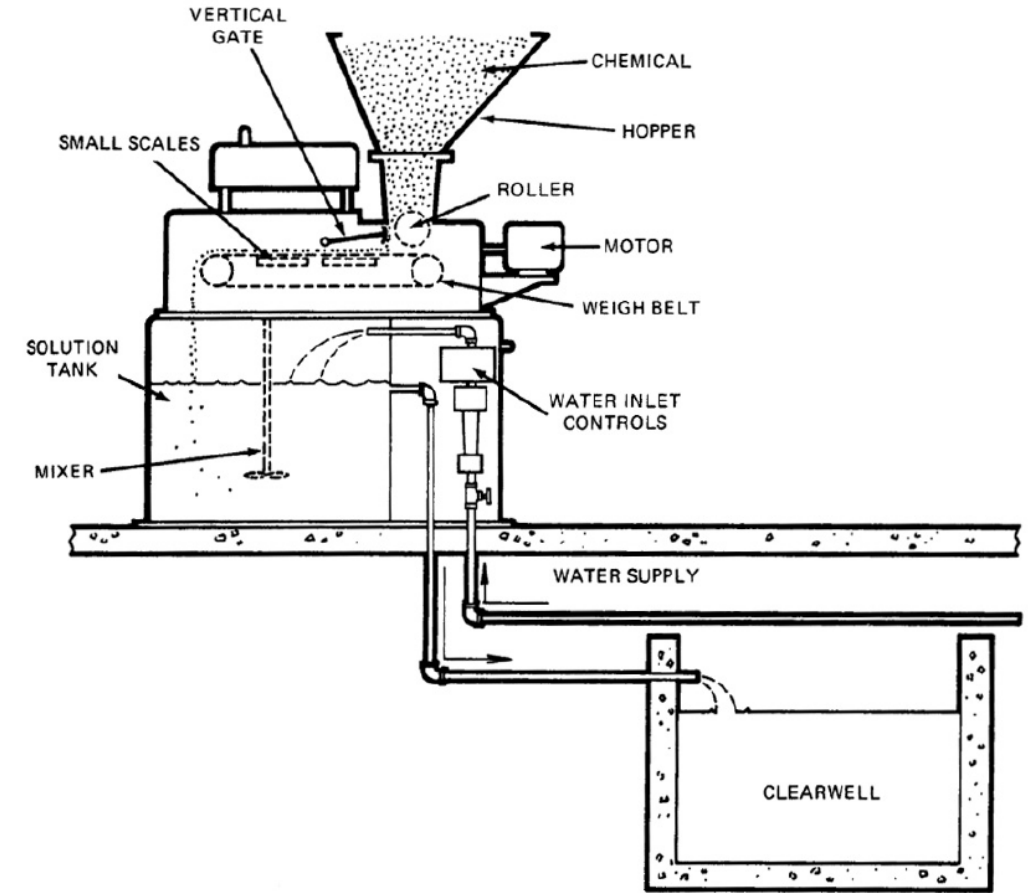
Pretreatment Equipment - Chemical Feeders

- Volumetric (most common)
 - Auger feeders
 - Positive displacement metering pumps



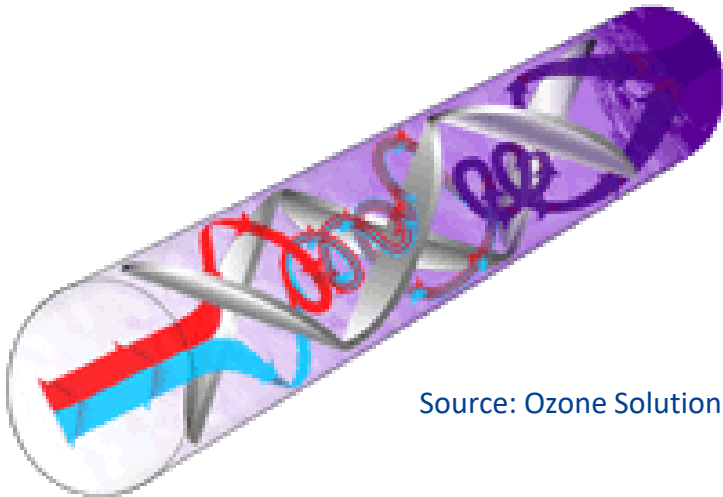
Pretreatment Equipment - Chemical Feeders

- Gravimetric
 - Conveyor with set of scales to maintain constant weight of materials on belt
 - Not used much in water treatment because most chemicals are corrosive and will damage the scale mechanism



Rapid Mix

- Rapid mixers
- In-line mixers
- Static mixers
- Aeration



Source: Ozone Solutions



Flocculation

- Occurs in large basin
- Physical process
- Microflocs bump together to create larger flocs

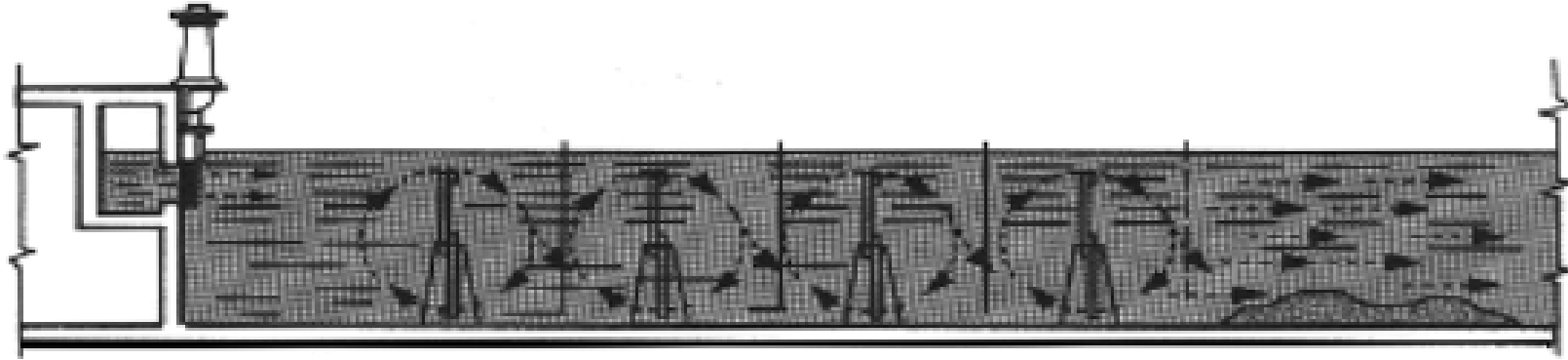


Flocculation

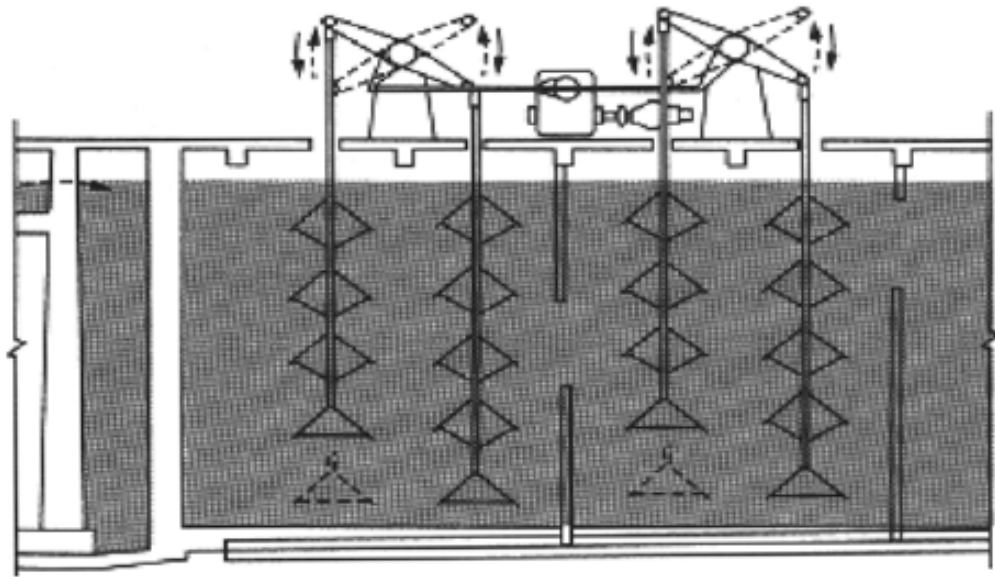
- Mixing to increase flocs impacts, but not to break apart flocs
- Too slow of mixing can result in settling in floc basin



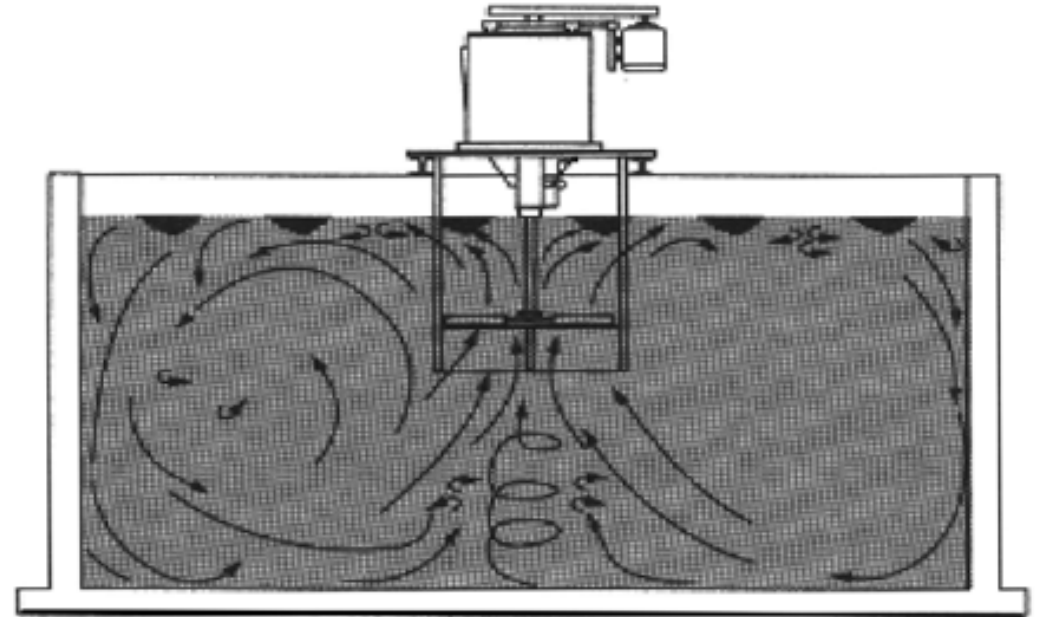
Flocculation Equipment



Propeller Flocculator



Walking-Beam Flocculator



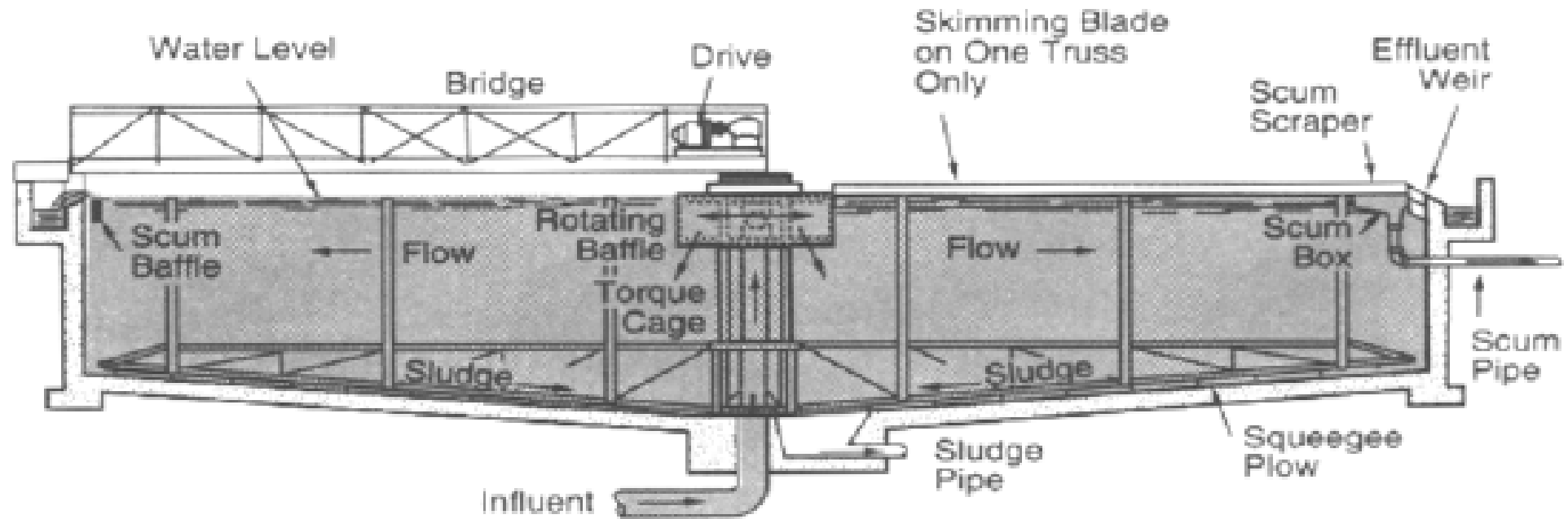
Turbine Flocculator



Sedimentation

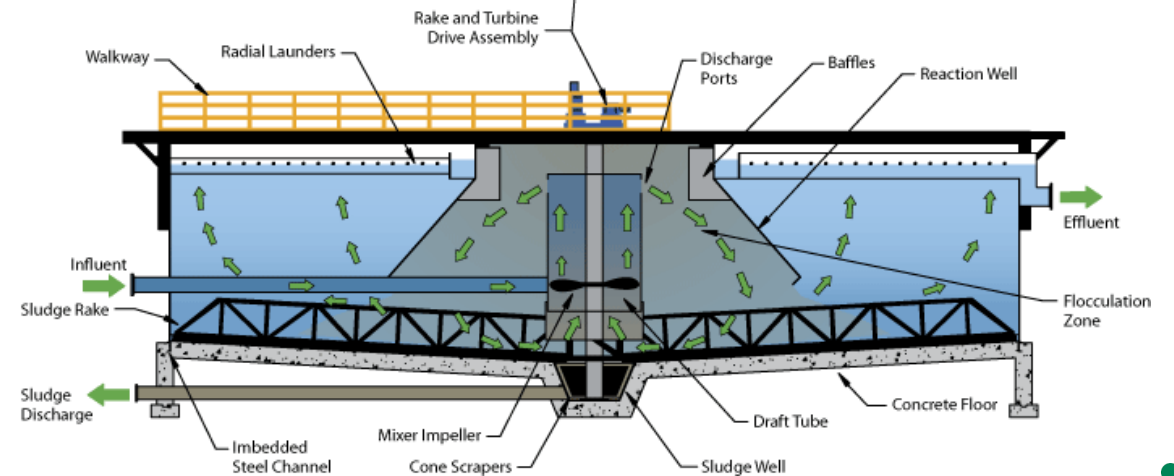
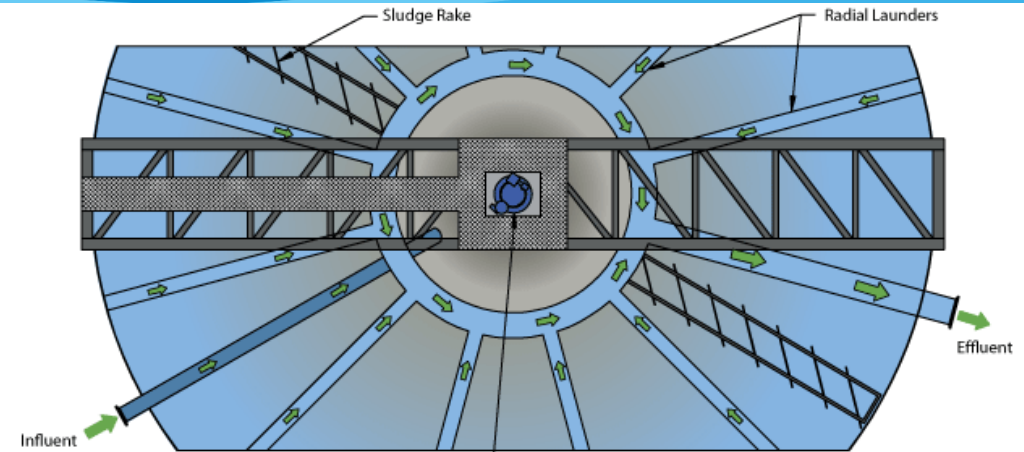
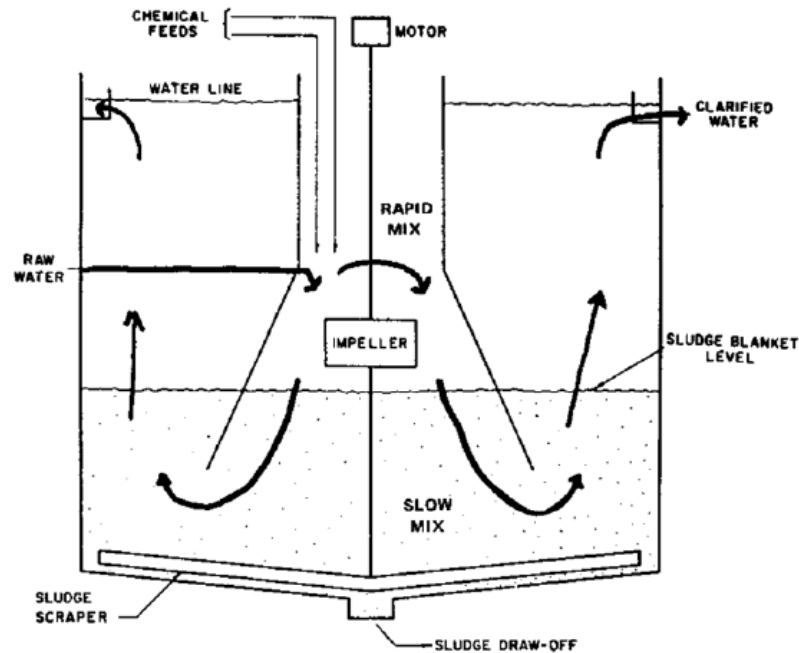
- Large basin with long detention time
- Sedimentation can be assisted by plate or tube settlers
- Mechanism at bottom to remove sludge

Circular Sedimentation Basin



Up-Flow Clarifiers/Solids Contact Basin

- Combine coagulation, flocculation, and sedimentation into one unit



2) Find the detention time in hours for a sedimentation basin that is 295 ft long, 80.0 ft wide, and with a water depth of 11.0 ft. Flow is 1.50 MGD

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible}$$

$$\text{Volume of Rectangular Tank}^* = (\text{Length})(\text{Width})(\text{Height})$$

$$\text{Vol of Sed Basin} = 295 \text{ ft} \times 80 \text{ ft} \times 11 \text{ ft} = 259,600 \text{ ft}^3$$

$$\text{Vol of Sed Basin, gal} = 259,600 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 1,942,000 \text{ gals}$$

$$\text{Vol of Sed Basin, MG} = 1,942,000 \text{ gal} \times \frac{1 \text{ MG}}{1,000,000 \text{ gal}} = 1.94 \text{ MG}$$

$$\text{Detention Time} = \frac{1.94 \text{ MG}}{1.5 \text{ MG/D}} = 1.29 \text{ days}$$

$$\text{Treatment Plant Detention Time} = 1.29 \text{ days} \times \frac{24 \text{ hour}}{\text{day}} = 31.0 \text{ hrs}$$

- A) 1.29 hours
- B) 4.15 hours
- C) 31.0 hours
- D) 69.8 hours

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