

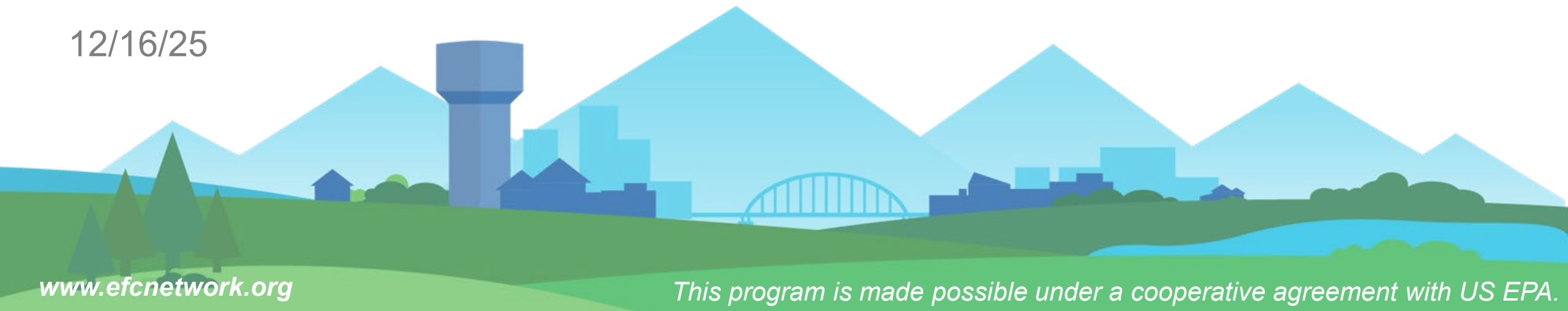


SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

US Territories Wastewater Operator Training Series

Session 13: Activated Sludge- Part 2

12/16/25



Your trainers for today:



A.J. Barney
Research Engineer



Valeria Cortes-Mora
Professional Intern



SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER



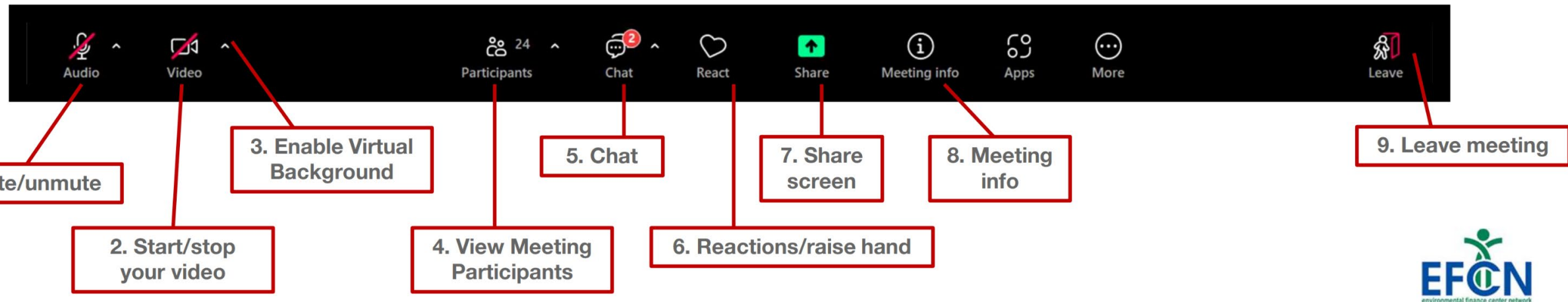
SCHOOL OF
ENGINEERING



This training series is funded by the 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.



WPI/ABC Operator Certification

Get the latest water industry news, insights, and resources from our new blog IMMERSE. [Check it out!](#)



Superior Water Starts Here™



Ask WooPI!

Make A Payment

[TESTING SERVICES](#) ▾ [CERTIFICATION](#) ▾ [MEMBERSHIP](#) ▾ [ABOUT US](#) ▾ [EVENTS](#) ▾

Search ...

Standardized Wastewater Treatment Operator Exams

Wastewater Treatment Operator Need-to-Know Criteria

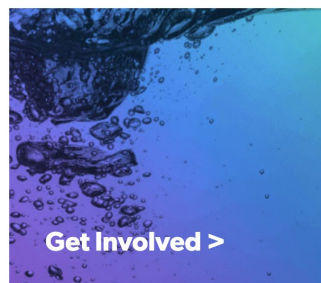
Need-to-Know Criteria outline the content that will be covered on WPI's standardized examinations provided through [ABC Testing](#), a WPI service.

- [Wastewater Treatment Operator Class I](#)
- [Wastewater Treatment Operator Class II](#)
- [Wastewater Treatment Operator Class III](#)
- [Wastewater Treatment Operator Class IV](#)

Wastewater Treatment Operator Formula/Conversion Table

WPI standardized exams are administered with a Formula/Conversion Table containing mathematical formulas and common abbreviations that may be present on the exam.

- [Wastewater Treatment Operator Formula/Conversion Table](#)



Schedule for 2025:

Date	Topic
6/24/25	Program Overview, Test Format, Study & Test Tips
7/8/25	Treatment Overview - Reg history, overview
7/22/25	WW Math Part 1 (Areas & Volumes)
8/5/25	WW Math Part 2 (Flow Rates & Detention Times)
8/19/25	Collection Systems - Gravity systems
9/2/25	Collection Systems - Pumping & force mains
9/16/25	Collection System Maintenance
9/30/25	Operator Safety/OSHA/Chemical Safety & Inventory
10/14/25	Preliminary Treatment
10/28/25	Primary Treatment: Sedimentation
11/11/25	Fixed-Film Media
12/2/25	Activated Sludge Part 1
12/16/25	Activated Sludge Part 2



https://swefc.unm.edu/home/op-cert-trainings/



[Home](#) [Our Work](#) [About](#) [Resources](#) [Blog](#) [Events](#) [Infohub](#) [EFLA](#) [Search](#)



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	
3	7/23/2025	WW Math Part 1 (Areas & Volumes)	
4	8/6/2025	WW Math Part 2 (Flow Rates & Detention Times)	
5	8/20/2025	Collection Systems – Gravity systems	
6	9/3/2025	Collection Systems – Pumping & Force Mains	
7	9/17/2025	Collection System Maintenance	
8	10/1/2025	Operator Safety/OSHA/Chemical Safety & Inventory	

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"

Activated Sludge Characteristics and Control Basics

Why are activated sludge process (ASP) characteristics and control important?

Biological process with more variables than physical and chemical processes

Operational data must be used to make process control adjustments

Characteristics change daily and the ASP process must be maintained in a balance state

Objectives of ASP:

- Maintain the aeration tank to produce floc-forming bacteria
- Flocculate and settle the flocs inside the secondary clarifier
- Manage the activated sludge to maintain a healthy proportion of microorganisms in the system



Influent Characteristics

Analysis of influent characteristics helps with treatment and making process control adjustments

Infiltration/ Inflow

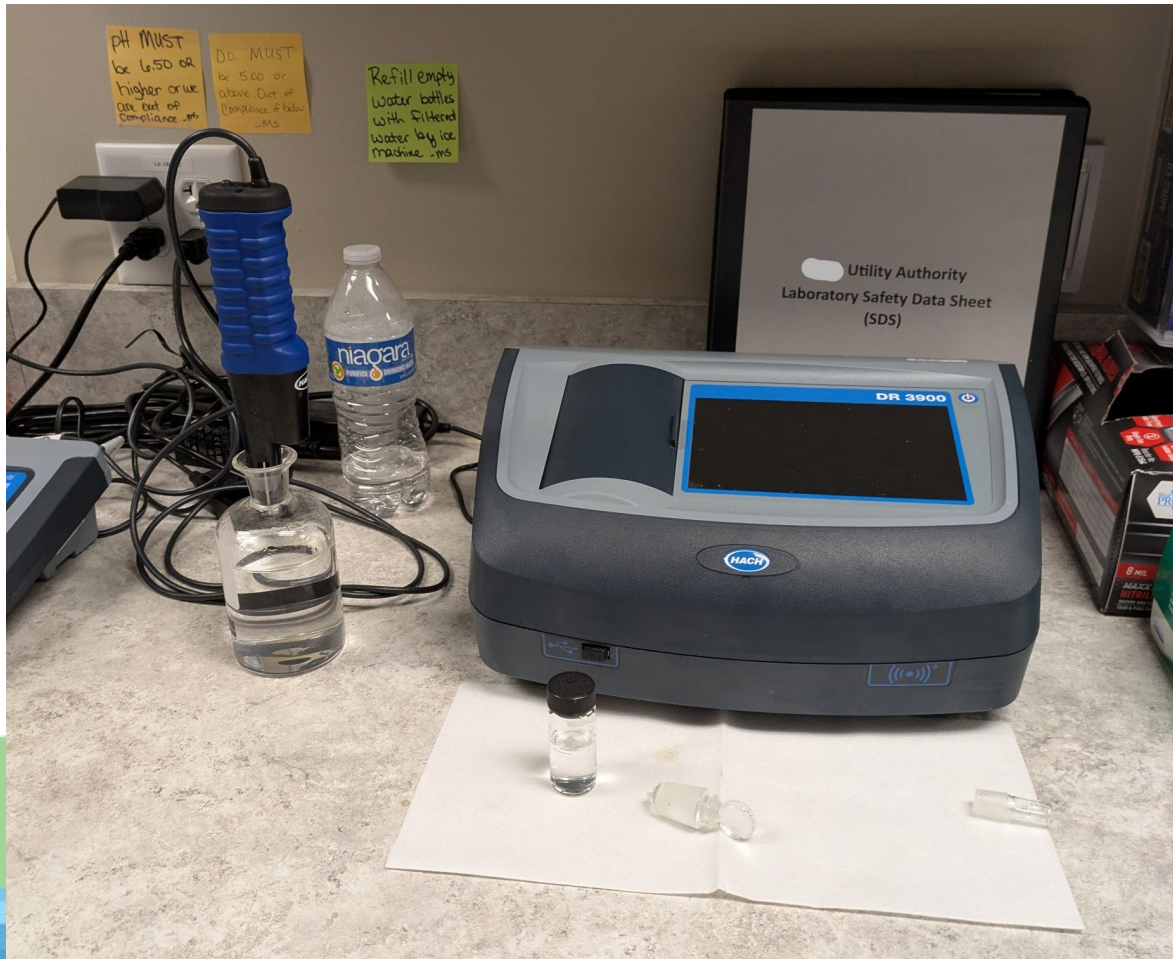
- Grit and silt
- Organic washout
- Changes in temperature

Septic shocks due to sitting wastewater

Industrial discharges can contain harmful pollutants



Influent Parameters



Flow Rate

Total Suspended Solids (TSS)

Volatile Suspended Solids (VSS)

Biochemical Oxygen Demand (BOD)

Chemical Oxygen Demand (COD)

Total Kjeldahl Nitrogen (TKN)

Ammonia (NH_3)

Nitrate (NO_3)

Temperature

pH

Alkalinity

Activated Sludge Process Variables



Dissolved Oxygen (DO)

Food-to-Microbe ratio (F/M)

Mixed Liquor Suspended solids (MLSS)

Mixed Liquor Volatile Suspended solids (MLVSS)

Solids Retention Time (SRT)

Mean Cell Residence Time (MCRT)

Sludge Volume Index (SVI)

Common Issues

Bulking Sludge
Foaming
Settling Problems
Sludge Overproduction
Nutrient Imbalance
Organic Overloading
Poor Flocculation



Healthy Activated Sludge

Visual

- Solid brown and sometimes grey colored activated sludge
- Diffused air should produce fine, crisp, white bubbles
- Formation of well-structured and dense flocs of microorganisms that settle easily for a distinct and dense sludge blanket

Olfactory (smell)

- Earthy smell- fresh soil
- Lack of foul odors

Unusual Sludge Correction

Unusual color,
aeration or
smells

- Aeration and system assessment

Pin Floc

- Increase F:M or decrease sludge age





Poll Question 1

Activated Sludge Characteristics/ Variables

Influent Flow Rate

Normal variations based on design, population served, and daily patterns.

Unusual increases and decreases in flow rate can impact the following:

- Hydraulic Residence Time
- Wastewater Dilution
- Solids Settling
- Oxygen Transfer
- Shock Loadings
- Organic Washout
- Operating Costs



Influent Flow Rate Troubleshooting

Increased Flow Rates

Increase DO

Divert flow

Increase MLSS or Return
Activated Sludge (RAS) return
rate

Decreased Flow Rates

Decrease DO

Decrease MLSS or RAS



TSS/ VSS



Influent 150-400 mg/L

Effluent 1-20 mg/L

Increased TSS/ VSS can lead to issues such as bulking and foaming, reduced oxygen transfer, and decrease in overall treatment efficiency.

Adequate primary clarification is important to remove excessive suspended solids before secondary treatment

Secondary clarifiers used to decrease suspended solids in the activated sludge process.

Activated Sludge Bacteria

- Nitrifying bacteria- Use oxygen to convert ammonia to nitrite and nitrite to nitrate.
 - Nitrosomonas and Nitrobacter
- Denitrifying bacteria- Convert nitrate to nitrite and nitrite to nitrogen gas.
- Heterotrophic bacteria- Primary consumers of organic material. Use unbound or bound oxygen.
- Floc-forming bacteria- filamentous bacteria that form flocculent biomass.
 - Flocs are large settleable clumps of microbial biomass.

BOD/ COD

BOD Influent 150-400 mg/L

BOD Effluent 10-20 mg/L

BOD and COD indicate how much oxygen the wastewater would consume if left untreated and how the wastewater may impact the environment.

Increased BOD/ COD requires more energy, microbial activity, and Oxygen to treat.

It is important to make adjustments to account for these types of increase and maintain proper sludge production.

Ammonia and TKN

Ammonia Influent 10- 60 m/L

Ammonia Effluent 1-10 mg/L

- Untreated ammonia and TKN results in eutrophication in receiving waters
- Urine>Urea>Ammonia
- Ammonia can be analyzed with laboratory analytics or a probe.

Ammonia Troubleshooting

- DO should be increased to remove elevated ammonia concentrations
- Increase recirculation
- Optimize pH or add alkalinity





Nitrate

Nitrate Effluent < 10 mg/L

- Nitrate is a nitrogen compound found in wastewater and the by-product of nitrification.
- Removed by denitrifying bacteria in the absence of oxygen.
- Large amounts of nitrate in water used as a drinking water source can result in methemoglobinemia.

Nitrate Removal

- Add anoxic zone
- Increase recycle rate (modified processes)

Temperature/ pH/ Alkalinity

High Temperature- Increases microbial activity, increase nitrification, increases bulking/ foaming

Low Temperature- decreases BOD removal, increases denitrification, increases oxygen solubility

Mesophilic (68-95°F) range is preferred

Excessive temperature change either way kills microbes and inhibits treatment

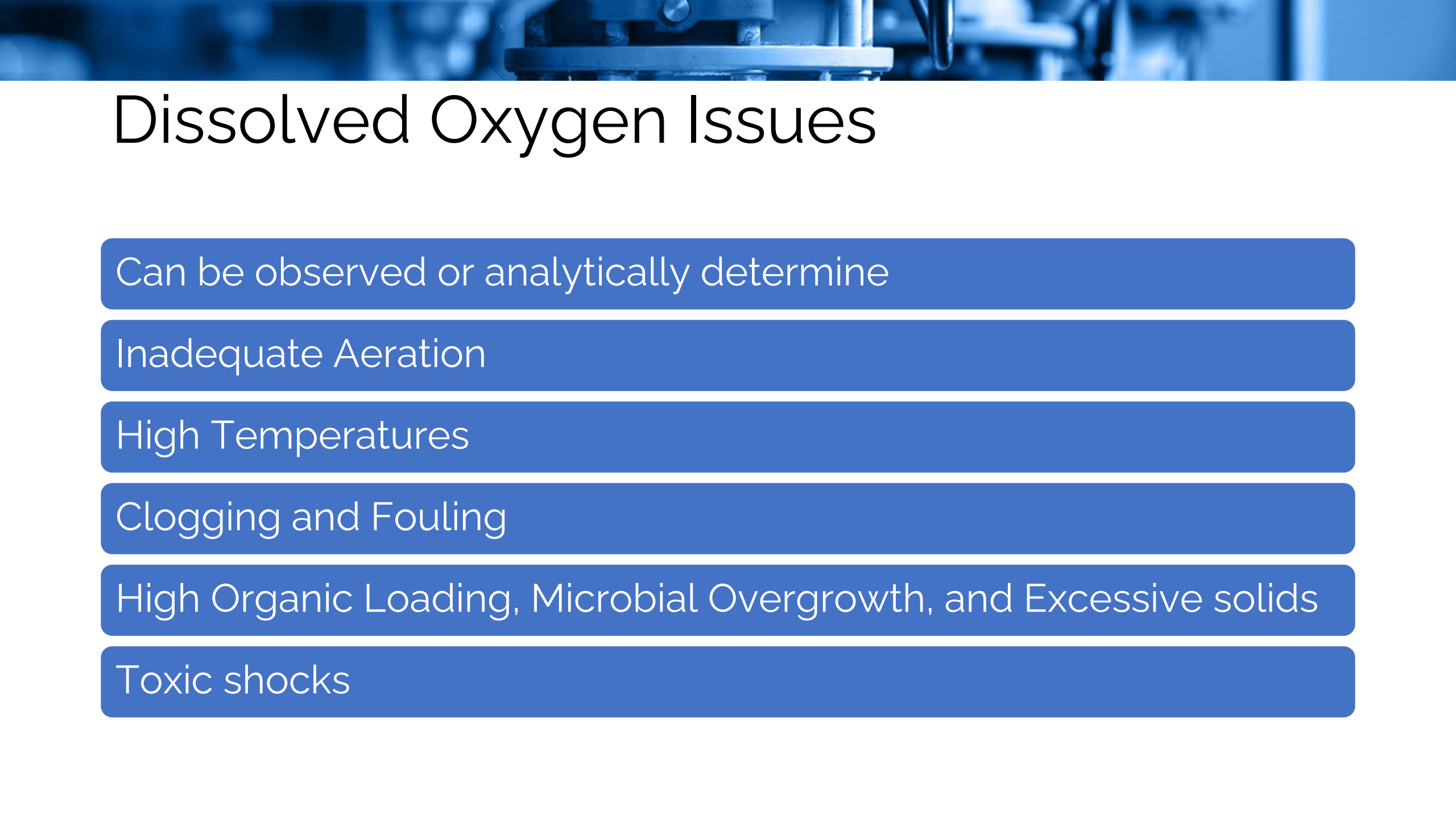
pH- microbial activity inhibited outside of 6.5-8.5

Dissolved Oxygen (DO)

DO concentration .5-4.0 mg/L

- Provides final electron acceptor for aerobic respiration and nitrification
- DO provided by blowers in and aeration tank and distributed by diffusers





Dissolved Oxygen Issues

Can be observed or analytically determine

Inadequate Aeration

High Temperatures

Clogging and Fouling

High Organic Loading, Microbial Overgrowth, and Excessive solids

Toxic shocks

Secondary Clarifier Sludge

Return Activated Sludge (RAS)-
Sludge that is pumped back to the
activated sludge process.

Waste Activated Sludge (WAS)-
Sludge that is removed from the
secondary clarifiers and activated
sludge process in general and
pumped to solids management
process.

Both control the sludge blanket in
the secondary clarifier.



Sludge Volume Index (SVI)

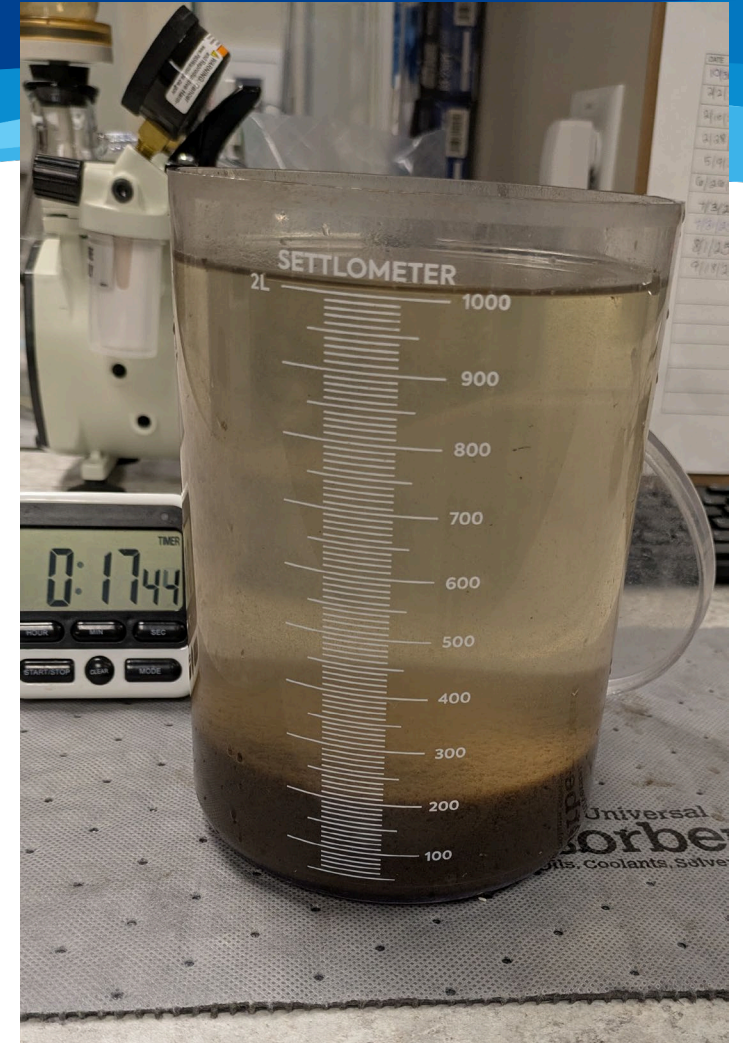
Parameter used to describe the settling characteristics of sludge

Volume of activated sludge after for 30-min

Tested with settleability test

- 1-2 liters of activated sludge sample
- Sample settles for 30 minutes
- Volume are recorded at 5 and 30 min

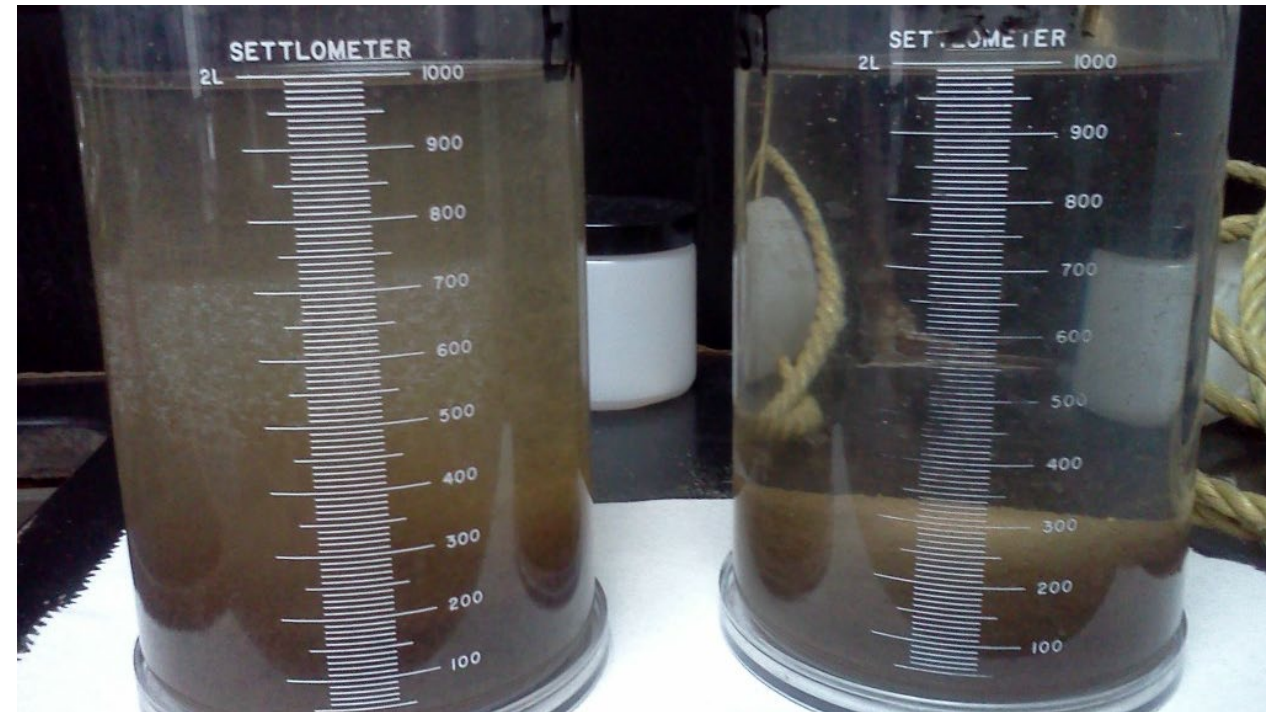
$$\text{Sludge Volume Index, mL/g} = \frac{\frac{V_{30, \text{ mL}}}{V_{\text{sample, L}}} \times 1,000 \text{ mg/g}}{\text{MLSS, mg/L}}$$



Sludge Volume Index (SVI)

Good SVI = 80 - 120

- Initial volume typically 1L or 1000 mL
- $SVI < 80$ indicates old sludge age
- $SVI > 150$ typically indicates filamentous issues
- SVI is controlled by optimizing MLSS through adjusting RAS and WAS
- Look for pin floc and other unusual settling



Mixed Liquor Suspended Solids (MLSS)

Mixed Liquor Volatile Suspended Solids (MLVSS)

1000-4000 mg/L

- MLSS is concentration of microorganisms and other suspended solids, such as inert particles and organic matter in the activated sludge process.
- MLVSS represents biomass present in activated sludge and is 70-80% of MLSS.
- Increase MLSS by decreasing sludge wasting, increasing sludge return rate, increasing aeration, and adding a supplemental carbon source.
- MLSS is decreased by increasing sludge wasting, decreasing the return rate, and decreasing aeration.



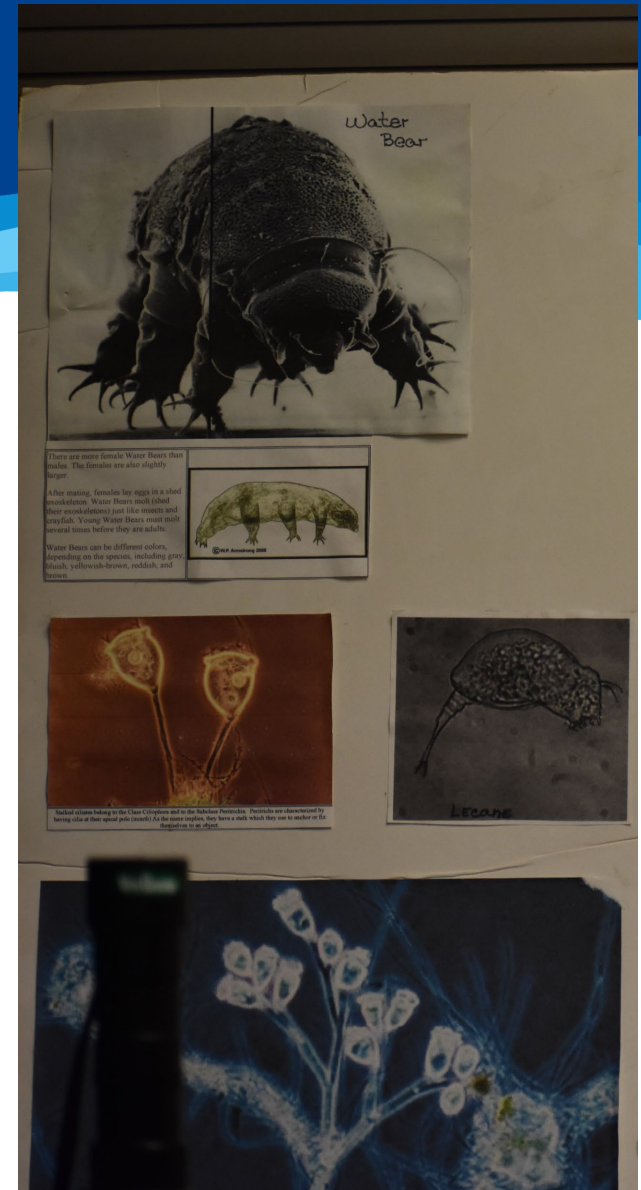
F:M Ratio

Represents the amount of organic material (food) entering a bioreactor compared to the mass of microorganisms available to consume the organic material

- BOD concentration represents the food in the reactor
- MLVSS concentration represents the microorganisms in the reactor

Monitoring the F:M ratio is essential to ensure that bioreactors are treating wastewater correctly and permit requirements are met

- Low F:M ratios limit microbial populations and decrease wastewater treatment
- High F:M ratios lead to excessive sludge production, which can lead to treatment issues and contribute unwanted solids
- The F:M ratio inversely correlates with the SRT/MCRT



Food-to-Microbe Ratio (F/M)

Desired Range 0.2 – 0.6

- Ratio of BOD to concentration of microbes in the form of MLVSS in the system.
- Low F/M correlates with high-efficiency organic matter removal and longer sludge age
 - Decrease F/M by increasing wasting, increasing DO
- High F/M encourages the growth of specialized microbes that remove nutrients such as nitrogen and phosphorus
 - Increase F/M by decreasing sludge wasting, decreasing DO, add supplemental carbon source

F:M Ratio Equation

$$\frac{F}{M} = \frac{\text{total rate of applied food}}{\text{total microbe biomass}} = \frac{Q \times \text{BOD}}{V_{ab} \times \text{MLVSS}} = \left[\frac{\text{lb BOD}}{\text{lb VSS} \cdot \text{day}} \right]$$

- Q = Flow Rate into aeration Tank
- BOD = concentration of BOD in the flow into Aeration Tank
- V_{ab} = volume of Aeration Tank
- MLSS = concentration of suspended solids in the Aeration Tank
- MLVSS (or VSS) = concentration of MLVSS in the Aeration Tank
 - Represented as portion of MLSS

Units are $\frac{\text{food mass}}{\text{microbe mass} \times \text{day}}$ (lb BOD/lb VSS/day or kg BOD/kg VSS/day)

- Units sometimes represents as just per day

Ideal F:M ratio is 0.2-0.6 lb BOD/lb VSS/day

Sludge Age

Indicates the average amount of time that microorganisms or solids spend in the activated sludge process

Ensures correct types of microbes are present and wastewater treatment is optimized

$$\text{sludge age (days)} = \frac{\text{mass of solids in aeration tank}}{\text{mass rate of solids entering aeration tank}} = \frac{V \times \text{MLSS}}{Q \times \text{TSS}_{\text{INF}}}$$

Operator certification tests and plant operations typically utilize more specific variants

- Solids Retention Time
- Minimum Cell Retention Time

Solids Retention Time (SRT) Mean Cell Residence Time (MCRT)

Represents the average time solids or cells are retained in the activated sludge process.

Directly relates to microbial activity, nutrient removal, sludge production, effluent quality, and energy efficiency.

SRT is determined by design parameters. Conventional plants = 3.5 – 10.0 days.

Primarily controlled through WAS- increasing sludge wasting reduces SRT and decreasing sludge wasting increases SRT.

SRT and MCRT

Some certifications treat these interchangeably, but some provide slightly different equations

- Sac State course uses SRT
- ABC Testing Formula/ Conversion Table treats them interchangeably

SRT= Length of time solids in the activated sludge reactor have been retained

MCRT equations sometimes do not include the TSSs in the secondary clarifier or only account for living solids

$$\text{SRT days} = \frac{(\text{Aeration Tank TSS, lb}) + (\text{Clarifier TSS, lb})}{(\text{TSS Wasted, lb/d ay}) + (\text{Effluent TSS, lb/d ay})}$$

$$\text{SRT, days} = \frac{(\text{Aeration Tank TSS, kg}) + (\text{Clarifier TSS, kg})}{(\text{TSS Wasted, kg/d ay}) + (\text{Effluent TSS, kg/d ay})}$$

Activated sludge process with ONLY BOD removal, have an SRT range of 1-5 days

Sludge Wasting

Process by which excess biomass or MLSS is remove from activated sludge processes

Referred to as waste activated sludge (WAS)

Variable that can be manipulated most readily to adjust F:M ratio and sludge age, MCRT and SRT

- There is limited control of influent, effluent, and their associated biomass or MLSS once the processes are operating
- The pumping of solids from the secondary clarifier can be adjusted easily

Rearrange SRT equation to calculate WAS rate:

Wasting Rate or Q_{WAS}

$$= \frac{\frac{MLSS \left(\frac{mg}{L} \right) \times [Volume_{Aerator}(Gal) + Volume_{Secondary\ Clarifier}(Gal)]}{MCRT} - \left[TSS_{EFF} \left(\frac{mg}{L} \right) \times Q_{EFF} \left(\frac{Gal}{day} \right) \right]}{TSS_{WAS} \left(\frac{mg}{L} \right)}$$

The background of the slide is a dark, textured surface filled with numerous question marks. Some question marks are a light, metallic gold color, while others are a dark, charcoal grey. They are scattered across the frame, creating a sense of depth and mystery. In the center, there is a semi-transparent dark blue rectangular box. Inside this box, on the left side, is a large, stylized question mark. The top half of this question mark is white, and the bottom half is dark blue, matching the box. To the right of this question mark, the text "Poll Question 2" is written in a clean, white, sans-serif font.

Poll Question 2

The background of the slide is a dark, textured surface filled with numerous question marks. Some question marks are a light, metallic gold color, while others are a dark, charcoal grey. They are scattered across the frame, creating a sense of depth and mystery. A semi-transparent dark blue rectangular box is centered horizontally and vertically, serving as a backdrop for the title text.

Poll Question 3

Abnormal Operating Conditions in Activated Sludge

Mechanical Malfunction



Mechanical, electrical, control equipment issues

Likelihood increases with increased automation

Mitigated with:

- Preventative maintenance schedules
- Adequate emergency maintenance plans and resources
- Capital Planning

Bulking Sludge

Abnormal growth of microorganisms (filamentous bacteria).

Flocs are bulky and settle poorly.

Controls

- Monitoring and process control
- Identify and reduce filamentous bacteria
- Nutrient balancing
- Sludge age control



Foaming



Excessive foaming in activated sludge treatment processes.

Results from filamentous bacteria *Nocardia* and *Microthrix parvicella*, and excessive surfactants.

Stiff white, brown, and very dark or black

Controls

Ensure proper MLSS, aeration, and nutrient balance

Chemical agents

Mechanical removal

Community out reach and pretreatment to minimize surfactants.

Monitor for seasonal changes.

Sludge Overproduction

Can lead to bulking, increased sludge age, additional disposal costs and reduced water quality.

Controls

- Maintaining proper:
 - SRT
 - MLSS
 - Nutrient balance
 - Aeration.



Nutrient Imbalance

Unequal ratio of essential nutrients (nitrogen and phosphorus)

Leads to bulking, sludge over production, and increased DO and energy consumption.

Controls

Nutrient monitoring

Nutrient dosing and balancing

Nutrient addition

Carbon source optimization

Return activated sludge control

Poor Flocculation

Inability of microorganisms to form well-defined and settleable floc structures.

Leads to difficulties in solids-liquid separation, increased effluent turbidity, and reduced treatment efficiency.

Controls

- Aeration control
- Proper mixing
- Limiting bulking and sludge overproduction





Toxic Loading

Can be caused by a variety of contaminants from domestic, commercial, and industrial sources

Leads to odor issues, sludge discoloration, decreases in treatment efficiency, and microbial die-off

Control

- Educational outreach and industrial pretreatment
- Redundancy to divert flow and dilute



Poll Question 4



Questions?

CONTACT INFORMATION



SOUTHWEST ENVIRONMENTAL FINANCE CENTER

A.J. Barney: ajbarney1@unm.edu

Department of Civil Engineering MSCo1 1070
1 University of New Mexico
Albuquerque, NM 87131
505-277-0644
swefc@unm.edu
<http://swefc.unm.edu>