



Biological Wastewater Treatment Training Series Presentation #7: Activated Sludge Process Control

Larry W. Moore, Ph.D., P.E.,
WEF Fellow
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OUTLINE

- **Introduction**
- **Activated Sludge Process Control**
 - Waste Mass
 - Dissolved Oxygen
 - Return Mass
 - Point of Influent Application
 - Activated Sludge Pressures

References: Metcalf & Eddy, 4th edition

Water Environment Federation: Activated Sludge Process Control

Introduction: Operational Challenges

- Know the plant capacity
 - Hydraulic - average and peak
 - Organic - BOD, CBOD
 - Solids - TSS, VSS
 - Inorganic - Ammonia, Inorganic Phosphorus, other
 - Nutrients - Total Nitrogen, Total Phosphorus
- Know the plant loading
 - Influent levels that may cause overload, violations, interferences, added costs

Introduction: Know Plant Operations

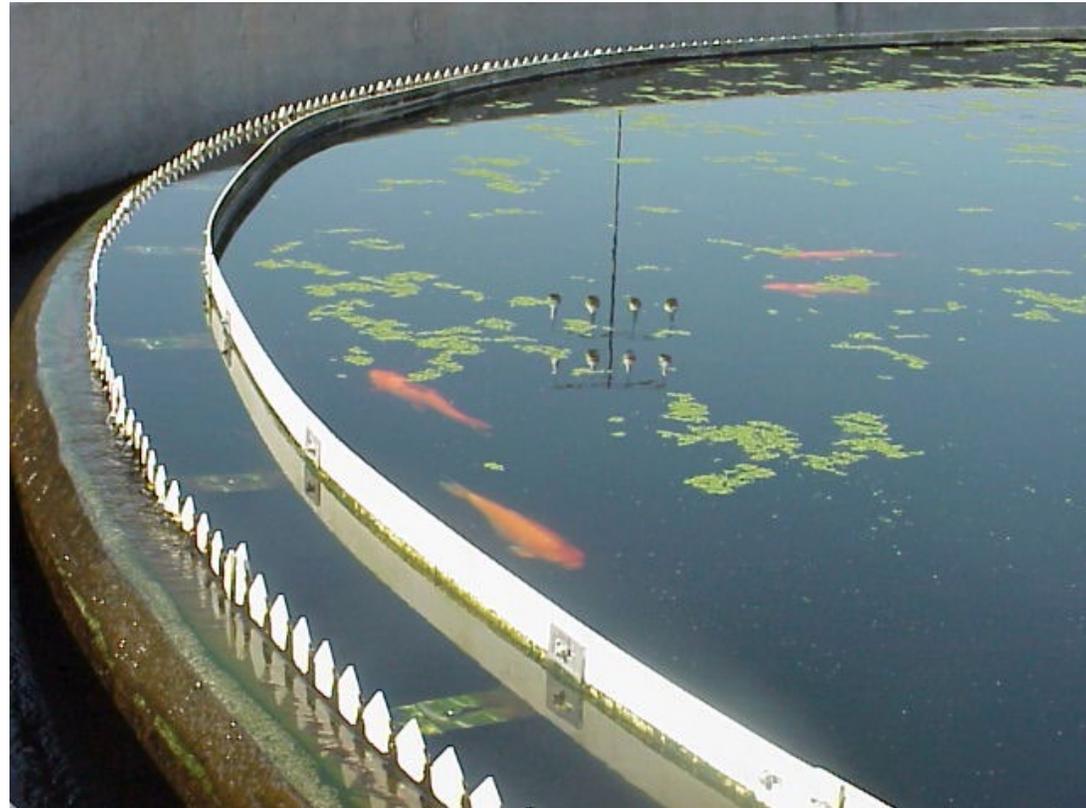


- What are basin capacities?
- What are the possible flow patterns?
- What are the process control tools?
- What process control tests should be performed?

Introduction: Basin Capacities & Flow

- EQ Basins
- Primary Clarifiers
- Aeration Basins
- Final Clarifiers
- RAS/WAS pumping

- Flow Possibilities
 - Mode of Operation
 - Recycle options



Introduction: Process Control Tools



- Biomass wasting
- Biomass return rate
- Aeration
 - Dissolved oxygen level
 - Aeration time/schedule
- Basins in use - HDT
- Mode of operation/ feed location
- Internal recycle
- Influent control

Introduction: Process Monitoring Methods

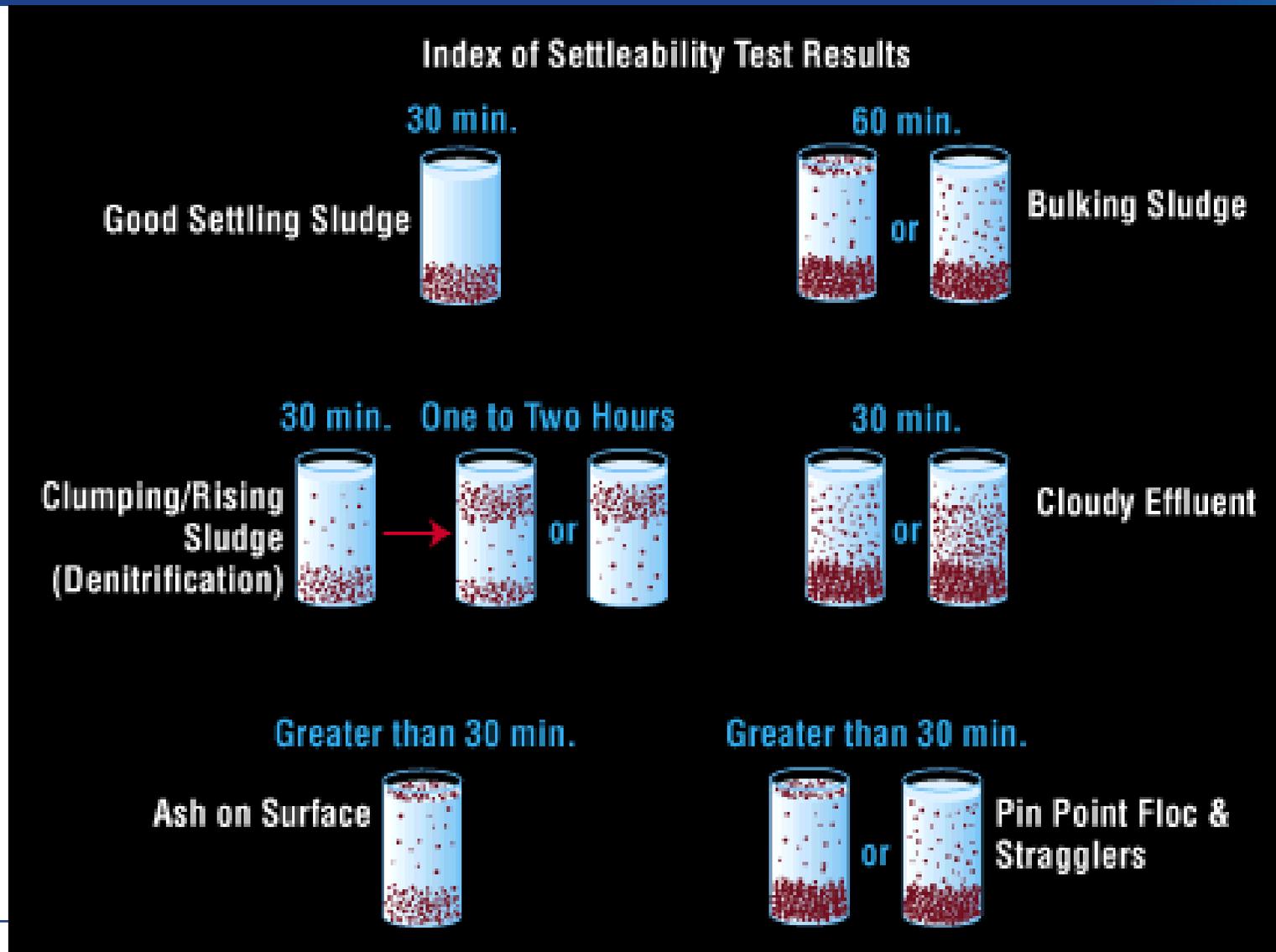
- Human senses
 - Visual appearance, odors, noise
- SCADA
- Process tests
 - Flow, D.O., pH, temperature, alkalinity, ORP, turbidity
 - Settleometer, sludge judge
 - MLSS, MLVSS
 - Centrifuge spins
 - Microscopic evaluation
 - Oxygen Uptake Rate (OUR), Specific Oxygen Uptake Rate (SOUR)

Introduction: Biomass Settleability

- **Settleometer**
 - Use settleometer ... not graduated cylinder
 - Indicator of clarifier performance
 - How well the biomass settles, compacts, and clears
 - May give mixed signals
 - Part of the SVI test
 - Diluted settleometer test



Introduction: Settleability Test Results



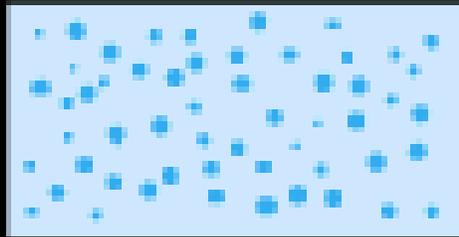
Introduction: Microscopic Evaluation

- **Floc analysis**, Jenkins' Book
 - General shape, size, dispersed cells
- Protozoan/ Metazoan counts
 - General indicator of sludge age
- **Filaments**
 - Abundance, inside/outside flock, bridging
 - Non-Phase microscope, ID - Nocardia, Beggiatoa
- Slime Bulking
 - India ink test



Activated Sludge Process Control

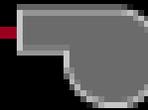
Biological Reactor



Clarifier



Return Activated Sludge



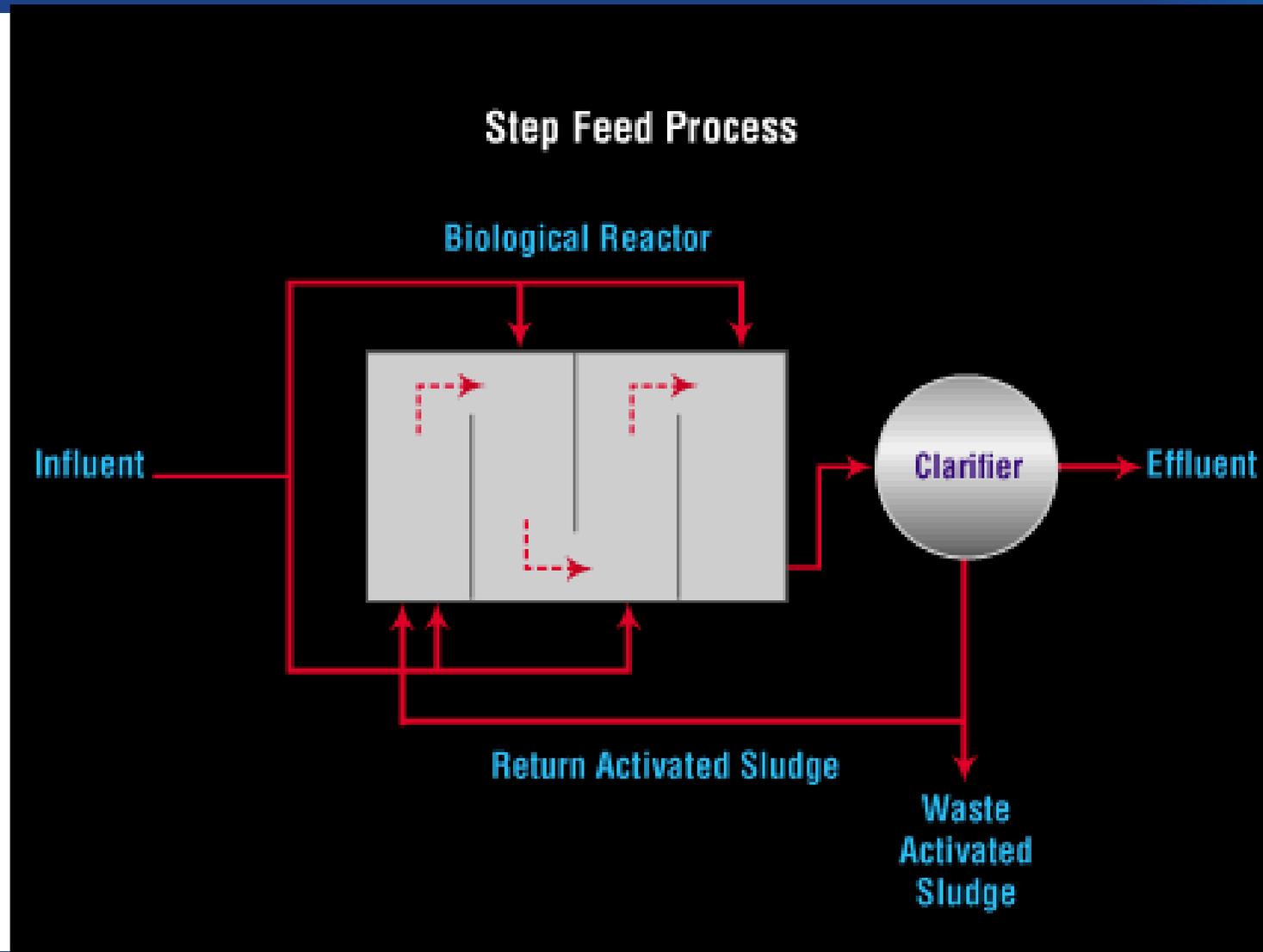
RAS
Pump



Control Methods

Waste Mass
Dissolved Oxygen
Return Mass
Point of Influent Application

Step Feed Activated Sludge



Waste Sludge

- Large effect
- Relatively fast effect on sludge quality
- Controls the entire system
- Pressure applied

Increase waste mass = *Treatment*
Decrease waste mass = *Oxidative*

Biomass Inventory

- Inventory of Biomass should answer three questions
 - How much sludge is in the system?
 - Where is it located?
 - How long has it been there?
- MLSS alone does not consider Clarifier Solids
 - Measure blanket depth at minimum.

Important Definitions for Biomass Calculations

WB	–	waste biomass, lb/day
ABI	–	aeration basin inventory, lb
MCRT	–	mean cell residence time, days
IWB	–	intentional waste biomass, lb/day
UWB	–	unintentional waste biomass, lb/day
WSF	–	waste sludge flow rate, mgd
CUC	–	clarifier underflow (TSS) concentration, mg/L

Waste Sludge Flow Determination

Choose MCRT Based on Pressure to be Applied

$$WB = \frac{ABI}{MCRT}$$

$$IWB = WB - UWB$$

$$WSF = IWB \div (CUC \times 8.34)$$

Dissolved Oxygen

- Relatively fast effect on sludge quality
- Does not have to be 2.0 mg/L
- High DO increases oxidation and nitrification
- DO desired depends on F/M ratio

Low-DO Filamentous Organisms

Type 1701

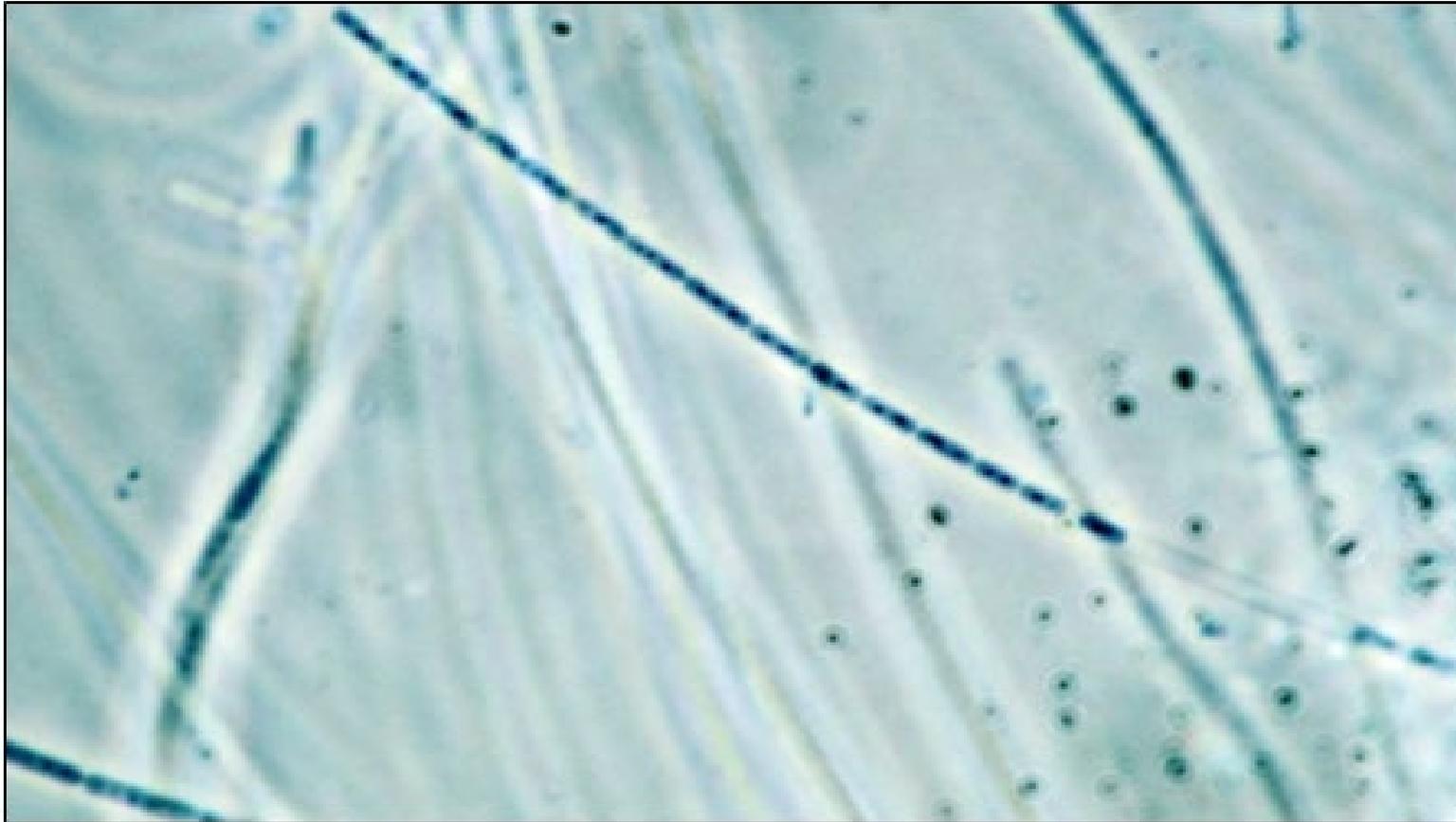
Sphaerotilus natans

Haliscomenobacter hydrossis

Microthrix parvicella

Low-DO Filamentous Organisms

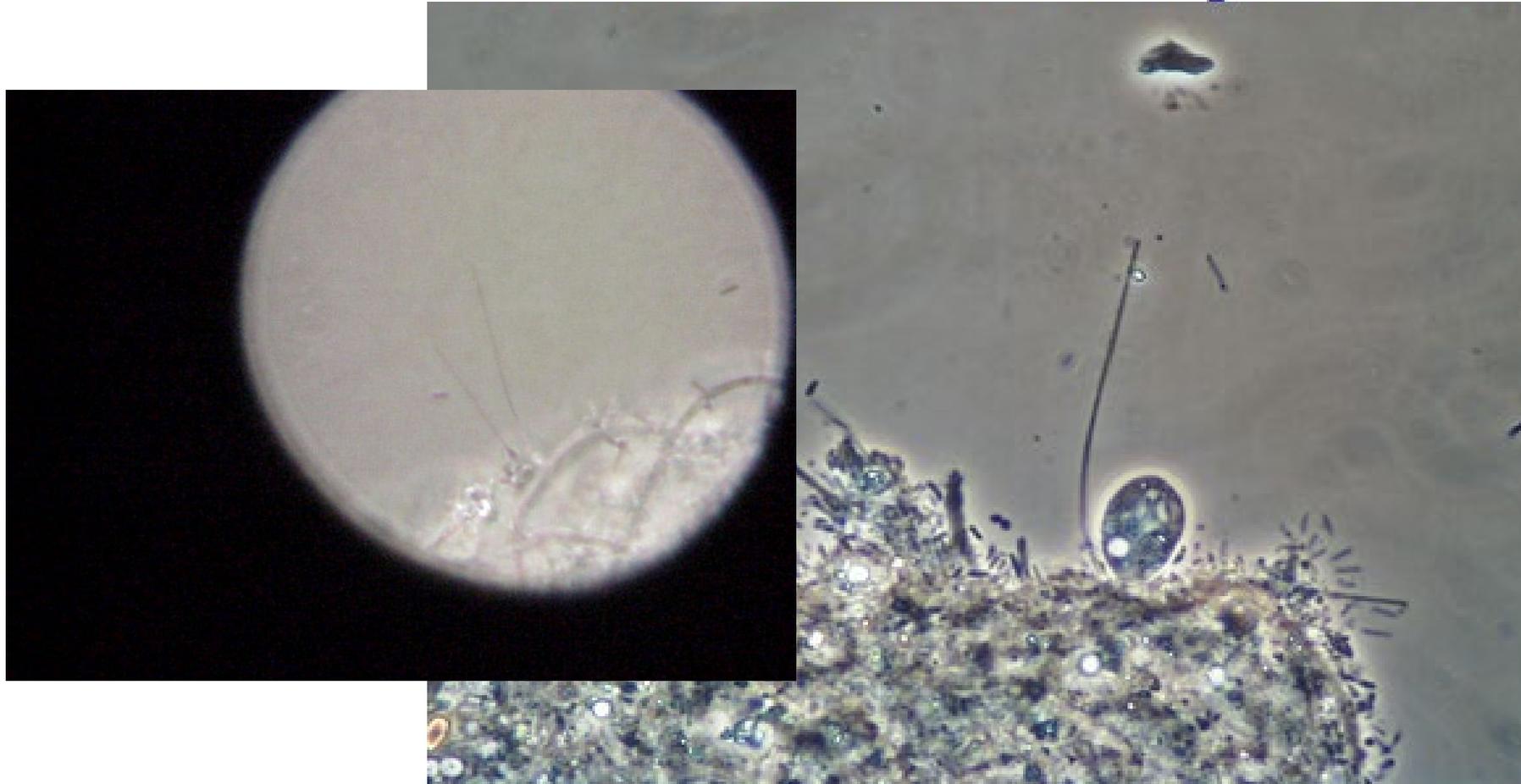
type 1701



Curved/bent filament, sheath, “sausage shaped” cells

Low-DO Filamentous Organisms

Haliscomenobacter hydrossis



1000x phase contrast

Return Sludge Flow

- Slow effect on sludge quality
- Return Sludge Flow (RSF) should be proportional to Q
- Control between units
- Pressure
 - Higher RSF = *Treatment*
 - Lower RSF = *Oxidative*
- RSF usually too high

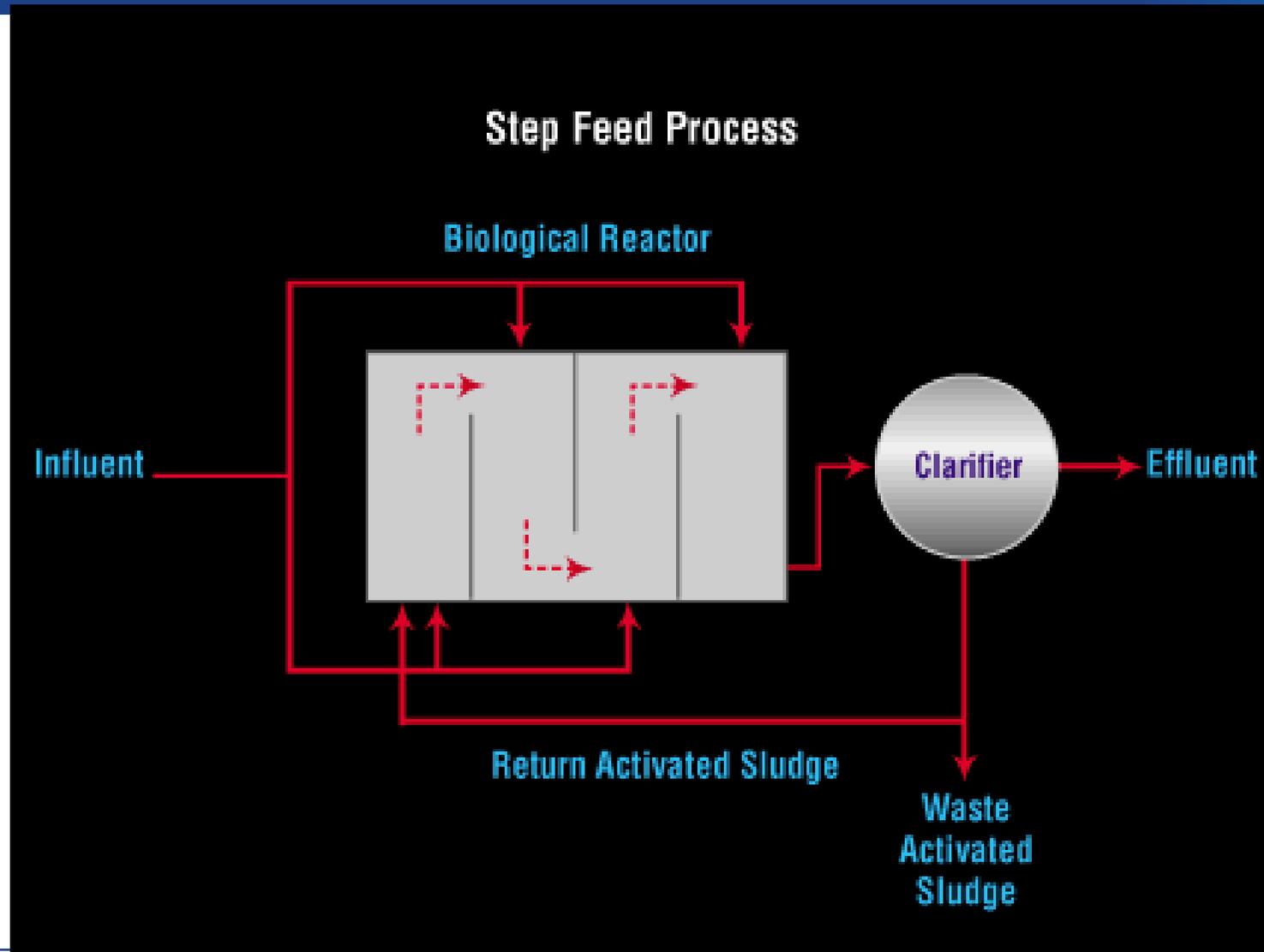
Point of Application

- Controls the system
- Affects sludge quality very quickly
- Very flexible

Quickly reduce clarifier solids loading (application down the tank)

Quickly increase SDT_A (application down the tank)

Step Feed Activated Sludge



Application at Head of Aeration Tank

Applies *Treatment* Pressure
Normally Provides Best Effluent Quality

Application at Head of Aeration Tank

Possible Problems

- Poor effluent quality with:
 - High hydraulic loading
 - Severe bulking sludge
- Produces high clarifier solids loading

Application Down the Aeration Tank

- Applies *oxidative* pressure
- Normally poorer effluent quality on routine basis
- Better effluent quality with:
 - High hydraulic loading
 - Severe bulking sludge
- Reduces clarifier solids loading

Pressures

- Sludge
 - *Treatment*
 - *Oxidation*
- Miscellaneous
 - Oxygen
 - Selector

More on Pressures

- Pressures applied externally by “Mother Nature”
- Apply pressure to equalize “Mother Nature”
- Apply pressure to maintain existing sludge quality
- Apply pressure to change sludge quality

Sludge *Treatment* Pressure

Makes Microorganisms Grow Faster
Tends to Make Sludge “Younger”

Sludge Oxidation Pressure

Makes Microorganisms Grow Slower
Tends to Make Sludge “Older”

Control Methods to Apply Pressure

Control Method	<i>Treatment Pressure</i>	<i>Oxidation Pressure</i>
<i>Waste</i>	Increase	Decrease
<i>Return Rate</i>	Increase	Decrease
<i>Point of Application</i>	Head of “A” Tank	Down the “A” Tank

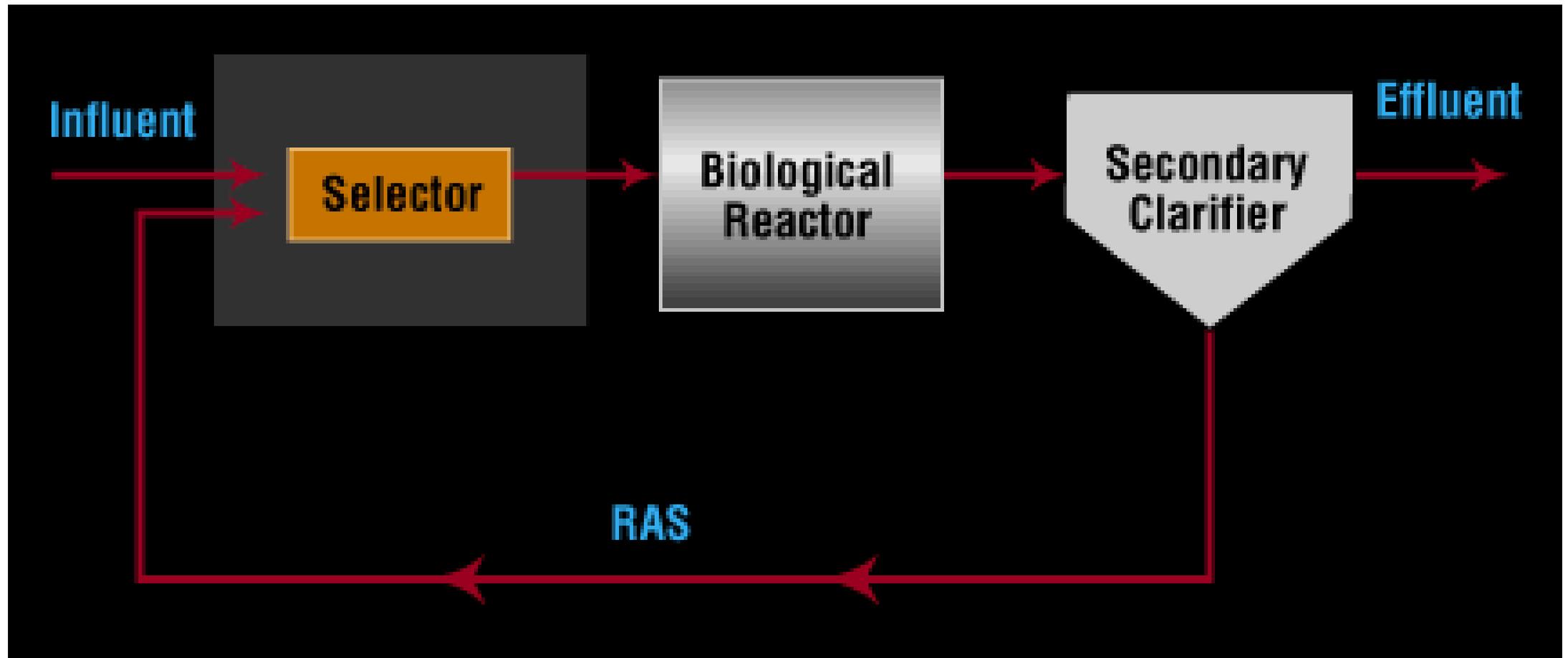
DO Pressure

High DO Assists Nitrification
Low DO May Grow Low-DO Filaments
0.0 mg/L DO Provides for Denitrification

Definition of a Selector

A *selector* in the activated sludge system is a small separate initial mixing zone(s) for RAS and influent wastewater. The term “selector” refers to the role of such a tank in “selecting” activated sludge microbes with desirable settling characteristics. These initial contact zones need to be compartmentalized (3 compartments are recommended).

Use of a Selector in Activated Sludge



Selector Pressure

Aerated

Provides High F/M
Helps in Completely-Mixed Systems

Selector Pressure

Anoxic

Reduces Nitrate Concentration
Selects Denitrifying Microorganisms

Selector Pressure

Anaerobic

Selects Non-aerobic Microorganisms
Provides Biological Phosphorus Removal

Results of Applied Pressure

Parameter	Result of Pressure	
	<i>Treatment</i>	<i>Oxidation</i>
MCRT	Younger	Older
ABI	Lower	Higher
SOUR	Higher	Lower

How to Control Using Pressure

Visual Inspection
Record Flow Rates
Complete Field Tests
Collect Samples
Test and Record Sample Data
Make Decisions on Pressures Required
Implement Decisions

Thank you!

For Questions or Comments please reach out to the following:

Dr. Larry Moore
mlarry@bellsouth.net

Thomas Wenning
Oak Ridge National Lab
wenningtj@ornl.gov