



Biological Wastewater Treatment Training Series Presentation #5: Activated Sludge Process Modifications – Part I

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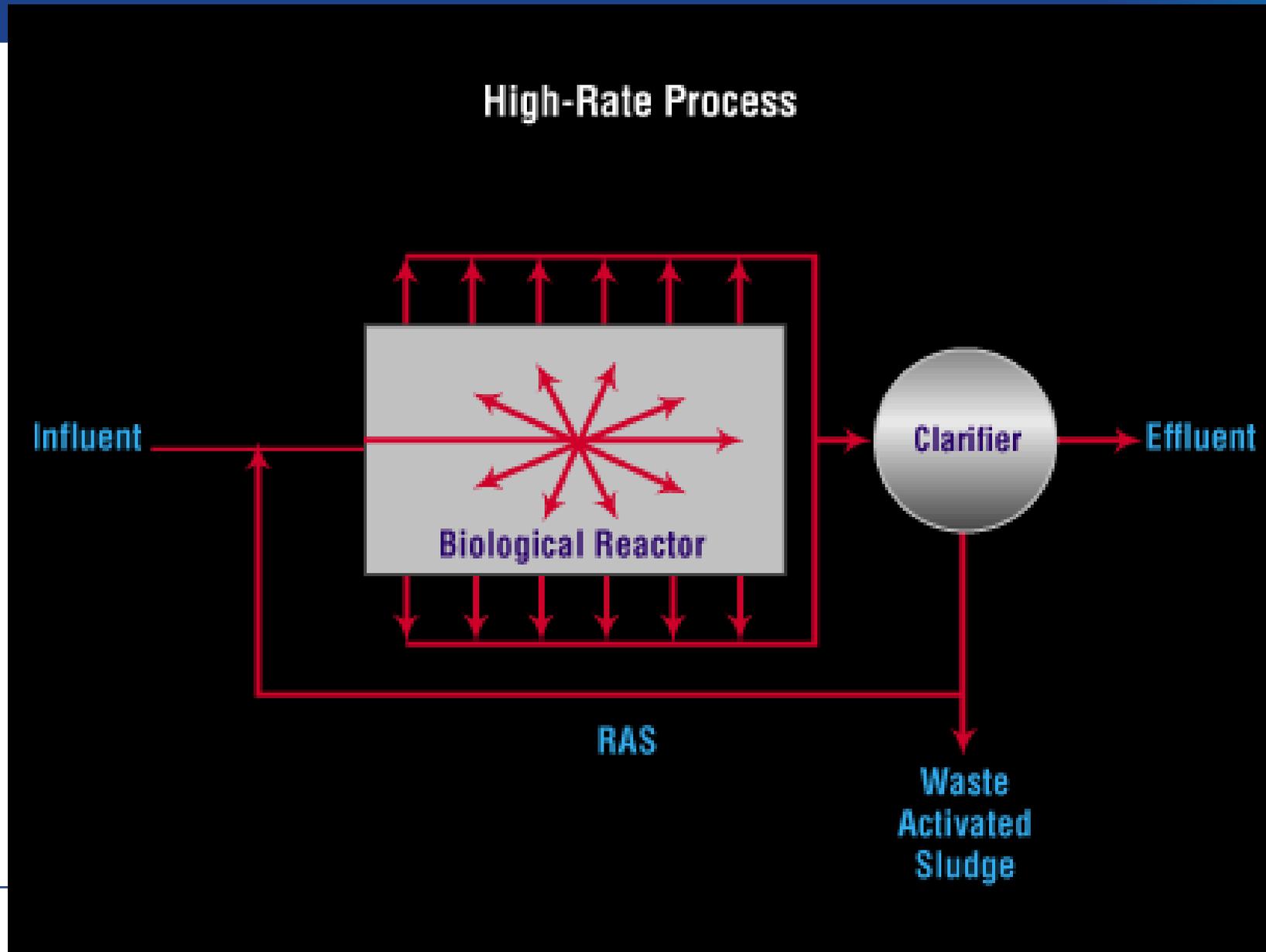
Basic Activated Sludge Process Components

- Influent pretreatment
- Aeration basin
- Secondary clarification
- Return activated sludge
- Waste activated sludge

Design Parameters for Activated Sludge Processes

Process Modification	SRT, days	F:M ratio, lb BOD applied/d/lb MLVSS	MLSS, mg/L
Conventional	5-15	0.2-0.4	1 500-3 000
Complete mix	5-15	0.2-0.6	2 500-4 000
Step Feed	5-15	0.2-0.4	2 000-3 500
Modified Aeration	0.2-0.5	1.5-5.0	200-1 000
Contact Stabilization	5-15	0.2-0.6	1 000-3 000
			4 000-10 000
Extended Aeration	20-30	0.05-0.15	3 000-6 000
High-rate Aeration	5-10	0.4-1.5	4 000-10 000
High-purity Oxygen	3-10	0.25-1.0	2 000-5 000
Oxidation Ditch	10-30	0.05-0.30	3 000-6 000
Single-stage Nitrification	8-20	0.10-0.25	2 000-3 500
Separate-stage Nitrification	15-100	0.05-0.20	2 000-3 500

High-Rate Activated Sludge Process



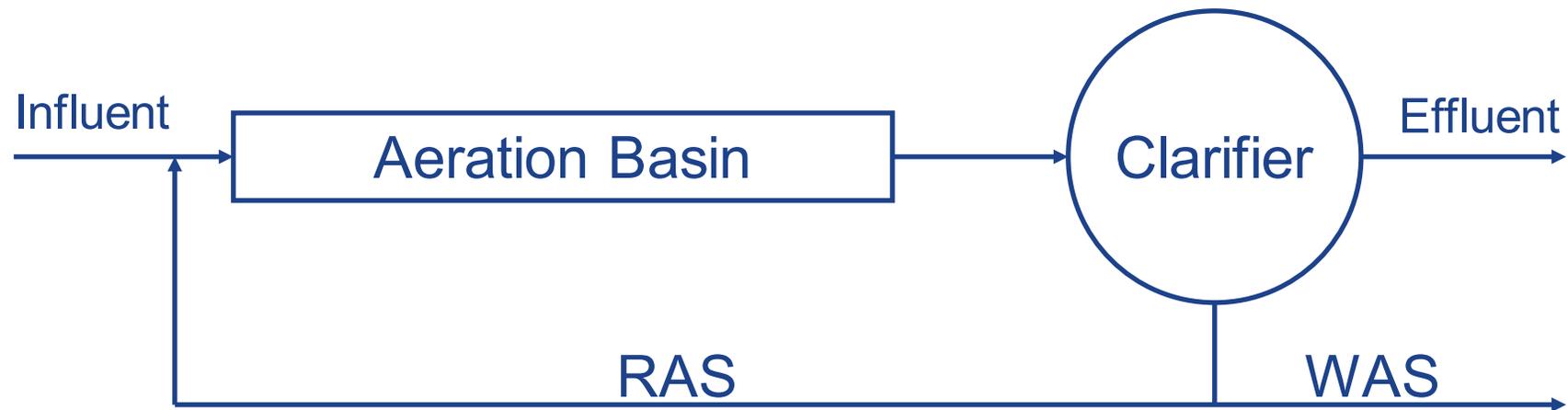
High Rate Activated Sludge

- Low BOD removal efficiency
- Essentially operates in log growth phase
- Poor bio-flocculation occurs
- Cannot consistently meet 30 mg/L BOD₅ and TSS effluent limits
- Aeration detention time = 1.5 to 3 hours

High Rate Activated Sludge

- MLSS = 500 to 1,500 mg/L
- SRT = 0.5 to 2 days
- F/M = 1.0 to 2.0 lb BOD₅/(day-lb MLVSS)
- Volumetric organic loading rate = 75 to 150 lb BOD₅/(d-1000 cu ft)
- Recycle ratio = 1.0 to 1.5
- Volatile fraction of MLSS = 0.8 to 0.9
- Most of influent BOD load is channeled into synthesis reaction

Conventional Activated Sludge



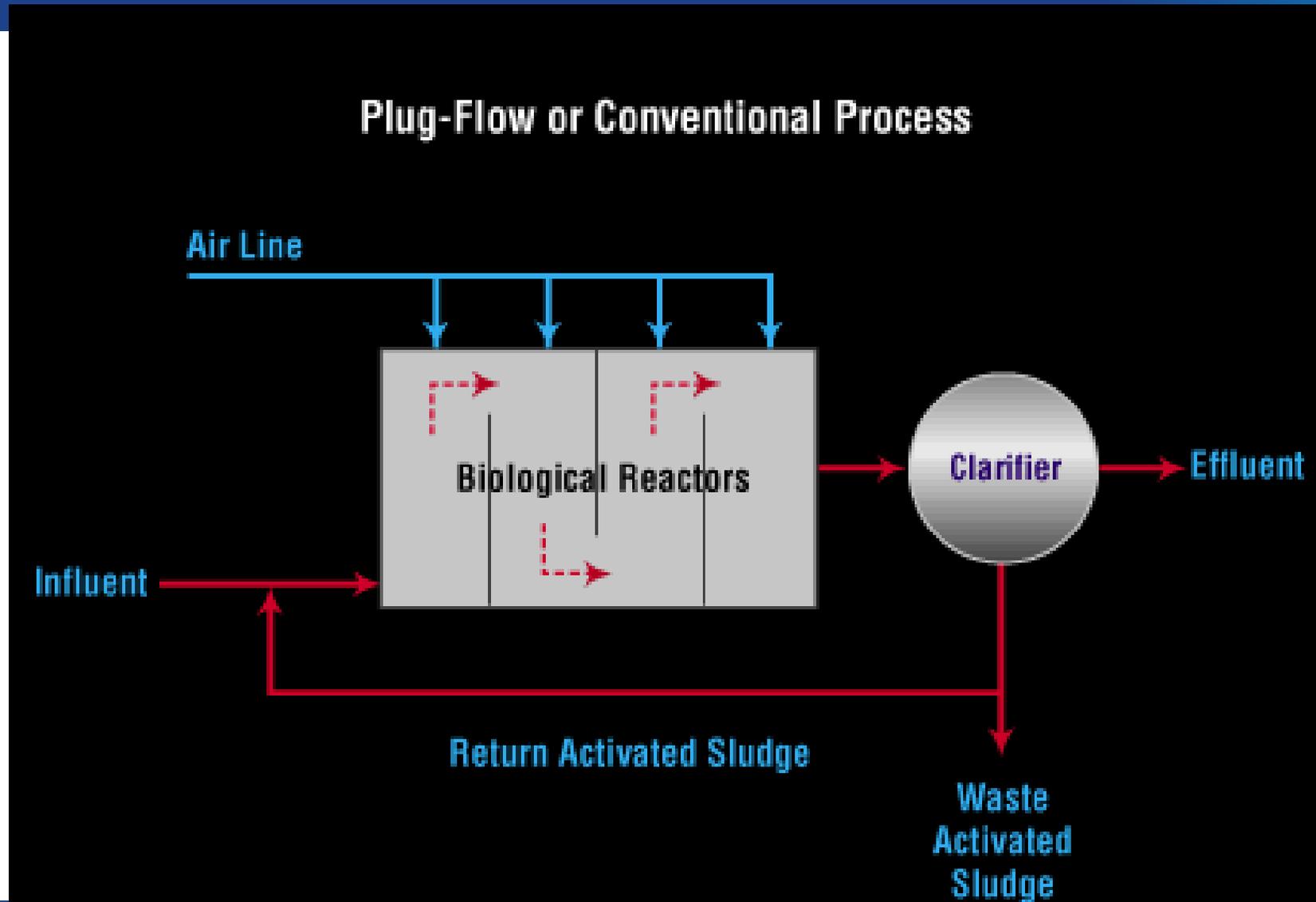
Conventional Activated Sludge

- 85% to 95% BOD₅ removal efficiency
- Essentially operates in declining/stationary growth phase
- Good bio-flocculation occurs
- Can consistently meet 30 mg/L BOD₅ and TSS effluent limits (under most conditions)
- Aeration detention time = 4 to 8 hours

Conventional Activated Sludge

- MLSS = 1,500 to 3,000 mg/L
- SRT = 5 to 15 days
- F/M = 0.2 to 0.6 lb BOD₅/(day-lb MLVSS)
- Volumetric organic loading rate = 20 to 60 lb BOD₅/(day-1000 cu ft)
- Recycle ratio = 0.25 to 0.75
- Volatile fraction of MLSS = 0.75 to 0.9
- Influent BOD load is somewhat evenly distributed between synthesis and energy reaction

Plug Flow Activated Sludge



Plug Flow Activated Sludge

Plug-Flow Process Typical Design Parameters

Application	Domestic and Industrial
BOD Removal Efficiency	85 - 95%
Aeration Type	Diffused or Mechanical
SRT (Biological Reactor)	5 - 15 days
Aeration Time	4 - 12 hours
MLSS	1500 - 3000 mg/L
RAS Flow	25 - 75% of the Influent
F:M	2 - 5 mg BOD/kg MLVSS • s (0.2 - 0.4 lb BOD/d/lb MLVSS)
Organic Loading	0.3 - 0.6 kg BOD/m ³ • d (20 - 40 lb BOD/d/1000 cu ft)

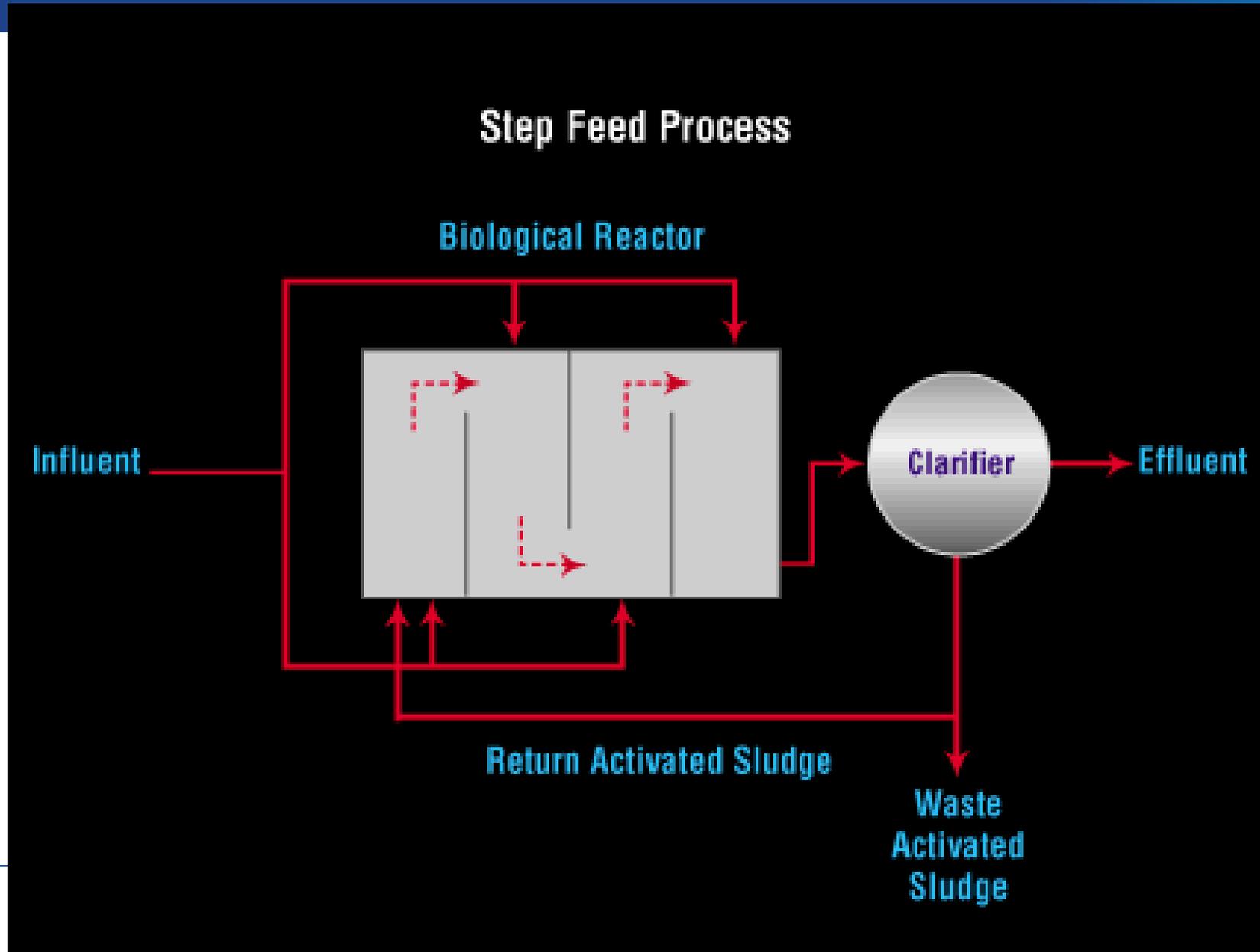
Plug Flow Activated Sludge

- Susceptible to shock loading
- Uneven O₂ uptake rate
- Low DO at front end of tank
- Most efficient type of reactor
- Short circuiting is not a problem

Tapered Aeration Activated Sludge

- Oxygen supply meets oxygen demand
- Maximum oxygen supply at front end of reactor
- Minimum oxygen supply at outlet end of reactor

Step Feed Activated Sludge



Step Feed Activated Sludge

Step Feed Process Typical Design Parameters

Application	Domestic and Industrial
BOD Removal Efficiency	85 - 95%
Aeration Type	Diffused
SRT (Biological Reactor)	5 - 15 days
Aeration Time	3 - 6 hours Flow 5 - 7.5 hours Solids
MLSS	2500 - 3500 mg/L
RAS Flow	25 - 75% of the Influent
F:M	2 - 5 mg BOD/kg MLVSS • s (0.2 - 0.4 lb BOD/d/lb MLVSS)
Organic Loading	0.6 - 1.0 kg BOD/m ³ • d (40 - 60 lb BOD/d/1000 cu ft)

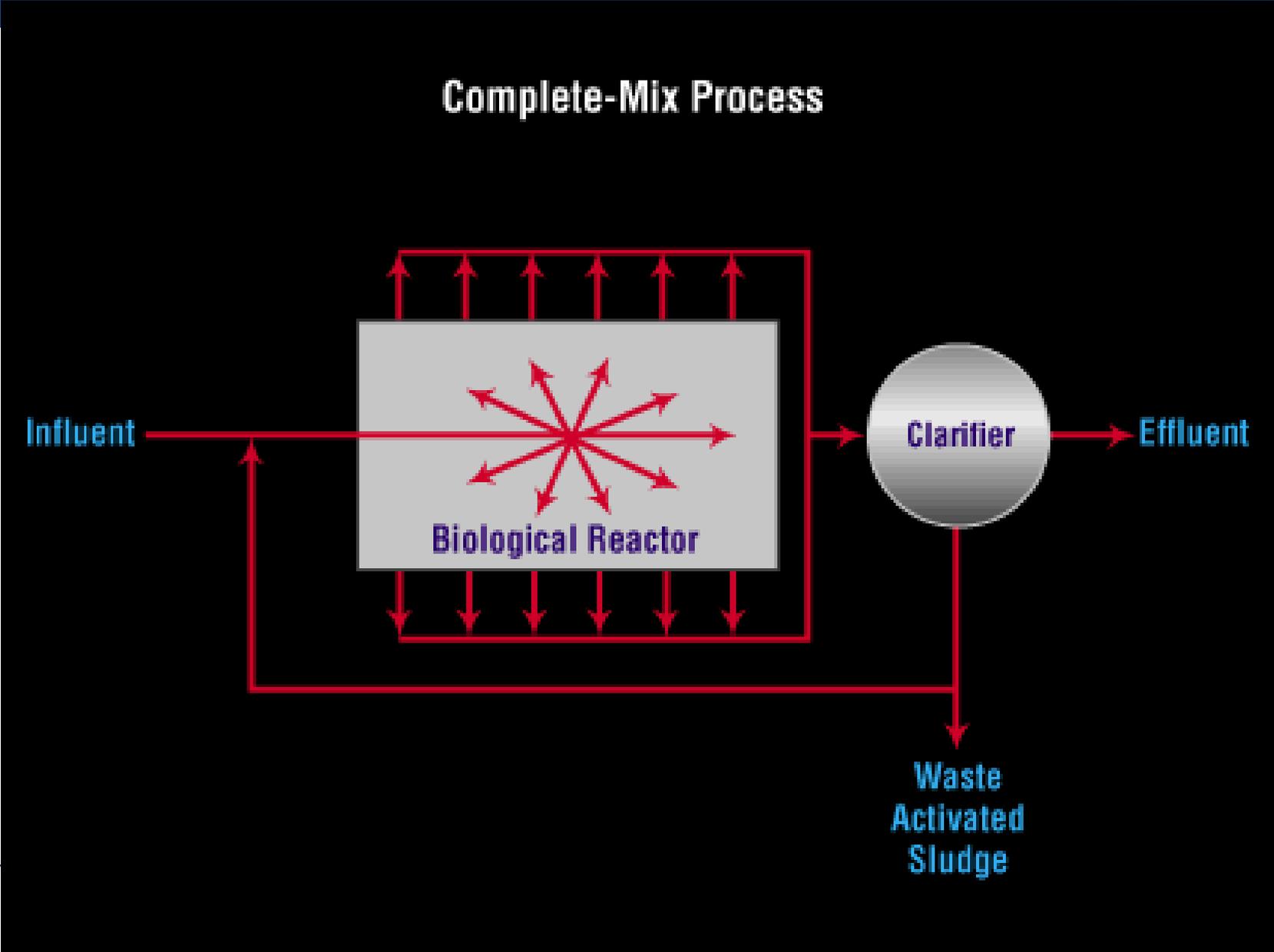
Step Feed Activated Sludge

- Evens out the oxygen demand somewhat
- Provides good flexibility
- Can carry a higher solids inventory
- Can operate at a higher organic loading rate

Step Feed Activated Sludge

- Can be operated as contact stabilization by feeding only the last zone
- Can be operated as plug flow by feeding only the first zone
- High wet-weather flows can be bypassed to the last zone to minimize solids loading on final clarifier
- Short circuiting and incomplete hydrolysis of particulate substrate may occur

Complete-Mix Activated Sludge



Complete-Mix Activated Sludge

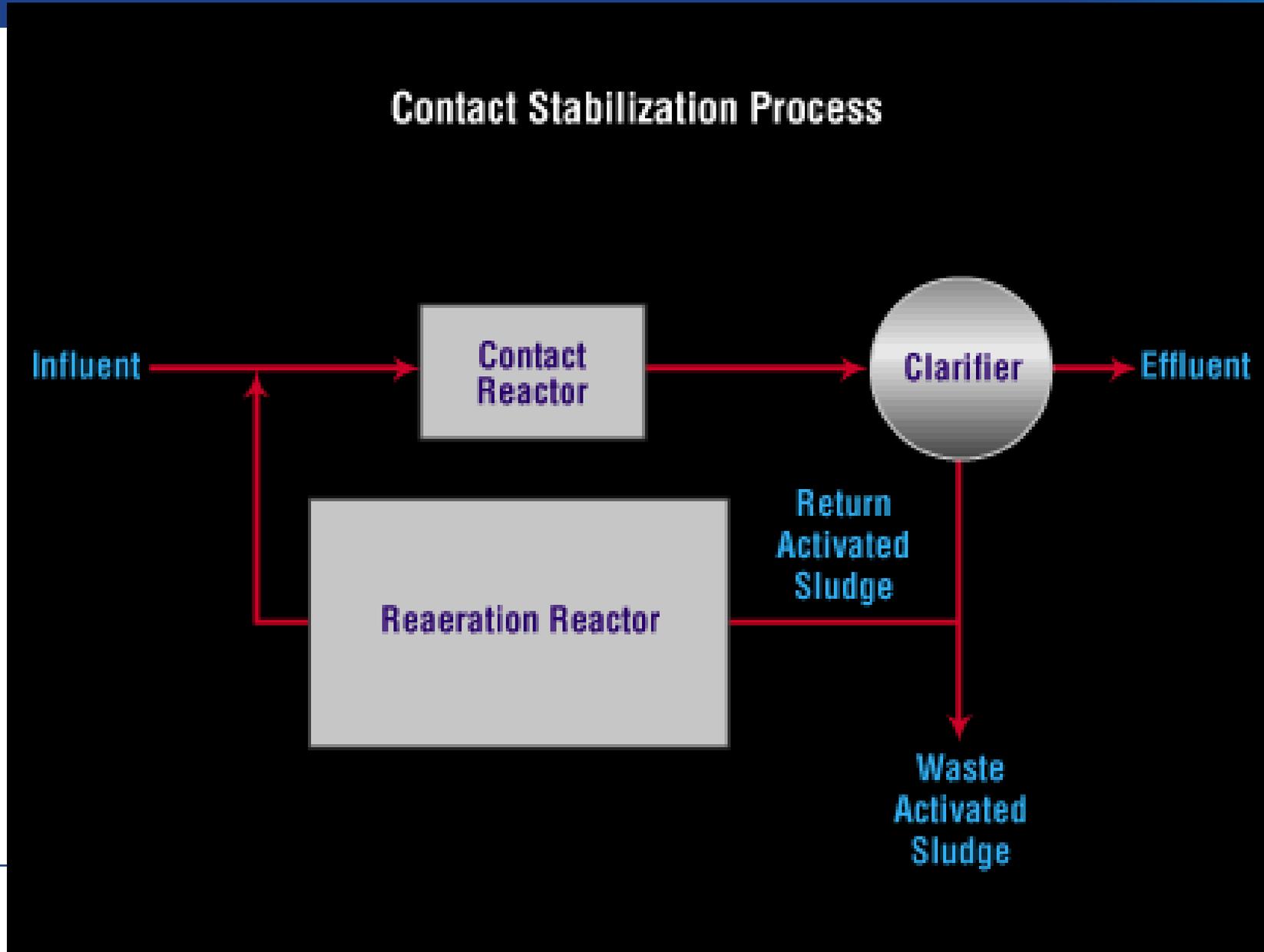
Complete-Mix Process Typical Design Parameters

Application	Domestic and Industrial
BOD Removal Efficiency	85 - 95%
Aeration Type	Mechanical
SRT (Biological Reactor)	5 - 15 days
Aeration Time	3 - 10 hours
MLSS	2 500 - 4 000 mg/L
RAS Flow	25 - 100% of the Influent
F:M	2 - 7 mg BOD/kg MLVSS • s (0.2 - 0.6 lb BOD/d/lb MLVSS)
Organic Loading	0.8 - 1.9 kg BOD/m³ • d (50 - 120 lb BOD/d/1000 cu ft)

Complete Mix Activated Sludge

- Uniform organic load on the aeration tank
- Uniform MLSS concentration
- Uniform oxygen demand
- Can handle shock loads well
- Susceptible to short circuiting
- Not as efficient as a plug flow reactor
- Susceptible to filamentous bulking problems

Contact Stabilization Activated Sludge



Contact Stabilization Activated Sludge

Contact Stabilization Process Typical Design Parameters

Application	Modification of Existing Plant
BOD Removal Efficiency	80 - 90%
Aeration Type	Diffused or Mechanical
SRT (Biological Reactor)	5 - 15 days
Aeration Time	0.5 - 1 hours Contact 3 -6 hours Reaeration
MLSS	1000 - 3000 mg/L Contact 4000 - 10000 mg/L Reaeration
RAS Flow	50 - 150% of the Influent
F:M	2 - 7 mg BOD/kg MLVSS • s (0.2 - 0.6 lb BOD/d/lb MLVSS)
Organic Loading	1.0 - 1.2 kg BOD/m ³ • d (60 - 75 lb BOD/d/1000 cu ft)

Contact Stabilization Activated Sludge

- Rapid removal of soluble BOD occurs in the contact zone
- Colloidal and particulate organics are adsorbed in the contact zone for degradation later in the stabilization zone
- Requires much less volume than complete-mix or plug-flow processes (cost-effective)
- Not good where nitrification is needed
- Susceptible to hydraulic shock loading

Thank you!

For Questions or Comments please reach out to the following:

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