Activated Sludge at 100 Years – What's Next?

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AAEE Workshop

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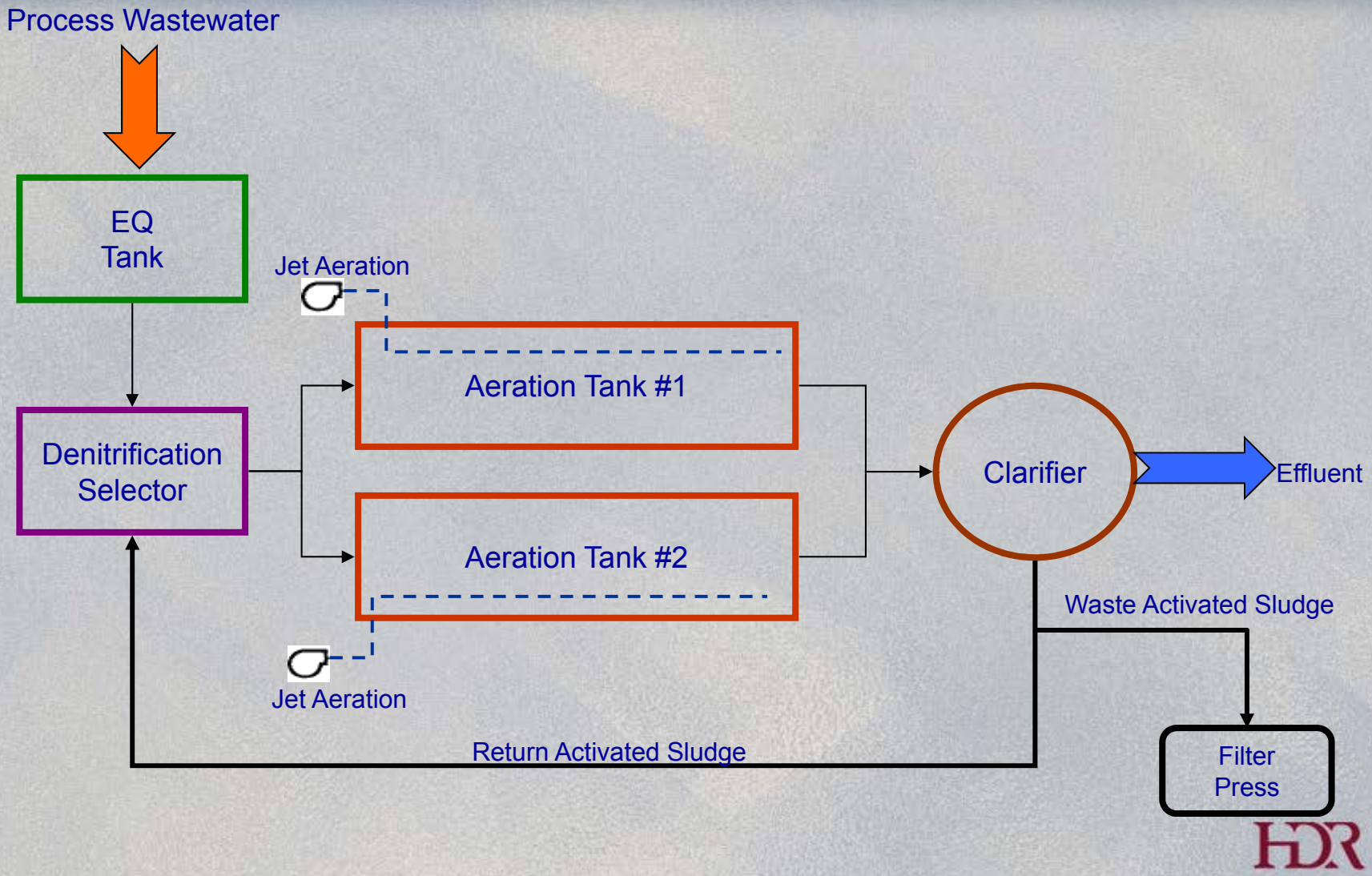
Outline

- **History and Key Milestones**
- **Basic Principles**
- **What's Next?**
  - Microbiology
  - Solids-Liquid Separation
  - Technologies
- **Treatability Testing & Process Modeling Tools**
- **Case Studies**
- **Summary**

Activated Sludge



History and Key Milestones

- 1913 – Initial research in MA and UK
- 20s – First plant in US in MA
- 40s – NYC step feed plants
- 50s – 300 AS plants in US, Aerated Lagoons at Pulp and Paper Mills
- 60s – SBRs
- 70s – Pure Oxygen, PACT and Deep Shaft
- 80s – Thermophilic Aerobic and Selectors
- 90s – MBRs and MBBRs
- 2000 to present – Sharon, Biomag, Nereda, Annamox
- 2014 forward – What's Next?

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Basic Principles

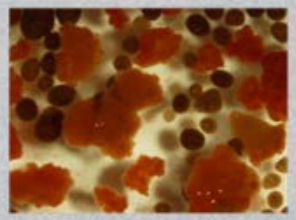
- Food to Microorganism Ratio (F/M)
- Solids retention time (SRT)
- Biodegradation rates/kinetics
- Temperature
- Oxygen utilization
- Biosolids production
- Nutrient requirements
- Acclimation
- Bioinhibition

What's Next

- Microbiology – Selecting Organisms
- Solids-Liquid Separation
- Technologies

Microbiology – Selecting Organisms

- Heterotrophic and Autotrophic bacteria
- Phosphorus removal bacteria
- Anammox bacteria
- Granules in Nerada
- Fungi
- Bioaugmentation – does it work?
- Others

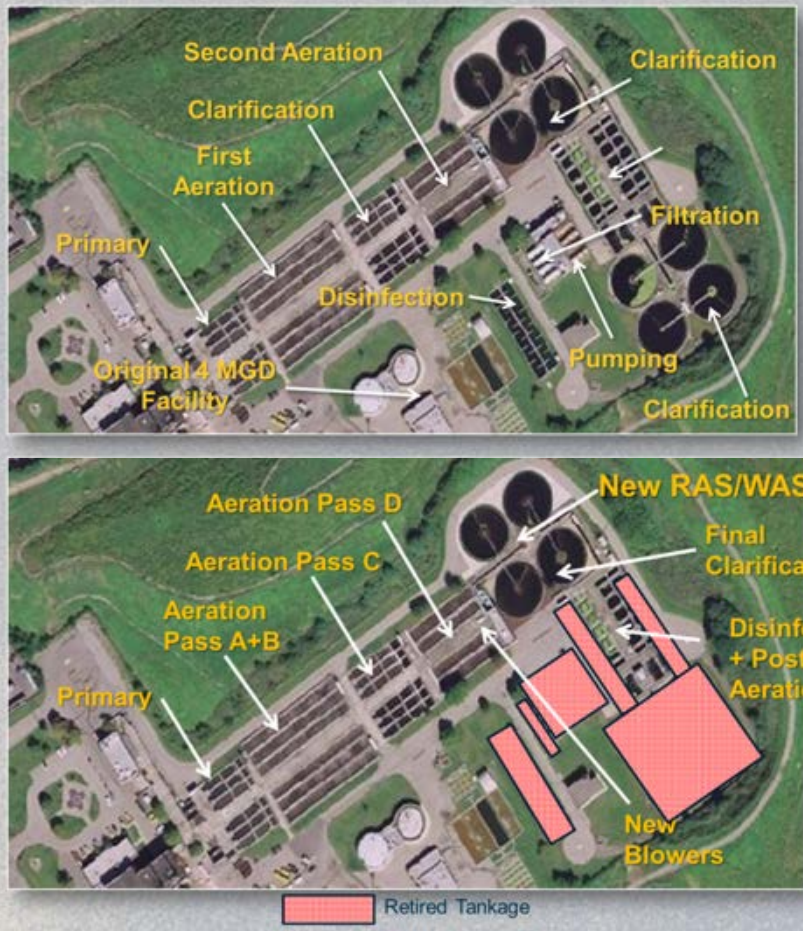


Solids – Liquid Separation

- Secondary Clarification
- PACT
- Membrane Bioreactor
- BioMag
- Granules

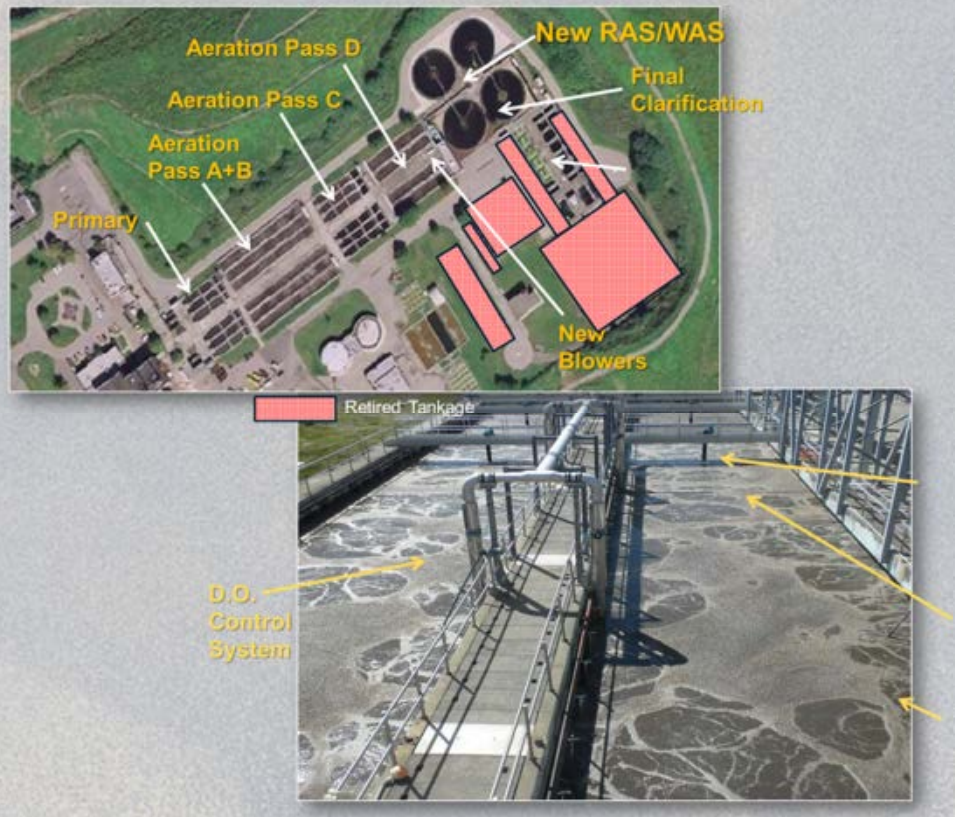
Technologies

- Conventional plug flow and completely mixed
- SBRs
- PACT and BioMag
- IFAS and MBBRs
- Membrane Bioreactor
- BioMag
- Nereda - Granular Sludge

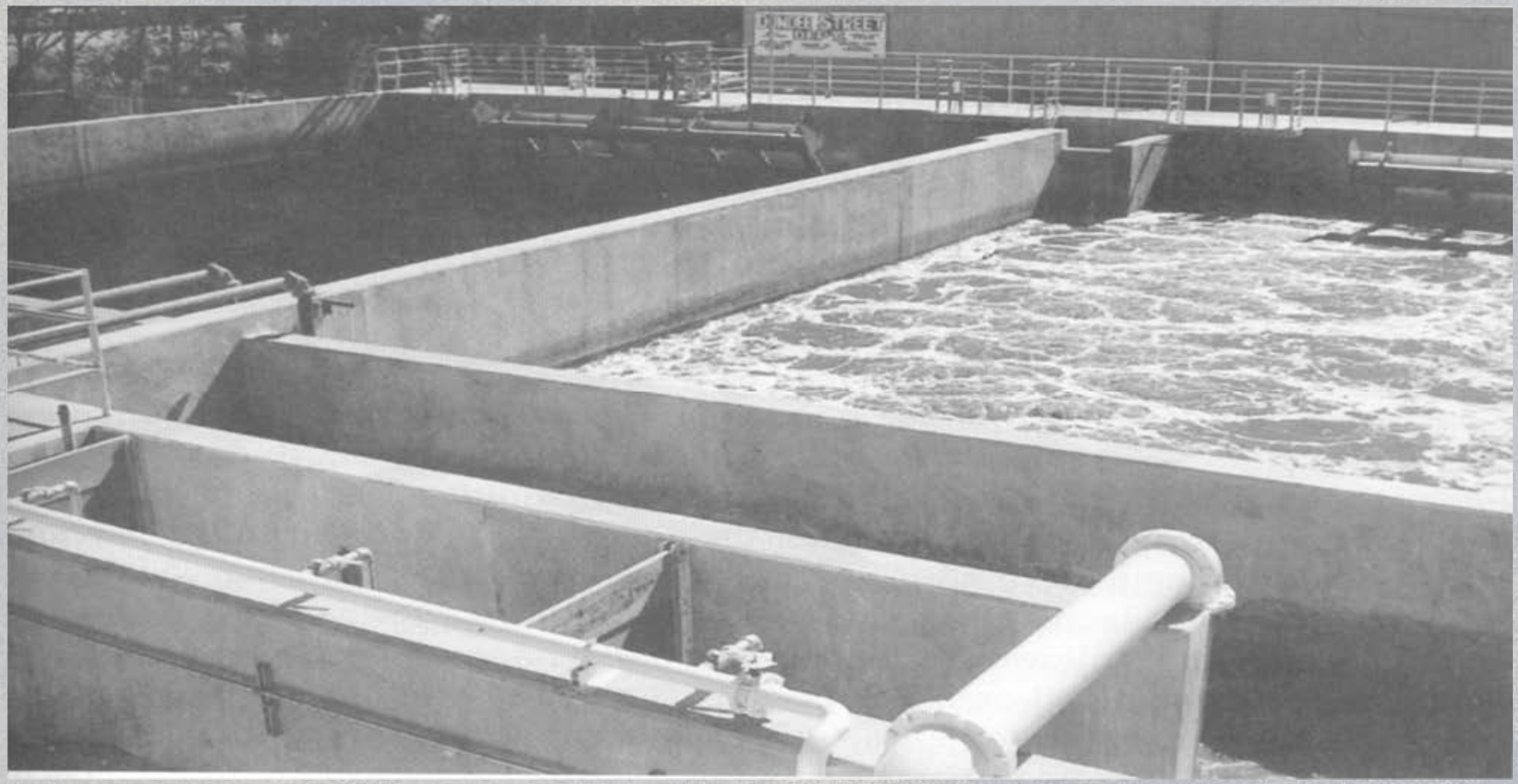


Key Milestones in Engineering

- Nutrient Removal and Recovery
- Process Models
- Diagnostic Testing
- Alternative Project Delivery
- Biosolids /Co-digestion
- Resource Recovery Facility versus Treatment Plant

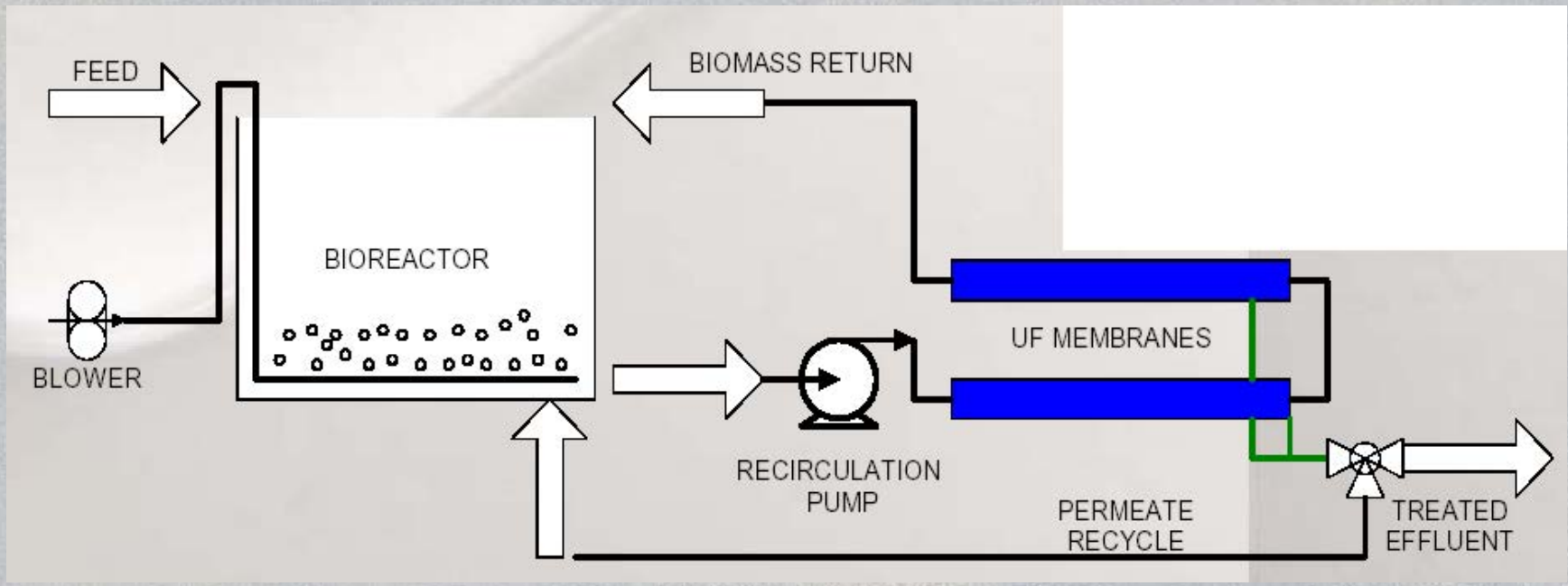


Sequencing Batch Reactor Plant

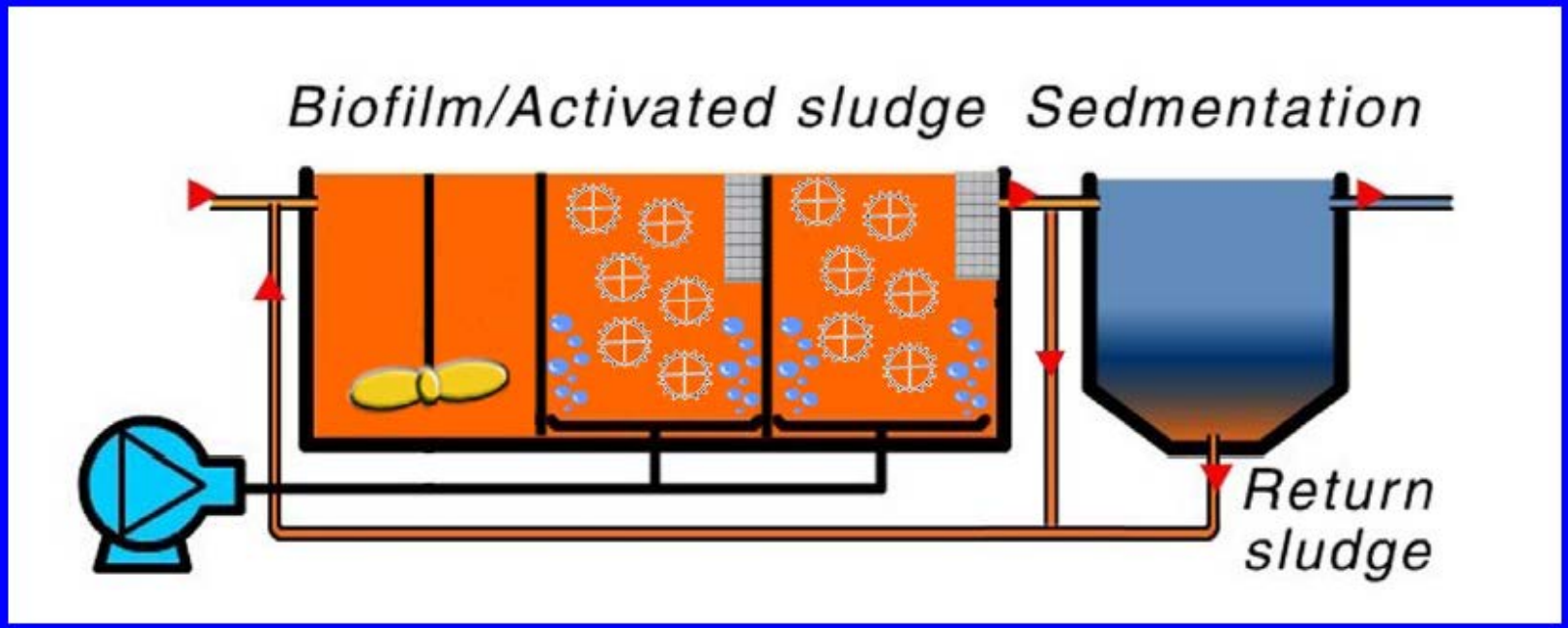


Oxidation Ditch

Membrane Bioreactor Process



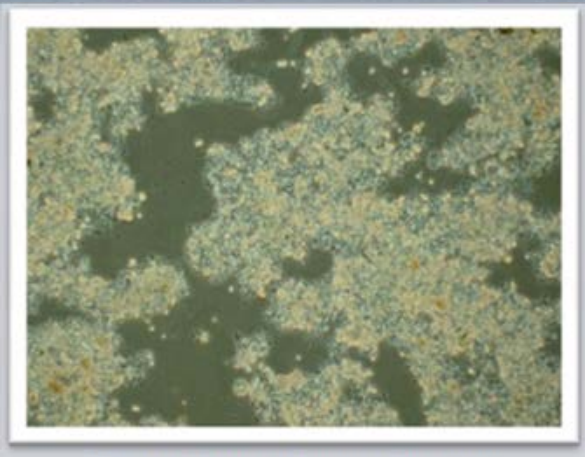
Fixed Film Technology



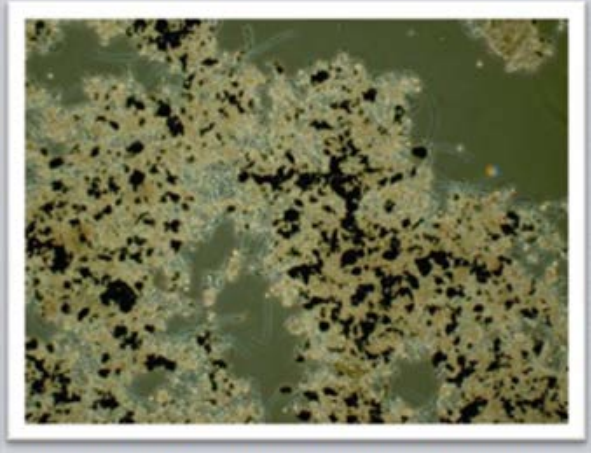
IFAS System with Pre-DN (Anoxic Zone)

BIOMAG

- Uses magnetite as ballast to enhance settling rates
- Applies magnetite to activated sludge to increase floc density and settling rates
- SG 5.6
- Hydrophobic
- Small – 30-60 um
- Magnetically Retrievable (polish)
- Requires high energy mixing to maintain solids in suspension

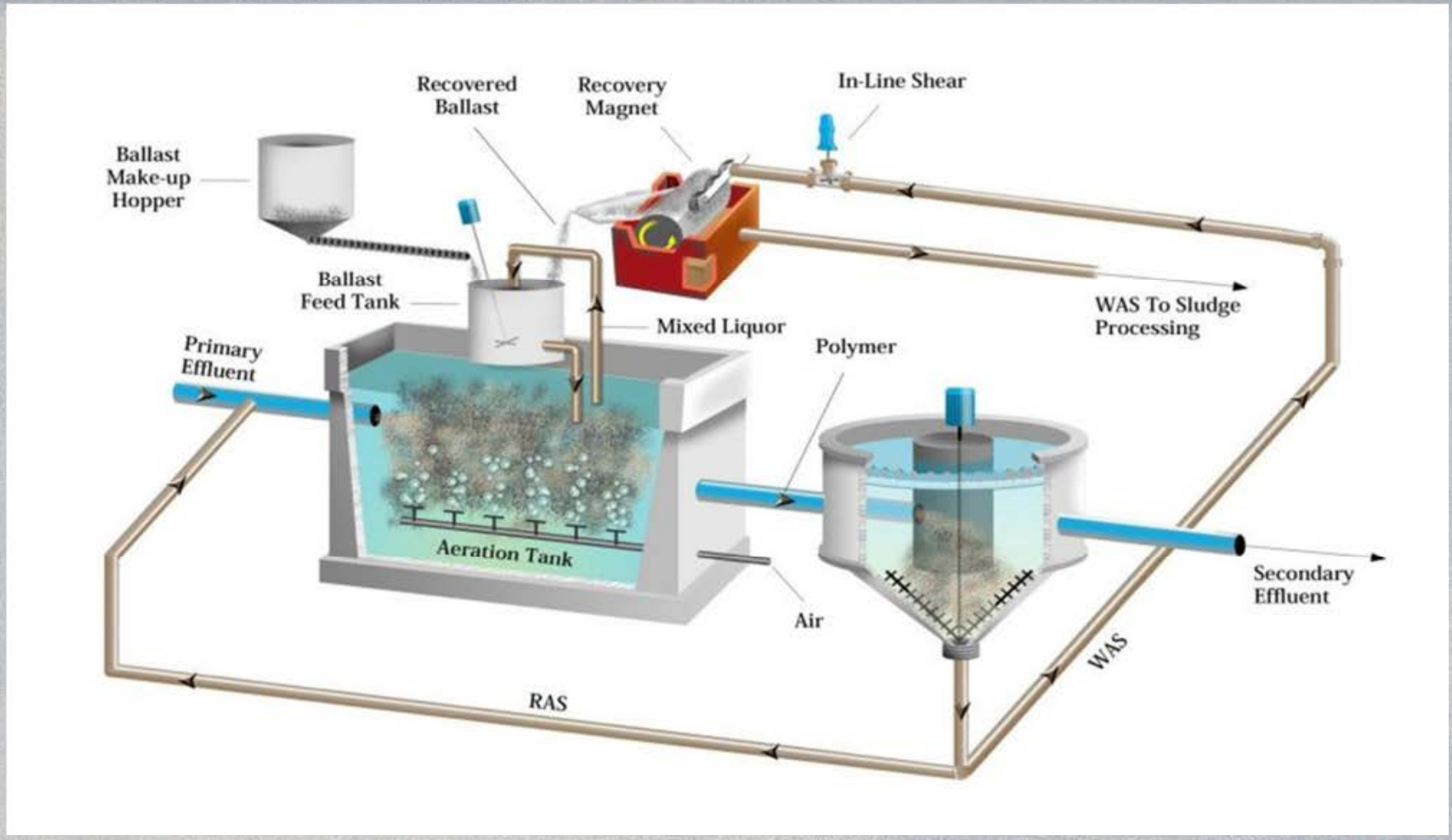


Flocs with no ballast settle slowly



Ballasted flocs settle rapidly and reliably

BIOMAG


Recovered Ballast
Recovery Magnet
In-Line Shear
Ballast Make-up Hopper
Ballast Feed Tank
Mixed Liquor
WAS To Sludge Processing
Primary Effluent
Polymer
Aeration Tank
Air
Secondary Effluent
WAS
RAS

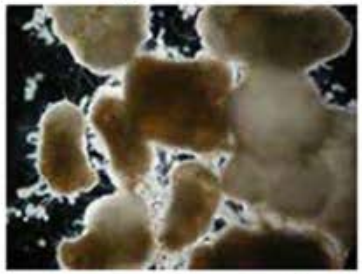
NEREDA : Granules

Instead of

activated sludge

use

aerobic granules



Aerobic granules

- Excellent settling properties
- Pure biomass, no support media required
- High biomass concentration
- Simultaneous extensive biological N- and P-removal
- Simple one-tank concept (no clarifiers)
- Small footprint
- Simple and easy operation
- Sustainable technology
- Low costs

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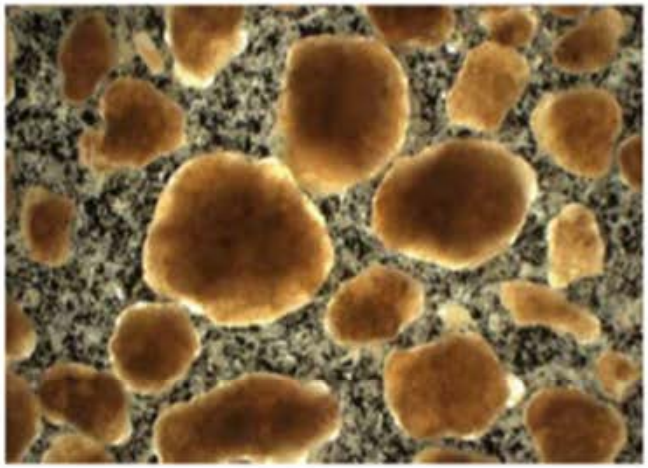
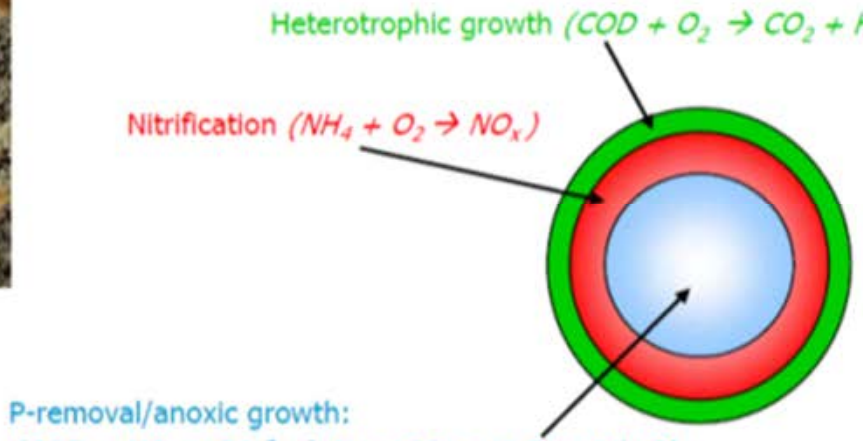
How to Make Granules



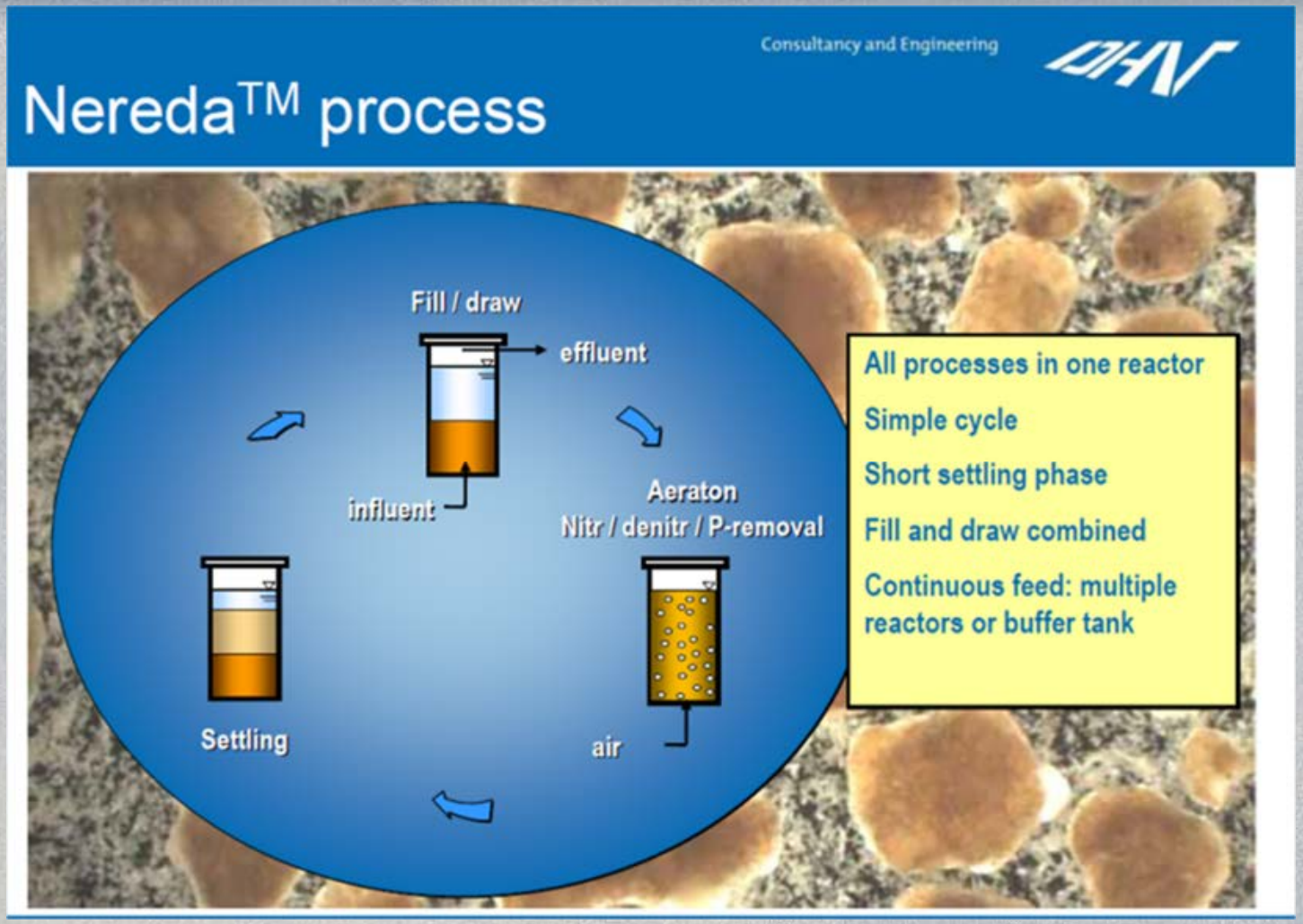
Selection mechanism:

settling pressure and/or short decant phase



Oxygen gradient in granule enables simultaneous COD, P and N-removal

SBR Mode Operation



Treatability Studies and Process Modeling Tools

- Laboratory bench scale studies (e.g., biological and physical/chemical technologies)
- On-site pilot studies (e.g., MBR and anaerobic treatment systems)
- Full-scale testing on a portion of existing plant
- Combine with modeling tools such as BIOWIN, GPSX, Toxchem, Water 9 and others

Case Study Activated Sludge – MLE Process

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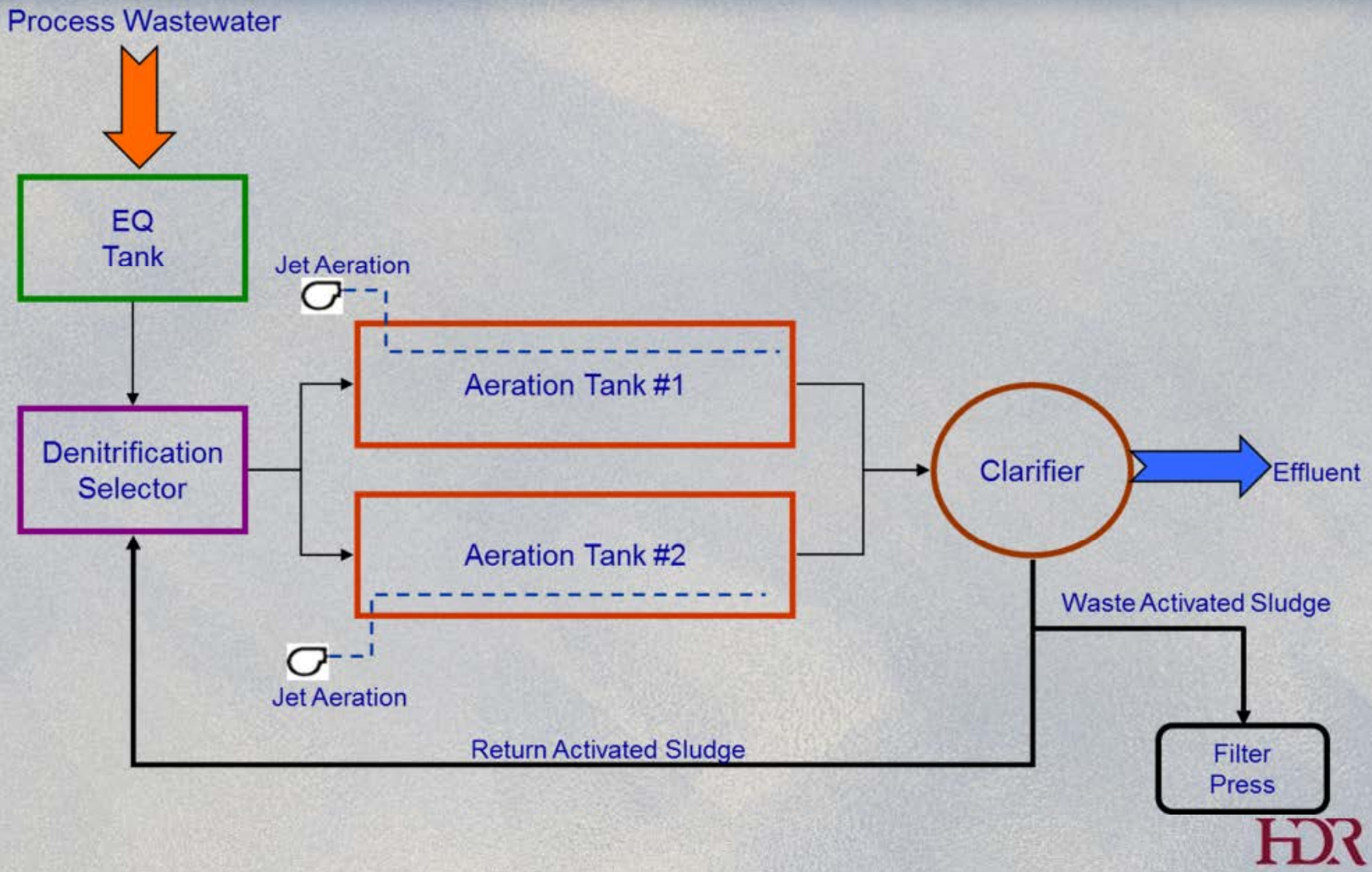
Modified Ludzak Ettinger (MLE) Process



History of Plant

- 2003 – Design of New WWTP – used bench scale treatability and process calculations
- 2008 – Design of Upgrade Capacity using BIOWIN calibration to full scale data
- 2008 – Nitrification upset – bench scale work on inhibition
- 2009 – Capacity study using BIOWIN and treatability
- 2013 – Evaluating upgrade of capacity and converting to MBR

Issues and Questions

- Can we design new technologies now without bench and pilot study?
- Is there enough full scale experience? (i.e., emerging technology or standard)
- When is technology mature enough? (i.e., MBR and MBBR)
- What about industrial wastewater projects versus municipal?
- Let's discuss on practice calls and PARR reviews – start in proposal scoping

Summary

- Activated sludge is healthy at 100
- Basic principles have not changed
- Changes are still happening/more to come
- Stay tuned for What's Next?