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Overview of Continuous Inflow SBR

Presentation Home

1. CAS Process
2. SBR Process
3. Continuous Inflow SBR Process
4. Aeration
5. Decanter
6. Other Mechanical Equipment
7. Controls
8. Ohio Installations

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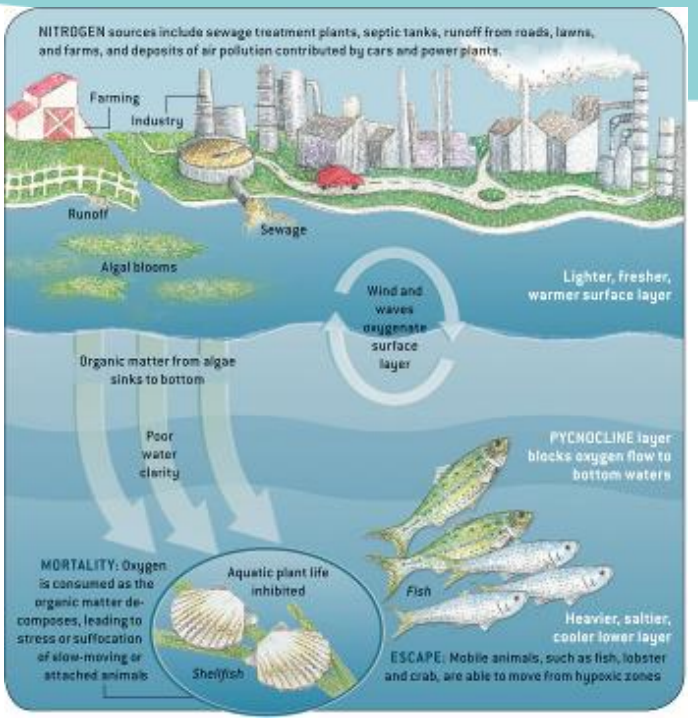
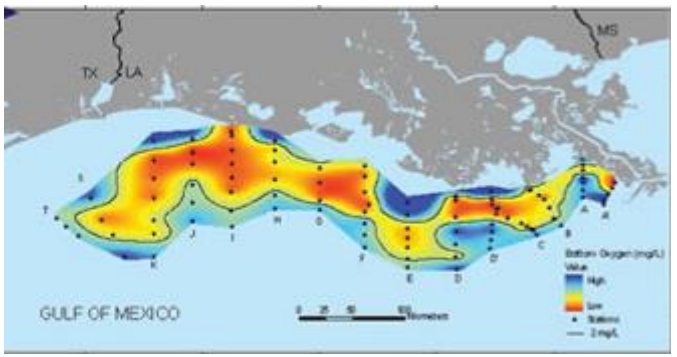
1. CAS Process

Wastewater—what is the concern?

- Nutrients
  - » Nitrogen
  - » Phosphorus
  - » Promote aquatic plant growth
- Hypoxia
  - » Low dissolved oxygen caused by decaying aquatic plant life
- Point and non-point sources
  - » Point (WWTP)
  - » Non-point (run-off)



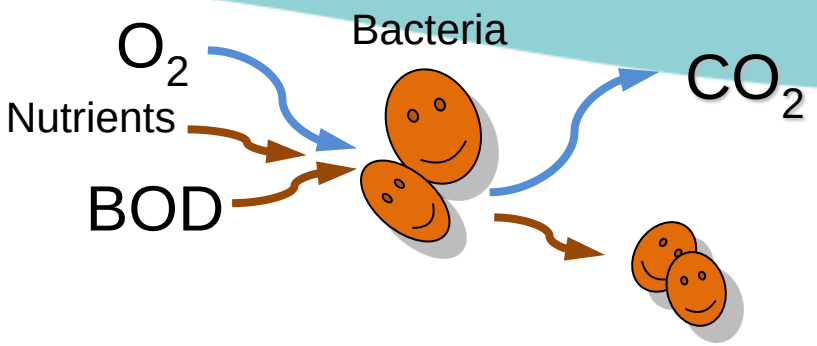


Principles of Biological Treatment

Carbon (BOD) removal

Removes the majority of pollutant load

Fast growing bacteria

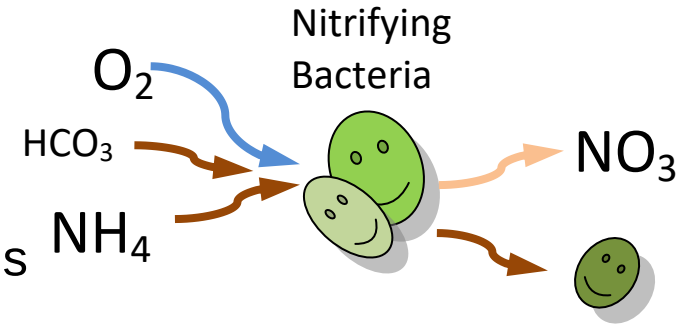


Nitrification

Converts ammonia (NH4) to nitrate (NO3)

Slow growing bacteria - 2 types

Can be flushed out of conventional systems

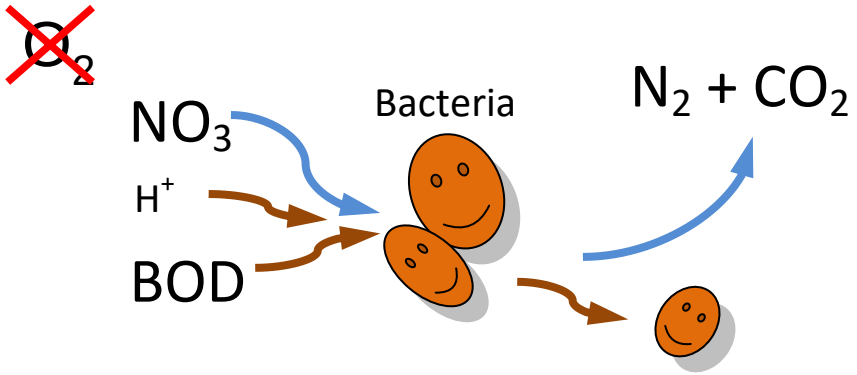


Denitrification

No Oxygen present

Bacteria use oxygen in Nitrate NO3

Nitrogen released as gas



Basic Terminology

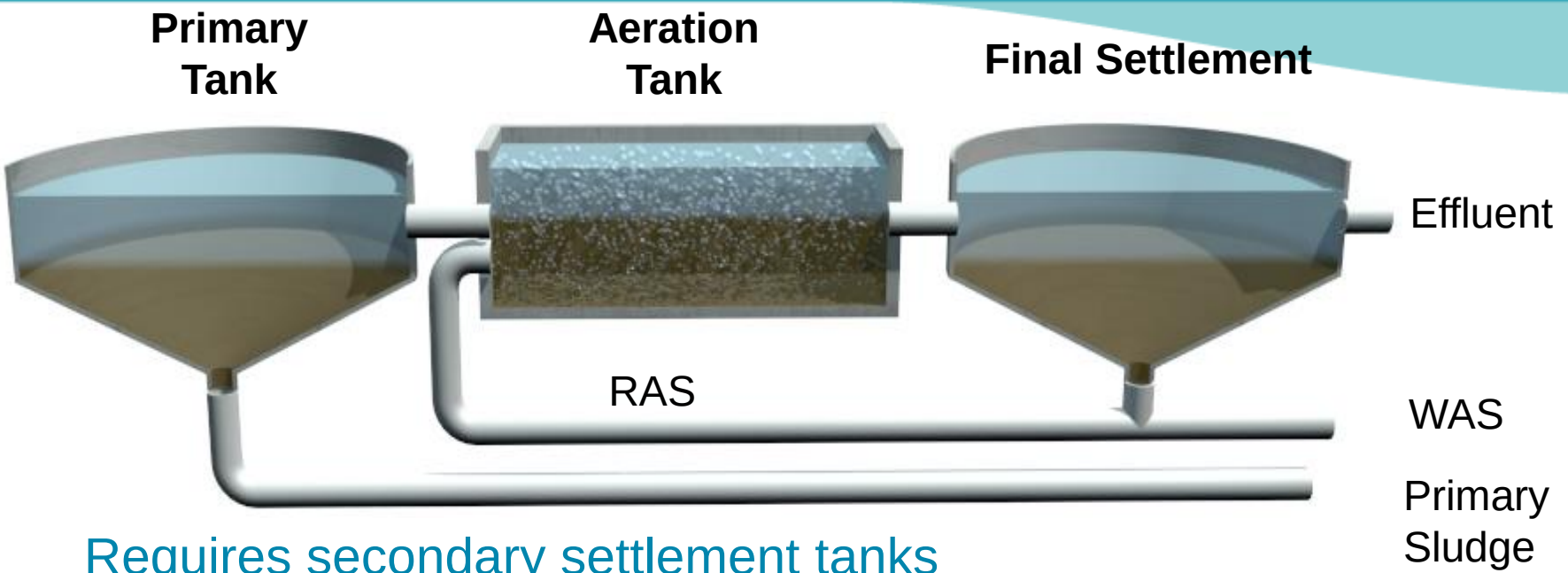
MLSS: Mixed Liquor Suspended Solids, biomass or microorganism mass including other particulates.

F/M Ratio: "F" is the food or biodegradable organic matter (BOD_5). "M" are the microorganisms or MLSS.

SRT (or MCRT): solids retention time or mean cell residence time is the average duration of time an organism spends in the system. Often the first step in plant design, dictated by need to nitrify and wastewater temperature.

Need to have basic understanding of the determinants and process understanding to be able to talk about biological systems.

Conventional Activated Sludge Process (CAS)



Requires secondary settlement tanks

- usually circular
- no shared wall construction
- complicated conical base construction

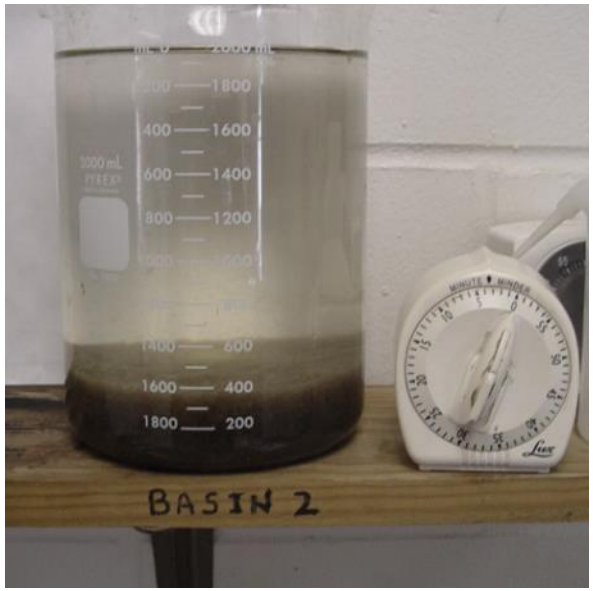
Requires RAS pumps

- Usually equal to the incoming flow
- Additional civil structures
- Significant power usage

Flexibility may be fixed by design

Activated Sludge – Summary

- Dissolved Oxygen is needed by biology to remove COD, BOD and ammonia
- Nutrients needed for cell growth
- Temperature affects reaction speed
- Selecting Floc forming bacteria
- Settling has to be good
- pH & Alkalinity may affect performance



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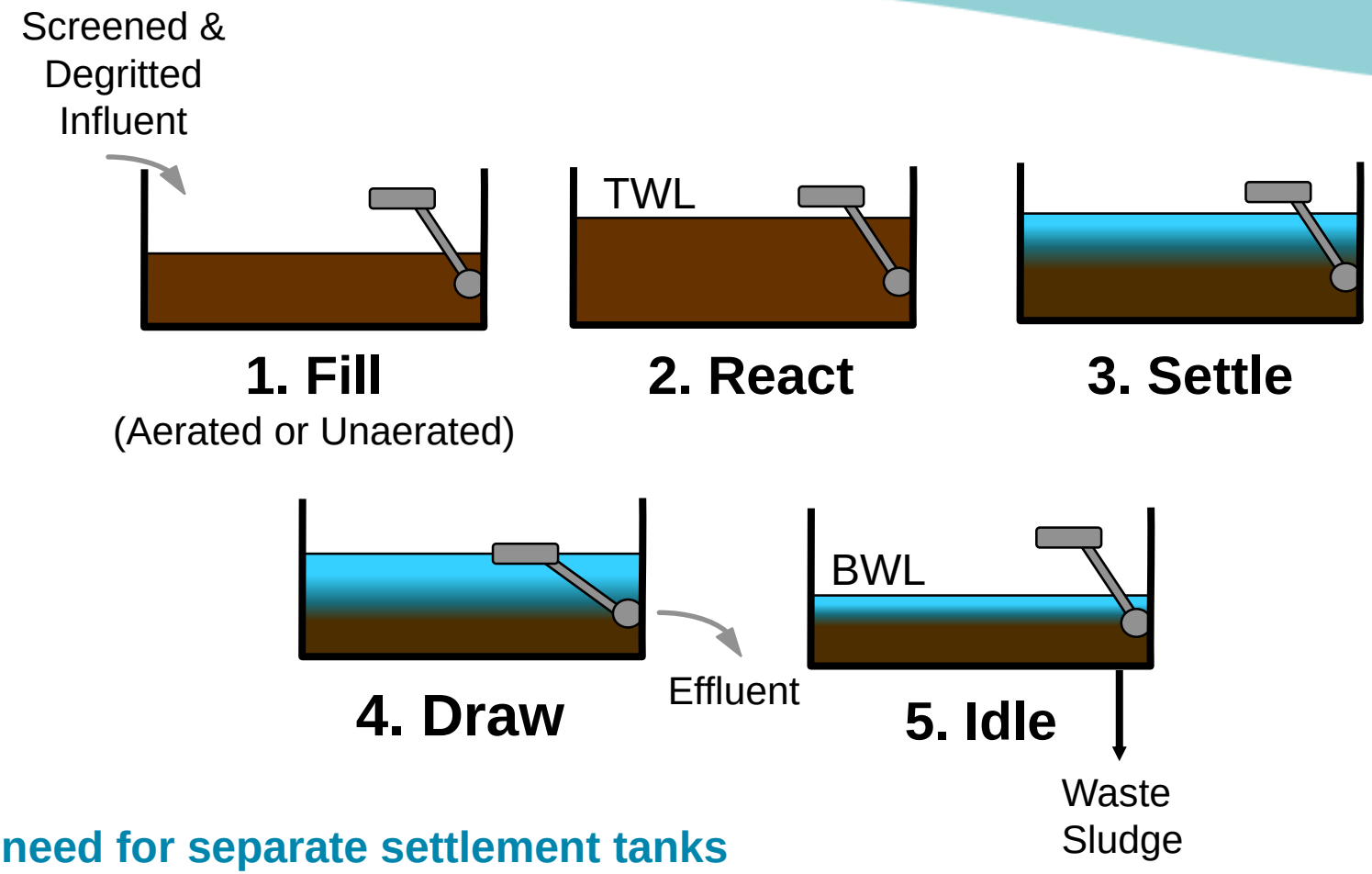
2. SBR Process

Conventional SBR Fill and Draw Theory

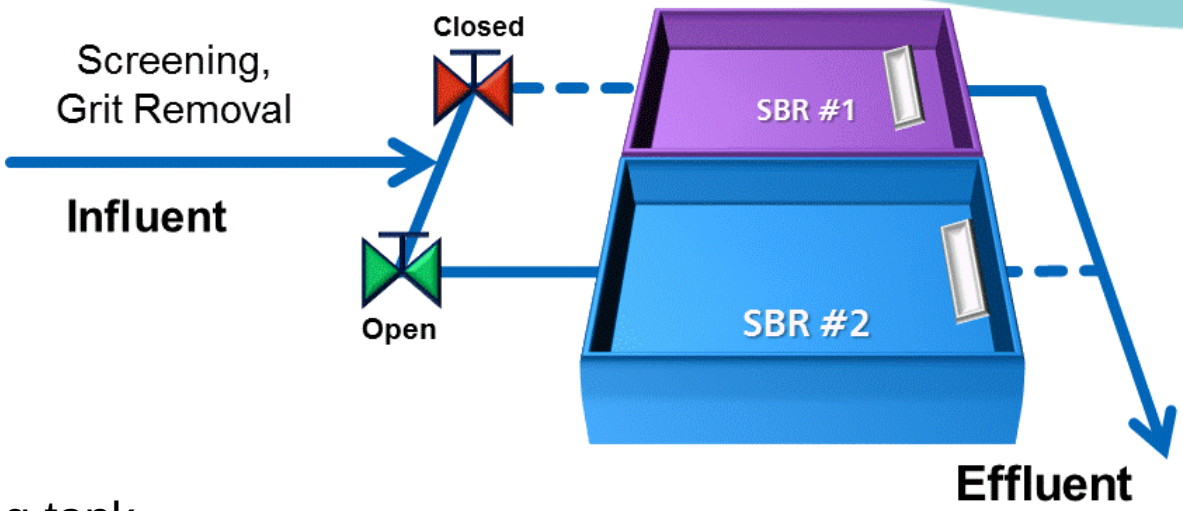


No need for separate settlement tanks
All treatment in the same basin
Can do shared wall construction

Typical SBR

Benefits:

Lower construction costs
Design flexibility
Improved performance



Shortcomings:

Need 2 reactors or balancing tank

Complicated valve arrangements & control

Cannot easily remove basin from service for maintenance

Carbon source interrupted in react phase reducing ability to remove nitrogen and phosphorus

Unequal loading of basins during diurnal cycle causes control problems. Each tank is a treatment works.

SBR Advantages vs. CAS

- Complete system. All treatment occurs in single tank; no separate reactor and clarifier
- Fully automated
- Elimination of RAS pumping and capital cost.
- Biological nutrient removal
    - Anaerobic
    - Anoxic
    - Aerobic
- Flexible process operation to suit changing needs.
- Consistent, high quality effluent achieved at variable flow and loading.

When is SBR the Best Technology?

High Peak to Average Flow Ratio (5:1)

- Won’t wash out solids
- Can operate with second storm

Limited Land Availability

- Uses less tanks, smaller footprint than CAS

BNR Requirements

- Variable anaerobic, anoxic, and aerobic time settings

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3. Continuous Inflow Process

Continuous Inflow SBR

Advanced SBR System

Over 1,000 installed worldwide

- Continuous Flow System
- Time Based System, simple to control
- Robust driven decanter design, easy to maintain
- Efficient aeration system
- Reliable process performance
- Significant capital and operational cost savings

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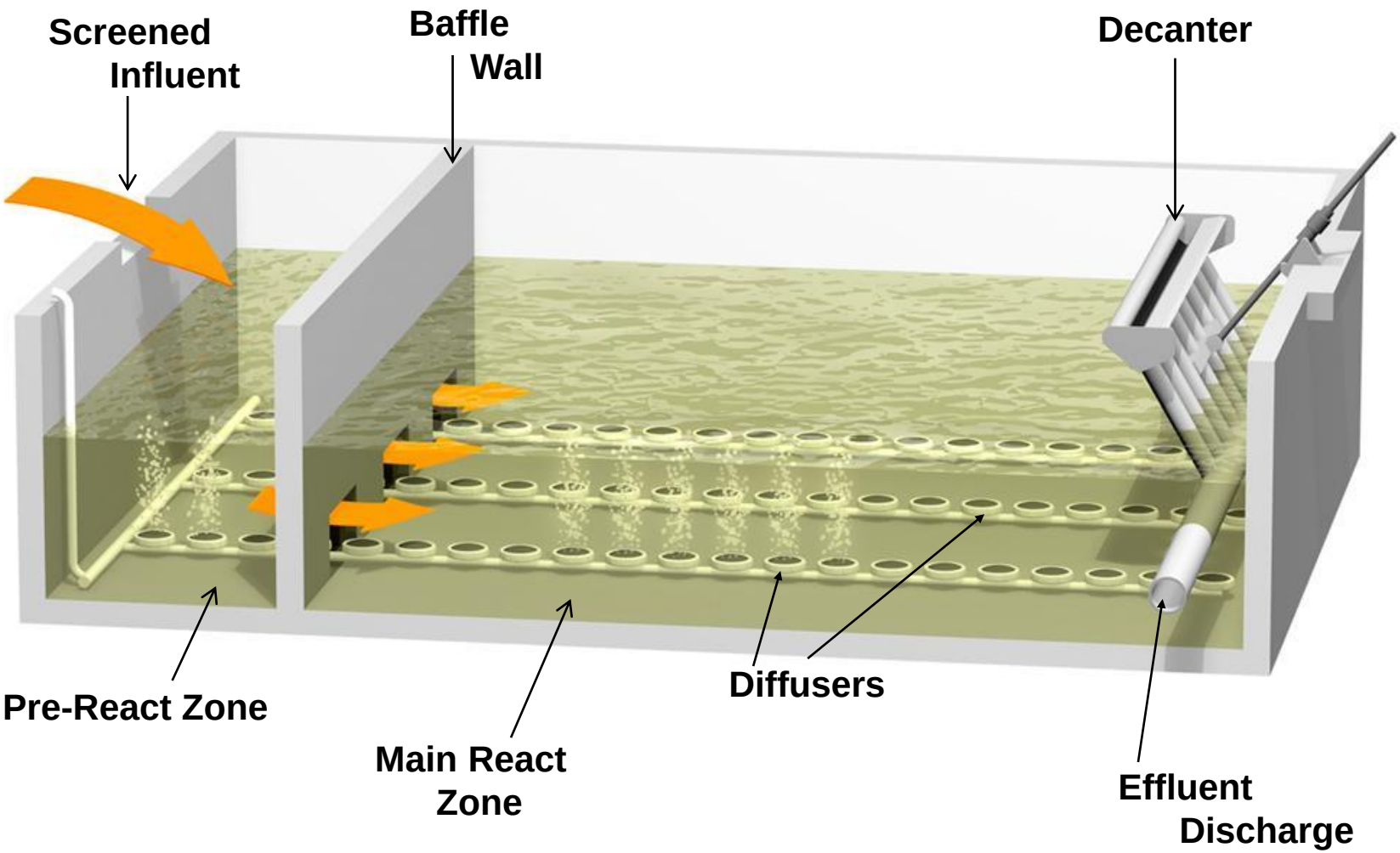
Basin Layout



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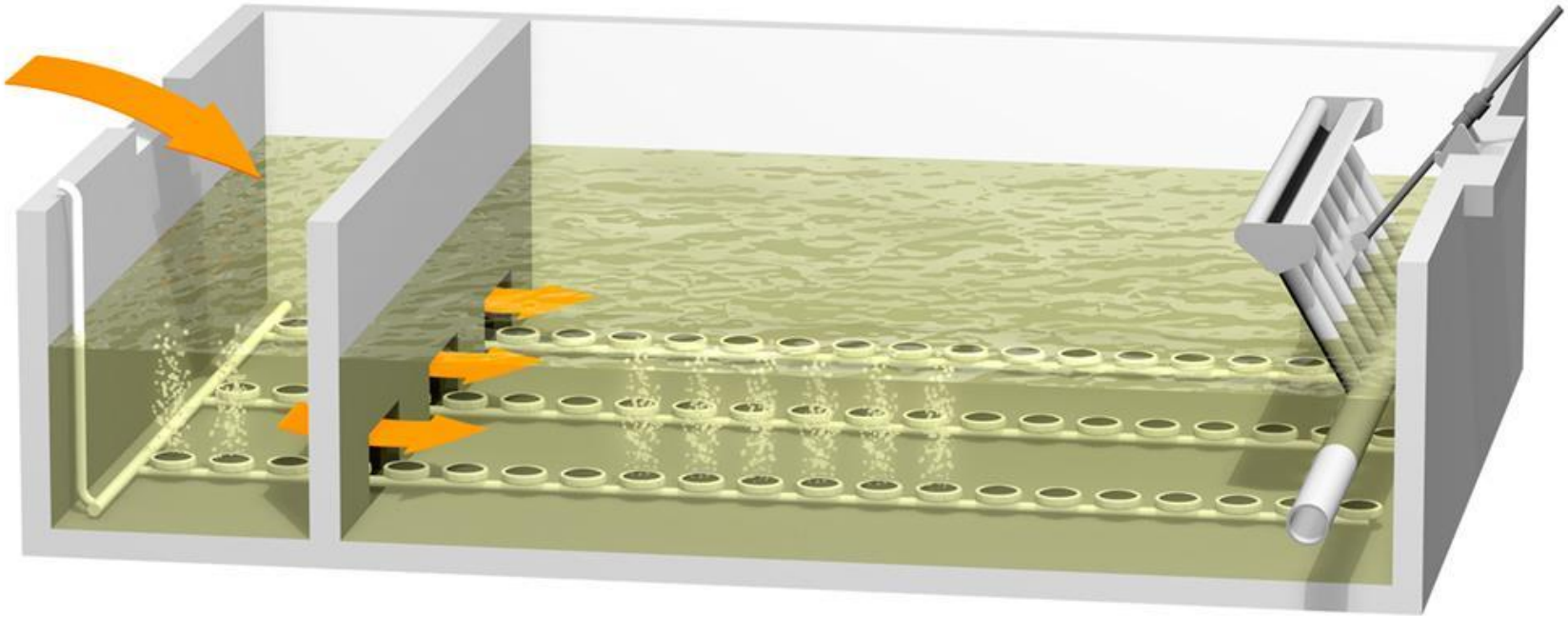
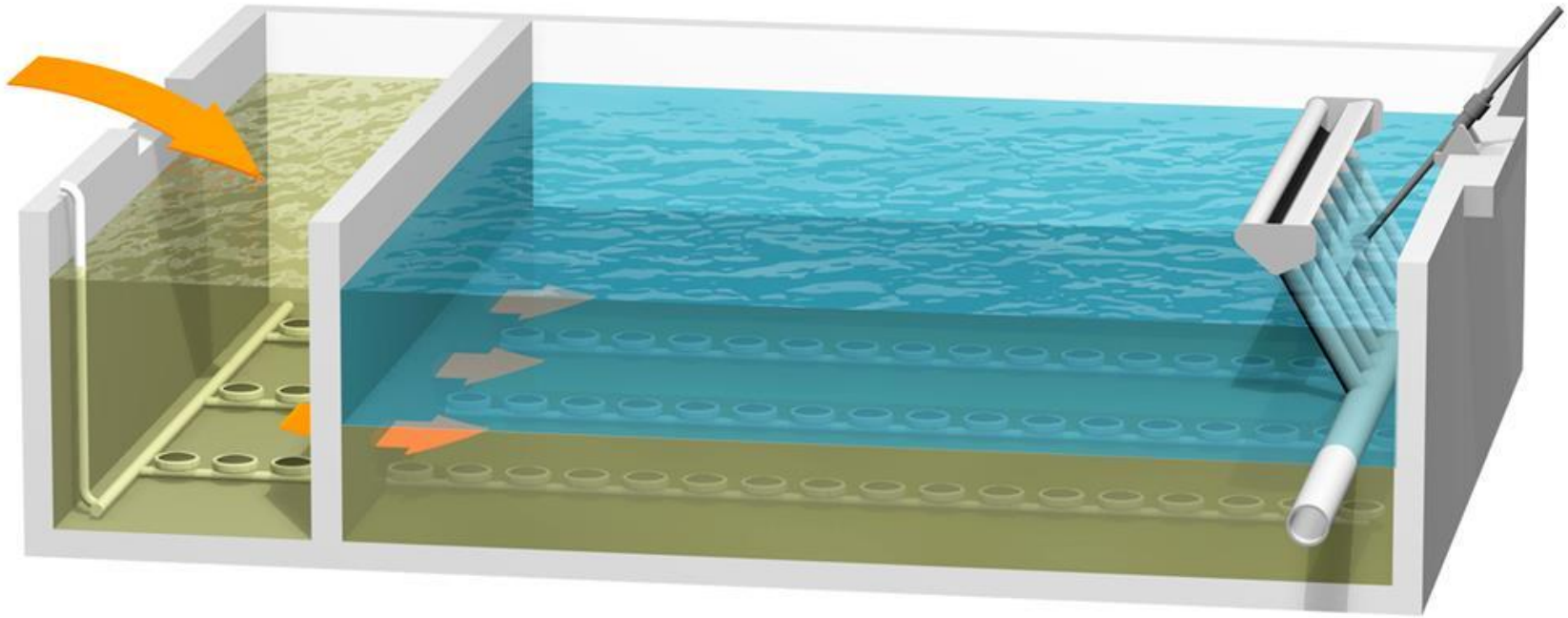
Phase 1 – React (aerate and anoxic)

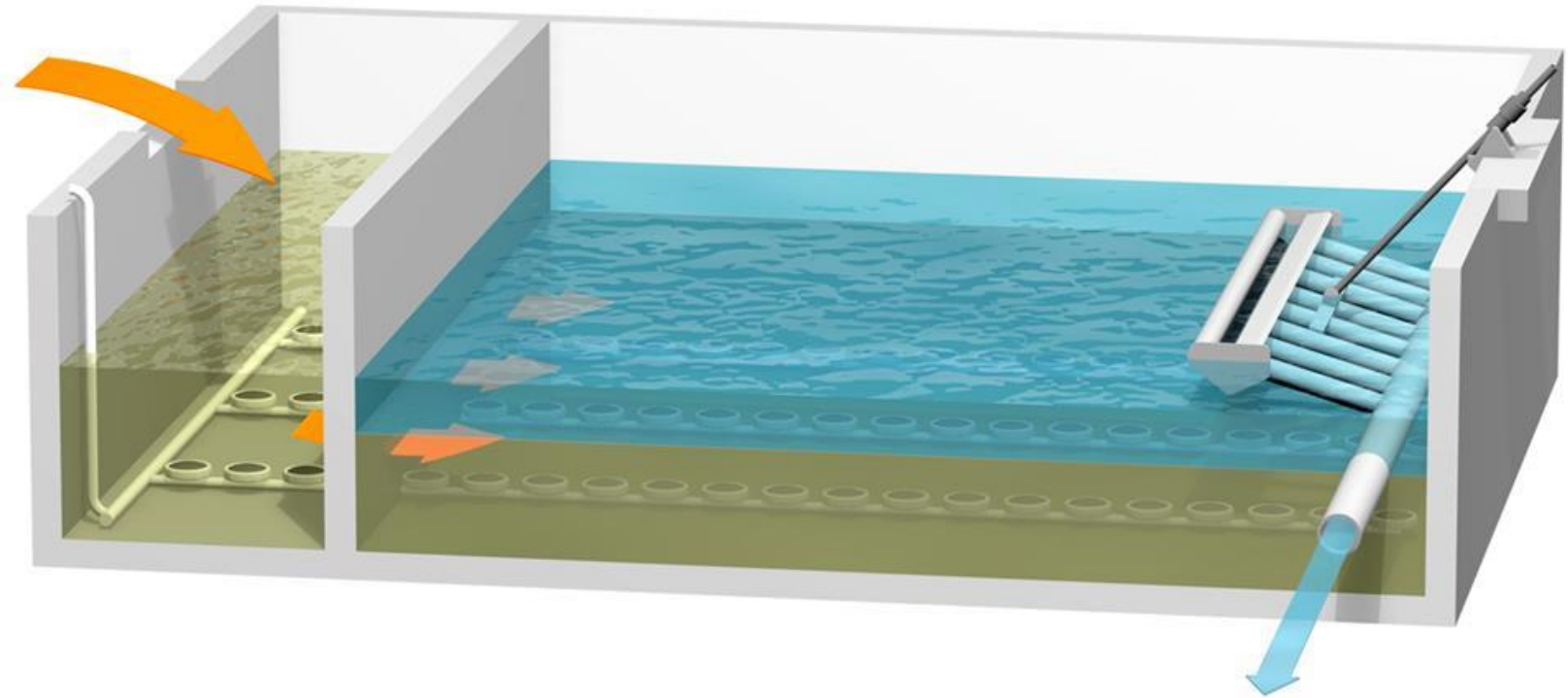


Phase 2 - Settle

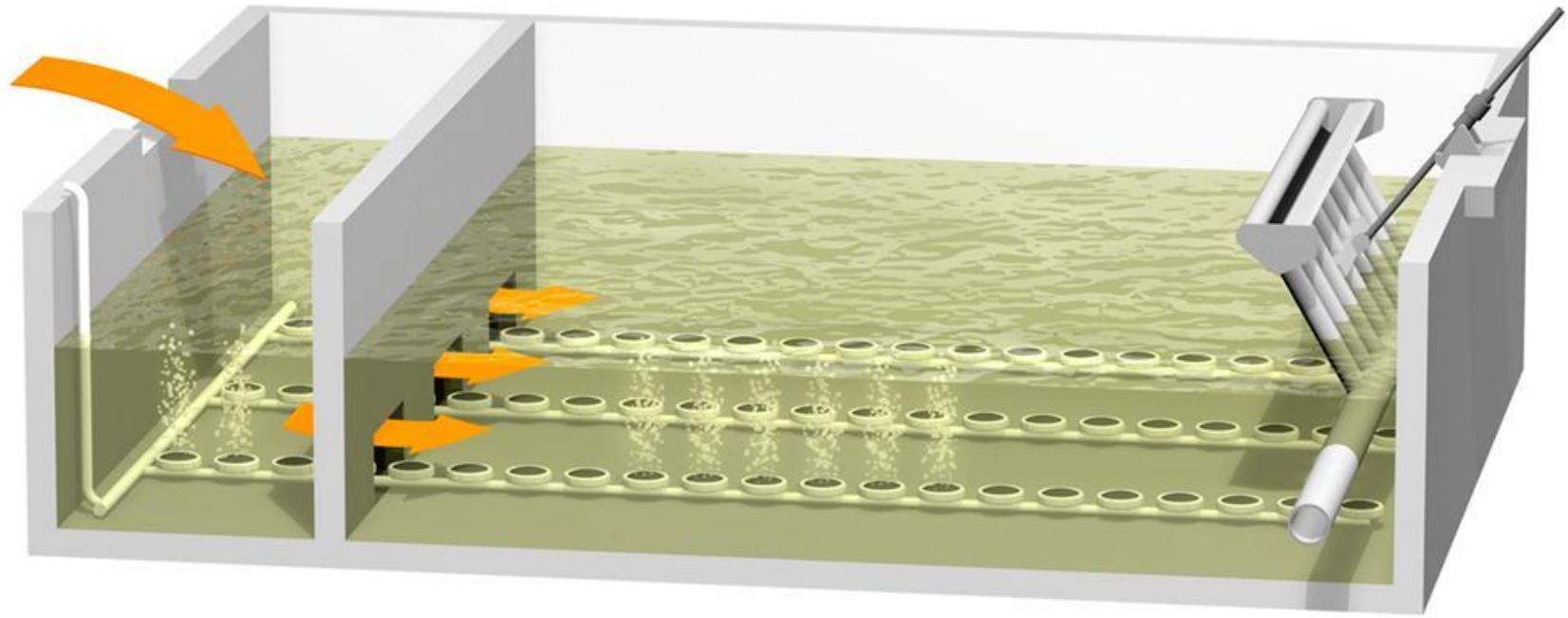


No aeration in pre react zone,
No turbulence travelling into settlement zone
Area maximised for settlement

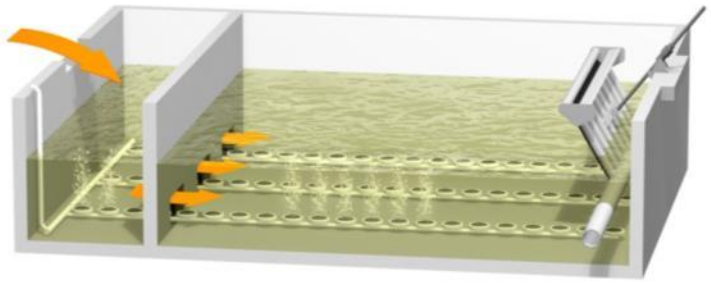
Phase 3 - Decant



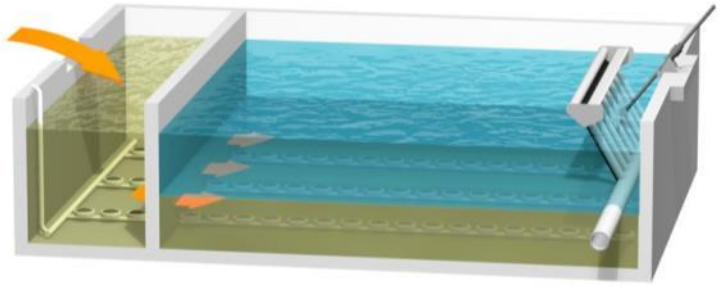
Phase 1 - Aerate



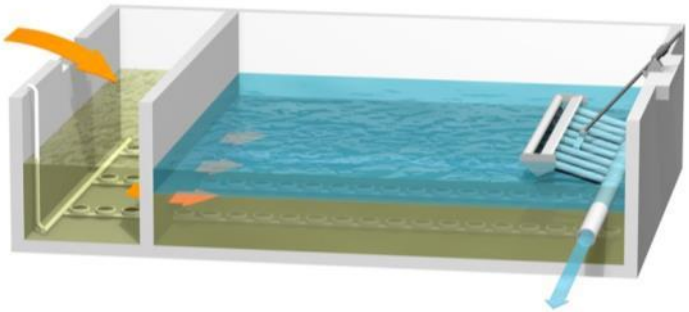
Operating Cycle



1. React



2. Settle



3. Decant

Treated Effluent

Continuous Flow

Un-Paralleled Performance

Continuous flow

Equal flow and load to ALL basins at ALL times

Diurnal variations received by ALL basins

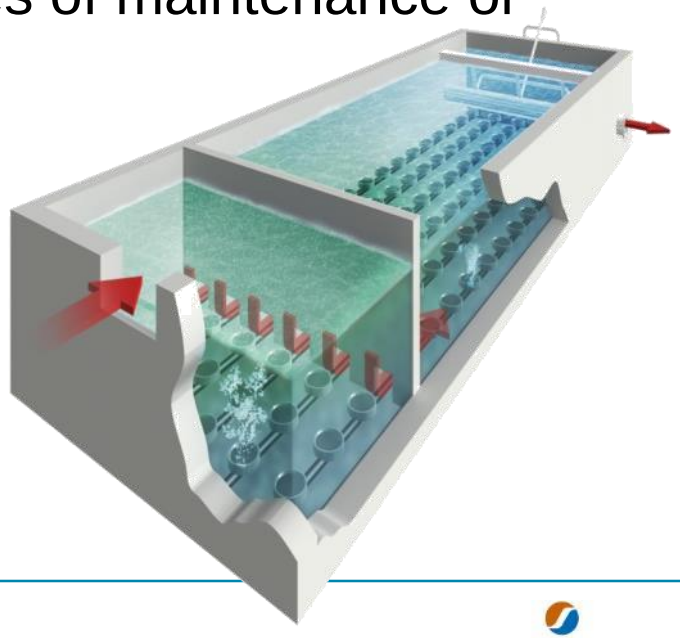
Biomass characterized the same in ALL basins

Simplifies process adjustments

Allows for single basin operation during times of maintenance or periods of low flow

Pre react sized to give selection effect

- Consistent, higher quality effluent
  (10 BOD/ 10 SS/ 1 Amm/ 10 TN/ 1 P average)
- High flows can be accommodated



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Design Security

- Optimized process design to suit specific requirements
- Uniquely suited to flow and load variations
- Proven performance
- No rule of thumb design
- Design on specification loads
- Experienced in rigorous process design approvals
- Expansion capability

Design Security

Sludge Blanket

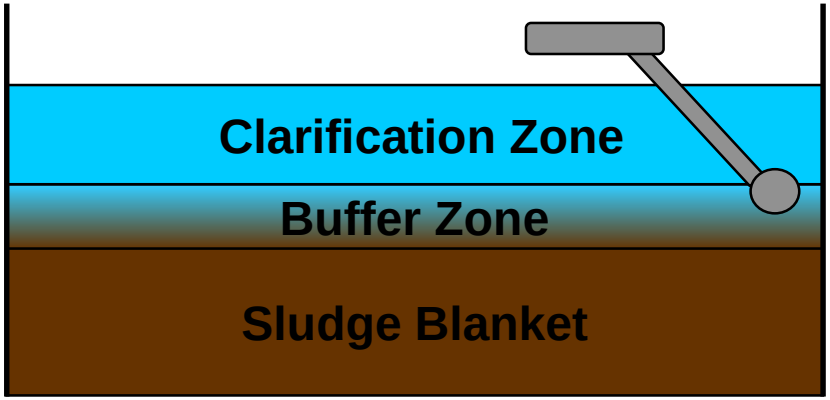
- Function of the Organic Loading
- Ratio F:M
- Assumed SVI = 150
- Chemical sludge due to alum addition for Bio P Removal

Buffer Zone

- About 3 ft
- Separates BWL from sludge blanket.
- Acts as a safety factor in ICEAS design.
- Critical design component for any SBR.

Clarification Zone

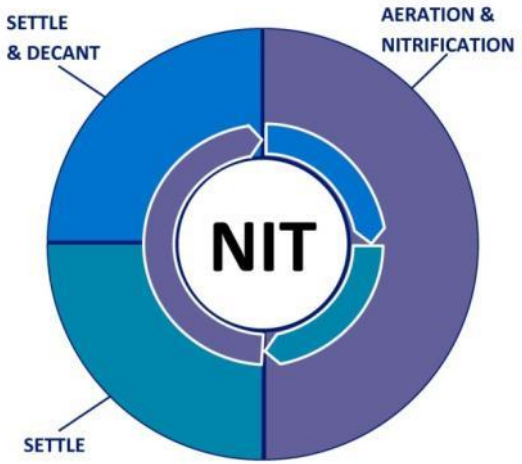
- The different between the maximum water level and bottom water level.
- Function of maximum flows and cycle times
- Limited to 1/3 of the top water level (or 2 M)



NIT & NDN(P) Operating Modes

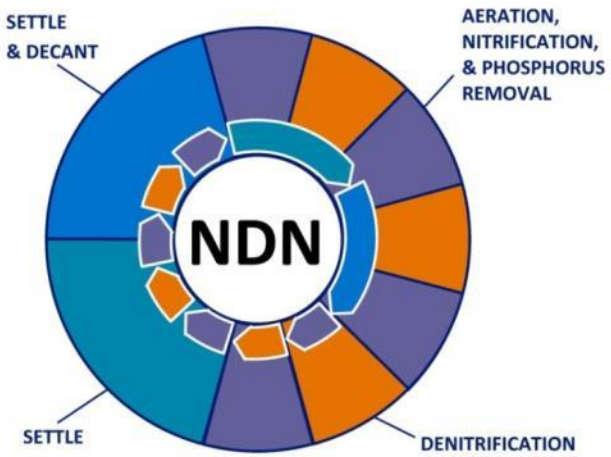
Nitrification (NIT)

- BOD & TSS removal
- Nitrification
- Partial denitrification



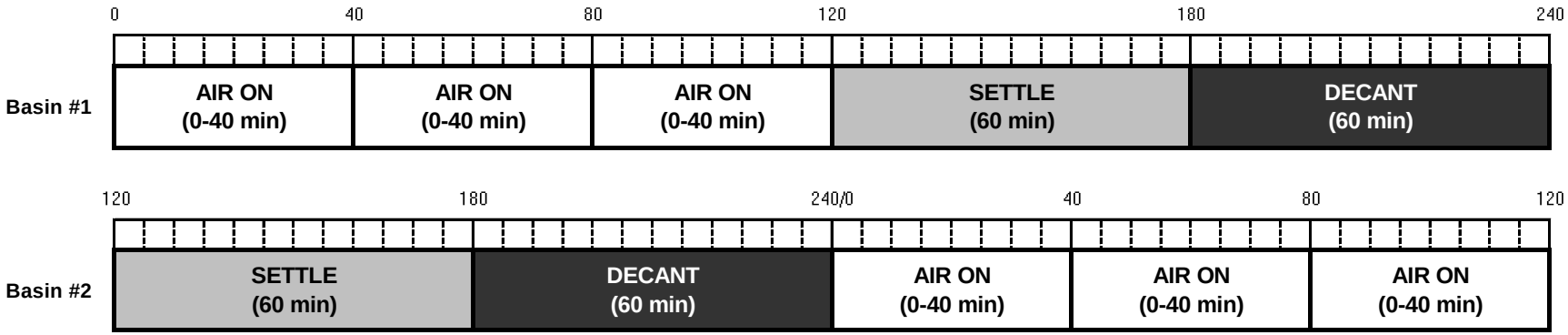
Nitrification, Denitrification, and Phosphorus Removal (NDNP)

- Complete nutrient removal
- Nitrogen
- Phosphorus



NIT Cycle Charts

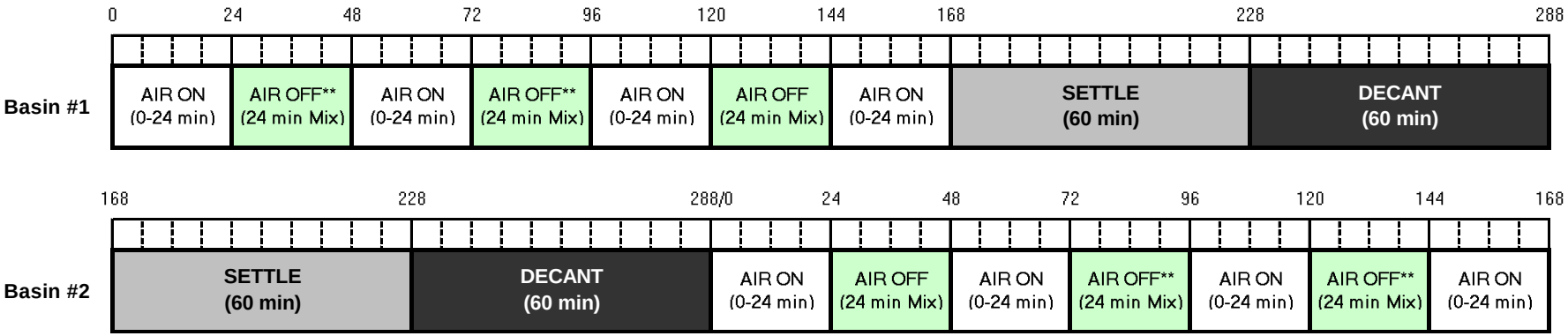
NIT Normal Cycle Operational Sequence (4 Hours)



2 Basin System

NDN(P) Cycle Charts

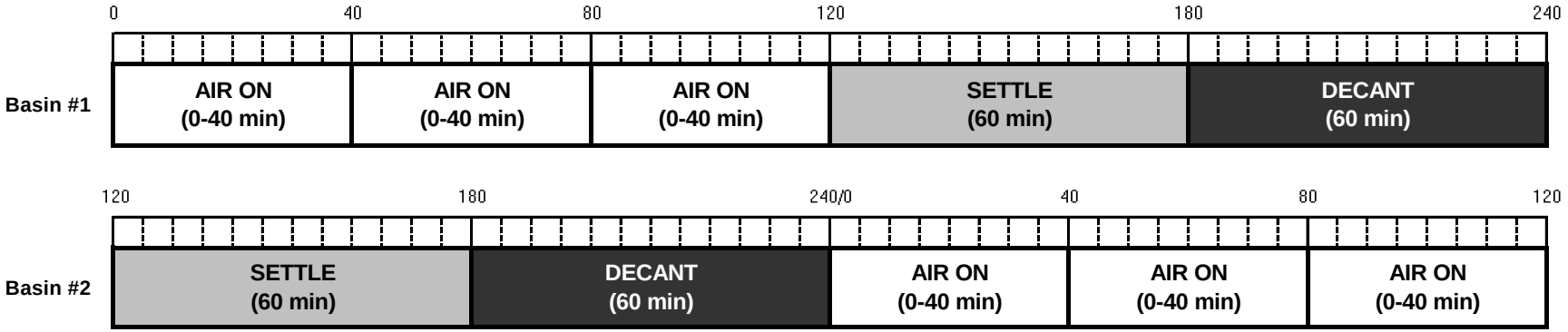
Normal Cycle Operational Sequence (4.8 Hours)



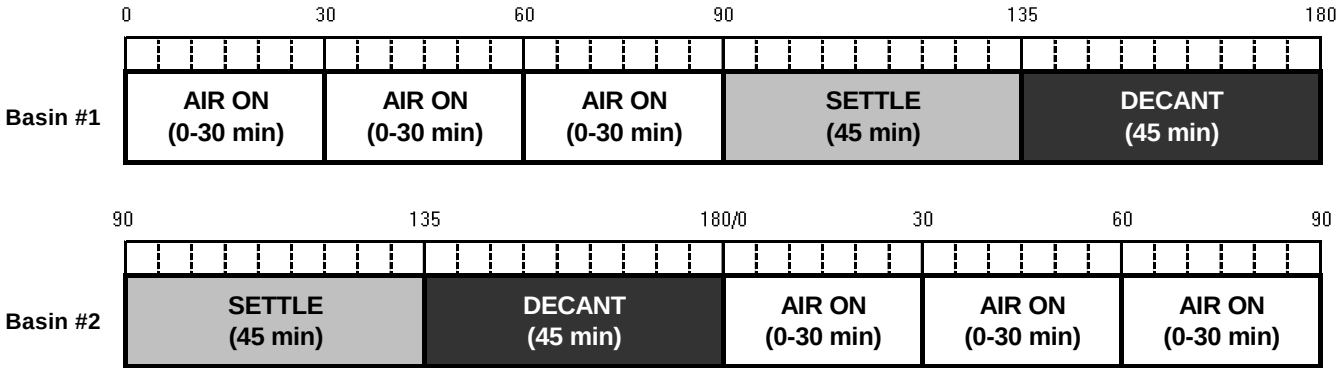
2 Basin System

NIT Cycle Charts

Normal Cycle Operational Sequence (4 Hours)

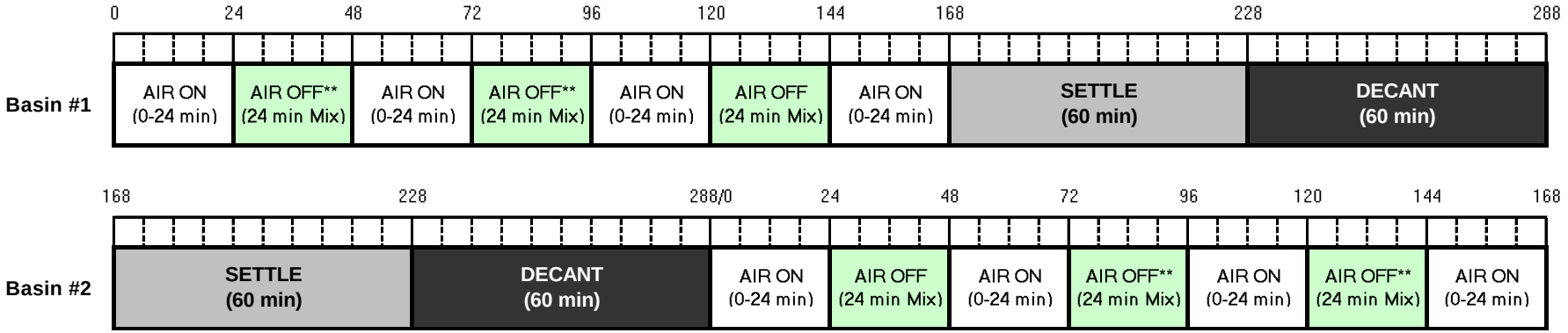


Storm Cycle Operational Sequence (3 Hours)

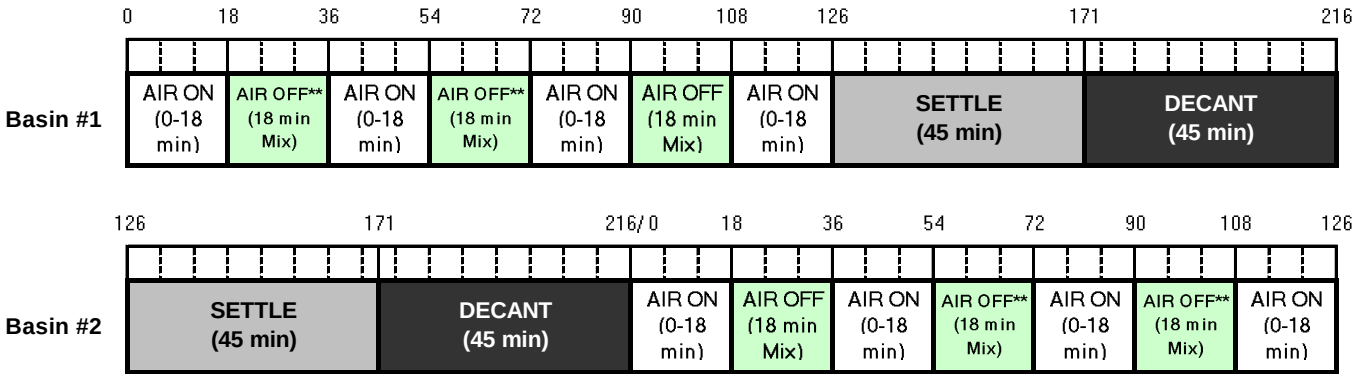


NDN Cycle Charts

Normal Cycle Operational Sequence (4.8 Hours)



Storm Cycle Operational Sequence (3.6 Hours)



Benefits

Reduced Capital costs

- Flat bottomed, shared wall construction
- Smaller Footprint
- Shared Blowers

Reduced operational cost

- High efficiency aeration system
- No RAS pumping

Easy to operate

- Simple process control
- Easy to maintain
- Possible to do single basin operation

Reduced risk

- Single source supplier with no interfaces

Proven, robust process

- More consistent, higher quality effluent (10 BOD/ 10 SS/ 1 Amm/ 1 P/ 10 TN average)
- Less affected by flow and load variations
- Proven hydraulic design
- Better decanter design
- Proven, 900+ plants world wide

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4. Aeration

Aeration

Sanitaire aeration system

- Energy efficient aeration
- Minimal maintenance
- Time proven durability

Fine Bubble Membrane Diffusers

Fine Bubble Membrane Diffusers

Silver Series

- EPDM (Ethylene Propylene Diene Monomer rubber) membrane
- High Efficiencies (8.8 lb O_2/BHP hr)
- Built in check valve
- Longer diffuser life
- Resistant to material property changes

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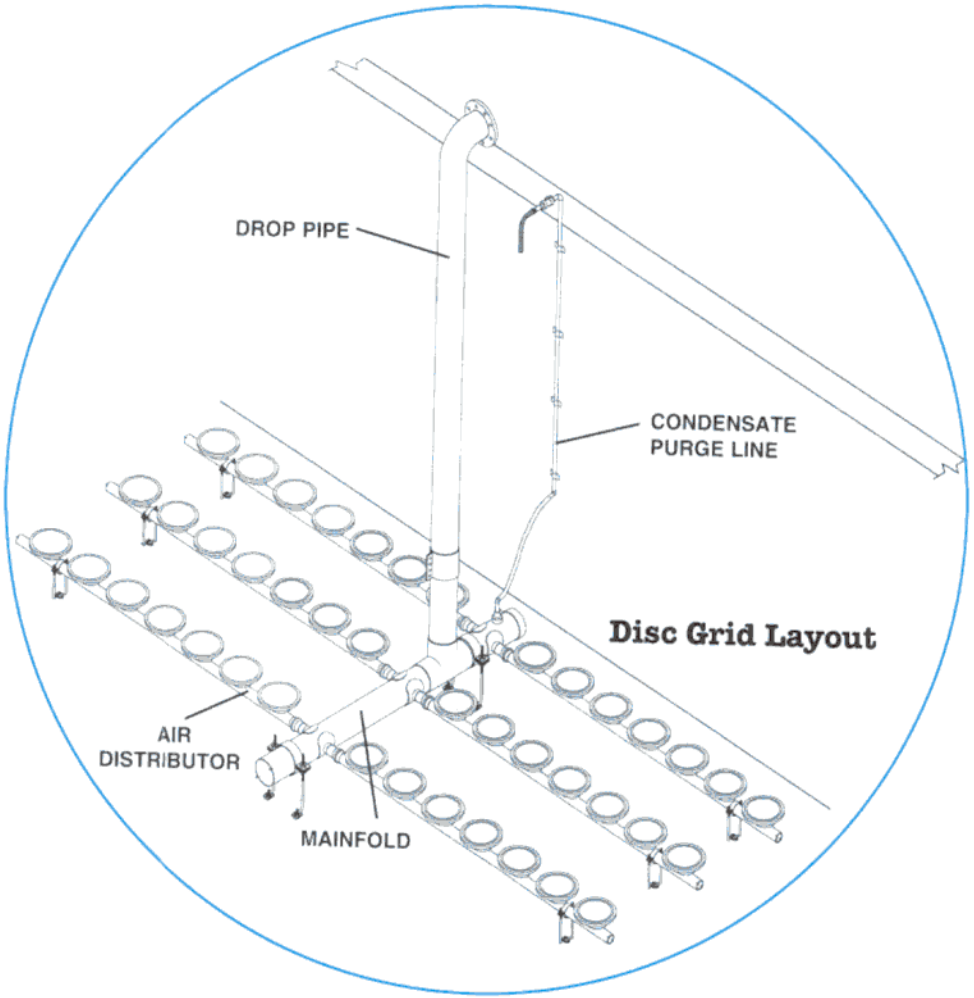
Fine Bubble Membrane Diffusers

Mechanical Features

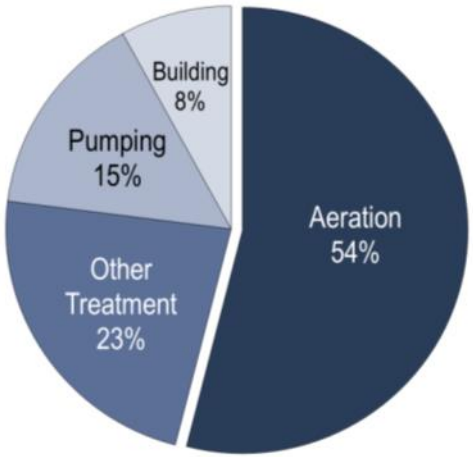
- Advanced membrane material engineered for domestic and industrial applications
- Piping system accommodates thermal expansion and contraction
- Fixed joints prevent air leakage, pipe separation and distributor rollover
- Rugged stainless steel supports, infinitely adjustable within their range

Diffuser Grid Layout



Sanitaire Aeration Equipment

Largest Performance Data Base in the Industry Substantiates Aeration System Design



- Fine bubble diffused aeration
- Full floor coverage
- Flexible aeration range
- Highly efficient aeration transfer
- Can achieve 4-6 kg O2/kWh in clean water
- Will guarantee aeration efficiency

Significant Cost Savings Gained Through Efficient Design of Aeration System and Control

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5. Decanter

Decanters

- ✓ Functions and Key Features
- ✓ Withdraw treated water
- ✓ Exclude floatables
- ✓ Accessible and easily serviced
- ✓ Ability to control
- ✓ “Active” instead of “Passive”

- All Decanters
- Most Decanters
- Sanitaire Decanter

Decanters

“Passive” vs. “Active” Decanting

- Passive Decanter = on or off with little flow rate control.
- Active Decanter = rate of decant is controllable and dependent on the influent flow rate.

Advantages of an Active Decanter

- Daily time allocated for Aeration, Mixing, Settle and Decant is not impacted by influent flow rate and cycle time.
- High quality effluent is maintained even during prolonged periods of peak hydraulic flow.

The Sanitaire decanter is an active device. Fixed and floating decanters are passive devices.

Decanter – Components

Trough assembly

- Scum exclusion components; float, plate, w

Down comers and vent tubes

Collector pipe

Discharge connection

Bearing assembly

Connecting rod

Electromechanical actuator

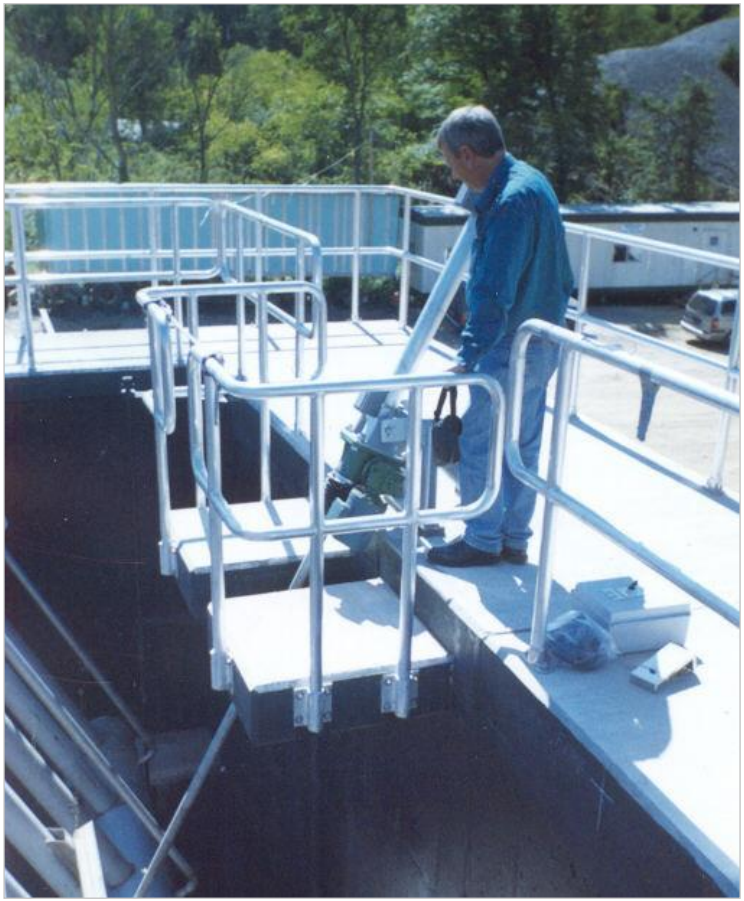
Decanter – Different Sizes

Single small decanter

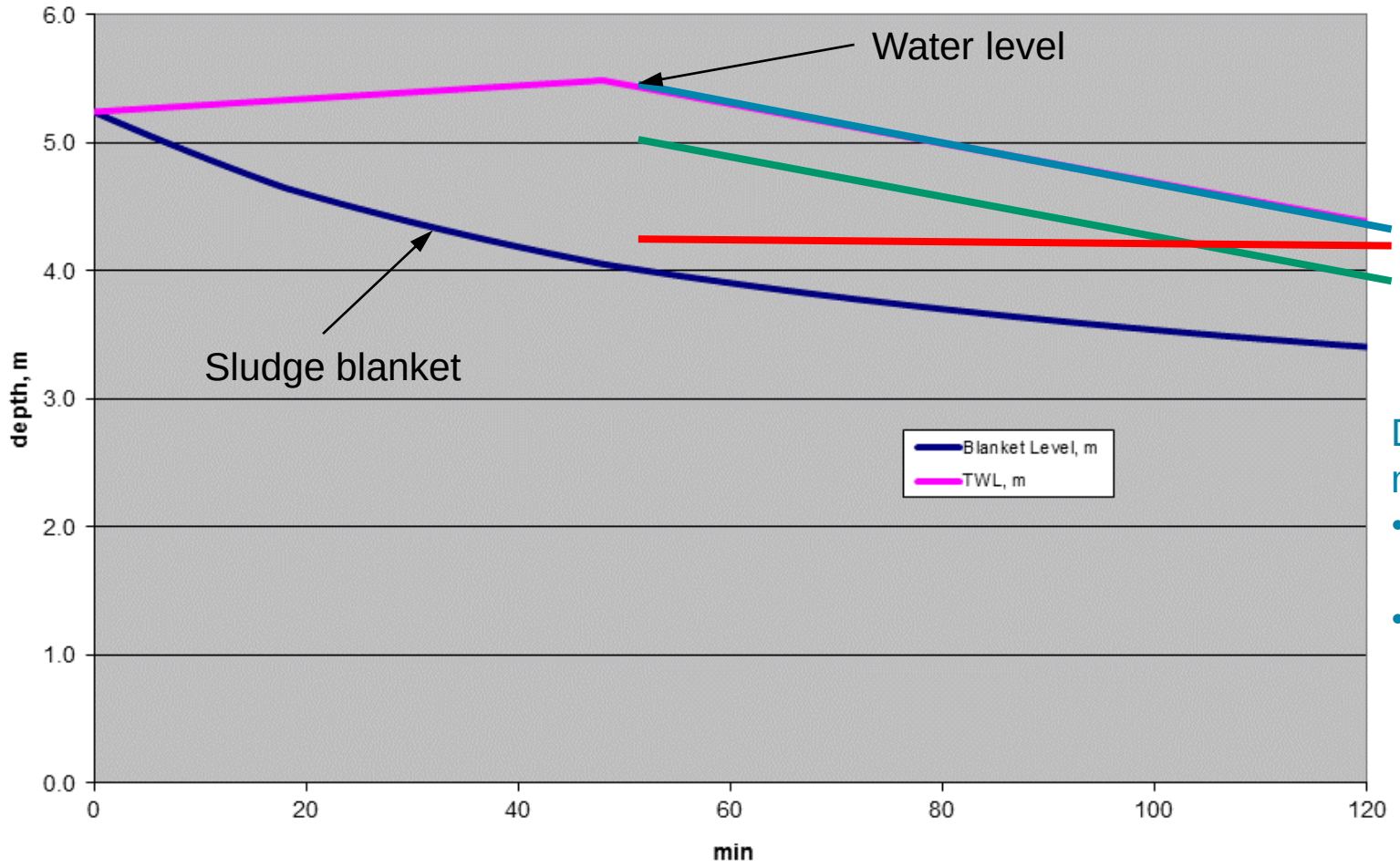
Dual large decanters

Decanter – Operation

- Discharge connection and a constant rate of effluent discharge
- Emergency overflow
- Decants from the top down
- Moving parts located outside of basin
- Parked above top water level when aerating
- Simple gravity flow
- All maintenance can be carried out from the top of the tank



Settlement comparison



Draw off point

Driven

Floating

Fixed

Driven decanter maximizes

- settlement time
- Distance from sludge blanket

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6. Other Mechanical Equipment

Blowers

Types

- Positive Displacement
- Single-Stage Centrifugal
- Multi-Stage Centrifugal

Options

- VFD Control
- Modulating Inlet Valves

Air Control Valves

Butterfly valve auto actuator

Open-Close control

Quality valve is very important

- Open – Permissive to aerate (turn on blowers)
- Closed – Permissive to decant

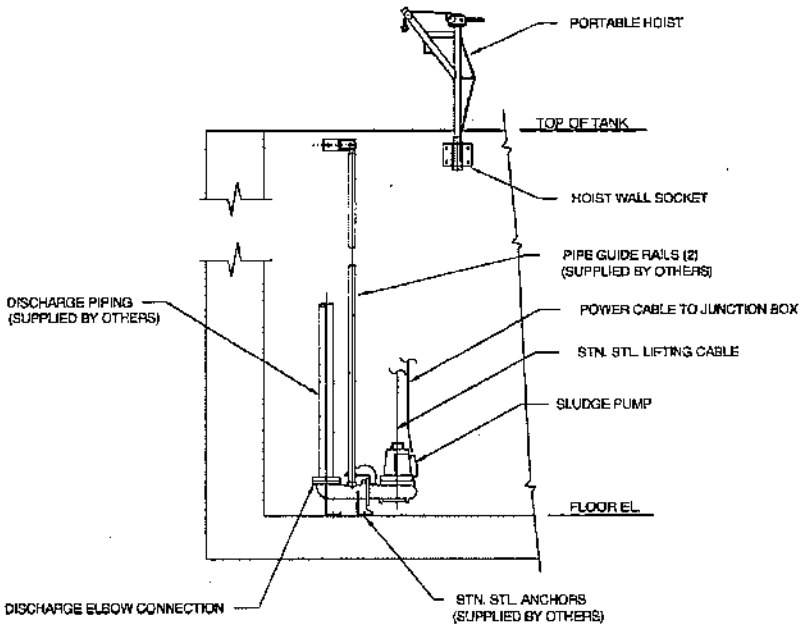
Purge/Depressurization System

Function and Purpose

- Removes accumulated moisture
- Visual check of system breach
- Aeration system open to atmosphere during settle/decant
- Integrated with control system

Waste Sludge Pumps

- Submersible Flygt
- Dry pit optional



Submersible Mixers

- Typically used for the NDN process
- Flygt 4600 series mixers (4630 through 4680)
- All stainless steel mounting hardware
- One or two mixers per basin
- Only in main react zone

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7. Controls

ICEAS Control Simplicity

- Fully automated process controls for stable and energy efficient operation
- Easy to understand and simple to use

Cycle control	Aeration control	Biomass control	Flow and level control	Settling phase control	Decant control

Time Based Cycle Control

OSCAR keeps track of where you are in the cycle and controls the required equipment

- Time based control system based on fixed cycle sequences
- Automatic start and stop of aeration, mixers, pumps and decanter as required for treatment
- Safety inhibitors and interlocks ensure trouble-free operation

Time Based Control System

Time based control has a limited number of fixed cycle times

- Fixed cycle times irrespective of flow up to intermediate design limit
- Switch to shorter fixed cycle time when intermediate design flow exceeded

Advantages

- Effective Control of Process Cycles
- High Flow Capability Without Solids Washout
- Operator Friendly
  - Simplicity of Operation
  - Easy for operator so see the cycle time
- Always have same daily aeration time in all cycles

Treatment Cycle

Normal Cycle vs. High Flow Cycle

- Up to Max Normal cycle Flow: Normal cycle
- Up to Maximum design flow: High flow
- Over Maximum design flow: Overflow weir

Typically 25 Percent Shorter Cycle for High Flow

- 4.0 hr NIT Normal cycle → 3.0 hr High Flow cycle
- 4.8 hr NDN Normal cycle → 3.6 hr High Flow cycle

Very High Flow Cycle can also be used (specialist design)

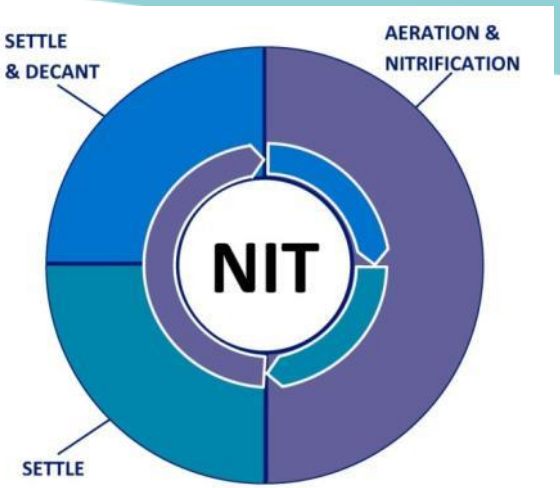
- 4.0 hr NIT Normal cycle → 2.0 hr Very High Flow cycle
- 4.8 hr NDN Normal cycle → 2.4 hr Very High Flow cycle

ICEAS NIT & NDN Control features

Operating Modes

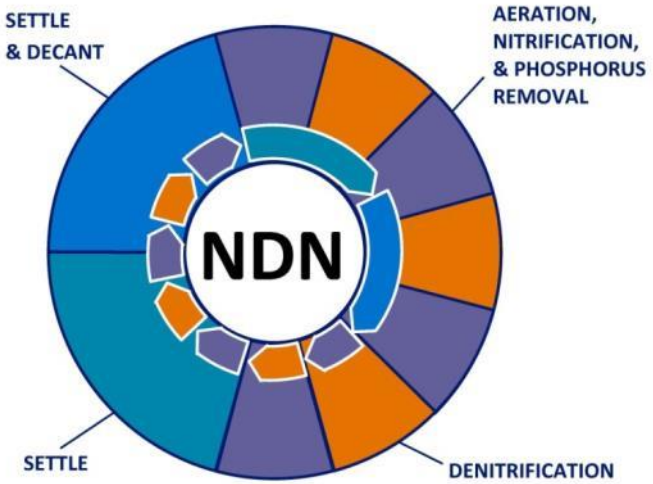
Nitrification (NIT)

- BOD & TSS Removal
- Nitrification
- Partial Denitrification



Nitrification, Denitrification (NDN) and Phosphorus Removal (NDNP)

- Complete nutrient removal
- Nitrogen
- Phosphorus



High flow variation

- Variable cycle times

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Flow and Level Control

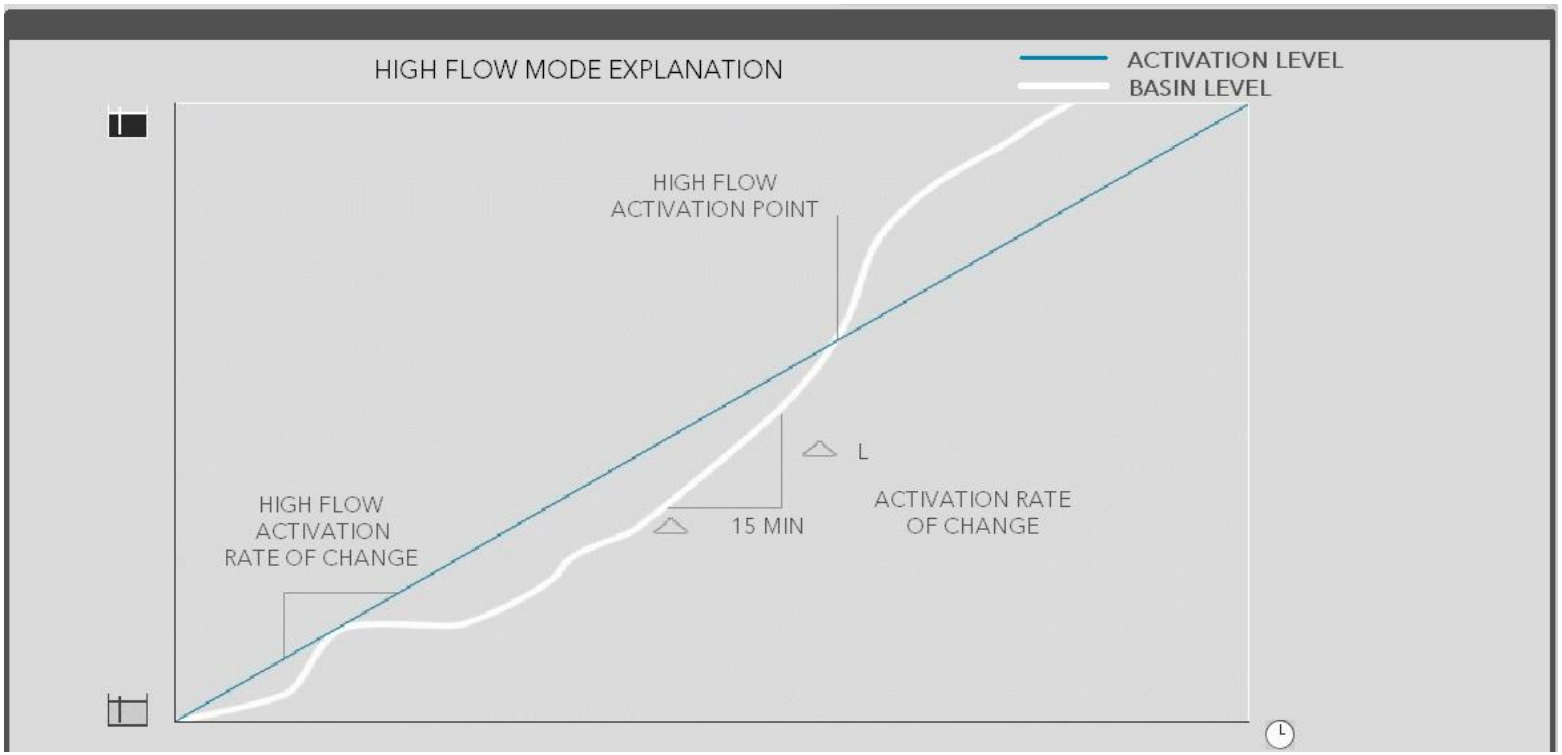
OSCAR automatically switch to high flow mode at high influent flows

- Basin level transmitters and float switch keep track of water rising speed
- Shorter cycle at high flows:
  - Sufficient hydraulic capability
  - Sufficient settling time
- Shorter cycle suspended automatically once flow reduced

Flow and Level Controls

High Flow Mode Operation:

- System will respond to a increased influent flow by measuring a rate of change in the tank level
- In High Flow mode the system clock speed up accordingly
- System will go in and out of high flow mode automatically



Level and Float Switch

Level Regulator Switch (ENM-10)

- Simple mechanical switch breaks the circuit when tilted
- Plastic casing – no wear, no maintenance
- Multiple cable lenghts for desired mounting height

Level Transmitting Unit (LTU 401)

- Ceramic thick-film sensor
- No foaming effects, as can be seen with ultrasonic sensors
- Installation inside PVC pipe protects from surge from pumps and turbulence
- Quick response time (20 ms)

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Nutrient Control - NURO

NURO – NUtrient Removal Optimization

Automated control of the ICEAS® aeration timing to optimize nitrogen and phosphorus removal

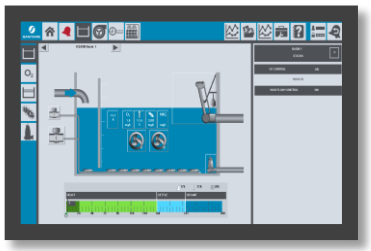
Benefits:

- Improved treatment stability
- Improved treatment capacity
- Reduce operation cost
- Control stability and less blower wear

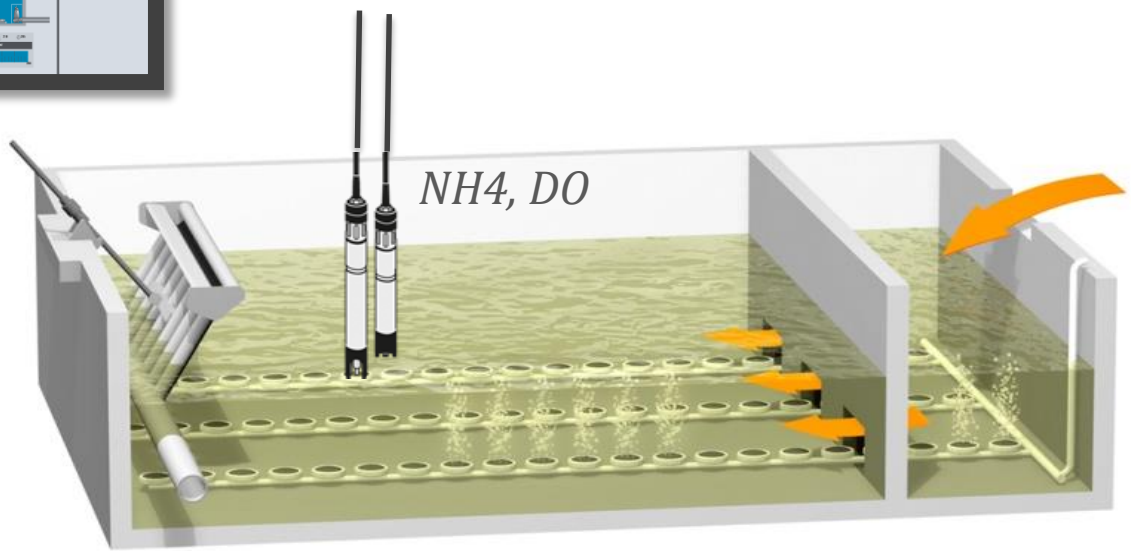
"The BNR controller reduced our aeration costs 15% and helped optimize biological phosphorus removal and minimize chemical consumption."
– Glen McCarty, Wastewater Superintendent, Green Lake, Wisconsin

ICEAS NURO control – How does it work?

1: Operator select target effluent NH4



2: Measure NH4 and temperature in the process



3: Control logic adjusts blower run time

OSCAR Aeration control still adjusts blower speed to maintain desired DO

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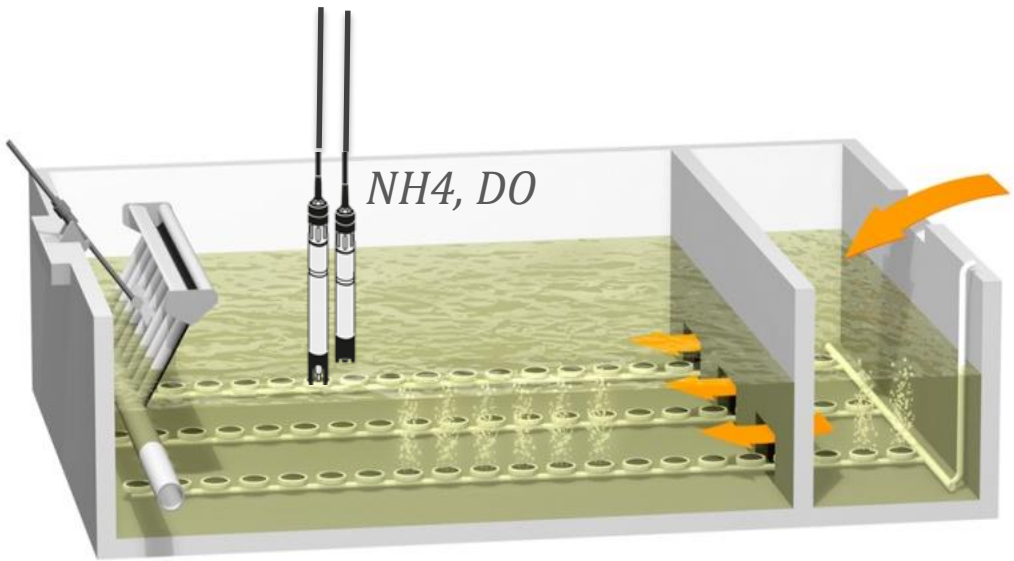
Treatment stability

Meet target effluent NH4

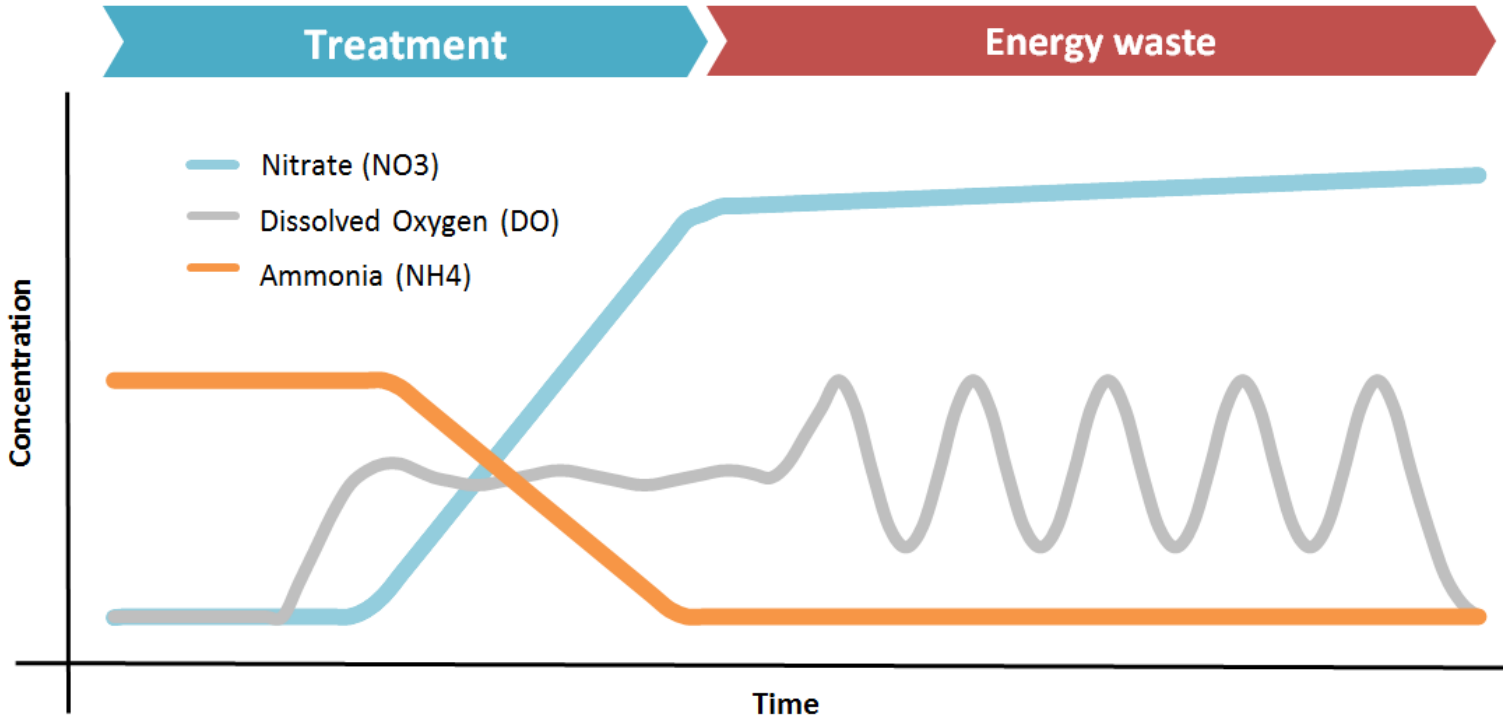
- Measure NH4 continuously
- React to load peaks during cycle
- Adjust for temperature and expected nitrification rate
  - meet permit also at cold temperatures



Improved treatment capacity

Without NURO:

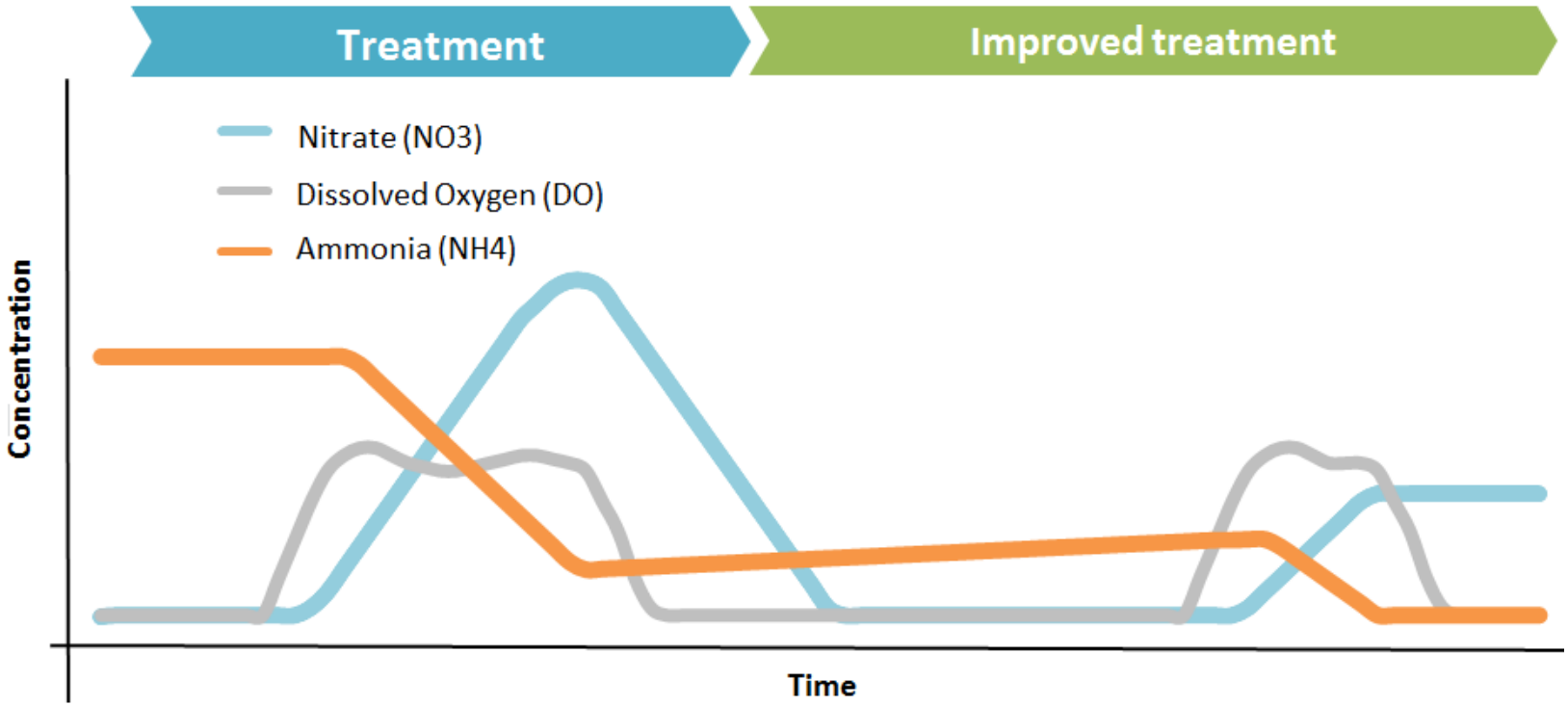
- In low loaded cycles, only first part of cycle used for treatment
- Remaining is energy wasted and unstable control
- Limited denitrification and bio-P



Improved treatment capacity

With NURO:

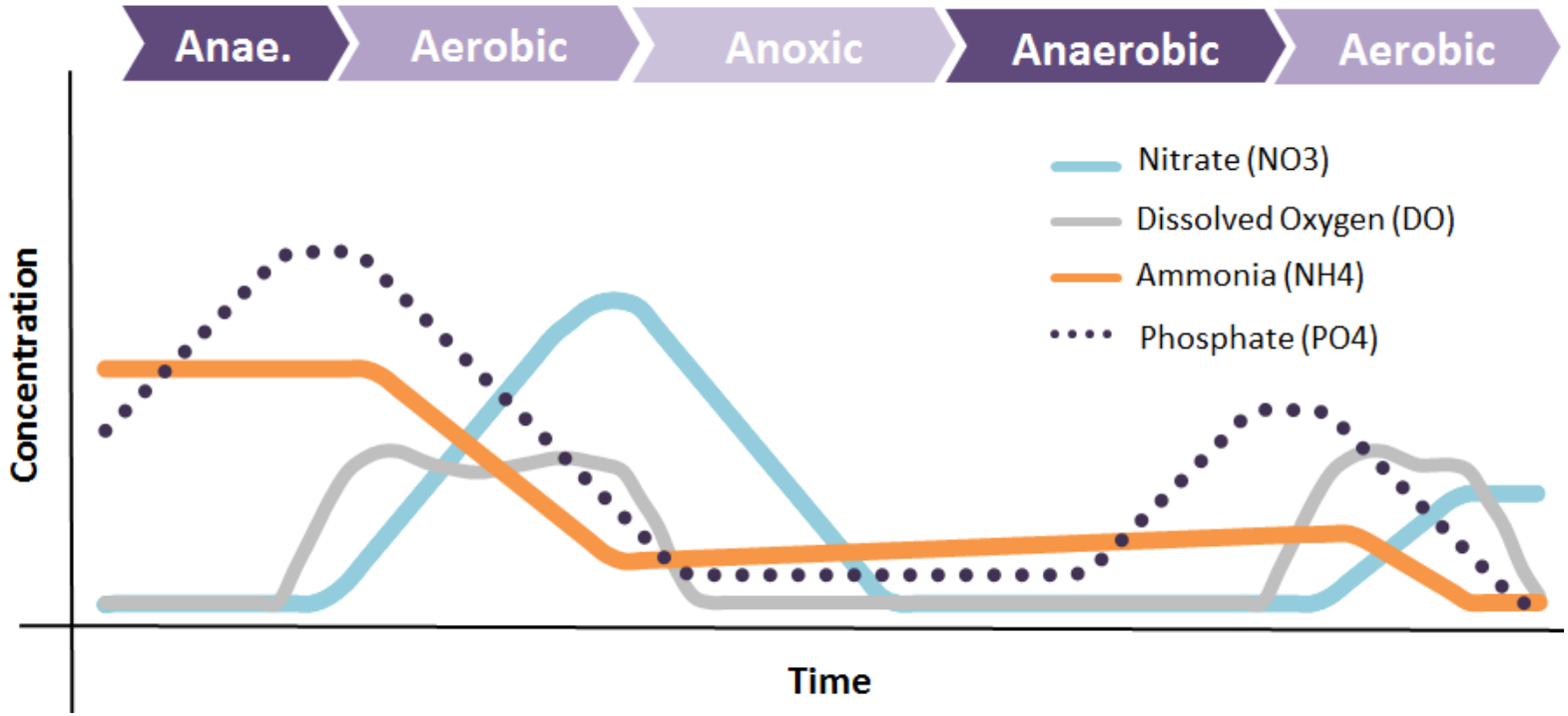
- Detect low loaded cycles and reduce aeration
- Allow for anoxic conditions and improved denitrification
- Aeration before settle allows for ammonia polishing before decant



Improved treatment capacity

With NURO:

- Optimizing conditions for bio-P
- Allow for anaerobic conditions in both react phase and settling phase
- Aeration before settle ensure phosphorus uptake before decant



OSCAR Biomass Control

SIMS – Sludge Inventory Management System

Automated sludge wasting by maintaining a required solids retention time or mixed liquor suspended solids concentration

Benefits:

- Reduced energy use associated with aeration and sludge handling
- Improved stability of plant operation
- Improved settling characteristics
- Overall improvement and consistency in effluent quality

"The plant consistently achieves BOD and TSS far below the state's limit, despite a one million gallon increase in raw influent."

–Satisfied customer

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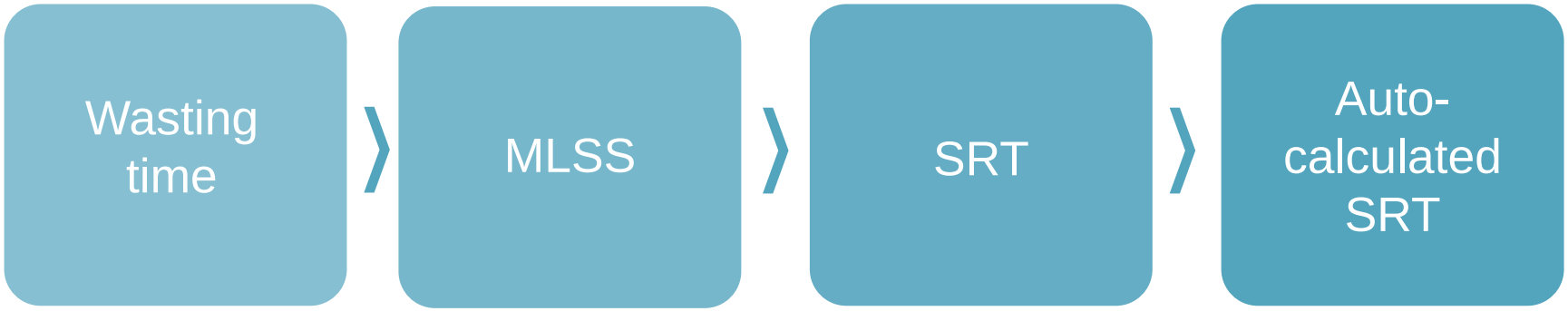
SIMS Control Flexibility

Four available modes of control



Set your preferred wasting time

Control to a constant MLSS

Control to a constant SRT

Control to an optimized SRT calculated for your current plant operation

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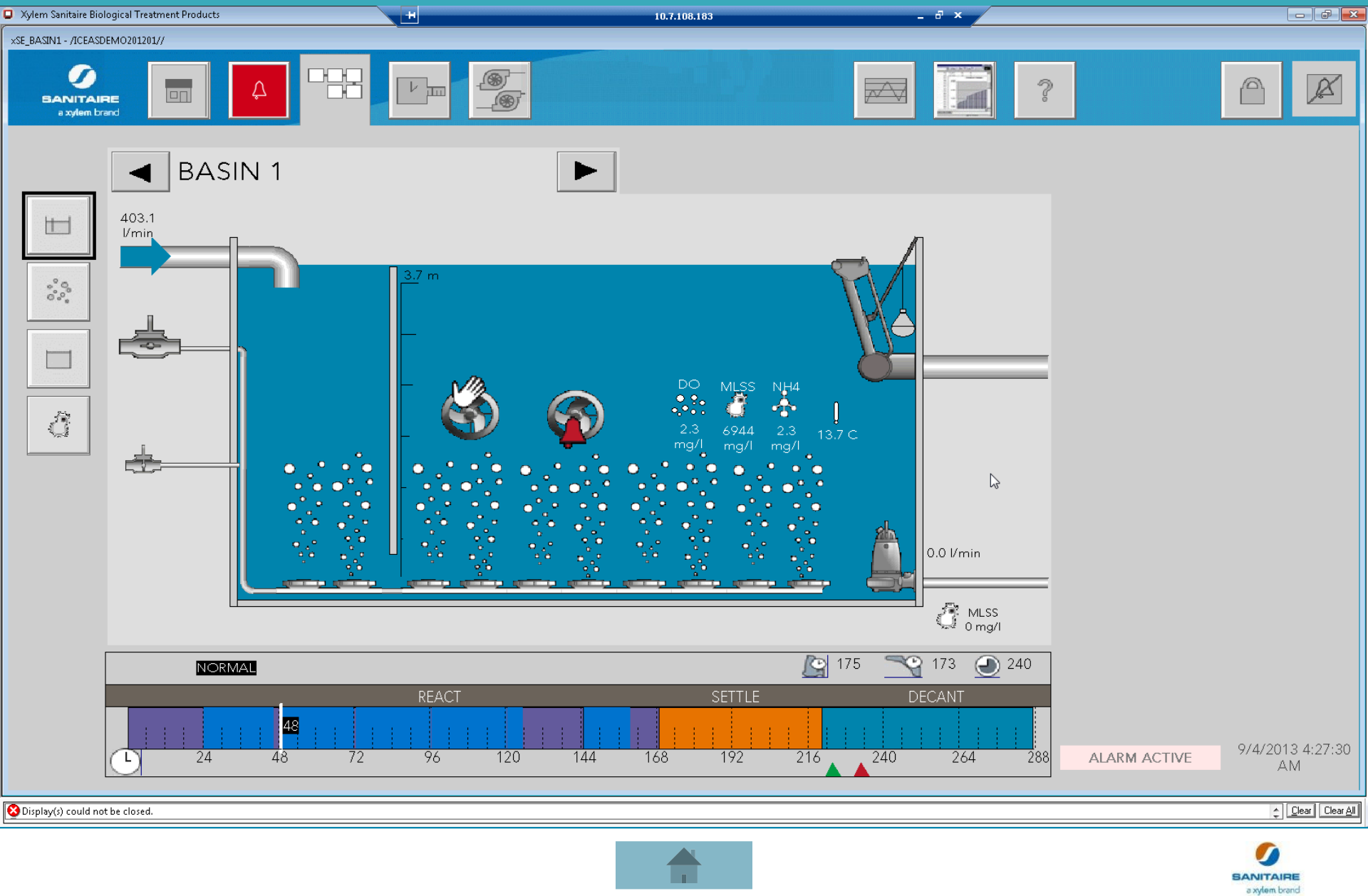
Master Control Panel

- Cabinet is NEMA 12 / IP 55 rated
- Programmable Logic Controller (PLC)
- Human Machine Interface (HMI)
- Instrumentation Controller and Communication Module
- Webport
- Hand-Off-Auto Control Switches for each device
  - Hand position is hardwired outside of the PLC and overrides the interlocks
  - Auto position will respond to the PLC program and includes interlocks
  - Provides reliable and assured equipment operation
- Pilot Lights to indicate when equipment is in use
- Power equipment such as motor starters and VFD's (or may be located in a separate Motor Control Center)

ICEAS Human Machine Interface (HMI)



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8. Recent Ohio Installations

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Upper Sandusky

Upper Sandusky Design Overview

Influent Conditions

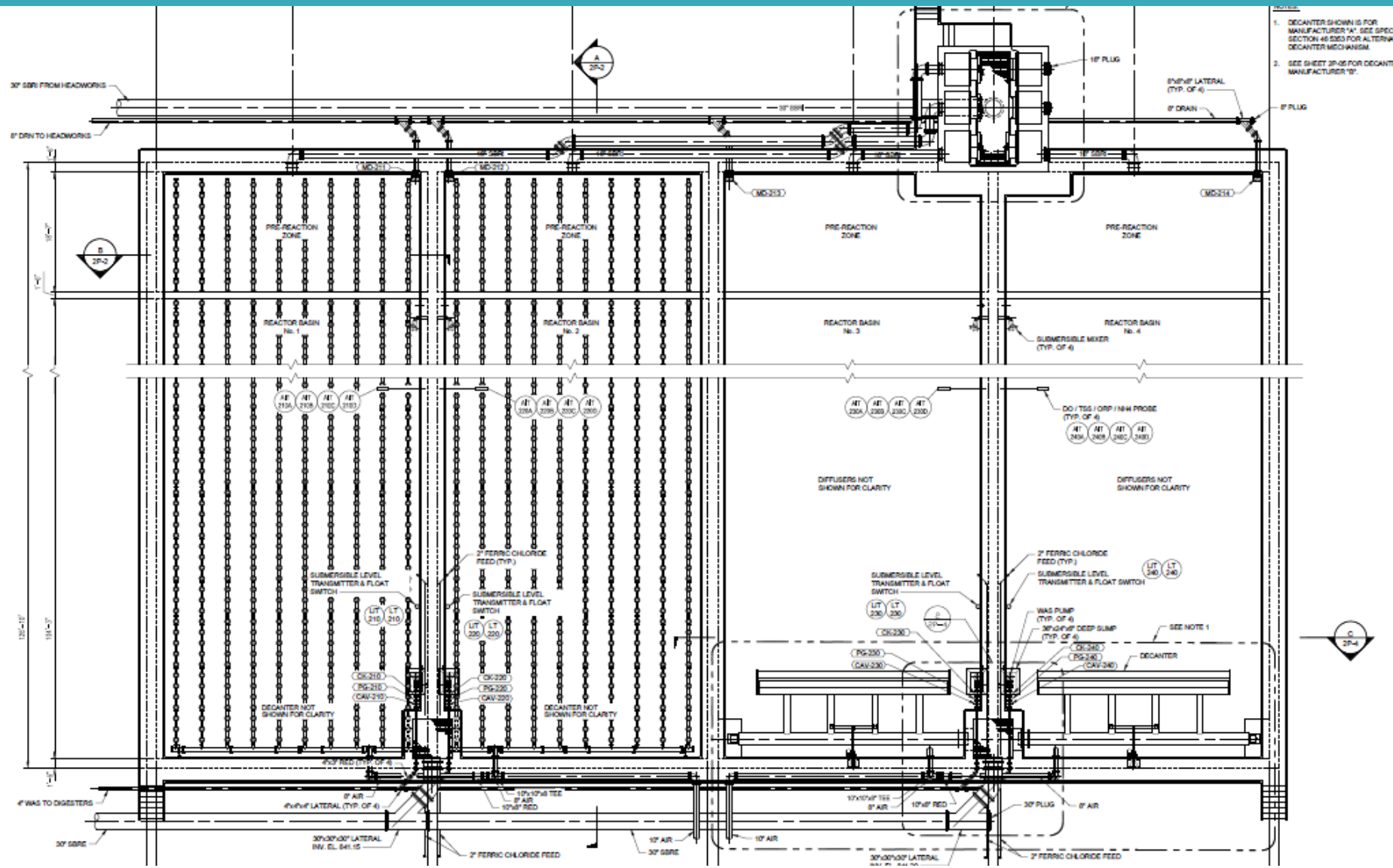
- Design Flow: 2 mgd
- Peak wet weather flow – 10 mgd

Effluent Conditions

- BOD: 10 mg/L
- TSS: 12 mg/L
- Ammonia (Summer): 1 mg/L
- Total Phosphorus: 1 mg/L

Equipment

- Two (2) 42‘ x 124‘ x 17‘ TWL tanks
- Three (3) 100 HP PD blowers
- Four (4) 15 HP submersible mixers
- Four (4) 2.4 HP WAS pumps



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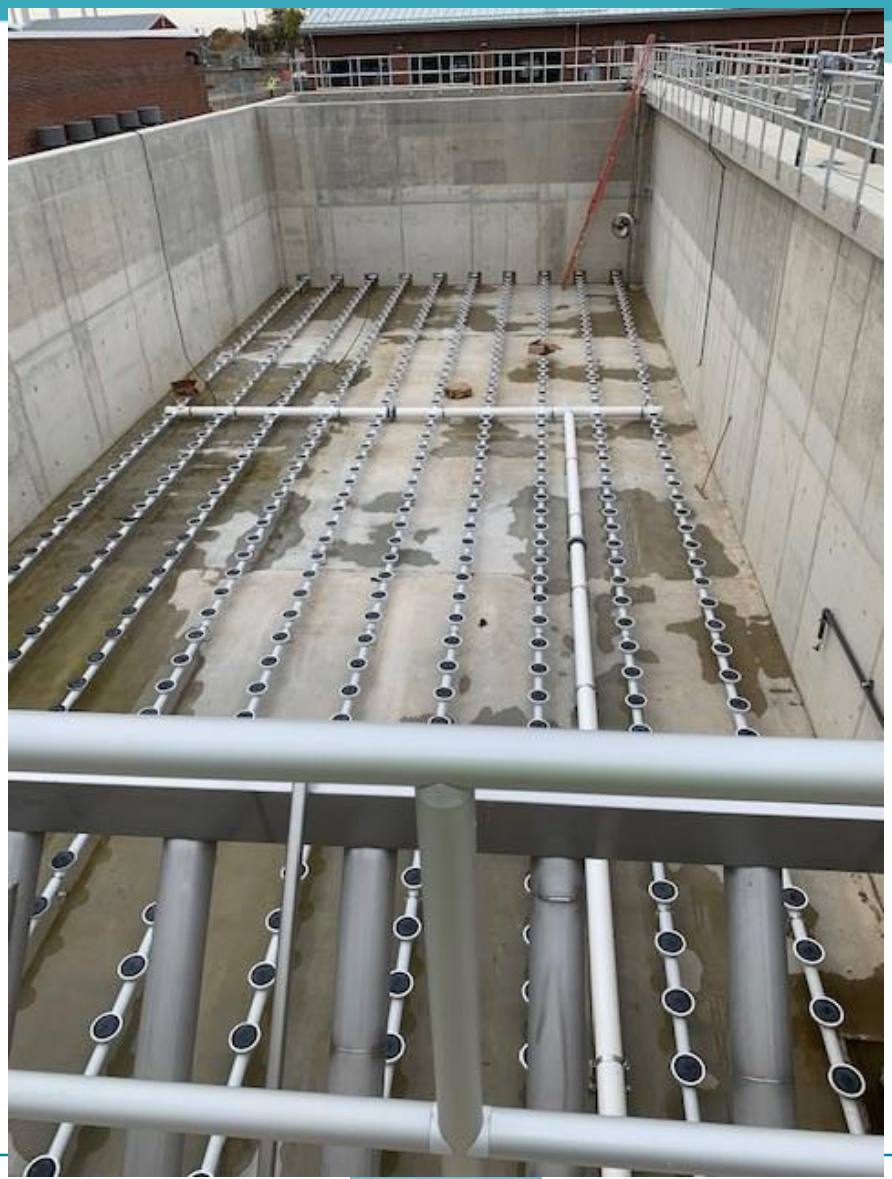

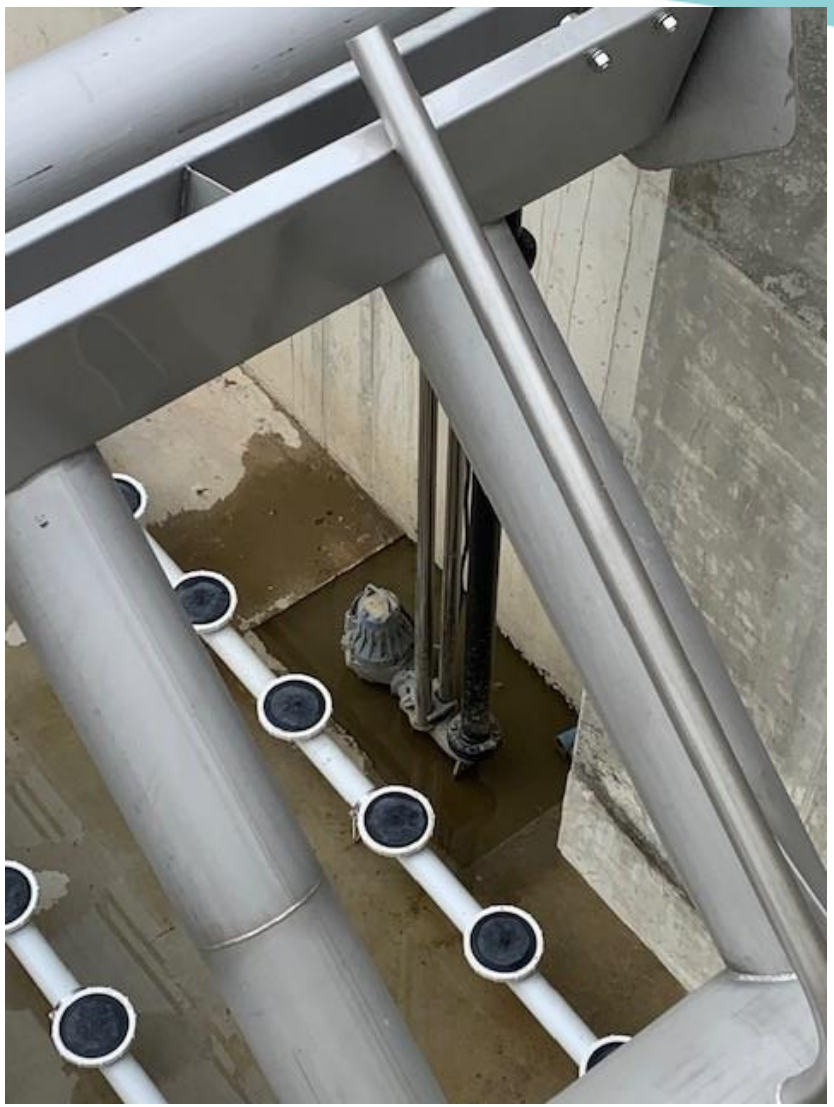

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Eldorado, OH

Eldorado Design Overview

Influent Conditions

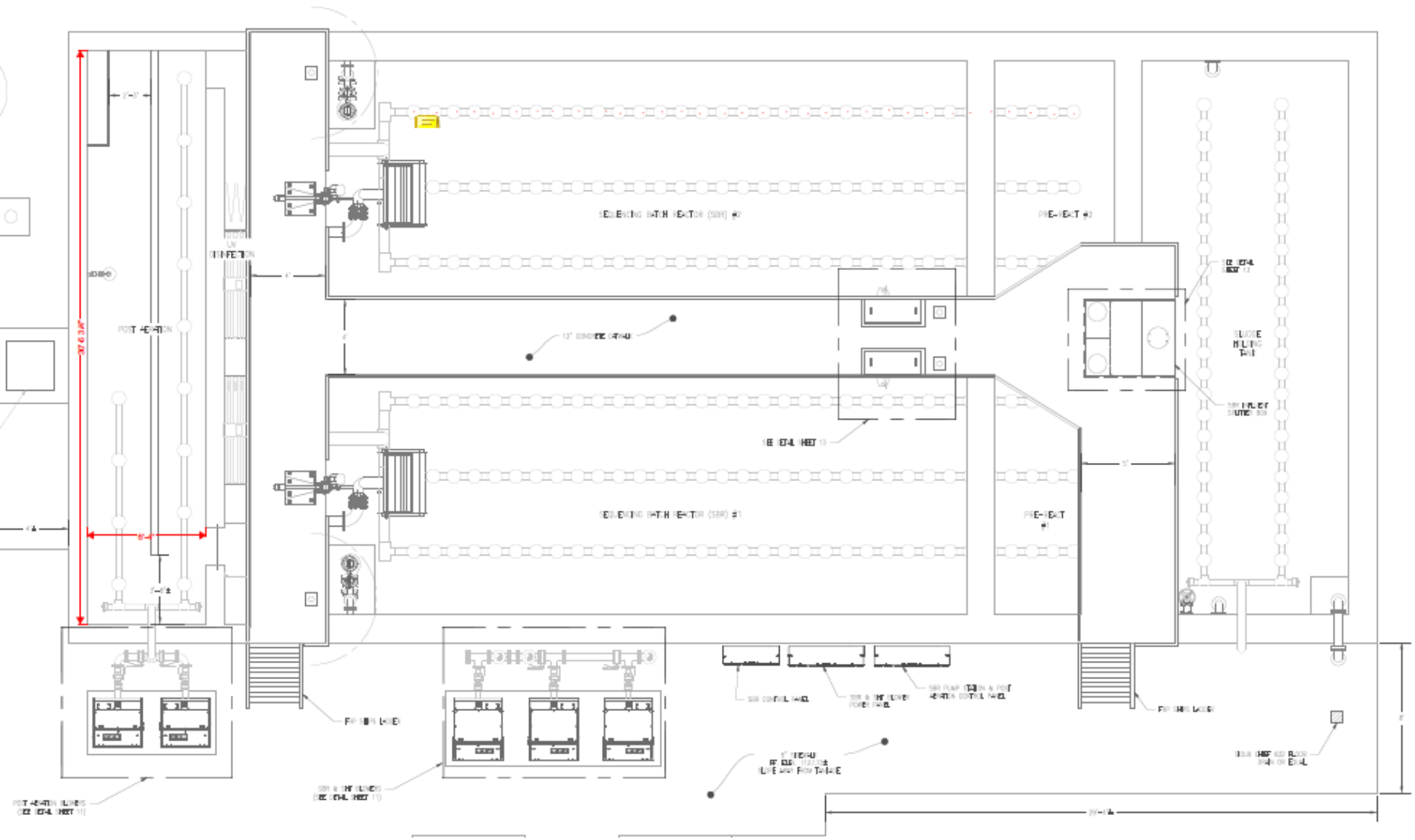
- Design Flow: 100,000 gpd
- Peak wet weather flow – 775,000 gpd

Effluent Conditions

- BOD: 10 mg/L
- TSS: 12 mg/L
- Ammonia (Summer): 1 mg/L

Equipment

- Two (2) 14‘ x 42‘ x 15‘ TWL tanks
- Two (2) 10 HP PD blowers
- Two (2) 4 HP submersible mixers
- Two (2) 2.4 HP WAS pumps



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Let’s solve water