Implementing & Optimizing Nitrogen Removal at Activated Sludge Wastewater Treatment Plants

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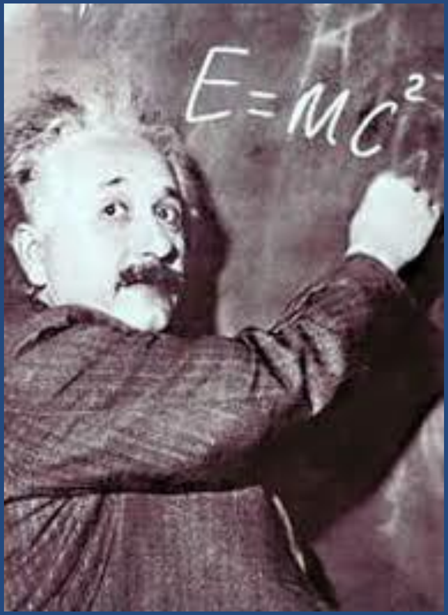
The Water Planet Company

www.cleanwaterops.com

Implementing/Optimizing N-Removal at Activated Sludge wastewater treatment plants



<u>Upcoming Webinars</u>

Phosphorus Removal in Activated Sludge – February 18th

P&N Removal in Activated Sludge – March 2014

Sequenced Aeration – April 2014

N&P Removal in Oxidation Ditches – May 2014

Trickling Filter Operations – June 2014

<u>Today's Webinar</u>

Habitats

Nitrogen Removal in SBR & MLE Plants

Modify Operations to Create the Right Habitats

Monitor & Optimize

Comments, Questions & Answers

Making the Treatment Plant a Good Home for the Bacteria that Live there

To optimize biological nitrogen removal, wastewater treatment plant operators need to provide bacteria with the habitats they like best.

Knowing a bit about technology…

And, being willing to experiment…

It isn't all that difficult to make most any treatment plant provide better Nitrogen Removal.

Biological Nitrogen Removal:
First, Ammonia (NH_4) is converted to Nitrate (NO_3)

Oxygen Rich Habitat

MLSS* of 2500+ mg/L (High Sludge Age / MCRT / low F:M)

ORP* of +100 to +150 mV (High DO)

Time* (high HRT … 24 hr, 12 hr, 6 hr, 4 hr)

Low BOD

Consumes Oxygen

Adds acid - Consumes 7 mg/L alkalinity per mg/L of $NH_4 \rightarrow NO_3$

*Approximate, each facility is different.

Biological Nitrogen Removal: Next, Nitrate (NO_3) is converted to Nitrogen Gas (N_2)

Oxygen Poor Habitat

ORP* of -100 mV or less (DO < 0.3 mg/L)

Surplus BOD* (100-250 mg/L: 5-10 times as much as NO_3)

Retention Time* of 45-90 minutes

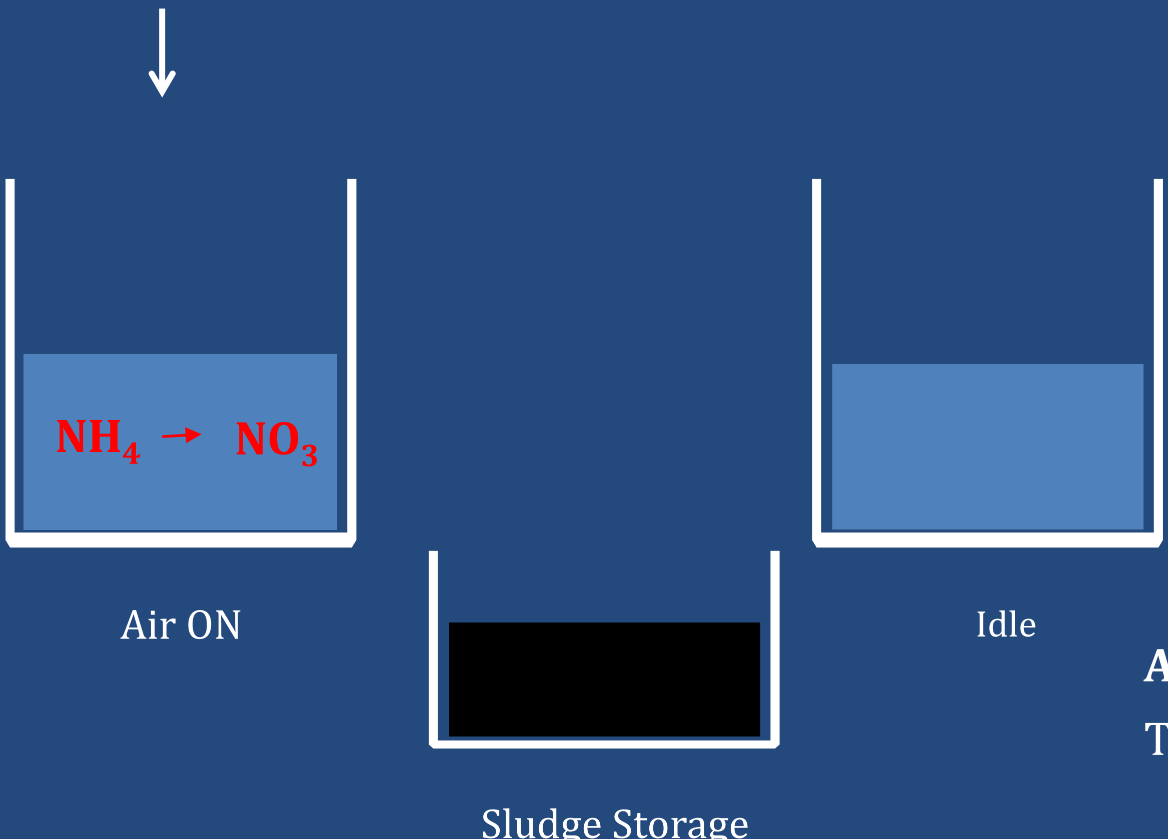
Gives back Oxygen

Gives back Alkalinity (3.5 mg/L per mg/L of $NO_3 \rightarrow N_2$)

*Approximate, each facility is different.

Nitrogen Removal in an SBR, Sequencing Batch Reactor

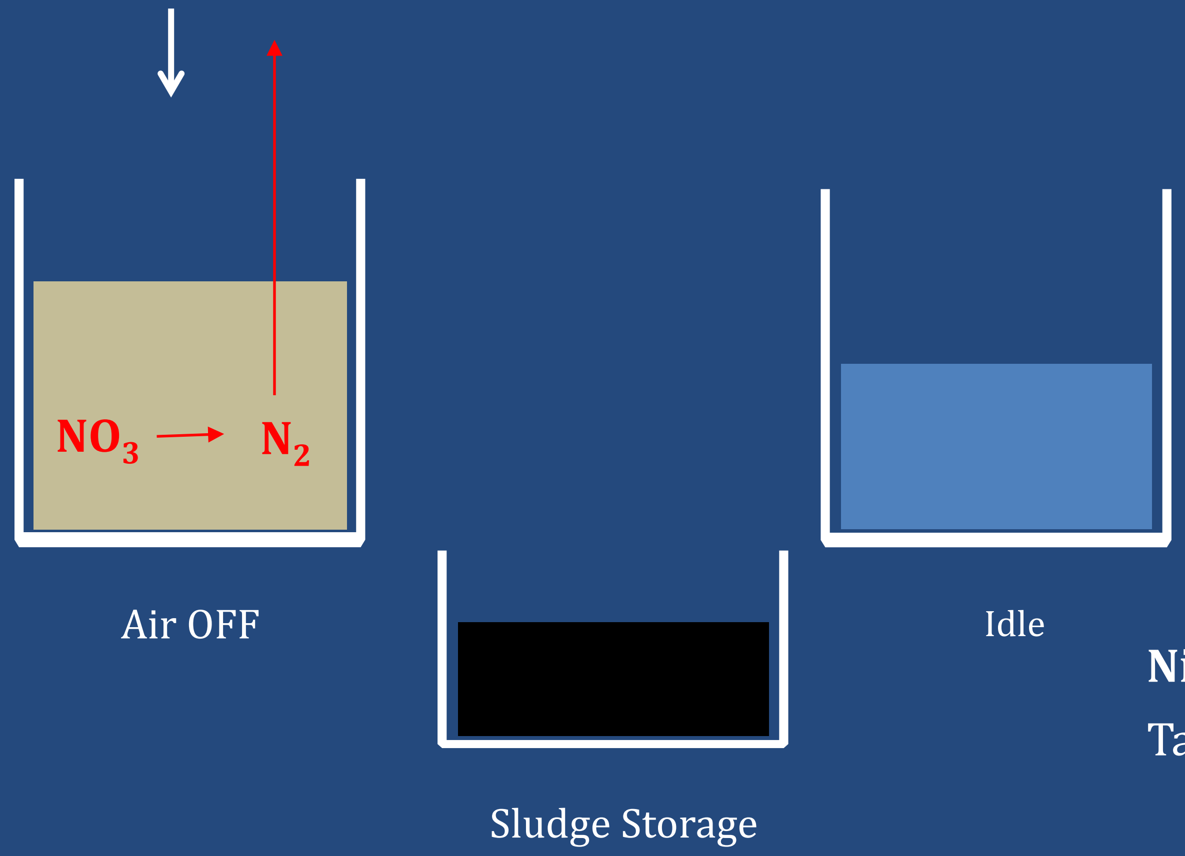
Sequencing Batch Reactor (SBR)
Ammonia (NH_4) Removal: Nitrification



Ammonia (NH_4) Removal

Target: $NH_4 < 0.5$ mg/L

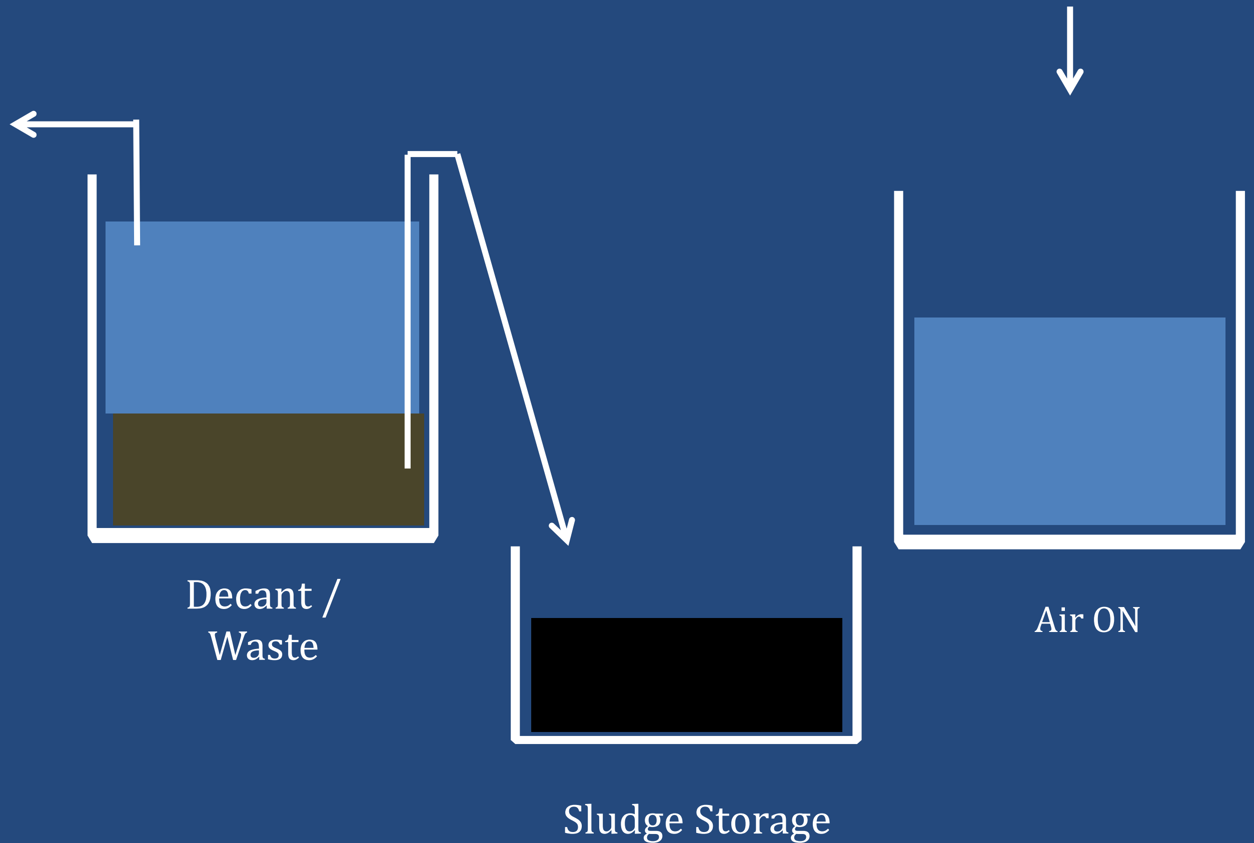
Sequencing Batch Reactor (SBR)
Nitrate (NO_3) Removal: Denitrification



Nitrate (NO_3) Removal

Target: $NO_3 < 4$ mg/L

Sequencing Batch Reactor (SBR)
Settle, Decant & Waste Sludge



SBR Process Control:

Establish cycle times that are long enough to provide optimal habitats.

And, short enough to allow all of the flow to be nitrified and denitrified.

Optimizing SBR cycle time

Too short

Will not reach +100 mV for Ammonia (NH_4) Removal.

Will not reach -100 mV for Nitrate (NO_3) Removal.

Note: Temperature and BOD affect Air OFF cycle.

Too long

Wastewater will pass through tank before all Ammonia (NH_4) converted to Nitrate (NO_3).

And, before all Nitrate (NO_3) is converted to Nitrogen Gas (N_2).

Just right

Good habitats …

ORP of +100 mV for 60 minutes

And, ORP of -100 mV for 30 minutes.

Bonus: Changing conditions will serve as a selector.

Nitrogen Removal:
MLE (Modified Ludzack-Ettinger) Process

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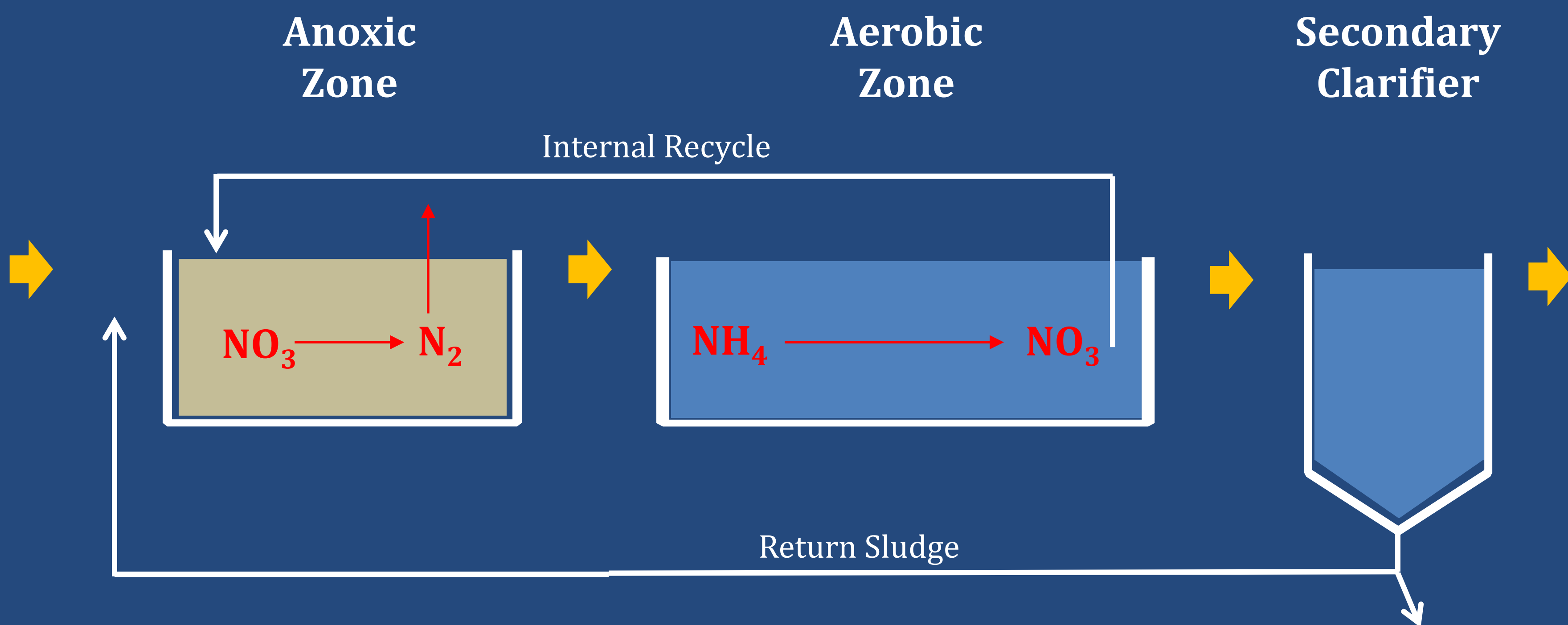


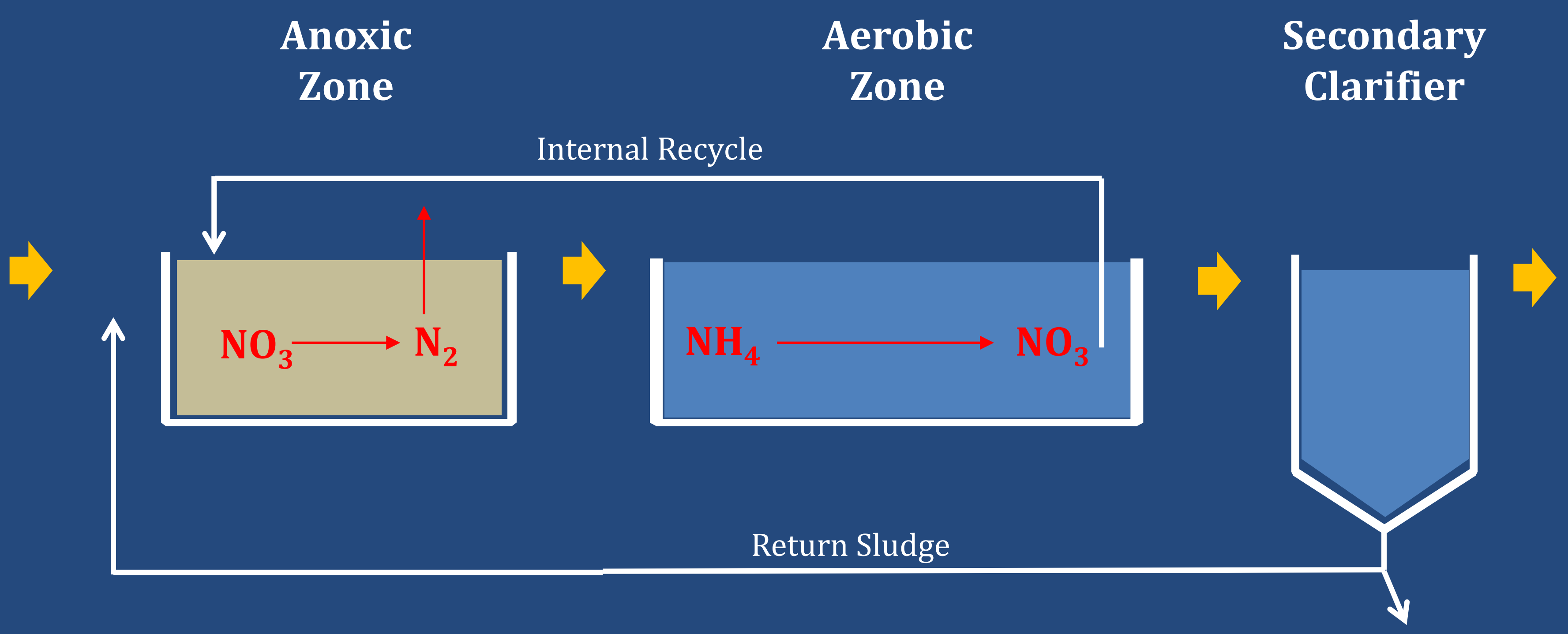
Ammonia (NH_4) Removal

Target: $NH_4 < 0.5$ mg/L

Nitrate (NO_3) Removal

Target NO_3 in Anoxic Tank: 0.5-2 mg/L

MLE (Modified Ludzack-Ettinger) Process



MLE Process Control:

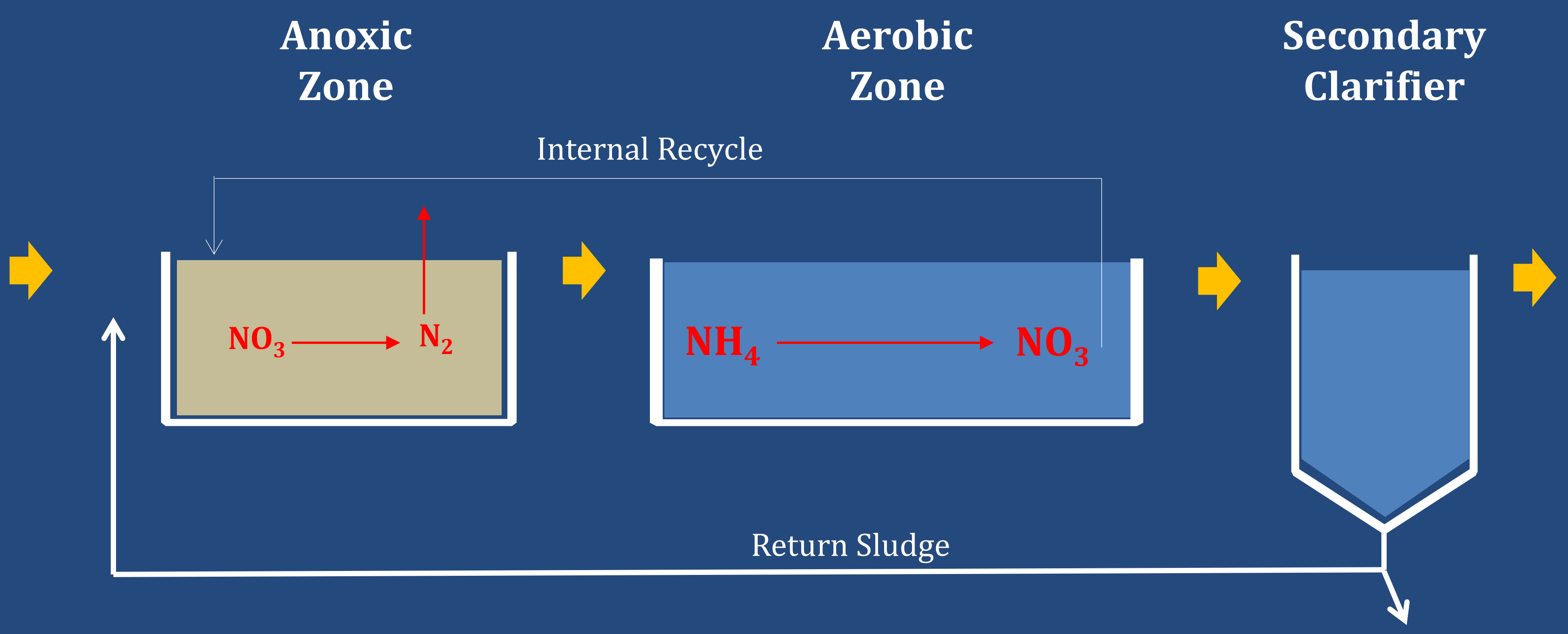
Proper Internal Recycle Rate; not too much / not too little.

ORP of +100 mV in Aerobic Zone for Ammonia (NH_4) Removal.

ORP of -75 to -150 mV in Anoxic Zone for Nitrate (NO_3) Removal.

Enough BOD to support Nitrate (NO_3) Removal.

MLE with not enough Internal Recycle



Ammonia (NH_4) Removal

Excellent Aerobic Habitat: ORP +150 mV

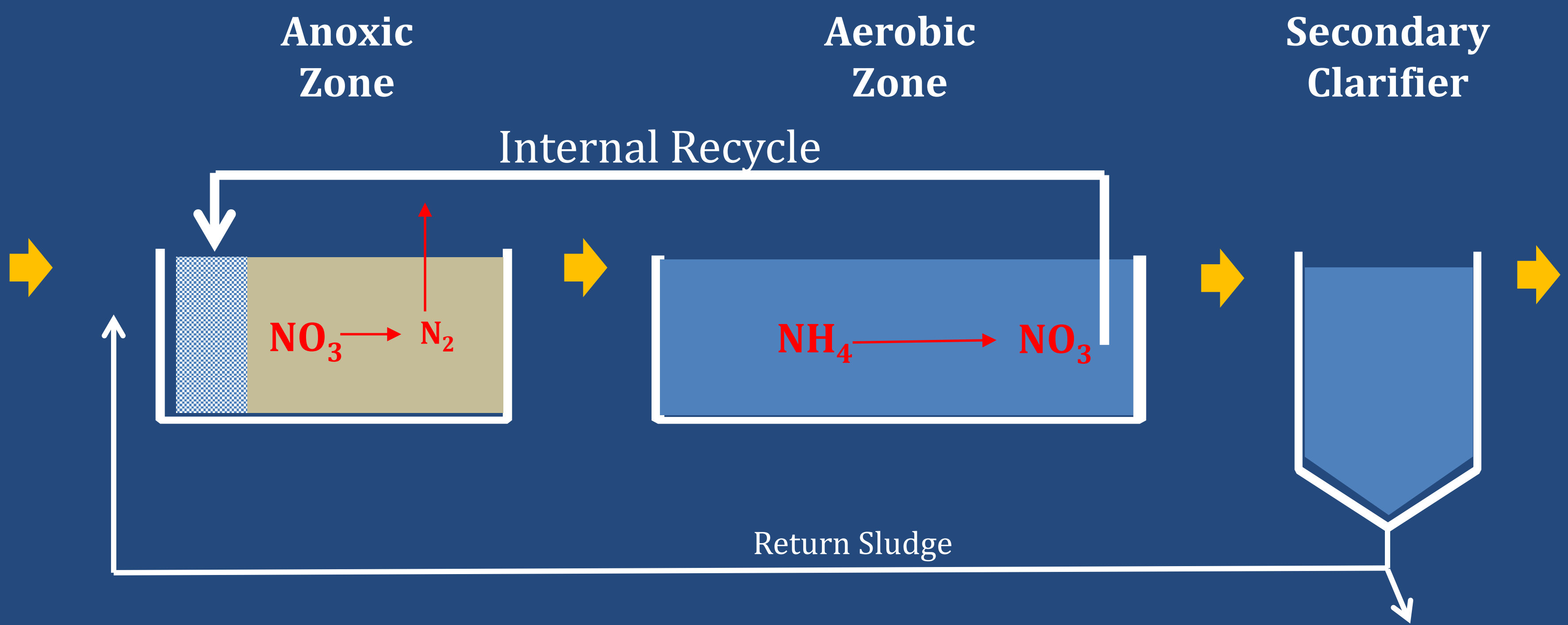
$NH_4 < 0.5$ mg/L

Nitrate (NO_3) Removal

Great Anoxic Habitat: ORP -150 mV or lower

$NO_3 > 4$ mg/L because too little NO_3 is returned to Anoxic Zone

MLE with too much Internal Recycle



Ammonia (NH_4) Removal

Good Aerobic Habitat: ORP +100 mV

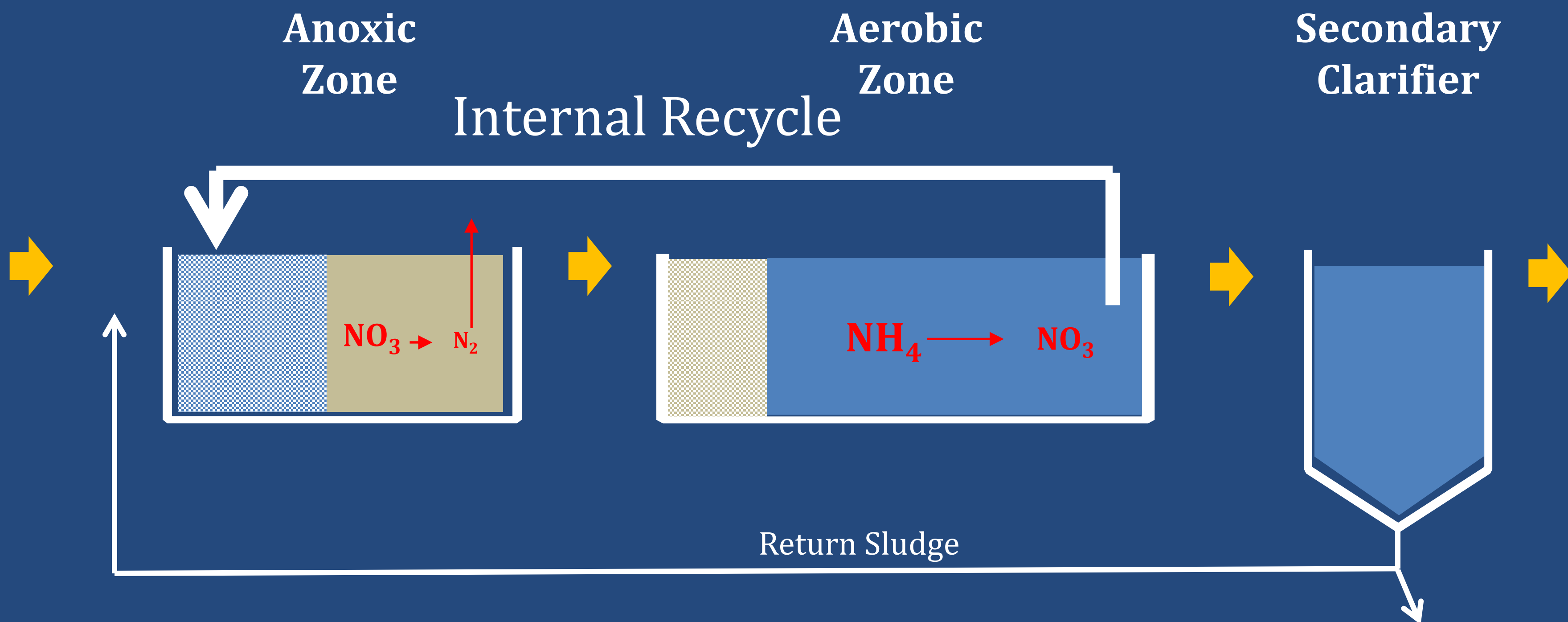
NH_4 < 0.5 mg/L

Nitrate (NO_3) Removal

Stressed Anoxic Habitat: ORP 0 to -100 mV

NO_3 > 4 mg/L: bacteria will not convert Ammonia (NH_4) to Nitrate (NO_3)

MLE with way too much Internal Recycle



Ammonia (NH_4) Removal

Poor Aerobic Habitat: ORP +50 mV

$NH_4 > 0.5$ mg/L

Nitrate (NO_3) Removal

Poor Anoxic Habitat: ORP 0 mV or higher

$NO_3 > 4$ mg/L


BACKGROUND
INFORMATION


COMPLETED

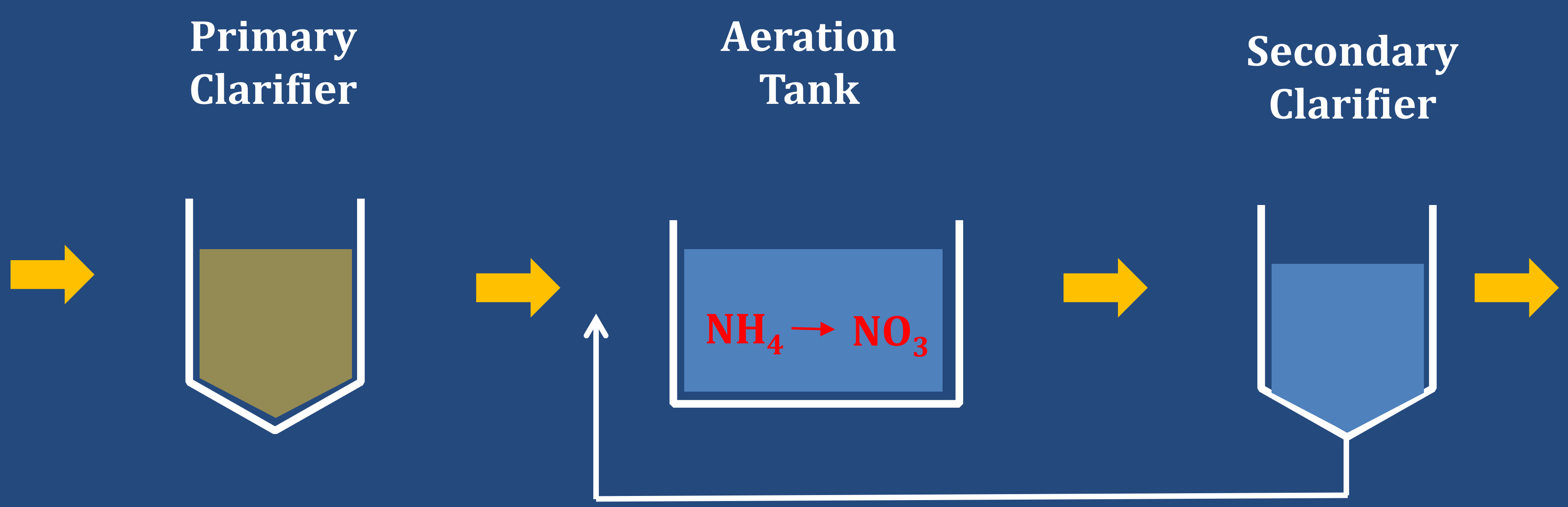
Experimenting with YOUR plant:
Finding the “Right” Process Control Strategy

… and, Optimizing Nitrogen Removal

Step 1

Optimize Ammonia (NH_4) Removal

Conventional Activated Sludge Plant



Ammonia (NH_4) Removal

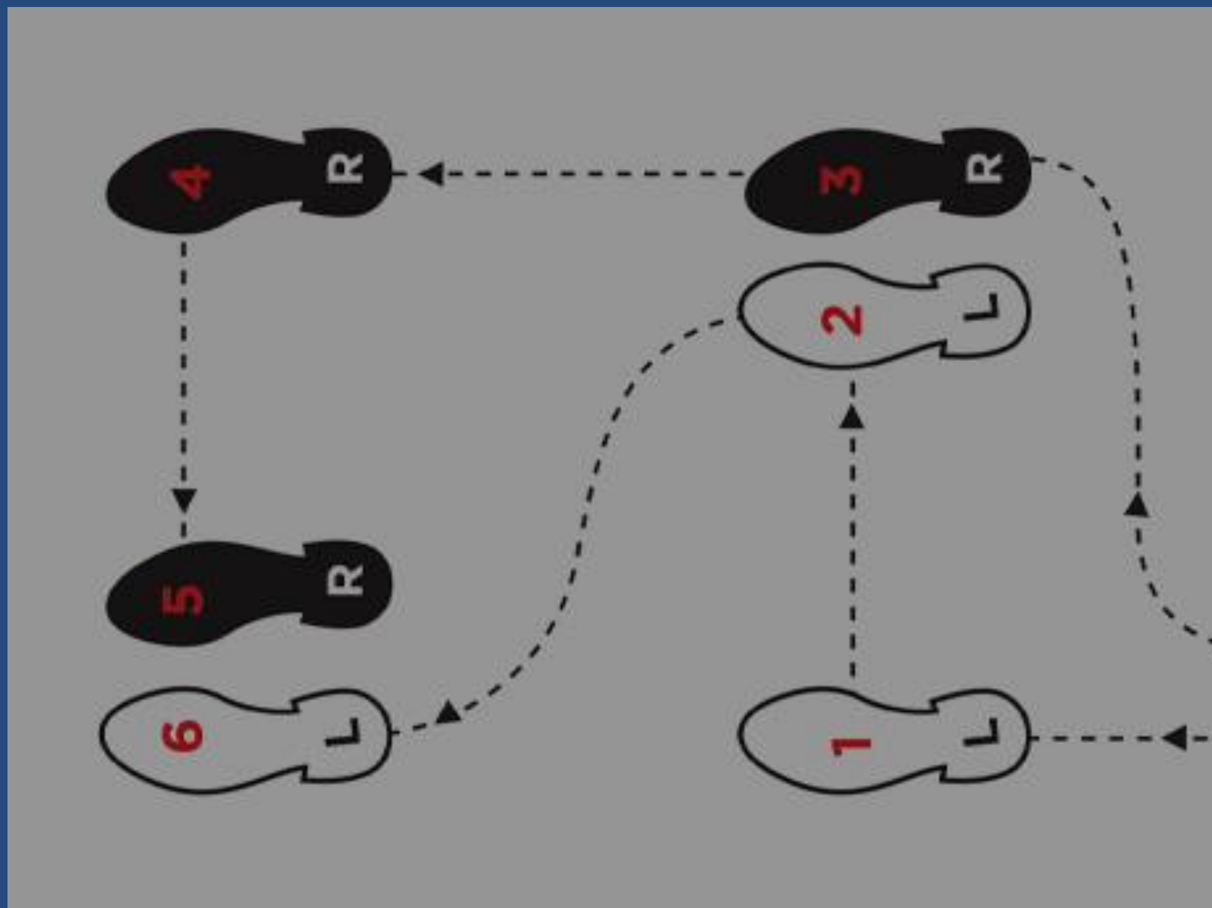
Target: less than 0.5 mg/L

Raise mixed liquor
... the higher the better for N-Removal.

Keep ORP at +100 mV (or higher) by adjusting DO settings until ...
... enough DO & ORP to reduce NH_4 to 0.5 mg/L ...
... but not so much as to move too much DO into Anoxic or waste electricity.

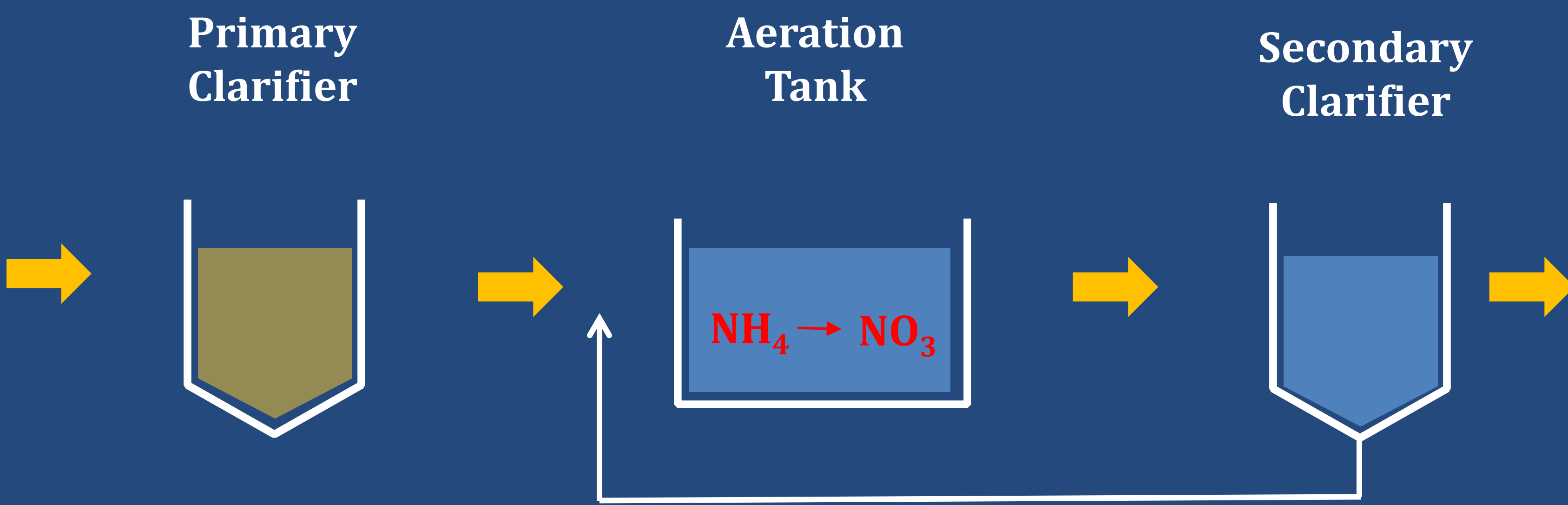
Warning: pH and Nitrite (NO_2)

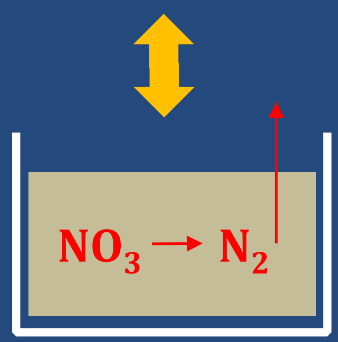
Step 2: Optimize Nitrate (NO_3) Removal



Operate Aeration Tank as SBR

Conventional Activated Sludge operated as SBR





Maintain Ammonia (NH_4) Removal

Target: $NH_4 < 0.5$ mg/L

ORP: +100 mV long enough (60 minutes)

Nitrate (NO_3) Removal

Target: $NO_3 < 4$ mg/L

ORP: -100 mV long enough (30 minutes)

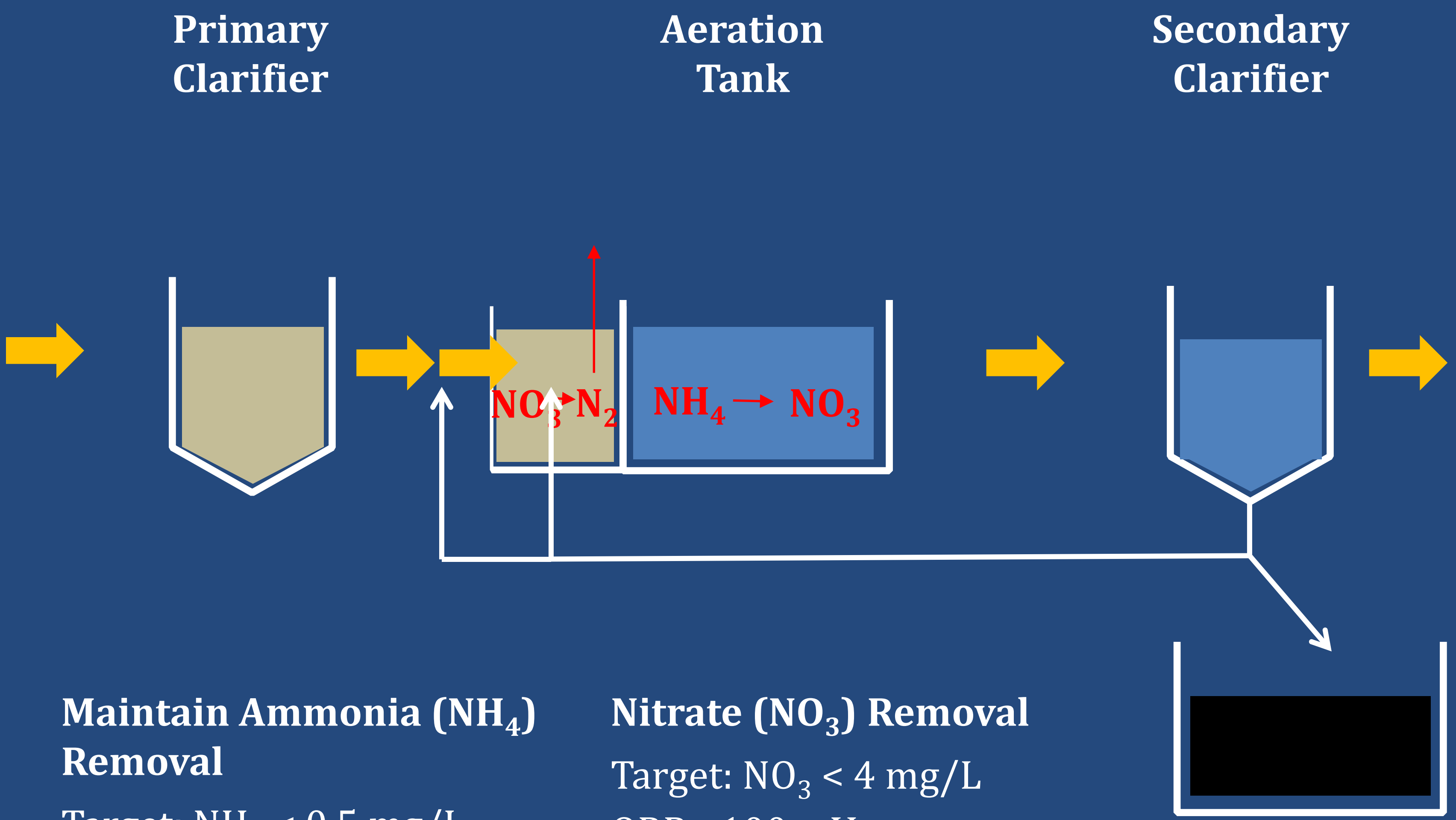
If habitats are good and NO_3 remains high, likely not enough BOD.

Search for additional BOD.

Cycle air ON to remove NH_4 & OFF to remove NO_3

Use ORP to adjust AirON/AirOFF times

Operate Aeration Tank as MLE



Maintain Ammonia (NH_4) Removal

Target: $NH_4 < 0.5$ mg/L

ORP: +100 mV

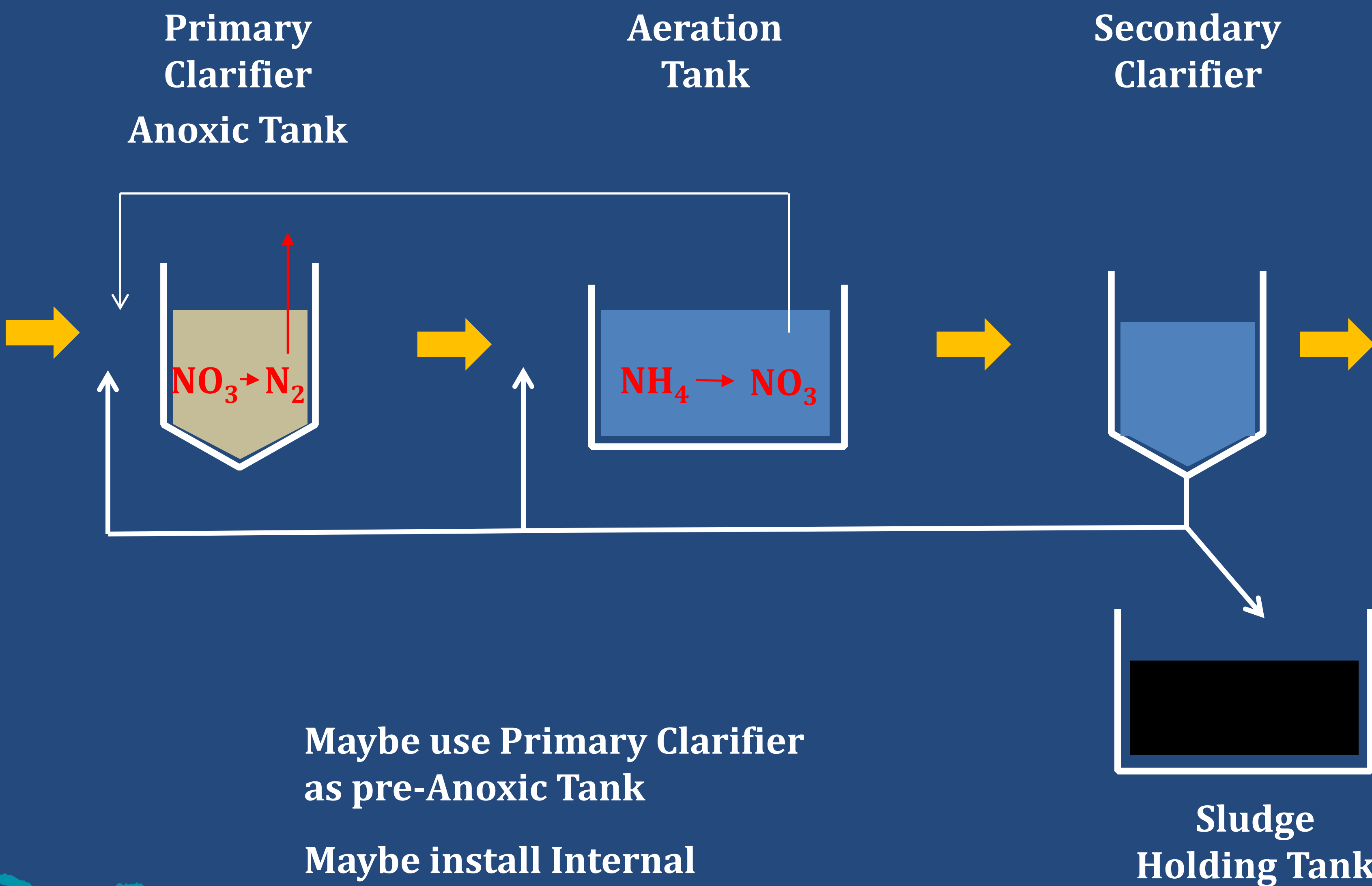
Nitrate (NO_3) Removal

Target: $NO_3 < 4$ mg/L

ORP: -100 mV

Unless RAS can be increased to 200% or more, NO_3 target of 4 mg/L will be hard to achieve

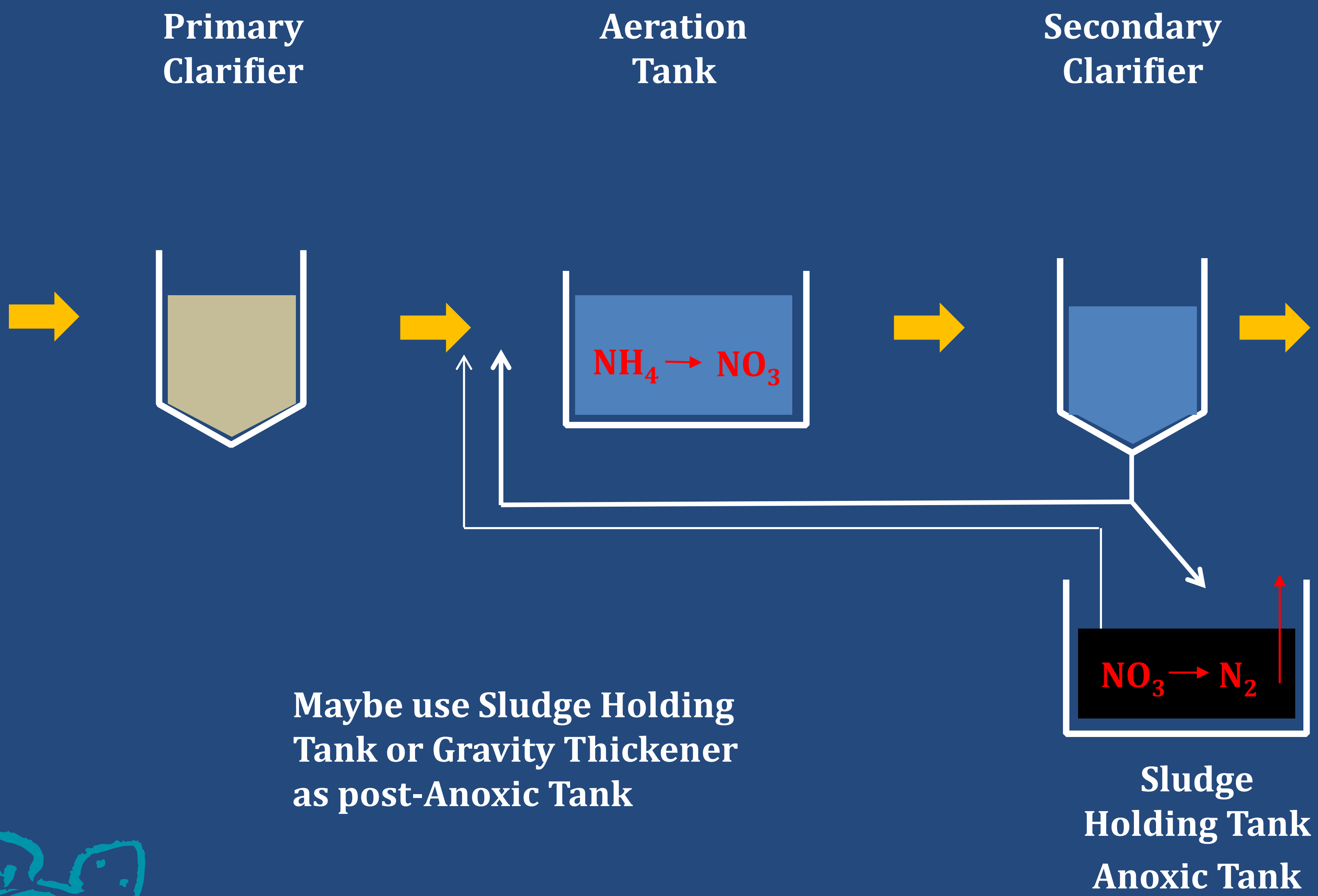
MLE Process Modification of Conventional AS Plant



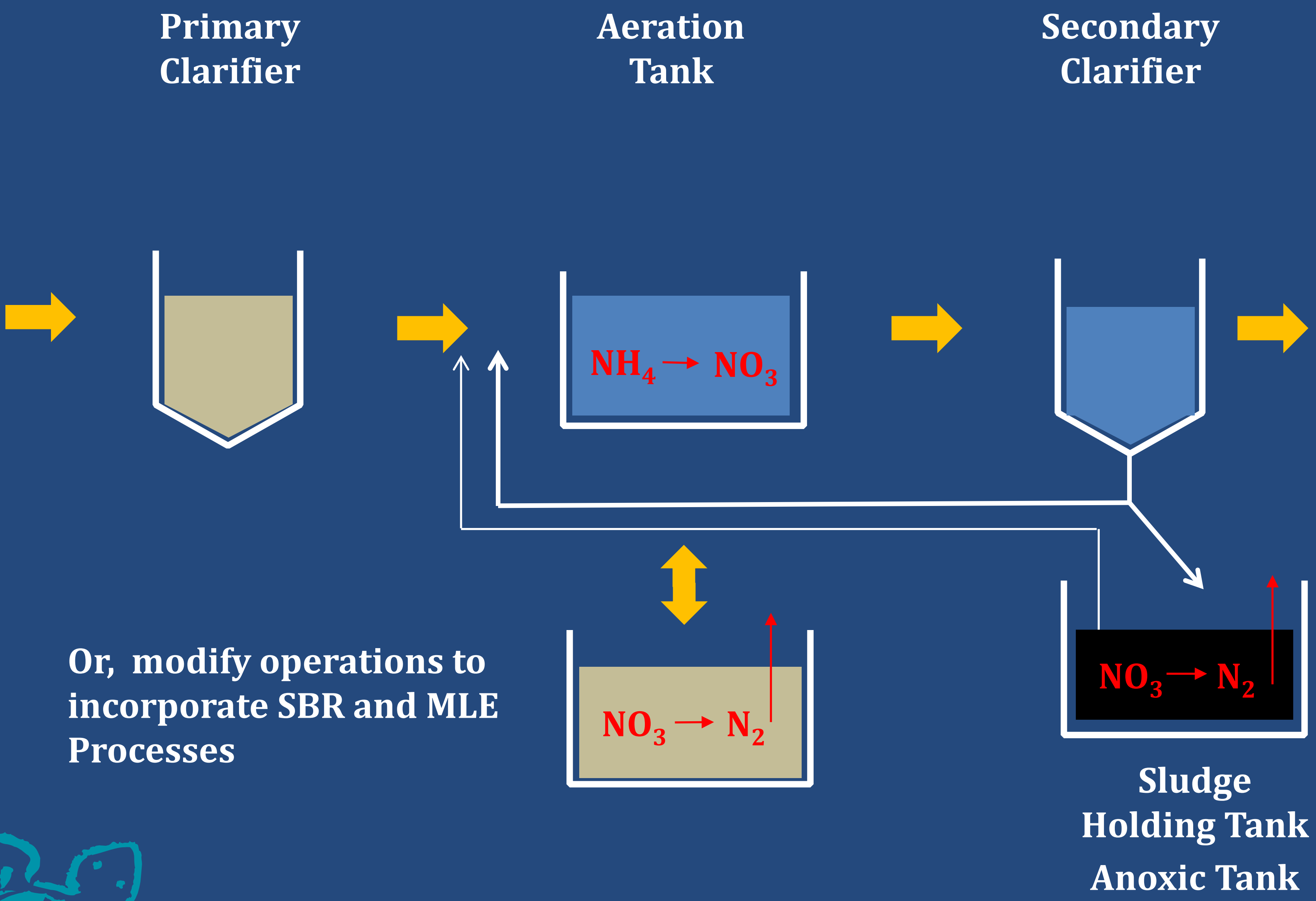
Maybe use Primary Clarifier as pre-Anoxic Tank

Maybe install Internal Recycle Pump(s)

MLE Process Modification of Conventional AS Plant



MLE Process Modification of Conventional AS Plant



MLE & SBR Modification of Conventional AS Plant

Monitor and Control the Process

Review and Analyze Data every day

- Maintain Optimized Habitats
- Monitor Treatment Efficiency

Be Prepared to make Process Changes every day

- Preemptive changes to keep Habitats Ideal
- Reactive changes to meet Treatment Requirements

Summary

Operational changes allow many (most) Activated Sludge Plants to remove nitrogen.

Provided alkalinity exists, first optimize Ammonia (NH_4) removal …

Dial in MLSS, DO/ORP

Maintain Ammonia (NH_4) removal while optimizing Nitrate (NO_3) removal …

Dial in ORP and look for sources of BOD

Keep an eye on effluent Nitrite (NO_2); > 0.5 mg/L is a problem.

Monitor and Adjust DAILY for the rest of your life!

THE WATER PLANET COMPANY

Making clean water affordable

Thank You!

g.weaver@cleanwaterops.com

<u>Upcoming Webinars</u>

11 AM EST February 18th: Activated Sludge Phosphorus Removal

March ‘14: Activated Sludge N&P Removal

April ‘14: Sequenced Aeration, an Innovative/Effective Process Design

May ‘14: N&P Removal in Oxidation Ditches

June ‘14: Trickling Filter Operations