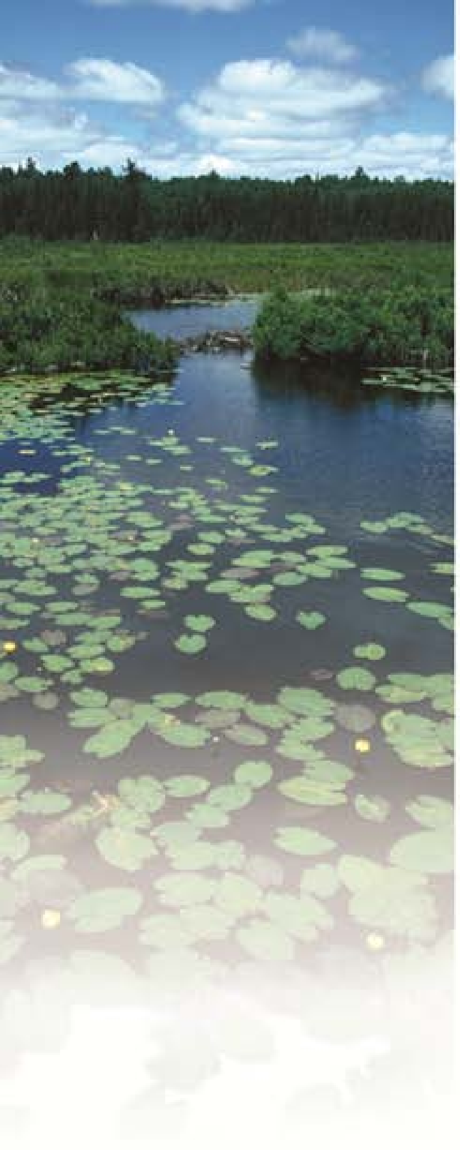

Sustainable Approaches to Meeting Potential Future Nutrient Limits – Part 2

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OWEA Annual Conference
23 June 2011

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Presentation Outline

- Why Remove Nutrients?
- Overview of Wastewater Treatment
- Nutrient Removal
  - Phosphorus Removal
  - Nitrogen Removal
- Sustainability Perspective
- Design & Operational Considerations
- Take Home Messages

Part 1

Part 2

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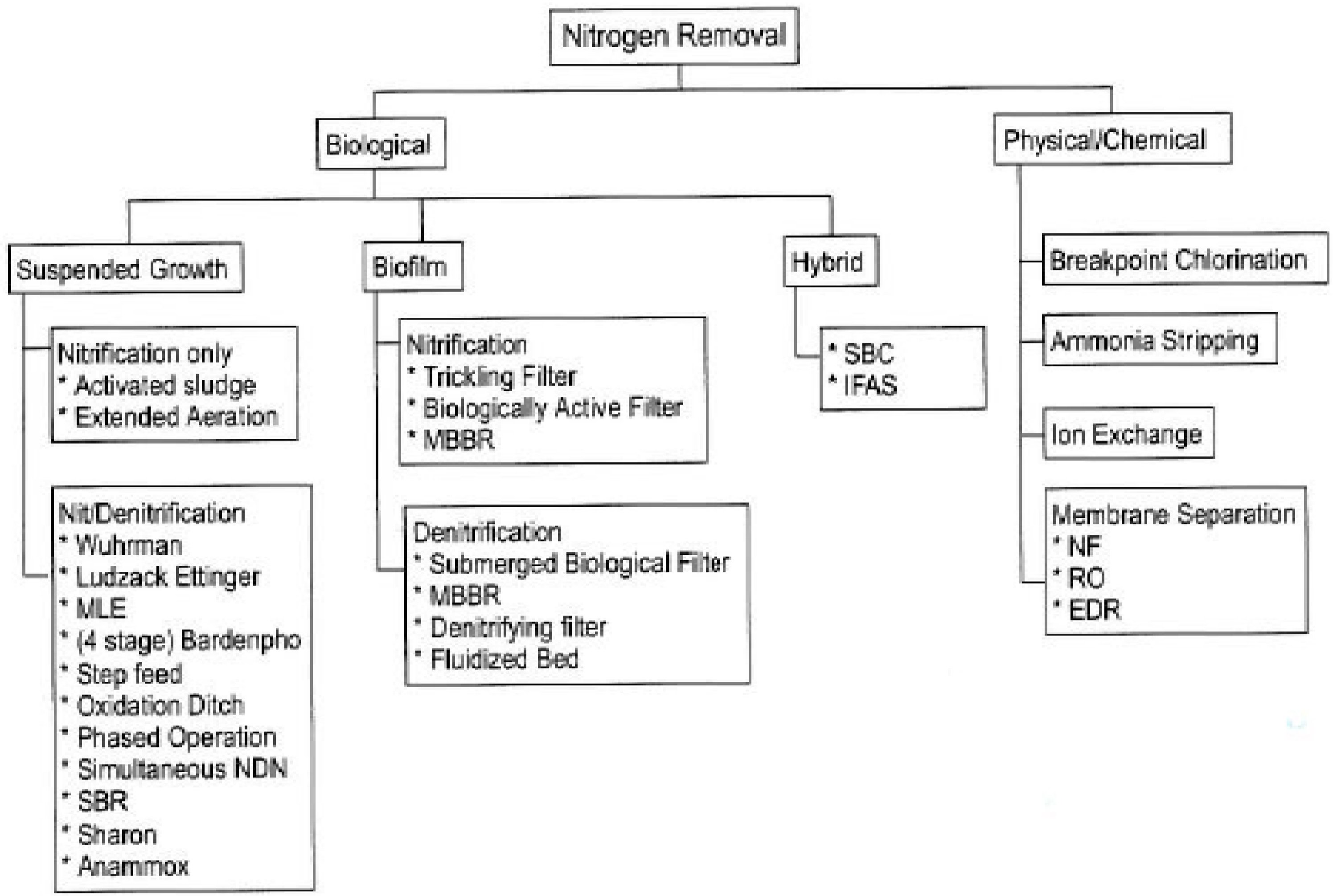
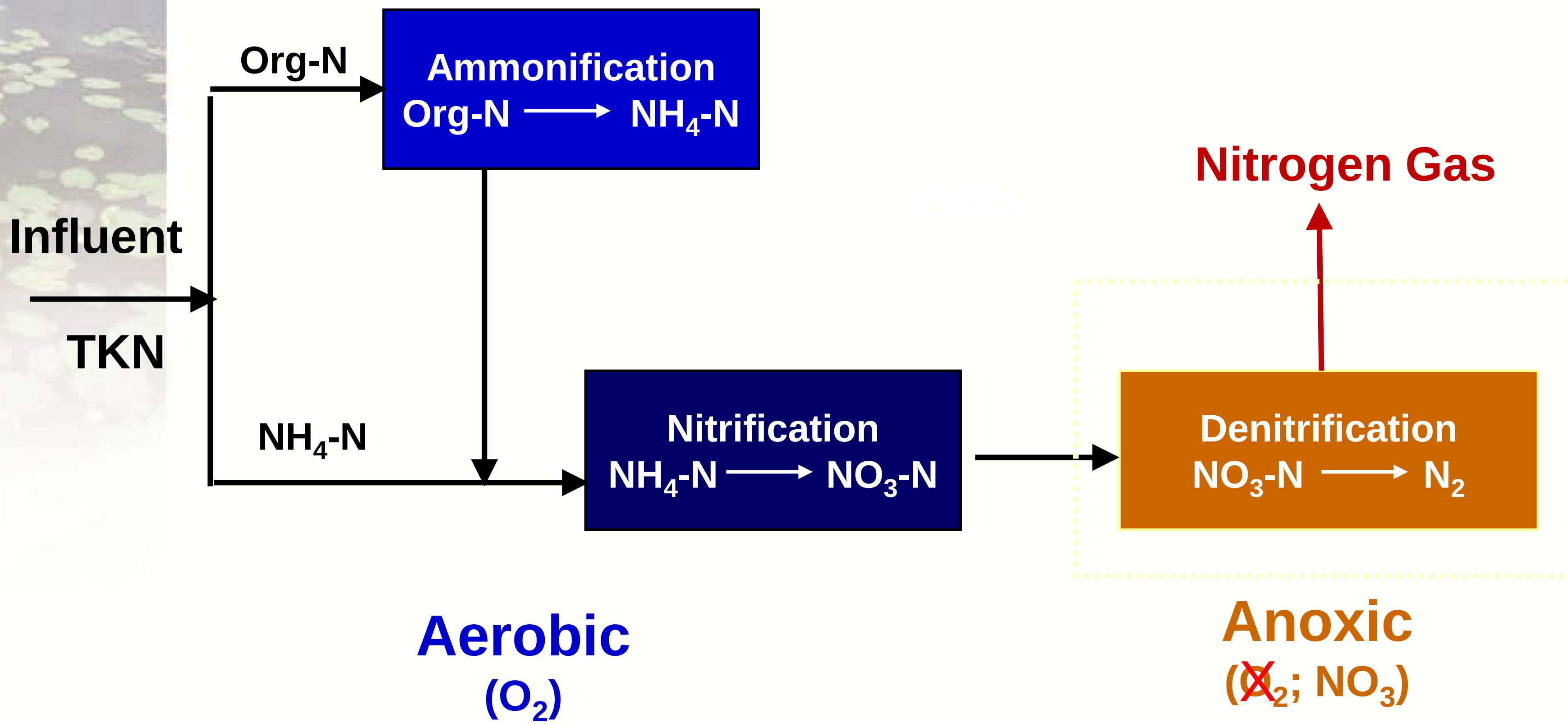
Nitrogen Removal Alternatives



Nitrogen Removal Processes



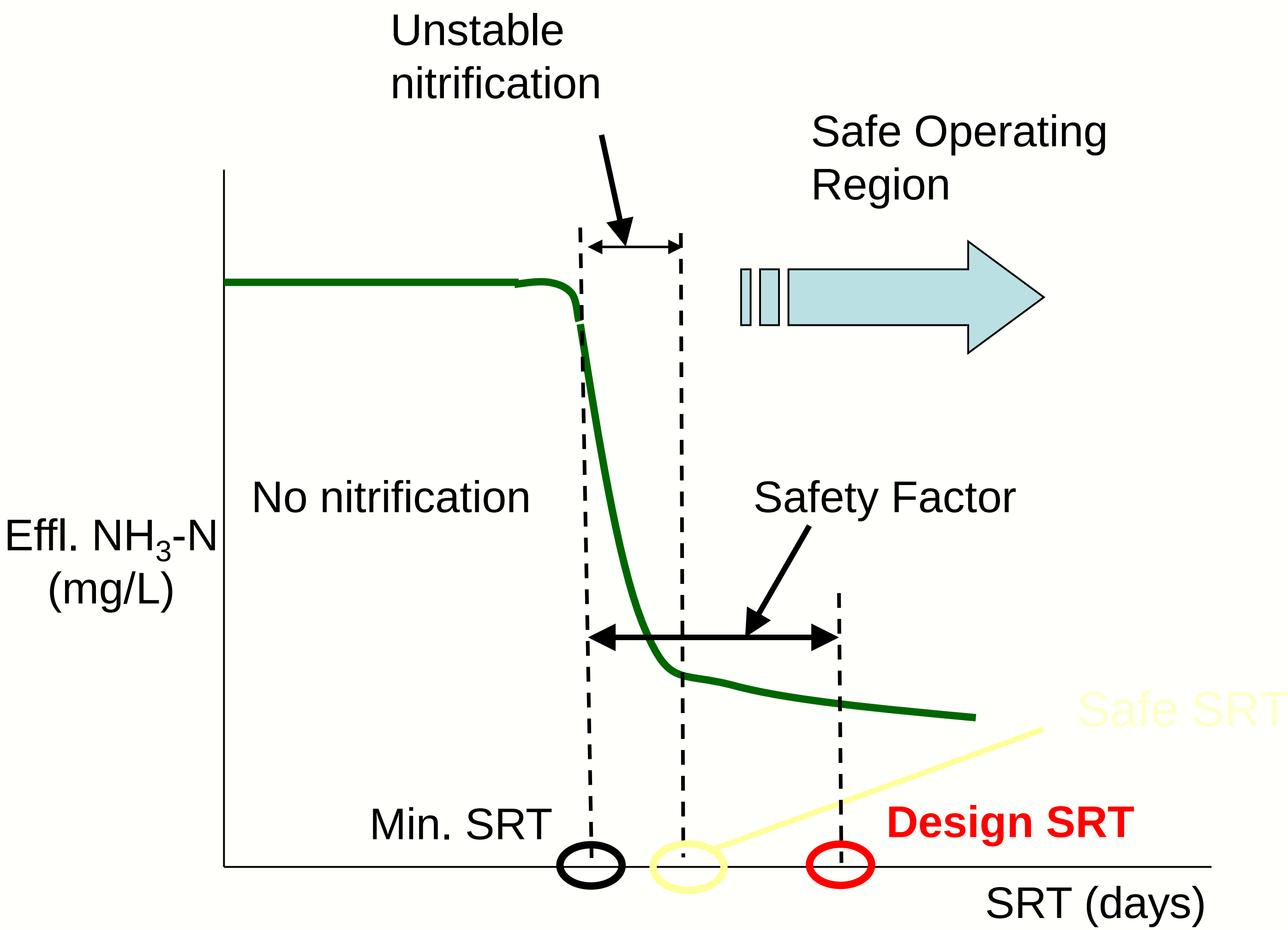
Nitrification

- Mediated by *Autotrophs*
- Conversion (oxidation) of ammonia to nitrate
- Does not result in significant nitrogen removal

Factors that impact nitrification

- Solids Retention Time (SRT)
- pH (Optimum: 6.5 - 8.0)
- DO (Optimum: 1.0 – 2.0 mg/L)
- Absence of inhibitory compounds
- Recycle load

Adequate SRT is Crucial for Reliable Nitrification



Denitrification

- Denitrification: Conversion (reduction) of nitrate to nitrogen gas

$$NO_3 \rightarrow N_2\ (g)$$

- Facultative heterotrophic organisms
- Results in nitrogen removal

Factors impacting denitrification

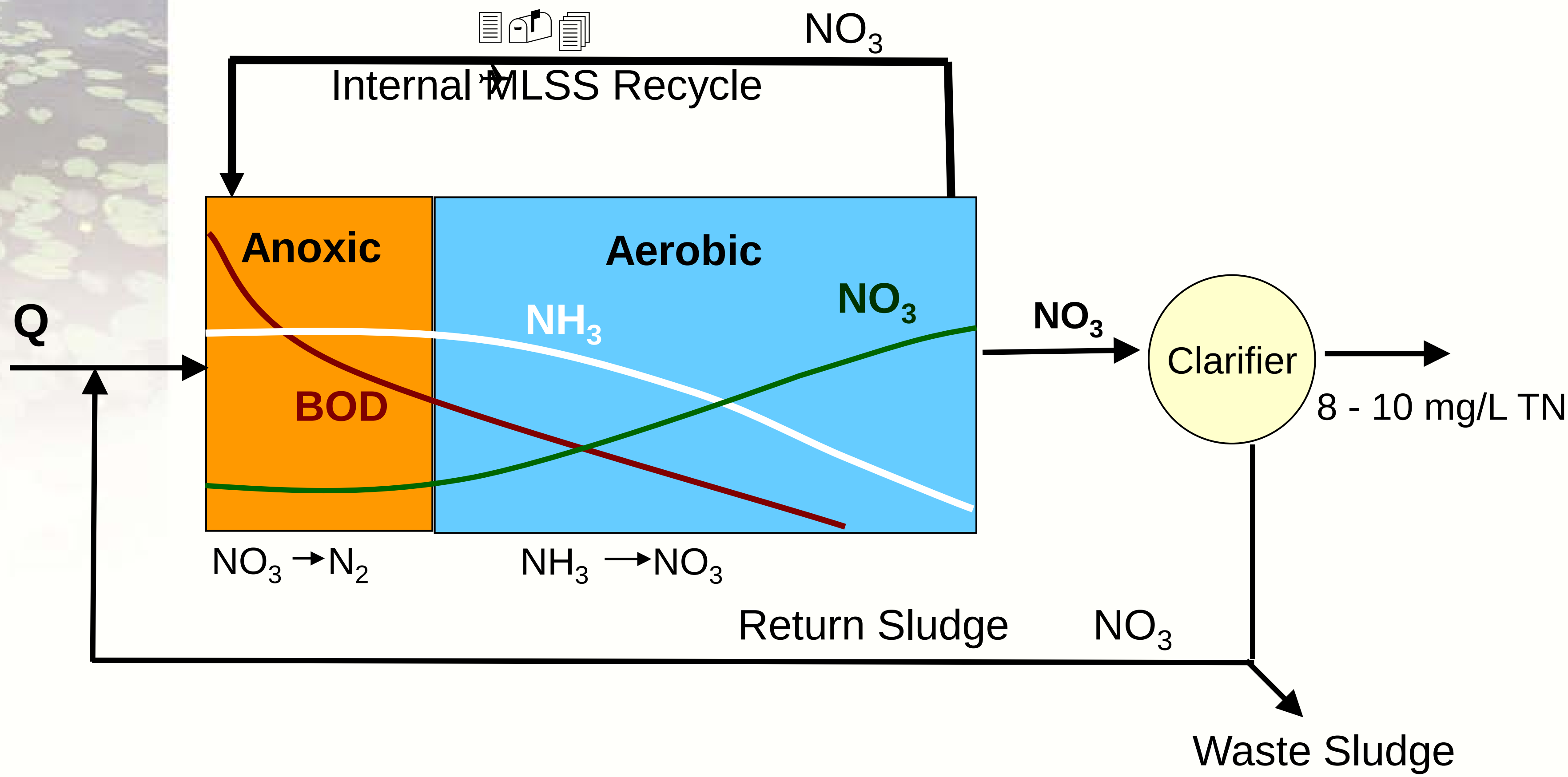
- Anoxic condition (Sufficient NO_3)
- Carbon source
- Adequate anoxic SRT
- Temperature

Nitrification vs. Denitrification

Factor	Nitrification	Denitrification
Environment	Aerobic	Anoxic
Oxygen source (Electron Acceptor)	Dissolved oxygen (DO)	Combined Oxygen (NO_3)
Type of Organism	Autotrophs	Heterotrophs
Energy (food) source Electron Donner)	Ammonia-N	Organic Matter
Carbon Source	Organic Matter	Inorganic (CO_2)
Oxygen	Demand (4.6 lb O_2 / lb NH_4 oxidized)	Credit (2.9 lb O_2 / lb NO_3 reduced)
Alkalinity (as $CaCO_3$)	Consumed (7.1 lb /lb NH_4 oxidized)	Produced (3.6 lb /lb NO_3 reduced)

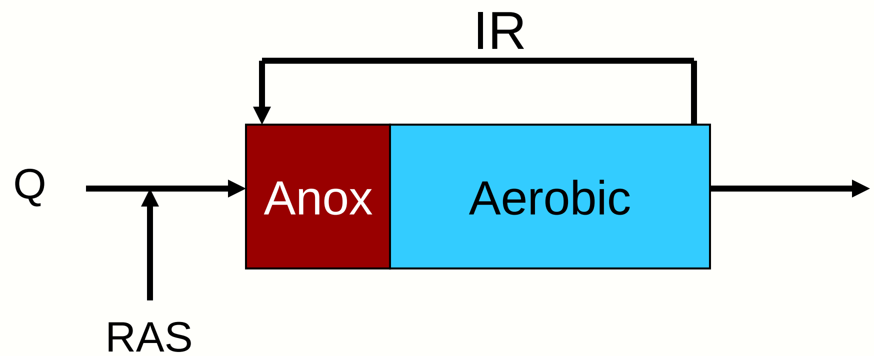
How is Nitrogen Removal Achieved in Practice?

Modified Ludzack-Ettinger (MLE) Process

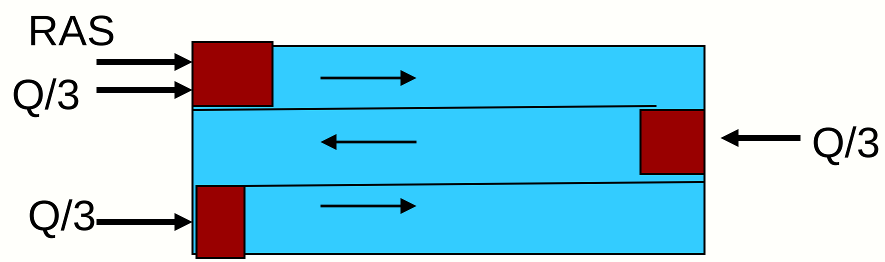


Nitrogen Removal Capability of Various Processes

MLE Process
TN = 8 - 10 mg/L

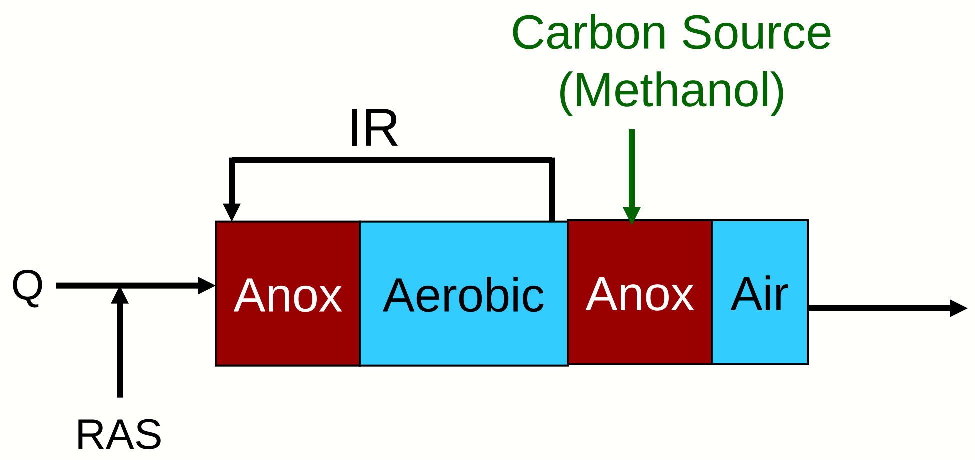


Step-Feed
TN = 8-10 mg/L

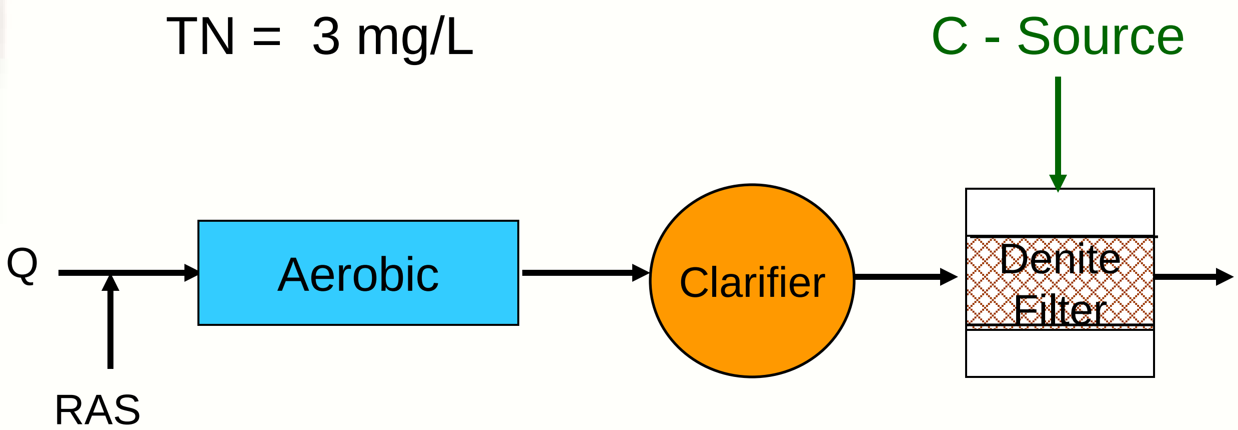


Nitrogen Removal Capability of Various Processes

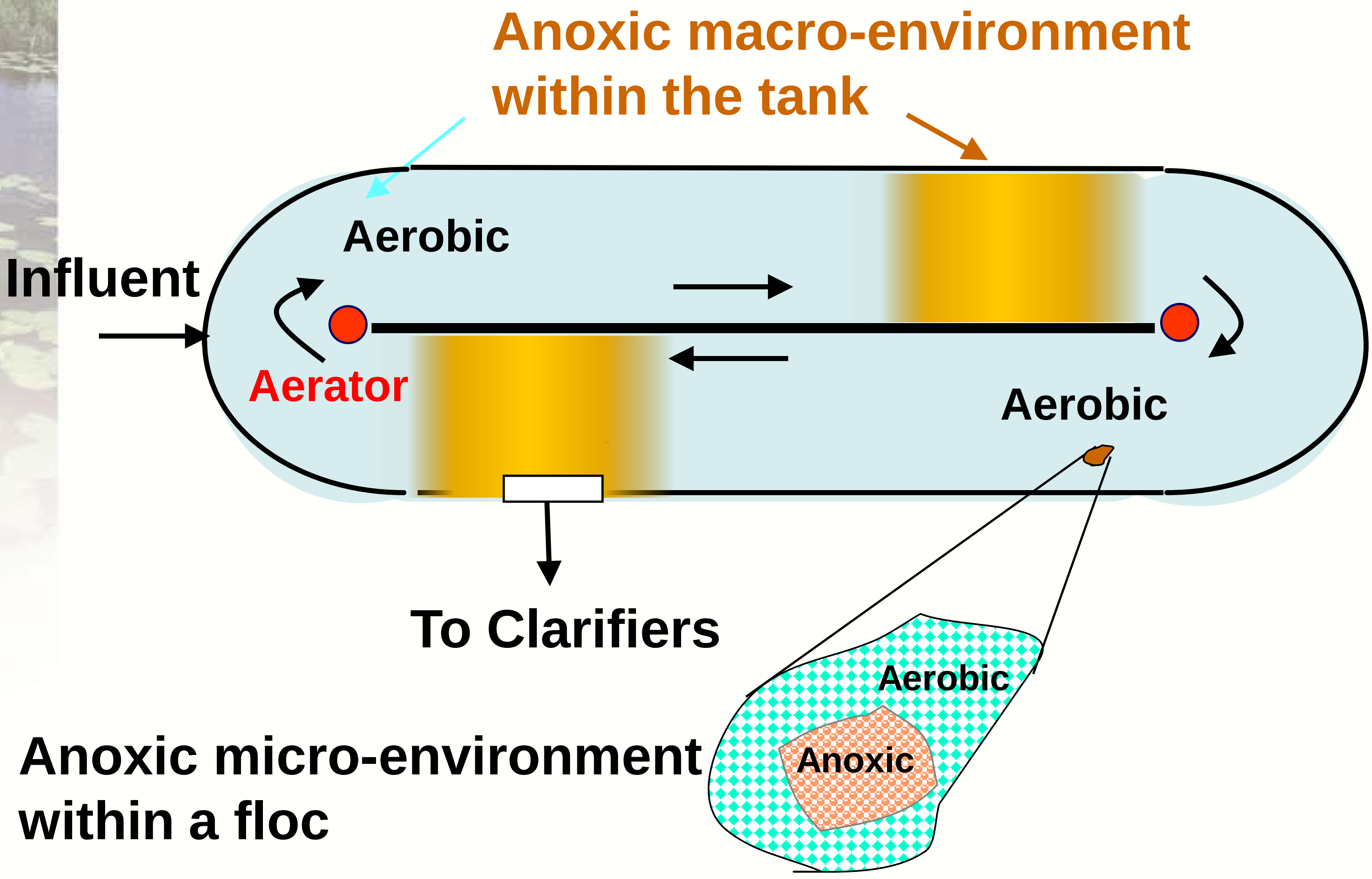
4-Stage Bardenpho
TN = 3 mg/L



Denitrification Filter
TN = 3 mg/L

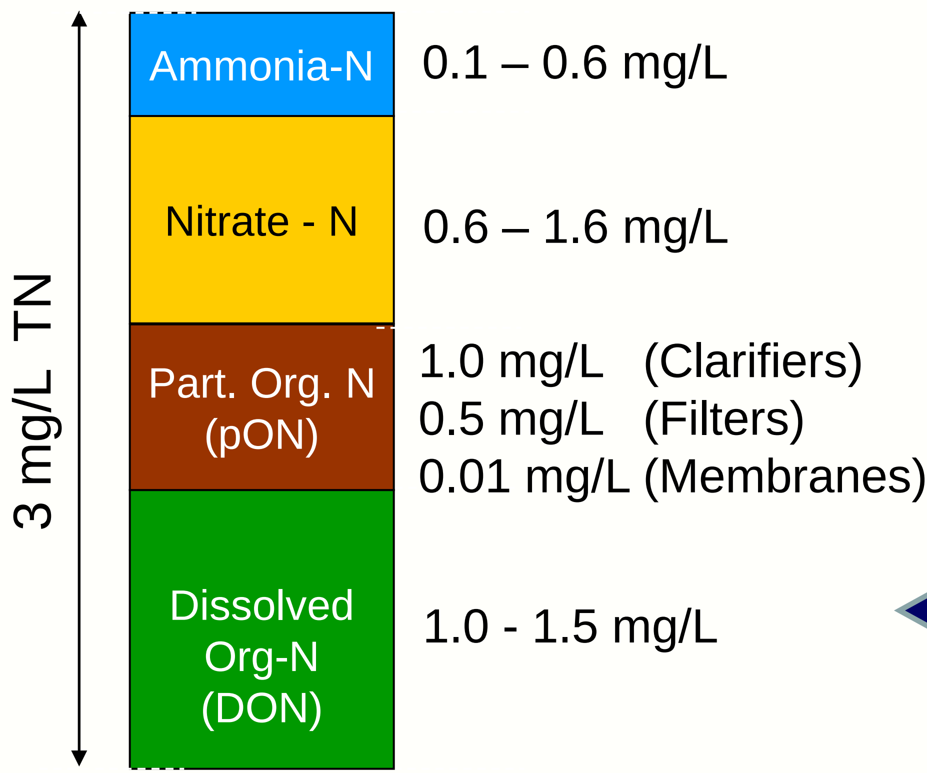


Informal Anoxic Zones Cause Simultaneous Nitrification/Denitrification



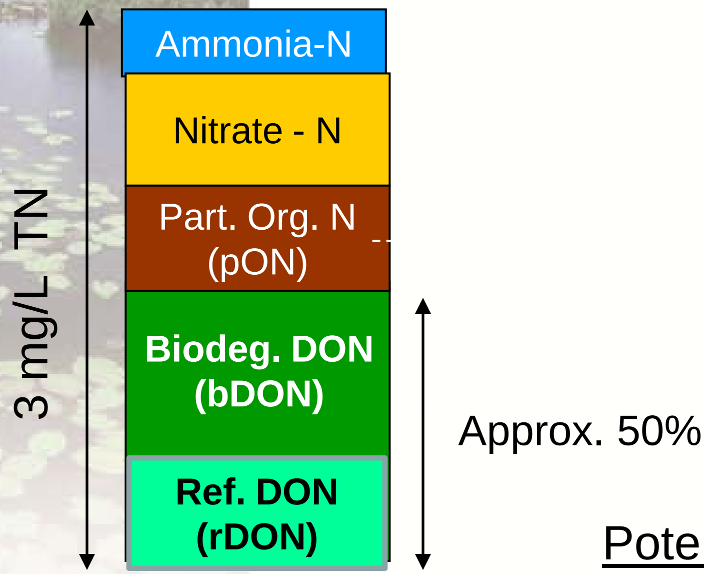
What is the Limit Of Technology (LOT) for TN

- The LOT with conventional treatment processes is 3 mg/L TN



Can we go lower than LOT?

Achieving < 3 mg/L TN Requires an Understanding of TN Speciation



- DON is the largest TN fraction of effluent (up to 50%)
- Achieving < 3mg/L (LOT) will require DON removal
- DON consists of :
  - Biodegradable DON (bDON)
  - Refractory DON (rDON)

Potential DON removal technologies

Process	bDON	rDON
Nitrification	+++	-
Denitrification w/supplemental C	+	-
Advanced oxidation	+	+
Reverse Osmosis	++++	++++

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Striking a Balance

- Nutrient removal facilities:
  - ➢ Incur significant capital and O&M costs
  - ➢ Have larger carbon footprint
    - Increased use of chemicals & energy – increased GHG emissions

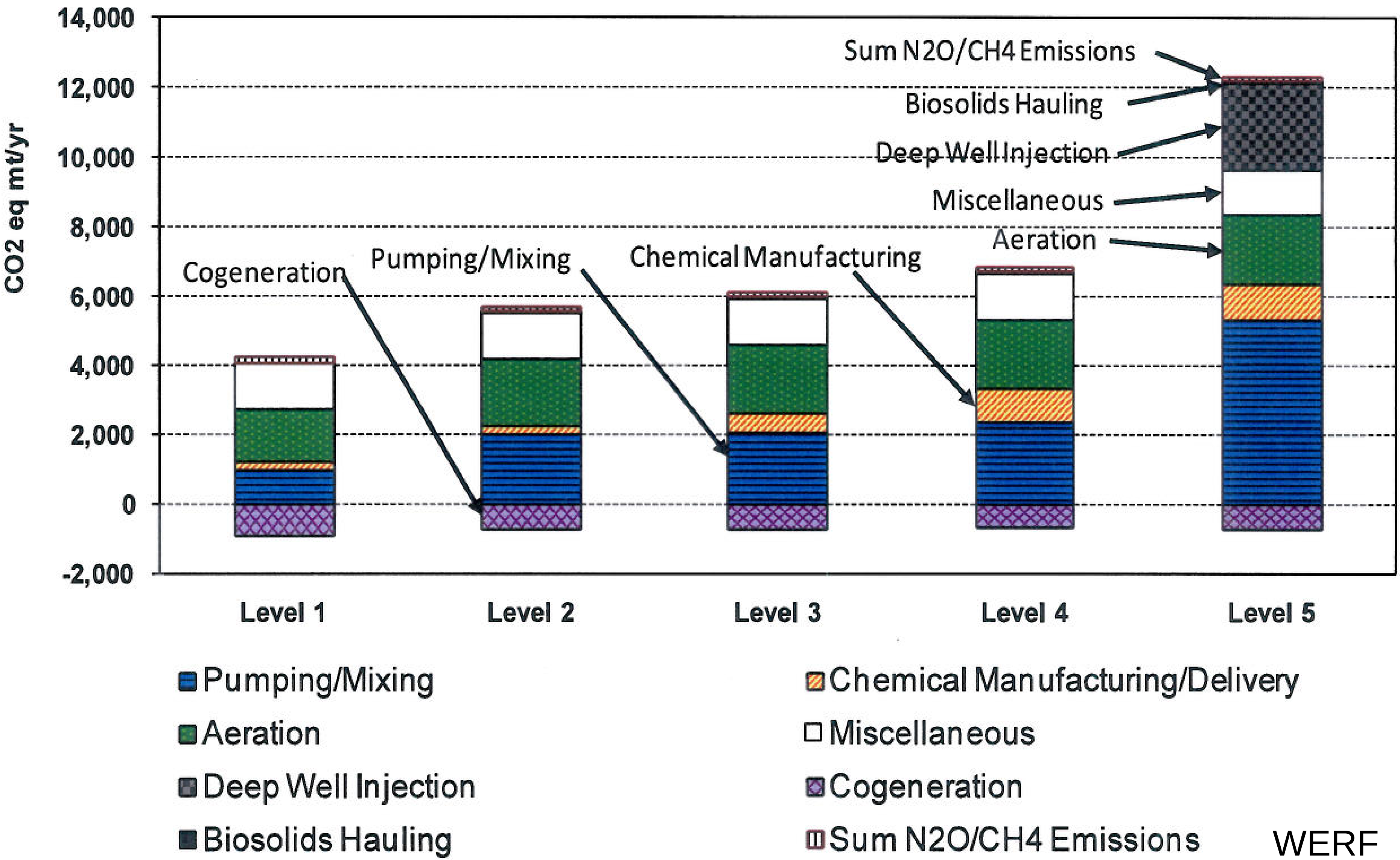
A decision to implement nutrient removal should be based on 'net' environmental benefit & costs

Summary of Ongoing WERF Study

- 10 mgd plant with following effluent objectives

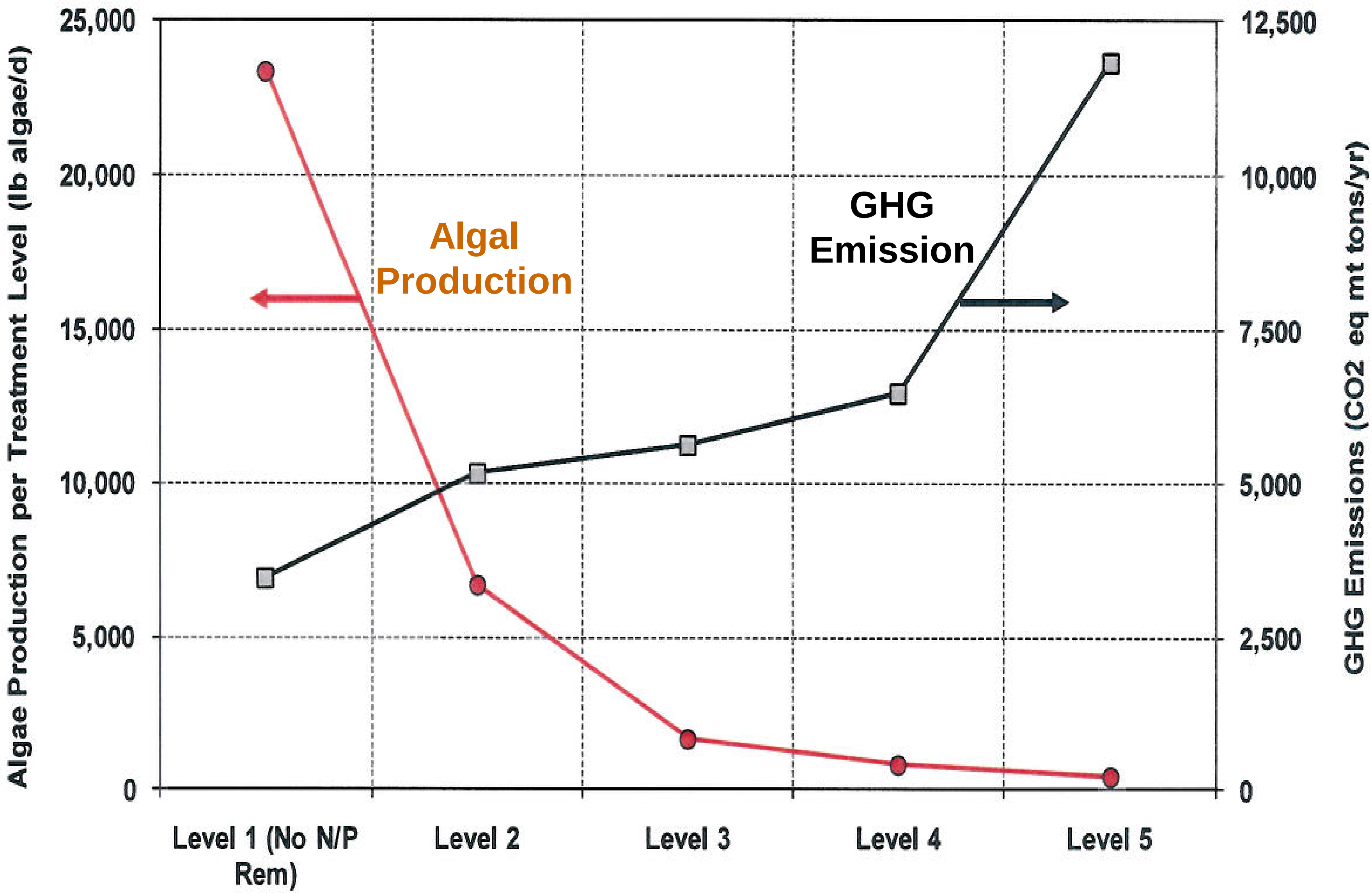
Level	BOD (mg/L)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
1 (Secondary)	30	30	-	-
2	-	-	8	1
3	-	-	4-8	0.1 – 0.3
4	-	-	3	0.1
5	-	-	<2	<0.05

Total GHG Emission Burden



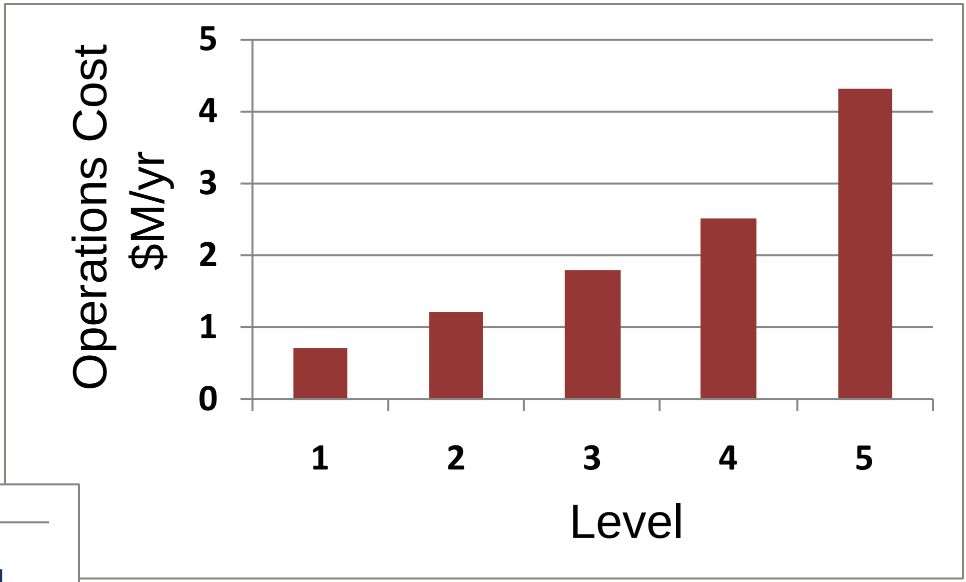
WERF

GHGs versus Algal Production

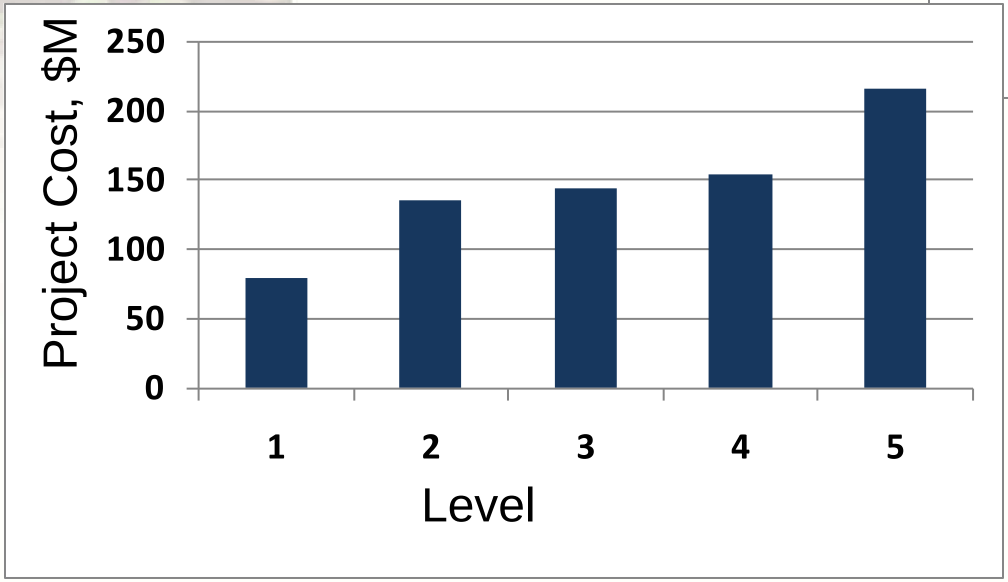


WERF

Capital & Operations Costs

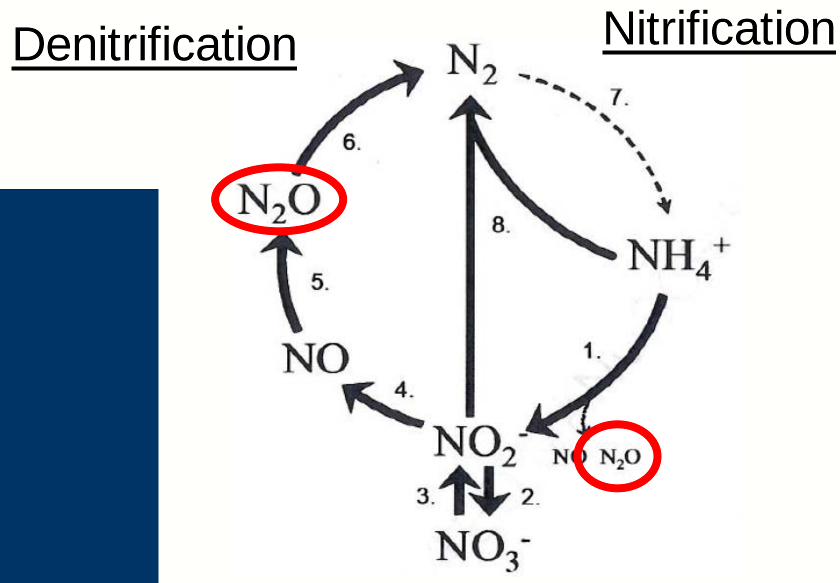


Excludes labor, maintenance, & membrane replacement costs



WERF

New Information on Nitrous Oxide Generation at WWTPs



- N_2O potentially produced during nitrification & always during denitrification.
- Potentially more during nitrification. Occurs due to:
  - Intermittent or incomplete nitrification
  - Repeated switching between aerobic & anoxic + high DO & NH_3-N
- But lower N_2O production in ox. ditches due to more uniform spatial DO profile

WERF

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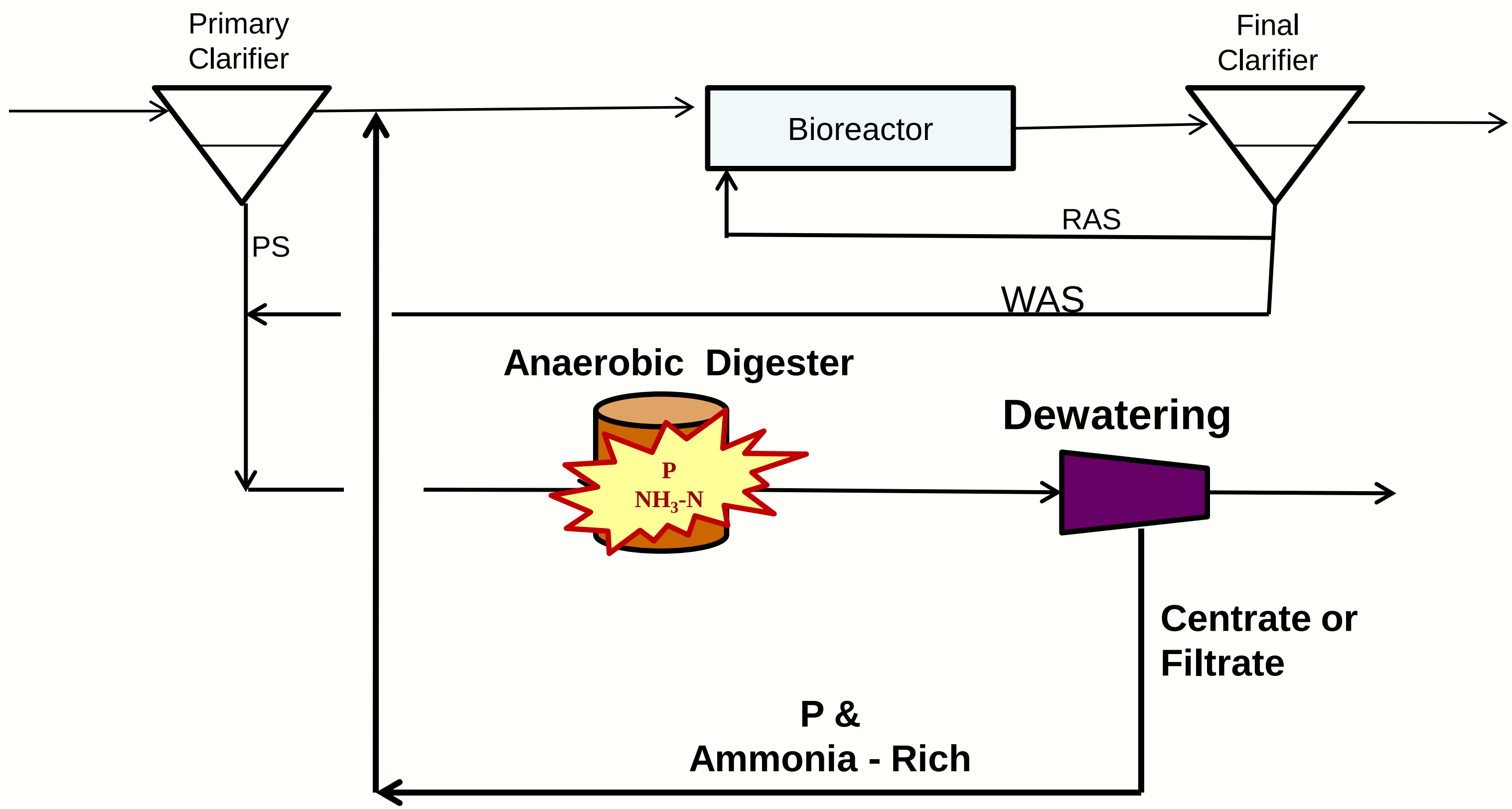
Recycle Management is Crucial for Meeting TP & TN Limits



- Anaerobic digestion releases P & ammonia.
- Dewatering centrate/filtrate can impose additional load on the main process

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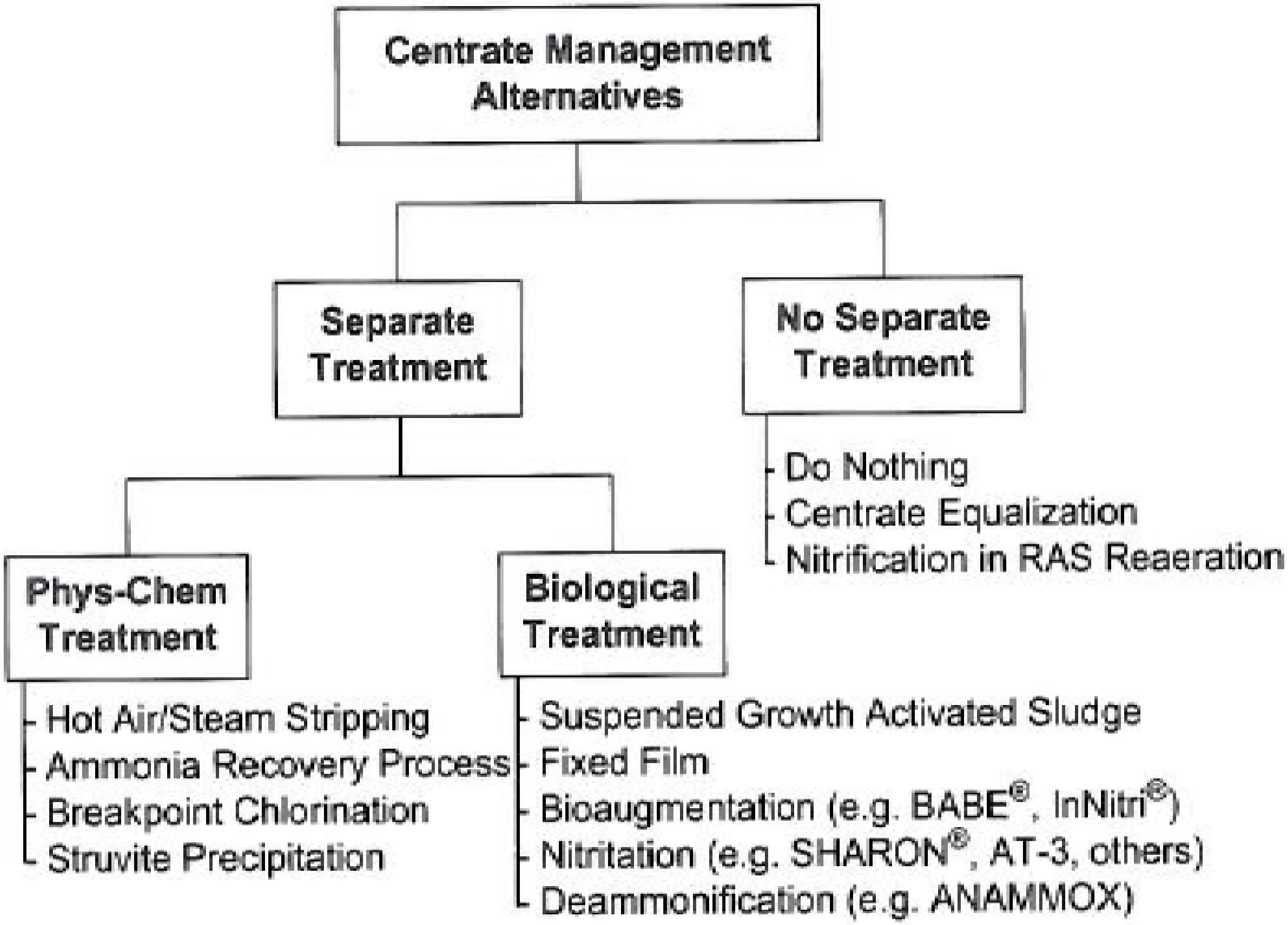
Sidestream Management Alternatives



The Dreaded Foam

More Design & Operational Considerations

- General design approach:
  - Influent characteristics
  - Effluent limits
  - The box in-between

- General process optimization approach:
  - First, nitrification & denitrification
  - Then, EBPR; add supplemental chemical, if required

- Smart automation:
  - Judicious use of instrumentation
    - Aeration control
    - SRT control

More Design & Operational Considerations

- Even flow splitting
  - Underloaded units often can not compensate for overloaded units
- Provision to control bulking & foaming.
- It takes two to tango!
  - Designers: provide operational flexibility.
  - Operators: use operational flexibility provided.

Take Home Messages

- Technology limits:
  - One anoxic zone/Ox ditches: 8 – 10 mg/L TN
  - Two anoxic zones/Denite filter: 3 mg/L TN
  - Tertiary treatment to remove DON: <3.0 mg/L TN
- The decision to achieve low N & P should be based on sustainability analysis.
- Data is not information.
- OH plants are not likely to see TN limit in the immediate future.

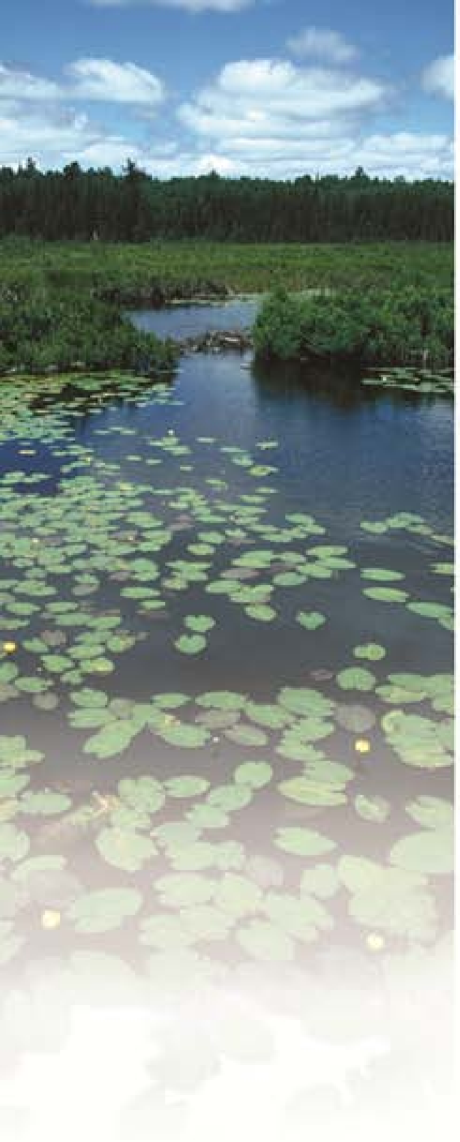
What Will the Ideal Plant of the Future Look Like?

Characteristics of the ideal plant of the future:

1. TN = 3-5 mg/L
2. TP ≤ 0.1 mg/L
3. Energy neutral
4. Resource recovery (P recovery)
5. Wet weather flow processing
6. Effluent reuse

Incorporate provision so that a plant can gradually evolve into the ideal plant of the future in a cost effective manner.


Questions?



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