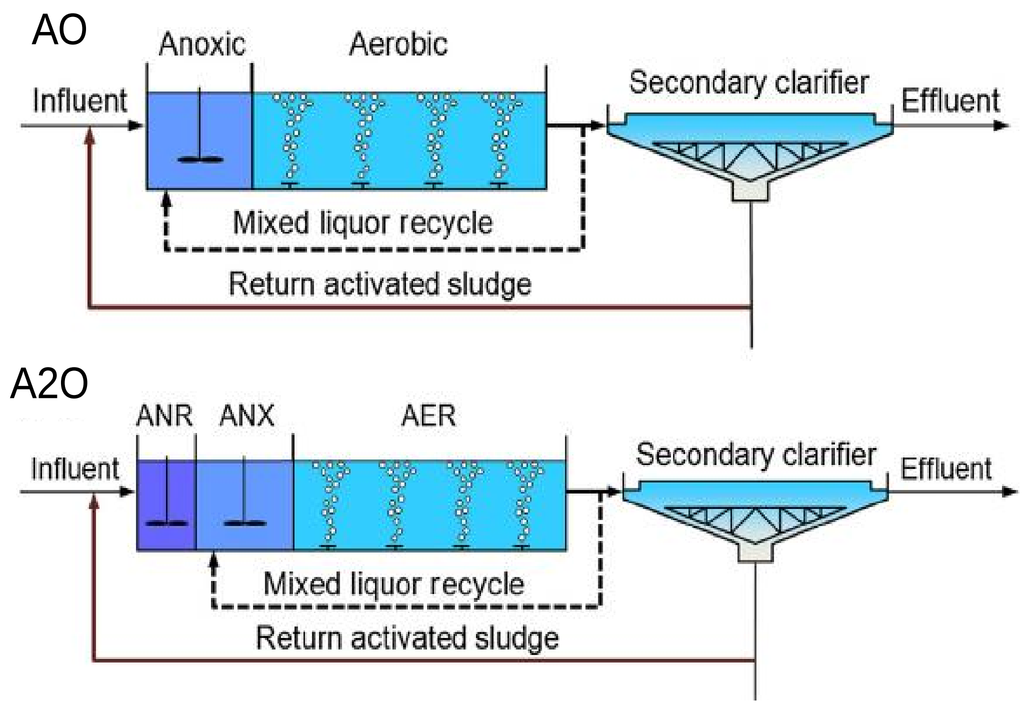
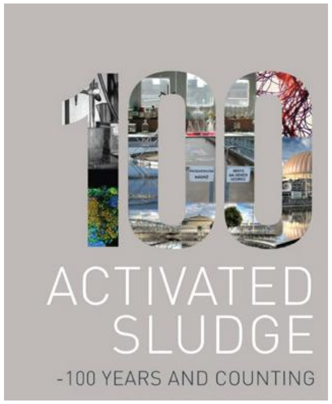
Nutrients Removal in MABR

Ronen Shechter, CTO

INTRODUCTION – BASIC PRINCIPLES IN WASTEWATER TREATMENT





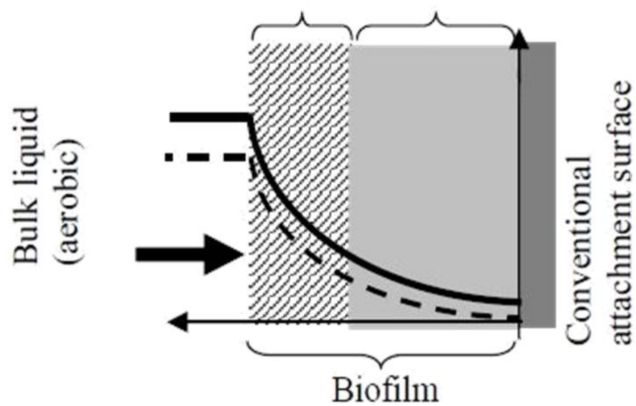
STILL A CHALLENGE:

- TN removal
- Energy efficiency
- Small plants

fluence

THE UNIQUE BIOFILM IN MABR

Conventional co-diffusion

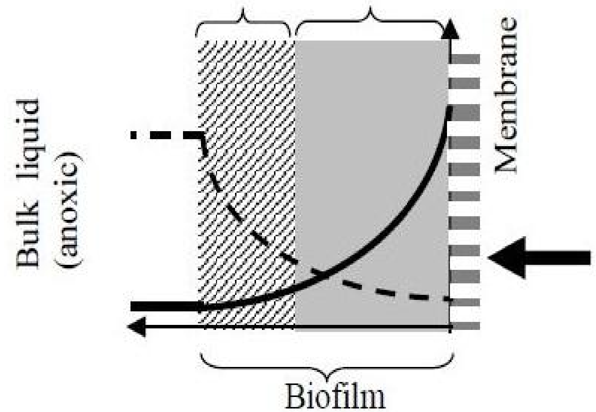


(a)

RBC

MBBR

MABR counter-diffusion

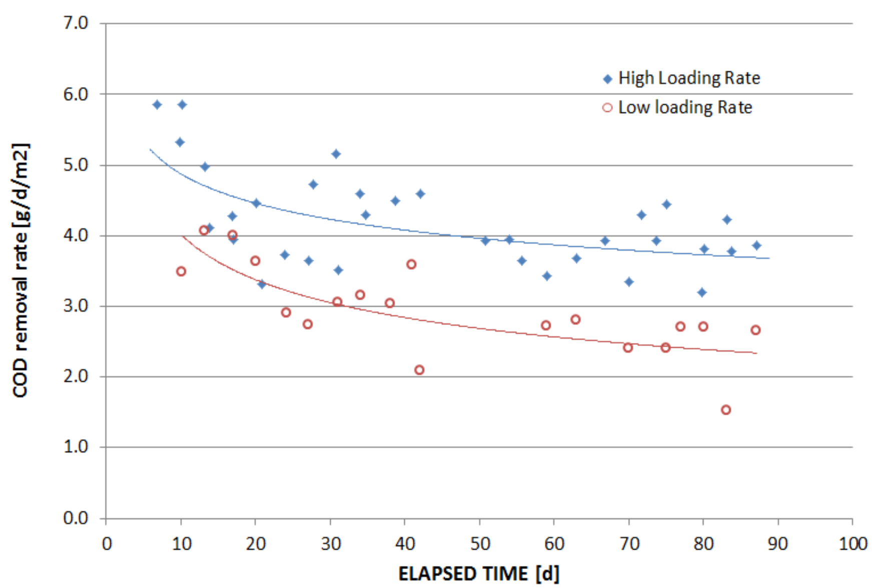


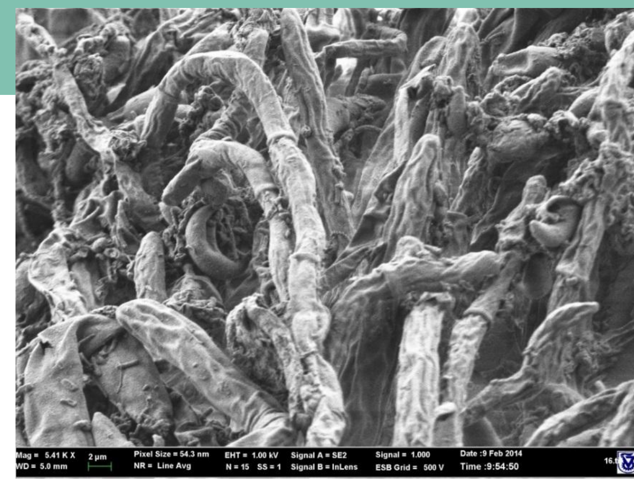
(b)

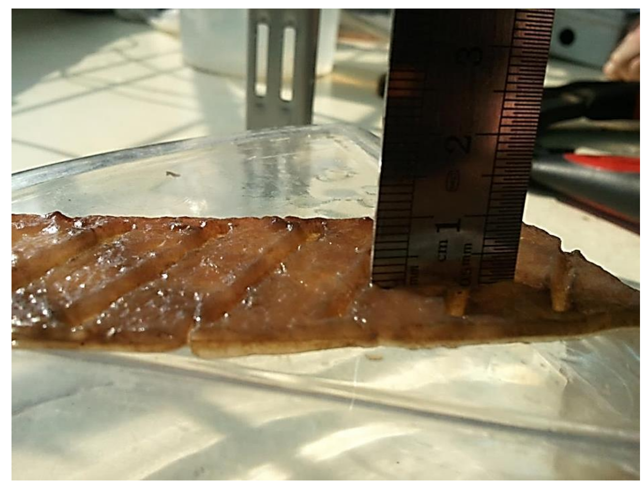
Images courtesy of Nerenberg, 2005

EXCESS GROWTH OF BIOFILMS

- Up to 5-6 mm thick on membranes at parts of the process that were highly loaded (BOD)
- Prevention is successful by holding sufficient MLSS → negligible BOD dissolved in the water







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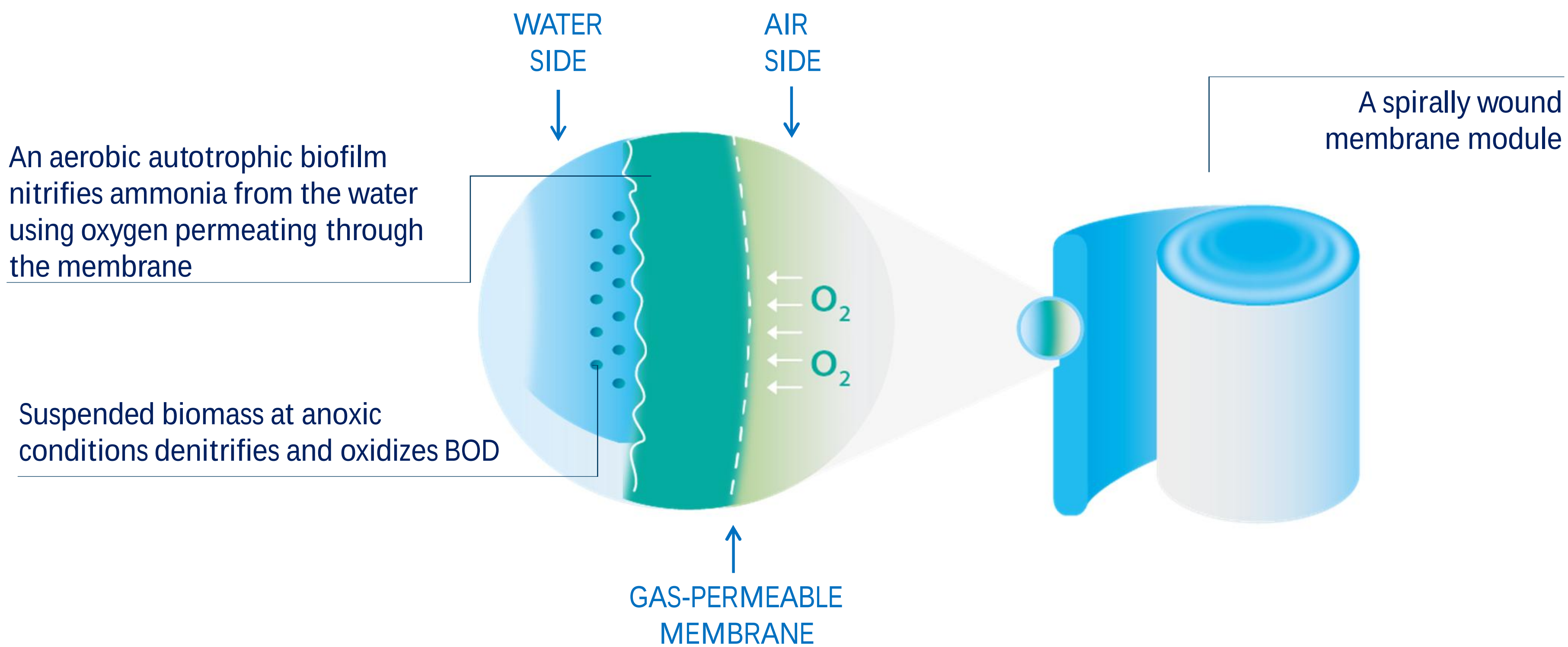
NON CLOGGING MABR OPERATING IN IFAS MODE



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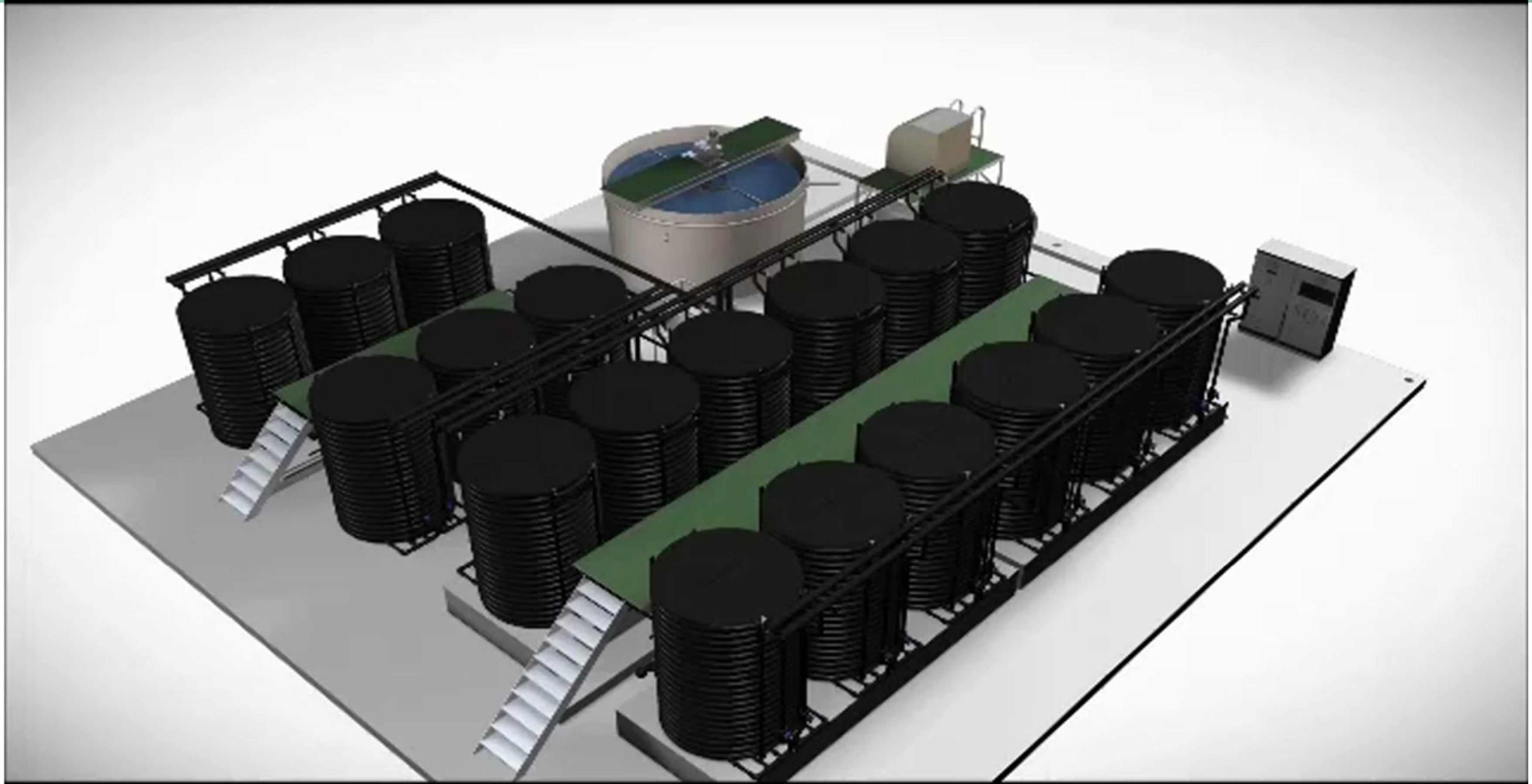
HOW IT WORKS

Case study video: Ha-Yogev plant



Combined sewer and dairy farms | 125 m3/d treatment capacity
Retrofit to add nitrogen removal

CASE STUDY: THE BORDEAUX PLANT, US VIRGIN ISLANDS

Design capacity: 92 m3/d

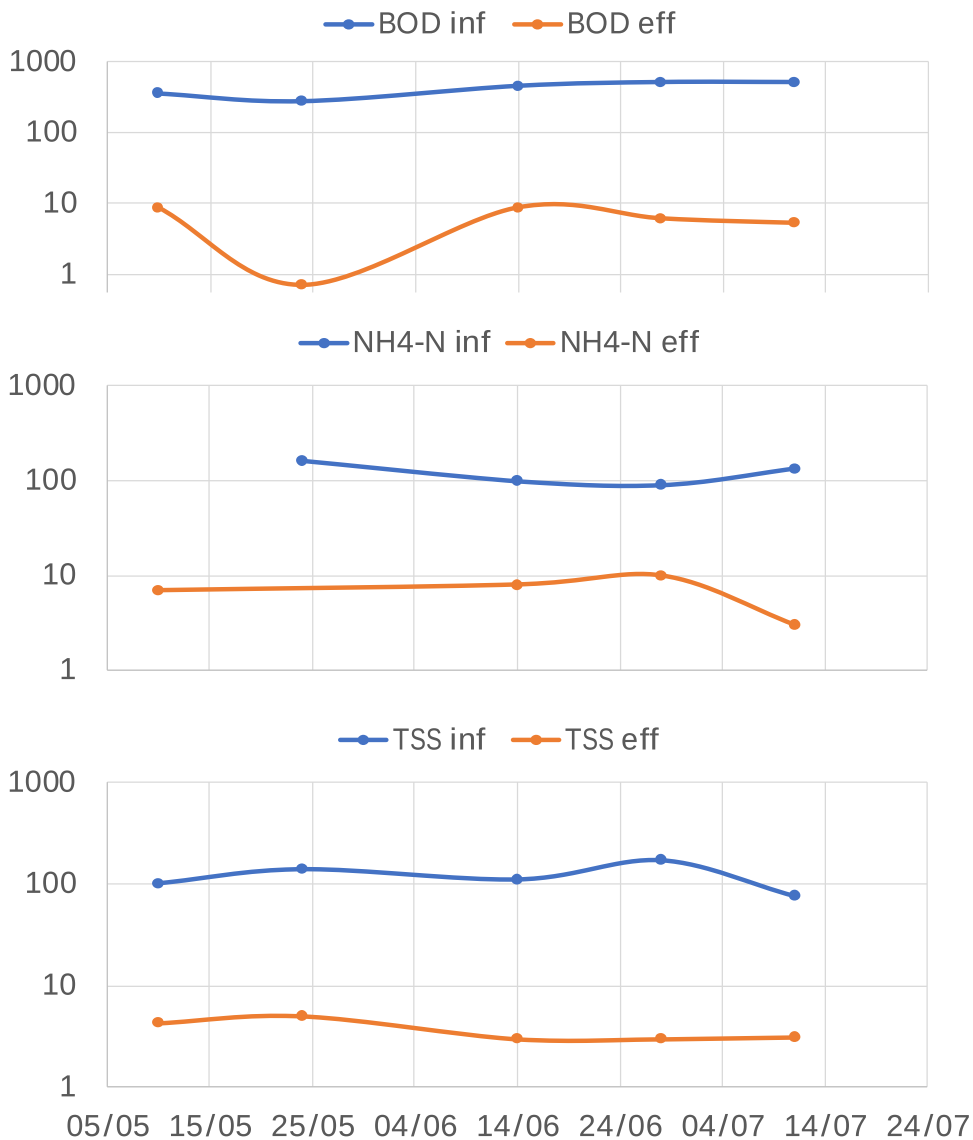
Effluent requirements:

TSS/BOD/TN/TP – 10/10/10/1

Tertiary treatment:

Filtration + chlorination

Commissioned: NOV 2016



PLANT PERFORMANCE

DEPARTMENT OF PLANNING AND NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL PROTECTION

8100 LINDBERG BAY, STE. #61
Cyril E. King Airport Terminal Building 2nd Floor
CHARLOTTE AMALIE, ST. THOMAS 00802
340-774-3320

TERRITORIAL POLLUTION DISCHARGE ELIMINATION SYSTEM

PERMIT NUMBER VI0039977

This Territorial Pollutant Discharge Elimination System (TPDES) permit is issued in compliance with Title 12 of the Virgin Islands Code (VIC), Chapter 7, Section 185 in accordance with the provisions of the Federal Water Pollution Control Act, as amended, (33 U.S. Code 1251 et seq.)

VIRGIN ISLANDS WASTE MANAGEMENT AUTHORITY – BORDEAUX POTW *(herein referred to as "the Permittee")*	
Mailing Address: *3200 Demarara, St. Thomas, USVI 00802*	**Physical Address:** *#6 West End Quarter, Estate Bordeaux, St. Thomas, USVI 00802*
Permittee name: *VIRGIN ISLANDS WASTE MANAGEMENT AUTHORITY- BORDEAUX POTW*	**Facility name:** *BORDEAUX POTW*
Permittee street address: *3200 Demarara*	**Facility street address:** *#6 West End Quarter, Estate Bordeaux*
Permittee city: *St. Thomas, USVI 00802*	**Facility city:** *St. Thomas, USVI 00802*
*The Department has classified this discharge as a **Minor, Municipal** discharge.*	

The Permittee is authorized to discharge from the facility named above to **Class B** receiving waters listed in the table below, in accordance with effluent limitations and monitoring requirements and other conditions set forth in Parts I, II, III, and IV hereof.

Outfall	Effluent description	Outfall latitude	Outfall longitude	Receiving water name and classification
001	Secondary Treatment	18°20'42.8"N	65°00'56.0"W	Polishing Pond (Fortuna Bay)

Date Original Application Received: **12/17/15** Date Complete Application Received: **4/11/16**

Permit Writer(s): Akil Jacobs Date: 4/24/17

Program Manager: Benjamin Keularts Date: 4/24/17

Director Approval: Norman D. Williams, Jr. Date: 4/24/17

This permit modification shall become effective on **May 1, 2017**.

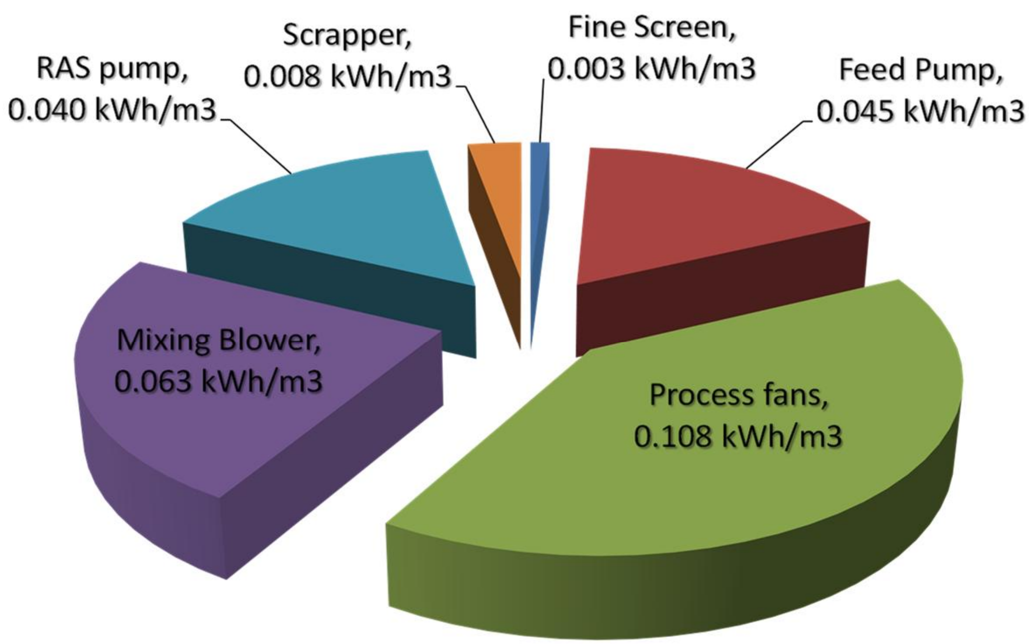
This permit and authorization to discharge expires at midnight on **September 30, 2021**, consistent with Title 12 of the VIC, Chapter 7, Section 185(e).

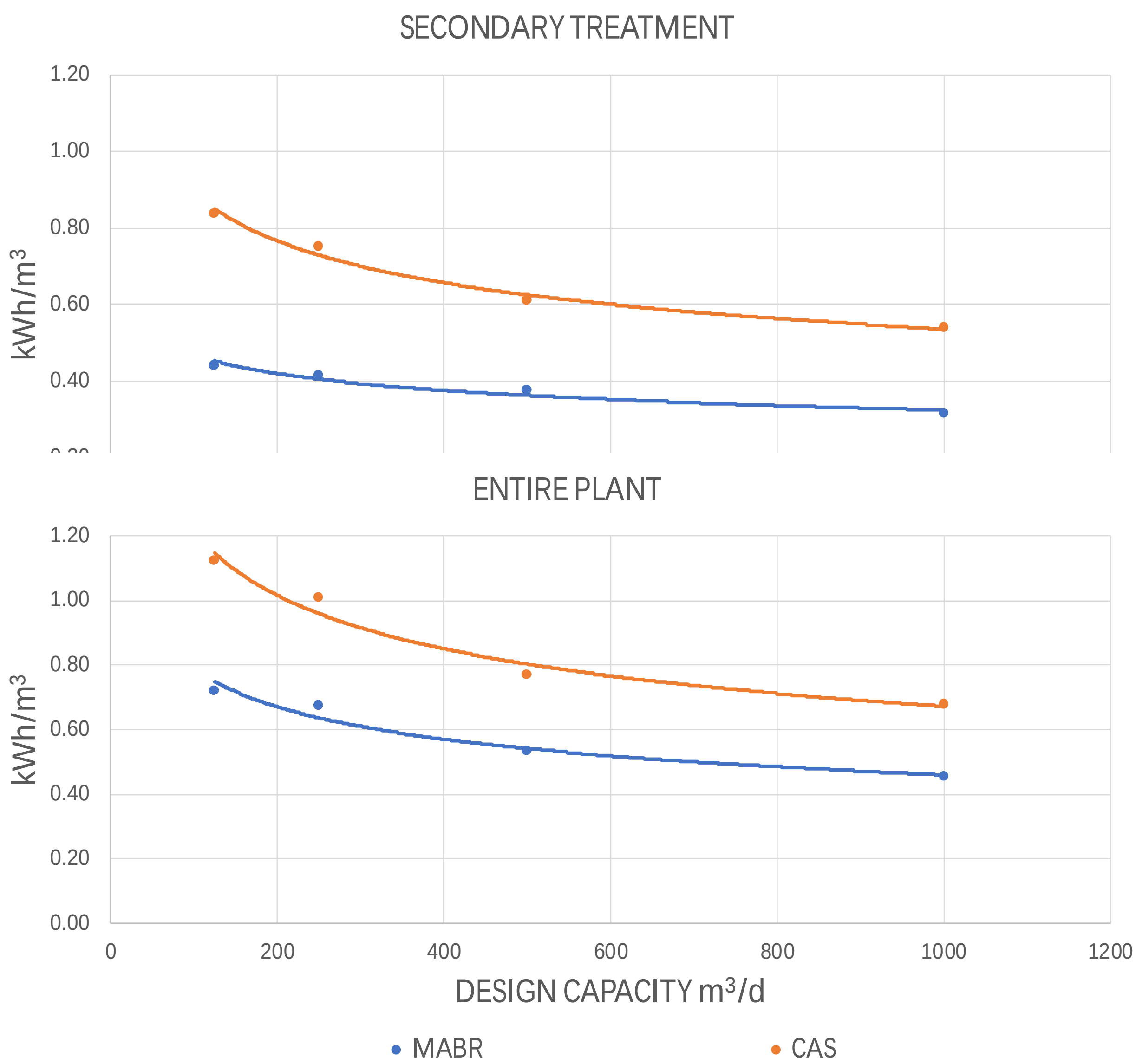
To renew this permit, a new application shall be submitted Date: **April 1, 2021**

Dawn L. Henry, ESQ.
Commissioner Date: April 24, 2017

ENERGY CONSUMPTION RESULTS FROM BORDEAUX PLANT

- Total secondary treatment 0.26 kWh/m^3
- Excluding feed pump 0.21 kWh/m^3





ENERGY COMPARISON

BASES:

DESIGN CALCULATION, EQUIPMENT SELECTION FOR EACH CASE

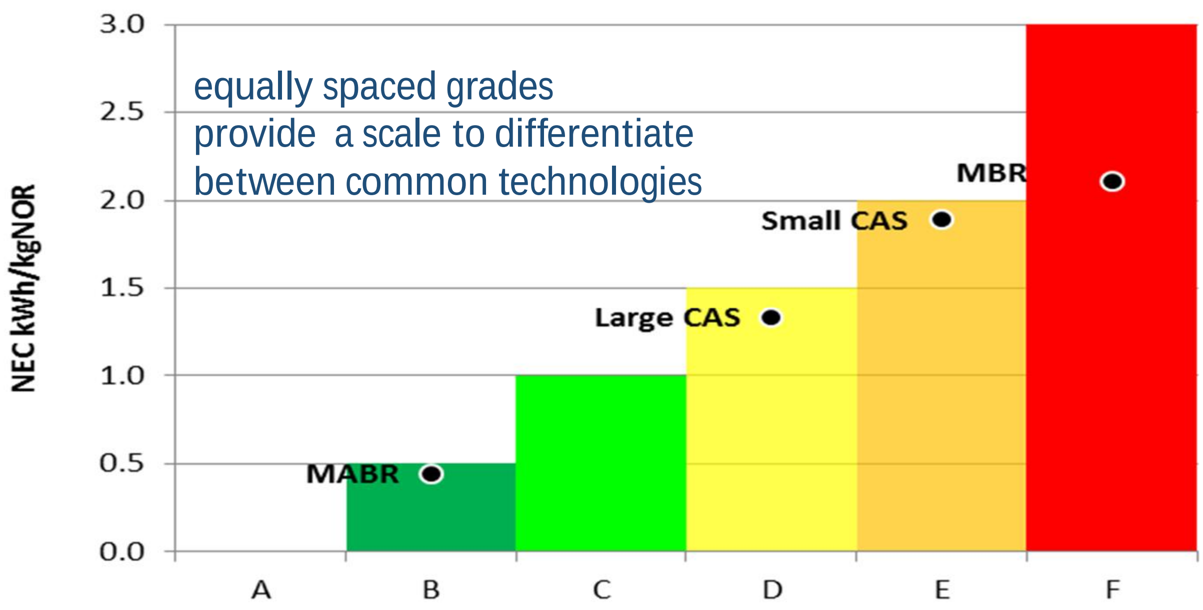
SAME TANK FOR BOTH PROCESSES

DESIGN TEMPERATURE 15°C

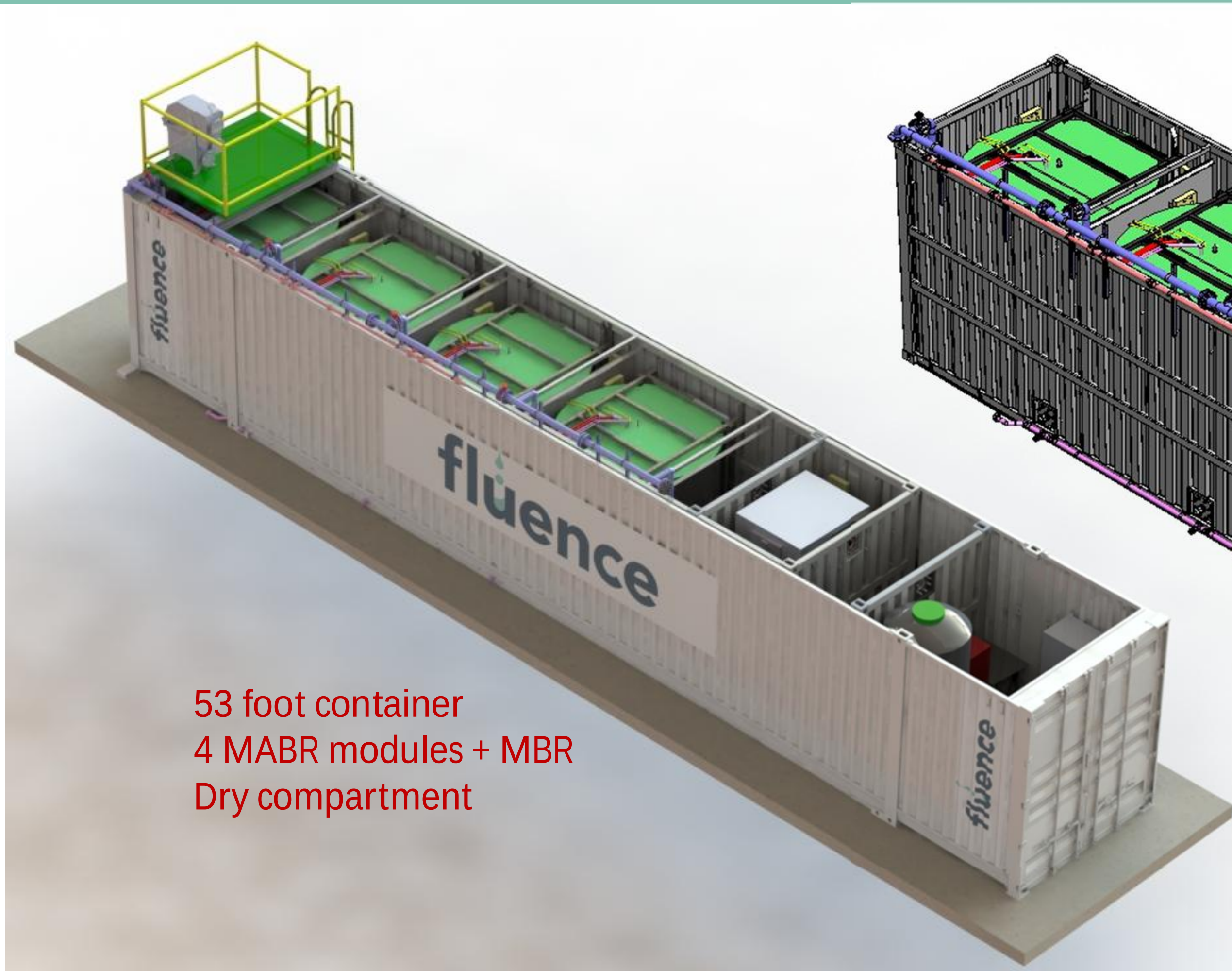
CHINA A1 EFFLUENT QUALITY

COMING UP: ISO 21939 (CD)
ENERGY CONSUMPTION OF BIOLOGICAL WASTEWATER TREATMENT

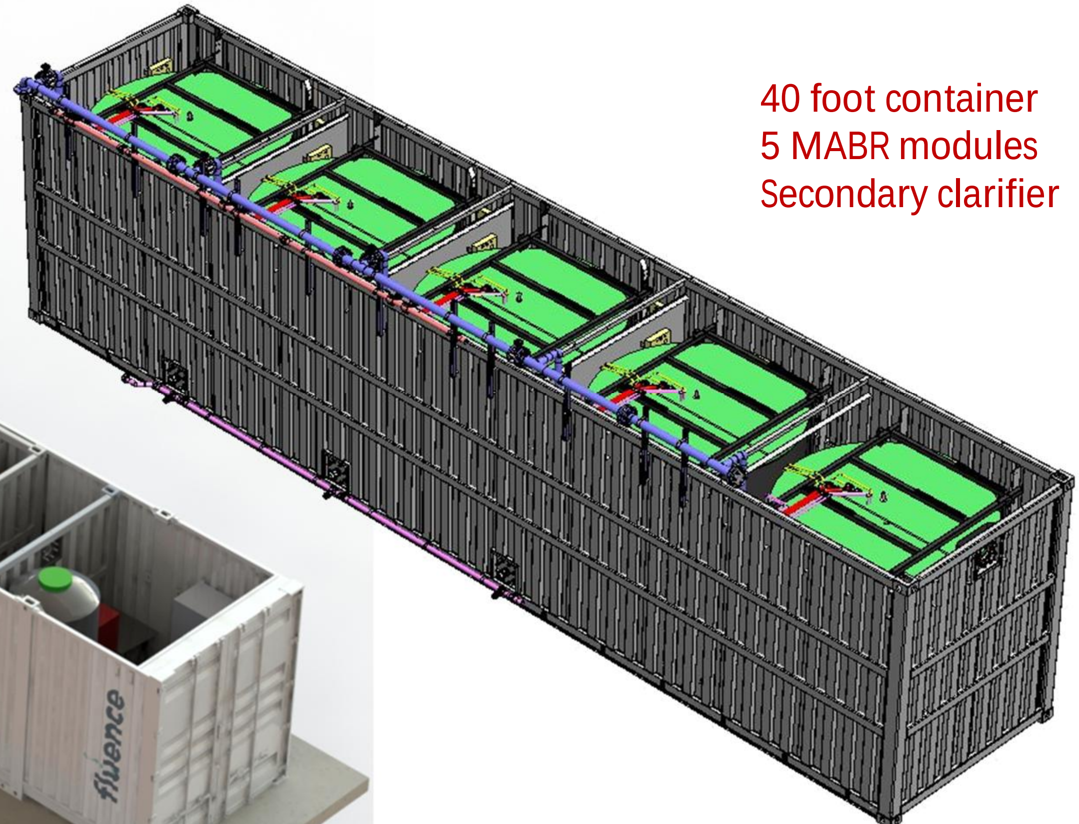
Category	A	B	C	D	E	F
Description	Net Positive	Very Low	Low	Medium	High	Very High
NEC kWh/kg	< 0.0	0.0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	> 2.0
Color Code						



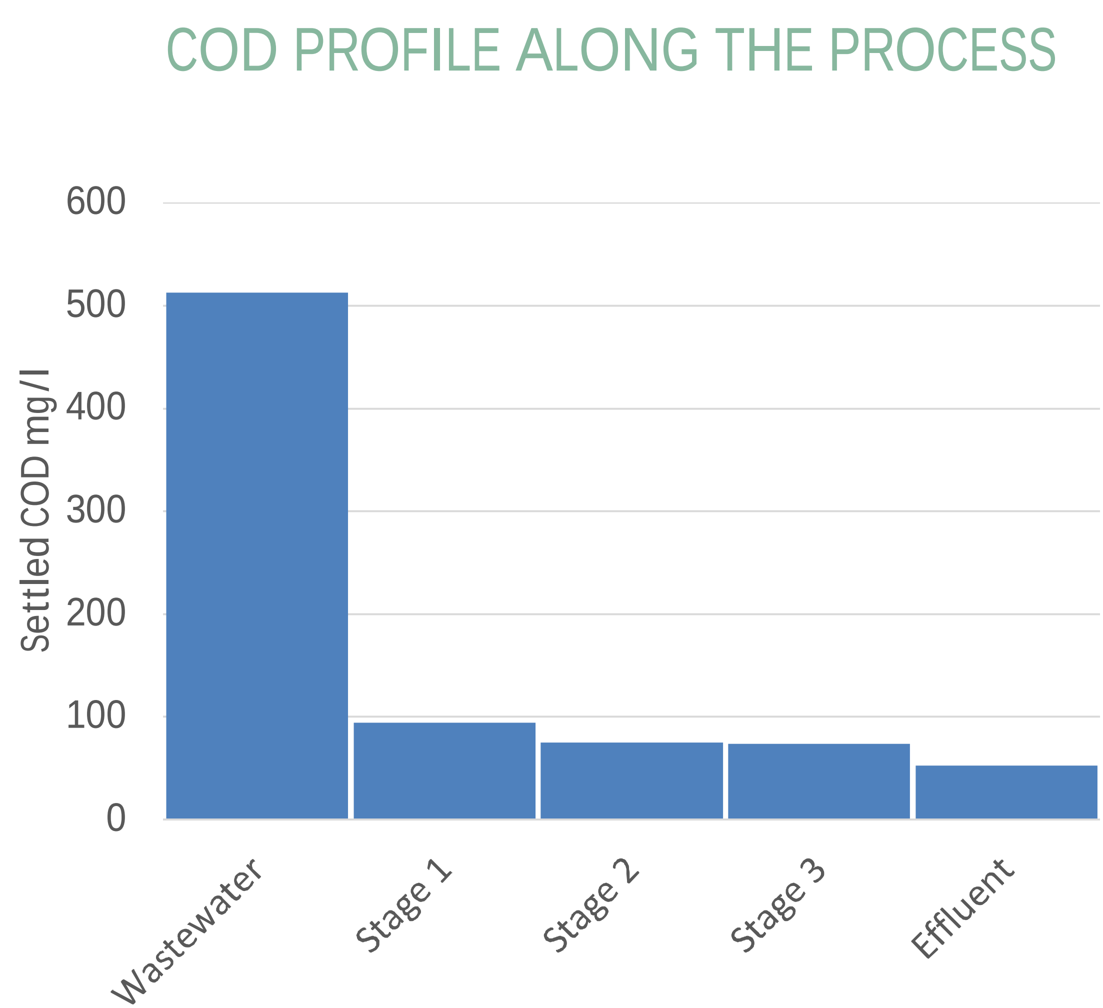
CONTAINER REACTOR CONFIGURATIONS



53 foot container
4 MABR modules + MBR
Dry compartment



40 foot container
5 MABR modules
Secondary clarifier



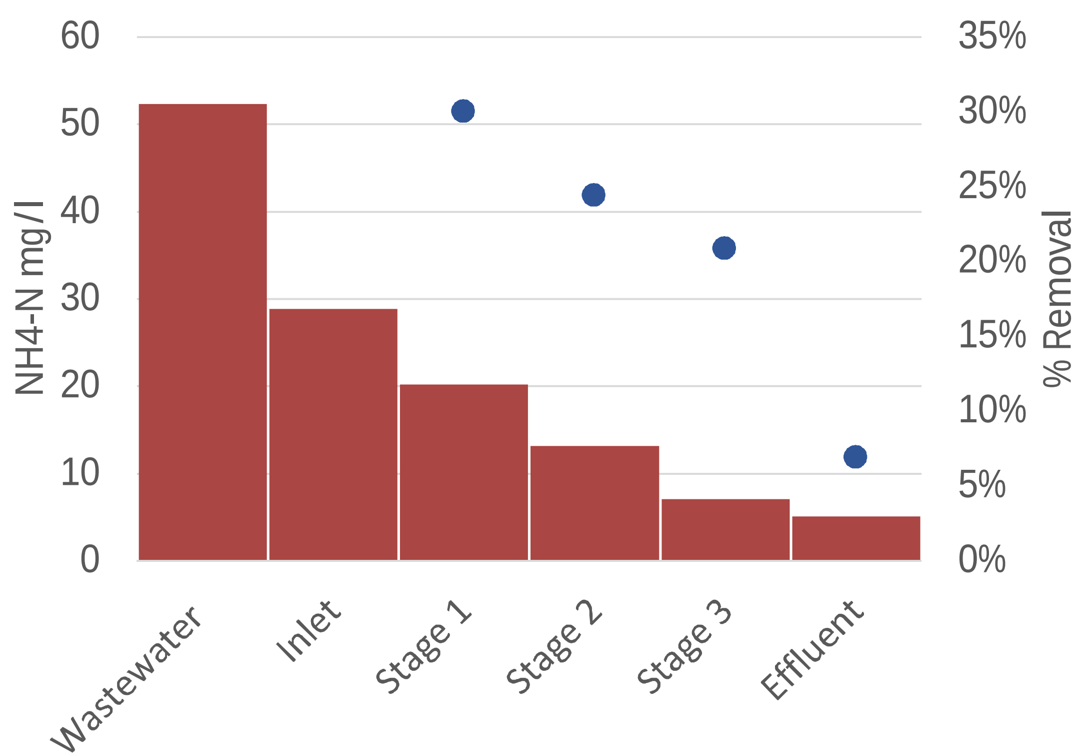
Almost no degradable organic carbon in the water throughout the process

Biosorption can be seen to occur as planned

This is what enables development of a nitrifying biofilm on the membranes

It also ensures denitrification is performed by the suspended biomass

AMMONIA PROFILE ALONG THE PROCESS

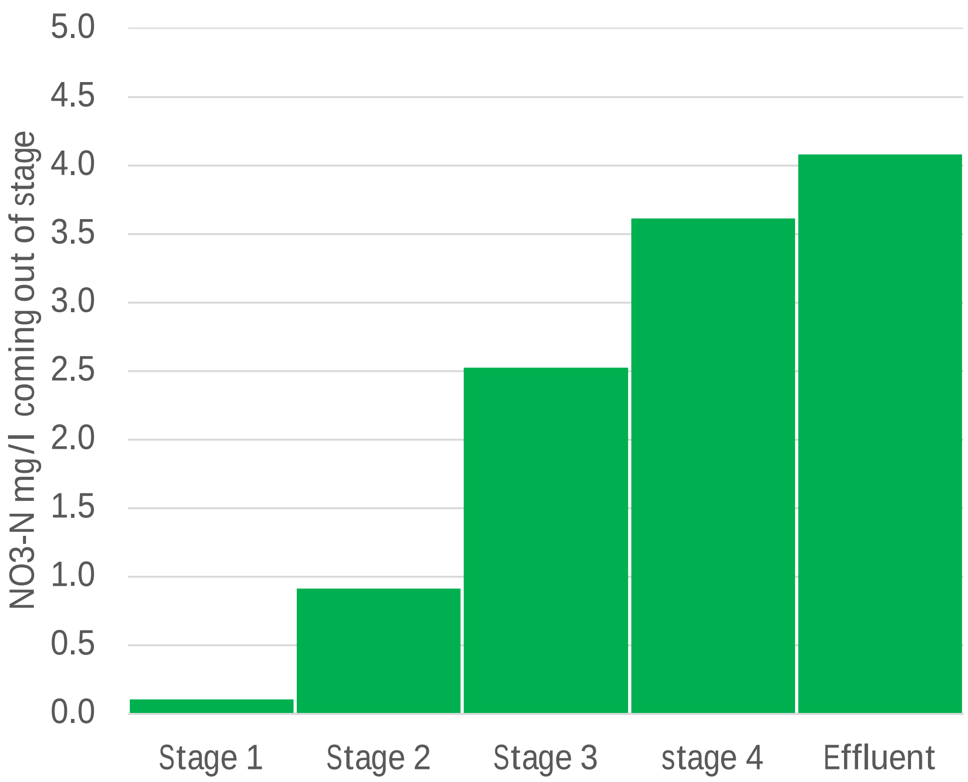


Ammonia concentration gradually decreases along the process → nitrification occurs along the entire process

Stage % removal is analogous to nitrification rate; both decrease with ammonia concentration along the process

Note that last stage (producing the effluent) is without a membrane

NITRATE PROFILE ALONG THE PROCESS



"Effluent" comes out of secondary clarifier; "stage 4" goes into secondary clarifier

Increase from clarifier inlet to outlet is inexplicable yet

Denitrification rate evidently decreases more than the nitrification rate according to the accumulation

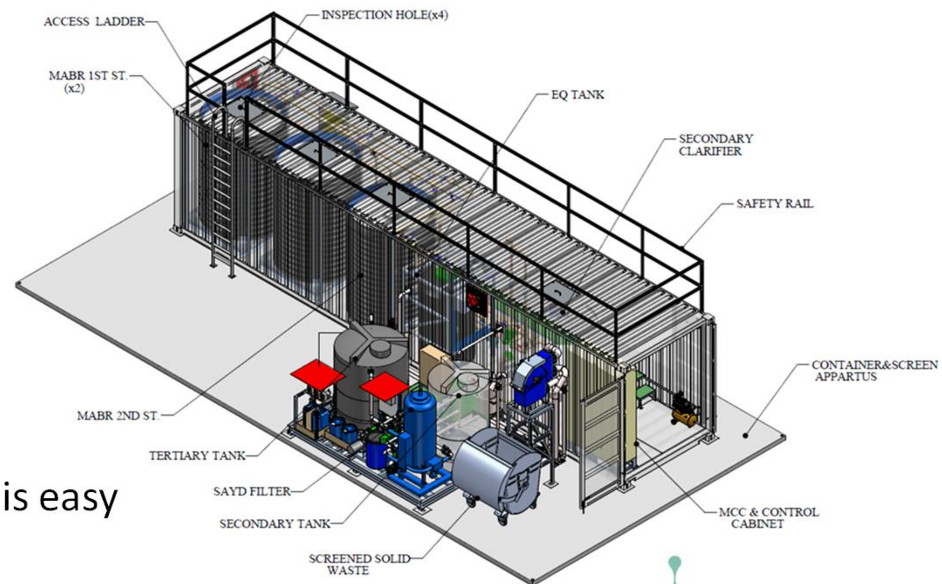
Part of the BOD is most probably oxidized by oxygen left over from the biofilm, more in downstream stages

PHOSPHOROUS REMOVAL

	Flowrate (m^3/d)	TP in (mg/l)	TP out (mg/l)	Reduction %	Stage 1 HRT (h)	Stage 1 ORP (mV)
SYSTEM 1	80	8.6	0.5	94%	2.1	-220
SYSTEM 2	24	7.46	1.46	80%	3.5	-120

SYSTEM 1: 4 stage containerized system (corresponding to the results shown before)

SYSTEM 2: 3 tanks arranged in 2 stages



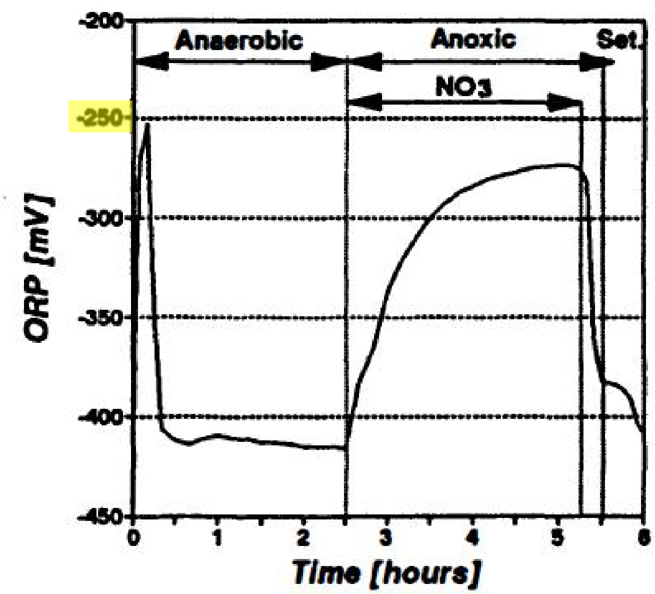
RELEVANCE TO SMALL PLANTS:

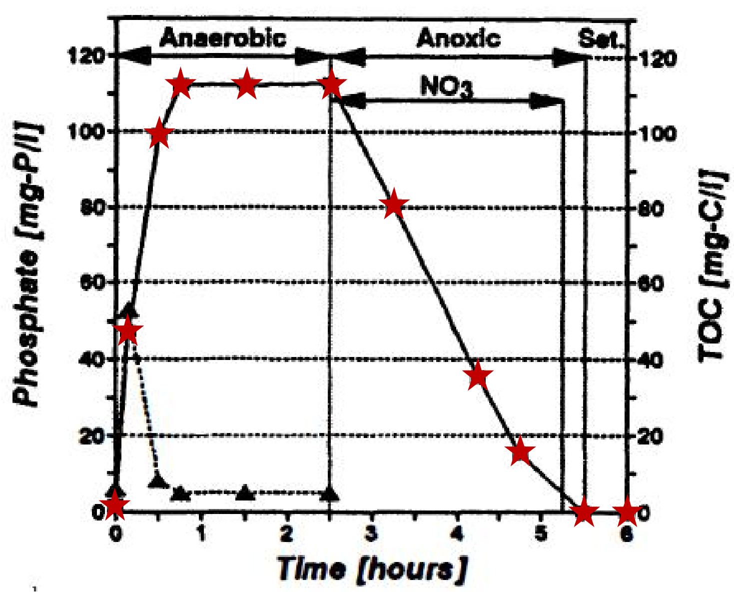
- P removal becomes important in small plants when used to create a distributed solution
- Ease of operation is critical, once-through operation is easy

fluence

CRITERIA FOR BIOLOGICAL PHOSPHOROUS REMOVAL

- EBPR – usually requires cycling between aerobic and anaerobic conditions
- Kuba, van Loosdrecht and Heijnen (1993) shows that anoxic conditions instead of aerobic fully enable Bio P Removal
- Barnard (2017) sets an ORP value of preferably less than -250mV instead of anaerobic conditions





Courtesy of Kuba, van Loosdrecht and Heijnen

CONCLUDING REMARKS

- Results to support process design and calculations are starting to accumulate from both operating commercial plants and full scale testing
- Results show that MABR enables SND at fully anoxic conditions, while also removing phosphorous
- The mechanisms that explains MABR performance are biosorption and staging; these create a low enough ORP to enable Bio-P removal
- Energy consumption for aeration in MABR is lower than conventional processes

fluence