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# Advanced High-Surface Area Ceramic Biological Filtration Media ReefresH<sub>2</sub>O™ with Cell-Pore™ Technology

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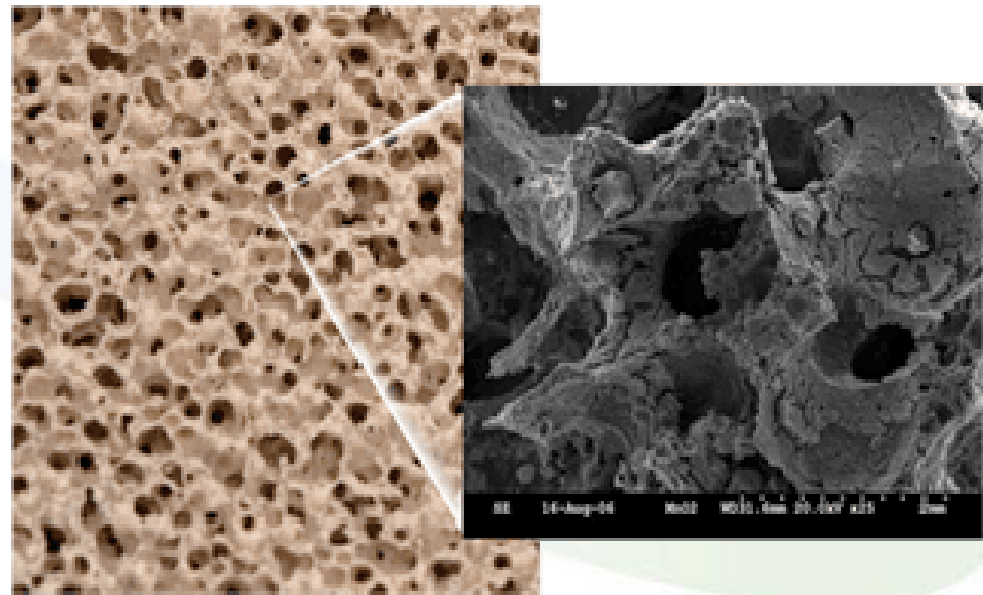
# Description/Properties of ReefresH<sub>2</sub>O

- ReefresH<sub>2</sub>O pore morphology is tri-modal, with interconnecting pores 0.5μm to 500μm
- Pore morphology description

<b>Major Large Pores</b>	<b>Interconnecting Pores</b>	<b>Cell Wall Porosity</b>
200-500 μm	50-200 μm	0.5-5 μm

# ReefresH<sub>2</sub>O with Cell-Pore Technology

- Image of ReefresH<sub>2</sub>O pore morphology with higher resolution inset (SEM)
- The current ReefresH<sub>2</sub>O product line slated for both the home aquarium hobbyist and the industrial marketplace



# Properties of ReefresH<sub>2</sub>O Products Used for Biological Filtration

- The ReefresH<sub>2</sub>O product line is manufactured to precise material characteristics based on its intended use

Product Description	Surface Area			
	Square Meters	Square Feet	Square Meters per Cubic Meter	Square Feet per Cubic Foot
5/8 inch Spheres	1.6	17.3	~460,000	~140,000
1 ¼ inch Spheres	12	130	~460,000	~140,000
9x9x1 inch Plates	600	6500	~127,000	~136,500
9x9x4 inch Blocks	1800	19,500	~381,000	~117,000

# Methods and Materials

- **Laboratory Trials – Columbus, OH**
  - Submerged Up-flow columns for nitrification
  - Submerged Up-flow columns for de-nitrification
  
- **Pilot Trials**
  - BGSU Marine Lab (Bowling Green, OH)
  - Aquarium of Niagara (Niagara Falls, NY)

# Pilot Trials

- Bowling Green State University Marine Laboratory – Bowling Green, OH
  - 800 Gallon Shark Tank
  - “Passive” de-nitrification in attached sump
- Aquarium of Niagara, Niagara Falls, NY
  - North Atlantic Tank (10,000 gallon)
  - Shark Tank (17,000 gallon)
  - Octopus Tank (1500 gallon)
  - Tidal Pool (175 gallon)
  - “Passive” biofiltration in “behind-scenes” sumps

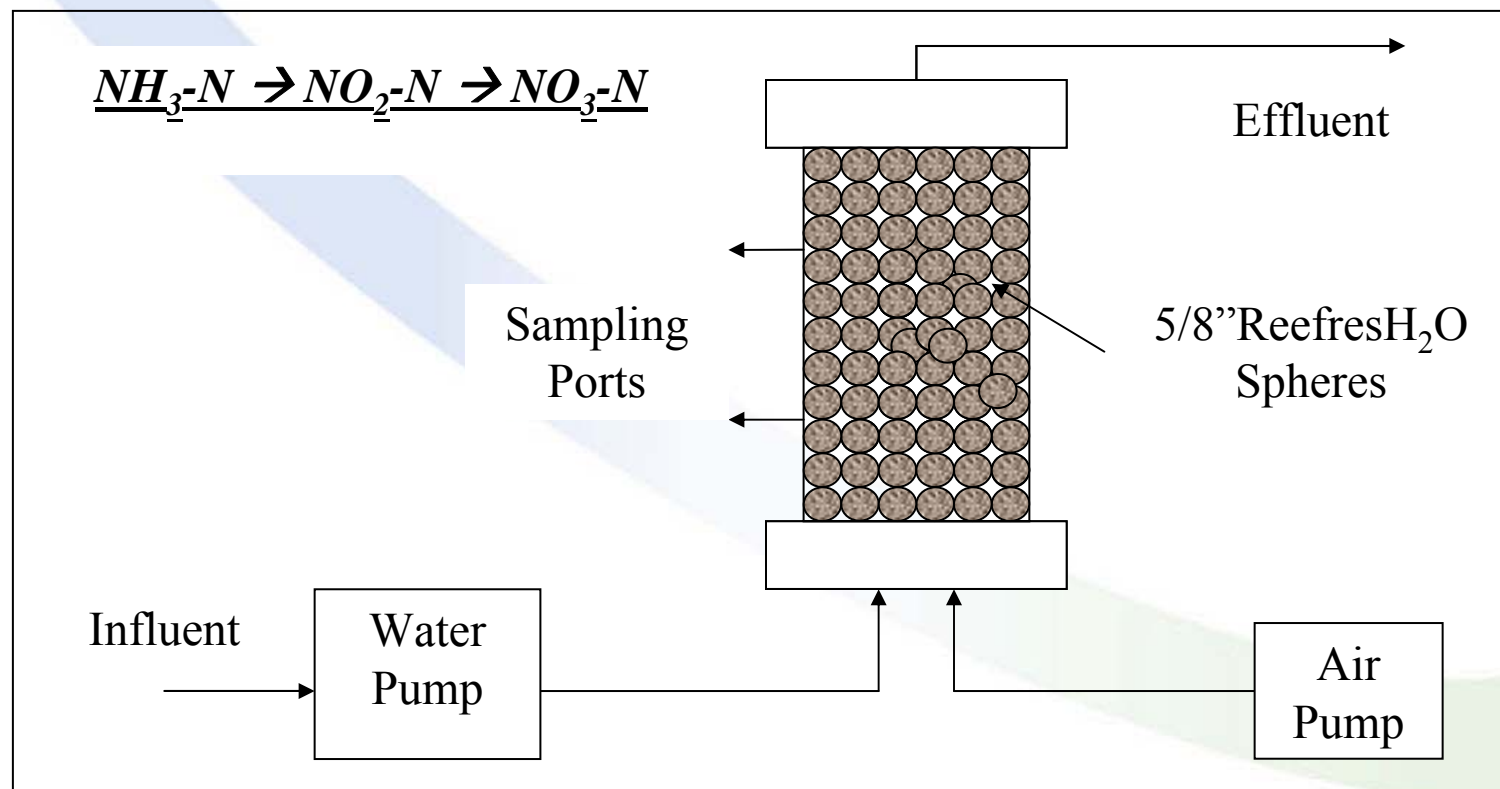
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# Results and Discussion

- Laboratory experiments
- Pilot installation trials

# Laboratory Trials – Columbus, OH

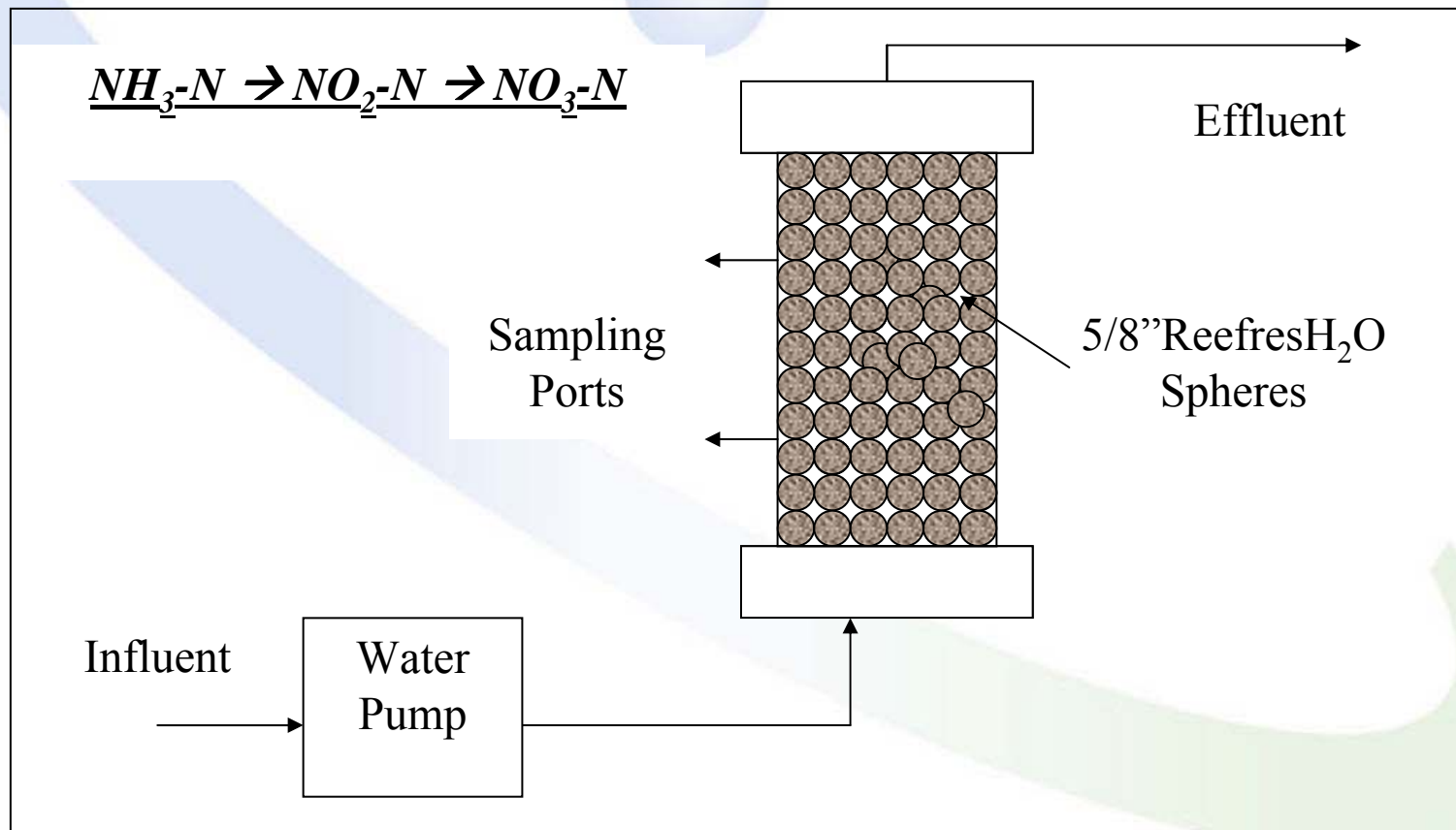
- 6 liter submerged up-flow nitrification with added air to maintain oxygen saturated water (Column I)





# Laboratory Trials – Columbus, OH

- 6 liter submerged up-flow column for nitrification without added air (Column II)

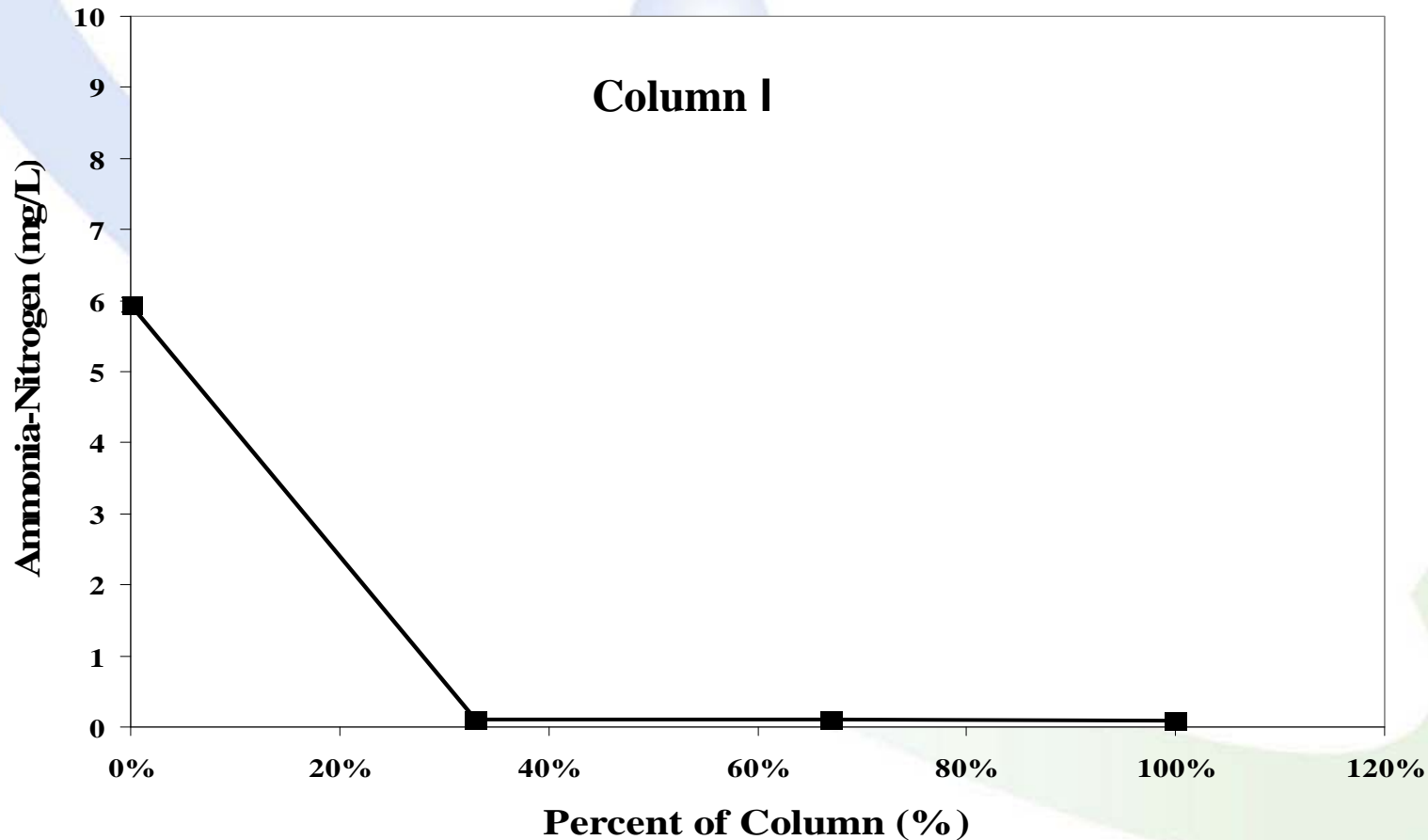


# Laboratory Results - Nitrification

Water Parameter	Influent Level	Effluent Level Column I Added Air	Effluent Level Column II Whole Column
Column Size	6 Liters (4 inch diameter by 30 inches long)		
Total Media	5.5 Liters of 5/8 inch Reefresh <sub>H2O</sub> Spheres pre-inoculated with Brightwell Aquatics Microbacter aerobic bacteria		
Flow Rate	200 ml/minute synthetic waste water (fresh)		
pH		~8	~8
Dissolved Oxygen	7.5	saturated	2.3 mg/L
Ammonia-Nitrogen	4-6 mg/L	< 0.1 mg/L	< 2 mg/L
Nitrite-Nitrogen	0-2 m/L	< 0.1 mg/L	< 2 mg/L
Nitrate-Nitrogen	2-5 mg/L	< 10 mg/L	< 7 mg/L
Nitrification Rate		<b>3.41 g/day</b> <b>620 mg/L/day</b>	<b>0.88 g/day</b> <b>160 mg/L/day</b>

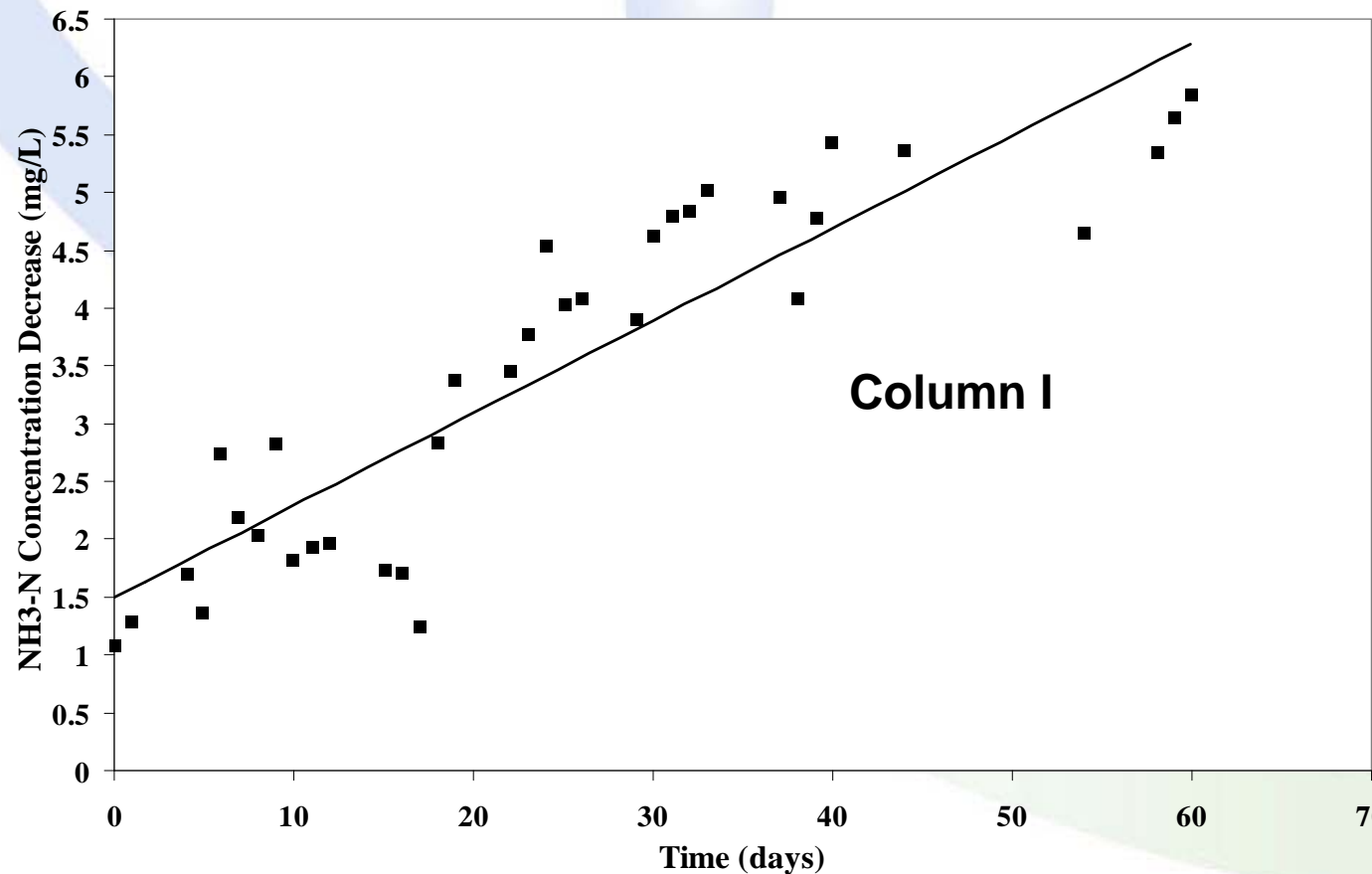
# Laboratory Nitrification with Added Air

## Ammonia Reduction Along Column Height

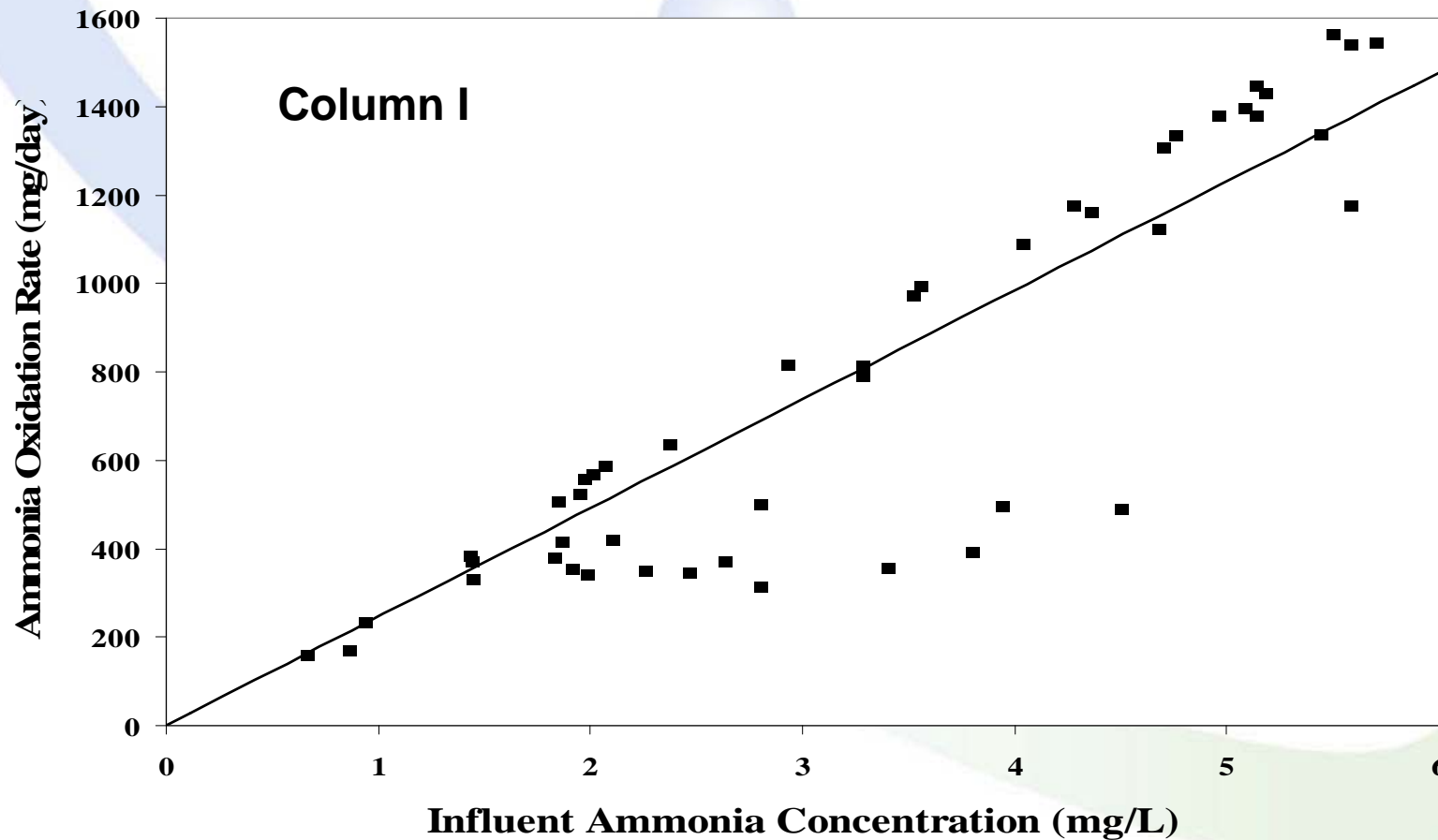


# Laboratory Nitrification with Added Air

## Ammonia Reduction Performance versus Time

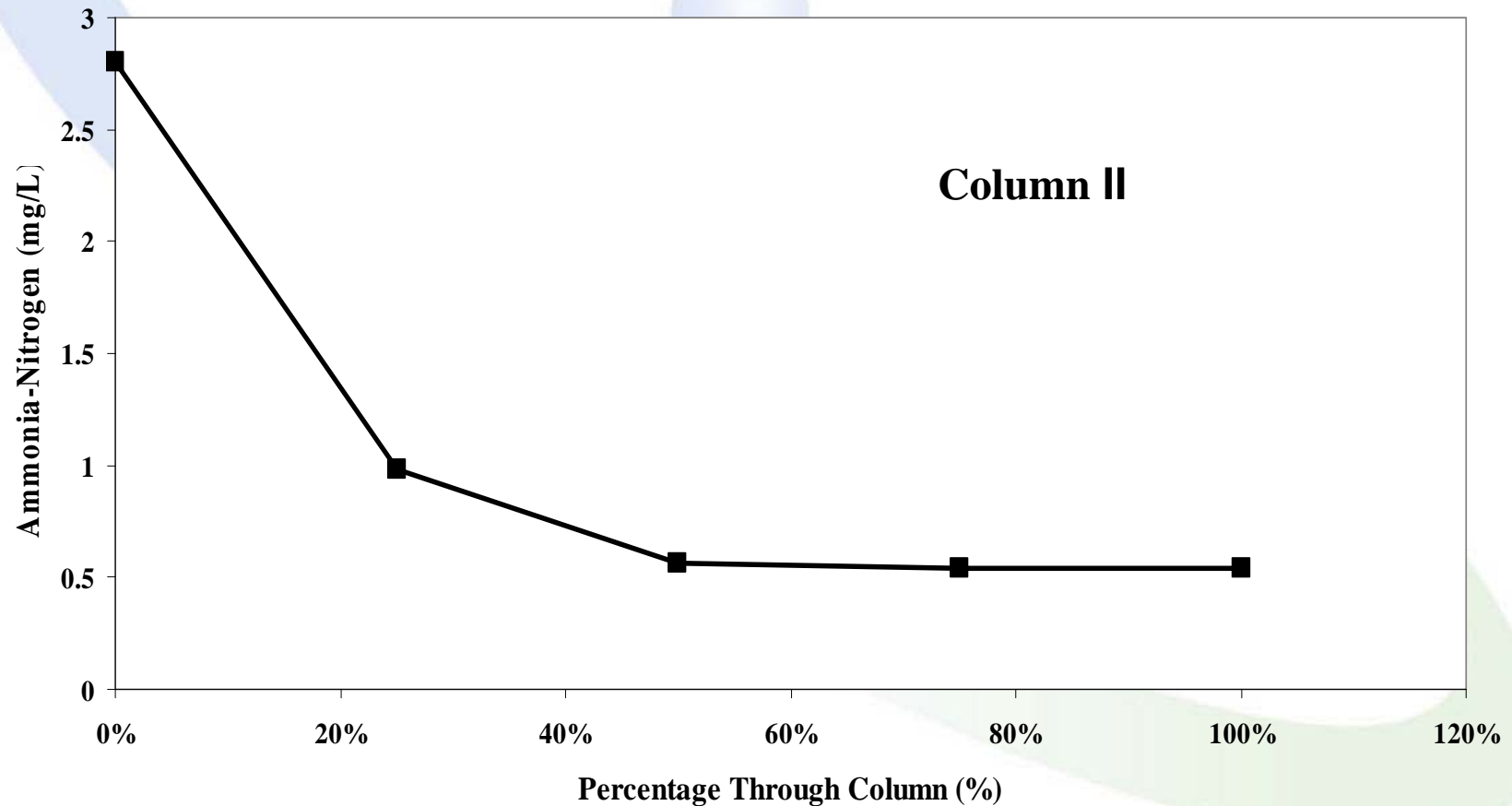


# Laboratory Nitrification with Added Air Ammonia Reduction versus Concentration



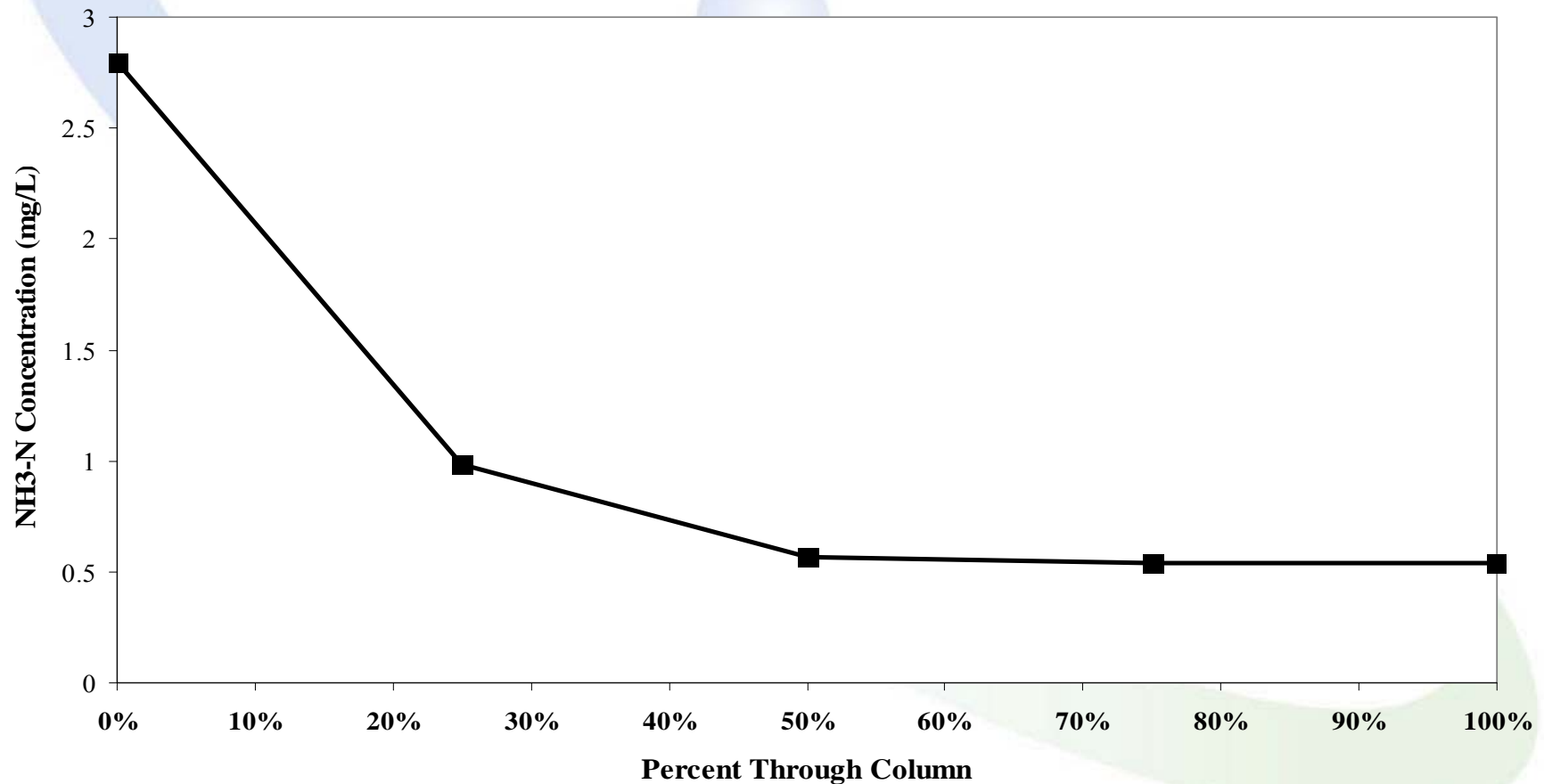
# Laboratory Nitrification without Air

## Ammonia Reduction Along Column Height



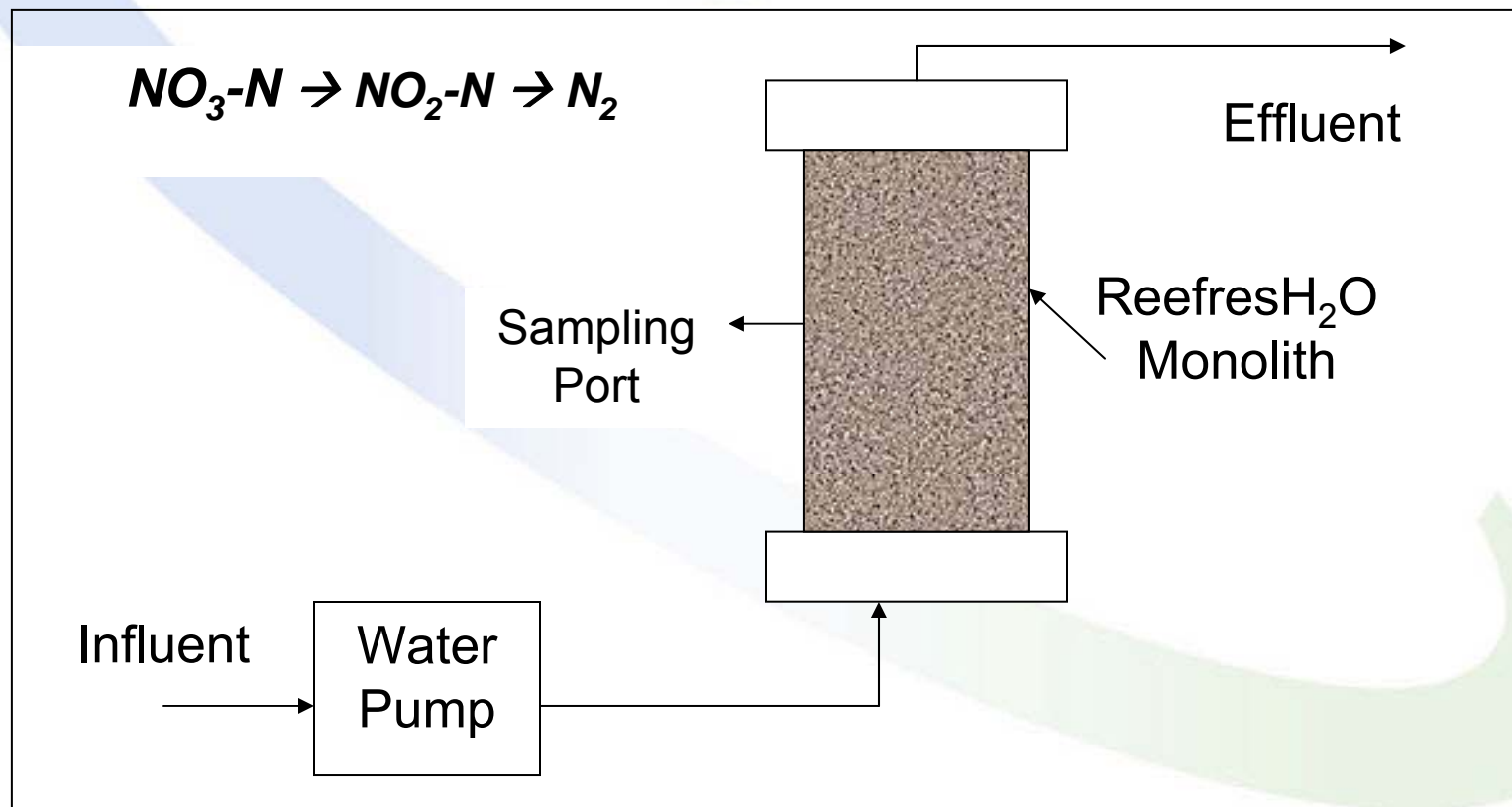
# Laboratory Nitrification without Air

## Ammonia Reduction Along Column Height



# Laboratory Trials – Columbus, OH

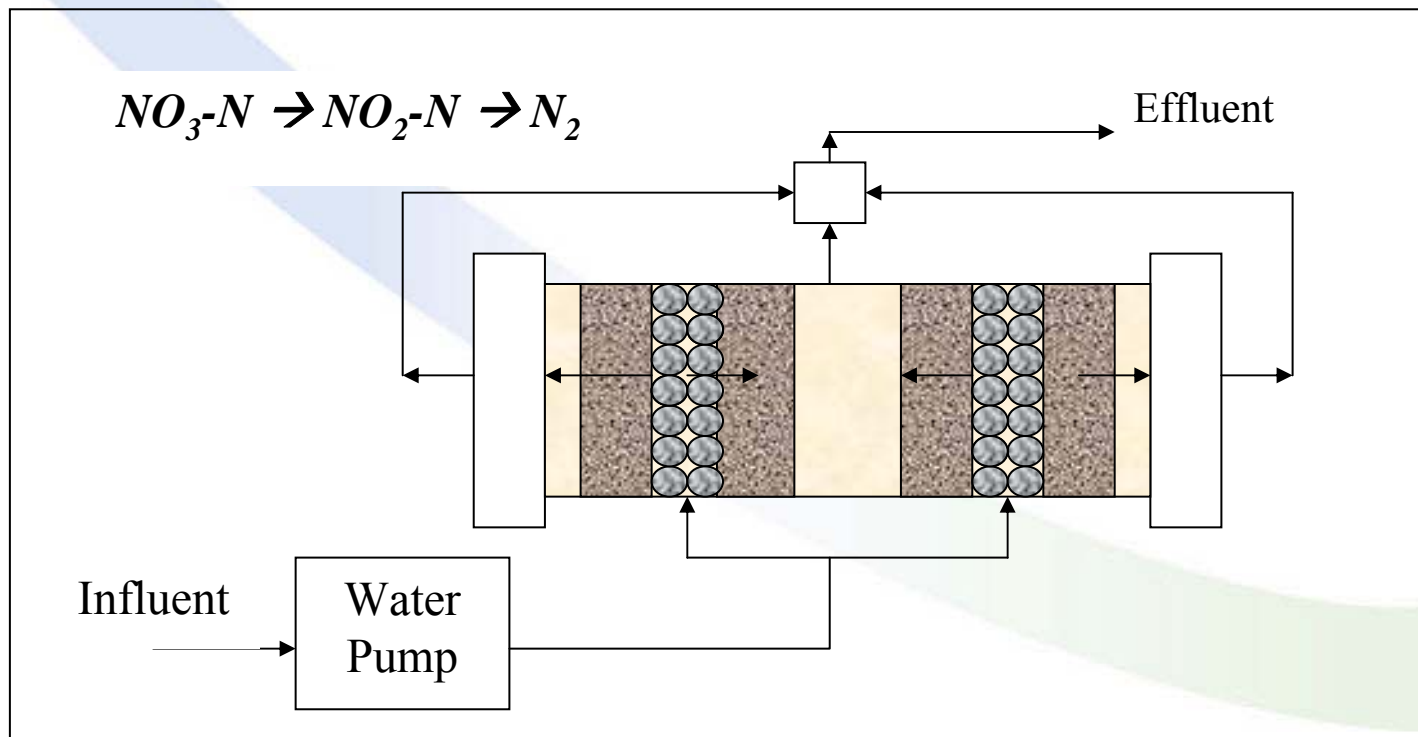
Laboratory evaluation using submerged up flow column for de-nitrification (Column III)





# Laboratory Trials – Columbus, OH

Laboratory evaluation using horizontal submerged up-flow column for de-nitrification (Column IV)



# Laboratory Trials – De-Nitrification

<b>Water Parameter</b>	<b>Effluent Level Column III Vertical</b>	<b>Effluent Level Column IV Horizontal</b>
Column Size	600 ml (2 inch diameter by 12 long)	2 Liter (4 inch diameter by 8 long)
Total Media	550 cc monolith pre-inoculated with Eco Labs Special Blend	Combined spheres and monolithic disks pre- inoculated Special Blend
Flow Rate	150 ml/minute	150 ml/minute
Residence Time	~ 4 minutes	~ 12 minutes

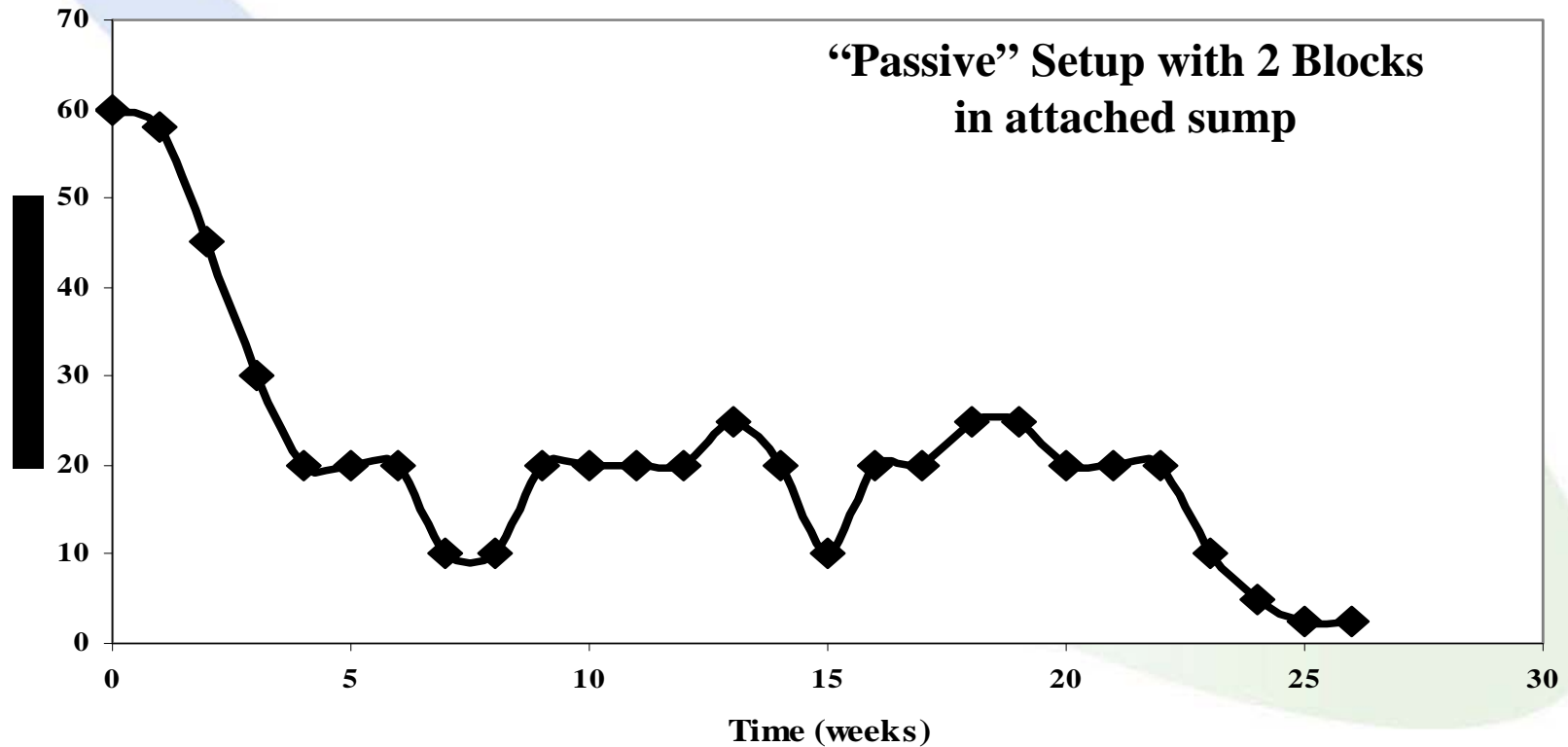
# Laboratory Trials – De-Nitrification

Water Parameter	Influent Level	Effluent Level Column III Vertical	Effluent Level Column IV Horizontal
pH	~8	7.5-7.9	7.5-7.9
Dissolved Oxygen	5-7 mg/L	2-4 mg/L	2-4 mg/L
Ammonia-Nitrogen	0-2 mg/L	< 0.1 mg/L	< 0.1 mg/L
Nitrite-Nitrogen	0-2 mg/L	< 0.1 mg/L	< 0.1mg/L
Nitrate-Nitrogen	40-50 mg/L	~ 16 mg/L	< 7 mg/L
De-Nitrification Rate		<b>7.1 g/day</b> <b>14 g/L/day</b>	<b>8.9 g/day</b> <b>5.23 g/L/day</b>
7-9 grams of Nitrate-Nitrogen removal amounts to ~ 2 mg/L in a 1000 gallon tank and is associated with a feed rate > ½ pound of 40% protein feed			

# Pilot Trials – BGSU 800 Gallon Tank

## Contents:

One three foot Bamboo shark, one 16 inch Emperor Snapper, two foot long Half Moons, one 10 inch Zebra Chub

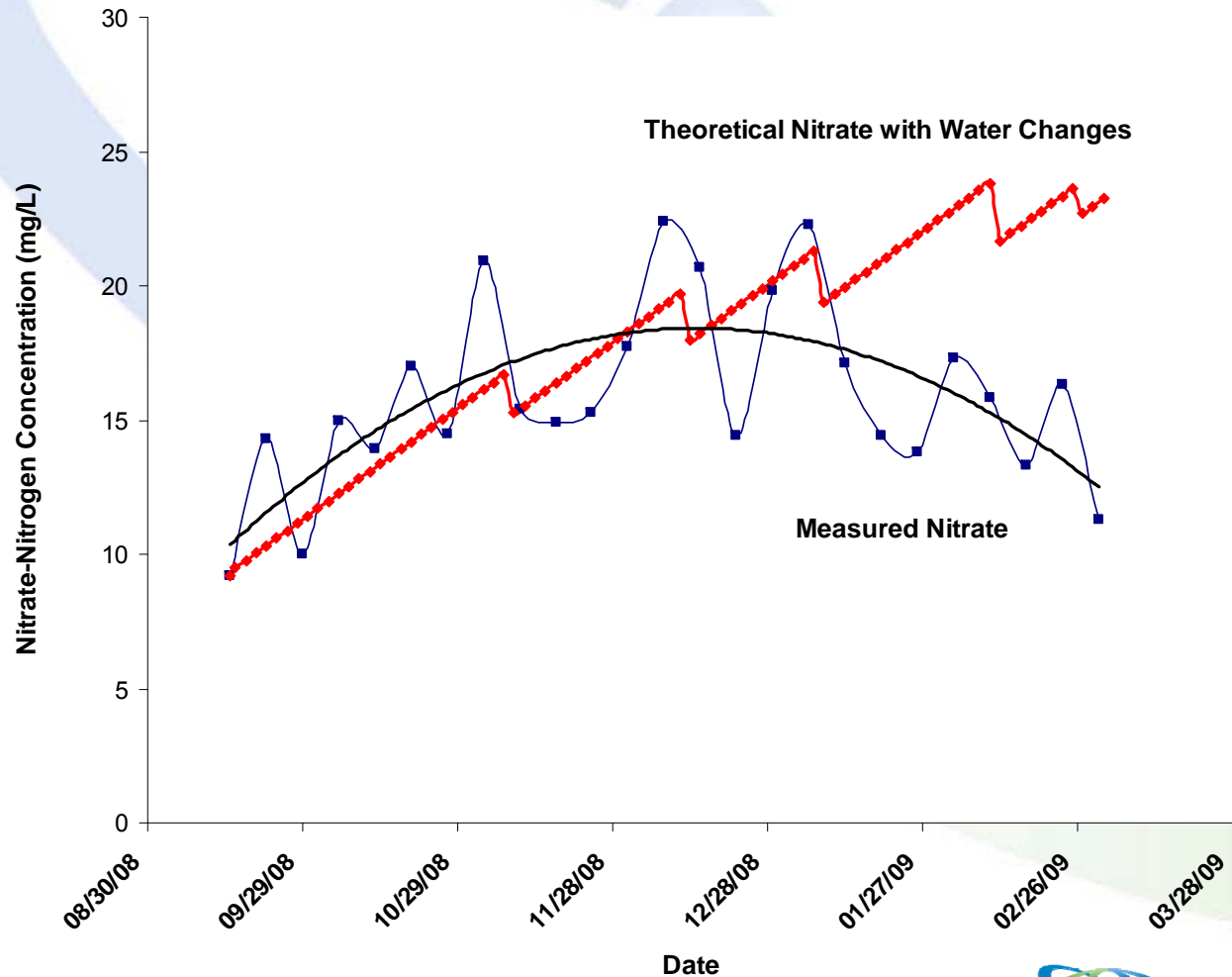


# Pilot Trials - Aquarium of Niagara

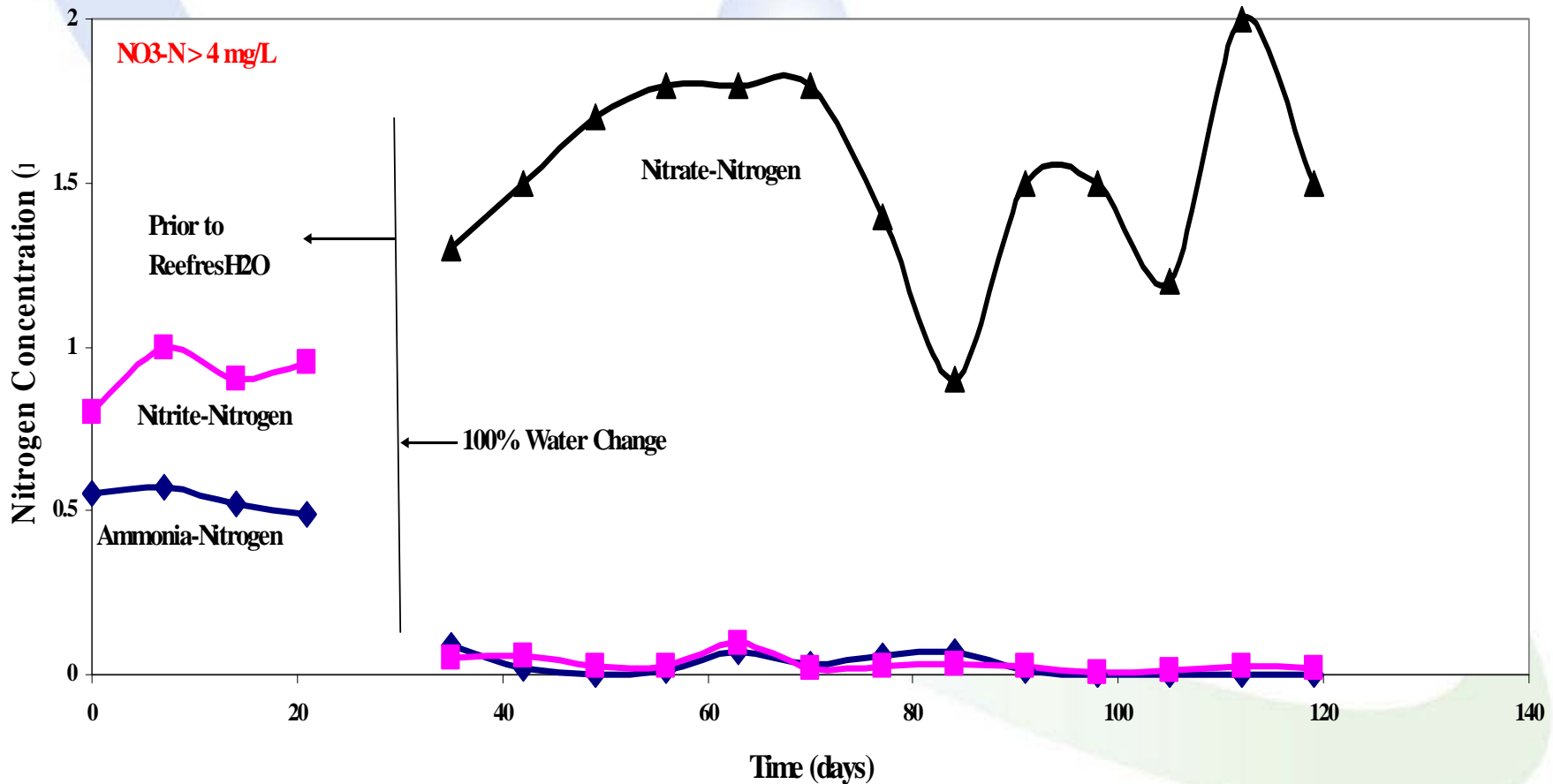
- “Passive” systems with 9x9x4 blocks added to sump
- Initial set up and operating parameters

Tank Description	Operating Conditions and Set Up			
	Temperature (°F)	Total Gallons	# of ReefresH <sub>2</sub> O Blocks	Volumetric Ratio (Water: ReefresH <sub>2</sub> O)
North Atlantic	56	10,000	12	594:1
Shark Tank	73	17,000	17	714:1
Octopus Tank	49	1,500	5	143:1
Tidal Pool	52	175	4	31:1

# Aquarium of Niagara 17,000 Gallon Shark Tank Trickle Filter with “Passive” ReefresH<sub>2</sub>O Blocks



# Aquarium of Niagara 1500 Gallon Octopus Tank



# Aquarium of Niagara Water Savings

Tank Description	Amount Water	Previous Weekly Change	New Weekly Change	Savings and Benefits
North Atlantic Tank	10,000 gallons	10-15% bi-weekly (estimated)	Proposed 10-15% monthly	~\$2,000 to 3,000
Shark Tank	17,000 gallons	10 % bi-weekly	10% monthly	\$3,250
Octopus Tank	1500 gallons	65 % weekly	20 % weekly	\$3,150 plus no nitrites
Tidal Pool	175 gallons	New set up, emphasis is on water clarity and healthier environment		

\* PLUS, Savings do not include cost of labor, but do include cost of ReefreshH2O



# Future Work

- Connect nitrification and de-nitrification columns together to show one pass total nitrogen control in laboratory setting
- Continue to work with Aquarium of Niagara to create higher efficiency biofiltration in smaller footprint filters
- Establish working relationship with other Public Aquariums
- Explore use of ReefresH<sub>2</sub>O in high density Aquaculture fish populations

# Acknowledgements

## ➤ Aquarium of Niagara

- Nancy Chapin, Executive Director
- Dr. F. E. Latson, MS, DVM
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- Chris Thompson
- Maurice Belisle

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# Questions / Discussion

Thank You