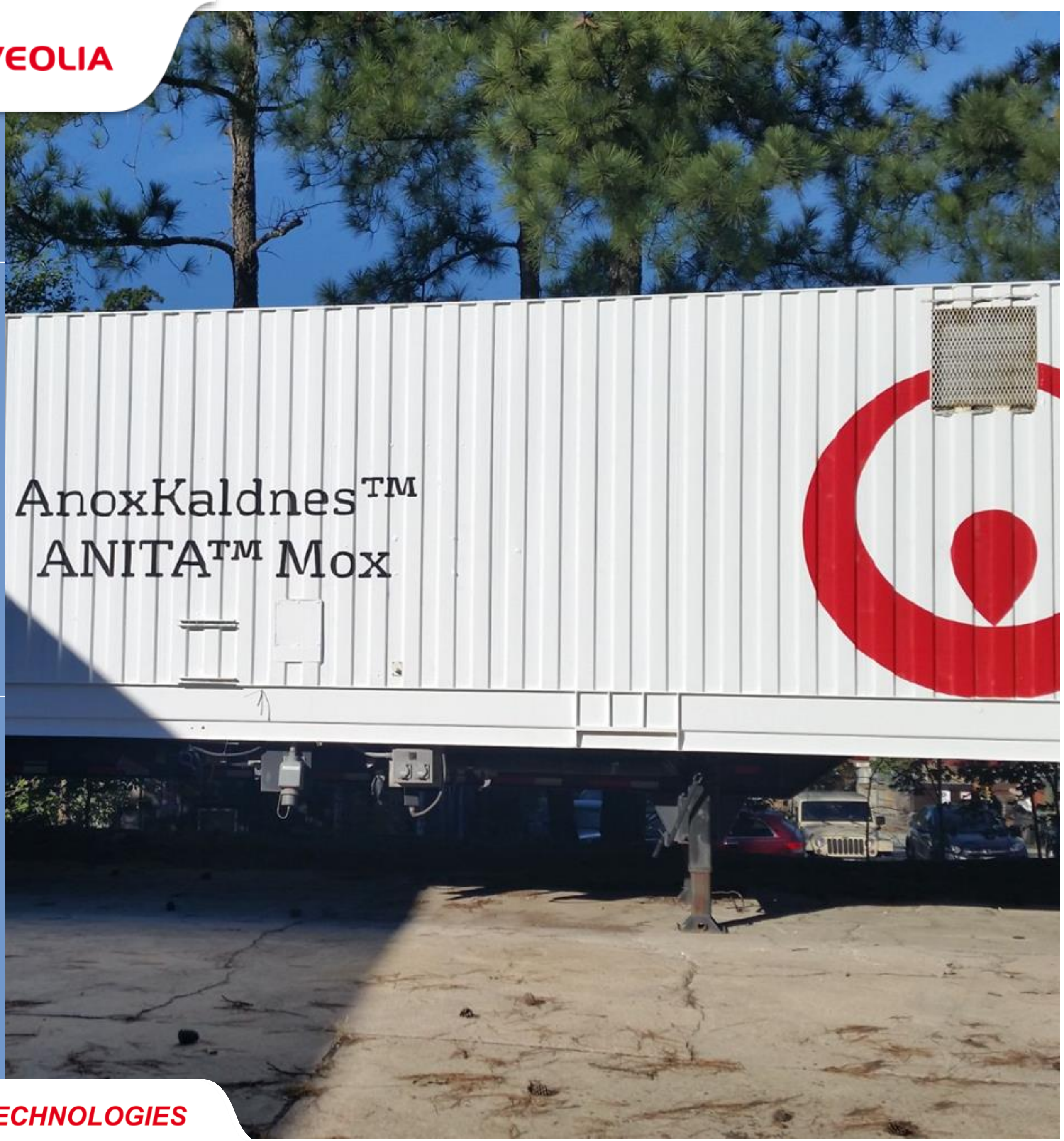
# First Hand Operating Experience of ANITA™ Mox Deammonification Through Long-Term Pilot Studies

Wednesday August 18th, 2021
2:00pm – 2:45pm EST

**Presenters**
Larry Li, Veolia Water Technologies, NC
Yang Oh Jin, Sioux City, IA
Hana C. Long, LACSD, CA
Michael Liu, LACSD, CA






WATER TECHNOLOGIES

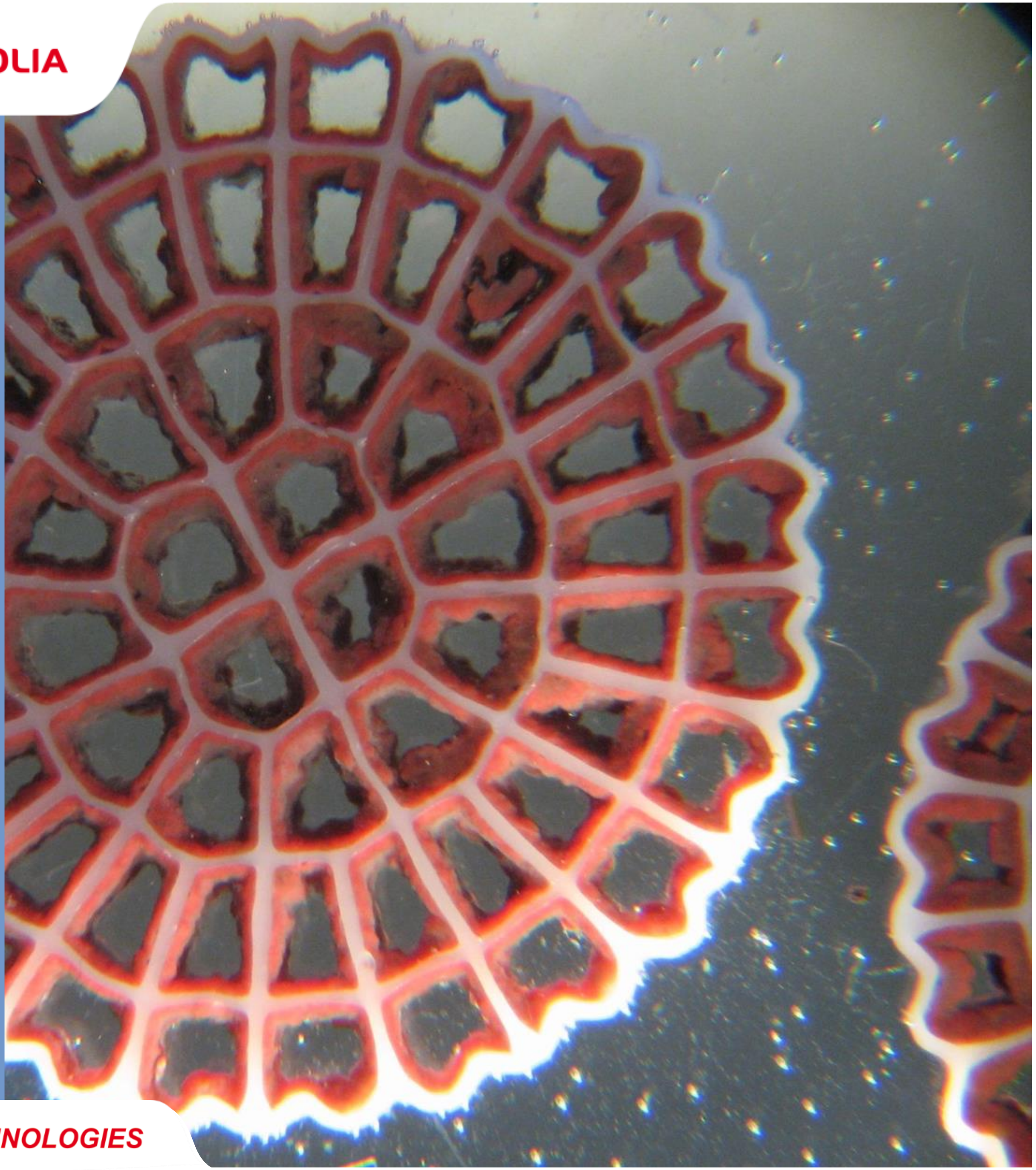
# SPEAKER INTRODUCTION

**Larry Li**
*Product Manager*
*Veolia Water Technologies (dba Kruger)*

**Yang Oh Jin**
*Utilities Program Manager*
*City of Sioux City*

**Hana C. Long**
*Project Engineer*
*LA County Sanitation Districts*

**Michael Liu**
*Supervising Engineer*
*LA County Sanitation Districts*



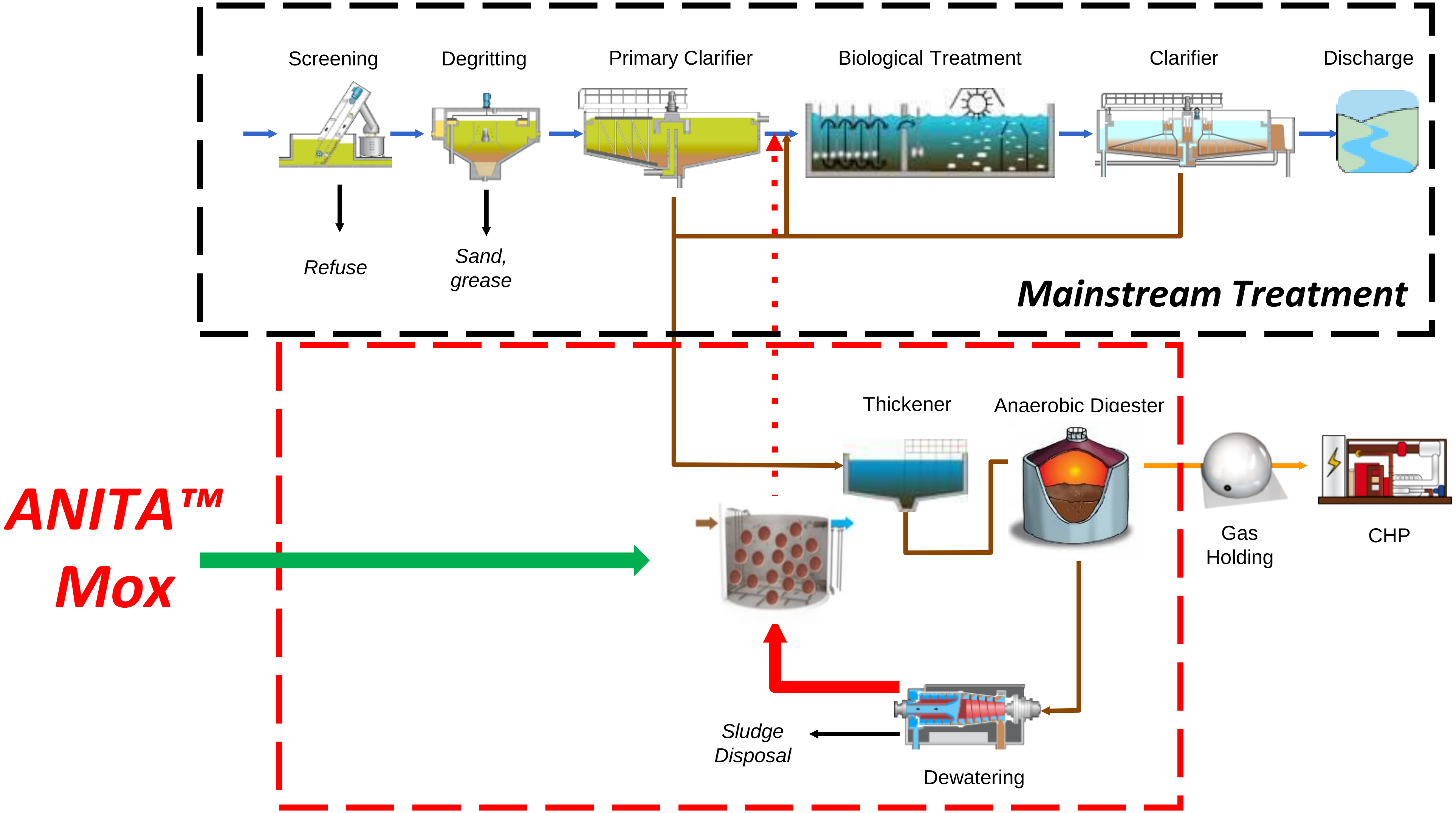
# *Topics of Discussion*

- **ANITA™ Mox Deammonification Process**
  - Principle
  - System
  - Project Update

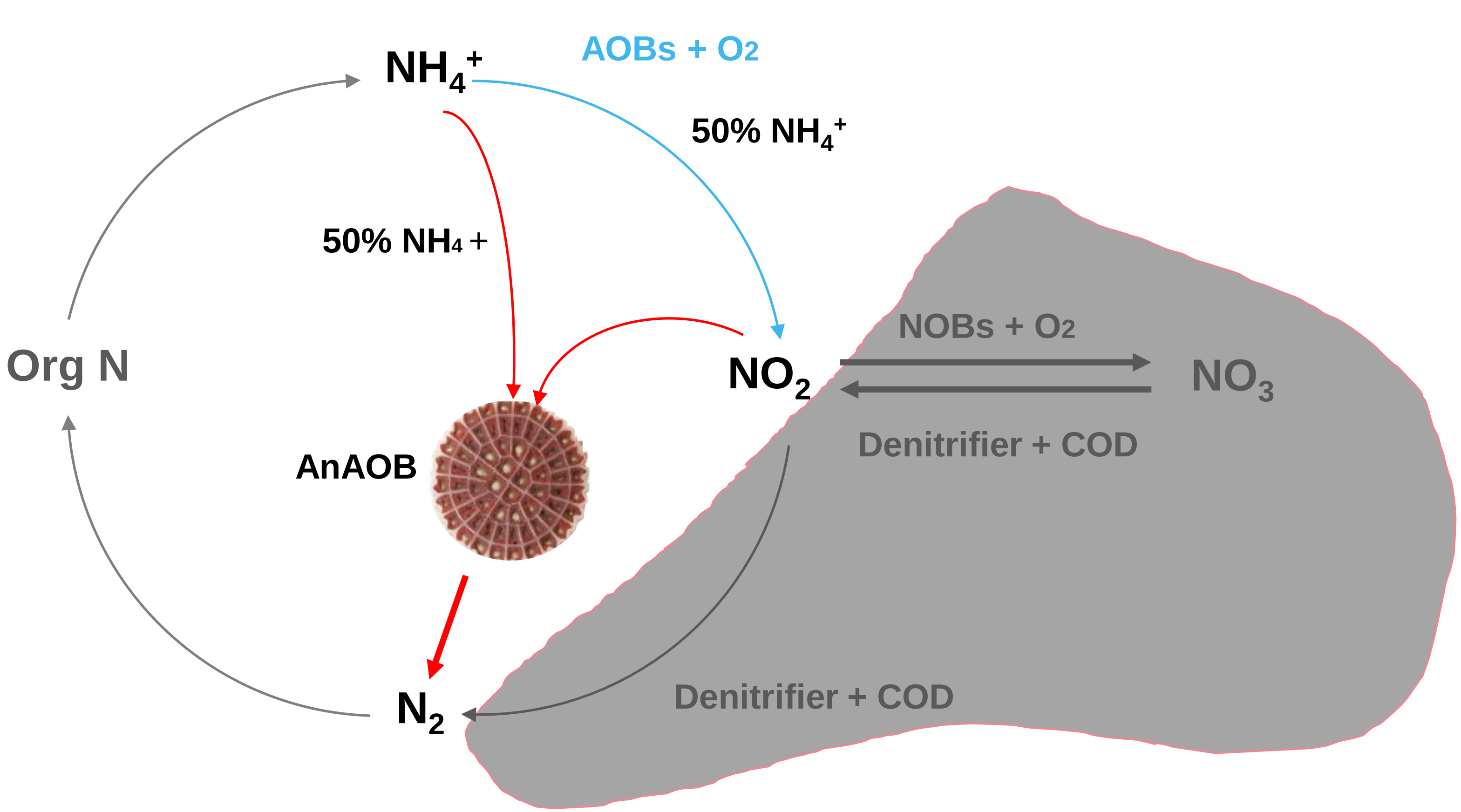
- **Sioux City Pilot Study**
  - Background
  - Pilot Drivers
  - Results

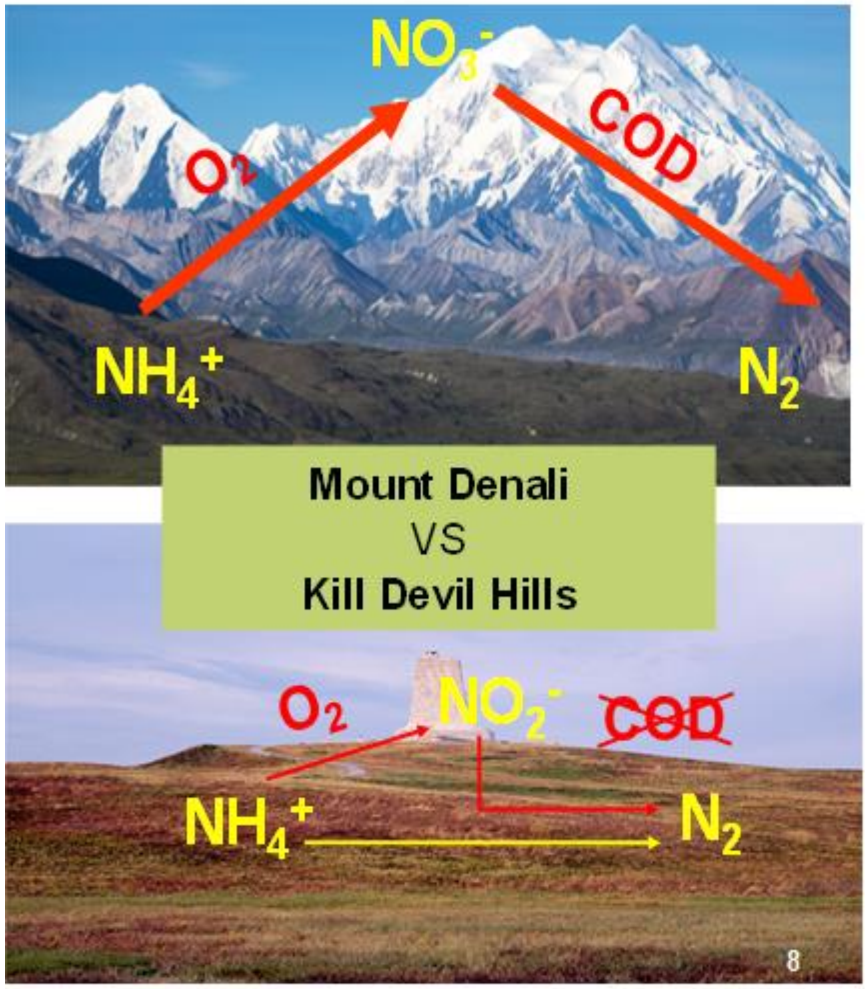
- **LA County Pilot Study**
  - Background
  - Pilot Drivers
  - Results

# ANITA™ Mox for Centrate/Filtrate Treatment



# ANITA™ Mox for Simplified Deammonification




Saves 60% O2 and 100% Carbon, 90% Sludge Reduction

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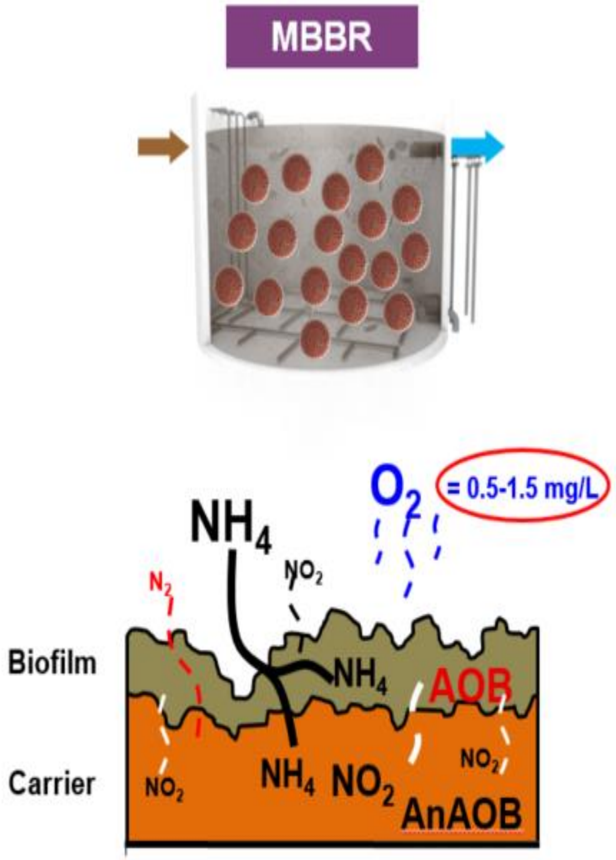
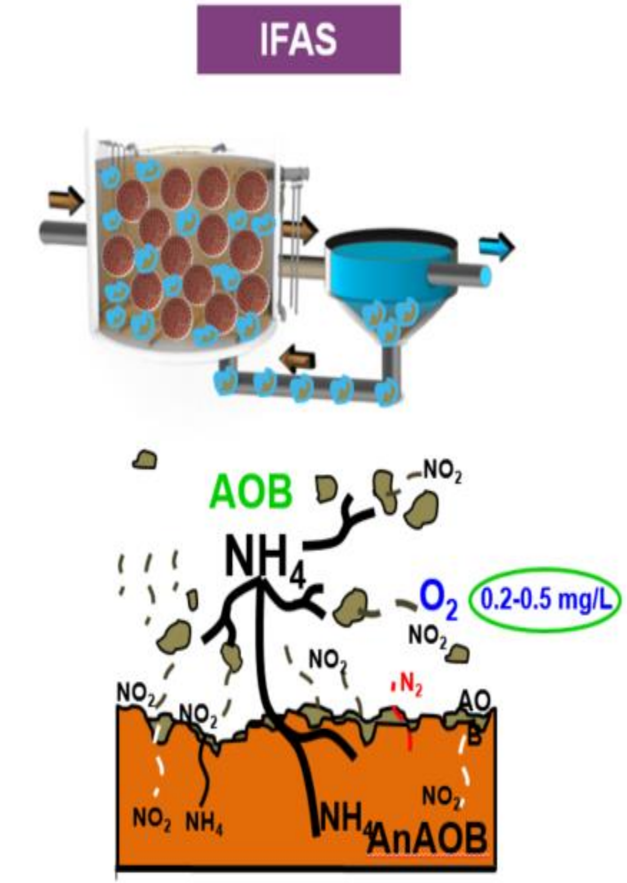
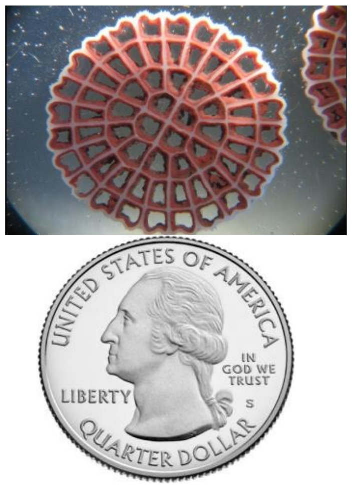
# Two Process Options for Flexibility & Expansion




AOB in biofilm = $NO_2^-$ limitation




AOB in flocs = less $NO_2^-$ limitation

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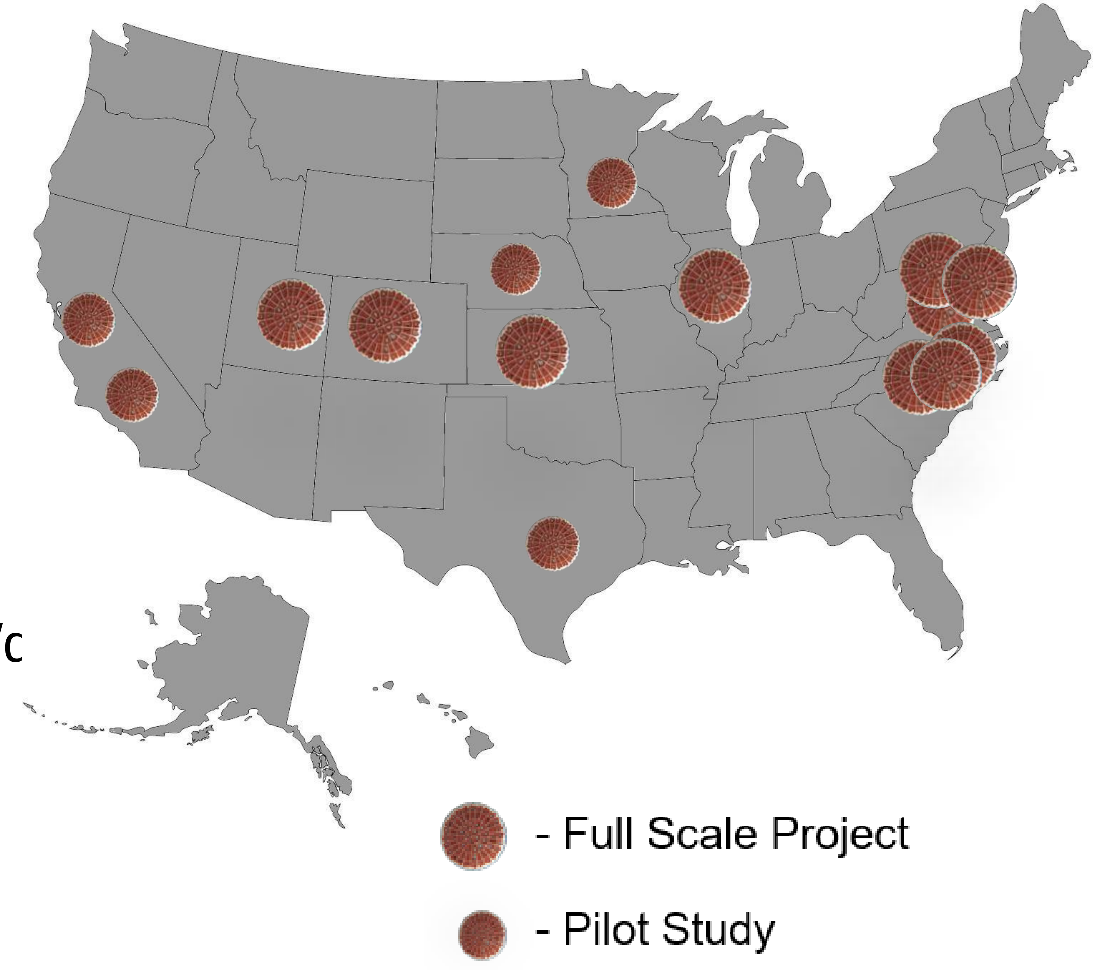
# Biofilm Technology Proven to Be Simple, Stable & Robust

- Operator friendly technology
- Resilient, works with flexible dewatering schedules
- Minimal operation and maintenance requirements
- Biofilm technology, significant lower risk of anammox washout
- Tolerate high range of TSS, polymer, DO, pH, NO2 residue etc.
- Greater protection from shocks/toxicity
- Reuse existing tanks, wide water depth (10-30ft) and geometry
- Capacity increase by adding more media, phased approach for expansion

# A Decade of Experience & 38 Plus Projects, 10 Plus in the US

- James River TP, VA (HRSD) (2014) – 550 lbs/day
- South Durham WRF, NC (2015) – 700 lbs/day
- Egan WRP, Chicago, IL (2016) – 2,000 lbs/day
- Denver Metro, CO (2017) – 9,000 lbs/day
- Howard County MD (2018) – 2,000 lbs/day
- Tomahawk Creek, KS (2021) – 950 lbs/day
- WSSC, MD (THP, 2022) – 5,700 lbs/day
- Central Valley, UT (2022) – 2,000 lbs/day
- North Durham NC (bid) – 700 lbs/day
- Raleigh Neuse NC (THP, bidding soon) – 3,400 lbs/c
- Other Preselected Projects



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# Sioux City – Plant Overview

## Sioux City WWTP

Flow rate~13 MGD
Service Population ~105,000
Wastewater from 3 states
and 2 EPA Regions (7&8)

- ~40 IU's ~400 FSE's
- Dakota Dunes
- Sgt. Bluff
- South Sioux City
- North Sioux City
- Sioux City

> Sioux City has the largest concentration of food industries in the United States.
>
> -Environmental Protection Agency

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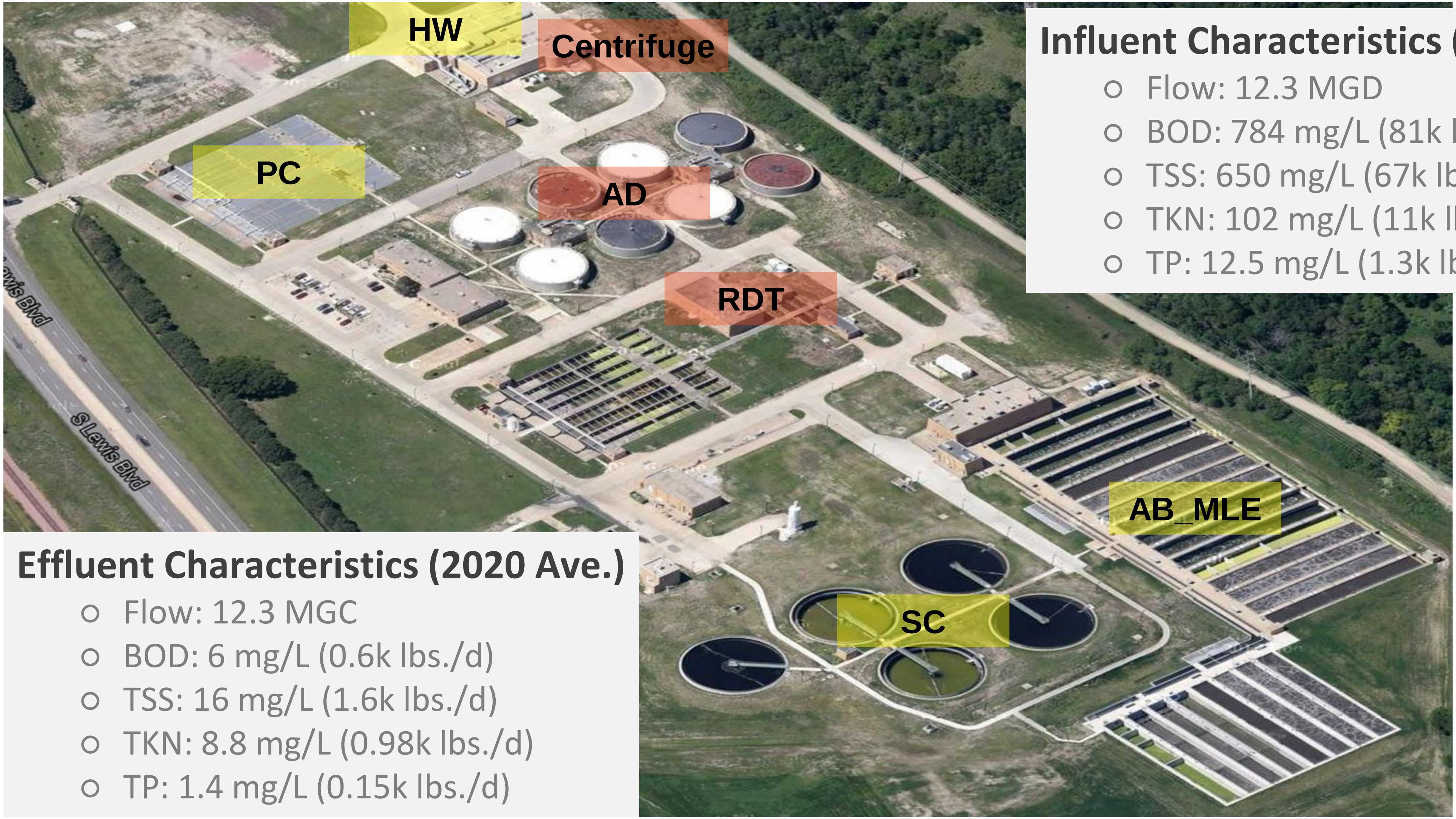
# Sioux City – Plant Overview



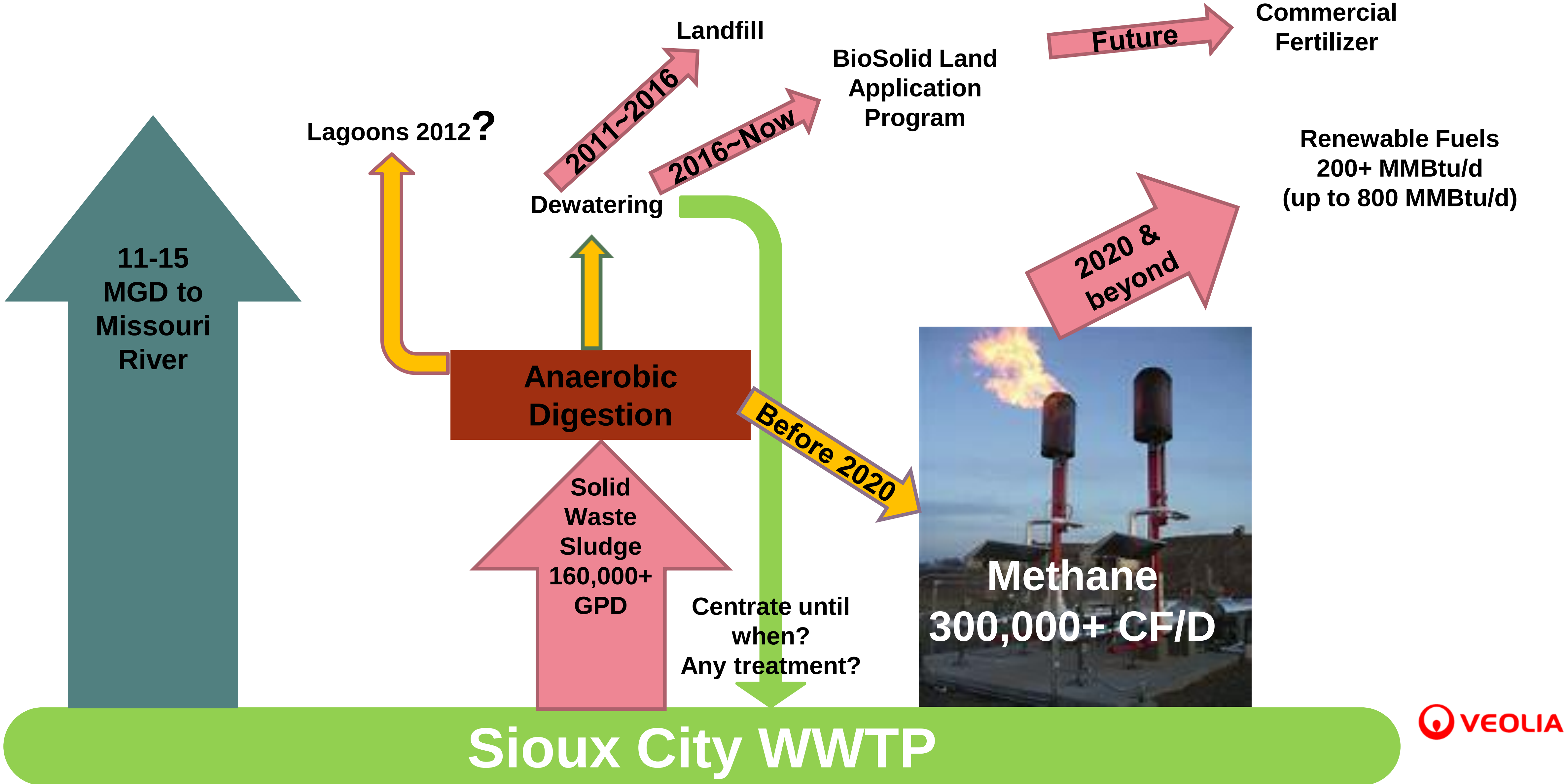

## Influent Characteristics (2020 Ave.)

- Flow: 12.3 MGD
- BOD: 784 mg/L (81k lbs./d)
- TSS: 650 mg/L (67k lbs./d)
- TKN: 102 mg/L (11k lbs./d)
- TP: 12.5 mg/L (1.3k lbs./d)

## Effluent Characteristics (2020 Ave.)

- Flow: 12.3 MGC
- BOD: 6 mg/L (0.6k lbs./d)
- TSS: 16 mg/L (1.6k lbs./d)
- TKN: 8.8 mg/L (0.98k lbs./d)
- TP: 1.4 mg/L (0.15k lbs./d)

# Sioux City – Plant Update History

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# Sioux City – Nutrient Reduction Strategy

## Timeline of NRS Report

- March 2017: First report to IDNR
- April 2020: IDNR requested City to perform new feasibility study
  - Flow change of industrial WW and flood
- December 2021: New Due date for NRS final report

## NRS Target

- 10 mg/L of TN & 1 mg/L of TP in final effluent
- 66% of TN and 75% of TP reduction (1-effluent/influent)

# Sioux City – ANITA™ Mox Pilot Test Overview

## Sioux City Centrate Characteristics

| Parameter | Units | Average | Standard deviation |
|---|---|---|---|
| COD | mg/L | 2,935 | 1,920 |
| Soluble COD | mg/L | 1,455 | 440 |
| $BOD_5$ | mg/L | 205 | 225 |
| Soluble $BOD_5$ | mg/L | 35 | 20 |
| TSS | mg/L | 1,540 | 1,860 |
| VSS | mg/L | 1,075 | 1,315 |
| TKN | mg/L | 880 | 185 |
| NH4-N | mg/L | 755 | 100 |
| Alkalinity | mg/L | 3,000 | 440 |
| Temperature Range | °C | 27.1 | 3.8 |

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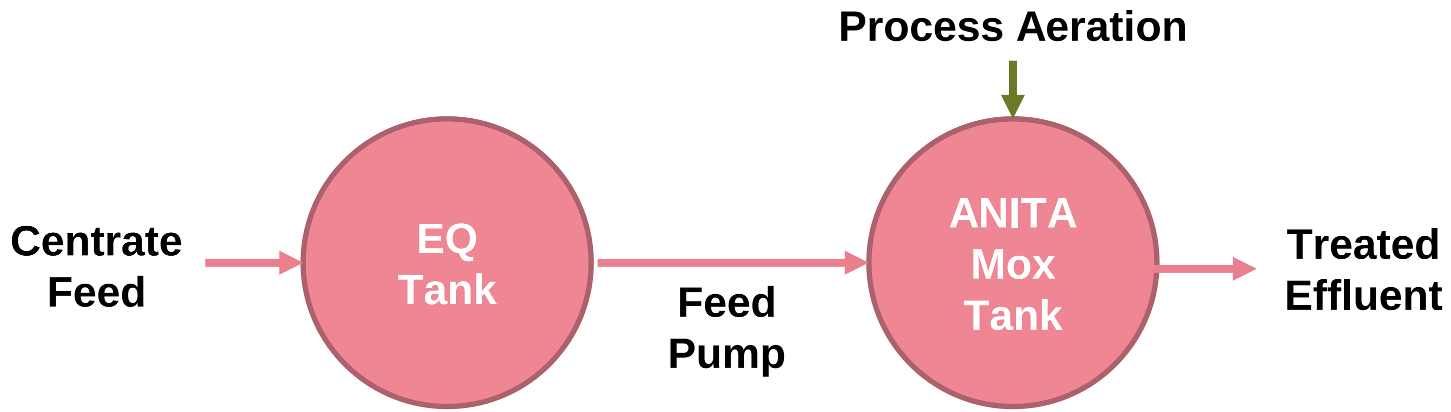
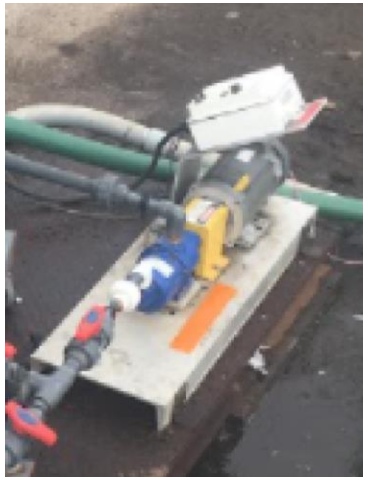
# Sioux City – ANITA™ Mox Pilot Test Overview

## Sioux City Pilot Schematic Diagram



### ANITA™ Mox Tank

- Active volume: 800 gal
- Media fill: 320 gal (40%) – Added 100% startup date

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# Sioux City – ANITA™ Mox Pilot Test Overview

## Testing Objectives

- Feed flow: 0.6 gpm (about 1 day HRT)
- Ammonia Removal efficiency: 80%

## Testing Schedule

| Pilot Study Schedule | | Start Date | End Date | Duration |
|---|---|---|---|---|
| Startup | Kruger onsite for pilot setup, biomass development | 3/02/2020 | 4/09/2020 | 6 weeks |
| Operation | Phase I: Steady Operation | 4/10/2020 | 11/17/2020 | 7 months |
| | Phase II: Robustness testing | 11/18/2020 | 3/31/2021 | 5 months |
| Total Pilot Duration | | 13 months | | |

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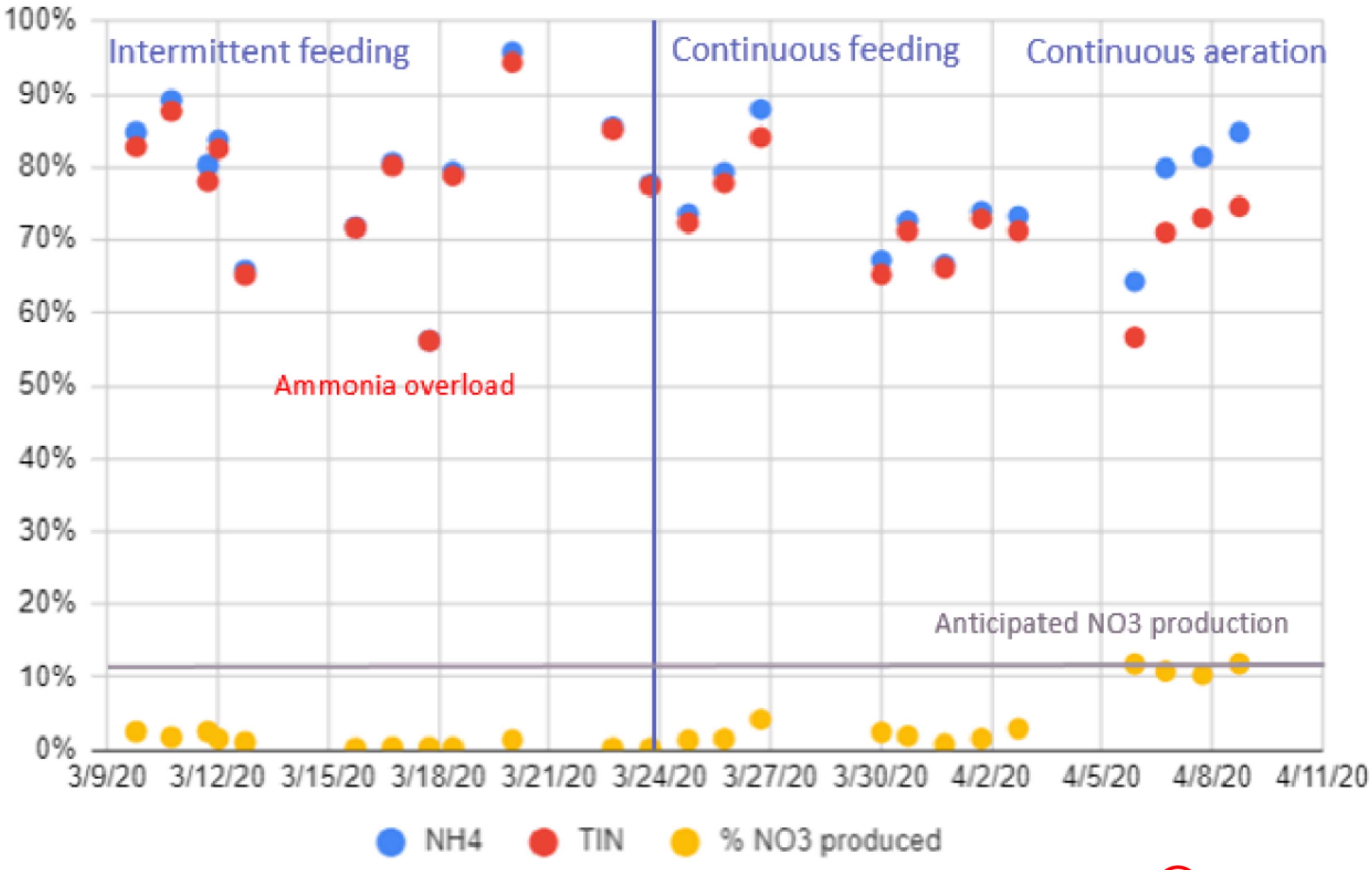
# Sioux City – ANITA™ Mox Pilot Test Results

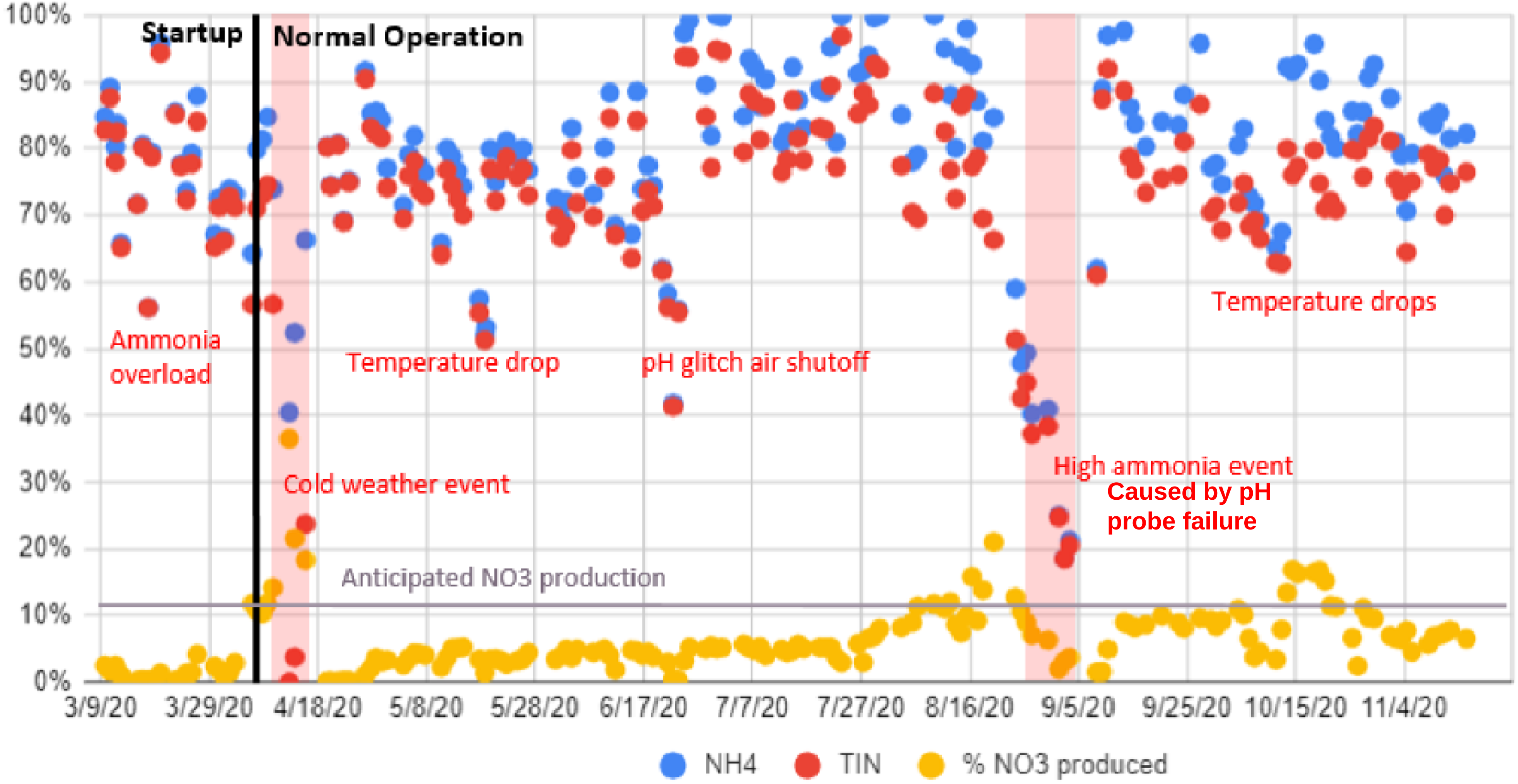
**Startup Phase (3/2/20–4/9/20)**

- Initial media loading: 40%
- Flow: 0.2 gpm
- Inf. Ammonia: 900 mg/L → eff.: 250 mg/L (72% removal rate)



# Sioux City – ANITA™ Mox Pilot Test Results

## Phase I (4/10/20 – 11/17/20: Steady Operation) – the most stable operational period

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# Sioux City – Summary & Conclusions

## Positive Outcomes

- No Anammox bacteria washout under high influent TSS (>3,400 mg/L)
- Overall ammonia removal performance was 70-90%
- No high TSS issue
- Stable operation under several stress conditions
- No NOB activity found
- Recovery time from stress conditions was within days

# Sioux City – Stress Conditions

## Robustness Testing – Subzero Ambient Temp.

- EQ tank was not maintaining the proper temp.
- Immersion heater was installer in the EQ tank

## Compressor Shutoffs

- The EQ tank & compressor unit were installed in centrifuge room
- The odor control system was malfunctioning ⟶ High $H_2S$
- Opening the door resulted in lowering the temperature

## Struvite Formation

- Struvite precipitation occurred in the EQ tank, Influent pump, and influent line ⟶ frequent clogs ⟶ lack of reliable centrate volume

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# Sioux City – Other Issues

## Failure of pH & DO probe

- Effluent ammonia concentration very high or low → recovered within few days

## Near starvation condition

- Extremely low effluent ammonia and high removal rate → when flow went back to normal, anammox activity was good

## BOD spike

- High effluent ammonia due to not enough oxygen → add non-potable water to reduce ammonia in the reactor (in full scale, DO control method would be overcome this issue)

# *Topics of Discussion*

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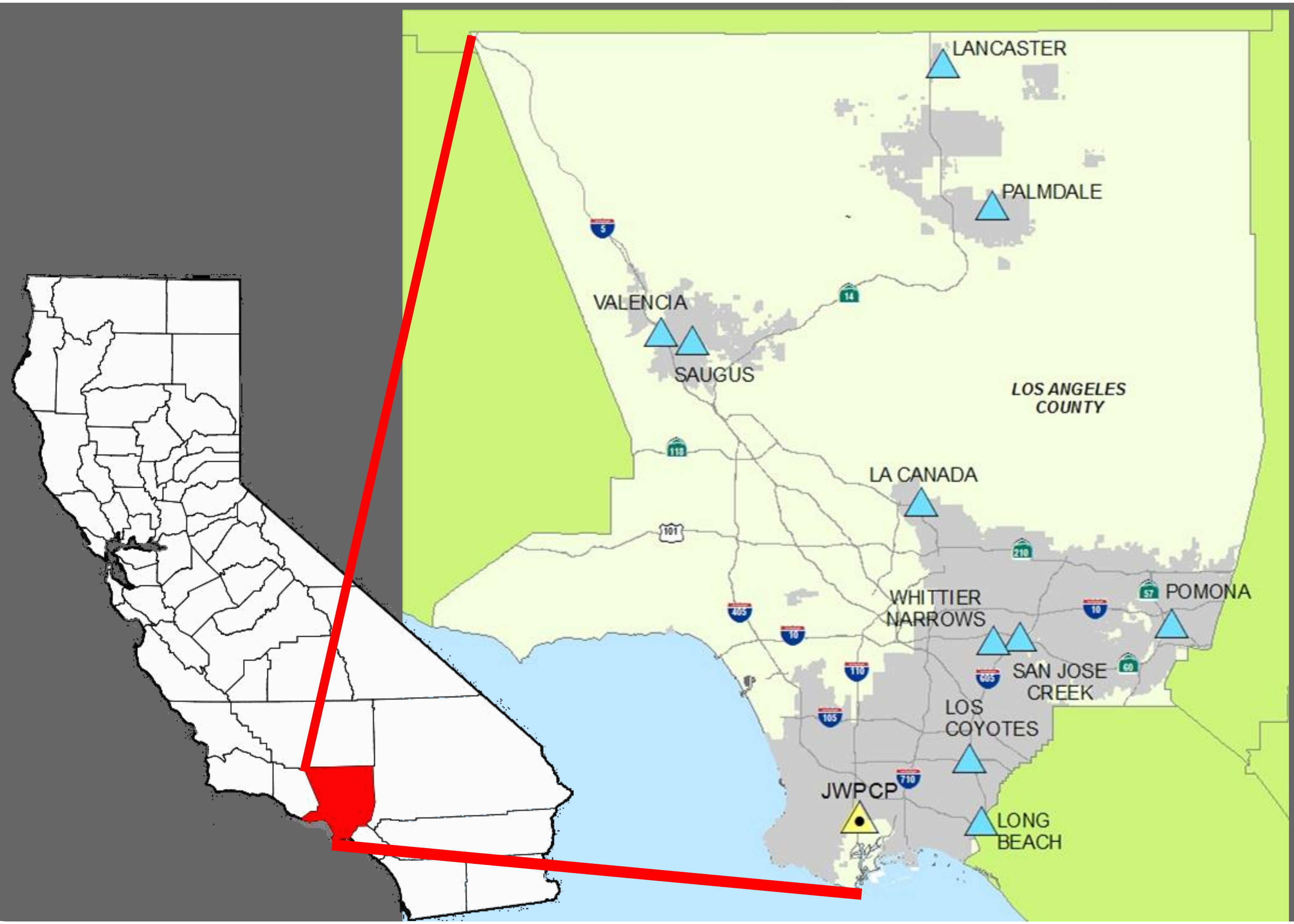
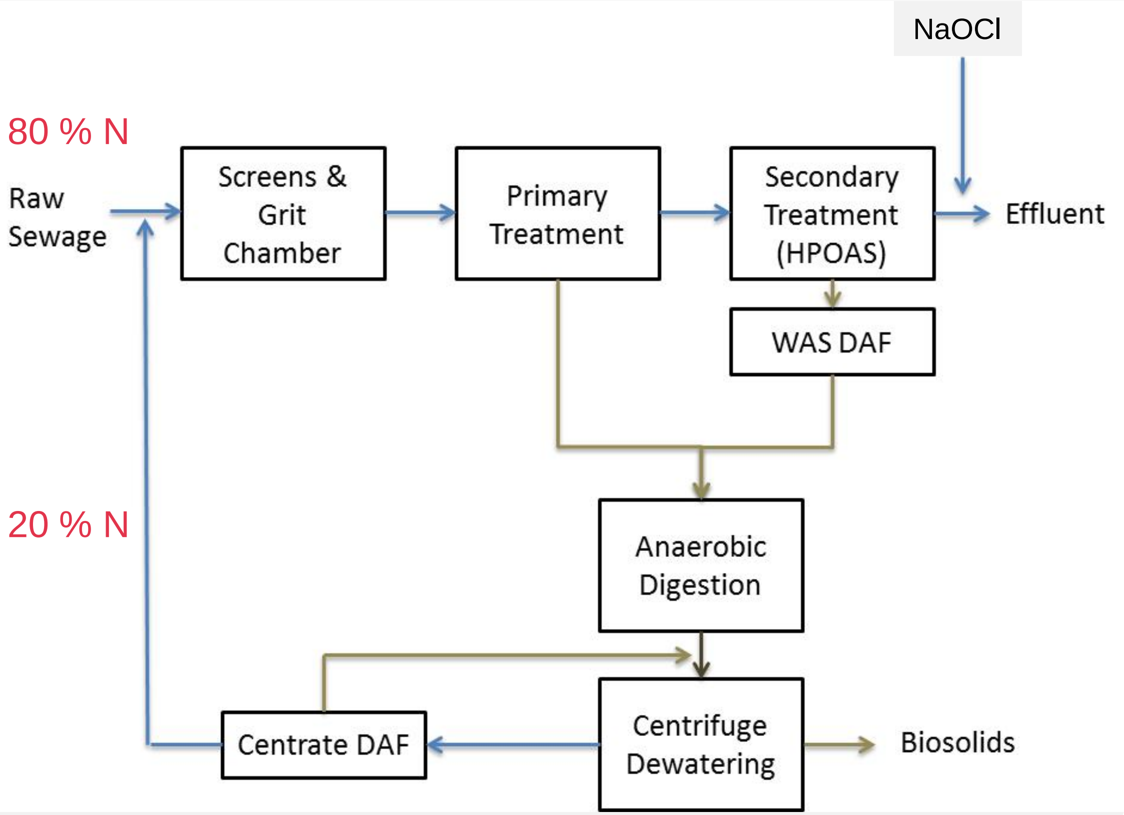
# *Los Angeles County Sanitation Districts*




- LACSD
  - 820 mi$^2$
  - 5.7 M residents
- JWPCP
  - 240-300 MGD
  - Regional solids handling facilities
  - Anaerobic Digestion / centrate dewatering

# Facility: Joint Water Pollution Control Plant

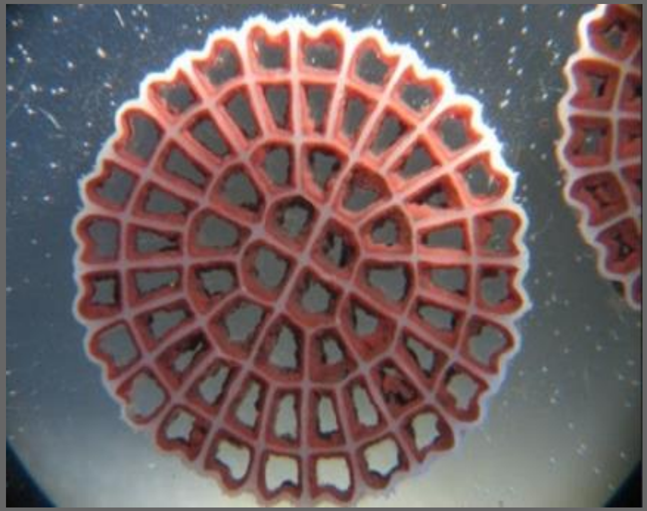



## Nitrogen Removal at the Joint Plant

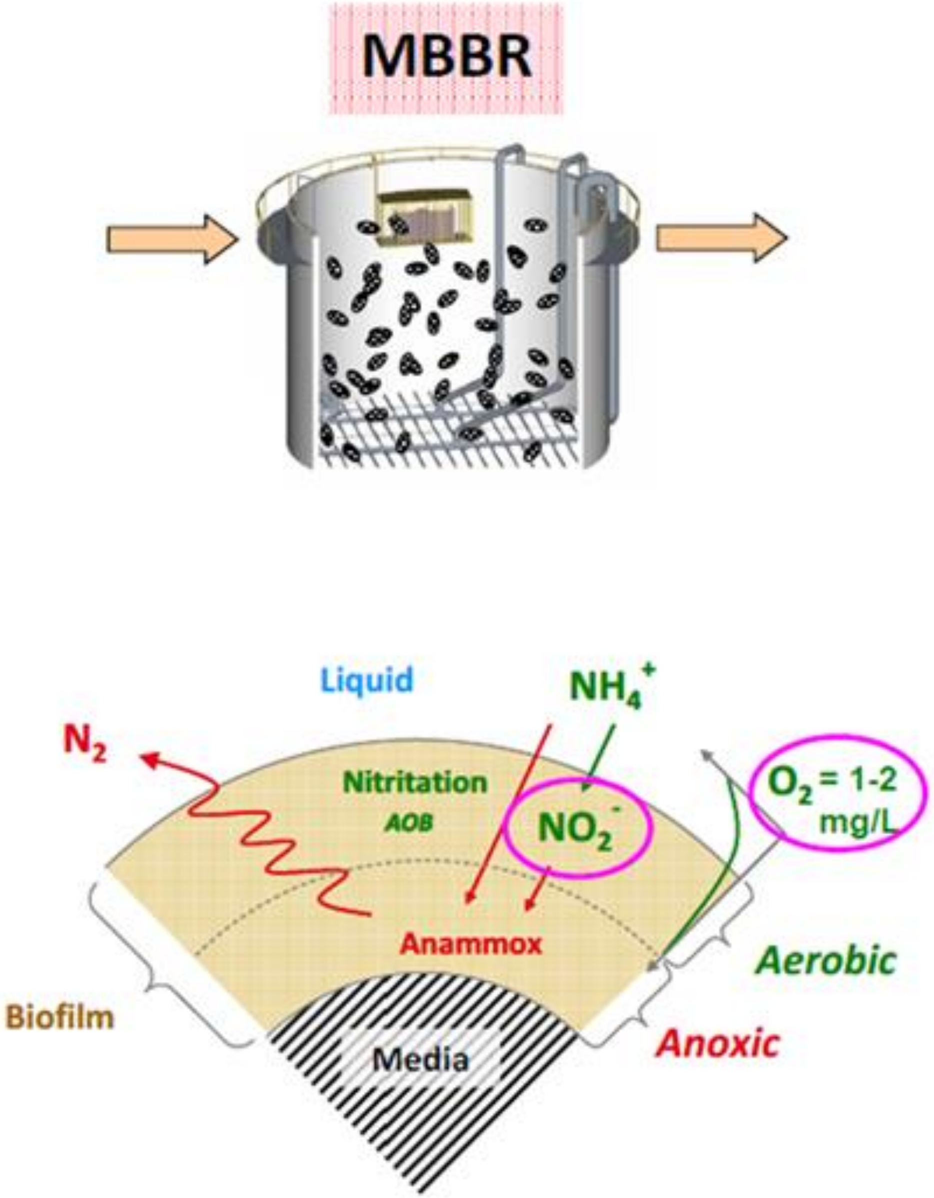
- Currently no effluent nitrogen limits
- Nitrogen removal may be necessary in the future
  - Regulatory (MLPA)
  - Reuse demand
- Centrate is a nitrogen rich stream
  - 1.5% of the hydraulic loading
  - 15-20% of the N-loading
- Targeting centrate for nitrogen removal would reduce the overall process size and cost.

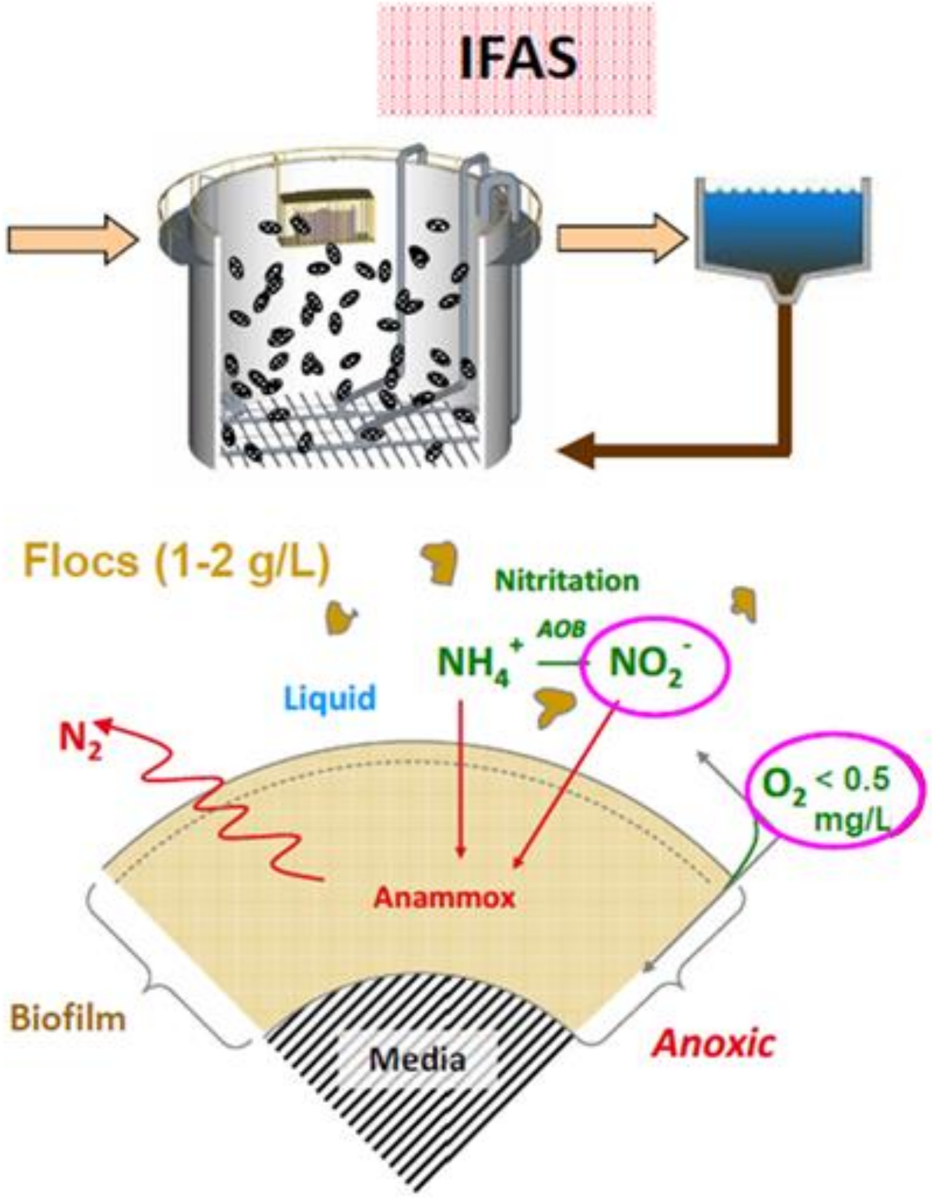
## *Research Questions*

- **Does this process work for JWPCP?**
  - Relatively low-N feed
- **How well does this process work?**
  - N removal efficiency
  - N removal rate
    - Volumetric (VRR – $kg/m^3$-d)
    - Surface area (SARR – $g/m^2$-d)
- **How easy and robust is this process to operate?**



# Variations of the ANITA™ Mox Process



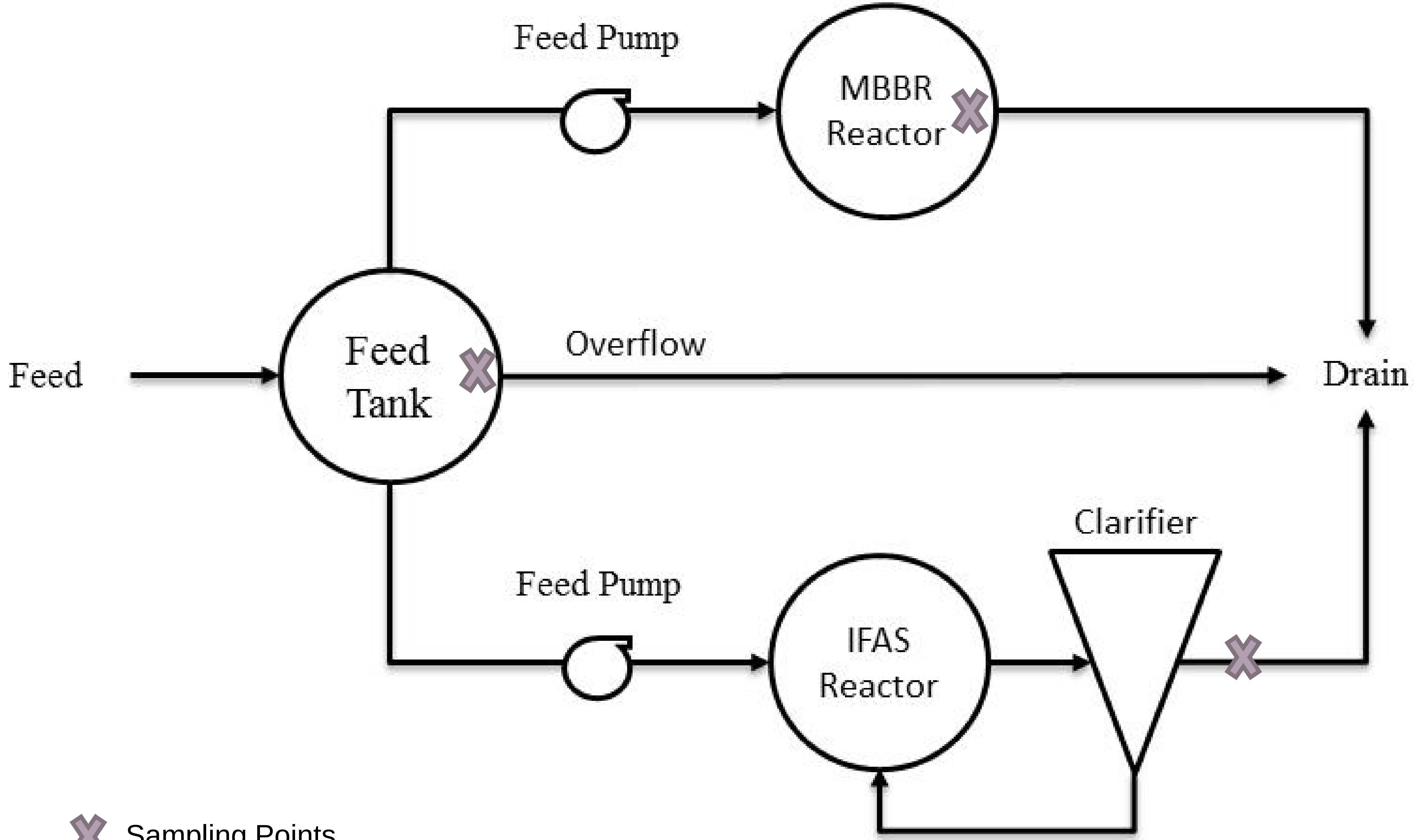



# Variations of the ANITA™ Mox Process

MBBR

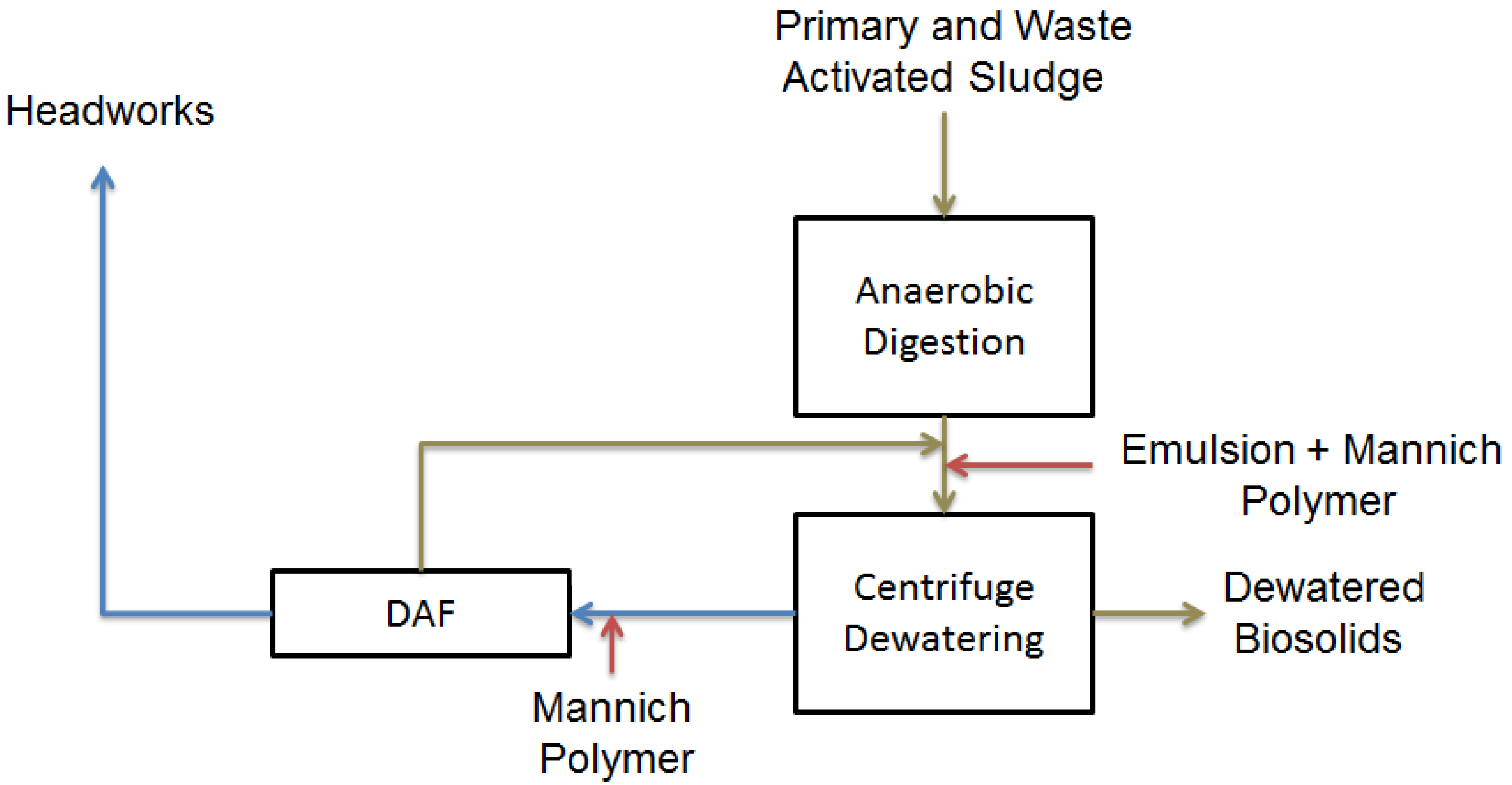
IFAS

# Pilot System Monitoring




Sampling Points

# Pilot Feed Sources




| | Pre-DAF | Post-DAF |
|---|---|---|
| MBBR | √ | √ |
| IFAS | √ | × |

# Pilot System Feed Characteristics

| Parameters | Unit | Pre-DAF* 8/21/2013~ 4/18/2014 | Post-DAF* 5/20/2013~ 8/20/2013 |
|---|---|---|---|
| **Nitrogen** | | | |
| TKN | mg N/L | 634 | 469 |
| $NH_4$ | mg N/L | 620 | 463 |
| **Organic matter** | | | |
| COD | mg/L | 365 | 181 |
| sCOD | mg/L | 153 | 128 |
| BOD | mg/L | 53 | 21 |
| **TSS** | mg/L | 195 | 64 |
| **Alkalinity** | mg CaCO3/L | 2,435 | 1,930 |

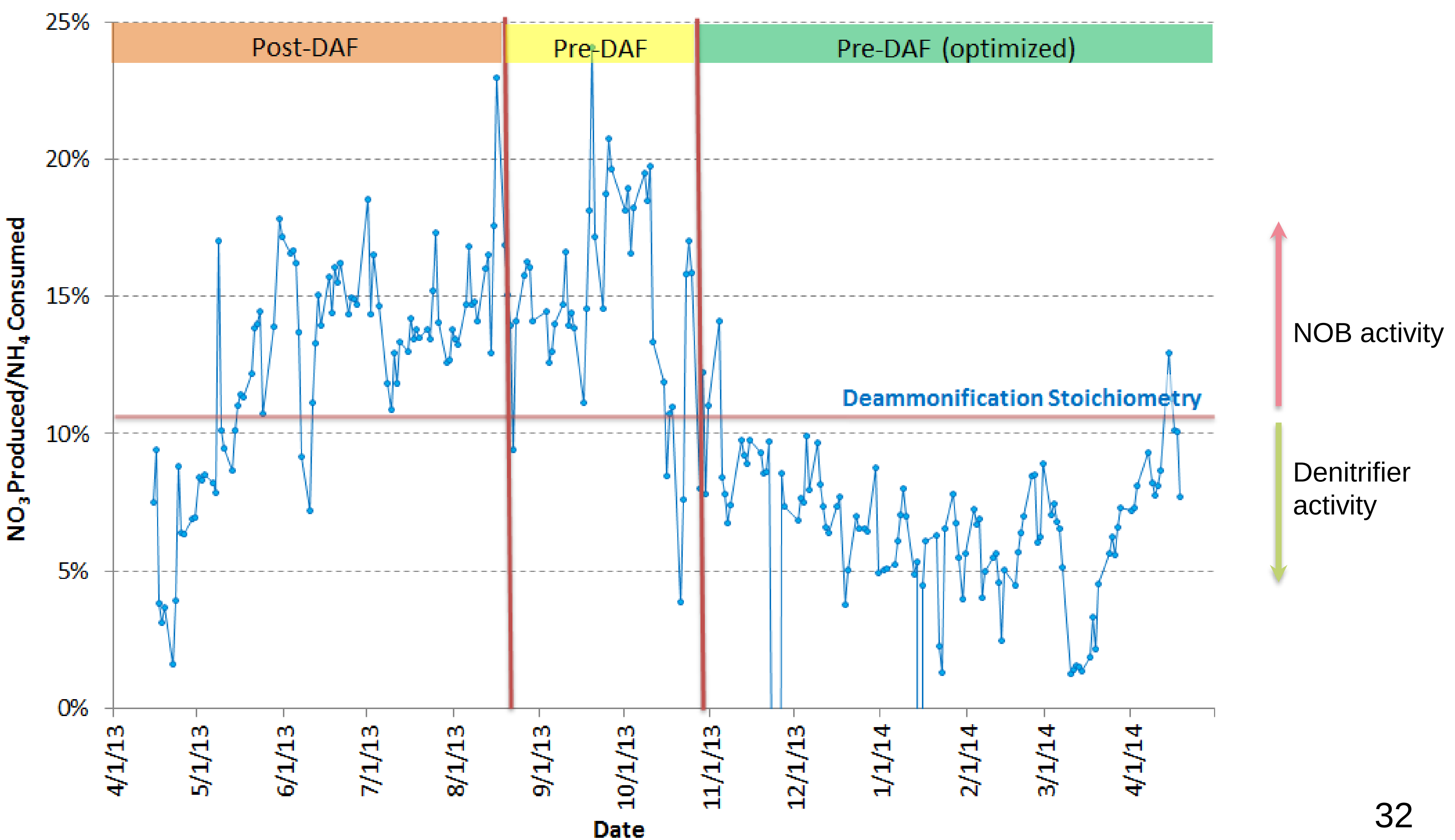
*Medians

# Capacity Testing Summary

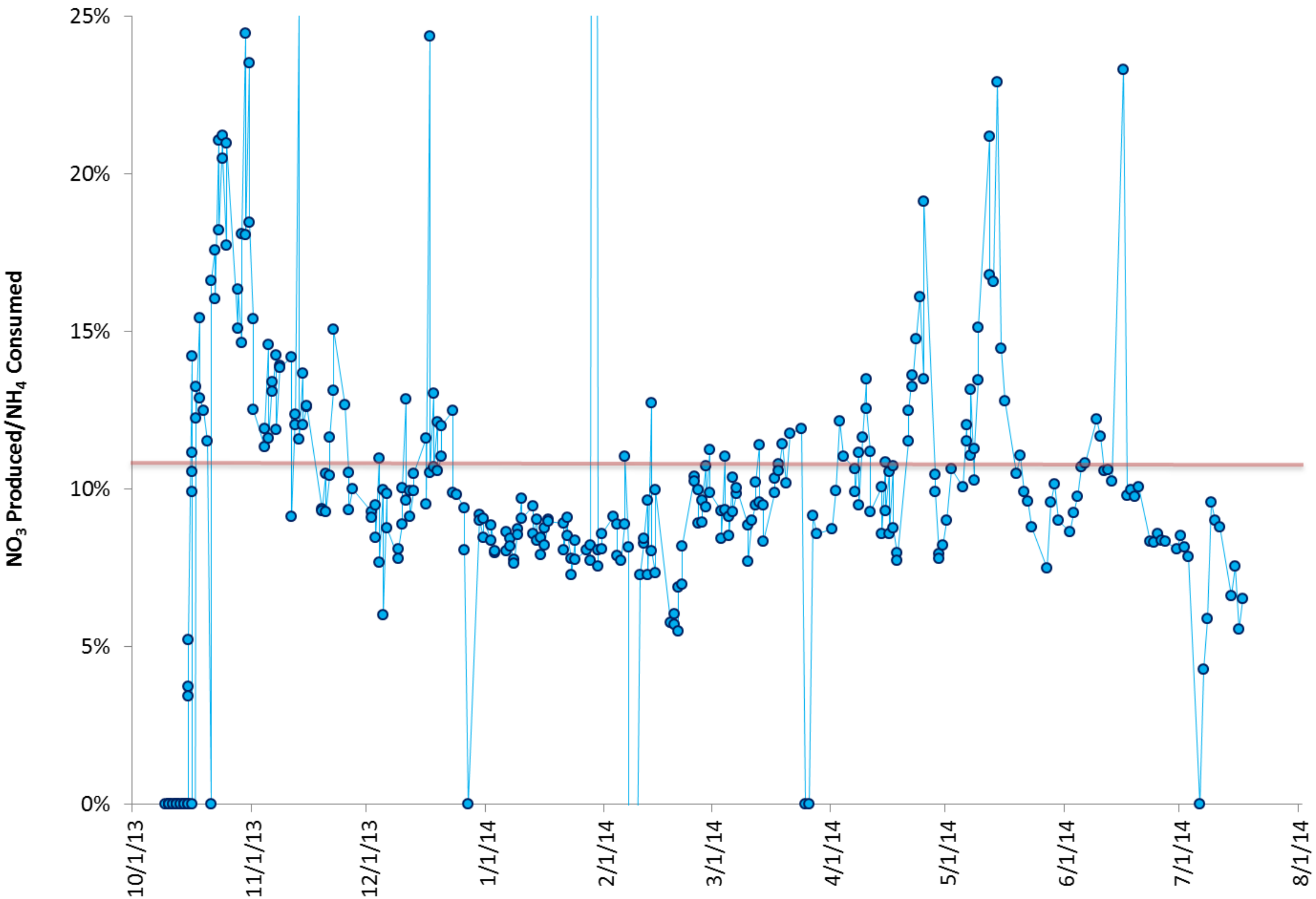
| Process | Feed/ Condition | $NH_4$ | | | TIN | | |
|---|---|---|---|---|---|---|---|
| | | Removal Efficiency | VRR ($kg/m^3$-d) | SARR ($g/m^2$-d) | Removal Efficiency | VRR ($kg/m^3$-d) | SARR ($g/m^2$-d) |
| MBBR* | RWHTF (Denver) | 81% | 0.8 | 2.0 | 75% | 0.7 | 1.9 |
| | Post-DAF | 85% | 0.5 | 1.3 | 70% | 0.4 | 1.1 |
| | Pre-DAF | 84% | 0.7 | 1.7 | 71% | 0.6 | 1.5 |
| | Pre-DAF (optimized) | 75% | 0.8 | 2.1 | 68% | 0.7 | 1.9 |
| IFAS* | Pre-DAF | 79% | 2.2 | 7.4 | 68% | 1.9 | 6.4 |

*Median values

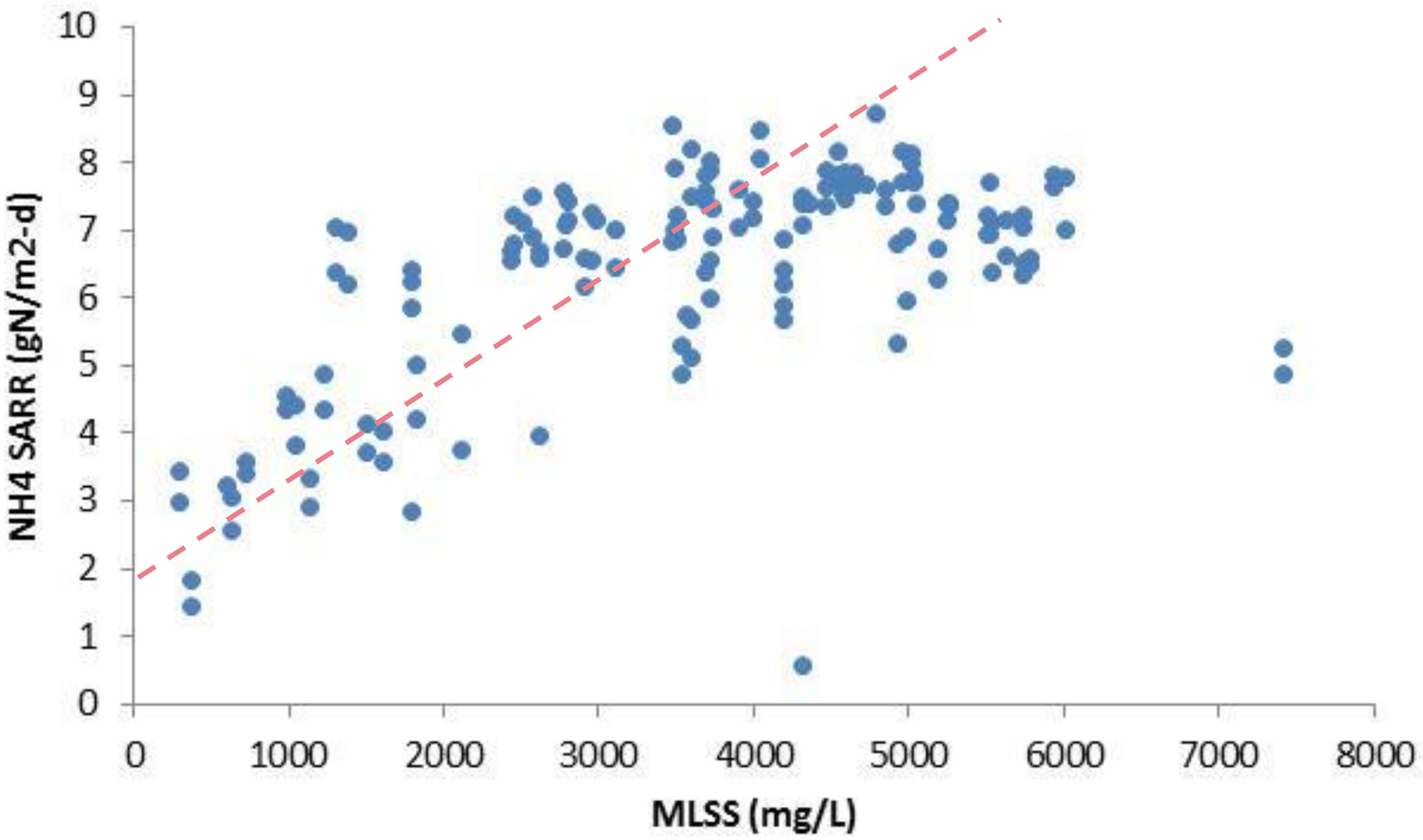
# MBBR: Nitrate Production



# IFAS: Nitrate Production



# IFAS: SARR Correlation with MLSS

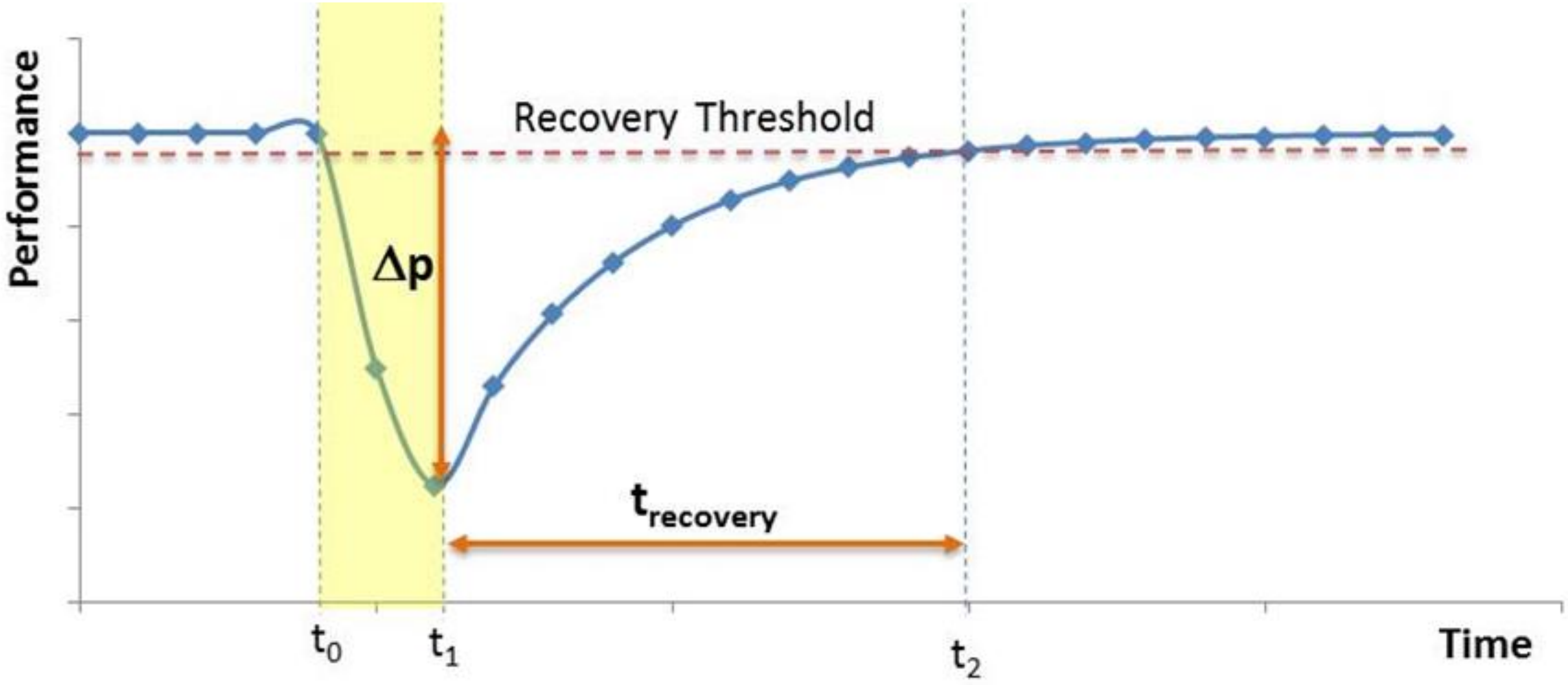



Each 1,000 mg/L translates to ~2 $g/m^2$-d in $NH_4$ SARR

# Robustness Testing

## Perturbation Tested

- Power Outage
- Feed Variance
- Aeration Variance




## Test Parameters

- Perturbation Period: 24 hours
- Performance Metrics: $NH_4$ and TIN SARR
- Recovery Threshold: 95% of baseline

Small Δp and $t_{recovery}$ → More Robust

# Robustness Testing Summary

| Test | Scenario | Perturbation Period | Performance Reduction (Δp) | Recovery Time ($t_{recovery}$) |
|---|---|---|---|---|
| 1 | Power Outage | 24 hr | None | None |
| 2 | No Feed $NH_4$ | 24 hr | None | None |
| 3 | Overfeed (2X) | 24 hr | 40% | 40 hr |
| 4a | Excess Mannich Polymer (13 ppm) | 72 hr | 9% | Not Tested |
| 4b | Excess Mannich Polymer (44 ppm) | 240 hr | 39% | 32 hr |
| 5 | No aeration | 24 hr | 96% | 40 hr |
| 6 | Over-aeration (+23%) | 24 hr | None | None |

# Summary of Findings

- **“Low-strength” centrate is treatable by ANITA™ Mox**
  - MBBR performs better on Pre-DAF than Post-DAF feed
    - Could be due to higher nutrient load and/or polymer
  - IFAS has higher removal rates than MBBR

- **ANITA™ Mox is robust against short-term perturbations**
  - 3/6 scenarios tested showed temporary capacity loss
  - Full recovery was achieved within 2 days in the worst case

# QUESTIONS

## Contact Us

Larry Li
Veolia Water Technologies
usmunicipal@veolia.com
www.veoliawatertech.com

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