EAST BAY MUNICIPAL UTILITY DISTRICT

EBMUD Anammox Pilot Test Results

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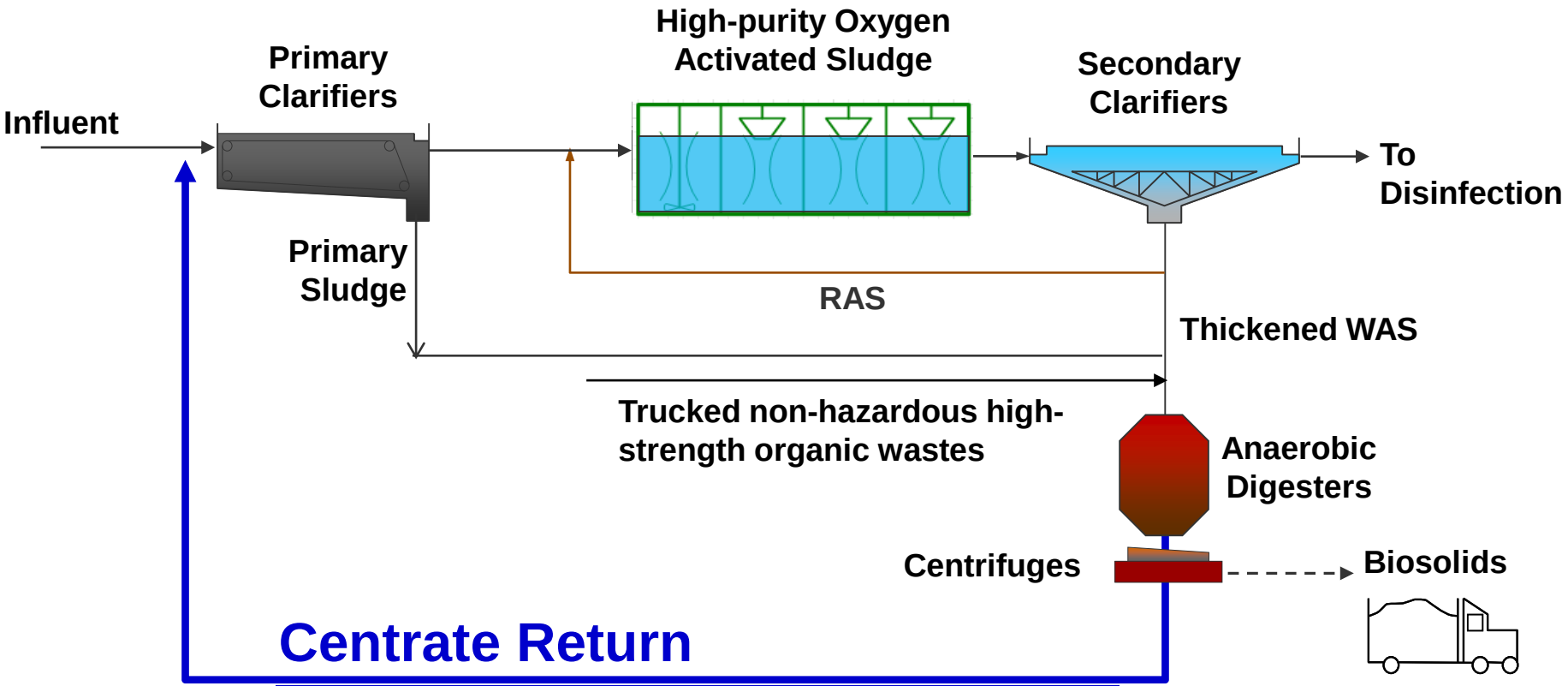
Outline

- Background
- Anammox Pilot Testing
- Next Steps
- Acknowledgements

Background
EBMUD Wastewater Service Area

- Serves 650,000 people
- Includes seven "satellite" communities
- Covers 88 square miles
- Main Wastewater Treatment Plant (MWWTP): dry weather flow ~50 mgd

Background
Sidestream at EBMUD MWWTP

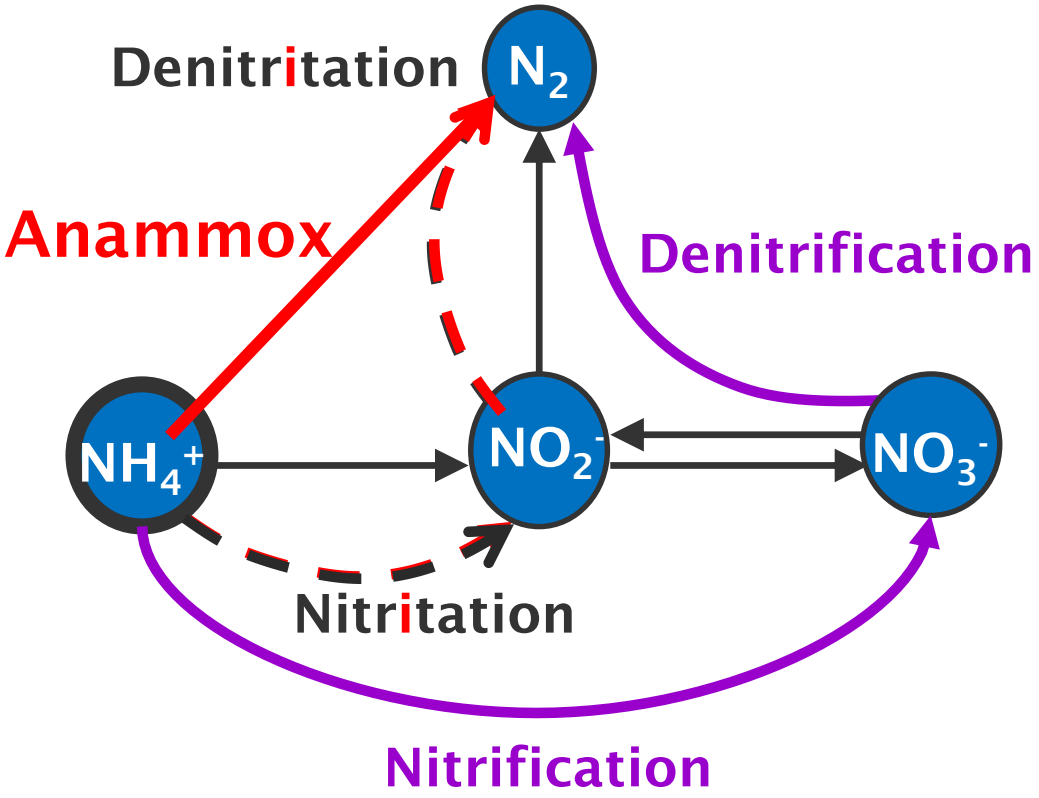


- ~1.2% of Plant Flow
- Typical WWTPs: 15-25% Plant N Load
- Temperature (>30 ºC)
- Insufficient Alkalinity and Carbon for Nitrification/Denitrification

Background
Benefits

Benefits:

- **Compact process**
- **~60% oxygen savings**
- **75-85% total nitrogen removal without chemical addition**
- **80% reduction in biomass production**



Anammox Pilot Testing
Goals

- **Evaluate feasibility of using anammox to treat EBMUD centrate**
  - EBMUD centrate: approximately 2,000 mg N/L
  - Typical for other WWTPs: 800 – 1,500 mg N/L
- **Determine feasibility of growing anammox bacteria from activated sludge**
- **Conduct a side-by-side evaluation of attached- versus suspended-growth anammox technologies**

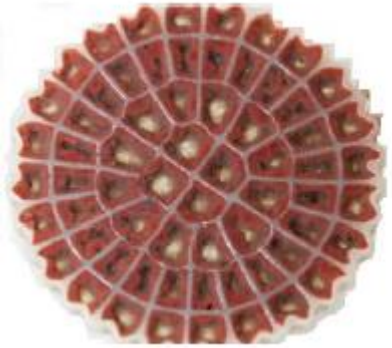
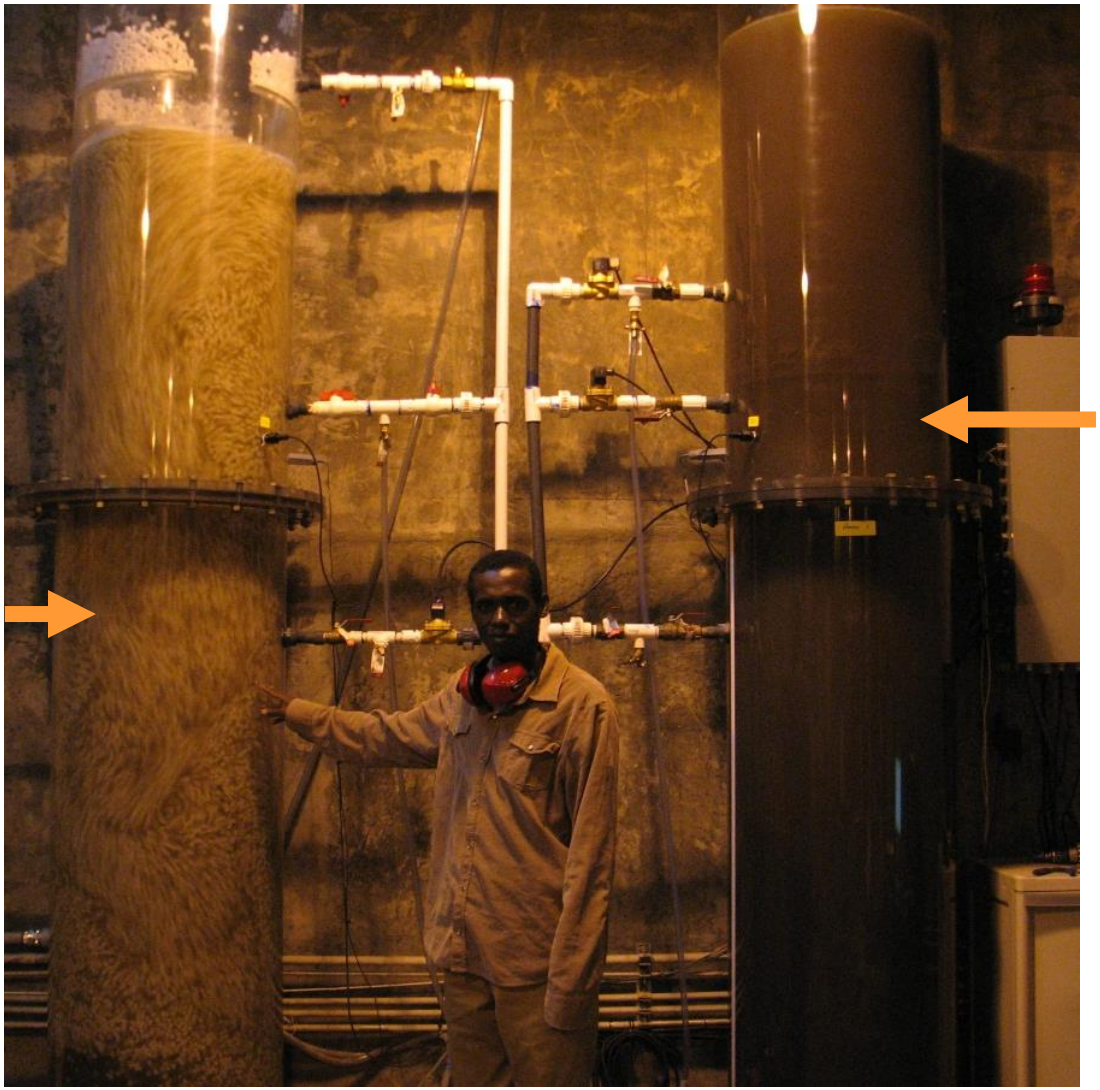


Photo courtesy of ANITA™ Mox by Krüger

Photo courtesy of DEMON® by WWW

Anammox Pilot Testing
Set Up



Reactor 2: Attached-growth
(260-gallon moving bed biofilm reactor)

Reactor 1: Suspended-growth
(260-gallon sequencing batch reactor)

Anammox Pilot Testing
Start Up

Reactor 2: Attached-growth

(Started in September 2013, with NO anammox seed)

Reactor 1: Suspended-growth

(Started in June for nitritation first, then July 2013 for anammox with 1-gal anammox seed from HRSD)

Added 1-gal anammox seed to 260-gallon reactor (0.4%)

Anammox Pilot Testing

Data Collection

	Variables
Key sidestream characteristics	Ammonia-N concentration
	Alkalinity/N ratio
	Temperature
	Total and soluble COD
	TSS
Process control strategy	pH range
	DO range
	Temperature
Process performance	Specific ammonia loading rate
	Ammonia removal efficiency
	Inorganic nitrogen removal efficiency
	Process stability
	Energy consumption

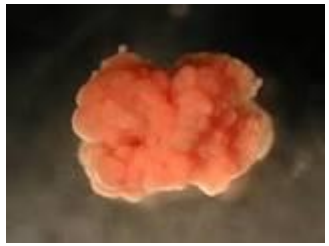
Inorganic Nitrogen: sum of NH_4^+, NO_2^-, and NO_3^-.

Anammox Pilot Testing

Results (15 months from June 2013 – September 2014)

- Anammox bacteria grew well on EBMUD centrate, prior to the process upset
- Anammox bacteria could be grown from nitrifying activated sludge
  - Reached half of the design loading rate in 6-9 months
- The attached-growth showed advantages over the suspended-growth anammox reactor
  - Allowed a higher ammonia loading rate in a shorter time

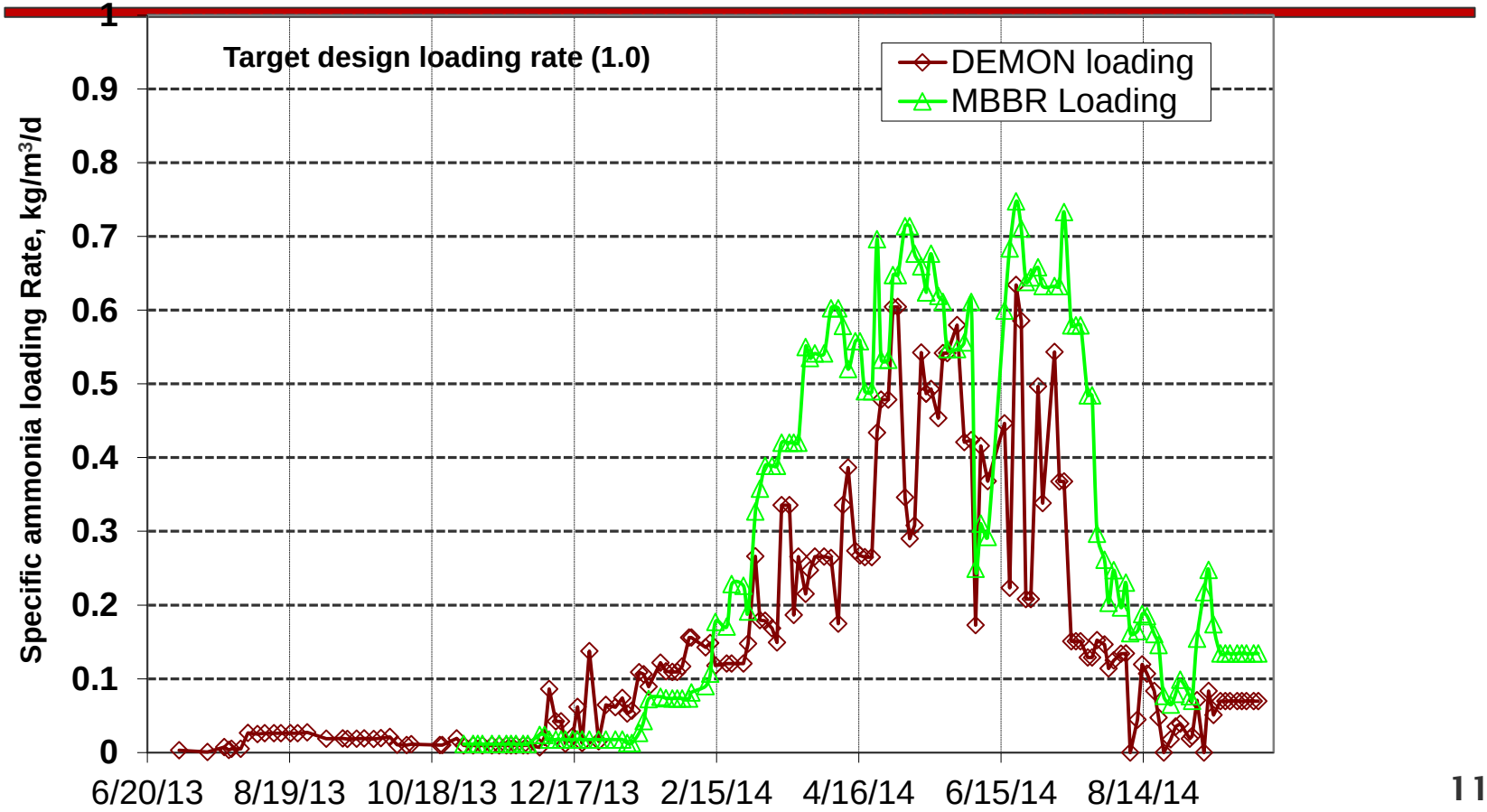
Nitrifying Activated Sludge



Anammox Bacteria
(photo by Delft University of Technology)

Anammox Pilot Testing
Results (cont'd)

- **Anammox bacteria appeared vulnerable to sharp loading swings, which resulted in high nitrite levels leading to process upsets**



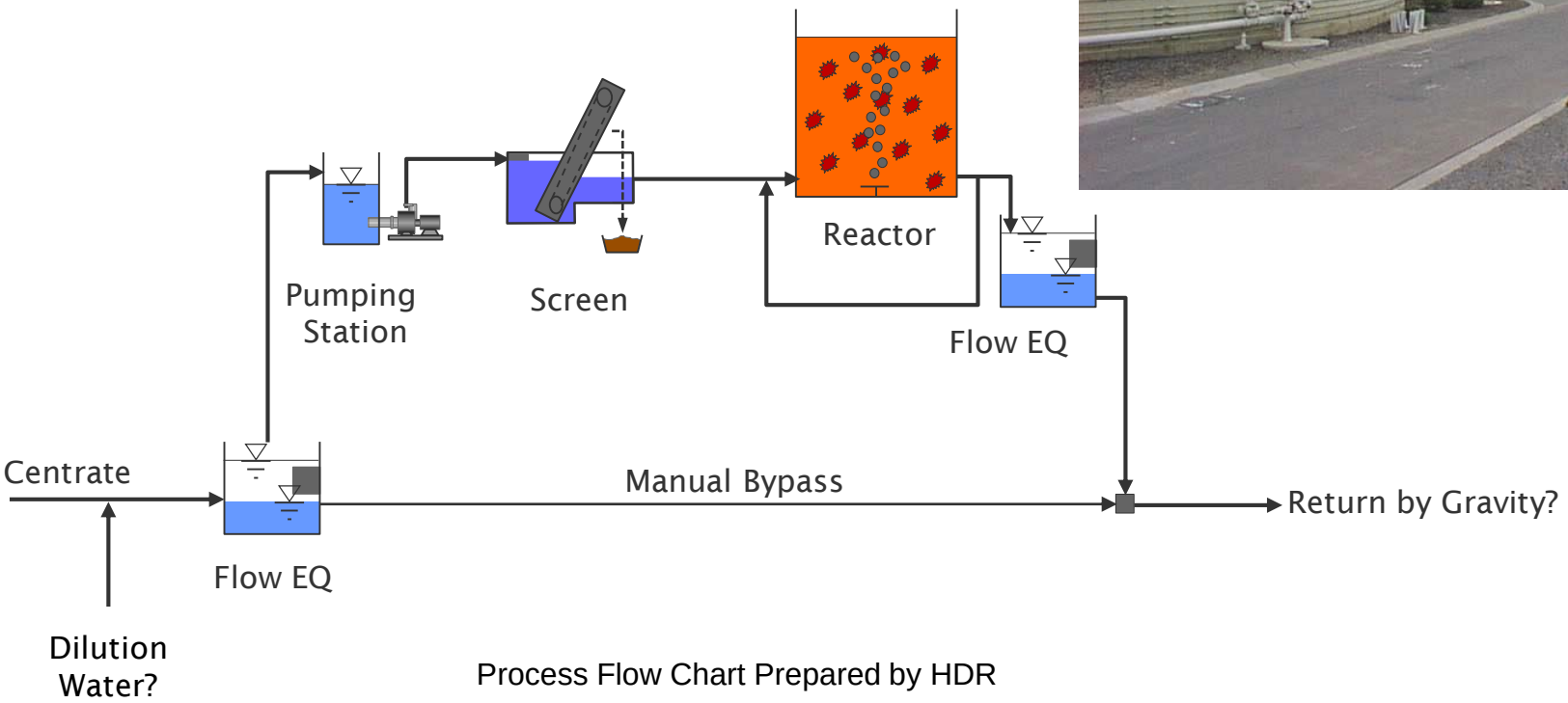
Anammox Pilot Testing
Lessons Learned

- Operating the anammox reactors requires a high level of monitoring and adjustment
- Anammox process is not as resilient as expected

True failure is when you fail and don't learn your lesson

Full-scale Anammox Requires Large Reactor Volume

Estimated anammox reactor volume would be equivalent to two to three 2-MG digesters to treat EBMUD 's sidestream



Process Flow Chart Prepared by HDR

Next Steps

- Work with sister agencies to complete pilot testing of viable sidestream treatment technologies
- Identify and monitor the development of more reliable and cost-effective sidestream treatment technologies
- Conduct sidestream treatment cost & benefits analysis for POTWs

Acknowledgements

- U.S. EPA Region 9 for providing partial funding support for the pilot testing and overseeing a regional Sidestream Nutrient Removal Study
  - EPA Project Managers:

    Terrence Fleming and Luisa Valiela
  - EPA Quality Assurance Manager:

    Joseph Eidelberg
- EBMUD project partners

Questions/Comments

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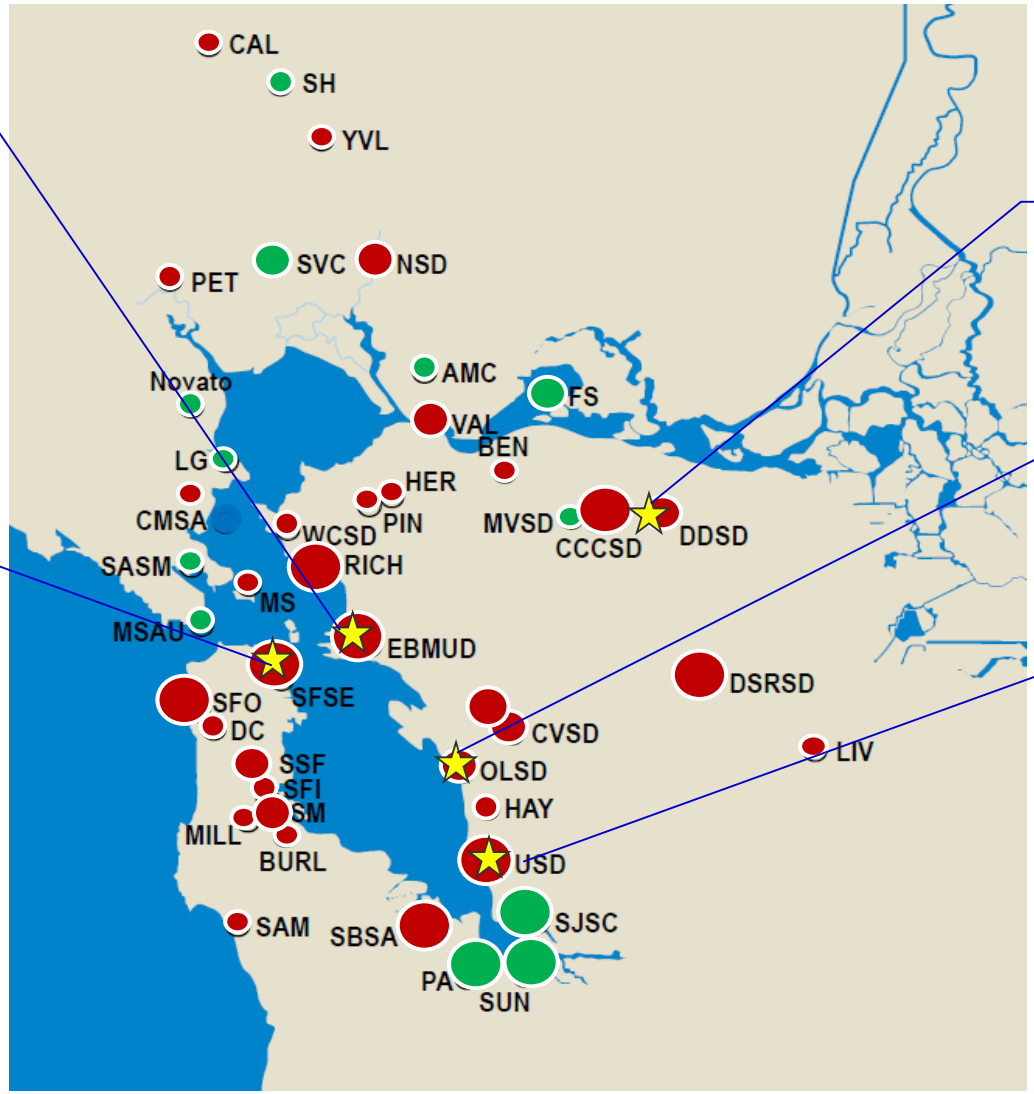
Backup

Bench and Pilot Testing by POTWs

EBMUD:
Anammox
- Suspended -growth
- Attached-growth

SFPUC:
Anammox
- Suspended -growth
- Attached-growth
- Zeolite



DD: CANDO

OLSD: Zeolite anammox

USD: Krüger ANITA™ Mox

Anammox Design Considerations

ANITA™ Mox Influent	Optimal	Possible	Challenging
Temperature, °C	**20-35**	15-20	<15 or >35
Ammonia-N, mg/L	**200-2,000**	50-200	<50 or >2,000
sbCOD/N ratio	**<0.5**	0.5-1.0	>1.0
TSS, mg/L	**<1,000**	1,000-2,000	>2,000
Alkalinity, mg/L $CaCO_3$: NH_4-N, mg/L	**>5**	4-5	<4

Source: Krüger vendor