Fixing the Drawbacks of Anaerobic Digestion by Recycling

What if your Digesters were the Sidestream?

THERMAL PROCESS SYSTEMS

CWWA Annual Conference
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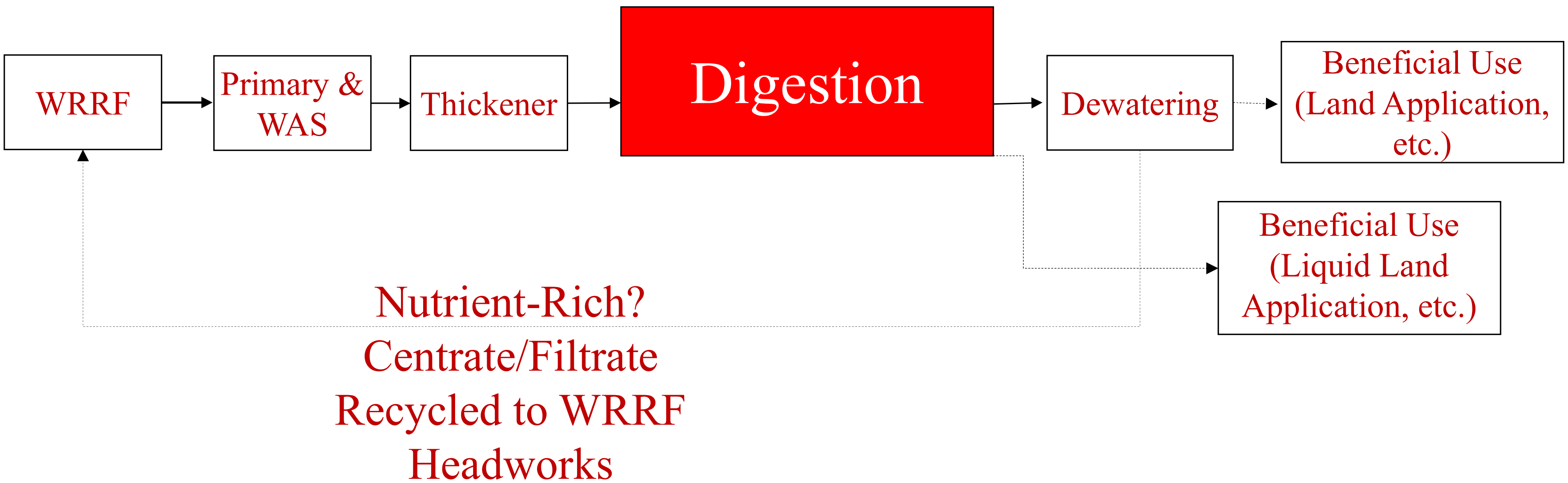
Sludge Digestion/Stabilization at a WRRF



Anaerobic Digestion Challenges

- Capacity for Food & other Feedstocks
- Nutrient Recycle from Dewatering
  - Ammonia Production
  - Phosphorus Release
- Struvite
- Hydrogen Sulfide (H_2S) Odor & Toxic
- Dewatering Performance Suffers

There are several solutions!

- Add Capacity – Build more tanks, THP, etc.
- Sidestream Deammonification (Anammox, etc.)
- Struvite Precipitation & Recovery (Mg Addition)
- Ferric Chloride Addition to control H_2S (& Struvite)
- Odor Control (chemical, scrubbers, etc.)

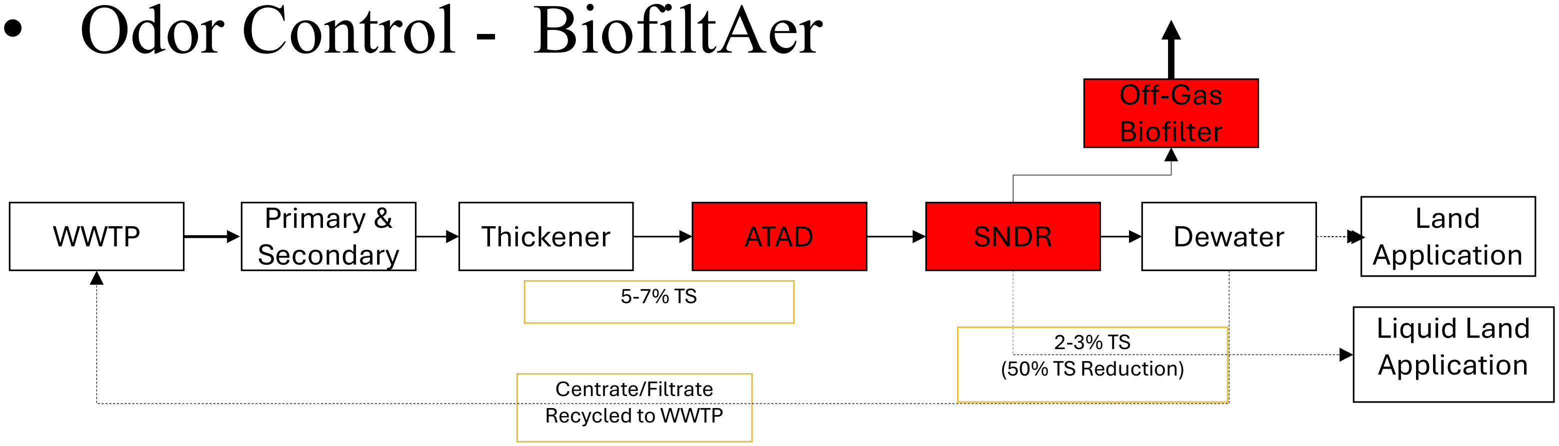
Most approaches require additional processes & chemicals, are **treating symptoms** and not focused on the digestion process…

What is ATAD?

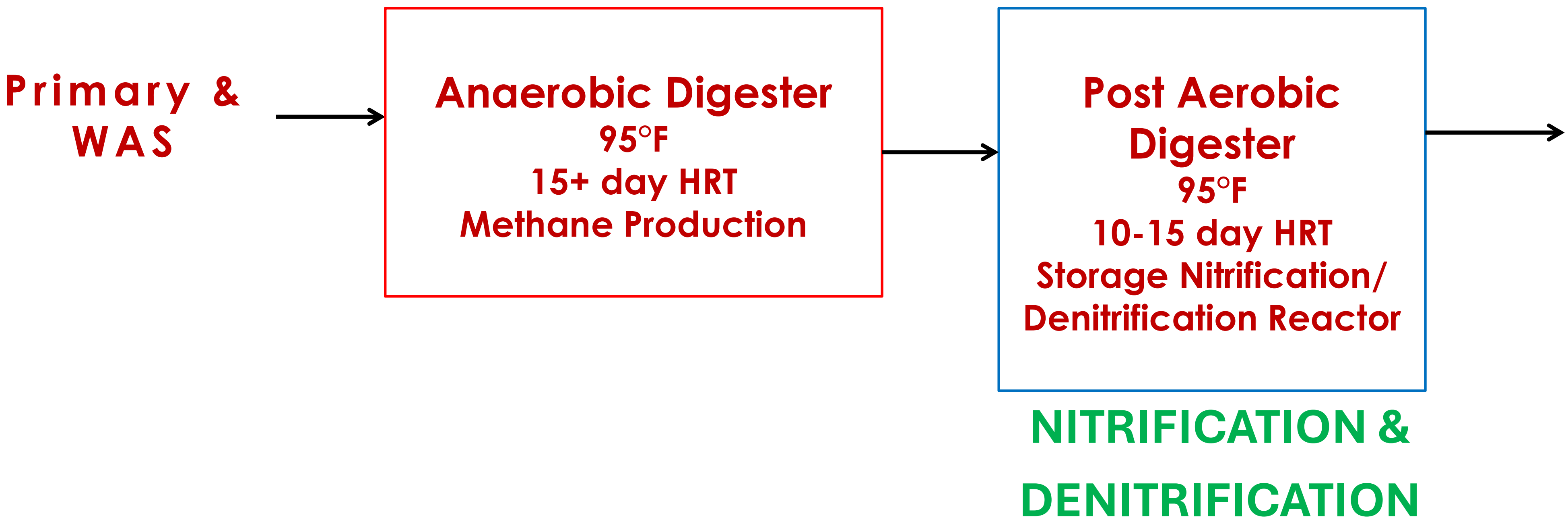
- **A**utothermal **T**hermophilic **A**erobic **D**igestion
- ATADs – Approved Class A option per EPA in the US in the 1990s
- About 25 Installations in US & Canada from 1992-1998.
- Early designs had odor, corrosion, over-foaming and other challenges.
- Most have now been replaced/repurposed or upgraded to 2nd Gen ATAD

2nd Generation
Two-Stage Class A Aerobic Digestion Process

- 1^{st} Stage - ThermAer (ATAD)
- **2^{nd} Stage –SNDR - Storage Nit/Denit Reactor**
- Odor Control - BiofiltAer



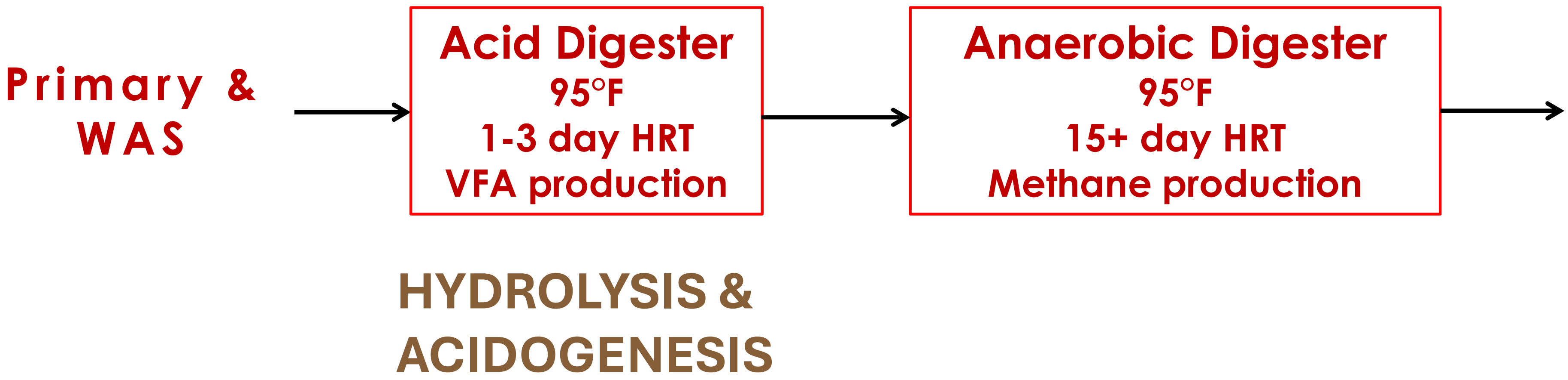
SNDR/Post Aerobic Digestion (PAD)



Anaerobic Digesters + N Removal

- 2012: Post Aerobic Digester/SNDR (Storage Nit/Denit Reactor)-Speedway, Indiana
- Nitrogen Reduction drove the project
- Additional benefits realized
- Variability of Anaerobic Digester performance required oversizing of the SNDR/PAD

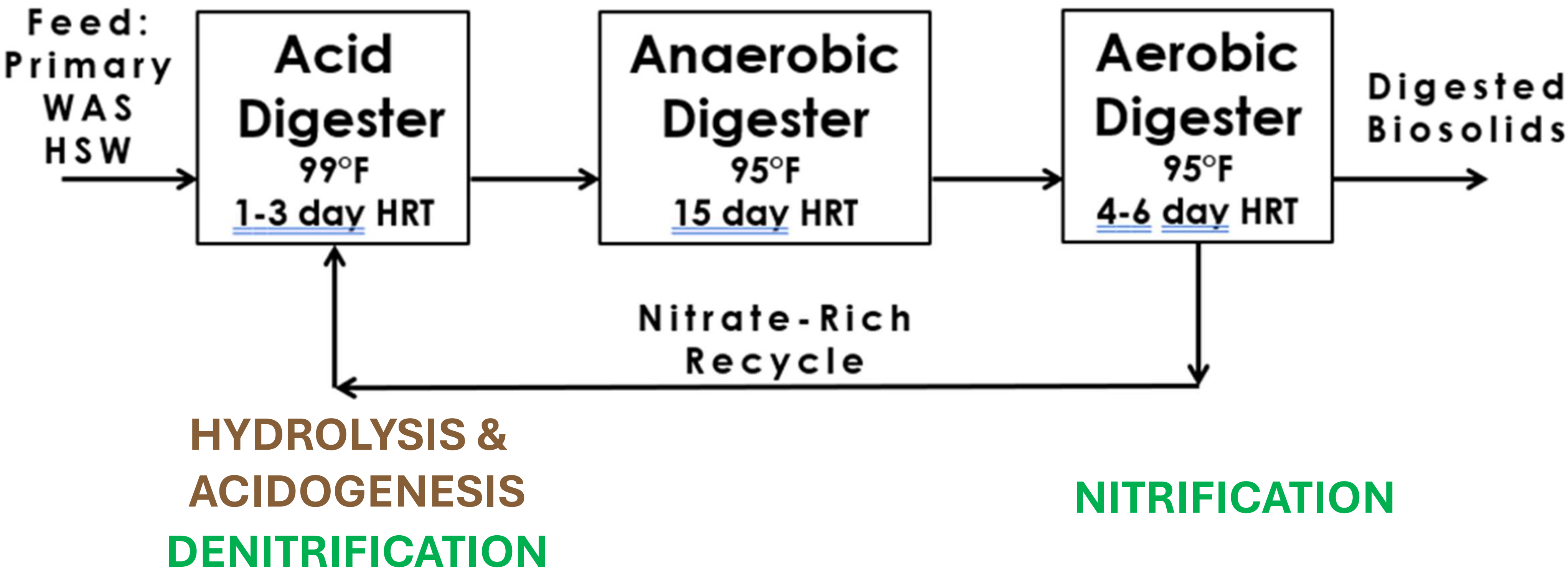
Two-Stage/Phase (aka Acid-Gas Digestion)



Acid + PAD…with a Recycle

- **Acid Digesters** have been used for decades to improve hydrolysis & digester performance.
- **Post Aerobic Digestion (PAD)** has been discussed & presented for nearly 20 years and used at a few facilities.
- Significant process improvements have been documented by adding **both** Acid Digestion **and** PAD **with a recycle loop.**

ExCalibAer Enhanced AD & Nutrient Removal



Process Benefits – Aerobic Digester

- 70-90% Ammonia Reduction
- Removes soluble COD, VFAs, proteins & carbohydrates (increased VSR)
- Improves dewatering
- Eliminates offensive odors in dewatering room and cake.
- Reduces alkalinity through nitrification

Acid Digesters don’t want to be acidic

- Typically operate with lower pH ~3.5 – 5.5
- Denitrification increases pH to 6.5 - 7 balance out VFAs
- Keeps hydrolytic bacteria & acidogens closer to optimal pH
- Improved hydrolysis-> Consistently higher VS destruction
- Enhanced fermentation improves efficiency of methanogens

Denitrification > Sulfate Reduction

Reactions	Chemical Formula	Free Energy kJ/mol
Aerobic Oxidation	$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$	-2880
Denitrification	$5\ C_6H_{12}O_6 + 24\ NO_3^- + 24\ H^+ \rightarrow 30\ CO_2 + 42\ H_2O + 12\ N_2$	-2720
Sulfate Reduction	$6\ C_6H_{12}O_6 + 6\ SO_4^{2-} + 9\ H^+ \rightarrow 12\ CO_2 + 12\ H_2O + 3\ H_2S + 3\ HS^-$	-492
Sulfate Reduction @ Equivalent Energy	$33\ C_6H_{12}O_6 + 33\ SO_4^{2-} + 49.5\ H^+ \rightarrow 66\ CO_2 + 66\ H_2O + 16.5\ H_2S + 16.5\ HS^-$	-2706

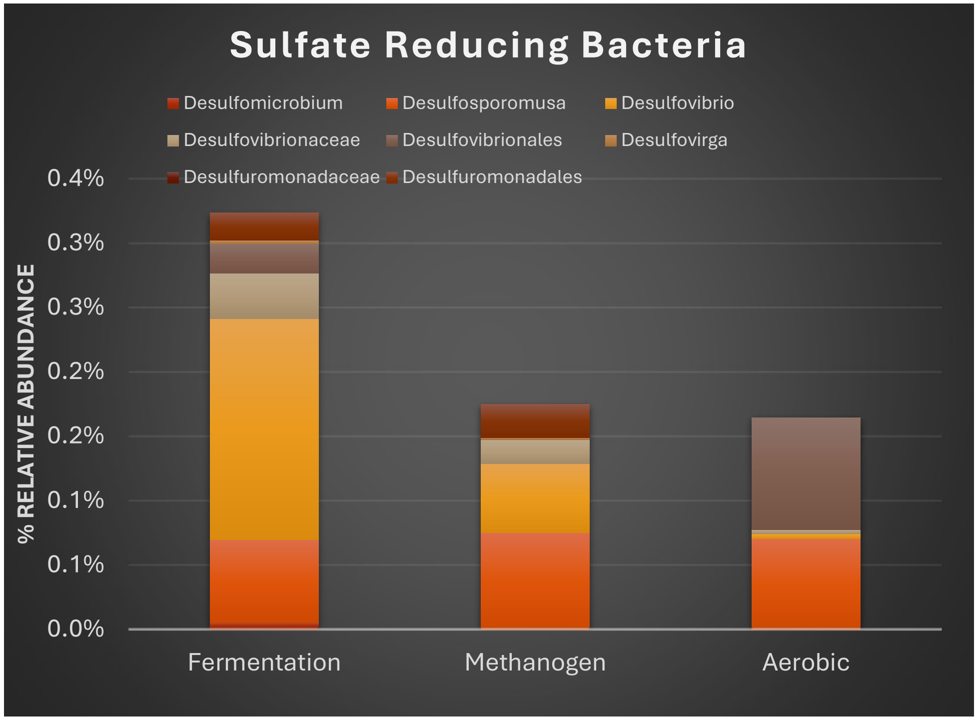
Hydrogen Sulfide Reduction

WRRF	Digester H2S (ppm)	Pilot H2S (ppm)	% reduction
1	300	.003	99%
2	1800	250	86%
3	20,000	500-1000	95% - 97.5%

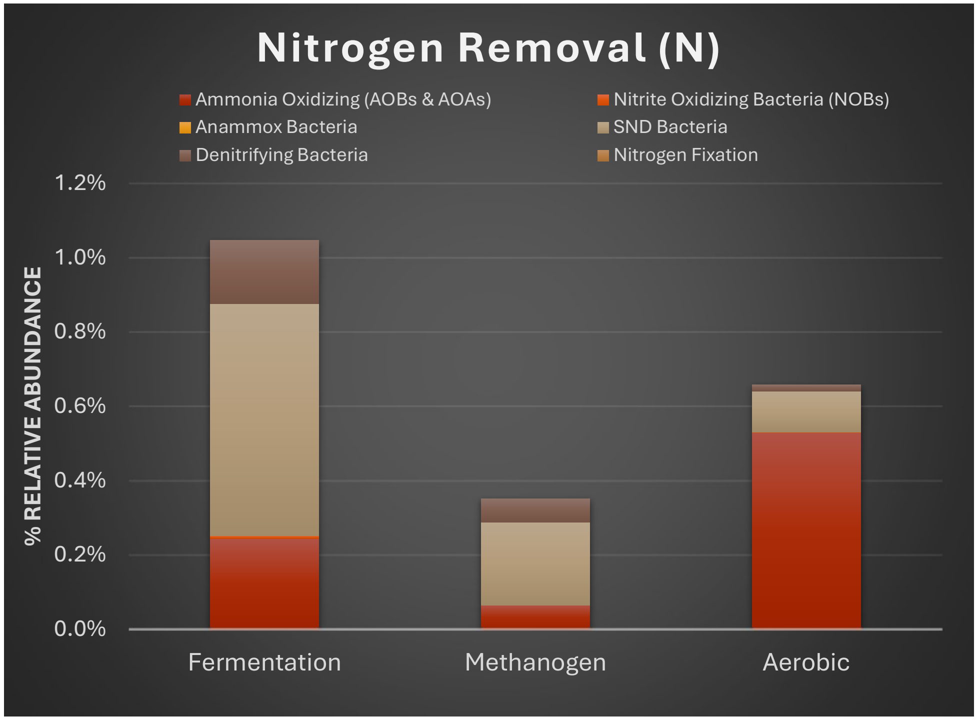
Note: All results were from samples with no metal salt (Ferric Chloride) addition.

Genomic Analysis – SRBs < N Removers

>50% reduction of SRBs from fermentation tank to methanogen reactor

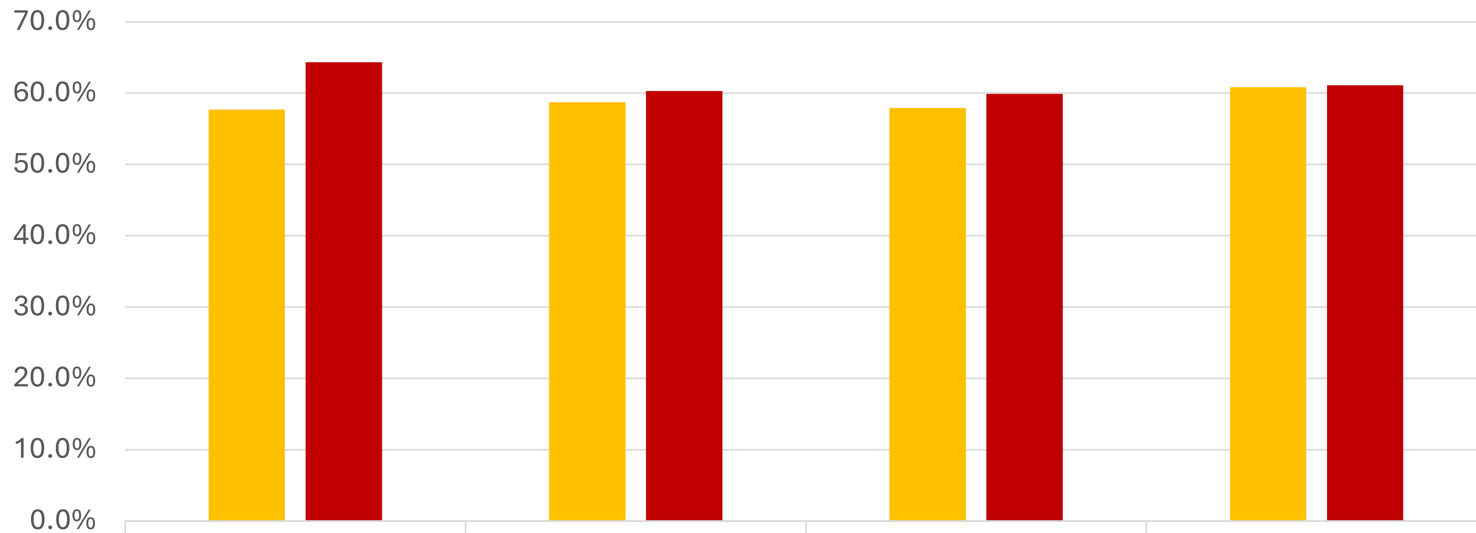


Significantly higher population of Nitrogen removal bacteria



Volatile Solids Reduction (VSR)

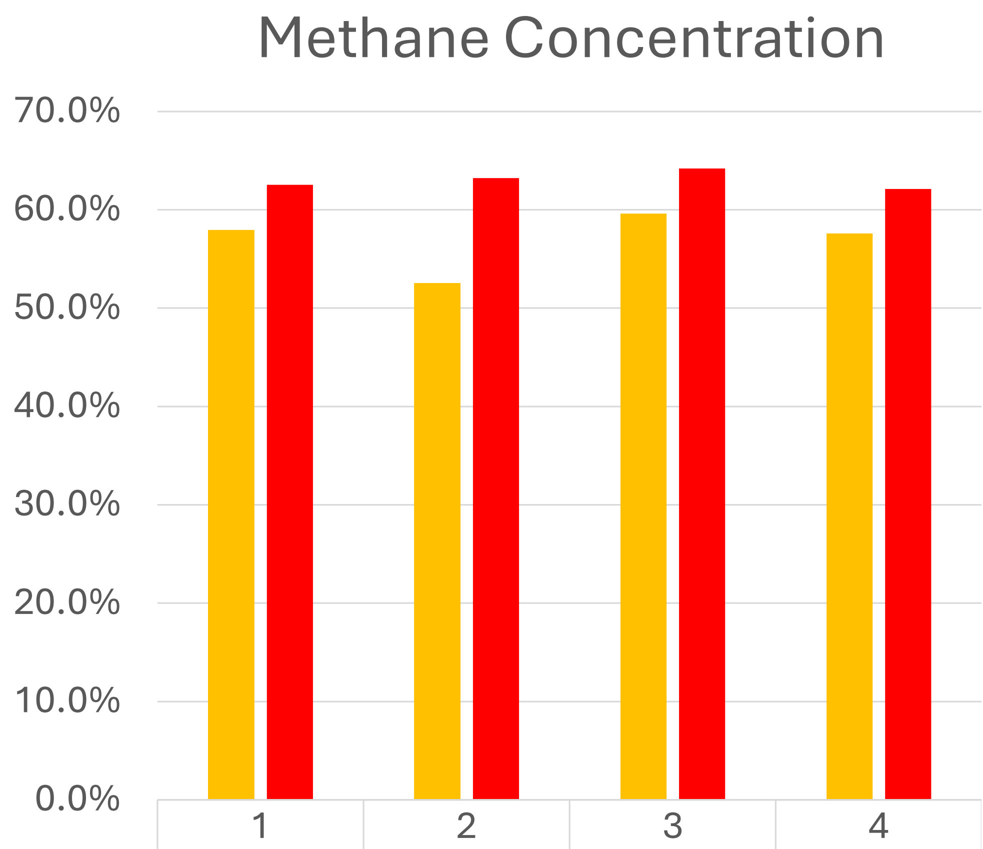
- Increased VSR through Anaerobic Digester
- Additional VSR in the Aerobic Digester



	1	2	3	4
MR	57.7%	58.7%	57.9%	60.8%
Total	64.3%	60.3%	59.9%	61.1%

Richer Biogas

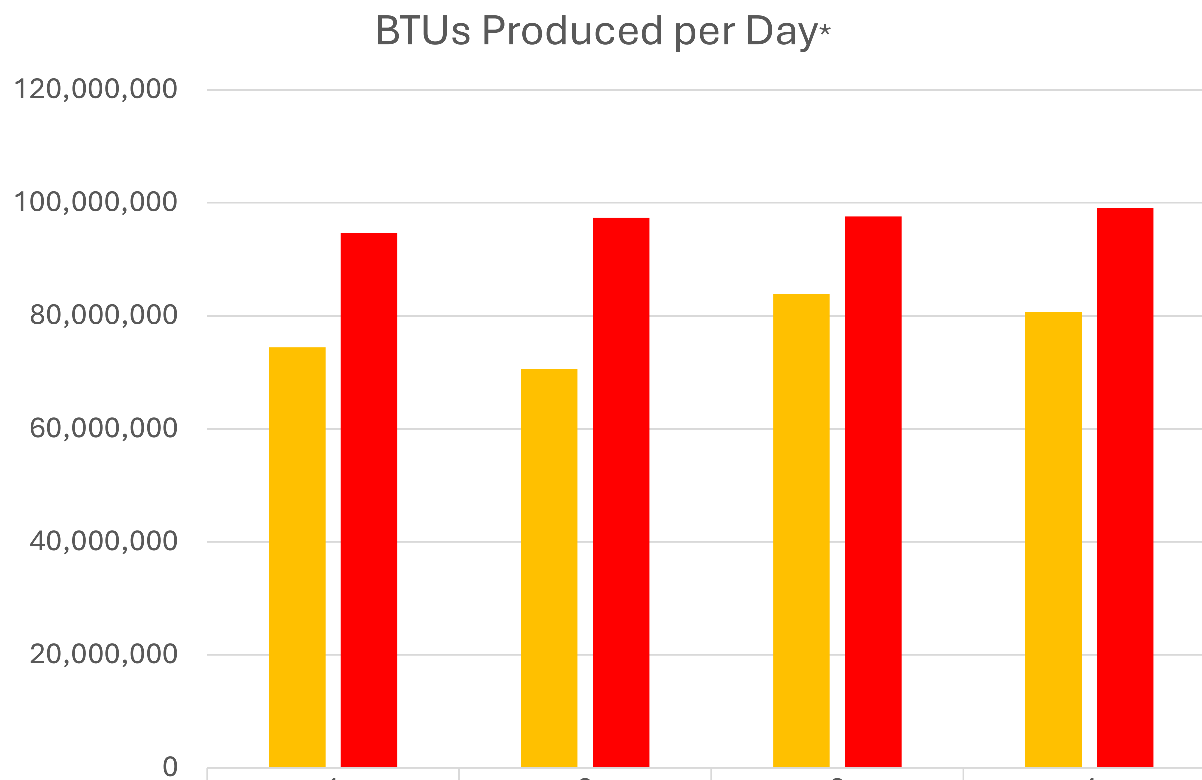
- Pilot Methane % consistently greater than full-scale conventional.
- Biogas production rate remained similar (13 – 14 ft^3/lb VSR)



	1	2	3	4
Facility	58.0%	52.5%	59.6%	57.6%
ExCalibAer™	62.5%	63.2%	64.2%	62.1%

Compounding Effects

- Increased VSR
- Increased Methane %
- Pilot showed consistent increase in total energy produced



	1	2	3	4
Facility	74,450,250	70,560,000	83,857,200	80,740,800
ExCalibAer™	94,664,063	97,383,300	97,575,975	99,111,600
Increase	27.2%	38.0%	16.4%	22.8%

*based upon 25,000 lbs/day, 75% VSS

Struvite Control– a different approach

- Recycle decreased Digester Ammonia concentrations from 1,500 mg/L to 500 mg/L
- Maintaining lower NH_3 keeps pH lower: 6.7 vs 7.2
- Lower ammonia & pH result in decreased struvite formation potential (without Ferric Chloride)

THERMAL PROCESS SYSTEMS
EXCALIBAER

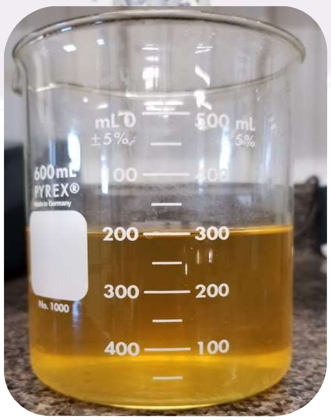
Biosolids Conditioning & P Recovery

Aerobic Digester
95°F
4-12 day HRT
5-15% additional VSR
Nitrification

Mechanical Dewatering

e.g. Centrifuge

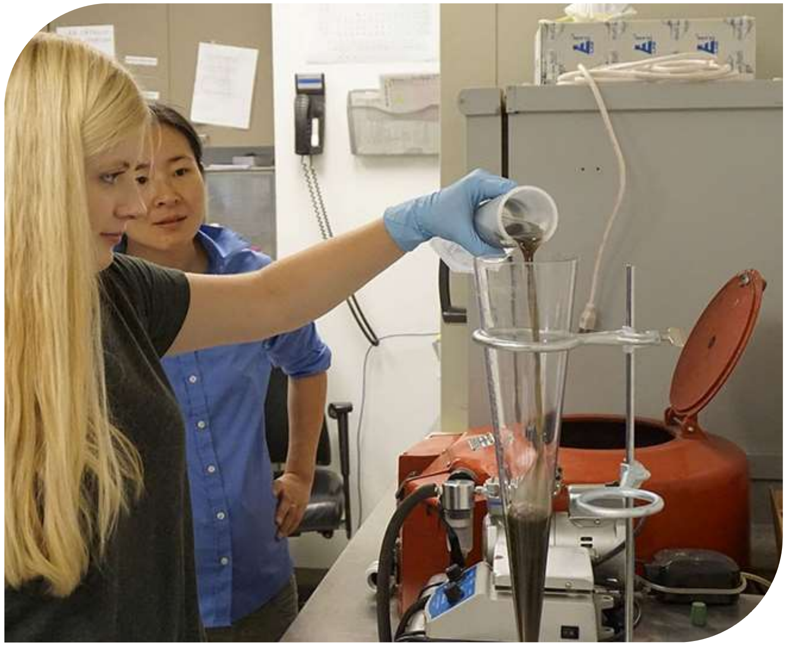
Low P Biosolids



P Recovery

Dewatering Results

- Lower solids mass(~30% less)
  - No metal salt addition
  - Higher Volatile Solids Reduction
- Less material to bind → less polymer required for dewatering
- Balances cake N/P ratio
- Reduced polymer requirement
- System provides major benefits to dewatering operations



Process Improvements

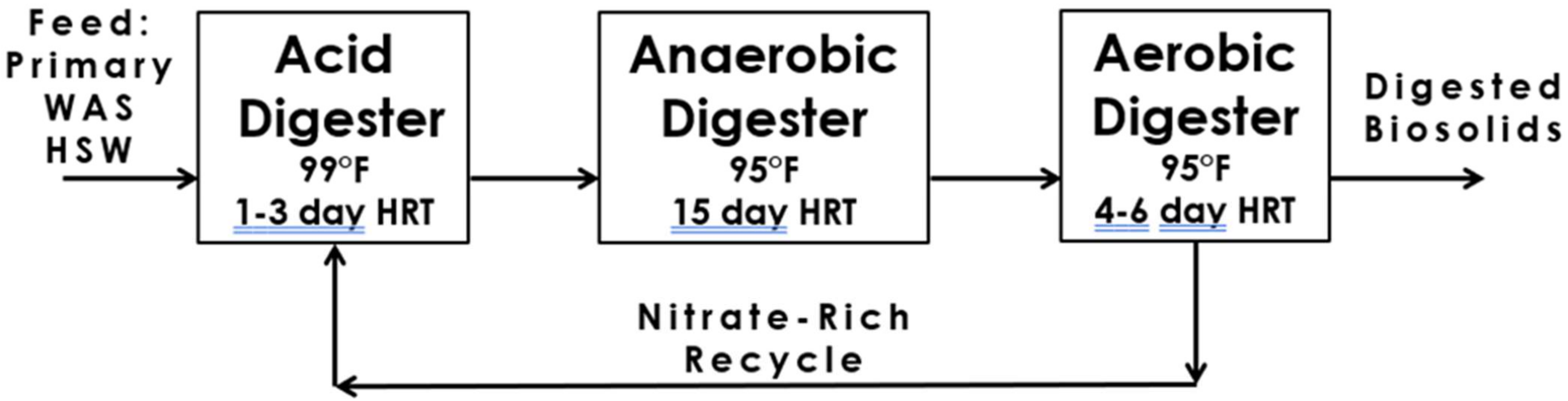
- Volume Reduction (higher VSR)
- Improved Dewatering
- Reduced Odors
- Reduction of H_2S and Struvite (with no Ferric Chloride)
- Nitrogen removal ***through the digesters***

Other Favorable "Side-Effects"

- Ability to handle HSW (food waste, septage, grease) & **additional nutrients**
- Fully-automated process control
- Easily integrated into existing tankage
- Lower overall HRT = more digester capacity
- Less Chemicals for pH, Struvite & H_2S Control

Conclusions

- By taking a more holistic approach, solutions arise that strike at the root of multiple problems.
- Additional benefits arise from addressing nutrient issues **within the solids (side?)stream**…in the Digesters.



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