SONICATED SLUDGE AS CARBON SOURCE FOR DENITRIFICATION

CASE STUDY OF FIRST AUSTRALIAN APPLICATION

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Introduction

- Cost effective N removal & energy neutrality
- Maroochydore STP & trial method
- Ultrasonic WAS lysis
- Results:
  - Nitrogen removal performance
  - Decreased sludge production
  - Economic evaluation
- Conclusion

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Our service area

Water and sewerage services.

Population of **700,000** people.

Geographical area of **5,223km²** north of Brisbane.

From Noosa and Cooroy to Woodford, Bribie Island, Redcliffe and Brendale.

STPs effluent release to coastal receiving waters.

The Need for Nitrogen Removal

- Maroochydore STP discharges into estuary
- N-limited environment
- Licence effluent total N < 3 mg/L
- Conventional nitrification-denitrification process
- Aeration → energy cost
- COD → methanol cost
- 15 day sludge age
- But compromised ability to generate biogas

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Maroochydore STP

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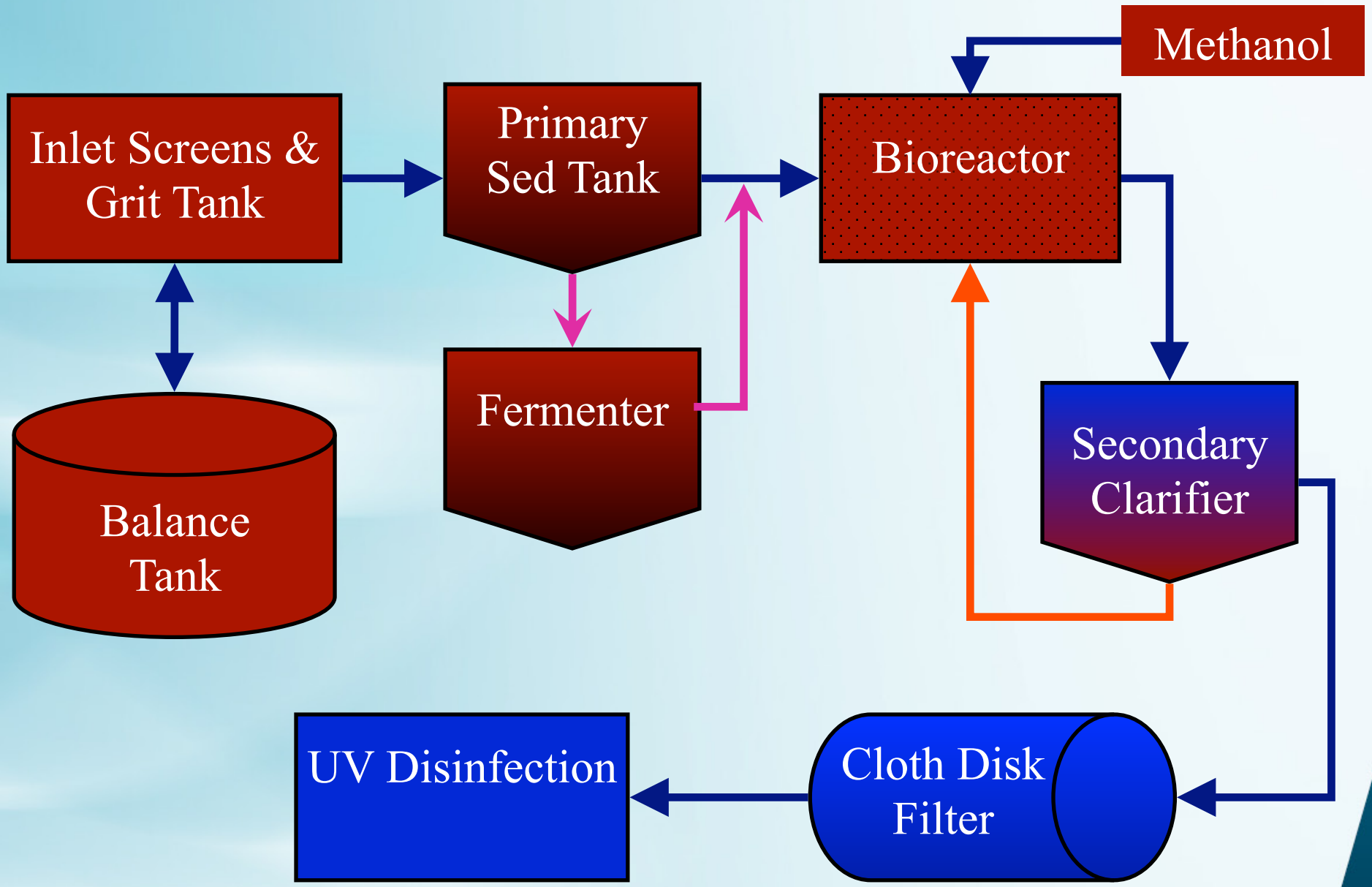
Maroochydore STP Liquid Process



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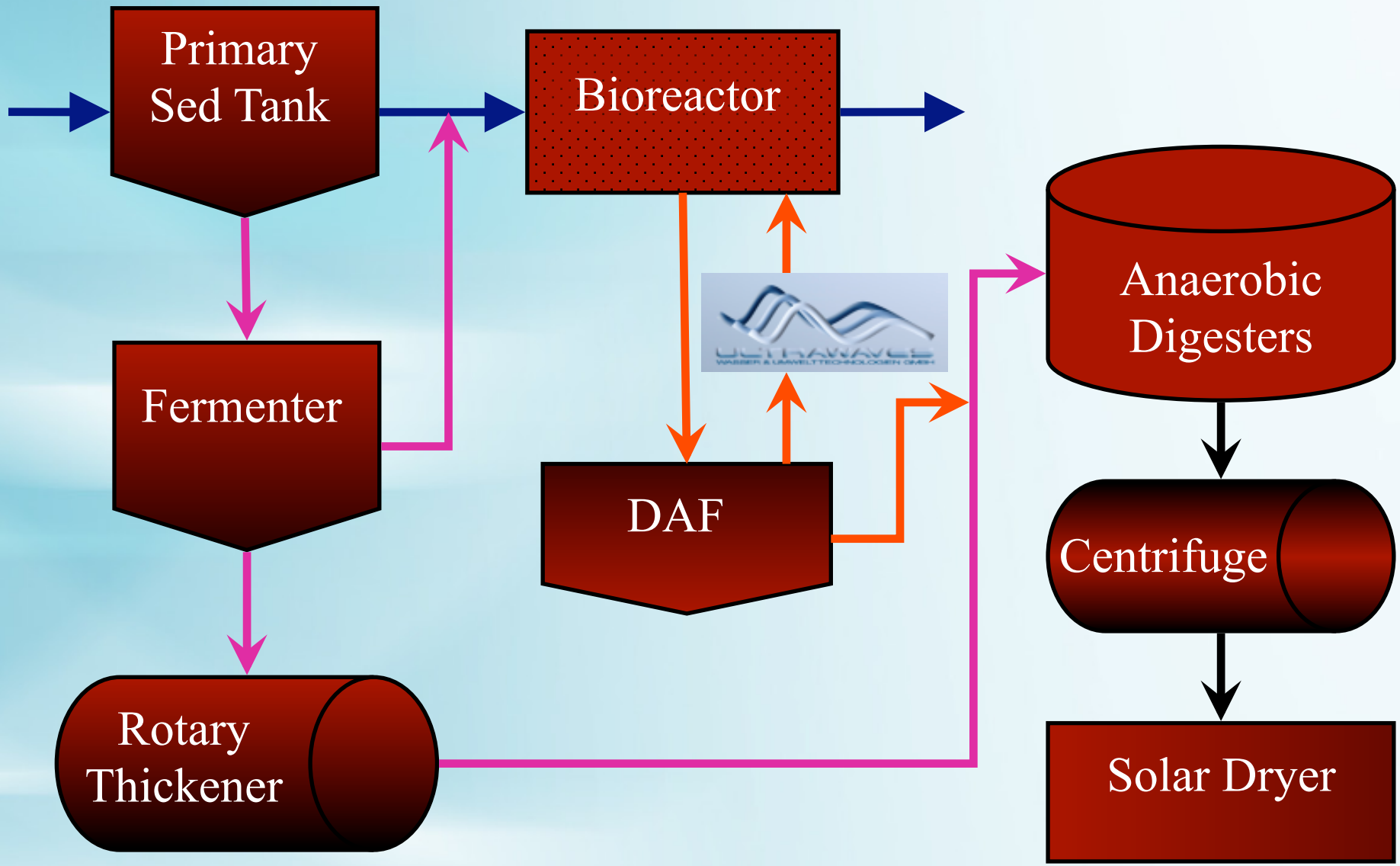
Maroochydore STP Solids Process



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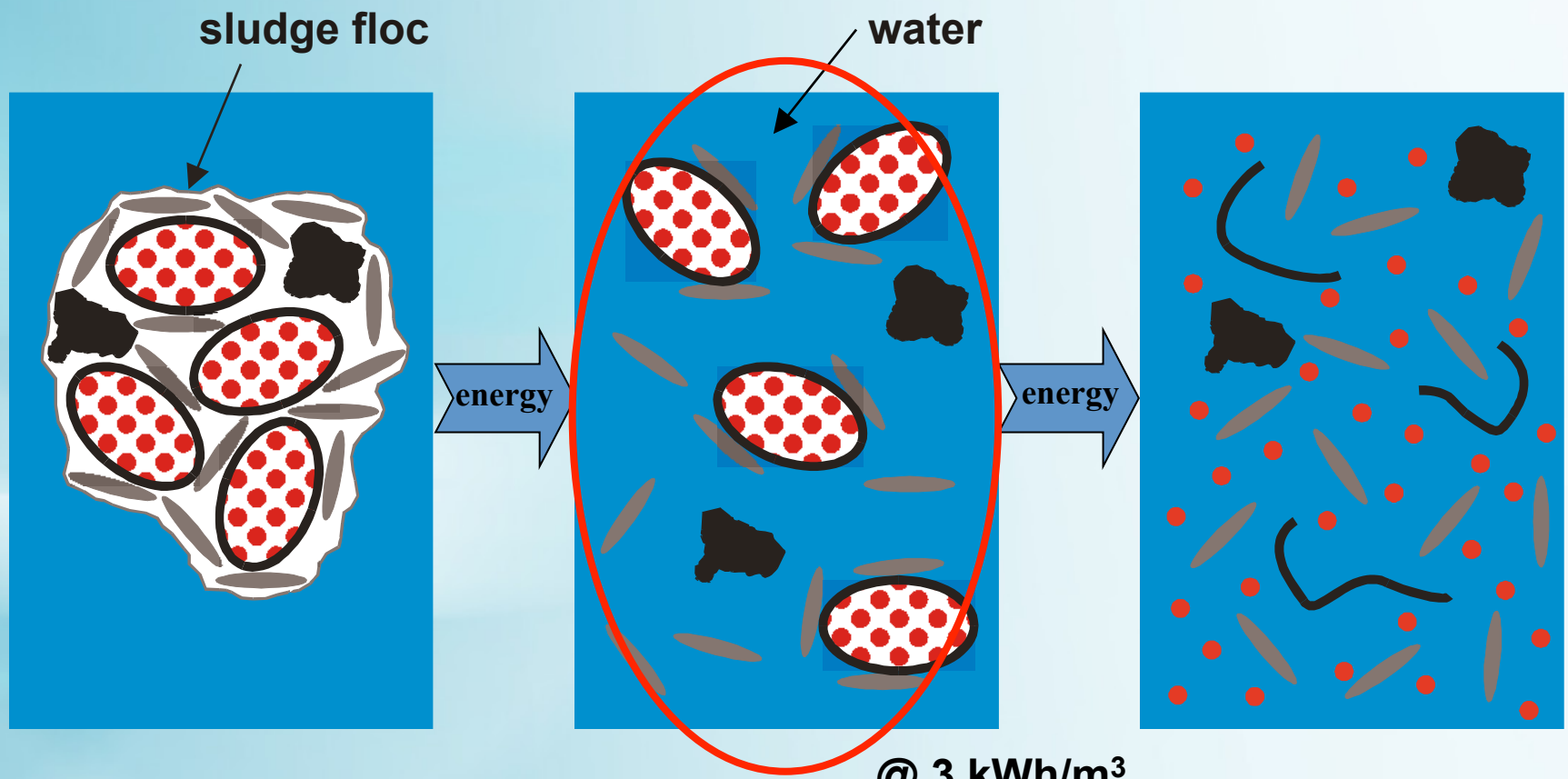
Ultrasonic Activated Sludge Lysis



TUHH
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ULTRAWAVES
WASSER & UMWELTTECHNOLOGIEN GMBH

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Ultrawaves Trial - one 5 kW unit

- Carbon → enhanced denitrification; no methanol
- Sonicated WAS = 25 m^3/d x 38 kg TSS/m^3

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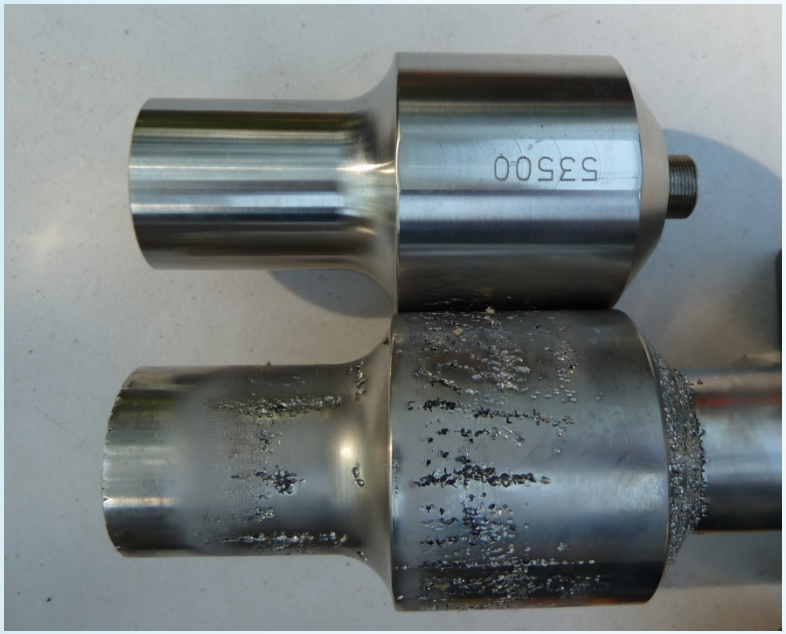
Ultrasonic Lysis Observations

- Soluble COD = 5 kg/d; Total COD = 850 kg/d
- Heterotrophic plate counts using two media:
- Yeast: Before $12x10^6$ cfu/mL; After $46x10^6$ cfu/mL
- R2A: Before $15x10^6$ cfu/mL; After $29x10^6$ cfu/mL
- Sonotrode erosion (after 15 months) → maintenance



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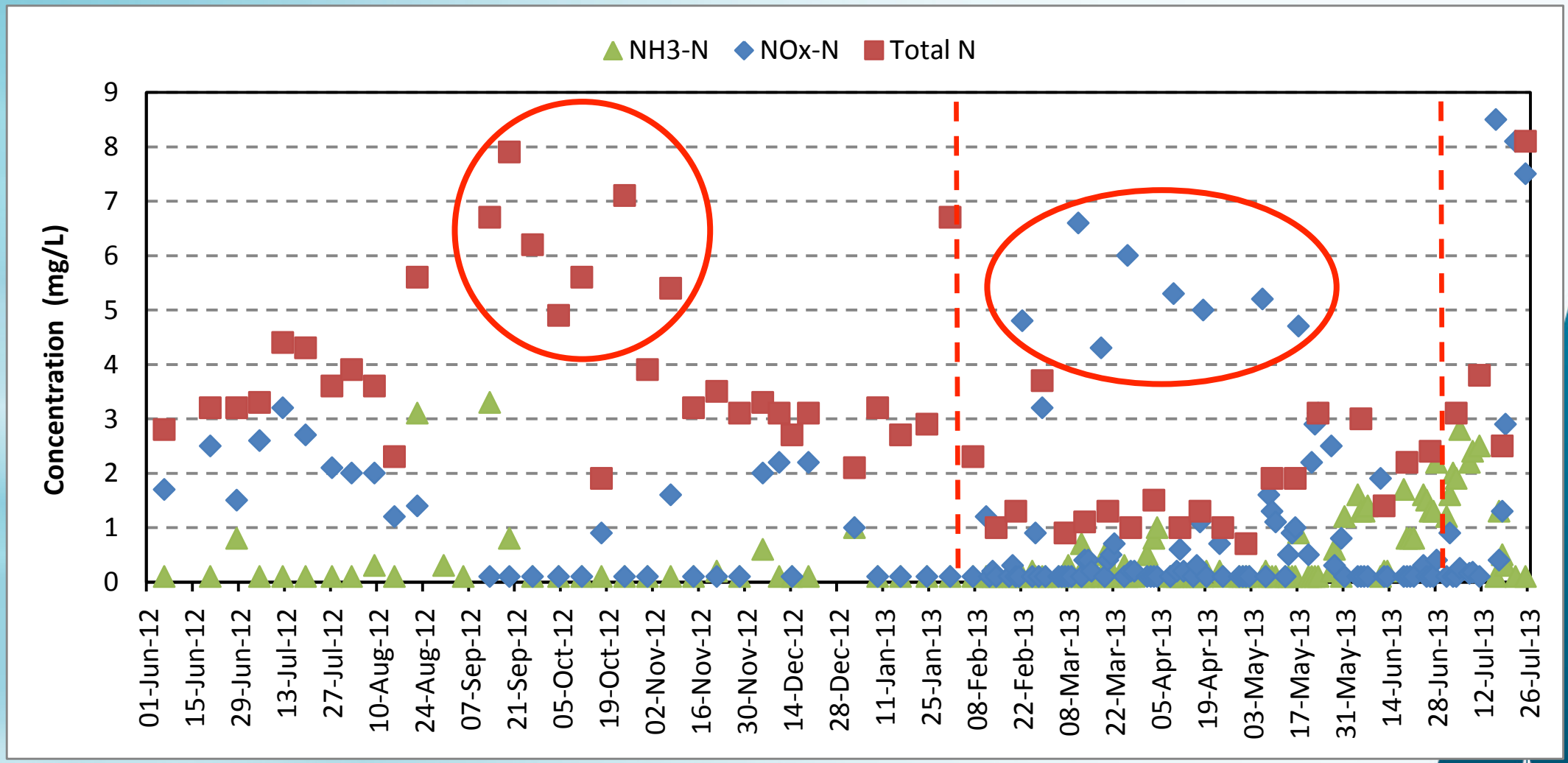
Results: Nitrogen Removal



- Trial 50%-ile effluent total N = 1.7 mg/L
- Trial was nitrate-limited

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Results: Nitrogen Removal Capacity

Nitrogen Removal Indicators	kg COD/d	kg N/d	NO_3-N mg/L
Effluent with no methanol and no Ultrawaves	-	57 kg/d	3.0 – 8.5 mg/L
De-aeration zone on-line nitrate analyser	-	86 kg/d	5 – 10 mg/ L
Methanol use before Ultrawaves trial	304 kg/d	101 kg/d	8.8 mg/L
COD of sonicated WAS (but not 100% biodegradable)	850 kg/d	99 kg/d (max)	8.6 mg/L (max)

- N removal capacity at least 57 kg/d; up to 90 kg/d

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Results: Sludge Production

Sludge Production Indicators	Baseline	Trial	Difference (%)
Mass balance VS destruction	935 kgVS/d	1075 kgVS/d	15%
Observed yield before digesters	0.47 kgVS/ kgCOD	0.45 kgVS/ kgCOD	4%
Observed yield after digesters	0.41 kgVS/ kgCOD	0.37 kgVS/ kgCOD	10%
Specific sludge prod^{n} (relative to EP)	51 gTS/EP/d	48 gTS/EP/d	6%

- 4% COD → CO_2 and 6% COD → Biogas (incl. CH_4)

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Results: Ultrawaves Costs

Cost Component	Unit Cost	Annual Cost	NPV
CAPEX - Ultrawaves units	$176,000 / unit	4 units in 2015 +1 unit in 2021	-$805,312
OPEX - power	120 kWh/d/unit x $0.12/kWh	$5,256/yr/unit	-$223,689
OPEX - sonotrode replacement	$2,250 x 5/unit	$11,250/unit every 18 mth	-$392,845
OPEX – booster shaft replacement	$1,740 x 5/unit	$8,700/unit every 3 yr	-$187,300

- Ultrawaves CAPEX + OPEX NPV = -$1,609,147

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Results: Economic Evaluation

- Annual OPEX savings:
- **Methanol** = 995 L/d x 0.77 kg/L x $640/T = **+$178,973**/yr (increasing with EP growth)
- **Biosolids** = 90 kgVS/d x 4 units x 45%TS x $60/T = **+$17,520**/yr (increasing with EP growth)
- Total OPEX savings NPV = +$2,128,017
- Ultrawaves CAPEX + OPEX NPV = -$1,609,147
- **Net Present Value = +$518,870**
- Installation (excluded above) needs to be <$500,000
- Conservative assumptions used, and more positive NPV with sensitivity analysis

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Discussion

- So ….. what do the results mean for cost effective N removal & energy neutrality
- Anaerobic reactor → Anammox → Mg/Lime P recovery …… are we ready?
- What about sunk capital of existing assets?
- Install primary sed tank upstream of existing bioreactors; increase capacity of existing bioreactors
- Install sonication using WAS as carbon source
- Anaerobic digesters VS destruction and biogas yield
- If primary sed tanks existing and improved N removal required, then sonication of WAS is an option

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Conclusion

- First successful full-scale application in Australia of WAS sonication for enhanced denitrification
- Complete nitrate removal was achieved during the trial and N removal capacity was at least 57 kg/d
- Sludge production was decreased by 100 kg/d
- Economic evaluation showed that the OPEX savings, especially for methanol, resulted in a positive NPV
- WAS sonication technology opens options to:
  - Increase bioreactor capacity with primary sed tank
  - Achieve N removal in COD-limited bioreactors
  - Decrease sludge production and increase biogas

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Thank you

Questions ?

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