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12-MONTH OPERATIONAL PERFORMANCE OF A DEMONSTRATION SCALE UASB AND HIGH-RATE ALGAE POND SYSTEM TREATING DOMESTIC REGIONAL SEWAGE

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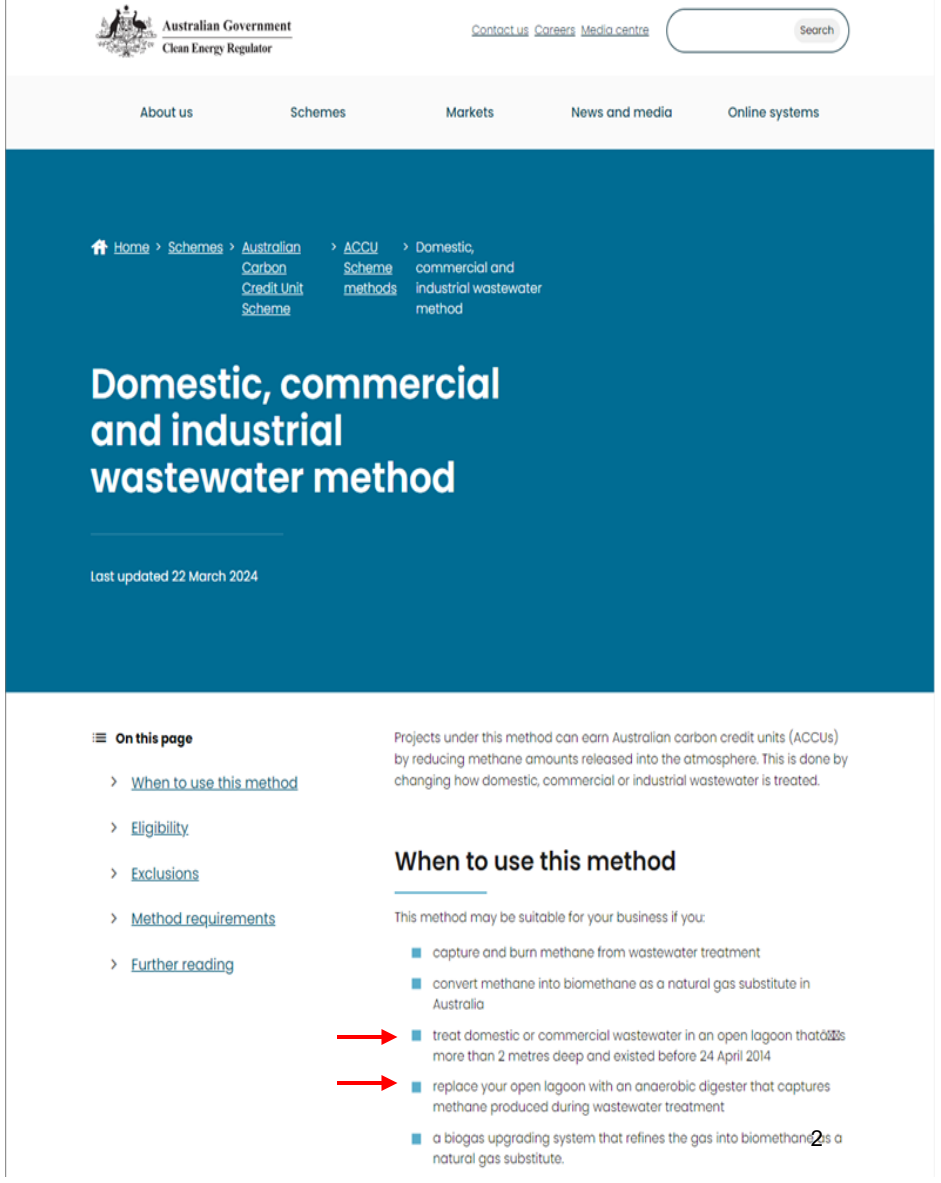
TRANSFORMING REGIONAL TREATMENT PROJECT

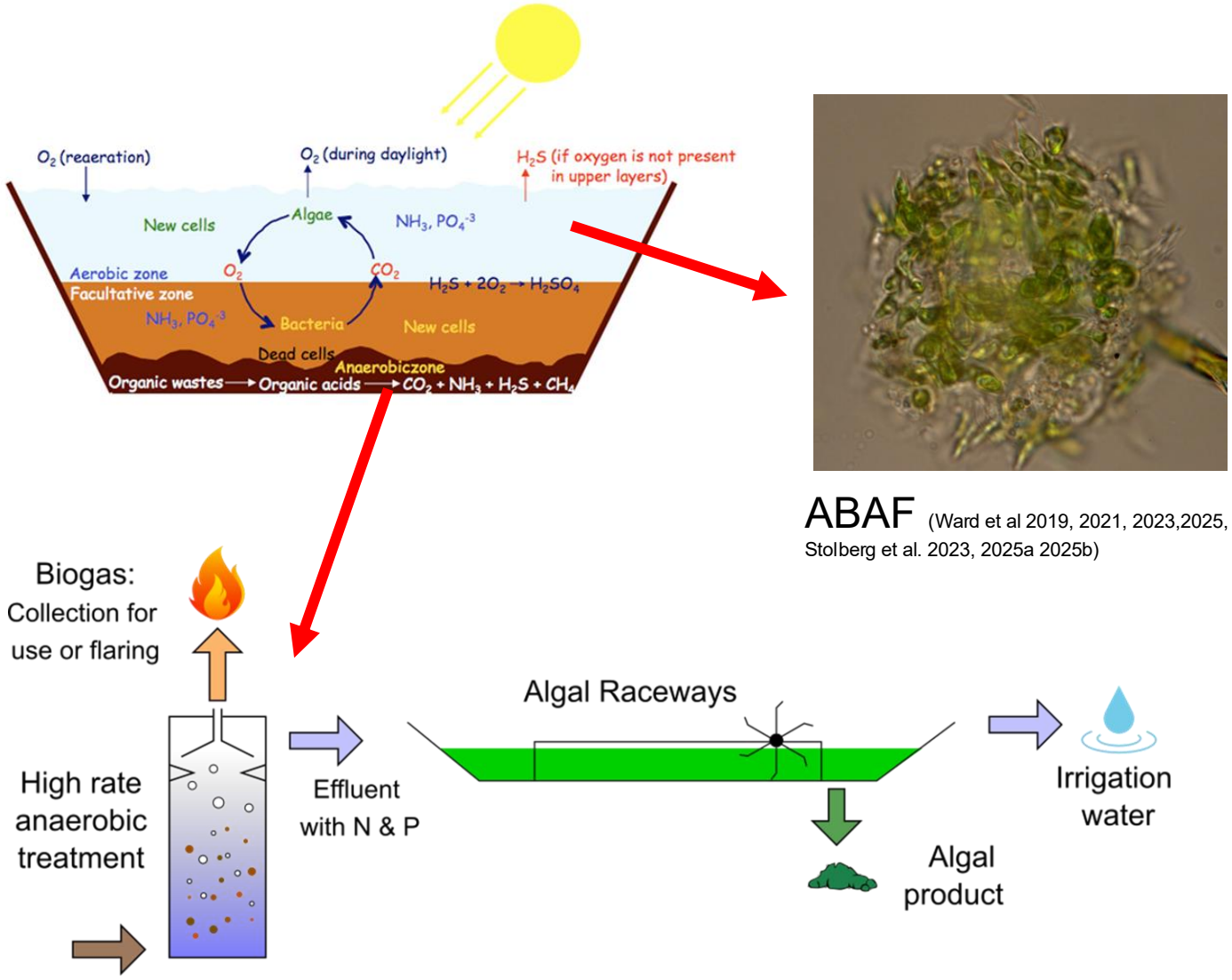
What the project addresses

• Sludge accumulation	• Unreliable nutrient removal
• Prone to stratification and wind driven mixing	• Poor pathogen removal
• Long retention times	• Cyanobacterial blooms
• Large evaporation losses	• GHG and odour emissions

The University of Western Australia
The University Of Queensland AUSTRALIA
Lockyer Valley Regional Council
Queensland Government Department of Environment and Science
Aquatec Maxcon Group
PowerWater
UrbanUtilities



High Rate UASB and HRAP System



ABAF (Ward et al 2019, 2021, 2023,2025, Stolberg et al. 2023, 2025a 2025b)

UASB PRE-TREATMENT FOR ALGAE GROWTH

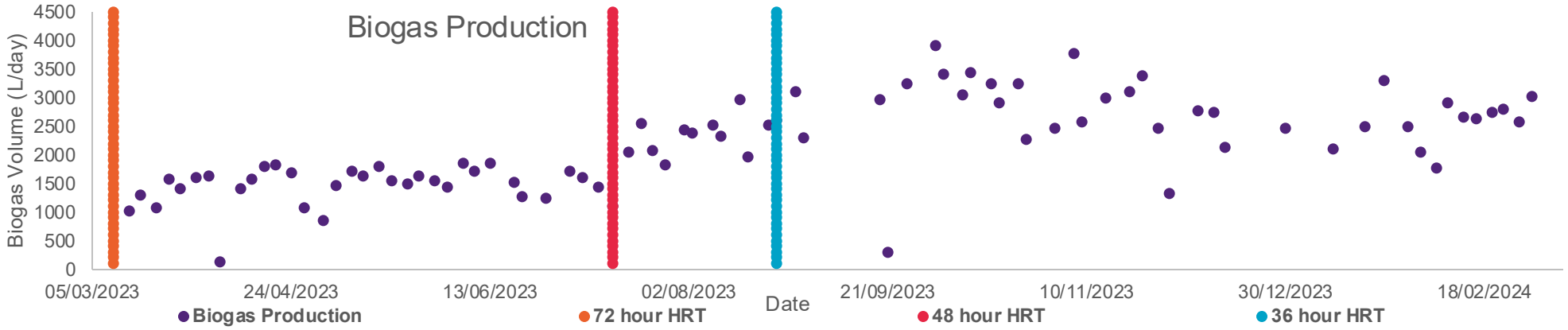
- N and P is solubilised into a bioavailable form.
- Removal of TSS highly beneficial for algae production.
- Pilot work demonstrated a reduction in turbidity which is also beneficial.
- The UASB pre-treatment of effluent is highly beneficial for algae growth

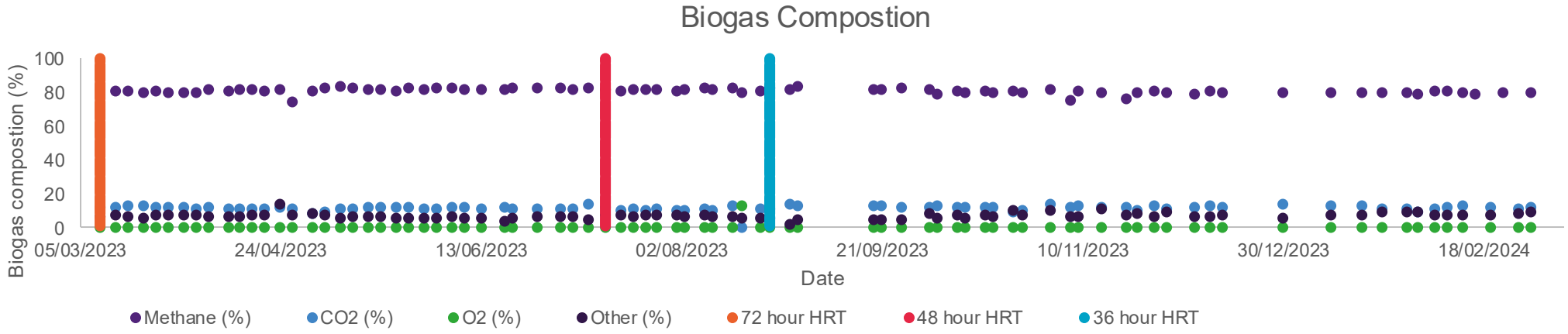
Parameter	72h HRT	48h HRT	36h HRT	12-month average
Increase in soluble N (%)	25 ± 17	25 ± 7	15 ± 11	22 ± 14
Increase in soluble P (%)	41 ±20	46 ± 14	31 ± 17	36 ± 19
TSS removal by UASB (%)	84±10	60±32	64±19	74±24

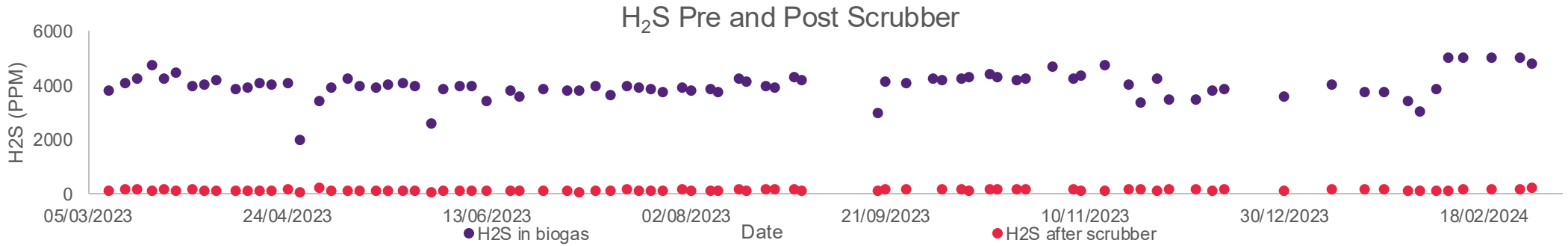
Lab Based Algae Growth Study

HRT (hours)	48	36	24	12	Undigested
Specific Growth Rate (Day)	0.74±0.08	0.67±0.02	0.60±0.09	0.51±0.06	0.48±0.11
Productivity (g/L/day)	0.55±0.03	0.32±0.07	0.23±0.02	0.21±0.05	0.21±0.06
Doubling Time (days)	1.36 ±0.15	1.49 ±0.04	1.70±0.25	1.98±0.17	2.15 ±0.48

TCOD removal rate
62 ± 6%

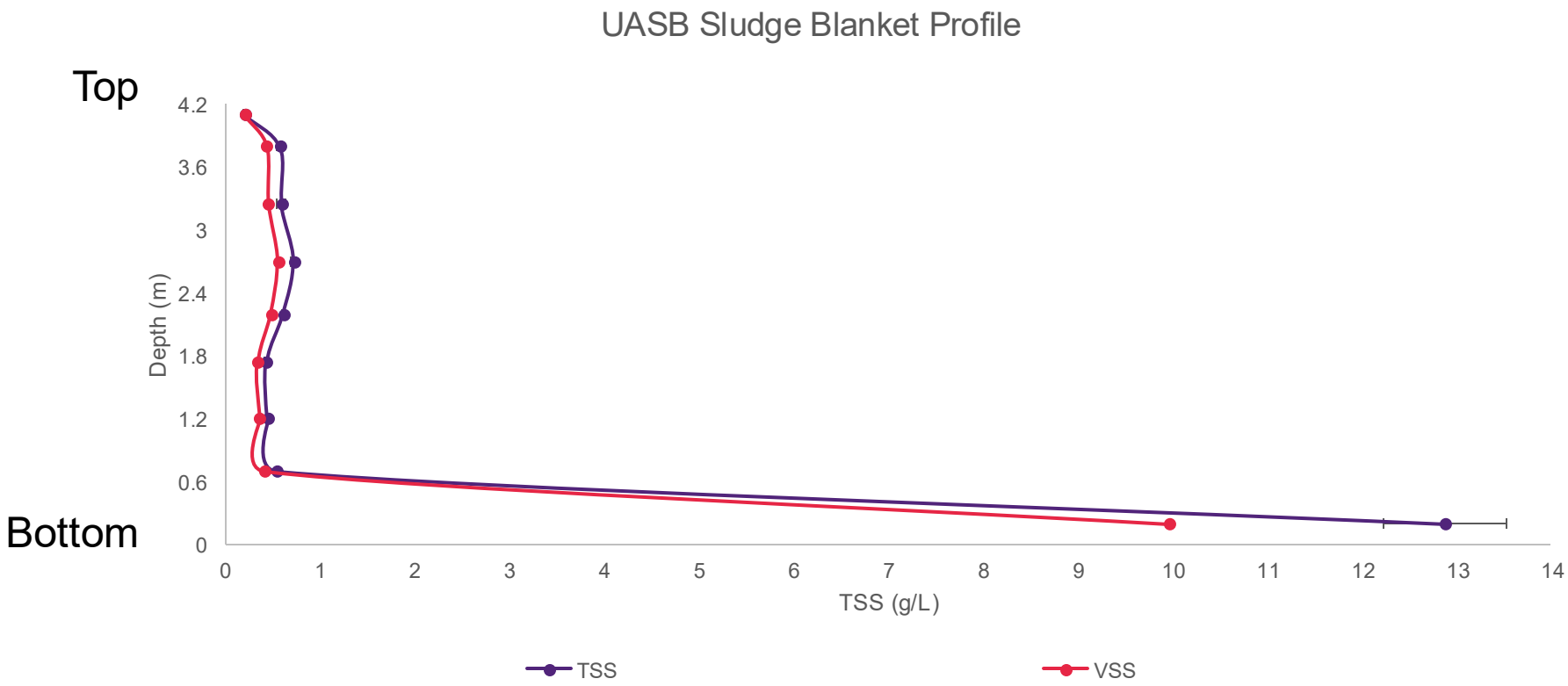






UASB SLUDGE ACCUMULATION

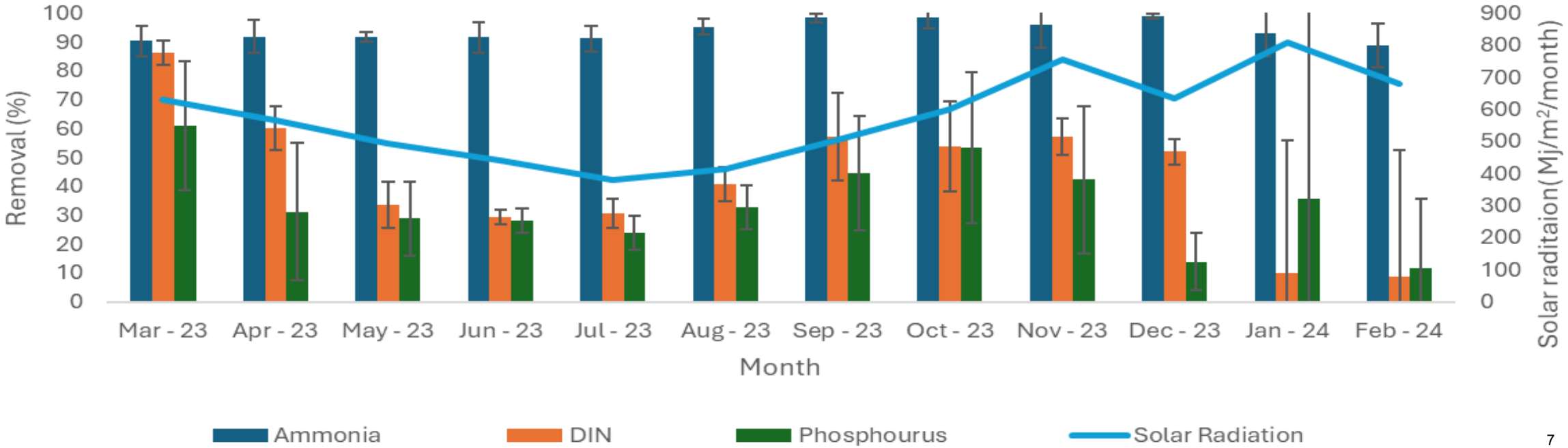
- 15-months continuous operation
- No sludge removed over this operational period
- Sludge in reactor appears to be associated with the sludge blanket and required for optimal operation



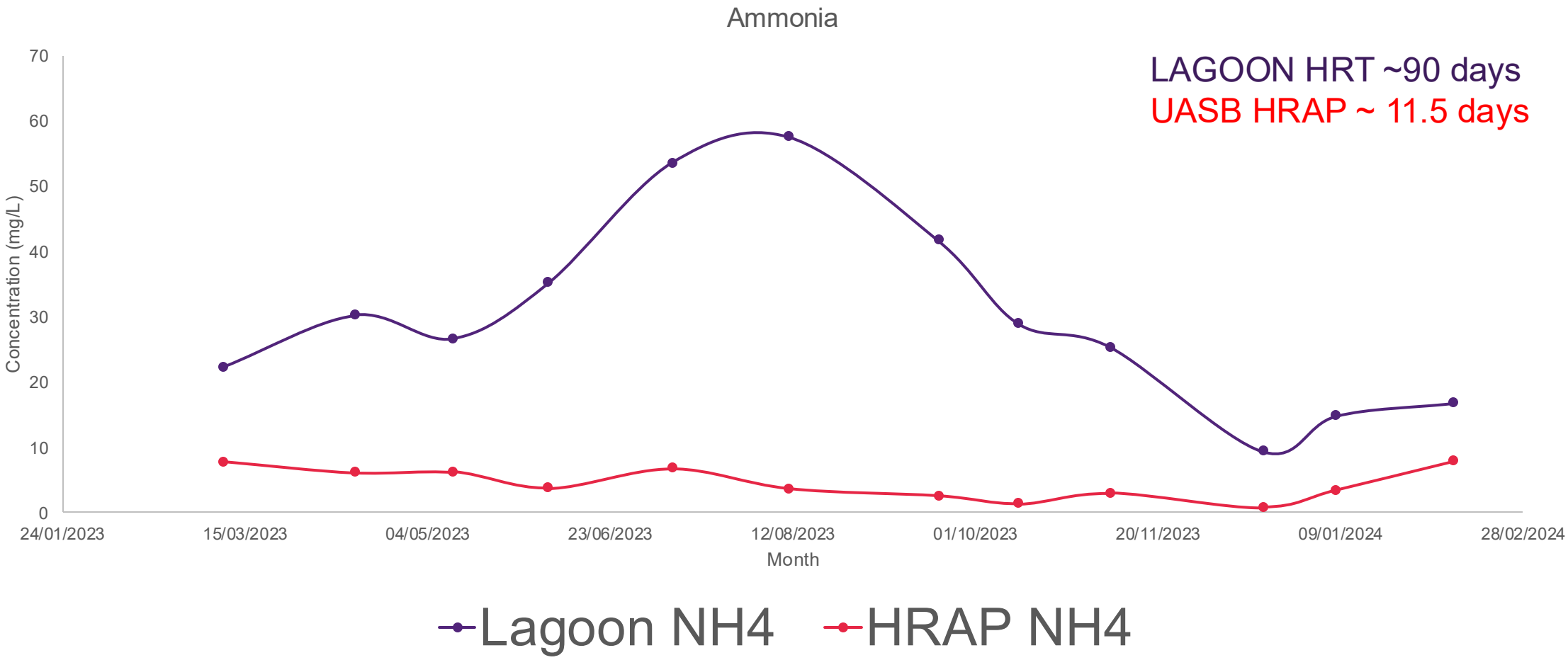
HRAP NUTRIENT REMOVAL

HRAP Effluent	Removal (%)
DIN	44.1 ± 29.9
NH_4	93.4 ± 5.6
PO_4	35.6 ±27.8

Month	Temp (C°)	DIN (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	NH_4 (mg/L)	NH_4 removal (%)	PO_4 (mg/L)	PO4 removal (%)
Mar	16.3 ± 0.4	11±3.1	3.2±2.9	0.1±0.2	7.7±4.2	90.4±5.3	4.1±2.2	60.9±22.5
Apr	18.5 ±2.8	30.8±7.1	20.9±7.4	3.9±4.9	6.1±4.1	91.9±5.6	6.8±2.3	31.2±23.8
May	12.7 ±3.3	49.3±6.4	1.2±0.5	41.9±5.5	6.2±1.4	91.7±1.8	6.8±1.3	28.7±12.9
Jun	12 ±3.4	39.3±24	1.5±0.9	34±21.9	3.7±2.9	91.5±5.3	5.0±3.2	28.2±4.2
Jul	14.8 ±2.2	53.7±2.7	0.9±0.3	46.1±3.3	6.7±3.3	91.2±4.6	7.3±0.2	24±5.9
Aug	16.2 ±2.8	39.5±15.3	1.9±2.1	39±2.6	3.5±2.1	95.2±2.7	6.3±0.6	32.7±7.4
Sep	21.1 ±3.9	58.±21.2	5.5±4	50.±17.7	2.5±2.1	98.3±1.5	10±3.7	44.5±19.9
Oct	25.1 ±3.9	37.2±11.7	1.3±0.6	34.6±13.8	1.3±2.5	98.4±3.6	5.2±2.7	53.3±26.1
Nov	23.6 ±4.5	31.1±3.5	0.5±0.3	27.7±2.8	2.9±5.4	95.8±7.7	5.3±2.2	42.3±25.6
Dec	27.9 ± 2.7	36.7±0.8	0.3±0.1	35.8±0.1	0.7±0.7	99±0.8	8±1.1	13.8±9.8
Jan	30.2 ± 2.0	58.3±19.1	0.1 ±0.2	54.8±16.1	3.4 ±3.6	92.9±8.1	7.1 ±2.8	35.5±76.9
Feb	28.5 ±3.3	52.9 ± 7.7	0.4 ±0.4	44.7 ±4.7	7.9 ±6.3	88.7±7.6	6.8 ±1.1	11.8±23.9



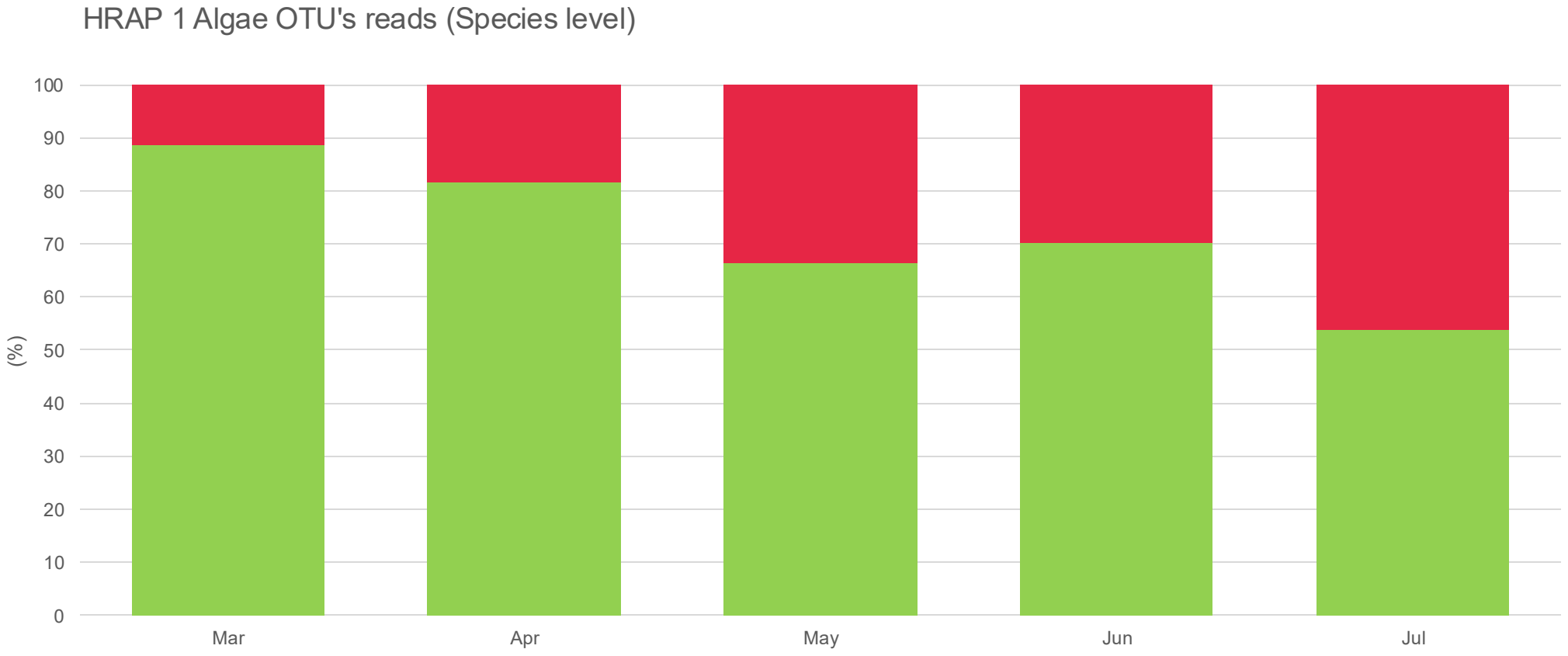
HELIDON LAGOON SYSTEM VERSES HRAP SYSTEM



Note: UASB removed approximately 15% of COD daily load from Lagoon influent

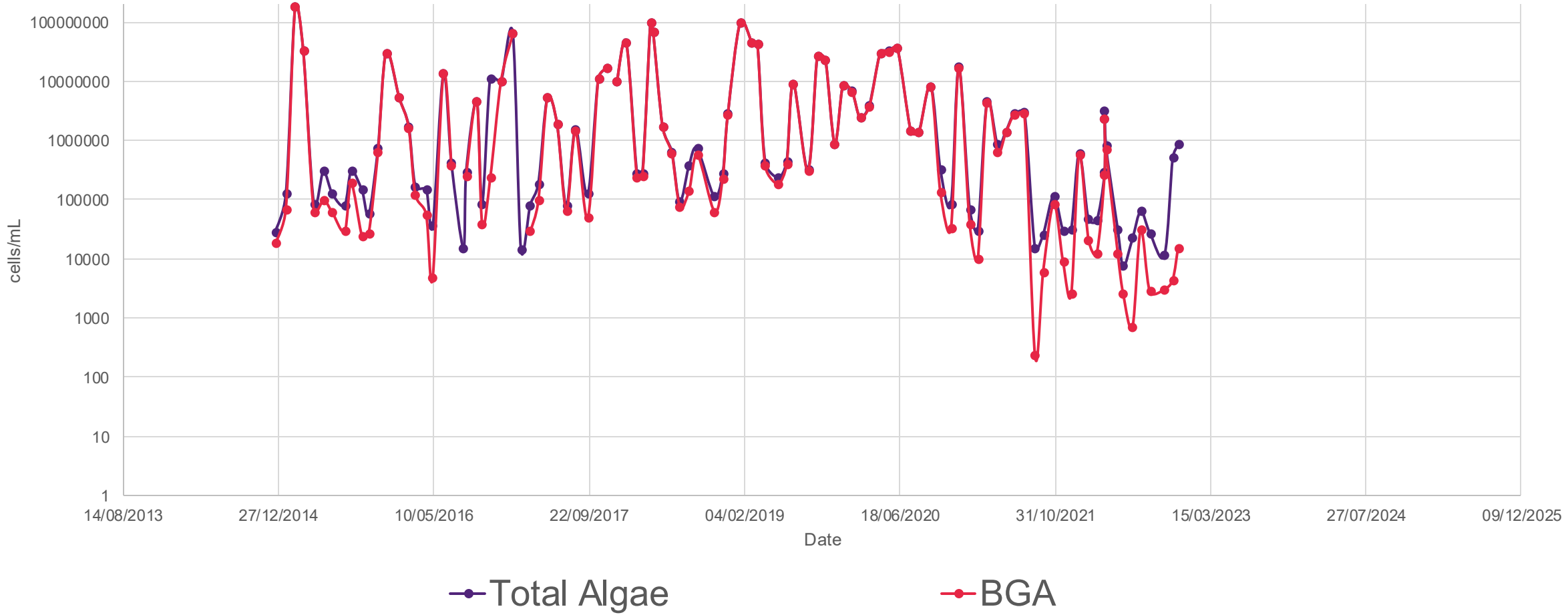
HRAP ALGAL COMMUNITY

16S & 18S rRNA amplicon sequencing with primer sets 16S & 18S 926F (50AAACTYAAAKGAATTGRCGG30) and 1392wR (50ACGGGCGGTGWGTRC-30).



HELIDON LAGOON ALGAE COMMUNITY

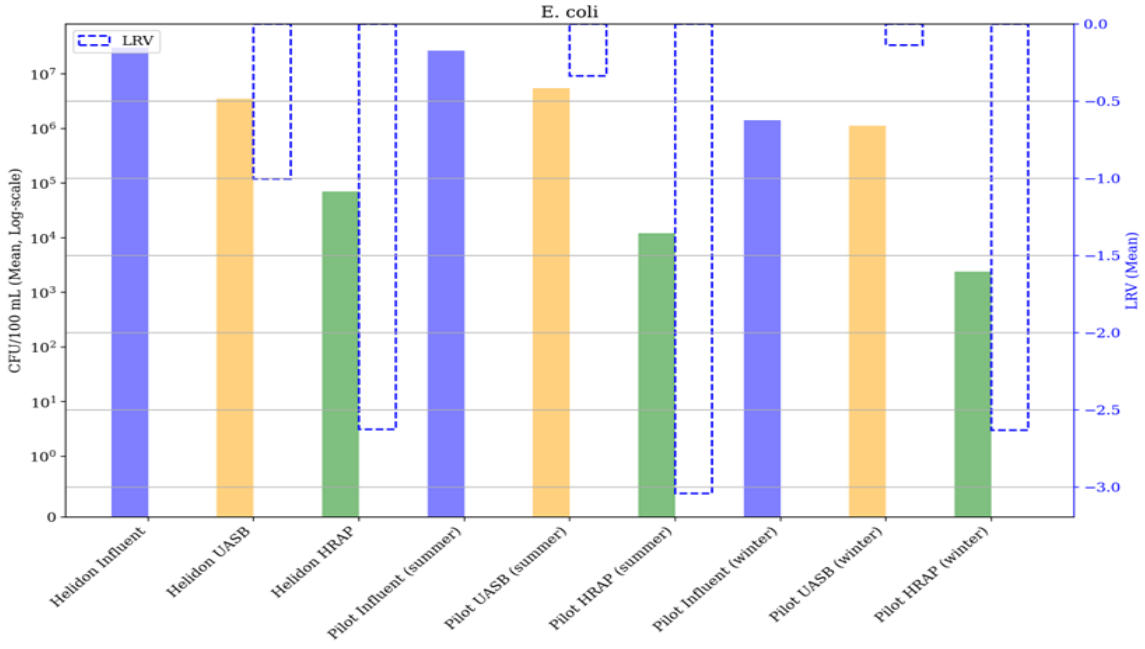
Historically 76% of Helidon lagoon community Blue Green Algae

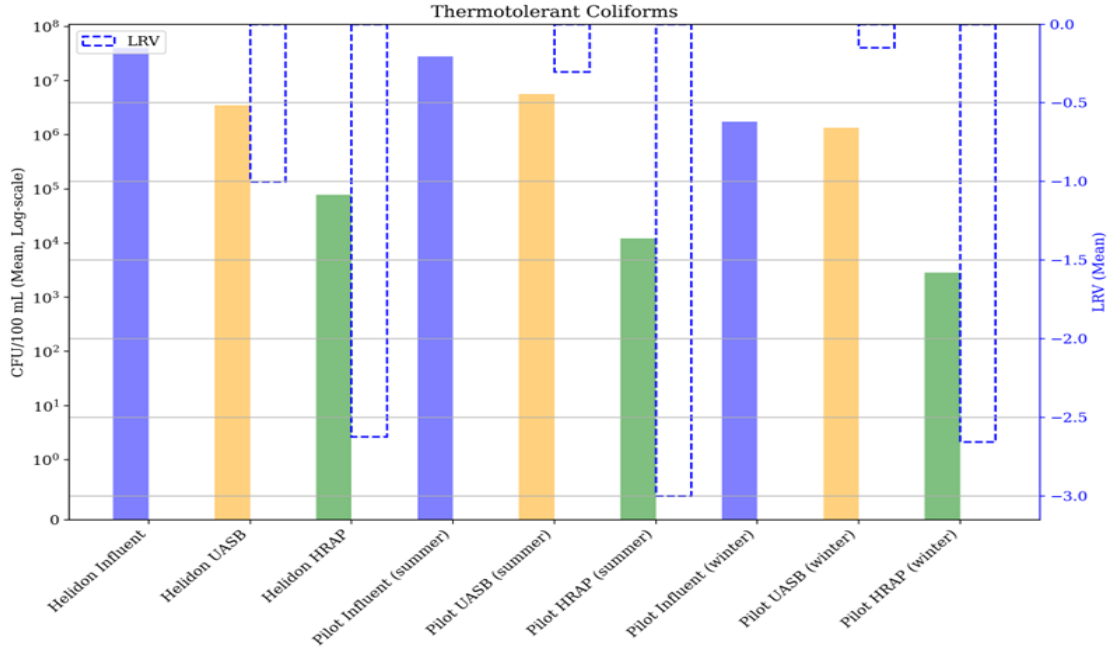


PATHOGEN REMOVAL

Log Reduction	Number of CFUs Remaining	Percentage Reduction
0 log	1,000,000	0%
1log	100,000	90%
2log	10,000	99%
3log	1,000	99.9%
4log	100	99.99%
5log	10	99.999%
6log	1	99.9999%

	LRV UASB	LRV HRAP
Pilot Summer Ecoli	-0.33 ± 0.72	-3.05 ± 1.01
Pilot Winter Ecoli	-0.13 ± 0.26	-2.63 ± 0.47
Helidon Demonstration Ecoli	-1.01 ± 0.67	-2.63 ± 0.34
Pilot Summer TColi	-0.30 ± 0.54	-3.01 ± 0.92
Pilot Winter TColi	-0.15 ± 0.27	-2.66± 0.48
Helidon Demonstration TColi	-1.06 ± 0.79	-2.66 ± 0.47





ALGAE TSS CONCENTRATION PRE AND POST CLARIFIER

TSS ~ 260 mg/L TSS ~ 60 mg/L

CONCLUSIONS

Outperforms Existing Lagoon Based System

UASB

- Viable high-rate regional pre-treatment process
- Beneficial pretreatment for algae growth with twin applicability to lagoon systems
- Loading rate had greater effect on biogas production than HRT
- Scrubber reduced H_2S levels to allow use of biogas
- GHG reductions and ability to earn Australian Carbon Credit Units
- Low sludge accumulation

HRAP

- Short treatment times
- High ammonia removal (no seasonal effect)
- Good DIN removal
- Nitrification process established
- Limited effect from rainfall
- No Blue Green algae detected
- High pathogen removal
- Biomass production
- Harvesting process developed
- Drying beds developed

Thank You and Questions

ACKNOWLEDGMENTS

This work was supported in part by the Cooperative Research Centre Projects (CRC-P) Transforming wastewater treatment in regional Australia with robust technology for multiple benefits through the Australian Government under Grant CRCPSIX000079 and the Advance Queensland Industry Research Fellowship (AQIRF173-2019RD2) titled Algae Bacteria Aggregated Flocs (ABAF) for wastewater treatment and algae industries.

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