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Cyanobacterial bloom management: Technology performance & optimisation assessments

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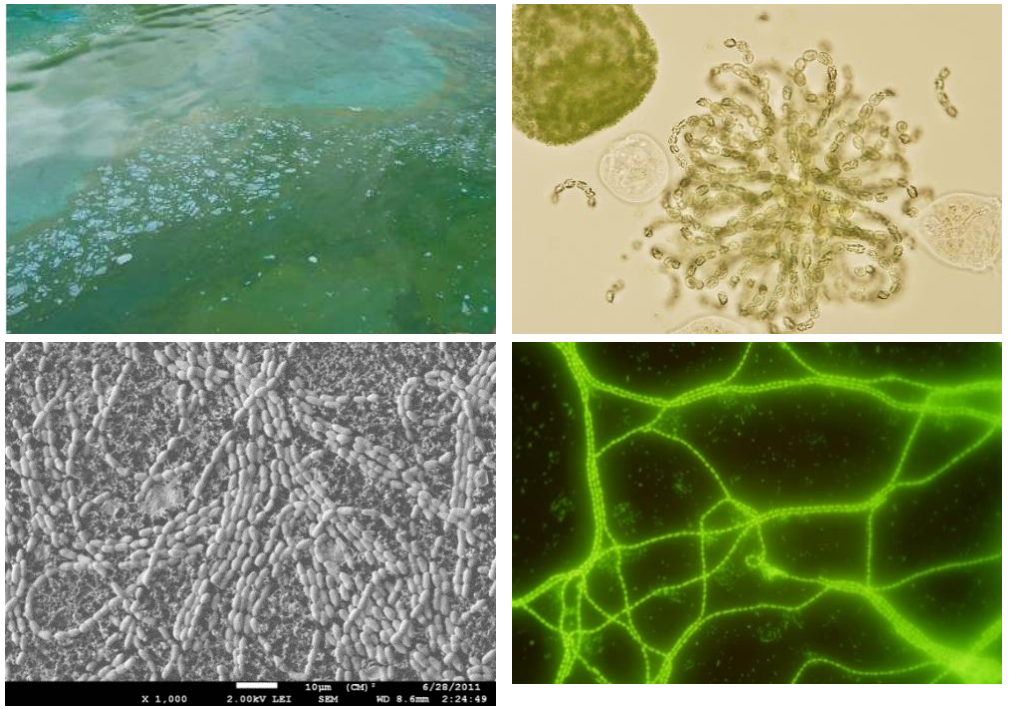
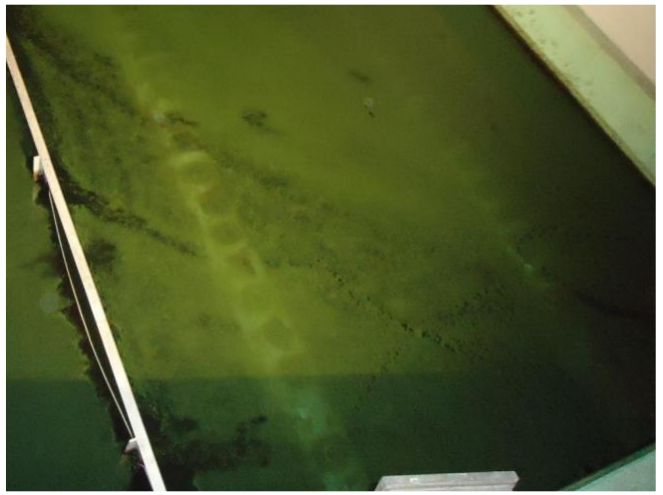


Cyanobacteria breakthrough into flocculation system

Cyanobacteria breakthrough into mixers

Cyanobacteria accumulation inside DAF sludge

Cyanobacteria breakthrough into clarified water



https://www.waterra.com.au/_r9227/media/system/attrib/file/2138/WaterRA_FS_Cyanobacteria.pdf

https://www.waterra.com.au/_r11700/media/system/attrib/file/2807/ColoSSoS_FS_BMAA_2021.pdf

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Survey of utilities across Australia and North America:

- Need for developing guidance for assessment and evaluation of harmful algal blooms, and implementation of monitoring and control strategies in source water and supply systems
- A clear and consistent approach to assessing the efficacy and performance of the growing number of algal bloom management technologies emerging on the market

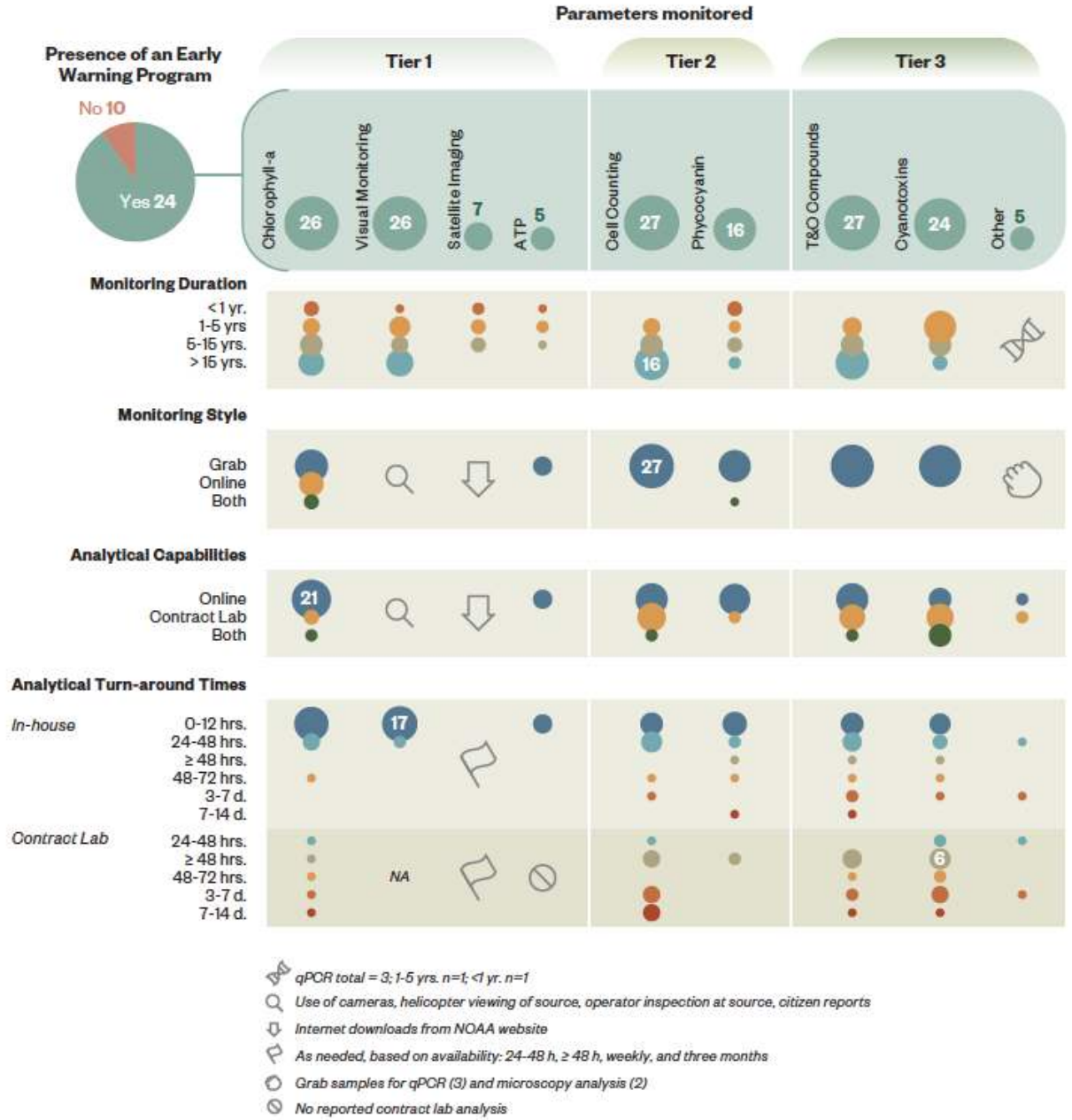


Figure 6. Summary of utility response (n=32) indicating parameters included in the early warning program and their overall performance.

- Water Research Foundation (#4912)
- F. Kibuye, H. Almuhtaram, A. Zamyadi, V. Gaget, C. Owen, R. Hofmann, E.C. Wert (2021) Utility practices and perspectives on monitoring and source control of cyanobacterial blooms. *AWWA Water Science (JAWWA)*, e1264. https://doi.org/10.1002/aws2.126426

WaterRA #1138: Protocols for algal bloom management - technology performance & optimisation assessments

Objective

- Developing a customisable protocol for selection, deployment and performance assessment of algal bloom management technologies using WaterVal princeps
- Sharing knowledge about performance of selected technologies during field trials

Benefits

- Addressing the knowledge gaps associated with appropriate selection, deployment, monitoring and overall performance assessment of technologies
- Provide insights into how the protocol is applied during real-world performance assessments of algal bloom technology, which will allow the learnings to be compared against the requirements in the protocol:
    - Trial package for Intelligent Water Network (IWN) - ***Source mitigation using sonication***
    - Trail package for Melbourne Water - ***Source monitoring & BAC pilot treatment***
    - Assessment package for Valley Water (California, USA) - ***Real time fluorescence source monitoring***
    - Assessment package for Water NSW - ***Real time fluorescence source monitoring***
    - Assessment package for Hunter Water - ***Remote sensing for source monitoring***
    - Exploring gaps in BMAA detection

Project funding partners

Project delivery team

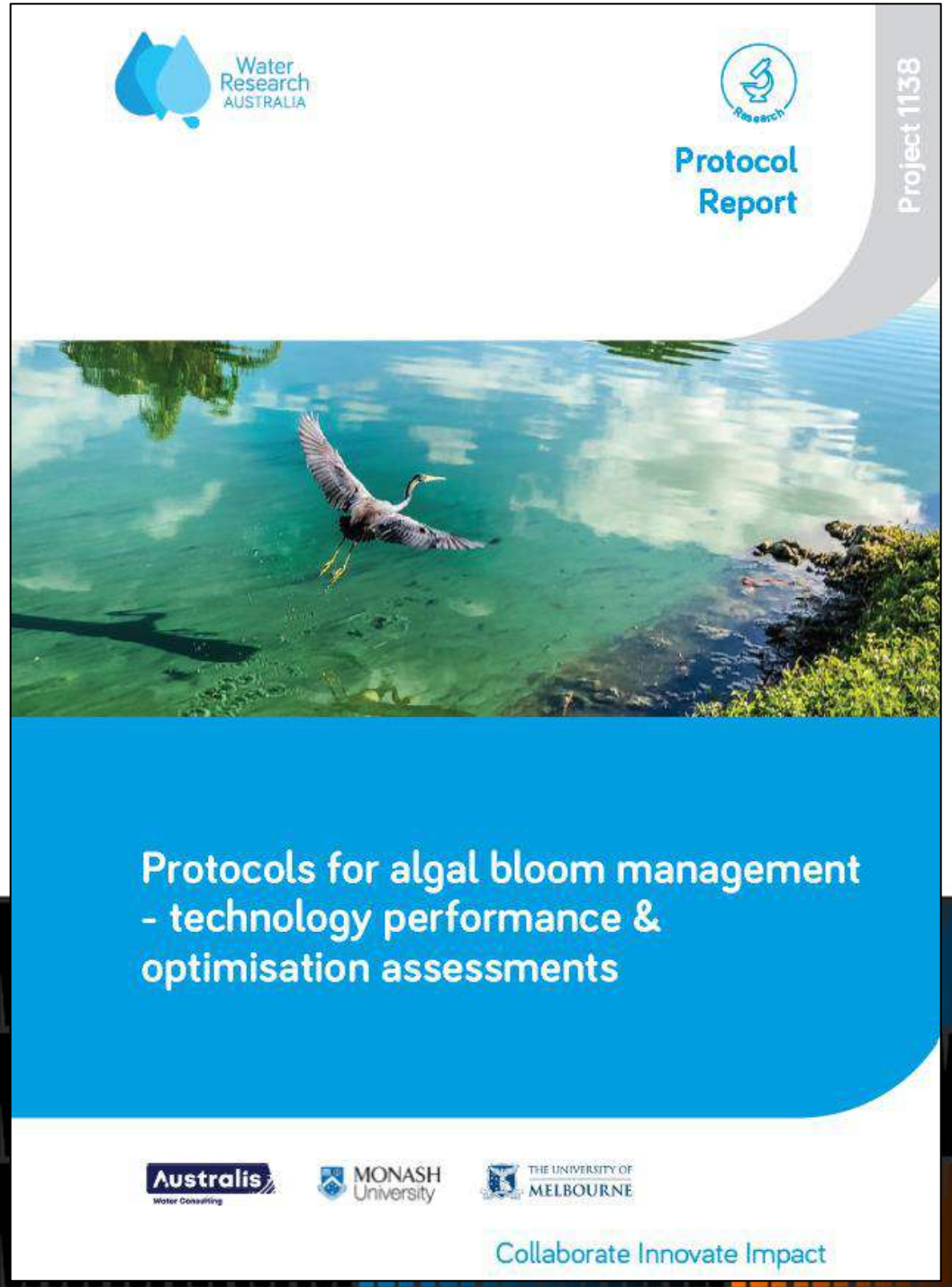
The document covers

- key considerations for technology selection, deployment, program design, and data assessment.

Considerations of these aspects of trial design

- will ensure that the trials will be robust and scientifically sound and
- will increase the likelihood of a successful in-situ technology trial.

- Success means: Clear understanding of why the selected tech works or not-working



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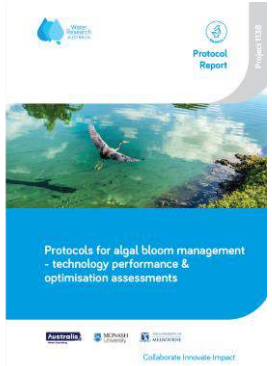

WaterVal Princeps

Elements of the WaterVal princeps were considered where appropriate to develop this technology performance and optimisation assessments protocol.

1. Identify the mechanisms of detection or mitigation by the target technology
2. Identify the target microorganism/metabolite, or appropriate surrogates, that are the subject of the validation study. Ensure that the target microorganism/metabolite/surrogates are present in an appropriate concentration
3. Identify the influencing factors that affect the efficacy of the target detection or mitigation tech
4. Identify the operational monitoring parameters that can be measured continually (ideally) and that will relate with the detection or removal of the target microorganism/metabolite
5. Identify the validation methodology to demonstrate the capability of the detection or mitigation tech
6. Describe a method to collect and analyse data to formulate evidence-based conclusions
7. Describe a method to determine the critical limits as well as an operational monitoring and control strategy
8. For mitigation tech only: Describe a method to determine the removal efficiency of a treatment process unit for each microorganism/metabolite group in each specific treatment process unit performing within defined critical limits
9. Provide a means for re-validation or additional onsite validation where proposed modifications are inconsistent with the previous validation test conditions

Scale of trials!

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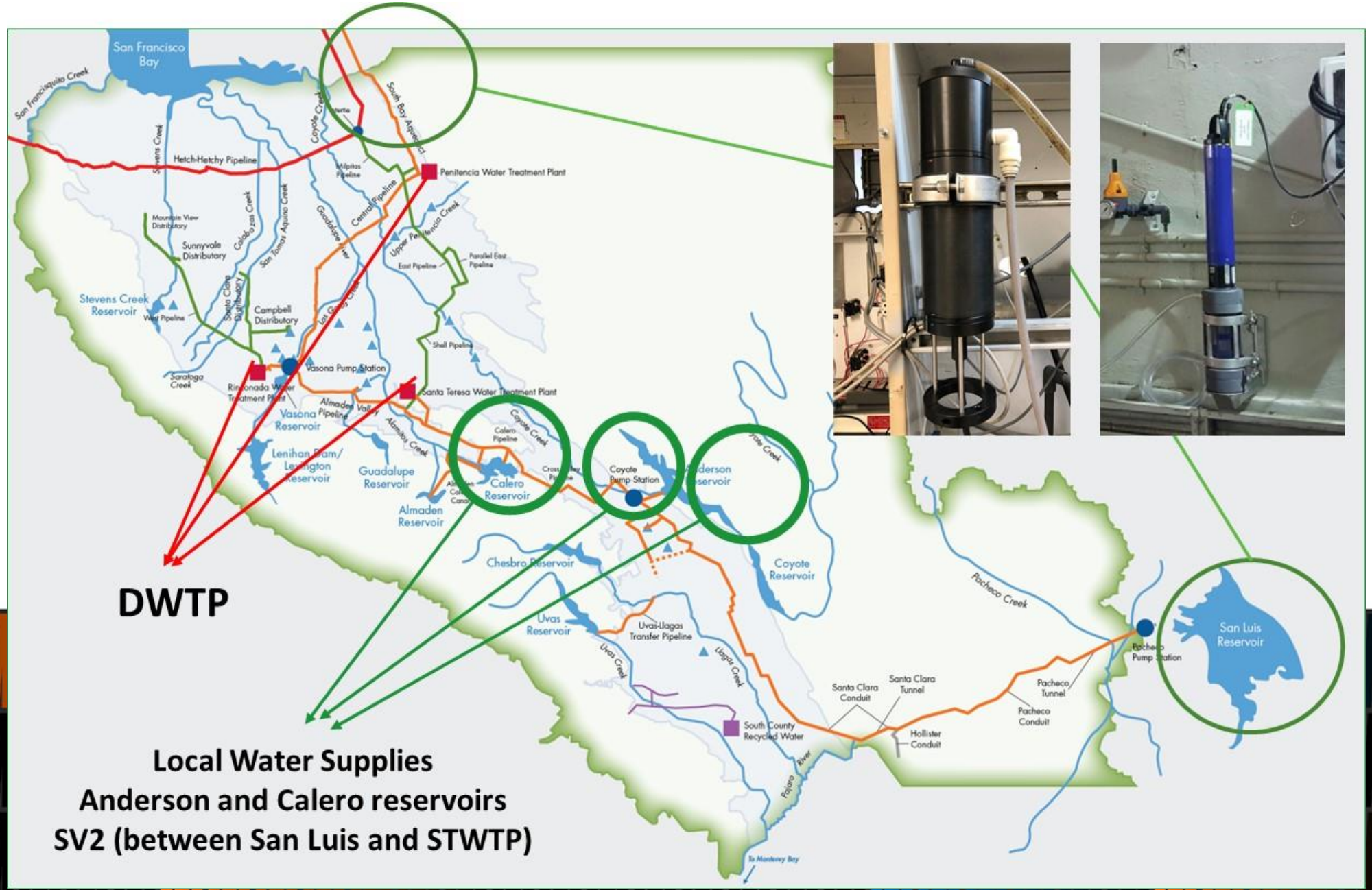
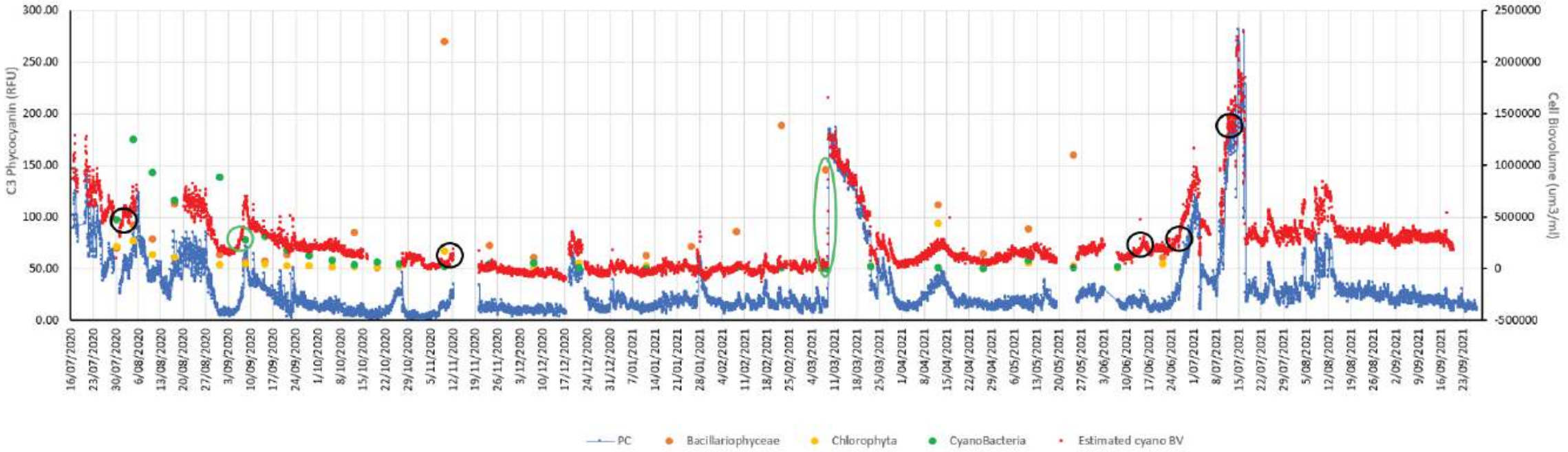
Valley Water

DEPARTMENT OF WATER RESOURCES · STATE OF CALIFORNIA ·

Assessment package for Valley Water – California:

- Developing an early warning system for management of cyanotoxins in source water





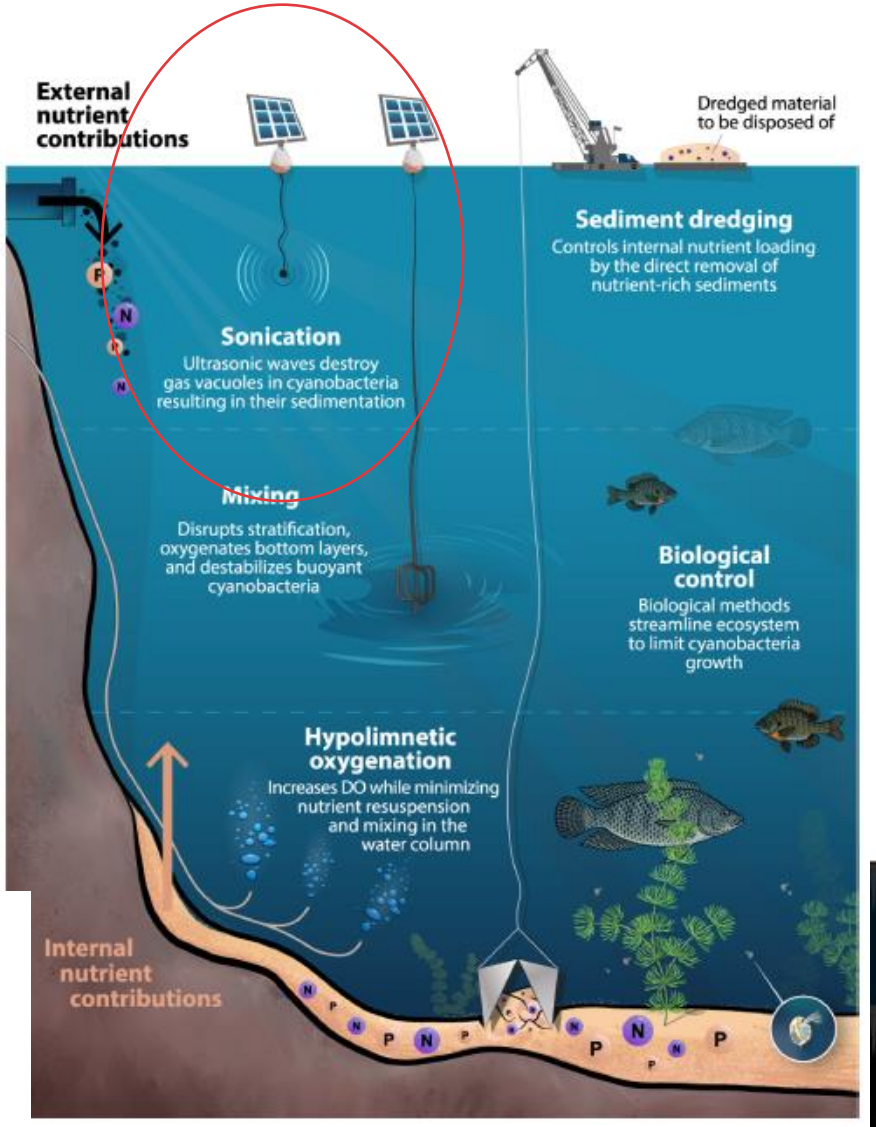
- ✓ Regression model (Pigment, Temp, NTU, pH) early warnings for exponential growth (circled)
- ✓ Sample at correct location of the probe and collect all the required big data
- ✓ Machine learning without a strong training set can't do magic; don't believe me ask ChatGPT?

- H. Almuhtaram, A. Zamyadi, R. Hofmann (2021) Machine learning for outlier detection in algal and cyanobacterial fluorescence signals. *Water Research*, 197, 117073. https://doi.org/10.1016/j.watres.2021.117073
- L. Vaughan, M. Zhang, H. Gu, J. Rose, C. Naughton, G. Medema, V. Allan, A. Roiko, L. Blackall, A. Zamyadi (2023) An exploration of challenges associated with machine learning for time series forecasting of COVID-19 community spread using wastewater-based epidemiological data. *Science of the Total Environment*, 858, 159748. https://doi.org/10.1016/j.scitotenv.2022.159748

Trial package for Intelligent Water Network (IWN):

- Does sonication work?
  - *"Maybe / Yes"* in small scale
  - *"No"* in large scale:
    - Never used enough sonicators for the size of the water body

- Trialling of this non-chemical dosing tool for cyanobacteria mitigation at the source



- F.A. Kibuye, A. Zamyadi, E.C. Wert (2021) A critical review on operation and performance of source water control strategies for cyanobacterial blooms: Part I-Chemical control methods. *Harmful Algae*. 109, 102099. https://doi.org/10.1016/j.hal.2021.102099
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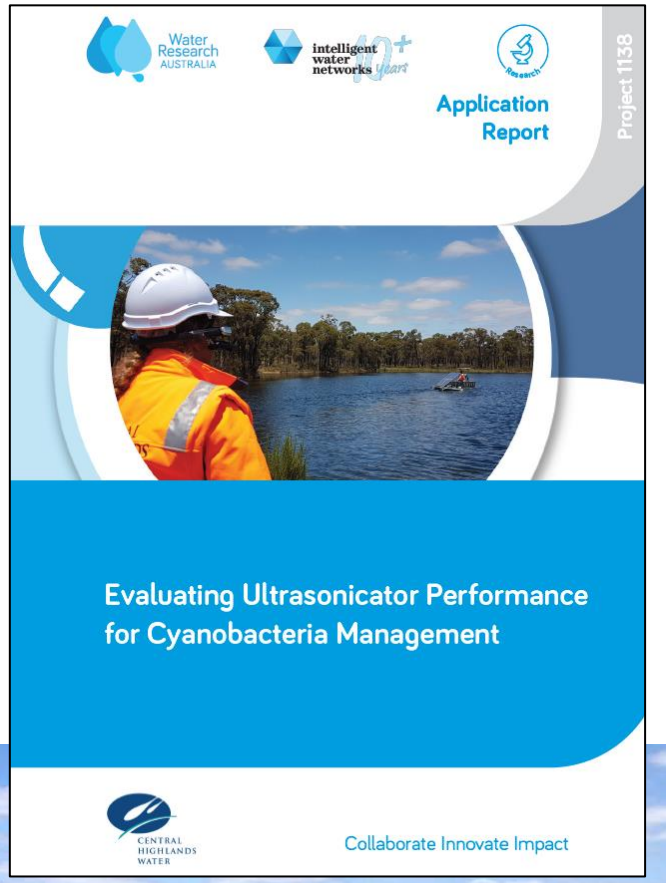
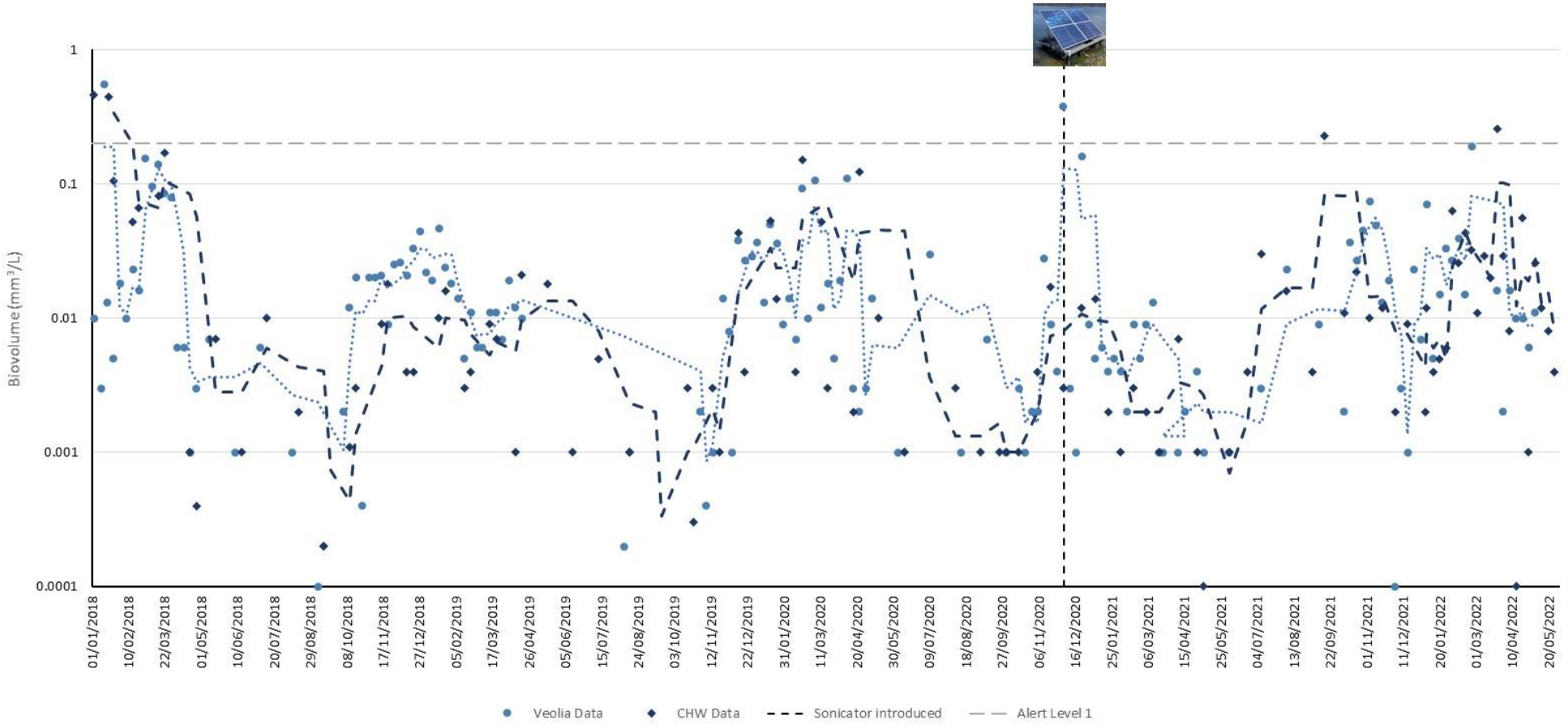
Trial package for Intelligent Water Network (IWN):

- Select correct number of sonicators for the waterbody size
- Developed the sampling protocol to collect systematic algal and cyanobacterial, and water quality data: Collected all necessary big data
- Sonication equipment was installed Dec 2020 to April 2022





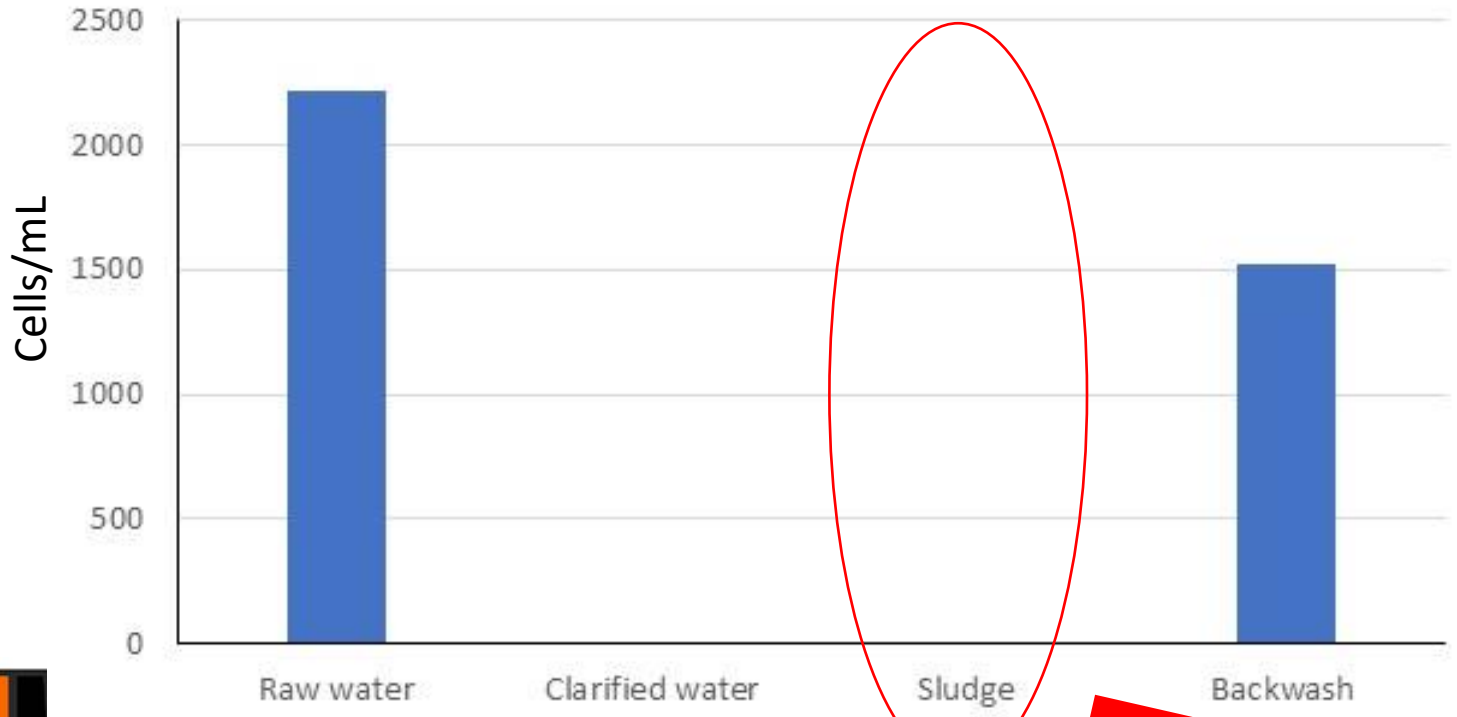
Conclusion from correctly scaled trial:

- No significant reduction was observed at the reservoir or the intake
- Operational issues at scale: Equipment reliability

Vaughan, D. Barnett, E. Bourke, H. Burrows, F. Robertson, B. Smith, J. Cashmore, M. Welk, M. Burch, A. Zamyadi (2023) Evaluating ultrasonicator performance for cyanobacteria management at freshwater sources. *Toxins*, 15, 186. https://doi.org/10.3390/toxins15030186

Research direction - our next steps:

- Fate of cells in full scale plants during and post extreme events
- Identify critical control points within the entire process
- Explore species-dependence of the efficiency of various water/sludge treatment.
- Response-strategy



Cyano Toxin qPCR - Total Cyanobacteria (16S rRNA)	copies/mL	3400
Cyano Toxin qPCR - Microcystin/Nodularin gene (mcyE/ndaF)	copies/mL	<18
Cyano Toxin qPCR - Cylindrospermopsin gene (cyrA)	copies/mL	<18
Cyano Toxin qPCR - Saxitoxin gene (Sxt A)	copies/mL	<18

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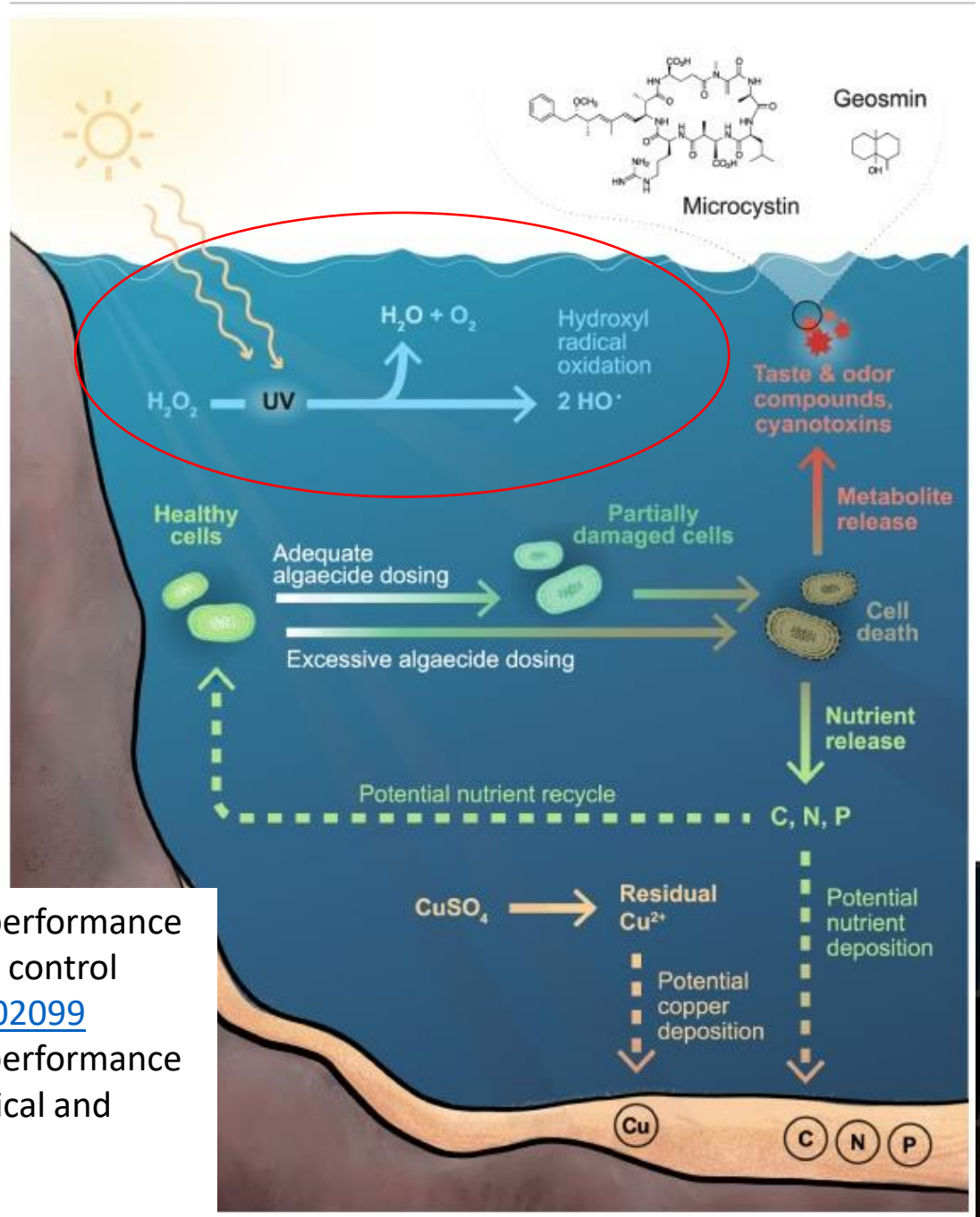
GIWaQ
Green Infrastructure and Water Quality

ONE WATER

Research direction - our next steps:

- What about dosing oxidants at real-world scale?
- How can we measure the performance at real-world scale?
- What else do we need to consider while treating at scale



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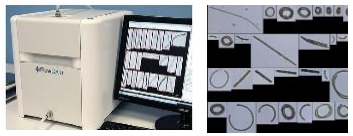
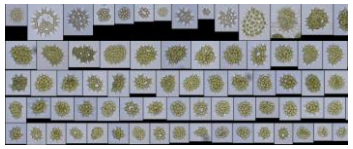
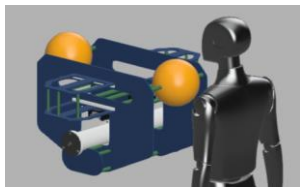
Eliminating microbial threats to water quality through sustainable smart management strategy

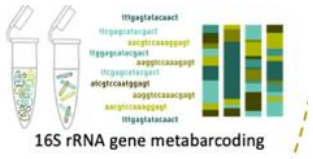
Harmful blooms





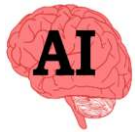


Automated cell imagery for real time monitoring

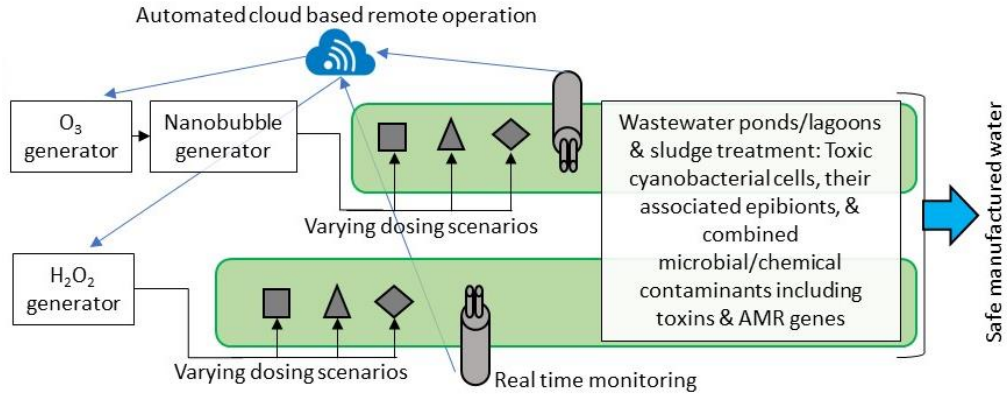


16S rRNA gene metabarcoding

Genome resolved metagenomics



Machine learning: Smart treatment strategy



Program 1: Supervised and knowledge-guided machine learning approaches for quantifying and identifying microorganisms (algae, cyanobacteria, methanogens) in water and wastewater treatment

Program 2: Scalable approaches for microbial treatment in manufactured water (Sustainable hydrogen economy based advanced treatment)

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THANK YOU

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