Cluster 4. Monitoring and Performance Optimisation

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Cluster Aim(s) and Objectives

Delivering a water sensitive city requires the implementation of biophysical systems that deliver multiple benefits to our urban communities. These multiple benefits include, for example: water production (water quality from a human health perspective and water quantity), ecosystem protection (water quality and water quantity to protect ecosystem function), micro-climate benefits (heat reduction for buildings and wider urban environment), social benefits (including, for example, aesthetic benefits), etc. An example of a biophysical system developed in Tranche 1 to deliver multiple benefits is greywater greenwalls; they produce an alternate water resource, protect receiving waterways, reduces urban heat island effects, whilst simultaneously improving the aesthetics of our surrounding environment. Many other examples exist.

Whilst these biophysical systems have been carefully designed (including those developed in Tranche 1 projects), there has been limited in field or *in-situ* monitoring of these systems. Furthermore, while multiple benefits have been suggested, there is no holistic framework which could be used to assess and ensure that the systems are delivering on these multiple benefits, now and into the future. Finally, it is well recognised that field performance monitoring is a critical step in the further development and optimisation of our biophysical systems. Indeed, the data obtained from monitoring the performance of a system is invaluable for future optimised design and implementation.

As such, the overarching aim of this cluster is **to validate that the biophysical water systems that we put in place are delivering the intended benefits, now and into the future**. It envisaged that this will be achieved through the development, testing and application of a validation and monitoring framework for biophysical water systems, which can assess their performance for multiple outcomes/benefits (anthropogenic and ecological benefits, including: waterway protection, urban heat cooling effects, other social and health benefits, etc.), and:

- aids in the selection of appropriate cost-effective, yet efficient, monitoring methods (including the use of appropriate surrogates and/or indicators for performance assessment, use of existing and cheap on-line sensors, etc.)
- is applicable across a wide range of spatial and temporal scales (including the need to ensure the systems are performing now and into the future, including informing maintenance regimes)
- provides information about when and where to monitor (acknowledging the fact that it is impossible to monitor all systems)
- includes necessary feedback loops to transfer critical knowledge from the performance monitoring to ensure optimised future design and implementation, and assess the efficiency gains achieved via this feedback loop (i.e. what are the benefits of monitoring?). This also includes the identification of critical risk factors and points of failure for the system.
- actively promotes the need to monitor - provides justification for investment into monitoring and learning about system performance. This includes evaluating the costs of monitoring versus the performance gains observed in future implementation from the monitoring (i.e. do future systems perform so much better that it outweighs the costs of the initial monitoring?)
- includes guidance on how to store and incentivise performance data sharing.

This framework will be applied to a number of case study systems around Australia.

Identified transition needs

Whilst Cluster 4 relates loosely to all 17 identified needs identified during the 2015 industry workshops, the cluster most closely delivers to the “on-ground practices” needs. In fact, Monitoring and Evaluation of water systems was identified as one of the key needs by industry partners, and this Cluster delivers directly on this aspect. The following outlines in more detail where Cluster 4 projects will significantly contribute towards the identified industry needs:

- **On-ground practices:**
  - *#10 Monitoring and evaluation for improved system design and performance.* This cluster is a direct response to this industry need.
  - *#7 Guidance on how to develop context-specific solutions and asset management regimes.* Cluster 4 will contribute to this need by providing field performance data for several Australian case studies.
  - *#8 Achieving multiple benefits through integrated planning, and design of water systems and the urban form.* Cluster 4 will contribute to this need in that the monitoring framework will focus on assessing the multiple benefits of our water system infrastructure, simultaneously providing the necessary feedback loops so monitoring data is used to optimise the design of future systems.
  - *# 11 Efficient and effective operations and maintenance systems to achieve water sensitive city outcomes.* As above, Cluster 4 will provide critical information about how to adequately maintain and manage our biophysical water infrastructure.
- **Enabling Structures:**
  - *#3 New financial model and incentives that recognises the values and benefits of WSC.* Cluster 4 will contribute to this need by providing accurate information on the multiple benefits that our biophysical water infrastructure can deliver, now and into the future.
  - *#6 Holistic evaluation frameworks to support water sensitive city investments.* This Cluster (4) will work closely with Cluster 5 to ensure the multiple benefits of water systems are accurately included in the evaluation frameworks, especially over time, hence supporting WSC investments.
- **Social capital:**
  - *#14 A culture of learning and innovation.* Cluster 4 will contribute to this need in that it will ensure a culture of learning about the performance of our water infrastructure and whether they are meeting our desired multiple benefits. Through the application of the monitoring framework, we can ensure that we learn from our mistakes and provide guidance on how to avoid these in the future.
  - *#15 Translation and sharing of water sensitive cities knowledge.* Cluster 4 will attempt to emphasise the importance of sharing monitoring data.

Knowledge base and research gaps

Existing knowledge base. Much of this Cluster's work will build on the outputs of Tranche 1 projects; indeed, the whole objective of this Cluster is to develop a monitoring framework to ensure that what we developed in T1 is delivering what was promised. Furthermore, we will be testing and applying this monitoring framework on several case studies around Australia which have implemented T1 biophysical infrastructure. The monitoring framework will build upon the knowledge base on the monitoring of environmental systems which exists both in CRC research organisations (Monash University, UQ, UWA) and CRC industry partners (e.g. Melbourne Water, Ku Ring Gai council, etc.). In particular, the validation framework developed during Tranche 1 in C1.1 and C1.3 (i.e. Kefeng Zhang's PhD) will be utilised as one part of the monitoring framework. The data derived from T1's B3 project will also be invaluable for the development of the monitoring framework, especially regarding the performance of our water infrastructure from a micro-climate perspective. Program C's expertise in assessing the multiple social and health benefits gained from these systems will be leveraged.

Research gaps. Although there is significant input from our T1 projects and CRC research and industry partners, there are a number of significant knowledge gaps which still remain to develop this framework:

- **Research Gap 1.** Limited *in-situ* and field monitoring of the biophysical water infrastructure developed in Tranche 1 research projects.
- **Research Gap 2.** Absence of a consistent framework which can assess whether the biophysical water infrastructure (implemented to help deliver a water sensitive city) are delivering on the intended multiple benefits/outcomes, now and into the future.

- **Research Gap 3.** Uncertainty around the methods and regimes required to validate and operationally monitor biophysical water infrastructure for multiple benefits/outcomes.

Targeted end-user group(s)

Cluster 4 will work closely with industry stakeholders to ensure that the current issues around monitoring of biophysical water infrastructure are well understood. Preliminary discussion within the researcher's group revealed (to be confirmed by our industry partners who are probably best placed to answer this question):

- Local Governments (who will apply the framework on systems which exist within their jurisdiction)
- Utilities and bulk water suppliers (who will utilise biophysical water infrastructure to deliver multiple benefits to the community)
- Technology developers (who will use the outputs to improve the design of their systems)
- Regulators and policy makers (who shall use the results to inform how these systems should be implemented and controlled)

Research questions and approach

Develop integrated framework

In each of the following work packages, we will be addressing the following research questions:

- **RQ1.** What type of monitoring framework is required to assess whether our biophysical water infrastructure is delivering on their intended multiple outcomes/benefits, now and into the future?
- **RQ2.** What indicators/surrogates can be used to monitor the performance of these systems, enabling us to validate their performance today and over their life span? e.g., which surrogates are needed for: water production, ecological protection, heat island benefits, social and human health benefits, etc?
- **RQ3.** For each surrogate or indicator, how frequent are measurements required?
- **RQ4.** Can these surrogates or indicators of system performance be measured using simple, cheap and efficient devices?

<u>Work Package 1. Validation and monitoring framework: water quality treatment for water production.</u>
We will extend the validation frameworks developed as part of C1.1/C1.3 and those developed in the NAT VAL project to develop a flexible framework for our water sensitive bio-physical infrastructure - moving from just a micropollutant-stormwater-biofilter focus to one which focuses on other treatment technologies used to deliver a water sensitive city (i.e. beyond biofilters to include other Water Sensitive Technologies, beyond micropollutants to include pathogens as well, and beyond stormwater to include greywater and wastewater recycling). In particular, a focus will on determining the appropriate surrogates/indicators for these treatment technologies which have not been adequately defined to date, so that they can be monitored throughout their lifetime. Integration with NAT VAL is critical and was identified as a major need from industry during our Industry Partner Needs and Opportunities workshops.
<u>Work Package 2. Validation and monitoring framework: water quality treatment and quantity control for ecological benefits.</u>
The focus will be on the validation and monitoring of treatment and removal of pollutants of concern to ecological protection (sediments, nutrients, heavy metals). Furthermore, there will be a focus on ensuring that the flow regimes which leave these systems are meeting the desired ecological benefits.
<u>Work Package 3. Validation and monitoring framework: heat island benefits.</u>
This Work Package will develop a validation and monitoring framework for ensuring that the heat island benefits of our biophysical water infrastructure are begin delivered.
<u>Work Package 4. Validation and monitoring framework: social and human health benefits.</u>
This Work Package will develop a validation and monitoring framework for ensuring that the social and human health benefits of our biophysical water infrastructure are begin delivered.

Integrate and apply integrated framework to XX Australian case studies

<u>Work Package 5. Integrate and apply the framework to XX Australian case-studies.</u>

The developed frameworks (WP1, WP2, WP3, WP4) will be combined into a single integrated framework which can be used to determine the validation and monitoring requirements of our biophysical water infrastructure. One output, for example, will be a matrix that could determine what needs to be monitored (and how often) for a given set of multiple benefits. The developed framework will be applied to XX Australian case studies, at a range of spatial scales and to a range of different biophysical infrastructure which have multiple intended benefits; this could be driven by our industry partners who could apply the framework to, for example, three case-studies, one in each Melbourne, Brisbane and Perth. One example case study could be the Monash City Council system, which treats greywater and stormwater using Tranche 1's water treatment technology (i.e. copper coated zeolites), whilst at the same time utilises these water sources to irrigate green walls which are designed to cool the surrounding urban environment and buildings and provide aesthetic benefits to the local community.

Work Package 6. Translation of framework into final guidelines.

This last Work Package will translate the integrated validation and monitoring framework developed in WP5, together with the lessons learned from applying this framework to the XX Australian case-studies, into a set of guidance documents. These documents (which could be similar in nature to the successful Biofiltration Guidelines delivered by C1.1) will be co-developed with industry.

Intended cluster outcomes and translation/adoption pathways

Key outcomes include:

- Monitoring framework which can be applied to understand whether the water system infrastructure is delivering on the intended benefits, and is applicable at a wide range of spatial and temporal scales.
- In-situ/field evidence of the performance of our water system infrastructure – we will apply our developed framework to several Australian case studies which have already implemented T1 water infrastructure (thereby providing the evidence required to suggest further implementation)
- Feedback to T1 researchers about some of the issues regarding T1 water infrastructure, allowing optimisation to occur (to improve performance, reduce implementation issues, or deal with maintenance frequencies).
- Evidence to support the concept of monitoring, via assessing the improvement gained in system performance from historical monitoring data.

Key pathways to uptake and adoption:

- Industry led projects will ensure it is uptaken and adopted.
- Working together with capacity building organisations to ensure uptake. Courses and information sessions about the framework.
- Guideline documents (e.g. FAWB Biofilter Guidelines) and publishing in industry read journals (e.g. C1.1/C1.3's validation framework published in AWA's Water).
- Industry ideas to ensure uptake and adoption?

Key skills and capacities required

This project requires a vast range of skill sets: validation, field monitoring, water treatment, ecological protection, microclimate, and social and human health. Furthermore, these skill sets should be delivered by a mix of academic and industry partners; this will ensure that while the framework is developed with scientific rigour, it is also applicable to the needs of our industry partners and is developed in a way which can be uptake and adopted easily by our identified end-users. We will also require industry capacity to help implement and apply the monitoring framework to local case studies. This will help us evaluate and improve the framework itself, while ensuring adequate uptake and adoption.