Industry Report

Circular Economy and the Water Sector of South East Queensland

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Executive Summary **3**

Acknowledgements **3**

Introduction **5**
Circular Economy 6
Water Use, Treatment and Management in South East Queensland 9

Workshop Presentations: Experience, Issues & New Developments in Water Management and the Circular Economy **14**
A Circular Approach within UK Water Management 15
Lessons from Yorkshire Water's Esholt Scheme 16
Public Acceptance of Water from Alternative Sources 17
Case study: Toowoomba water recycling facility 17
Suggestions for improving public perception of recycled water 18
A Practitioner Perspective of Water Management at Lion 18
New Research in Water Management 19

Workshop Findings **20**
Methodology 21
Problems 22
Opportunities for Solutions 23
Gains from solutions 24
Solution Barriers 26
Circular Economy for the SEQ Water System 28

Exploring Circular Solutions for the SEQ Water Sector **29**
Circular Economy Playbook for Water Intensive Corporates 30
Can you play a part in this ongoing research? 31

Workshop Presenters **32**

References **34**

Executive Summary

This report examines the concept of the circular economy and its potential application to the water sector in South East Queensland. The circular economy is an industrial system that is restorative and regenerative by intention and design. Circular economy refers to efficient regenerative production and consumption powered by reverse-loop manufacturing, renewable resources and low-carbon energy. In essence, rather than a system based on resource consumption, the natural value of resources is considered, and the system designed so the concept of waste becomes redundant.

The University of Queensland Business School, Business Sustainability Initiative in partnership with the University of Exeter, Centre for Circular Economy held a workshop on 27 November 2019 to assess the potential for the circular economy to be applied to the water sector in South East Queensland. The design thinking workshop was attended by over 40 individuals from across academia, business and government who evaluated the problems and opportunities posed to water management in the South East Queensland region.

This report details the findings of the workshop, highlighting the major problems and areas of opportunity to apply circular principles to the South East Queensland water sector.

Acknowledgements

We would like to acknowledge the workshop presenters and participants for their time in attending the workshop and sharing their knowledge towards progressing a circular approach to water management. We would particularly like to thank Professor Peter Hopkinson, Professor Sara Dolnicar, Mr Tri Tran, Professor Steven Kenway and Dr Shihu Hu for their time presenting at the colloquium and Dr Katie Meissner, Ms Gisella Marquez and Ms Qiang Fu for their assistance with this project. We also acknowledge and are grateful for the support of the QUEX Institute for the grant to hold the workshop. The authors thank the Bureau of Meteorology, Seqwater and the Ellen MacArthur Foundation for permission to reproduce the diagrams in this report.

About The University of Queensland Business School – Business Sustainability Initiative

The University of Queensland (UQ) Business School is independently ranked as one of the top business schools in Australia and among the leading institutions worldwide. Our mission is to cultivate courageous thinkers who empower future leaders to positively transform business and society. Based at the St Lucia campus as part of the Faculty of Business, Economics and Law, the School brings together 12,000 students and over 200 subject experts.

The Business School is renowned for its cutting-edge research, outstanding academic staff, depth of educational programs and close links with leading global organisations. The School also carries AACSB International and EQUIS accreditation – the first school in Australia to receive this prestigious accreditation across its full range of programs.

The Business Sustainability Initiative (BSI) is a dedicated research area within the school that leads the way in a rapidly changing business landscape, championing environmentally and socially conscious business practices and designing strategies for a sustainable future. With over 20 experienced researchers covering all disciplines of business research, the BSI is actively making an impact on issues that affect business and society.

More information: **business.uq.edu.au/business-sustainability-initiative**

About the University of Exeter – Centre for Circular Economy

The University of Exeter is a Russell Group University. The Business School is ranked as one the top Business schools in the UK. Its mission is to deliver outstanding and innovative business education and research that addresses the major challenges confronting businesses and society. It recently joined an elite group of international institutions in achieving the coveted “triple crown” accreditation status.

The Exeter Centre for Circular Economy (ECCE) was formally launched in September 2018. ECCE is a new research centre comprising over 30 staff based in three locations - Streatham, Penryn and London. We are a multi-disciplinary team composed of economists, engineers, designers, sociologists, management academics and practitioners. With over £6M of live awards we are the largest specialist circular economy research grouping in the UK. The Centre’s vision is ‘*to be the leading UK centre for Circular Economy engaging in innovative research, knowledge transfer and executive education projects. We engage in projects that develop circular economy theory and practice designed to transform our economy, creating regenerative wealth and well-being*’.

Its aims are to:

- play a leading role in the development of the theory and evidence base for circular economy;
- bring world leaders in academia and industry to the Centre to share in co-creation of new research, educational initiatives and dedicated projects for our corporate partners;
- disseminate innovative and important research findings through high quality research publications, conferences and via educational offerings to business, government, academics and other stakeholders;
- establish networks that bring business, government and civil society leaders together with circular economy academics from the world’s top universities.

More information: **business-school.exeter.ac.uk/research/centres/circular**

Introduction

Circular Economy

> *"A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems."*
> Ellen MacArthur Foundation, 2020

A circular economy at its simplest refers to an economic system that is able to generate business profit and economic growth, deliver benefits to consumers, radically increase resource productivity whilst also regenerating, rather than depleting, natural capital such as soils, ecosystems and water which play a crucial, but often undervalued role in many economic and social activities.

A circular economy has been defined in different ways in the literature and its definition continues to evolve. The main goals are maintaining the circulation of products and materials at their highest value for the longest time, and to designing out waste from the outset. Achieving these goals requires the avoidance or elimination of contaminants, toxins and pollutants to maintain continuous loops and cascades of materials, avoiding the degradation of materials and the avoidance of passing on costs during-repeat use cycles (see Figure 1).

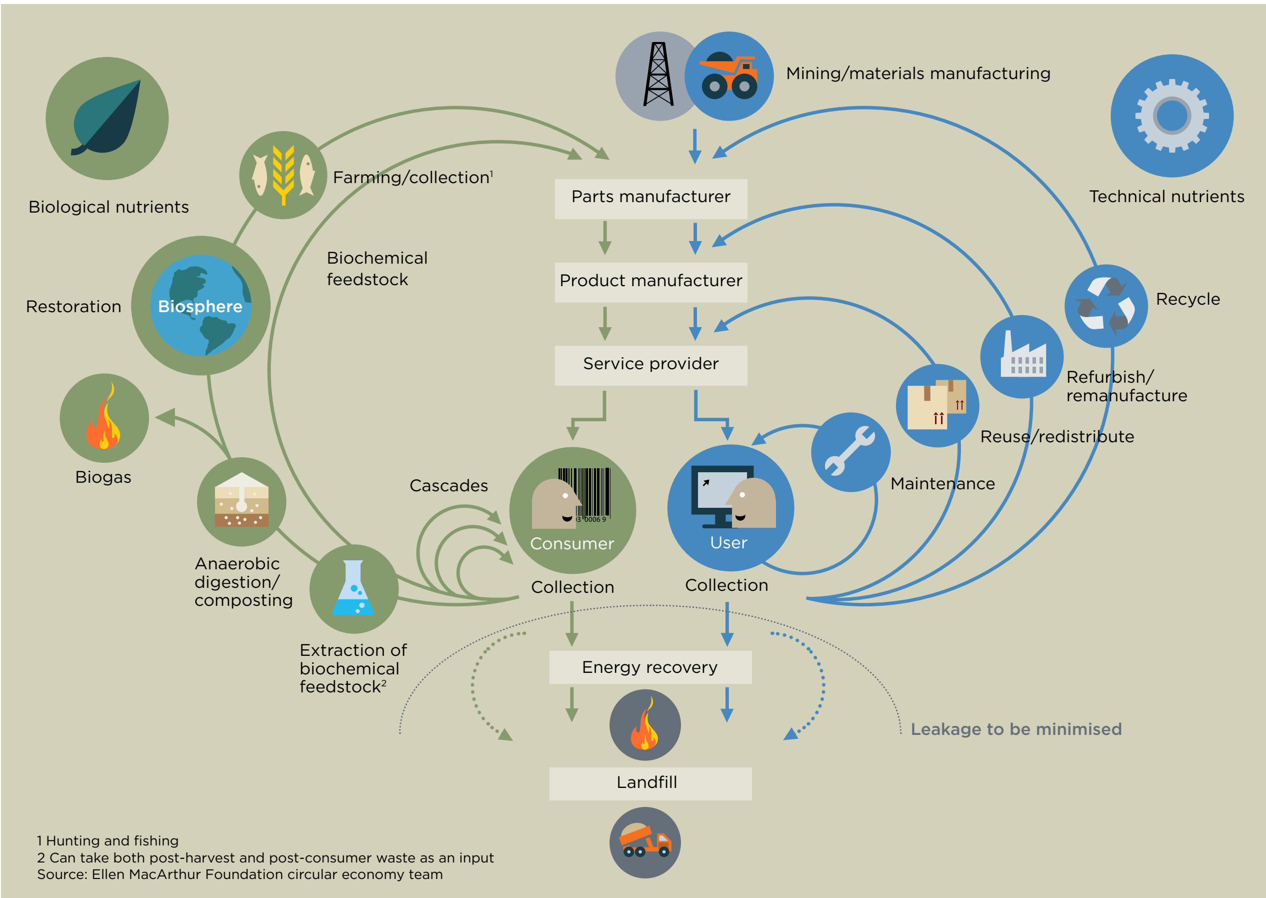


Figure 1. The Circular Economy[i] Copyright © Ellen MacArthur Foundation, Towards the Circular Economy, p. 24, (2013). We acknowledge that this diagram is an unofficial translation and does not suggest or imply that the content has been endorsed or approved by the Ellen MacArthur Foundation.

Another key principle in the circular economy is the distinction between biological and technical material spheres which lead to different strategies and solutions for product design, business models and the design of infrastructure and wider systems. Products designed for decomposition in the biological sphere are known as products of consumption. They are designed to cascade safely through biological systems. Products designed for the technical sphere are known as products of service. They are technically durable, and the aim is to retain these in high-value loops via maintenance, re-use, remanufacture and refurbishment. Eventually some materials will lose their value and quality and can be recycled. Recycling, however, is a low-value recovery business model due to contamination and toxicity. Beyond this some materials might be considered suitable for energy recovery, although this is a loop of last resort.

The idea of a circular economy has gained traction with policy makers, businesses and the academic community as a credible framework to re-think the relationship between resources and economic modes of production and consumption. It moves away from a throughput one-way system to one in which resources, products, components, information and wealth circulates to generate prosperity and resilient futures for all. With an expanding global population, rising per capita incomes, increase in middle class consumers, as well as increasingly interconnected economies, the stresses and pressures on the world's resources will continue to intensify - placing more pressure on natural capital, including essential life support systems such as water.

In the face of these pressures, the linear model for water management - where water is abstracted, transported long distances, treated to a very high standard, used once and then discharged - is economically and environmentally unsustainable. Proposals to increase supply, to meet demand, put in more flood defences and reduce costs are doomed to fail in this linear system. Opportunities exist across the whole industry, but this requires a whole system approach to overcome linear lock in, split incentives, and a culture of short-term reactive solutions to crisis and political cycles. There has been relatively less focus on circular economy applied to the water sector than manufacturing or agriculture. Recent reports by the Ellen MacArthur Foundation have started to address this.

Table 1 proposes some high-level strategies and actions that align to the foundational principles of circular economy. How these apply and work in practice requires research and evidence. Figure 2 aligns these principles to a modified version of the butterfly diagram, emphasising the role of open natural systems in the water and hydrological cycle and the interaction with human managed systems, which are critical to reducing demand, avoiding contamination and the recycling and recirculation of water at its highest value.

Circular Economy Principles (Ellen MacArthur Foundation)	**Water Systems Management**
Principle 1: Design out waste externalities	• Optimise the amount of energy, minerals, and chemicals use in operation of water systems in concert with other systems. • Optimise use of water within sub-basin in relation adjacent sub-basins (e.g. use in agriculture or evaporative cooling). • Use measures or solutions which deliver the same outcome without using water.
Principle 2: Keep Resources in Use	• Optimise resource yields (water use & reuse, energy, minerals, and chemicals) within water systems. • Optimise energy or resource extraction from the water system and maximise their use. • Optimise value generated in the interfaces of water systems with other systems.
Principle 3: Regenerate Natural Capital	• Maximise environmental flows by reducing consumptive and non-consumptive uses of water. • Preserve and enhance the natural capital (e.g. river restoration, pollution prevention, quality of effluent, etc.) • Ensure minimum disruption to natural water systems from human interactions and use.

Table 1 Circular economy principles for water systems management[ii]

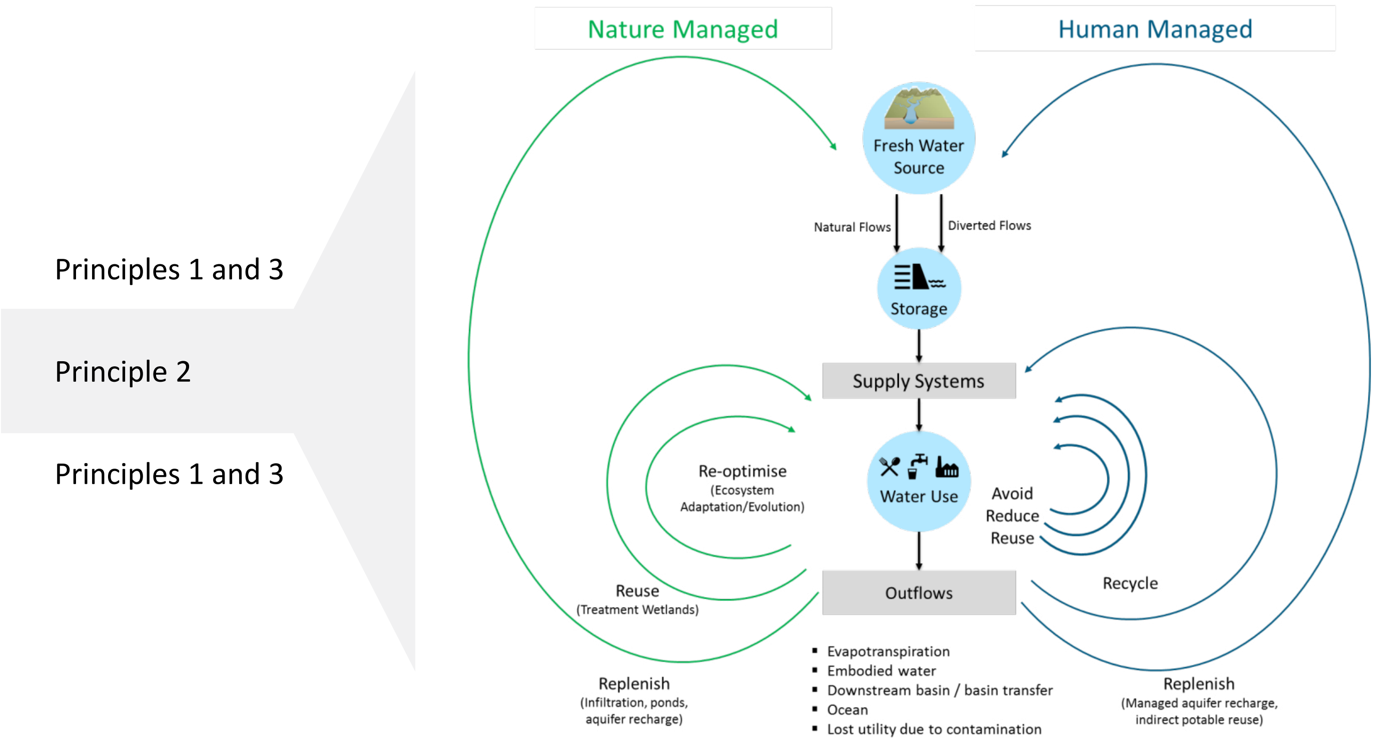


Figure 2. A 'systems perspective' -applying circular economy principles to water systems[iii]

Water Use, Treatment and Management in South East Queensland

South East Queensland (SEQ) covers an area of 24,283km2 and is home to 72% of the population of Queensland with over 3.2 million residents.[iv] The area is situated along the lower coast of Queensland and contains areas of indigenous and ecological significance including one Ramsar wetland. Like many parts of Australia, SEQ has experienced extremes in water availability from periods of severe extended droughts (e.g. the millennium drought) to extreme flooding events (e.g. 2011). As the impacts of climate change are increasingly felt, it is likely that these fluctuations in water availability will be further exacerbated. Uncertain water availability together with an increasing population necessitates that water management is a focus of research and organisational action.

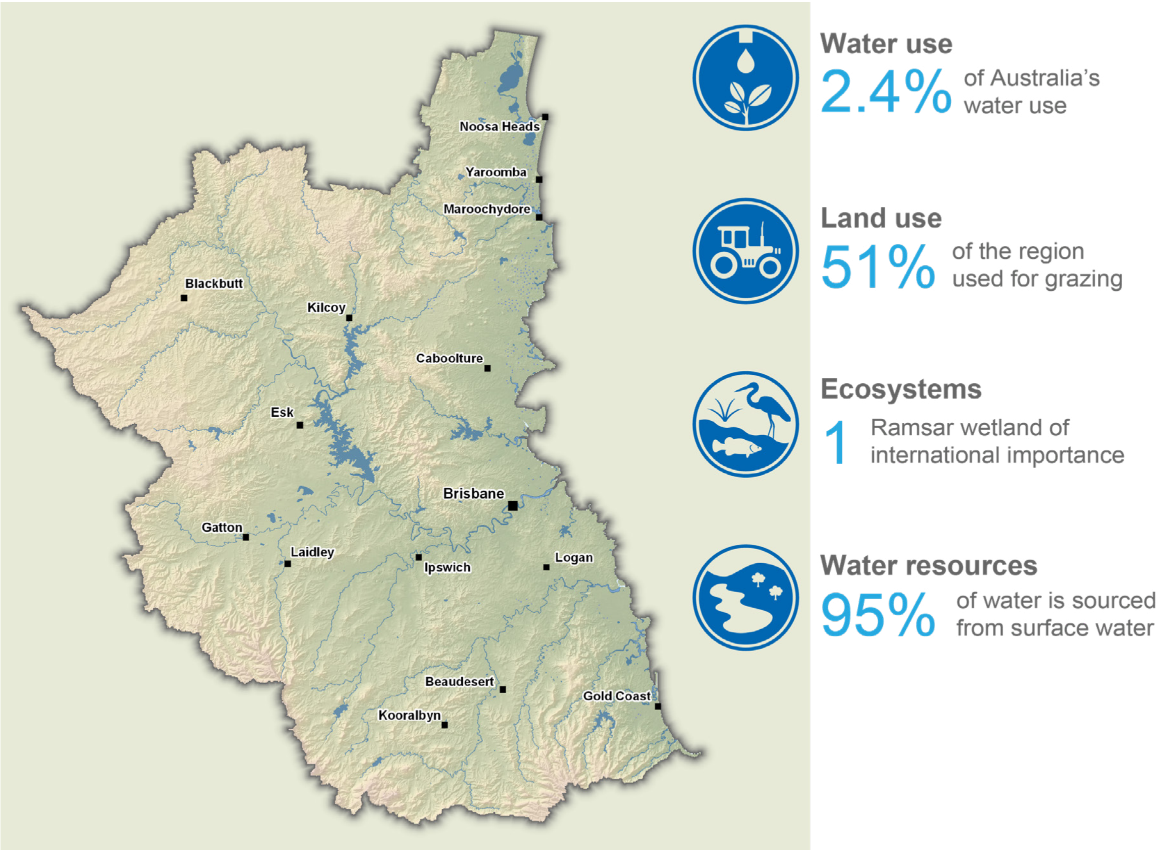


Figure 3. South East Queensland Region[v]

The majority of water in SEQ comes from surface water supplies, although there are also limited ground water sources. Surface water is mainly used for urban supply with ground water supplementing primarily agricultural requirements and the supply of some towns e.g. Rainbow Beach. Management plans are in place for both the surface water and high use aquifers.[vi] Urban land use activities include construction, tourism and manufacturing, and these are major water users in SEQ despite covering a relatively small area (8% of the region) (Figure 4).[vii] Outside urban areas, grazing is the predominant land use (Figure 4), occupying more than 50% of the region. SEQ has developed desalination and recycled water facilities that can supplement natural water supplies.[viii] The establishment and use of these facilities, initiated during the millennium drought, has been contentious, however, they have the ability to be used in urban, agricultural and industrial supply (e.g. the power sector).

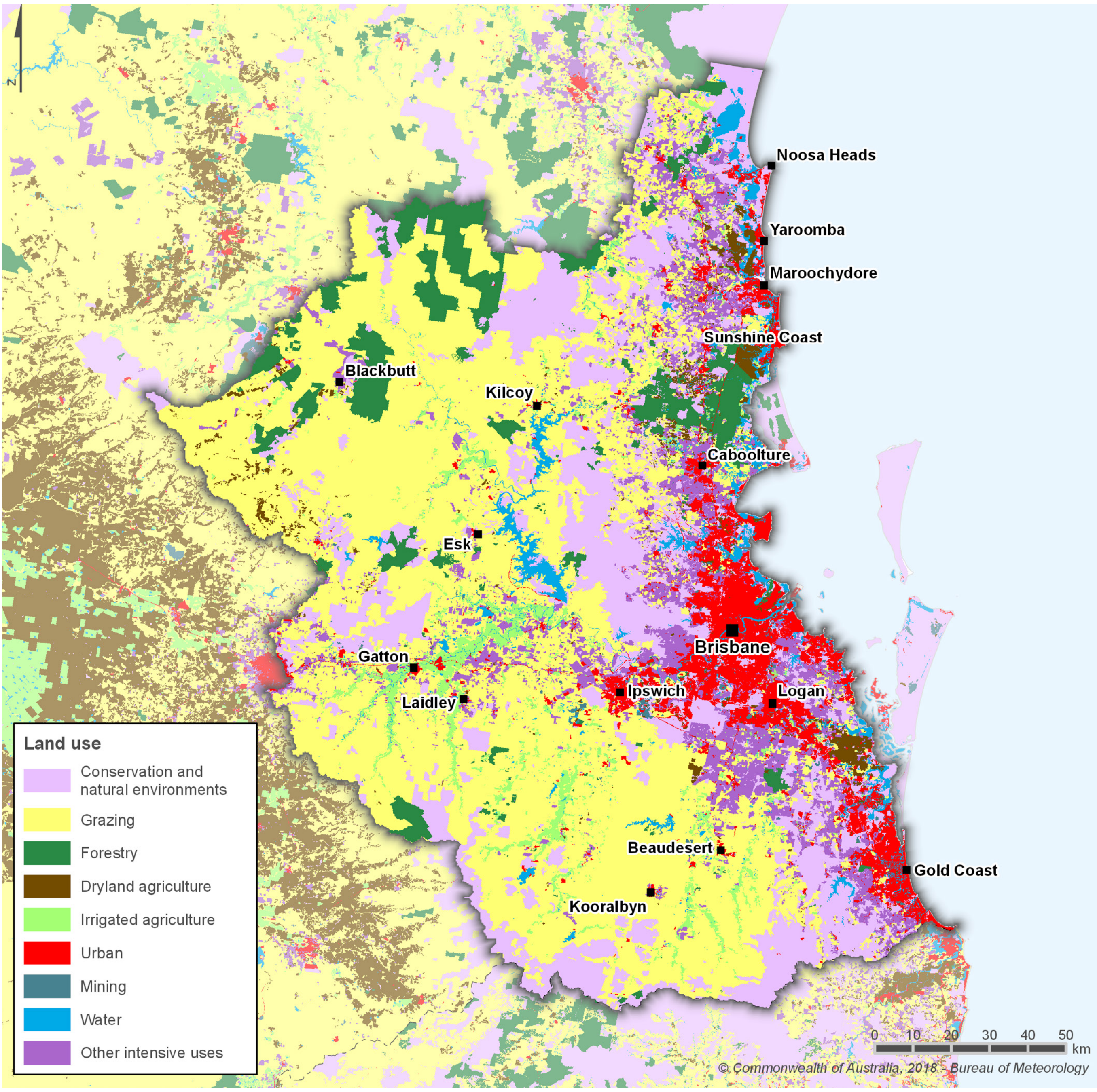
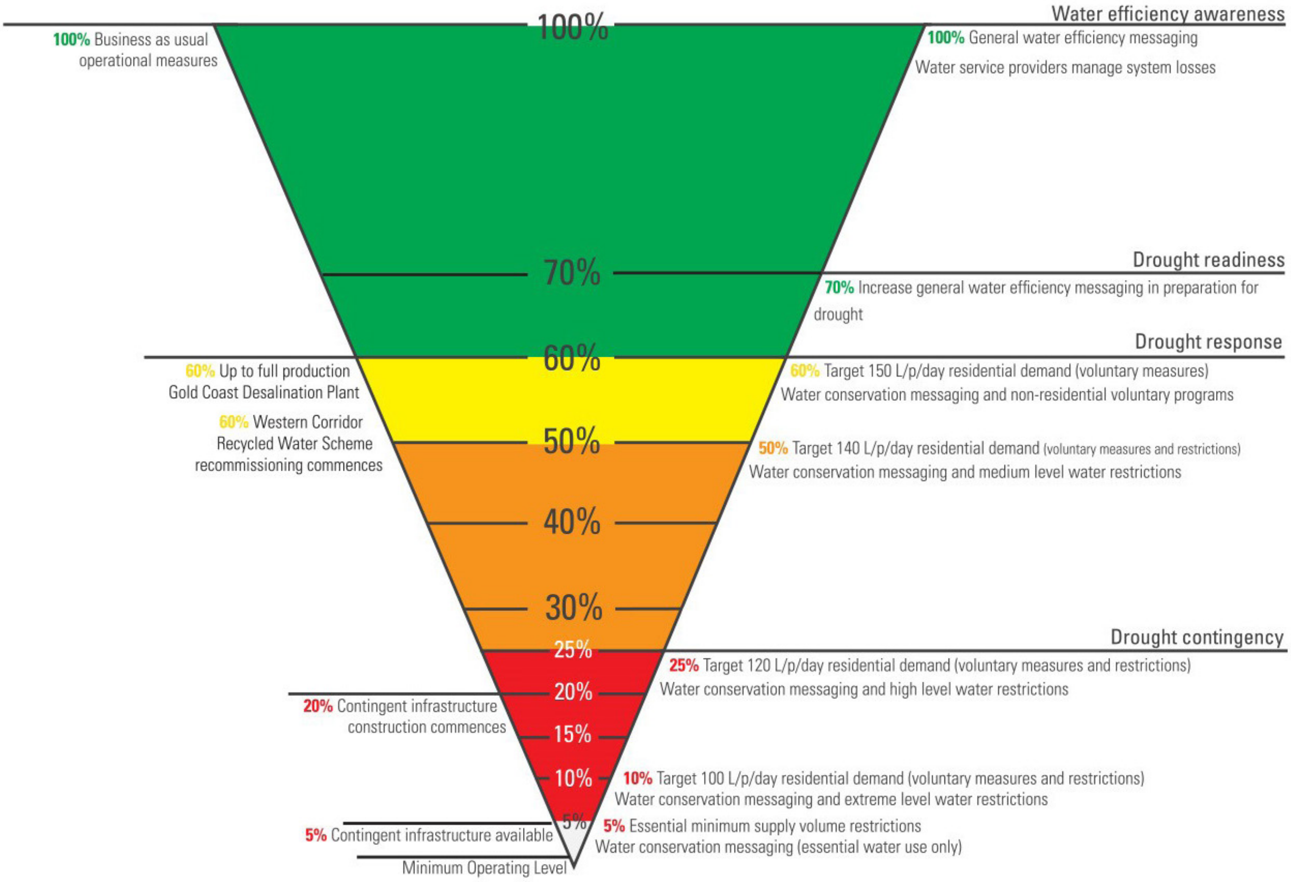


Figure 4. Land use in the SEQ Region[ix]

The majority of water storage in the region (80%) occurs in five main dams: Wivenhoe, Somerset, Hinze, North Pine and Wyaralong.[x] Wivenhoe and Somerset dams have flood capacity above their drinking water storage. Under the Seqwater water security program, plans are in place for actions at each level of system water availability (see Figure 5). The Western Corridor Recycled Water Scheme and the Gold Coast Desalination Plant are included in these plans at 60%.



Notes:

1. Percentages are based on the combined volume of the SEQ Water Grid dams
2. Demand management targets are SEQ regional averages.

Figure 5. Drought Response Triggers[xi]

The **Western Corridor Recycled Water Scheme** is a system of wastewater treatment plants and pipeline network that can produce purified recycled water to drinking water standards from treated wastewater produced in homes and from industrial and commercial activities (Figure 6).[xii]

> *"Nature already recycles water but not always at the right place at the right time."*[xiii]

In SEQ, wastewater intended for recycling is sent to advanced water treatment plants at Bundamba (west of Brisbane), Gibson Island and Luggage Point (east of Brisbane) to be passed through different processes to produce purified recycled water (Figure 6). This recycled water is then pumped to Wivenhoe Dam where it blends with rainwater runoff stored in the dam. Once this water is released from the Wivenhoe Dam, it travels down the Brisbane River where it is again treated at water treatment plants to meet drinking water standards before being delivered to homes, businesses and industrial users.[xiv] This scheme was created under the SEQ's drought response plan.

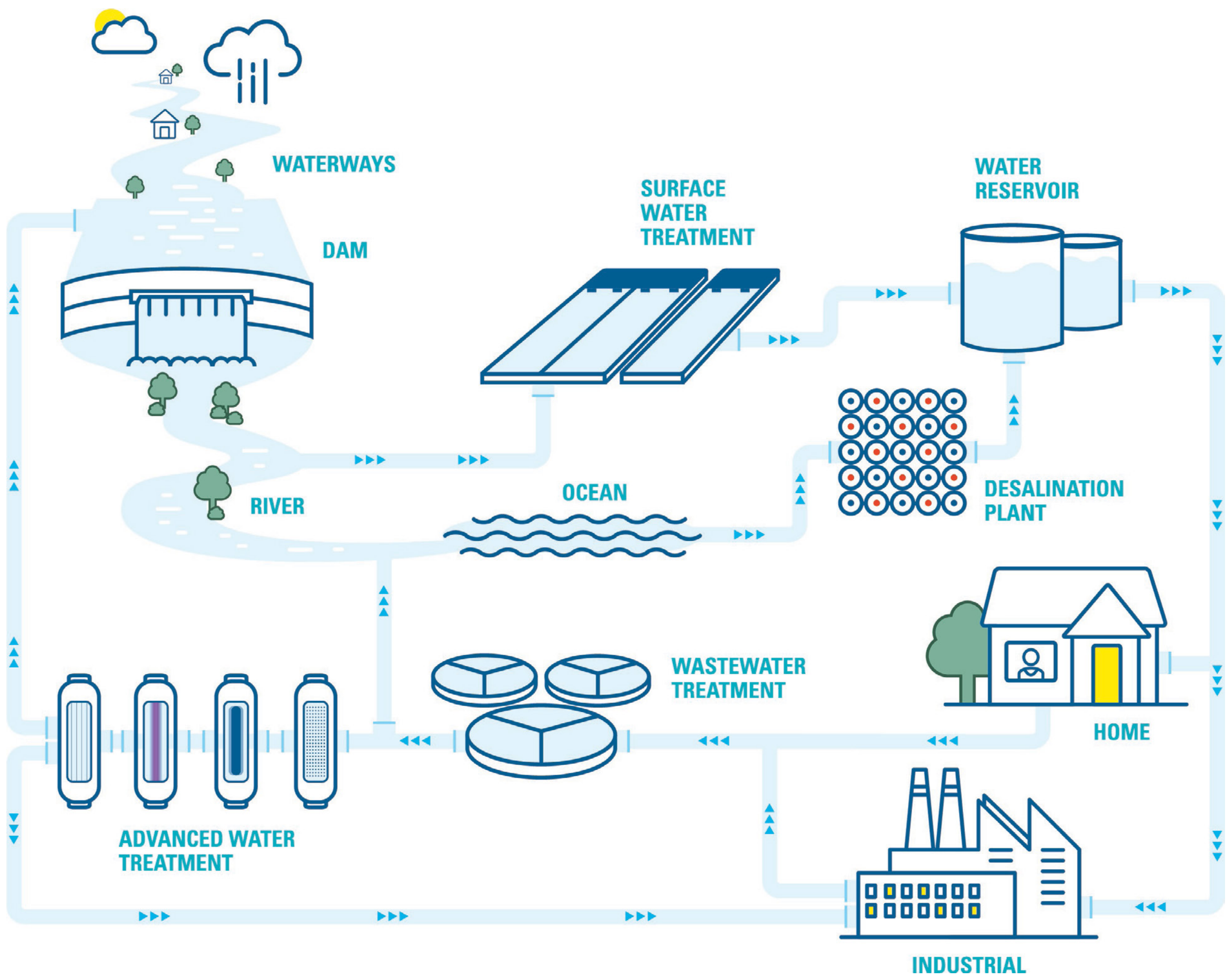


Figure 6. Purified recycled water[xv]

This recycled drinking water system is activated when the combined levels of drinking water dams reach 60% of their capacity.[xvi] When drinking water dam levels are high the scheme is in "care and maintenance" mode.[xvii]

The **Gold Coast Desalination Plant**, located at Tugan, has the capability to turn sea water into drinking water, providing an alternative source of water during times of extreme weather or when other services are offline. The plant is capable of producing 133ML of drinking water each day. Servicing the Gold Coast, Logan and Brisbane, the plant applies reverse osmosis technology to remove the salt and other minerals from sea water. The permeate water produced by the process is then re-mineralised and then either blended with other treated water or directly distributed to consumers (Figure 6).[xviii] The plant generally operates in a "hot standby" mode.[xix] The plant employs energy recovery processes by reusing the high-pressure brine achieving a 97% process recover of energy that would have been lost.[xx]

Seqwater is the Queensland Government Bulk Water Supply Authority. The company is responsible for providing safe, reliable and affordable water to the SEQ area. They also work in the areas of flood mitigation, catchment management, and the supply of irrigation water. The water grid covered by Seqwater is detailed in Figure 7.[xxi]

Bulk water supplied by Seqwater is retailed by several providers within the SEQ region. Queensland Urban Utilities provides services to Brisbane, Ipswich, Lockyer Valley, Scenic Rim, and Somerset local council areas; Unitywater provides water services to Moreton Bay, Sunshine Coast and Noosa local council areas whilst water is supplied to Logan, Redland and Gold Coast areas by their own local councils.[xxii]

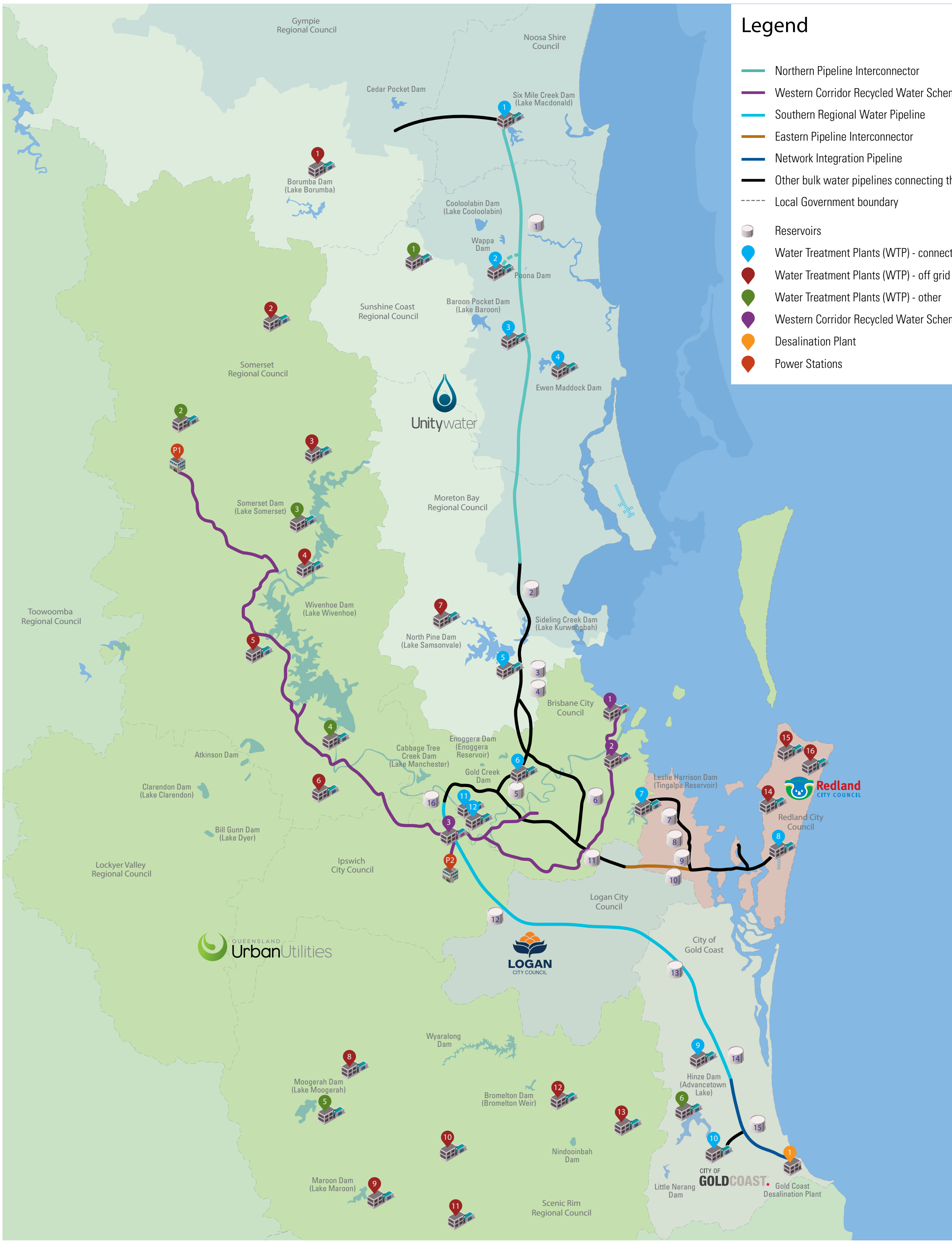
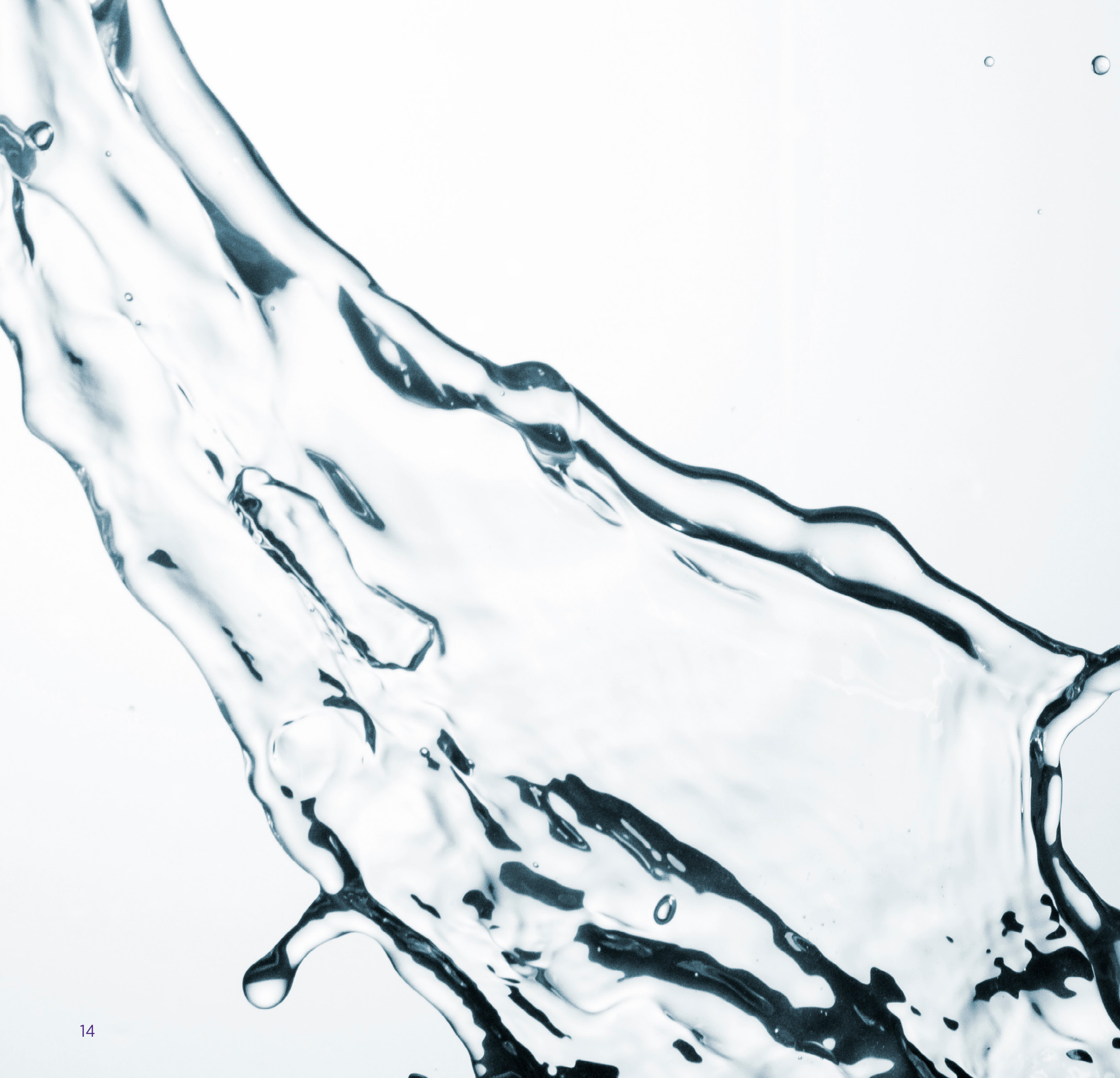


Figure 7. SEQ water grid[xxiii]

Workshop presentations:

Experiences, Issues & New Developments in Water Management and the Circular Economy



A Circular Approach within UK Water Management

Session presented by: Professor Peter Hopkinson, University of Exeter, UK

Water represents a particularly interesting sector for circular economy. In principle it is inherently circular, but human activity has disturbed small and large water and hydrological cycles in profound ways, leading to a series of complex supply, demand and quality challenges and their interaction with wider socio-ecological systems

This take-pollute-discharge model lies at the heart of many debates about future supply and demand, water scarcity and how we manage water in the future. Calls to increase supply, reduce demand, put in more flood defences and reduce costs are doomed to fail in a linear system. An alternative approach is to re-think water supply and use as a circular economy system rather than an end of pipe problem. This requires avoiding contamination of water in the first place and system level re-design that ensures water maintains it value at the highest quality in each use phase. This requires a cultural transformation in the water industry which continues to operate on a 'big' pipe 20th Century sanitation model. To replace this will be disruptive, and require pioneering and committed leadership amongst many stakeholders.

The principles of a circular economy translate into value creation potential through four primary means (Figure 8). To create, maintain and capture value, we need to think about water in a different way – as a consumable, rather than as a commodity. This requires avoiding contaminating water flows with toxic or hazardous materials and other substances that are easy to separate or extract across the water cycle, and allow water to be used in future cycles at a profit. Contaminants, toxins, medical compounds and unidentified chemicals and substances are costly to extract and cause unknown and long-term damage to human health and eco-systems.

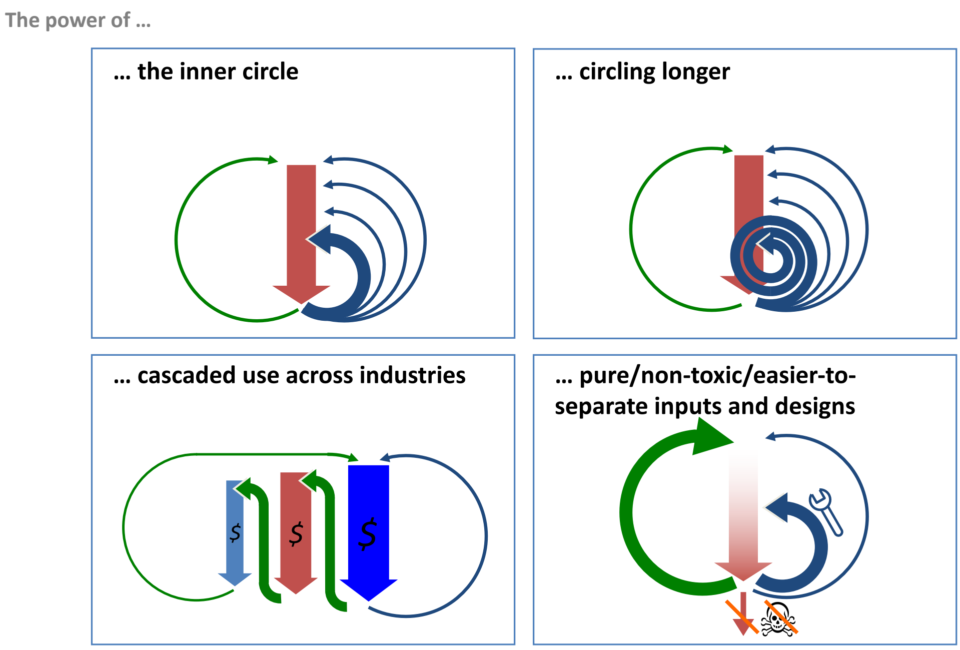


Figure 8. Economic value drivers – typical levers.[xxiv] Copyright © Ellen MacArthur Foundation, Towards the Circular Economy, p. 30-31, (2013). We acknowledge that this diagram is an unofficial translation and does not suggest or imply that the content has been endorsed or approved by the Ellen MacArthur Foundation.

Lessons from Yorkshire Water's Esholt Scheme

There are many potential circular economy value loops that lead to a potential positive business case. By themselves however, these are unlikely to make a step change in unlocking value. In the UK, companies such as Yorkshire Water (YW) have recognised the potential of taking the bigger view, and have embarked on a pioneering project to re-design Esholt Sewage Treatment Works to achieve circular economy principles. The initiative started from YW turning 800,000 tonnes of filter media (blast furnace slag and river terrace gravel) into a multi-million pound revenue rather than a £20m liability waste, and unlocking development of the land. With an estimated £100MGVA and potential to generate 2000 new jobs, the Esholt Institute for Water and Wetland Research programme is designed around integrating value creation and capture from utilising materials flows and assets in entirely different ways from historic linear thinking.

Some of the key projects are:

- Extracting and re-using nutrients, heat and energy and alternative water resources
- Storm water attenuation through sludge lagoon reclamation, reducing downstream flooding risk as part of the Leeds Flood Attenuation Scheme (FAS)
- Eco-homes development on redundant land - planning permission has been submitted for 150 new homes, targeting less than 80l per capita consumption of potable water and with water saving infrastructure throughout the development, including separated surface water and sewer networks, rainwater harvesting and off-grid low impact waste water treatment
- A new circular economy business park - utilising the 26 ha of redundant filter bed land - subject to planning, this area will provide space for organisations looking to maximise the benefits of the sustainable heat, power, nutrients and sub-potable water and other resources
- Controlled environment agriculture (vertical farms) - growing high value crops without the need for pesticides by utilising the heating, cooling, water, CO^2 and land space. This includes hydroponics (plant propagation), aquaculture (animal husbandry in water, fish in this case) combined in the term aquaponics and brokerage of underutilised resources.

The Esholt scheme is an example of how one company translated the grounding principles of a circular economy and value loops to build a powerful business case for a transformation based on known technologies and systems thinking. These principles and this approach are highly transferable, based on a systematic and comprehensive methodology focussed on redesigning systems and rethinking assets and flows (Figure 8). Information about Yorkshire Water's Esholt scheme can be found here: **yorkshirewater.com/news-media/2019/esholt-planning-submission-2019**

Public Acceptance of Water from Alternative Sources

Session presented by: Professor Sara Dolnicar, The University of Queensland, Business School.

Key components of the circular economy are repurposing, reusing and recycling. For the water industry in SEQ, this has posed a significant challenge to date, due to tremendous public suspicion of recycled water. This is particularly true for using water in activities that directly touch the body, with a survey of 1000 Australians finding that most respondents (55%) cited health concerns with recycled water.[xxv] The diagram below shows results from this survey on participants' willingness to use recycled water for particular activities:

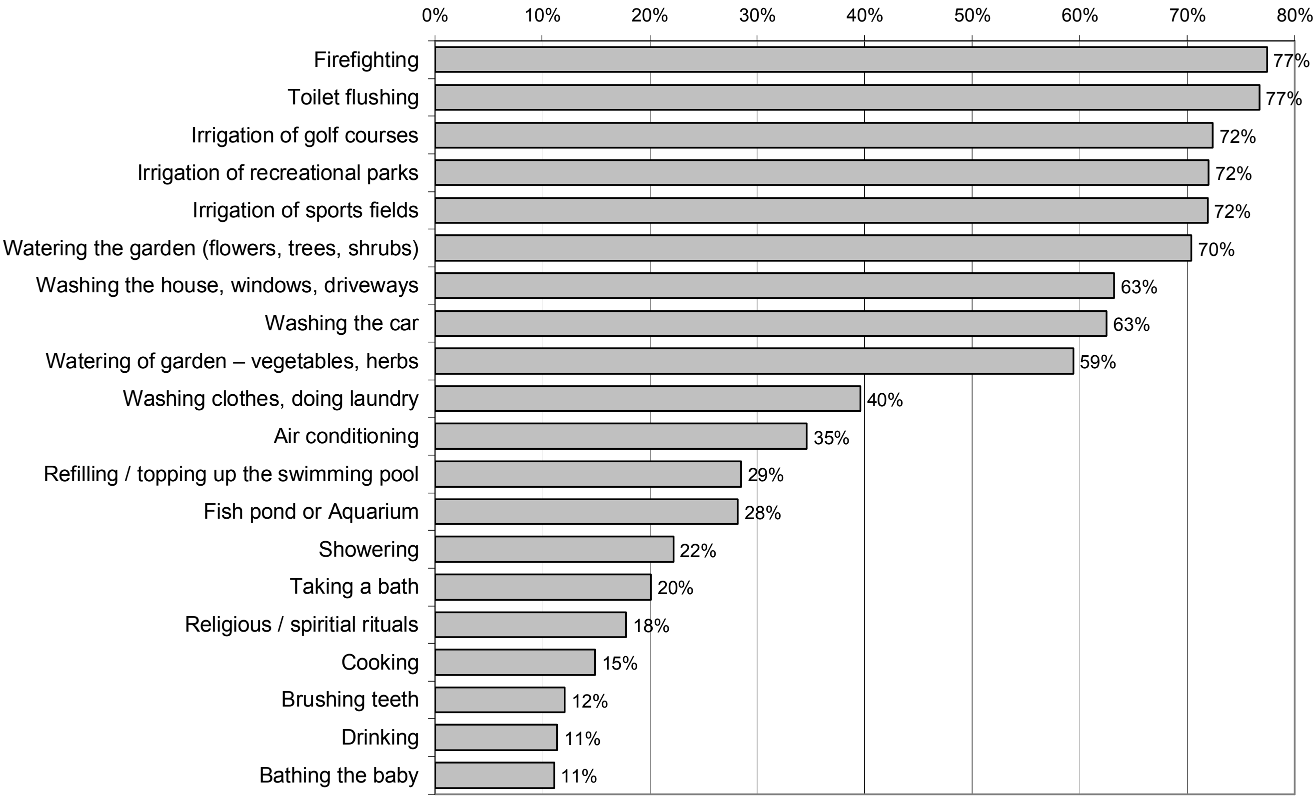


Figure 9. Willingness to use recycled water.[xxvi]

Case study: Toowoomba water recycling facility

A pertinent example of the public's poor perceptions of recycled water is Toowoomba's attempt to build a water recycling facility. In 2005, Toowoomba was facing significant water shortages due to extended drought. The Toowoomba city council proposed, as part of a larger suite of solutions, to build a recycling facility that would provide the city with potable-quality recycled water. This plan faced significant backlash from the community and in July 2006, a referendum saw 62% of residents vote against this recycling scheme. The city council was not able to effectively dispel the community's concerns about recycled water and the facility was never built. The failure of the recycled water project was in large part due to a significant opposition (scare) campaign run by community groups.[xxvii] Furthermore, an analysis of the media coverage at the time found a lack of scientific evidence, impartiality or balanced views about recycling water being reflected in the media.[xxviii]

Suggestions for improving public perception of recycled water

The case of Toowoomba, as well as recent research into acceptance of recycled water, show that the following can assist with improving public perception:

- Education - research shows that educating the public about the safety of recycled water can significantly increase the likelihood of using recycled water[xxix]
- Public discussion of recycling should not only be during crisis periods (droughts)
- Working with the media on a continuous basis; in particular, including reliable and trusted information sources, such as water scientists or academics, in the conversation
- Using marketing to reposition recycled water e.g. allowing the public to tour a water recycling facility
- Increasing acceptance by showing recycled water in use in prominent public spaces, e.g. in public swimming pools.

A Practitioner Perspective of Water Management at Lion

Session presented by: Mr. Tri Tran, Lion (XXXX)

Water is the primary input into making beer. Water is used not only in the final product, but also is necessary for cleaning and cooling equipment throughout the process. Figure 10 below is a simplified diagram of water usage through the beer-making process.

Lion has committed to improving the environmental sustainability of its operations, including reducing carbon emissions, responsible sourcing, modifying packaging to include recyclable materials. Reducing water usage is a significant part of this plan. In 2018 Lion mapped its water risk and impact in its supply chain in order to identify stress areas and in 2019 developed a water stewardship plan.

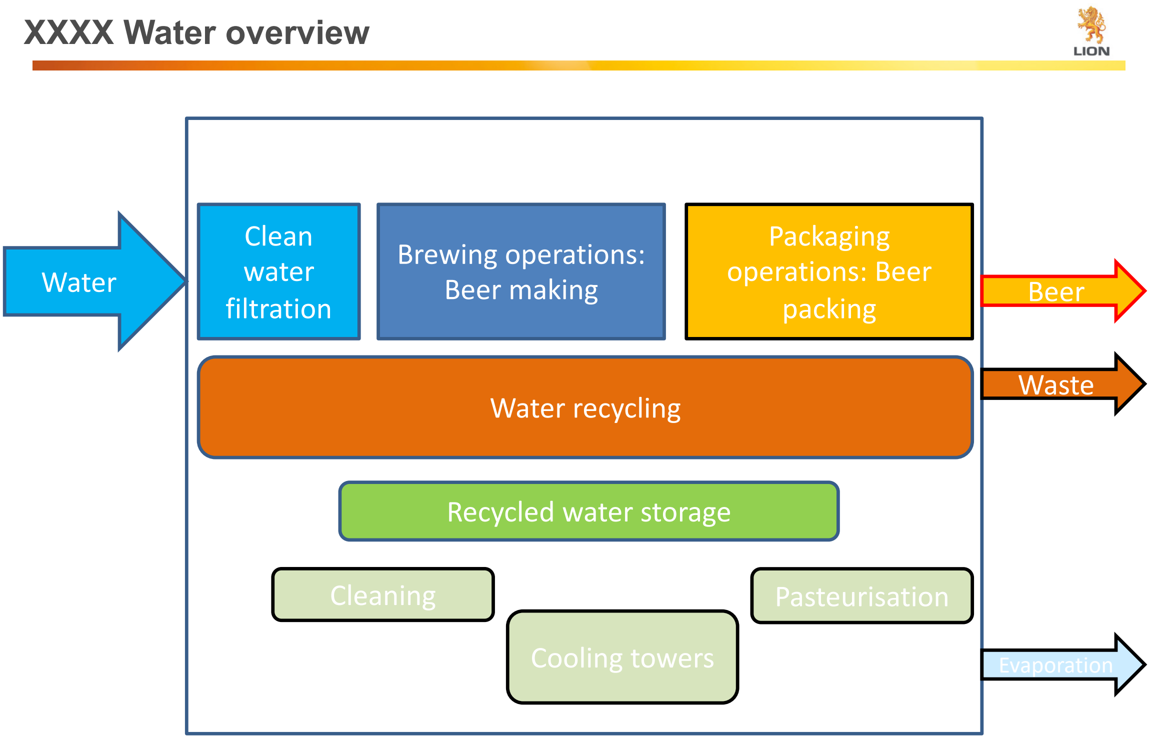


Figure 10. Water use in XXXX brewery

As part of this process, XXXX tracked its water usage over time. In 2017, XXXX used 2.98l of water to produce one litre of beer. By 2019, this ratio had decreased to 2.57l of water per litre of beer produced, making it the most water-efficient brewery within Lion. XXXX is now working towards achieving levels of 2.2l of water per litre of beer, which would make it a world leader.

Key factors that were involved in reducing water usage:

- Investment in a water recycling plant at the brewery, with support from the Queensland Government
- Optimising the water recycling plant, which utilises micro-filtration and reverse osmosis treatment processes, to achieve an end water product which is free of bacteria and viruses and very low in inorganic impurities and heavy metals
- Using recycled water in cleaning and cooling
- Working internally to seek new uses for the recycled water.

New Research in Water Management

Session presented by Professor Steven Kenway and Dr. Shihu Hu, UQ Advanced Water Management Centre

The Advanced Water Management Centre (AWMC) is an internationally recognised research centre focused on innovative water technology and management. Our latest research is progressing a paradigm shift away from solely protecting receiving waters against eutrophication via wastewater nutrient removal, towards a more circular economy approach which utilises technology to maximise water, nutrient and energy recovery.

Applying circular economy principals enables households, industries and governments to close loops for water, materials and energy recovery and reuse, creating social, economic and environmental value for the communities.

Current research themes in water mangement for circular economy

We partner with over 100 different utilities, industry groups, research and educational institutions to help the water industry identify opportunities that enable their transition to the circular economy. Here are some examples:

- Low energy and carbon demand nitrogen removal to enable bioenergy recovery
- High rate carbon partitioning, capture and recovery processes
- Advanced sludge digestion process for converting carbon to biogas
- Phosphorous removal and recovery
- Nutrient recovery from source-separated urine with microbial electroconcentration cells
- Organics and nutrients recovery by purple phototrophic bacteria to produce single cell protein
- Biogas convertion to liquid chemcials.

Workshop Findings

Methodology

Integrated with workshop presentations was a design thinking process, facilitated by Cameron Turner, allowing workshop participants to contribute their knowledge to articulate problems and potential areas of opportunity for taking a circular approach in the water sector. The data was collected from workshop participants, transcribed, coded and analysed for key trends using NVivo software.

Participants were given the option to provide data for inclusion in the research (with ethical clearance confirmed). The following breakdown is provided of participants from each sector that released data.

- Academic - Business: 3
- Academic - Technical: 10
- Community: 2
- Consultant: 1
- Council 4
- Government: 1
- Industry: 5
- Water sector - Bulk: 4
- Water Sector - Retail: 5

The results provided in this report are based on these participants' submissions.

This report provides the key findings from the workshop, highlighting major problems and areas of opportunity in applying circular principles to the SEQ water sector.

Study Findings

The data collected from the workshop participants has been analysed under the following four areas:

- Problems
- Opportunities for Solutions
- Gains from Solutions
- Solution Barriers.

In this section of the report, the key themes from each of the areas are presented and discussed.

Problems

The workshop participants highlighted ten key problem areas or perceived 'pain points' in current water management (Figure 11). The top six problems are and discussed in detail below.

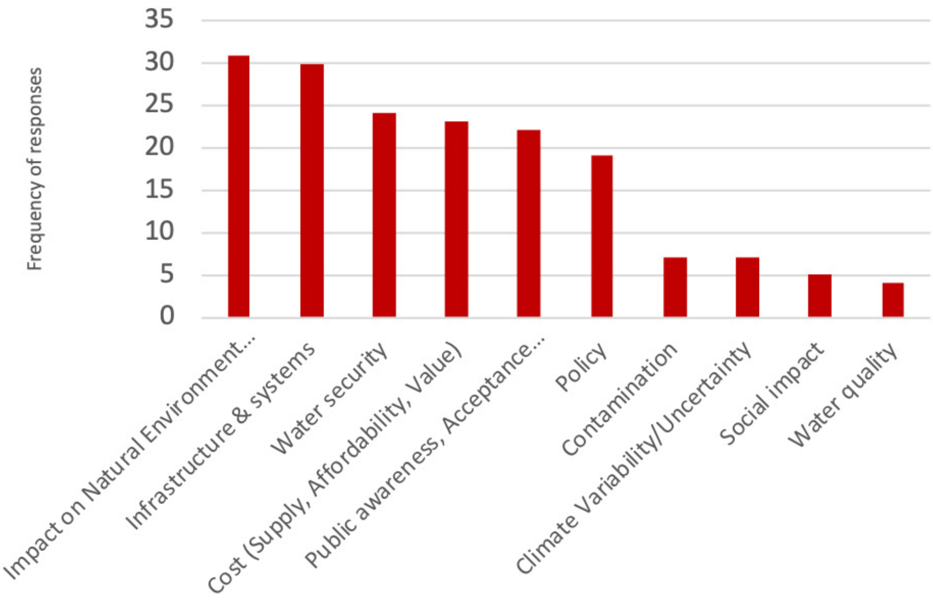


Figure 11. Top ten problem areas

1. Impact on the Natural Environment

The impact on the natural environment was a core problem identified by the workshop participants. Specifically, their concerns related to problems associated with the overuse and depletion of water supplies, the pollution or contamination of water supplies, and the current processes where water is discharged with waste, thus impacting the environment and limiting its reuse.

2. Infrastructure and Systems

Workshop responses perceived current infrastructure to be inefficient, not used to full effect, or 'patched up' as a short-term solution when something goes wrong. During the workshop discussion process, the current linear design of the system was raised as a key issue. In addition to raising issues with the system itself, participants discussed the need for data (or access to data) to enable better, more efficient decision making.

3. Water Security

Not surprisingly the issue of water security was raised by many respondents. Although most participants who were concerned about water security related it to supply and availability, wasteful behaviour was also a recurring sub-theme, including the use of potable water where non-potable would be suitable. The issue of climate change on water security and the need for a long-term water security plan also presented. Discussions within groups at the workshop mentioned resilience, planning for water security and the resource implications of a changing climate.

4. Cost (Supply, affordability, value)

The cost of water was discussed as an issue on multiple fronts. Some participants commented on the cost of recycled or desalinated water, querying how the cost would compare to traditional water sources. Other respondents were concerned with the affordability of water to consumers (particularly those in a low-income bracket) and the way water itself is valued. Water can be viewed as a service, as a source of energy and as a carrier.[xxx] The variation of costs between sites due to infrastructure and the potential for partnering with others to overcome cost issues were also identified.

5. Public Awareness, Acceptance & Trust

Improving acceptance of recycled water, improving water literacy and improving understanding of the impact of end-user consumption on supply were popular discussion points during the workshop, and featured in participant responses. The need for education well in advance of water management action (e.g. due to drought or population changes) was a topic of interest. The 'urgh' factor was reported to exist both in the community and within companies working against the introduction of water recycling measures.

6. Policy

Participants outlined problems with policy, with concerns over fragmented governance and overlapping responsibilities between agencies mentioned. A focus on 'business as usual' and exiting planning processes was reported, restricting investment and the updating of plans to support circularity. Participants perceived that the system was viewed as linear rather than circular and that further leadership is needed to make progress on water management towards circularity. Several participants expressed the view that strong leadership would work to make change within the system, but one individual also pointed out that strong leadership would also play a role in shaping the mindset of the population.

Opportunities for Solutions

Participants were asked where they saw opportunities for solutions to the water management related problems they were facing. Eight areas of potential solution were identified with the most prominent being partnering, followed by education and responsible use. The results in this section were fairly evenly spread across participant sectors. The top three solutions are discussed below.

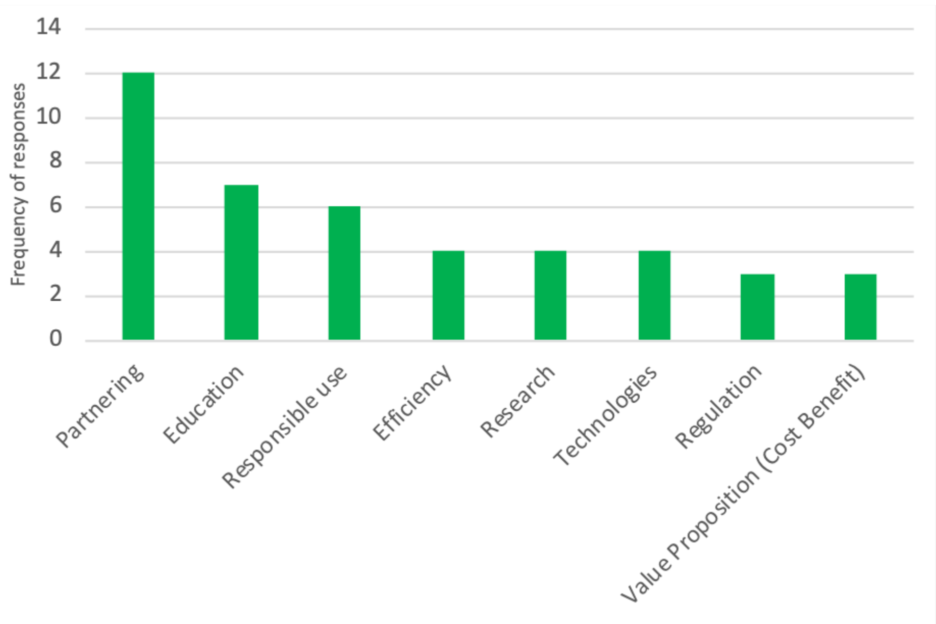


Figure 12. Top eight potential solutions

1. Partnering

Partnering was the most commonly mentioned current solution. Participants cited collaboration between industry, government and researchers, for example following a model like Oxley Creek Transformation, to develop integrated solutions and strategies that include more perspectives and broader information. Oxley Creek Transformation Pty Ltd was established in 2017 as a subsidiary of the Brisbane City Council, to revision the Oxley Creek corridor, delivering environmental, social and economic benefits.

2. Education

Respondents recommended training on alternative designs to be integral to finding a solution to these water problems. Special mentions were made of youth programs as well as creating knowledge through site visits and community forums.

3. Responsible Use

Respondents recommending responsible use as a solution were spread between those advocating personal responsibility and those seeking responsibility at a system level. One respondent referred to the Oxley Creek Transformation Model.

Gains from Solutions

Associated with solutions, the workshop participants identified a number of gains that could be achieved through more effective water management. It is possible to see links back to the problem areas identified earlier, with the top two anticipated gains identified as benefiting the environment and the performance of companies initiating the solutions.

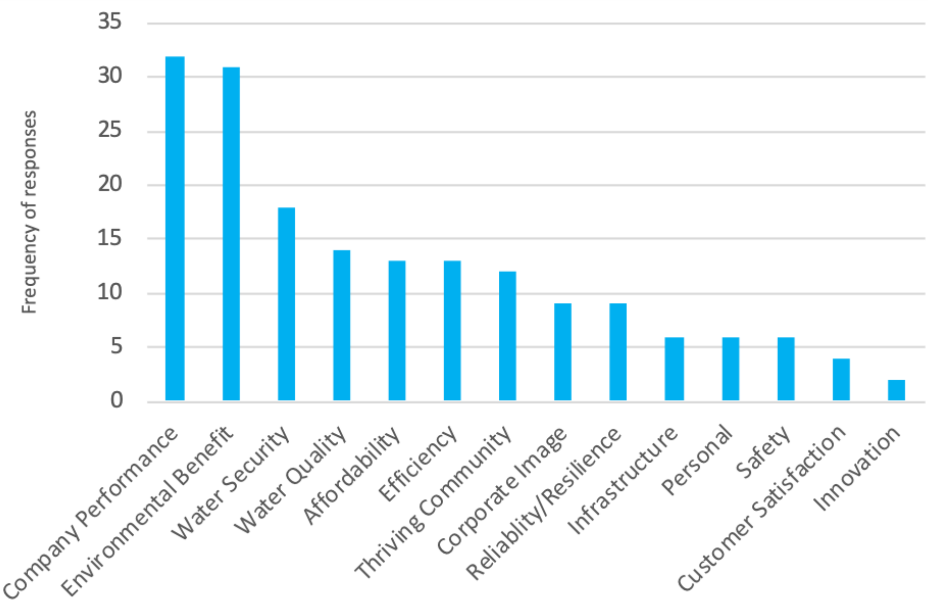


Figure 13. Gains from more effective water management

1. Company Performance (Cost reduction or revenue increase)

Participants, primarily those from industry backgrounds, noted potential gains to company performance from implementing water management solutions. Terms used by participants include time, money, cost-saving, revenue, margins, annual performance goals, cost reduction and financial return.

2. Environmental Benefit

The second main area of benefit identified by participants, particularly from an academic background, was to the natural environment. General references were made to reducing the impact on the environment and improving sustainability through reduced water usage and recycling water. More specific comments include reference to making better use of by-products to reduce impact on the environment, also creating an avenue for revenue (an opportunity). Making better use of the by-products also benefits the water treatment plants by taking the waste out of the water before release from industrial sites.

3. Water Security

Increases in water security were mentioned by participants. Specific reference was made to reducing water usage, using recycled water, and changing water use behaviours to secure water supplies for domestic and agriculture (linked to food security).

4. Water Quality

Although water quality benefits were mentioned, little extra information was provided by participants other than ensuring water quality was important.

5. Affordability

Some participants made reference to general affordability issues such as ‘reduced water bill costs.’ Note: comments from respondents in this section made it hard to distinguish between affordability (for the end user) and supply costs.

6. Efficiency

Three different interpretations of efficiency were found in the data. 1. More efficient use of water (reducing water waste), particularly potable water (with links back to water security). 2. More efficient use of energy to supply water, which links to a reduced impact on the environment. 3. Improving productivity (capacity to produce more water).

7. Thriving Community

Reference was made to improved water/energy systems, hence communities experiencing environmental and social benefits such as becoming more resilient, more sustainable and more liveable. One participant also made reference to improving ‘economic opportunities for first nations groups.’ Possible links exist back to improved company performance which is also seen a contributing to a thriving community.

Solution Barriers

The workshop sought to understand the current barriers participants perceived to acting on the solutions identified for effective water management. Ten barriers to implementing solutions were reported by the participants. The main two barriers identified were those of governance, policies and politics, and cognitive barriers. These two dominant barriers are discussed below.

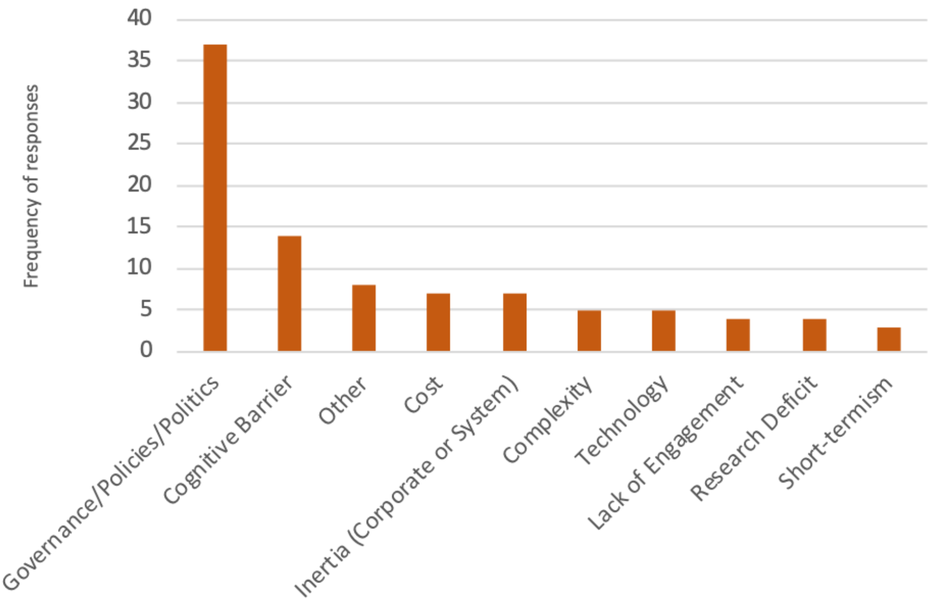


Figure 14. Ten barriers to implementing solutions

1. Governance or Policies or Politics

The dominant barrier to implementing solutions for water issues was linked to the political, governance and policy setting within Queensland. Participants mentioned fractured governance, politicising water, lack of leadership, closing water research centres, operating in silos, lack of unification/too many agendas and different priorities, system is linear rather than circular, information asymmetries, and changes in government as all barriers to implementing solutions to improve water management.

2. Cognitive Barriers

Interestingly, cognitive barriers featured in the respondent replies. Individual respondents mentioned: denial, unwillingness to change lifestyle, lack of knowledge and attachment to farm/land as issues. Within an organisational and government context, the lack of system thinking for long term challenges was identified as a barrier with some participants perceiving that the short term focus on profitability was creating a barrier to change.

Way Forward

Table 2 summarises the key findings from the analysis.

Problems	Solutions	Gains	Barriers
• Impact on the natural environment • Cost • Water security • Public awareness, acceptance & trust • Policy • Contamination • Climate variability/ uncertainty • Social impact • Water quality	• Partnering • Education • Responsible use • Efficiency • Research • Technologies • Regulation • Value proposition • Decentralising • Training	• Company performance • Environmental benefit • Water security • Water quality • Affordability • Efficiency • Thriving community • Corporate image • Reliability/resiliency • Infrastructure • Personal • Safety • Customer satisfaction • Innovation	• Governance/policies/ politics • Cognitive barriers • Other • Cost • Inertia (Corporate or system) • Complexity • Technology • Lack of engagement • Research deficit • Short-termism

Table 2. Key findings from the workshop – problems, solutions, gains and barriers to effective water management in SEQ.

Having examined the themes that emerged from the workshop, we can identify that although there are some significant barriers to overcome, particularly around politics, policy and cognitive change issues, there are opportunities to apply circular principles to water management in SEQ. These opportunities, however, cannot be pursued in isolation; a point reinforced by the prevalence of 'partnering' and 'education' as critical components of success within the research results. The circular economy relies on understanding and enabling the flow of resources (including waste and energy) within a system. Infrastructure is needed to support the flow of these resources from one company/service provider to another, and the sharing of resource details and data which are integral to support the resource management and transferal process.

There are significant potential gains that can be achieved through a circular approach to water management with returns identified for the natural environment, the companies involved, as well as for the community/customers. Linked to these potential gains it is clear that the circular economy needs to be examined at both a **system level**, with resulting gains for the natural environment and society, and at a **corporate level** to identify areas of efficiency, reuse and avenues for waste to be a resource either within the company or within an alternative sector.

The next steps in this review are presented in the section below broken into *CE for the SEQ Water System, and, the CE Playbook for Water Intensive Corporates*.

Circular Economy for Water Systems

It is vital that the SEQ water system is mapped to understand the flows in each interrelated sector including current flows, bottlenecks, areas of potential supply, and waste streams. This systems perspective will allow the sector to progress from its current linear model to a more circular model of operation, with associated resource efficiency gains.

There are multiple opportunities to recover resources and energy from existing waste water treatment processes (Figure 15). These include direct re-use of energy and heat, extracting and using nutrients, and new forms of treatment to enable the direct use of effluent or utilise new sources of non-potable supply (brackish/industrial water).

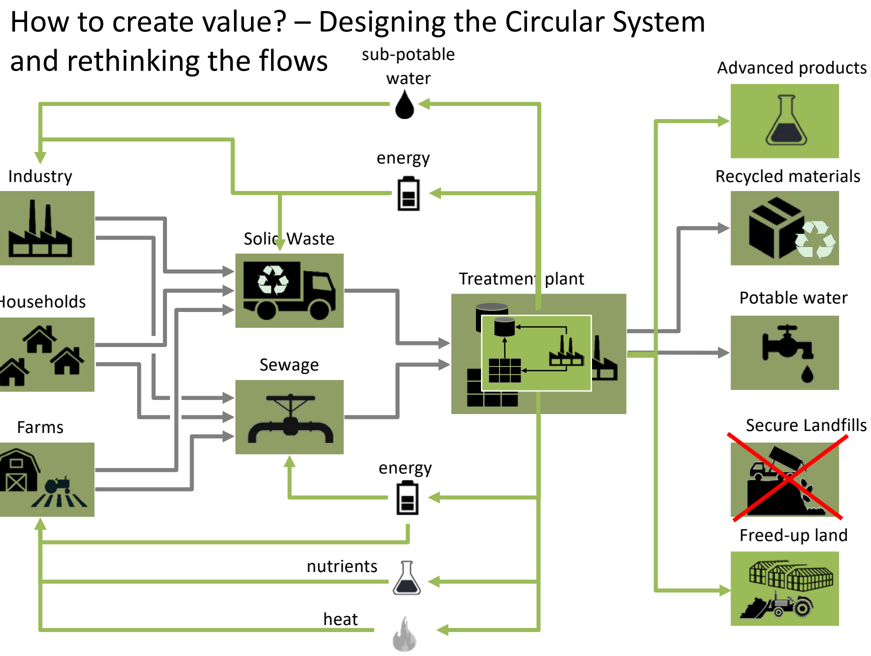


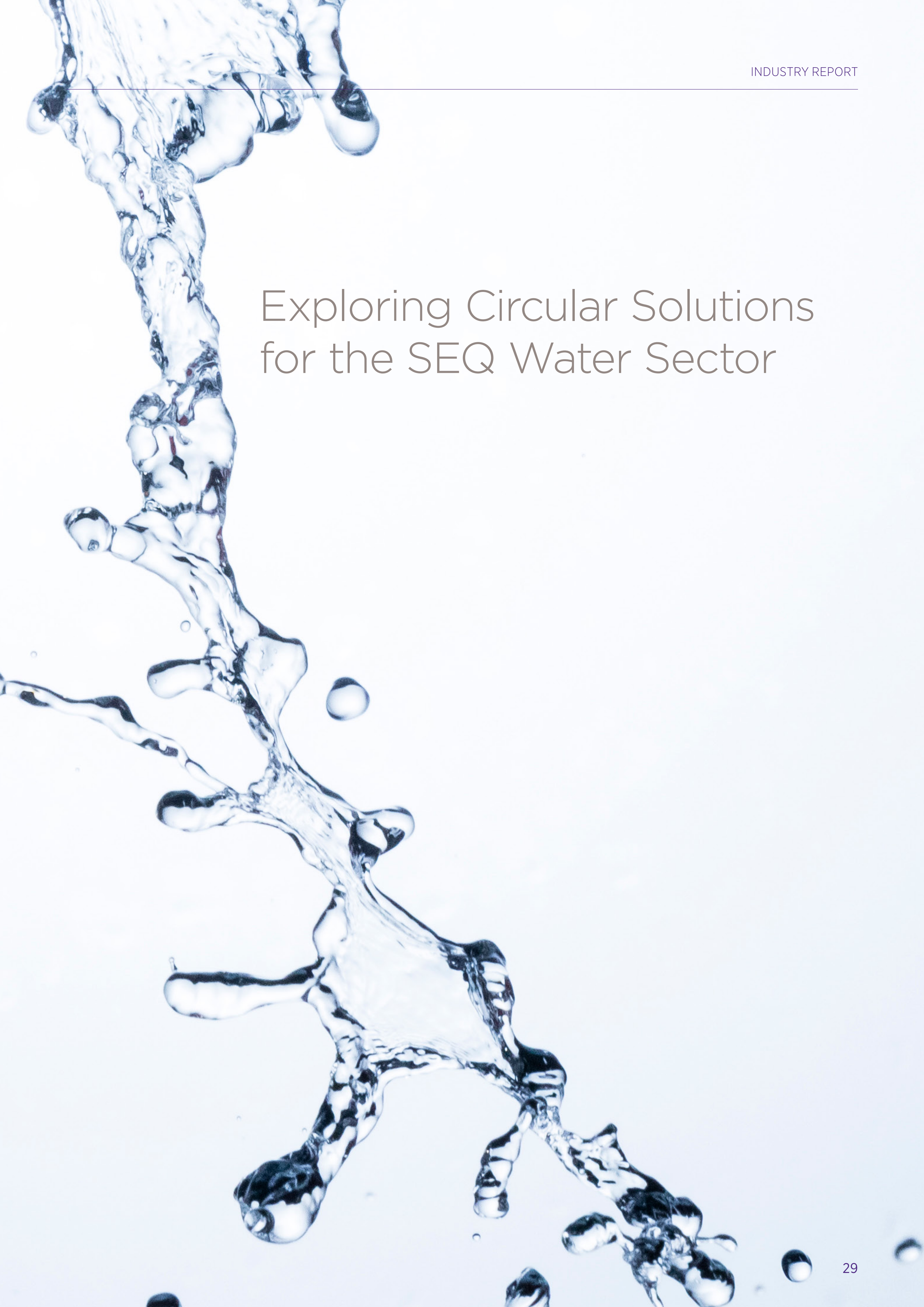
Figure 15. How to create value? - Designing the circular system and rethinking the flows.[xxxi]

The water industry is also an asset-intensive industry with extensive distribution networks and facilities, many of these requiring major capital renewal, maintenance and decommissioning as technical advances make certain processes redundant. This creates new opportunities to generate value from using existing assets for more services (telecommunications, additional resource recovery e.g. green and food waste); shifting the business model to selling performance e.g. managing pumping stations through third party performance models, rather than ownership; innovative business models to reduce water consumption, and re-using or reconfiguring assets for alternative uses.

There are many more circular ways to design and manage water supplies, waste water treatment and entire catchment areas than the current linear model. The scope for system redesign is enormous but offers potential solutions to providing safe, secure and pure future supplies, reducing the material requirements to run the system, and unlocking new forms of value creation by blending material flows, assets and new technologies in partnership with multi party stakeholders. Water companies such as Yorkshire Water in the UK are pioneering and leading the way in delivering strategic circular economy solutions.

To transform the linearity of current water system to a more circular design, further research is required to map the water, energy and waste flows in the SEQ region.

Exploring Circular Solutions for the SEQ Water Sector



Circular Economy Playbook for Water Intensive Corporates

Water-intensive companies are themselves sub-systems within the wider water use system. Examining specific companies to understand their water consumption and release of water will assist with understanding resource flows, potential for circularity, and current inefficiencies.

Planning is underway to establish a playbook of examples for the application of circular economy principles to water management in specific industry sectors. It will specifically address the following future benefits:

- Achieve customer expectations and superior customer outcomes
- Promote and accelerate circular economy solutions and future high value systems level innovation deploying technology, new business models, process and product design and digitalisation
- Improve resource productivity and mitigate risk from regulatory, investor and societal pressures

This report has set out the main principles of circular economy, why circular economy is relevant to the water industry and all businesses, and communities reliant on water. It has also suggested some circular economy business models and solutions which have the potential to create and capture new value. To build on the report requires more case examples, evidence and practical tools to:

- Map and value resource flows at company/project/product level and address value leakage within current processes/assets at a variety of scales
- Create organisational and operational solutions to radically drive improved resource productivity, restore, regenerate, build and maintain stocks and flows of high quality water resources
- Create new partnerships and boundary-spanning value ecosystem to transform and enable whole system management of water resources, end of life usage of products (details of waste/resource/durability) and interaction with associated land, water and atmospheric systems
- Provide a blueprint for companies to close the circular economy implementation gap and transform into water companies of the future.

At its completion it is intended that the playbook will allow organisations to evaluate specific projects or products identifying areas with the potential to apply circular principles.

To complete the playbook, we need your help. Further research is needed to fully evaluate specific examples of where the circular economy principles can be applied at a corporate level. Companies with a significant role in the water sector (e.g., as high water consumers) are being sought for inclusion as case studies.

Can you play a part in this ongoing research?

If you see value in this work and would like to support our ongoing research, there are three avenues for you to get involved:

1. **As a Case Company**. Is your company water intensive? Would you like to hear more about the potential to participate in this research project as a case study company? Please get in touch via the details below. Participants and their companies can choose to participate anonymously if they wish.

2. **As a Funder**. Would you consider funding further research into circular economy and the water sector? We are seeking further funding to continue this research. Please get in touch via the details below.

3. **As a Participant**. Would you be interested in participating in a follow up workshop? Please get in touch via the details below.

You can email the team via Dr Belinda Wade at **b.wade@uq.edu.au**.

Workshop Presenters

Professor Peter Hopkinson, University of Exeter, UK

Position: Director of Centre for Circular Economy

Peter is Director of the University Exeter Centre for Circular Economy that brings together academic researchers, business, policy makers and civic society to support the transition to a circular economy. He set up and ran the world's first MBA in circular economy and a global online executive education programme for leading global businesses, innovation companies and educators. He is most concerned with developing the scientific evidence base for circular economy theory and practice at varying scales and within different industrial contexts.

Professor Sara Dolnicar, The University of Queensland, Business School

Position: Professor in Tourism

Sara has worked to improve market segmentation methodology and refine empirical measures used in social science research. She has applied her work primarily to tourism, but also to the areas of environmental volunteering, foster care and public acceptance of water alternatives. Her current research program focuses on developing and experimentally testing measures that trigger pro-environmental behaviour in tourists. The ARC has supported Sara's research since 2003. In 2019 she was awarded the Australian Research Council's most prestigious recognition: a Laureate Fellowship. Sara's work has been cited more than 12,000 times, she has won more than 30 national and international awards, and is an elected Fellows of numerous associations, including the Academy for the Social Sciences in Australia.

Mr. Tri Tran, Lion (XXXX)

Position: Utilities & Process Services Leader

Tri Graduated from UQ in 2005, in electrical engineering majoring in computer systems. An early career in the electronics industry was followed by a move to OneSteel with roles as a Technical Production Support Engineer (PLCs & automation); Electrical Reliability Engineer; Electrical projects Engineer; OPEX - High Voltage Engineer (national role) and Site Electrical Engineer, Newcastle Pipe & Tube mill. In 2013 Tri left the steel manufacturing and mining industry to join Lion as the Site Electrical Engineer, Control & Automation Leader, taking up the role of Utilities & Process Services Leader at Lion in 2017. Tri has recently taken a new position as the Engineering Manager for Tribe Breweries.

Associate Professor Steven Kenway, The University of Queensland, Advanced Water Management Centre

Position: UQ Amplify Researcher

Associate Professor Kenway has 28 years' experience in research, industry, government, and consulting. His research addresses water and related energy, GHG, food, and cost flows through households, utilities, cities, and economies. His research topics focus on integrated water and energy planning, sustainable urban infill and water security. This involves developing analysis tools for both direct and embodied impacts of water supply and use. He leads the water-energy-carbon research group at UQ, has authored over 115 peer-reviewed articles and attracted over $7m in research funding.

Dr. Shihu Hu, The University of Queensland, Advanced Water Management Centre

Position: UQ Amplify Fellow

As a water scientist and engineer, over the last ten years, Shihu has worked intensively with Australian water industry partners in developing and demonstrating novel sustainable wastewater treatment technologies to recover energy and nutrients from wastewater.
Dr Hu also works an environmental scientist, and has been working on the fundamental understanding of the microbial processes which underpin the natural carbon, nitrogen and metal cycles on Earth.

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