LOCAL RECYCLED WATER IN SYDNEY – WHAT'S HAPPPENING AND WHY

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ABSTRACT
Local recycled water systems have the potential to meet many of the opportunities and challenges currently faced by the urban water industry. Recently there has been an increased installation of local recycled water in Sydney, however, there is a lack of agreement as to their overall value.

This paper examines the evolution of local recycled water investment in Sydney to clearly identify what is driving (or limiting) investment. In doing so, it explains the nature and complexity of the interactions between the social, environmental and institutional context, and the decision to invest in distributed recycled water systems, particularly the impact on the evaluation of costs and benefits.

INTRODUCTION
Like many other major cities, Sydney is looking for ways to adapt to the broad range of challenges in the urban water industry, and has aspirations of achieving livability outcomes (NSW Office of Water 2010). Sydney is Australia's largest city with around 4.6 million people in the greater Sydney region (NSW Government 2014), and is serviced by an extensive centralised water and wastewater network, owned and operated by Sydney Water (a government owned monopoly provider). Regional and local master planning have identified recycled water investment as an important part of securing water supplies and creating a resilient and liveable city (City of Sydney 2012; NSW Office of Water 2010). These plans have been supported with political and policy decisions that aim to promote recycled water options and support increased competition within the water sector (New South Wales Government 2006).

Within this context, recycled water infrastructure in Sydney has increased rapidly in the last decade. While recycled water is just one option that can help address the numerous challenges facing urban water, it does provide an integrated solution that benefits water supply and reliability; improves waterway quality by reducing wastewater disposal, nutrient loadings and water extractions; manages the impacts of growth on existing infrastructure; and helps support livability options (Burgess et al. 2015; Libralato, Volpi Ghirardini & Avezzù 2012; Tram Vo et al. 2014; Turner et al. 2016; Watson, Mitchell & Fane 2013). Despite recycled water's many benefits and increased public acceptance within Australia (Dolnicar & Schäfer 2009), it is often difficult to justify investment in individual projects (Marsden Jacob Associates 2013).

This paper analyses the evolution of local recycled water in Sydney to reveal why recycled water investment, particularly for local recycled water, is the subject of such debate. Using an extensive database of nearly 250 actual recycled water investments, an historical analysis of recycled water investment is reviewed in the context of changing social, environmental and institutional contexts. In doing so it reveals that in addition to strong environmental drivers, institutional, policy and particularly funding arrangements are instrumental to both the investments that have occurred to date, and the role recycled water can and will play in the urban water's future.

METHODOLOGY
This paper presents the findings of a PhD research project investigating the role of local recycled water systems in urban water management. The research uses an extensive review of aggregate information from nearly 250 actual local recycled water and stormwater investments in Sydney. Initially sites were identified, using the Metropolitan Water Directorate website, augmented and cross referenced with:

- projects that had funds allocated through the NSW Water Savings Fund and other State and Federal grants;
- businesses required to develop Water Savings Action Plans under the Energy Administration Amendment (Water and Energy Savings) Act 2005;
- Green Building Council of Australia's building register; and
- the Water Industry Competition Act licensee database

To ensure the list of sites was comprehensive, a final web search was conducted for "Sydney" AND "recycled water" OR "wastewater reuse" OR "water recycling". While comprehensive, it is possible this review was not exhaustive. However, the range and number of sites provides a sound basis for the analysis.

Next, site-specific data was collected for each scheme, including whether the scheme had been constructed and was reported to be operating. Web searches identified the investor, the source of recycled water, the end uses, the capacity of the system, costs and benefits and key drivers. This data was generally self-reported, so numbers likely represent ultimate demand or capacity, and publically available information reported drivers rather than limitations. The data was aggregated into a new database to facilitate trend analysis.

These investments were then reviewed in the context of the wide range of relevant policy documents and regulatory instruments, as of 2015, including those that provided necessary historical context. Over 40 documents (Acts, guidelines, policy documents and special reports) were reviewed. The data was then enriched, by incorporating insights gained through nine semi-structured interviews to establish the developer, operator, utility and user perspectives from 4 sites.

RESULTS AND DISCUSSION

Recycled water has increased in response to distinct phases of environmental and regulatory drivers

The number of Sydney's distributed recycled water schemes and the total recycled water capacity has increased rapidly in the last decade (Figure 1). The increase has been in response to strong environmental and social drivers in conjunction with a range of policy and regulatory measures.

Prior to the 1980s, recycled water use in Sydney was limited to opportunistic irrigation. The irrigation occurred close to inland sewage treatment plants that were already providing a high level of wastewater treatment. These schemes were seen as a valuable way of reducing nutrient and wastewater impacts on sensitive inland river systems (Sydney Water 2011a, 2011b) and providing reliable (and sometimes cheap) irrigation (Moxon 2004).

During the 1990s, several large recycled water schemes were facilitated by a regulatory push to improve waterway health. Measures were included in Sydney Water's governing Act and Operating Licence to reduced wastewater discharge and minimise freshwater extractions. At the same time environmental agencies placed more stringent requirements on wastewater discharges. The combination of regulatory directions and water quality issues with population growth and community pressure created the impetus for Sydney's first large residential recycled water scheme – Rouse Hill (Cooper 2003; Dean 2004), Wollongong Recycled Water Plant (Prothero et al. 2004) and further large scale irrigation at Picton and Gerroa. However, there was a substantial delay in the supply of recycled water to customers for Rouse Hill (2001) and Wollongong (2006), mainly due to the innovative nature of the schemes requiring regulatory frameworks to be developed in parallel (Cooper 2003; Sydney Water 2002).

Although recycled water use had steadily increased in Sydney since the 1960's it was conditions during the extreme drought of 2003-2009 that saw an almost exponential growth in recycled water (Figure 1). However, the foundations laid by the earlier schemes in terms of customer engagement and procedures developed for regulatory oversight were critical to supporting the explosion of recycled water that occurred over the drought period.

In response to growing water shortages, the NSW Government rolled out a comprehensive multi-pronged approach encompassing a wide range of mechanisms to encourage not only innovation in recycling but a higher level of private sector involvement, which facilitated the rapid growth in recycled water schemes. Policy measures developed by the Government encouraged recycled water via recycled water targets (see the Metropolitan Water Plan 2004, 2006)[1] and provided technical and financial support (see for example the Every Drop Counts Business Program Sydney Water 2009 and the Water Saving Fund and subsequent iterations). The government also sought to create investment opportunities and a degree of investment certainty via measures such as the Water Industry Competition Act, SEPP - Sydney Growth Centres, developing sewer mining policies, access arrangements and defining procedures to recover avoided costs.

Additional regulatory measures enacted over this period both encouraged and required alternative water source to be tapped. Restrictions prohibited certain used of potable water, which in particular drove recycled water investment for large irrigators, which resulted in recycled wastewater irrigation of golf courses tripling since 2003. Although restrictions provided a critical drive for recycled water investment, it was a the more complex combination of technical (improved capabilities of treatment technology), economic (reduced cost of treatment technology and rapidly increasing potable water costs), social (increasing customer acceptance) and policy factors (including grants and sewer mining arrangements) that enabled the rapid drought response.

Diversity in recycled water has clear institutional distinctions

In addition to a rapid increase in scale of recycled water, Sydney has also experienced diversification across source, end use and scheme ownership

[1] (New South Wales Department of Infrastructure Planning and Natural Resources 2004; New South Wales Government 2006)

(Figure 2, Figure 3). Although there is diversity in the scale and type of investment across Sydney, the investments are very distinctive between investors generally reflecting their institutional responsibilities. Local councils account for the greatest number of schemes, but only a small portion of recycled water volume, dominated by stormwater recycling (Figure 3). The dominance of stormwater schemes is most likely due to the siloed institutional arrangements where councils have responsibility for the management of stormwater systems, flooding and local water quality. In Sydney, councils have no responsibility for potable water supply and wastewater disposal, which until recently has been the sole domain of the public utility (Sydney Water). In contrast, Sydney Water has a much smaller number of schemes, but has almost three quarters of the recycled water capacity (Figure 2). By far the most diverse sub-group is private investment, which is likely to reflect the greater diversity in responsibilities and drivers within this group. While some of the earliest schemes in Sydney were privately operated (although they relied on Sydney Water to produce the recycled water) the greatest shift was a result of policy incentives and regulatory changes made from the mid 2000's in response to drought. These changes, supplemented by rising green building demand, created a previously unprecedented environment to allow the increase in private investment in urban recycled water in Sydney.

There were very few recycled water schemes that incorporated integrated sources. This likely reflects the compartmentalised nature of the regulatory framework and institutional responsibilities (discussed above), combined with the ongoing challenges for implementing integrated water management (Brown & Farrelly 2009; Ferguson et al. 2013; Floyd et al. 2014; Mitchell 2004)). The few projects that did combine multiple sources were driven (at least in part) by sustainable water servicing objectives, and provided a total water service (see WRAMS and Central Park for example). This appears to be a different approach to that taken generally in Sydney where water, wastewater and recycled water projects are evaluated on whether they are the least cost way to provide an individual service.

Where to next?

Government policy and regulation, in conjunction with environmental conditions, were instrumental and extremely effective in driving a broad range of recycled water investments by just as diverse group of investors. However, since the decision to construct a desalination plant in Sydney[2] and the subsequent end to the drought, government funding and support of new recycled water schemes has been limited (Turner et al. 2016) and there has been a distinct decline in new recycled water schemes (Figure 1). Furthermore, past recycled water investments have been called into question (for example see Independent Pricing and Regulatory Tribunal 2016, pp. 57-8). However, there are still some important, if no longer urgent, drivers for recycled water investment in Sydney, including meeting customer expectations (Metropolitan Water Directorate 2014), contributing towards liveability outcomes and managing the impacts of growth on the existing infrastructure and surrounding waterways.

Accounting for the full range of costs and benefits

Limitations in accounting for the full range of costs and benefits are often highlighted as a barrier to continuing to sustain and build on recycled water investments in Sydney. Certainly there are many ongoing challenges with identifying and including the costs and benefits of recycled water, which are compounded by the broader more complex set of stakeholders involved in private small scale recycled water (Watson, Fane & Mitchell 2017). In particular many impacts are not only difficult to measure, are site specific and difficult to transfer between sites (for example willingness to pay or environmental and health benefits associated with healthy green open space), they can also be uncertain, occur in the future and vary depending on the environmental conditions and regulations at the time (Watson, Mukheibir & Mitchell unpublished). Certain impacts will exist only during certain time periods or climatic conditions, which may be difficult to predict. For example, keeping open space green is only relevant during dry or drought conditions and varies depending on the capacity of the centralised system's capacity and restrictions rules. In other instances the type and magnitude of impacts can vary depending on the interactions between the centralised systems, the environment and the broader regulatory context. For example, reductions in nutrient discharge are likely to provide greater benefit when wastewater is discharged to rivers and streams than when wastewater is discharged through deep ocean outfalls.

In instances where benefits are both cumulative and difficult to value, including them in assessment frameworks becomes even more challenging. Benefits, such as resilience and reducing overbuild, are not only difficult to predict and measure, they are critically reliant on the way the centralised and local systems (as well as their interfaces) are planned, regulated and managed. It some cases, they rely on a critical mass for benefits to be realised - which is equally true for negative impacts. To adequately account for these benefits, the interplay between centralised options and alternatives, and the capacity and capability of smaller systems need to be determined.

[2] Completed in 2010

With the introduction of local water servicing options into the wider urban water planning process, the mix of private and public responsibilities for the delivery of these services continues to evolve. The changing paradigm results in a different and much broader distribution of impacts than has traditionally occurred. Private local recycled water, in particular, changes the distribution of impacts between different groups. Most significantly it can place the upfront and ongoing costs on a smaller customer group than larger centralised systems. In contrast, as a cumulative strategy, benefits of local recycled water systems can accrue to the broader community (greening, urban cooling) and potentially to the public utility (avoided costs, resilience). Yet again these benefits are difficult to value, cumulative, uncertain and occur in the future. Identifying appropriate benefit transfer mechanisms that reflect value, but are simple and transparent to administer is another area where further work is required, particularly if the industry aims to leverage private funds to maximise centralised asset value and provide liveability outcomes.

While continuing to improve measurement and assessment tools, particularly in the areas of resilience and liveability, will be an important factor in improving the capacity to make efficient recycled water investment decisions, the discussion above however, demonstrates that the full picture is more complex. Considering the interplay between environmental, social and regulatory conditions, together with the interaction between local recycled water and the centralised system is critical for identifying and measuring impacts more robustly. This will lead to making decisions that maximise the existing investments in centralised infrastructure and capitalise on additional benefits local recycled water can provide.

Costs – like comparing apples and oranges

Despite the broad range of impacts, the case examples studied reveal that cost was a critical consideration, and the price of recycled water was regularly compared to the cost of potable water (Watson, Mukheibir & Mitchell 2017). However, a combination of geographical and system design features, government pricing policies, complex and risk-averse regulatory structures and limited information availability, makes competing on price alone challenging in Sydney (Watson, Mitchell & Fane 2013).

During the past decade there have been a number of effective changes designed to encourage competition and innovative solutions, and promote integrated climate independent sources, particularly during the drought period. Whilst all recycled water systems provide ongoing contributions to Sydney's long term supply demand balance, funding arrangements do not reflect this, and there are major disparities in the way similar schemes have been funded. Generally all recycled water schemes must be self-funding (ring-fenced), however a small number of larger schemes received the backing of regulatory direction, enabling their costs to be incorporated into the potable water price, (for example Rosehill). Many smaller recycled water schemes received partial grant support for construction only. These differences create ongoing variations for pricing arrangements and potentially long-term project viability.

In addition, changes designed to promote recycled water and innovation in practice can be counteracted by opposing policy levers that in some instances were developed for entirely different purpose, particularly within the spheres of pricing policy, competition and resource security (Watson, Mukheibir & Mitchell 2017)(Figure 4). Recognising this complex, contradictory and shifting context goes some way to explaining why investment in distributed systems can be perceived as difficult, complex, costly and risky.

Therefore, despite the impetus for recycled water often being strongly driven by environmental conditions, actual local recycled water investment was found to be the result of a more complex interaction between who is involved, the costs and benefits, attributes of the community, and perhaps most importantly the regulatory frameworks and institutional arrangements (Figure 5). The generalisable insight from this work is that a systematic, systemic detailed review of the influences on existing investment provides a strong and defensible base from which to develop strategies to address unitentded consequences and remove barriers to future investments.

CONCLUSION

Local recycled water has the potential to provide effective and efficient solutions to many of the key issues facing the water industry. The capacity of distributed systems to provide efficient servicing at the urban fringes, and in constrained areas, its potential to increase the resilience of the centralised system and provide customers with differentiated services is increasingly recognised. Furthermore, private investment in this sector has the potential to enable competition in a monopoly industry, foster innovation and decrease the public funds required for infrastructure augmentation. In the current setting in Sydney, both public and private investment is occurring. Yet the ongoing role of these systems and their long term value at both a site level and as a long term strategy to extend the value of existing centralised infrastructure, is still disputed.

In Sydney, local recycled water systems have been emerging due to strong environmental and social drivers, despite the sometimes complex and conflicting regulatory environment. However, the ability to deliver truly integrated services continues

to be challenging, with Sydney providing very few examples of projects that combine multiple sources. This perhaps reflects a regulatory environment that is still complex and segregated. Local recycled water (and indeed all alternatives) would benefit from a clear regulatory definition of the role of the urban water industry, and in particular it would benefit from guidance on planning, delivering and funding wider social and liveability objectives.

The initial hypothesis for the research was that improved information on the full range of costs and benefits of distributed recycled water systems would lead to better investment decisions and potentially greater consensus on the value and ongoing role for these systems. The industry would benefit greatly from better data, and more simple and robust methods for inclusion in decision-making processes (for example, data on resilience, reliability, public health and social benefits).

Perhaps more importantly, however, identifying, valuing and including impacts in the decision-making process is only one part of the puzzle. The interactions between the impacts of the system; the environmental, social, regulatory and institutional setting; and who is making decisions are a complex but critical component of explaining what investment occurs, and therefore what role distributed recycled water systems (or any alternative) can have in urban water servicing. It is critical to clearly identify and consider this complex interplay to determine whether current policies and regulatory and institutional settings are appropriately designed to drive investment that meets the broad objectives of the water industry for the future.

Within the Sydney region, distributed recycled water has emerged as an effective site-specific solution in a broad variety of circumstances. However, under the current conditions (including regulatory and institutional arrangements) it is likely that distributed recycled water will remain a limited, boutique and fringe solution, responding to sites' or users' specific requirements, similar to the investments that have occurred to date.

For distributed recycled water to become a more mainstream strategy for addressing the challenges faced by the urban water sector, a number of changes are likely to be required. As discussed previously, an important first step is to clearly identify the objectives of the urban water industry, and then agree on how distributed recycled water contributes to these objectives. However, as has been shown in Sydney, acknowledging the benefits and calculating their value does not ensure their widespread inclusion in regulatory processes.

Clear and equitable price signals, and simple and predictable benefit transfer mechanisms are key areas for change. To assist with developing more robust signals for efficient investment, broader dissemination of the current capacity of centralised infrastructure and investment triggers is needed to provide an opportunity for the market to respond with solutions that benefit the private recycled water providers and their customers as well as the public utilities and their customers. Under current conditions there is very little data available that would signal to external investors where their investment would provide any benefit to centralised systems.

The focus of the current regulatory process in NSW on efficiencies over four-year periods for separate water, wastewater, stormwater and recycled water services, and the least cost 'just in time' delivery of significant infrastructure, may miss opportunities associated with integrated infrastructure. Certainly, the stark differentiation between revenue recovery rules for recycled water and those for other water and wastewater services is a significant barrier to recycled water investment. Comparisons with regulations in other jurisdictions are likely to provide further insights (e.g. the state of Victoria, Australia, is proposing one clear objective for pricing that maximises the long term best interests of the customer).

Finally, and perhaps most importantly, there needs to be broad acknowledgement of the complexity of trade-offs between environmental conditions, community preferences, and institutional and regulatory settings. This explicit acknowledgement will facilitate a broader discussion on how to recognise and align these processes, - this is critical to ensuring distributed recycled water investment occurs in a manner which best supports the ongoing sustainability of the urban water industry.

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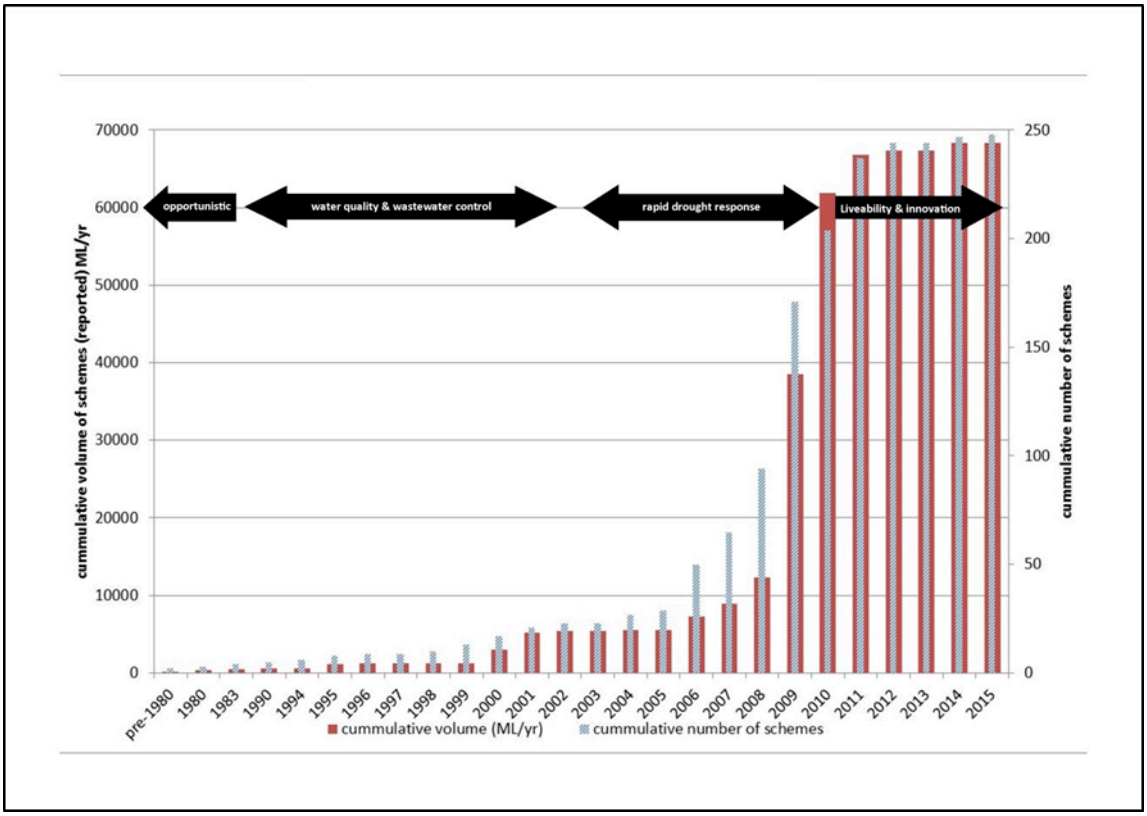

Figure 1: Reuse schemes in Sydney 1980:2015

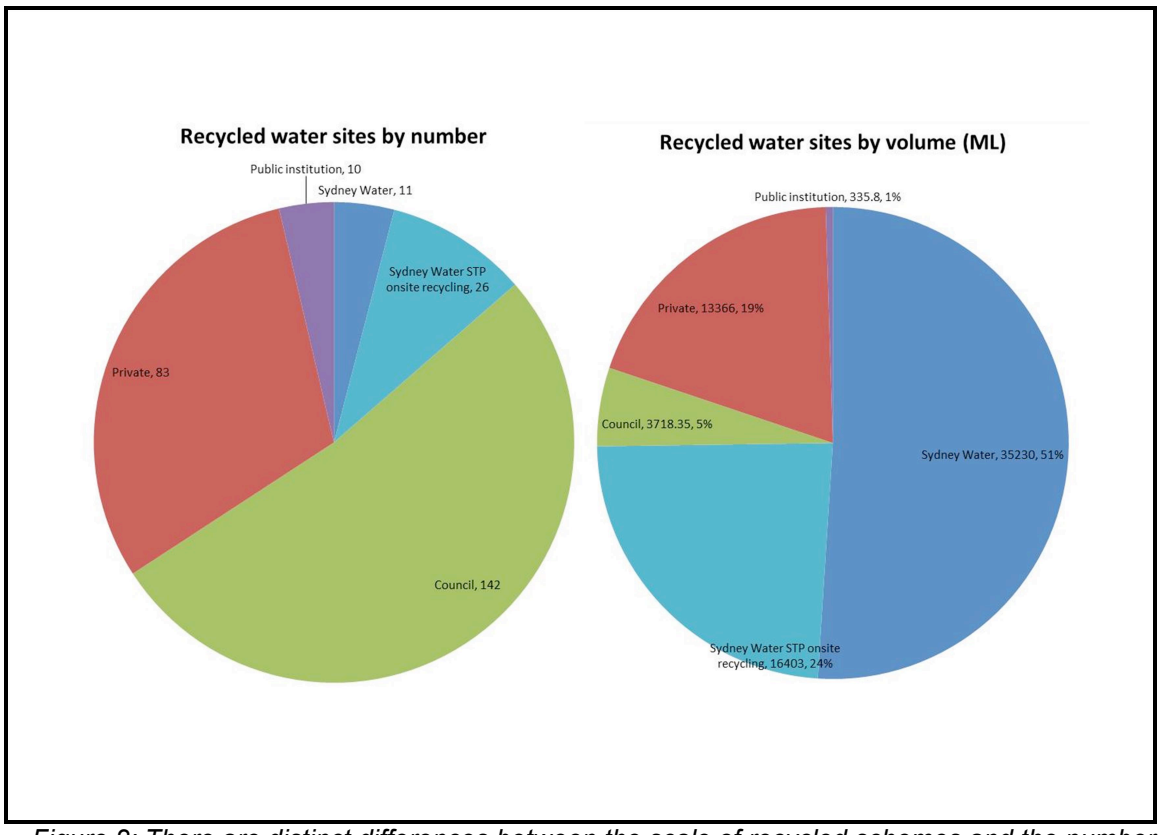

Figure 2: There are distinct differences between the scale of recycled schemes and the number of schemes between investor types

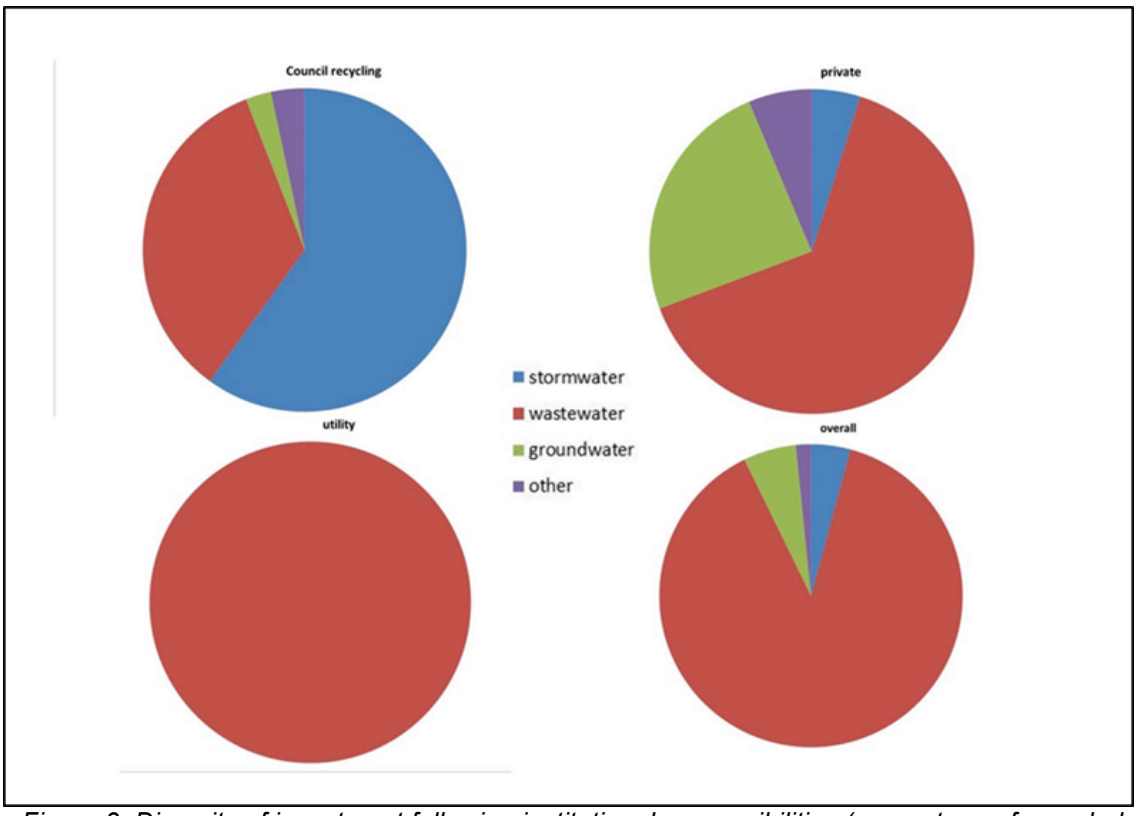

Figure 3: Diversity of investment following institutional responsibilities (percentage of recycled water by source and investor)

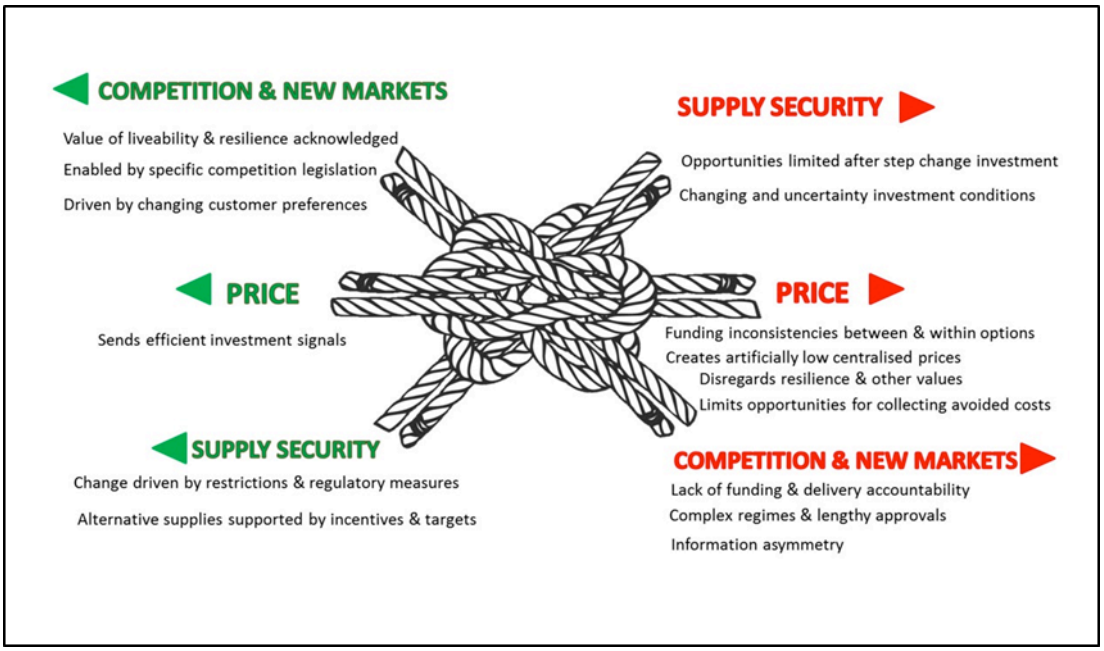

Figure 4: The oppositional nature of the policy and regulatory environment for local recycled water

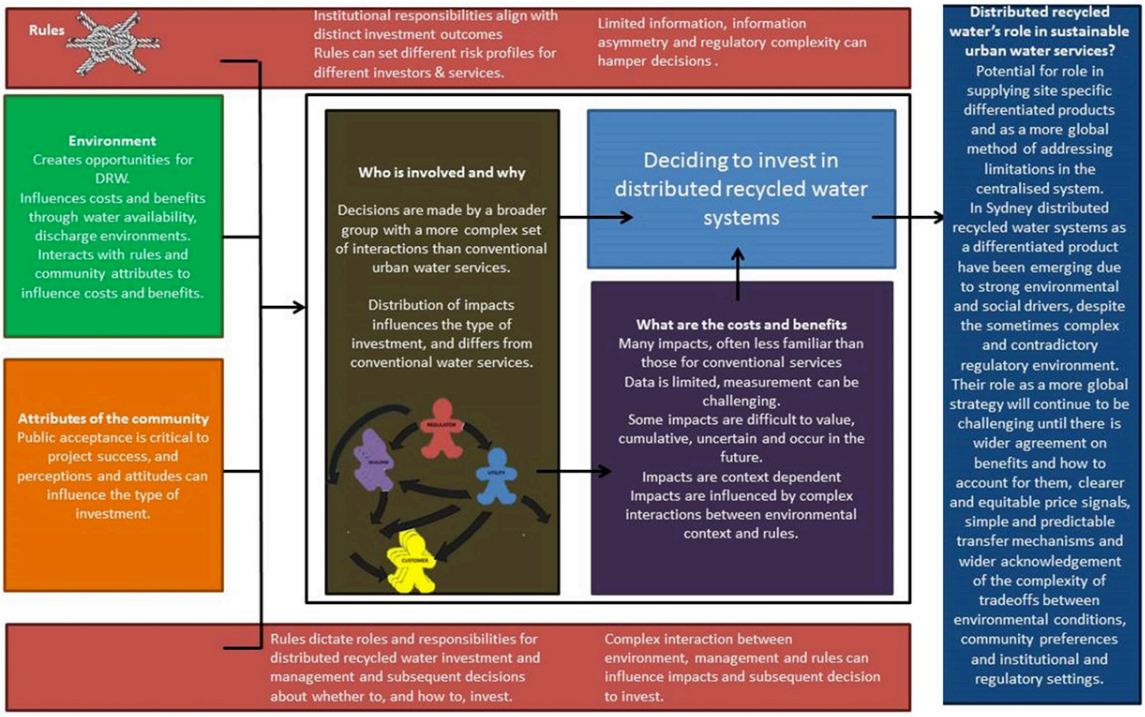

Figure 5: The complex interactions between environmental and social factors, who is involved and costs and benefits all contribute to local recycled water outcomes