

# *Demand forecasting: a risky business*

This cross-cutting theme demonstrates that deviations from demand forecasts are common across quite different recycled water schemes. These demand risks can be significant, leading to unanticipated financial and operational consequences on account of both increased costs and lower revenues.

The paper explains that demand risk is a serious issue because it has a cognitive and behavioural dimension - this is a difficult thing for us to do. The paper explores other instances of getting it wrong in demand forecasting, beyond water recycling, and provides guidance on how to notice and mitigate the risk of demand uncertainty.

**ABOUT THE PROJECT**

This national collaborative research project entitled "Building industry capability to make recycled water investment decisions" sought to fill significant gaps in the Australian water sector's knowledge by investigating and reporting on actual costs, benefits and risks of water recycling **as they are experienced in practice.**

This project was undertaken with the support of the Australian Water Recycling Centre of Excellence by the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS), in collaboration with 12 partner organisations representing diverse interests, roles and responsibilities in water recycling. ISF is grateful for the generous cash and in-kind support from these partners: UTS, Sydney Water Corporation, Yarra Valley Water, Ku-ring-gai Council, NSW Office of Water, Lend Lease, Independent Pricing and Regulatory Tribunal (IPART), QLD Department Environment & Resource Management, Siemens, WJP Solutions, Sydney Coastal Councils Group, and Water Services Association of Australia (WSAA).

ISF also wishes to acknowledge the generous contributions of the project's research participants – approximately 80 key informants from our 12 project partners and 30 other participating organisations.

Eight diverse water recycling schemes from across Australia were selected for detailed investigation via a participatory process with project partners. The depth of the case studies is complemented by six papers exploring cross-cutting themes that emerged from the detailed case studies, complemented by insights from outside the water sector.

For each case study and theme, data collection included semi-structured interviews with representatives of all key parties (e.g. regulators, owners/investors, operators, customers, etc) and document review. These inputs were analysed and documented in a case study narrative. In accordance with UTS ethics processes, research participants agreed to participate, and provided feedback on drafts and permission to release outputs. The specific details of the case studies and themes were then integrated into two synthesis documents targeting two distinct groups: policy makers and investors/planners.

The outcomes of the project include this paper and are documented in a suite of practical, accessible resources:

- 8 Case Studies
- 6 Cross-cutting Themes
- Policy Paper, and
- Investment Guide.

For more information about the project, and to access the other resources visit [www.waterrecyclinginvestment.com](http://www.waterrecyclinginvestment.com)

**ABOUT THE AUTHORS**

The Institute for Sustainable Futures (ISF) is a flagship research institute at the University of Technology, Sydney. ISF's mission is to create change toward sustainable futures through independent, project-based research with government, industry and community. For further information visit [www.isf.uts.edu.au](http://www.isf.uts.edu.au)

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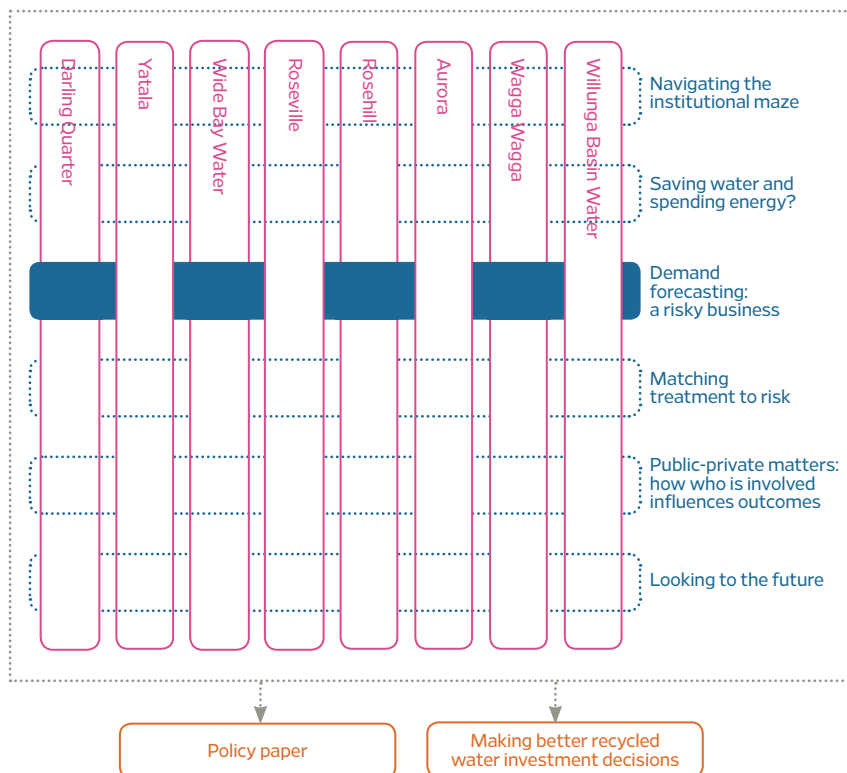
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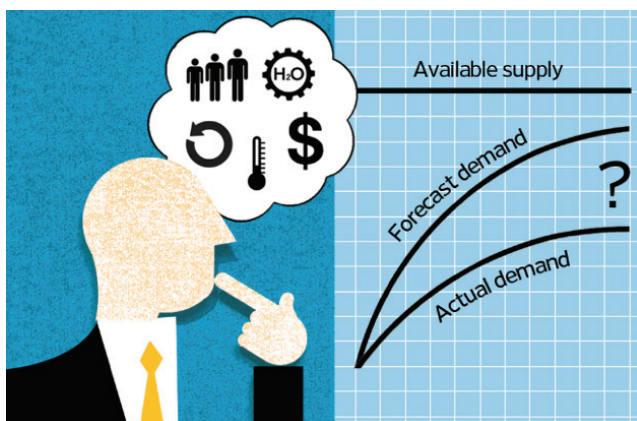


## Key findings

This paper illustrates that regardless of the recycled water end user (residential, industrial, agricultural), significant deviations from forecast demand do happen. Recognising and engaging upfront with uncertainty in demand forecasts, and the associated risks, is essential if water recycling investments are to deliver on their potential. Overestimating demand is a widespread phenomenon beyond the water sector, because it is rooted in human cognitive and behavioural biases. That means it is widely studied, and resources are available to help identify, minimise and manage the risks associated with engaging with uncertainty in demand forecasting.

## Characterising uncertainty in demand forecasting

Water supply systems are designed to meet a certain forecast demand, which can only be determined on the basis of assumptions about the future, for example about population growth, and trends in water efficiency technological advances, water conservation behaviour and attitudes, climate change, and energy prices. Therefore, there is always uncertainty and a degree of risk that the forecast demand will deviate from the actual demand. The mismatch can be in terms of the maximum demand and/or the rate of demand growth over time. The higher the uncertainty of the assumptions made, the higher the risk of a deviation, often with cost consequences. The most common discrepancy is between a higher forecast and lower actual demand. One could reasonably argue that all investments should aim for this, since good planning would include some contingency. However, in this analysis we are interested in situations where this gap is substantial, and has led to unnecessary costs such as higher or earlier capital expenditure than necessary, an inability to operate the plant optimally, or additional costs associated with disposing or storing surplus supply.



## Water recycling stories of demand deviations and uncertainty abound

From our case study investigations, it seems that to date in Australia, significant demand deviations and unplanned-for uncertainties are commonplace for recycled water systems.<sup>1</sup> Existing recycled water schemes provide opportunities for learning from different manifestations of demand deviations. Our investigation of the recycling schemes at Aurora (a residential scheme in Victoria), Wide Bay Water (an agricultural scheme in Queensland) and Rosehill (an industrial scheme in New South Wales) revealed uncertainties in key determinants of the size and scale of the scheme that had not been accounted for in planning and investment decisions. In each case, there has been both a lower recycled water demand and a slower rate of demand uptake than expected.

### Rosehill

#### ROSEHILL



Public-private partnership supplying high quality recycled water to industrial customers in Western Sydney. Supply commenced in October 2011.

#### CAPACITY

**20** ML/d

#### CLASS OF WATER

**A**

#### TYPE

Ultrafiltration and reverse osmosis

#### USAGE

Industrial processes and irrigation

#### Ownership & management

- AquaNet Sydney Pty Ltd  
*Water retailer part of the Jemena Group. Leads the private consortium Rosehill Recycled Water Scheme (RRWS) who is the owner of the scheme*
- Veolia  
*Operates the treatment plant on behalf of AquaNet*
- SPI Rosehill Network  
*Operates the distribution network on behalf of AquaNet*
- Sydney Water Corporation (SWC)  
*Water retailer. Purchases water from RRWS and retails water to industrial and irrigation users*

### Drivers, planning & design

The idea of this recycling water scheme was initiated during the extreme drought conditions of mid-2000s. AquaNet (previously known as AGL), saw an opportunity to put disused gas mains across Sydney to good use by developing a recycled water network and approached the state government with the idea of a recycled water scheme. Around the same time, the NSW Government's 2004 Metropolitan Water Plan identified that wastewater recycling was a critical option to meet water security objectives for the greater Sydney region. A study by the state government identified the industrial users in the Rosehill area as potential customers for a recycled water scheme. The aim of the scheme would be to reduce demand on potable water supplies.

The Rosehill scheme involved an extensive period of tendering and procurement processes conducted by Sydney Water. The project was awarded to the consortium led by AquaNet and involving Veolia as the entity responsible for constructing and operating the treatment plant. The negotiations prior to commencement influenced the magnitude of the demand risk and how it was shared. Critical aspects of these negotiations were the scale of the plant, expectations from all parties that demand would grow, and the private-public partnership (PPP) financial model. In terms of the financial model, Sydney Water as the retailer to the foundation customers bore the demand risk, as they had a take-or-pay guaranteed amount to AquaNet. The private consortium, in turn, bore other risks such as the risks associated with the design, construction, operation and maintenance of the plant.

### Demand deviations

Sydney Water holds five-year contracts (2010–2015) to supply recycled water to foundation customers with an opt-out clause after 5 years under specific circumstances, and a 20-year contract to purchase recycled water from AquaNet. Two of the foundation customers are expected to discontinue their operations prior to the end of their five-year contract terms, which will result in a reduction in revenue for Sydney Water. Other foundation customers have however continued to take recycled water at or above their take-or-pay contracted volumes.

From the private sector consortium perspective, although they have a guaranteed revenue stream for 20 years and hence will be able to cover their operational costs and their expected construction costs, they have not been able to contract as many additional customers as they expected.


### Consequences

The net impact on Sydney Water is that total demand is less than anticipated. The revenue equivalent will be borne by Sydney Water's customer base and is expected to be in the order of \$2 per household per year.

Some foundation customers who are using less than their anticipated amounts of water are also bearing costs, as they are contracted for 5 years at take-or-pay volumes. However, in at least some cases, the financial costs may have already been offset by financial benefits related to cost savings associated with the use of high quality water in industrial processing.

For the consortium, as additional industrial or residential customers have not yet been contracted, their expectations that they would generate additional revenue, on top of the revenue stream from Sydney Water, have not been met.

## Wide Bay Water

HERVEY BAY	
	
<p>The Hervey Bay Water recycling scheme is located in the Fraser Coast Region in Queensland and comprises three sewage treatment plants.</p>	
ELI CREEK	
<b>CAPACITY</b> <b>4.5</b> ML/d	<b>CLASS OF WATER</b> <b>B</b>
<b>TYPE</b> Activated sludge/trickling filter	
<b>USAGE</b> Golf course, cane farms, plantations	
PULGUL CREEK	
<b>CAPACITY</b> <b>5.0</b> ML/d	<b>CLASS OF WATER</b> <b>B</b>
<b>TYPE</b> Activated sludge plus intermittently decanted extended aeration	
<b>USAGE</b> Cane farms, plantations, sporting fields, airport	
NIKENBAH	
<b>CAPACITY</b> <b>4.8</b> ML/d	<b>CLASS OF WATER</b> <b>A</b>
<b>TYPE</b> MBR with biological nutrient removal	
<b>USAGE</b> Cane farms, plantations	

### Ownership & management

- Wide Bay Water Corporation (WBWC)  
*Water retailer. Owner and operator of scheme*

### Drivers, planning & design

Investment in this recycling water scheme was aimed at minimising sewage discharge to sensitive coastal and riverine waters, with strong environmental, commercial and recreational value to the region. In parallel, WBWC was set a stringent aspirational target in its licence condition of 90% discharge to land. However, land-based demands had to be identified. WBWC initially identified irrigating cane growers as third-party customers. Sugar cane growing is a major industry in the region and it is of significant economic importance. In the midst of the drought period, access to recycled water for irrigation was seen as a benefit to maximise productivity, maintain cane yields, and help to keep the local mill operational. However, the cane irrigation season is short and rainfall-dependent. This, in parallel with population growth, meant that wastewater production increased over time, and significant additional land-based recycled water schemes were required to absorb this surplus. WBWC invested in land (an appreciating asset) for irrigated hardwood plantations to produce poles for the energy sector. The availability of a combination of subsidies over many years, some under the sugar industry reform program, meant there was a financially attractive opportunity to invest in several recycling schemes.

### Demand limitations

Not all local cane farmers are in a position to take recycled water, and some of those who are have limitations to the amount they take. Many are dryland farmers, and do not wish to irrigate. Of those that do irrigate, many do not crop to maximum productivity. The prevalence of dryland farming and low-intensity irrigation reflects in part the demography of those involved in the industry, with many older farmers and hobby farmers.

In total, about one-third of cane farmers in the region take recycled water. Irrigation with recycled water is limited in this region by the sodic nature of the coastal soils, which require regular monitoring of soil structure.

As the population grows, the target shifts: larger volumes of recycled water are produced, which must be disposed of to land for WBWC to meet its percentage-based licence condition. During wet years, it is doubly difficult because irrigation demands are greatly reduced.

### Consequences


The financial impact of low third-party demand in wet years is partly offset by the design of the supply contracts (between WBWC and irrigators), under which farmers pay for 90% of their recycled water allocation irrespective of how much they actually use.

In wet years however, the 90% reuse target is not met, and greater mass loads are discharged

to the bay than the levels specified in WBWC operating licence. The ecological impact of increased discharge is uncertain, and may be offset by high baseline discharge from the nearby Mary River during wet years (hence the net additional impact from the scheme may be low).

There are potential risks of discharging recycled water on land and they require management. It appears that soil structure has been monitored regularly and to date there has not been damage.

## Aurora

AURORA	
 <p>Aurora's water recycling scheme is located in a greenfield residential development in Melbourne's northern urban fringe. The plant commenced operation in 2009.</p>	
<b>CAPACITY</b> <b>3.5</b> ML/d	<b>CLASS OF WATER</b> <b>A</b>
<b>TYPE</b> Prefiltration, ultrafiltration membrane treatment, UV disinfection, chlorination	
<b>USAGE</b> Toilet flushing, garden watering and car washing, irrigation of public open space	

### Ownership & management

- Urban and Regional Land Corporation (URLC) (1979 - 2003), VicUrban (2003 - present) *Victorian government's urban developer at the time. Instigator of scheme*
- Yarra Valley Water (YVW) *Water retailer. Owner and operator of scheme*

### Drivers, planning & design

The idea of this recycling water scheme was developer led. VicUrban had a mandate for demonstrating the viability of a strong sustainable development agenda to the commercial development sector, and the recycling scheme enabled enable it to carry out the water aspect of that agenda. The design of the recycling scheme was thus determined by the size and lot density of the development, with the construction plan being largely guided by the developer's initially aggressive timeline for selling the lots. The plant was built in a single stage. Yarra Valley Water's consultants believed it would be cheaper to build the whole plant in one go, especially given the aggressive timeline, instead of taking a staged approach to construction.



### Demand deviations

In 2003 URLC merged with Docklands Authority, which led to a strengthening of the commercial imperative of Aurora. With the objective of higher returns, VicUrban reduced the lot density and redesigned the layout of the development, putting a hold on Aurora for 12 months. This resulted in reduced recycled water demand, and a delay of the construction plan.

The knock-on effect was that by the time the development was ready to proceed, the broader economic circumstances had changed and there was a slowdown in market conditions, so the uptake of lots was significantly slower than anticipated.

### Consequences

The combination of lower and slower growing demand meant that the recycling plant could not be commissioned as planned. Instead, it was mothballed for 2-3 years after construction because of inadequate flows. This had cost implications for both YVW and the developer.

Because the plant could not function on low volumes, and there was no other sewerage outlet for Aurora, in the early years of the land release, sewage had to be trucked away for treatment and disposal elsewhere. It was the developer's responsibility to meet these additional costs.

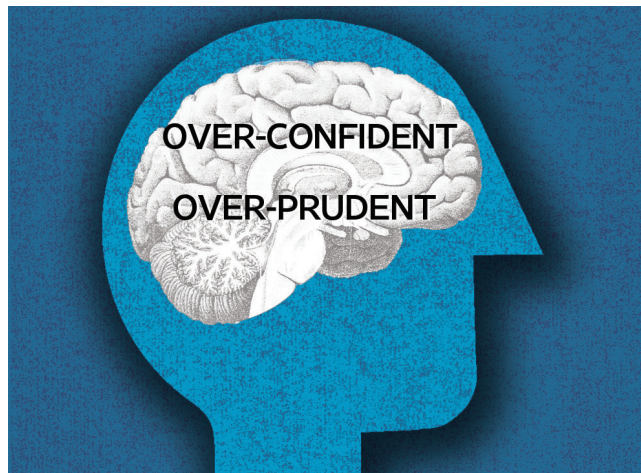
For YVW, there was the opportunity cost of investing well before the need existed, as well as the cost of re-servicing plant due to not being able to commission it on schedule. The plant has had ongoing operational issues, some of which may be associated with the fast pace of the initial design and construction at a time when there was little experience of such schemes in the marketplace. Whenever the recycled water plant is inoperable, Aurora's recycled water demand is met with potable water that Yarra Valley Water must purchase from Melbourne Water, increasing costs to and decreasing revenue for Yarra Valley Water.

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## ***People programming: Cognitive bias and unintentional misrepresentation***

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Overestimating demand is widespread, in areas as diverse as infrastructure design and financial services provision. As a result, it is well-studied. Studies in behavioural psychology explain that decision-making in the face of complexity and uncertainty, is often not a rational, impartial process, and is largely influenced by cognitive and behavioural bias (Barber and Odean 2001; Hammond et al 1998; Barry 2008). This has received particular attention in the area of financial and economic forecasting. The field of behavioural finance has evolved in an attempt to increase understanding of the reasoning patterns of



financial forecasters (Ricciardi and Simon 2000; van der Venter & Michayluk 2008).

Based on historical analysis of business decisions, Harvard Business School experts (Hammond et al., 1998) identify eight psychological traps that can affect decision-making processes. These traps expose ourselves to far greater risks than we anticipate, or lead to missed opportunities. Three of these biases affect forecasting processes in particular: overconfidence, prudence, and recallability. We may fall into the overconfidence trap when we are excessively confident of our own judgements and overestimate the accuracy of our forecast. In other cases, when faced with a high-risk decision, we may fall into the prudence trap, and be over-prudent and adjust our estimates closer to the 'worst-case' scenario, despite the chances of it happening being very low. We may also fall into the recallability trap, when our estimates are disproportionately influenced by dramatic past events strongly impressed in our memory (Hammond et al 1998).

In the area of transport, cases of over-estimating demand are well documented and research indicates these are also strongly linked to cognitive and behavioural bias (Bain 2009; Flyvberg 2005; Li and Hensher 2010; GHD 2011). In a study of project overruns in transportation infrastructure projects, Flyvbjerg (2005) concludes that the main causes of forecast inaccuracies are not technical faults but psychological and political factors. Flyvbjerg (2005) further explains that overestimation of benefits and underestimation of costs and risks, can occur unintentionally due to optimism bias, or be done strategically to favour a specific political or economic agenda.

To summarise, there is strong evidence from diverse fields that demand forecasting is a risky business. Water planners need to be aware of the considerable potential for cognitive bias and strategic misrepresentation to influence future projections of recycled water schemes.

## Coping with the risk of demand uncertainty

These stories of demand uncertainties illustrate that deviations can happen in any context of water recycling, and therefore careful consideration of uncertainties in demand forecast assumptions is worthwhile when planning a water recycling scheme.

The Victorian Smart Water Fund's 'Options Assessment Framework'<sup>2</sup> (Mukheiber & Mitchell 2011) is a useful guide to exploring and characterising uncertainties. The 'Making Better Recycled Water Investment Decisions' document that accompanies this paper includes specific guidance, hints and resources.

Part of what is needed to address these problems is a structured process to reveal the assumptions and associated uncertainties, identify the underlying influences behind those uncertainties, assess their likelihood, and evaluate their impact on demand. This can involve taking a scenario approach, where financial uncertainties can be modelled so that their implications can be included in decision-making processes. For example, in the case of the WBW water recycling scheme, internal rates of return on a range of scenarios, including the optimistic returns (full uptake, dry year), as well as other scenarios, could have been calculated. Once this is done, appropriate management responses can then be planned.

However, this process of identifying and assessing uncertainties is itself subject to the influence of cognitive bias and strategic misrepresentation, as explained above. Culmsee & Awati (2011) describe cognitive biases as meta-risks, that is, risks that affect the process of risk analysis. Therefore, managing demand risk involves parallel consideration of how these meta-risks may affect the decision-making process.

Decision-makers need to familiarise themselves with the psychological traps that can distort their thought processes, and make a conscious effort to compensate for these (Hammond et al 1998). This means the approach to project management should acknowledge that project leaders do not follow a rational and reliable approach to decision-making. As Shore (2008) explains, projects and organisational cultures play an important role in shaping the environment within which cognitive biases occur. Therefore, for some organisations, reducing the influence of biases in decision-making processes requires a significant degree of self-awareness, and may involve change of management practices.

Collecting outside views of people with no or low stakes in the decision, through for example workshops, avoids estimates from being dominated by the thinking processes of a



few people, and thus may help prevent issues of cognitive bias and strategic misrepresentation (Hammond et al 1998; Liu and Napier 2009).

Overall, adaptive management offers flexibility in dealing with uncertainties as they arise. For example, in the case of Aurora, staging the construction to match the growth of the development over time would have reduced up-front costs and would have provided an opportunity to include improved treatment technologies in the later stages.

A structured process of identifying and assessing uncertainties also opens the space for negotiating who is best-placed to manage the impacts associated with different types of demand risks and how these responsibilities might be allocated in an equitable manner. This topic is further explored in the 'Public-private matters: how who is involved influences outcomes' paper.

## Summary

Demand risk is significant in recycled water planning and investment. The probability of getting the demand estimates wrong is high, and the consequences can be significant in cost and operational terms. Those that took a just in case approach. There are cognitive traps here - we are 'hardwired' to make unhelpful judgements. Avoiding these pitfalls is possible, but it requires effort in two directions. Firstly, it requires explicit attention to the psychological traps, and a corporate culture that values failure and learning from experience. Secondly, it requires a structured practical process to uncover and assess all the relevant sources of demand uncertainty, from political shifts to changes in the market. See the 'Making Better Recycled Water Investment Decisions' document arising from this project, for just such a process. Another way of characterising this issue is to distinguish between 'just in case' and 'just in time' approaches to water planning. This characterisation and its implications are explored in the 'Looking to the Future' theme paper.

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**Notes**

1. A higher actual demand and lower forecast demand is also possible, although our study has not unearthed any examples. That situation would be a missed opportunity for suppliers, and could represent a water security issue for end users.
2. See [www.smartwater.com.au/knowledge-hub/water-smart-cities/integrated-water-management/options-assessment-framework.html](http://www.smartwater.com.au/knowledge-hub/water-smart-cities/integrated-water-management/options-assessment-framework.html)

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