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Sustainable Urban Water Service Systems

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EXECUTIVE SUMMARY

The water industry in Australia and internationally is on the verge of significant change, moving from commodity supply to service provision. This change provides unparalleled opportunities to incorporate sustainability into planning and delivery of water services.

In this paper, we outline the drivers behind the change, propose the simple principle of 'living within our means' to underpin the transition from supply side thinking to water service provision, and give a set of guiding strategies to exemplify this principle.

Consistent with the principle of 'living within our means', we propose two maxims for time-dependent actions to move toward sustainability. Our first maxim, 'Picking the low hanging fruit', is an essential step, likely to produce results in the short term, and deliver marginal changes in how water is used. In terms of planning for the future, it is most aligned with forecasting. Our second maxim, 'Challenging existing assumptions', is also essential, and is focused on a longer timeframe and delivering step changes in the water business, which is more aligned with backcasting. Together, they are necessary and sufficient conditions for sustainable urban water systems.

We give a series of examples, covering different scales (tens to tens of thousands of customers), different stages of development (concept design, construction, operation), and different categories of end users (residential, commercial, industrial) to show how these maxims work in practice.

Under the maxim of 'pick the low hanging fruit' we describe a hierarchy for directing actions, and show how applying the hierarchy provides better opportunities to move towards sustainability. The first priority is to reduce the volume of water necessary to fulfil a particular service or meet a demand. The second priority is to match the quality of water required to fulfil a service with the quality of water supplied for that service. This concept is also known as source substitution or implementing the water quality cascade. Taken either separately or together, both of these actions provide additional benefits in terms of the resources (energy, materials, and cost) necessary to deliver a particular water service.

Under the maxim of 'challenge existing assumptions' we show how extending the usual boundaries for costing of service provision for greenfield sites can significantly broaden the range of feasible alternatives. We also give an example of how an industrial cooling service provided by water can be replaced by air at a similar levelised cost, providing significant environmental benefits in the process.

INTRODUCTION

The water industry in Australia and internationally is on the verge of a significant move from commodity supply to service provision. The drivers behind this change include

- ✓ Increasing interest in holistic thinking;
- ✓ Increasing recognition of potential resources in stormwater and sewage nutrients;

- ✓ Increasingly limited access to adequate and affordable water resources;
- ✓ Aging infrastructure;
- ✓ Increasingly expensive maintenance of highly centralised systems;
- ✓ Increasing treatment costs;
- ✓ Increasingly stringent discharge licences;
- ✓ New approaches to water pricing, infrastructure provision, and competition.

In this paper we outline a principle, some strategies, and two maxims to provide a framework for taking actions to meet these challenges. By way of a series of examples, we show how these maxims are already contributing to changing practices.

LIVING WITHIN OUR MEANS

The terms 'sustainability' and 'sustainable development' are now generally accepted and often invoked in the water industry[1].

Sustainability is a rich contextual concept and is inherently values based. Definitions therefore abound. What constitutes a sustainable system is inherently context dependent, temporally, spatially, and culturally. Since the term 'definition' infers one right answer, we prefer to use the term 'perceptions' because it implies a multiplicity of right answers. Many scholars have written about the variation in perceptions about sustainability (see Carew and Mitchell, 2002, for a review). Such a discussion is beyond the scope of this paper. The key point is that the diversity of perceptions about what constitutes sustainability serves to strengthen the concept, rather than to weaken it.

In New Zealand, the Parliamentary Commissioner on the Environment (2000) outlined the following definition '*sustainable development is not a fixed state, but rather a process of change*' and further, that this change process needs to be one '*in which the use of resources, technological development, and institutional change are managed so as to meet future as well as present needs while at all times not reducing the health and life-supporting capacities of ecological systems*.' We find this definition useful when thinking about water systems because it explicitly recognises both the physical (technological) and behavioural (institutional) influences on resource use. Sustainable urban water systems encompass both these influences, just as most perceptions (definitions) of sustainability and/or sustainable development share two fundamental concepts related to these influences: equity amongst all people, both now and into the future, and recognition of ultimate resource limits.

These are the influences and concepts we draw on when we propose 'living within our means' as a single simple principle for thinking about sustainability. This simple principle underpins the transition from 'supply-side thinking' to the approach of 'water service provision'[2].

What kinds of guiding strategies for urban water systems might be consistent with 'living within our means'?

- ✓ Recognising the limits of a catchment and the water that is available within it;
- ✓ Ensuring water use is efficient *i.e.* use the lowest volume of water necessary to provide a service or to meet a demand;

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[1] In November 2002, the International Water Association held a conference in Venice, Italy, in its 'Leading Edge' series entitled 'Sustainability in the Water Sector'.

[2] For a discussion of integrated resource planning as a means of providing water related services and the comparison with supply side planning see Howe and White (1999), White and Fane (2001)

- ✓ Ensuring water use is effective *i.e.* use the lowest quality of water necessary to provide a service;
- ✓ Ensuring sufficient and appropriate quality flows to our local ecosystems;
- ✓ Maximising the efficiency of the use of energy and materials to deliver a service;
- ✓ Investing in new and existing infrastructure consistent with these strategies; and
- ✓ Investing in institutional structures and arrangements which facilitate these strategies

We return to examples of these strategies in action in subsequent sections of the paper. In the next section, we outline two maxims for thinking about the future and taking action to move towards sustainable urban water systems.

PREDICTING THE FUTURE AND TAKING ACTION

We have said that sustainable systems are contextual, and influenced temporally. In the remainder of this paper, we develop two maxims which encompass time-dependent actions to move towards sustainability: 'pick the low-hanging fruit', and 'challenge existing assumptions'. Picking the low hanging fruit is an essential step likely to produce results in the short term, and deliver needed marginal changes in how water is used. Challenging existing assumptions is also essential, and is focused on a longer timeframe and delivering step changes in the water business. Together, they are necessary and sufficient conditions for sustainable urban water systems.

Planning for the future is a core activity of all water businesses. Whilst predicting the future is impossible, there are a wide range of techniques for thinking about what might happen, and how we can influence that. In very general terms, these methods can be categorised as either forecasting or backcasting. Figure 1, adapted from Dreborg (1996) illustrates the difference between forecasting and backcasting. Forecasting methods are based on current dominant trends, and therefore tend to describe futures that look similar to the present. Forecasting methods struggle to anticipate surprises and discontinuities. Backcasting, on the other hand, begins by defining a preferred future, and then works backwards to determine alternative feasible physical and behavioural paths connecting the preferred future with the present. Thus, the solutions generated by backcasting are independent of current dominant trends. A water service provision model of the future therefore requires the application of both forecasting and backcasting.

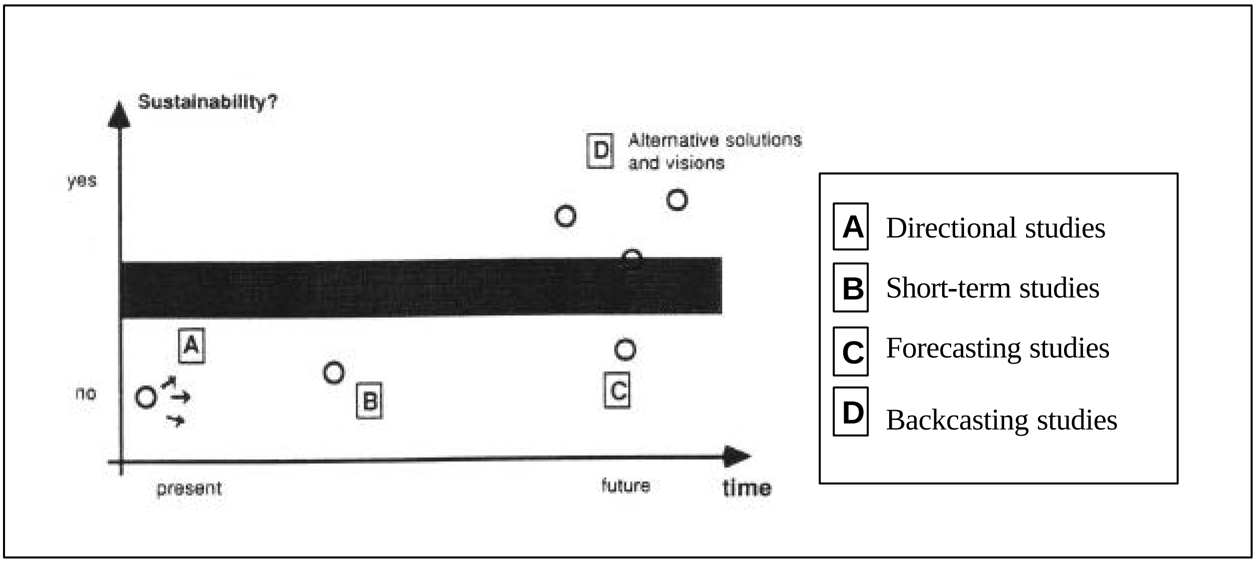

Figure 1 Application of backcasting to sustainability (Dreborg 1996)

Forecasting and backcasting are complementary in planning for the future. When thinking about a future incorporating sustainable urban water service provision, forecasting is more aligned with our maxim of picking the low hanging fruit. Our second maxim, challenge existing assumptions, is more aligned with backcasting.

Our view, illustrated in Figure 2, is that these two maxims inform each other, and so both are necessary, and best implemented in an ongoing iterative circular approach. Challenging existing assumptions will generate different perspectives, and with a different perspective, we might identify different low hanging fruit. Identifying and acting on different low hanging fruits changes our current position, so the path from our current position to the preferred future changes, and so forth.

To make this explicit, think about Australiaville Water, a large urban water utility. Australiaville Water's long-term predictions show that with the expected rise in population, long-term rainfall trends, and the need to increase environmental flows, the security of supply of existing storages will be reduced. Options that may be proposed include new water supply storages, transferring water from neighbouring catchments or even desalination. At the same time, Australiaville Water might challenge its existing assumption that more supply is the only option for meeting the demand. It might do this by evaluating the cost and benefits to the community of investing directly in the improvement of water efficiency by its customers and through reducing system losses. This process, known as least cost planning or integrated resource planning, begins with end use analysis, and asks whether there are opportunities for reducing demand which have a lower cost per unit volume than equivalent supply augmentation options. In most cases, reducing demand by installing water efficient showerheads, taps, toilets, washing machines, cooling towers and urinals is the cheapest, fastest, and most sustainable way to obtain new water for increasing population or environmental needs.

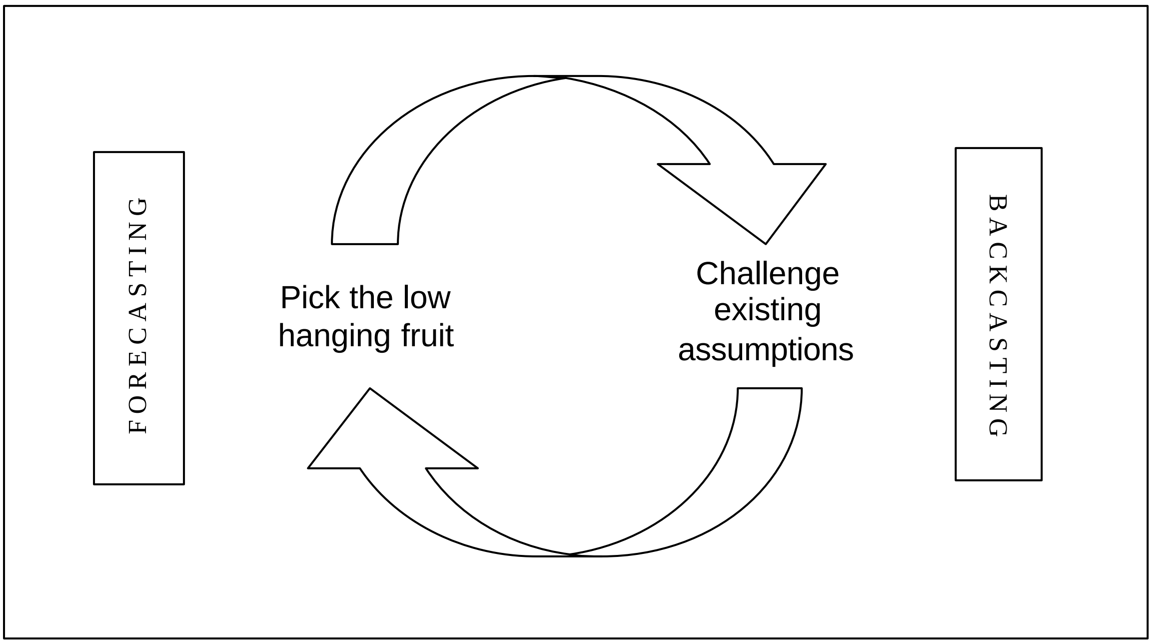

Figure 2 The relationship between forecasting, backcasting, and maxims for action

In the sections that follow, we demonstrate the fruits of these labours with examples chosen to illustrate three dimensions: stage of development (e.g. concept design, construction, operation, renovation), scale of development (from tens of customers to thousands of customers), and type of development (residential, commercial, industrial).

PICKING THE LOW HANGING FRUIT

The first of our maxims for action, pick the low hanging fruit, refers to actions that are easy to do now, more or less within the existing urban water system, that will pay sustainability dividends in both the short and long term. These kinds of actions are aimed at making the most of the system as it stands, and include a focus on, for example, water efficiency.

We see a hierarchy within low hanging opportunities:

1. Demand management: Maximise water efficiency and implement source control
2. Water quality cascade: Match required water quality with water quality supplied

Demand management means looking at what our customers use water for (end uses) and determining whether the same service could be provided by using less water. The classic example here is the installation of water efficient showerheads[3] and tap regulators that can save between 23 and 35 kL/hh/year in large scale programs (Sarac, Day, and White 2002).

Improved water efficiency is often associated with reduced energy consumption and greenhouse gas emissions as well as reduced costs for water treatment, sewage transport and treatment, and re-distribution or discharge.

In its new building sustainability rating tool, BASIX, PlanningNSW (see http://www.planning.nsw.gov.au/ for details) will provide a performance based scoring system based on the reduction of demand for water through implementing water efficiency and through applying the water quality cascade and implementing source substitution. The most useful features of this tool are firstly that it gives developers, builders, plumbers, home renovators, and consent authorities a consistent set of figures to work from, and secondly, it enables consistent ranking of different water saving opportunities.

Implementing demand management first, opens up more opportunities for better matches between the quality of water required for specific end uses and the level of treatment, and therefore quality, of water supplied. For example, a concept study carried out by the Institute for Sustainable Futures for Sydney Water's new corporate headquarters showed that the building could, in principle, have accommodated up to 1 000 people using only rainwater captured on site as the water source. This was possible through significant efficiency improvements by low water use dual flush toilets, waterless urinals, sensor-operated high efficiency taps in hand-basins, and water efficient showerheads, and, most significantly, treatment and reuse of effluent and the use of ground source heat pumps rather than cooling towers (Chanan *et al.* 2003)

Similarly, a new residential, commercial, and public space development at Kogarah Town Square in Sydney implemented the principles of demand management and the water quality cascade. With the objective of improving stormwater management and reducing

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[3] The US has had mandatory performance standards for showerheads and many other water using fixtures, since 1994. Australian initiatives in this area have led to moves for mandatory labelling (Day and White 2002)

water use, rainwater from the site is collected and used for toilet flushing and landscape water use (Jha *et al.*, 2001).

An example of the potential for improved water efficiency within the industrial sector is provided in the recent experience of the Gladstone region of Queensland. In this region, large industrial customers have historically been subject to long term contracts with little, if any, incentive to improve water efficiency. Recent droughts have meant that allocations have been reduced and restrictions brought into force. Most industries met 10% restrictions with minor changes in practice, very little or no capital investment, and often reductions in operating costs. Reductions in demand of up to 50% are being achieved with capital investment in improved processes.

CHALLENGING EXISTING ASSUMPTIONS

Our second maxim for action, challenge existing assumptions, is a longer term approach aligned with backcasting. Existing assumptions must first be identified before they can be challenged. Identifying assumptions behind business-as-usual requires us to step back a little, and see what it is we are taking for granted in our decisions.

A starting point here could be the assumption that having a single pipe supplying one quality of water for all end uses is the best option. We could start by asking the question 'what do we mean by 'best'?'. Do we mean 'cheapest'? And by cheapest, do we mean 'lowest capital cost'? And by lowest capital cost, do we mean 'lowest capital cost for the portion of the system for which we have to pay'?

In a recent study for Sydney Water, a joint project of the Institute for Sustainable Futures and CSIRO Urban Water, we showed that the system boundary used to assess the costs significantly influences the comparative capital costs for vastly differing systems[4]. Instead of breaking up the capital costs for servicing a new subdivisions according to who normally pays (*e.g.* the water utility is responsible for delivering bulk water and removing bulk sewage and charges the developer a headworks contribution, the developer is responsible for all infrastructure from the boundary of the estate to the boundary of an individual property, and the home buyer is responsible for the infrastructure within their property), we included all the pro-rated costs of all the infrastructure necessary to supply the service, regardless of the location of the infrastructure. On this basis, annualised capital costs for all options varied by less than 10% (*i.e.* less than the likely error in the cost estimates).

Another common assumption is that water, sewage, and stormwater systems should be considered and planned for separately. Thinking in terms of a total water cycle can enable quite different solutions. For example, in a greenfield residential development in Melbourne's northern outskirts, water efficiency assumptions have reduced projected demand of internal residential use by 45 L/p/d. Further reductions through source substitution enabled by water cycle thinking include using rainwater for the hot water supply (44 L/p/d) and reclaimed water for toilet flushing (23 L/p/d) and garden watering (33 L/p/d). Overall, this gives a 70% reduction on demand from the reticulated water system.

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[4] For a greenfield estate for approximately 12 000 lots in Sydney's southwest, we developed a series of conceptual servicing plans which varied from business as usual (dependence on highly centralised off-estate water supply, wastewater treatment and discharge) through estate and neighbourhood scale technologies, to allotment scale technologies. Costs were assumed to include everything necessary to supply the service. All off-estate infrastructure was appropriately pro-rated, and on-estate costs included distribution and supply to the house, rather than to the property boundary.

One of the most influential applications of the water quality cascade that also involves challenging existing assumptions is to replace a high quality water stream with no water stream at all. In other words, to think in terms of providing a service rather than providing water. For example, in Gladstone, approximately 80% of the raw water demand comes from industry and approximately 80% of industry's demand is for cooling. More than half of this cooling demand is from coal-fired base-load power stations in a different catchment. Like the new power station at Milmerran in Queensland, these power stations could instead be air-cooled. Taking a total resource cost approach, the relative unit cost of converting to air cooling, and making the limited raw water available for uses for which there is no feasible substitute, appears to be roughly similar to the cost of augmenting supply by either desalination or a pipeline from another catchment.

CONCLUSION

The Australian and international water industry is on the verge of significant change, and a significant opportunity to embrace sustainability in its operations. We have proposed a simple principle (*live within our means*) to underpin the transition from supply-side thinking to water service provision. We exemplified that principle with a set of strategies, and then showed how a combination of forecasting and backcasting are necessary for predicting a water service provision model of the future. We proposed two maxims for enacting the future planning methodologies (*pick the low hanging fruit* for forecasting and *challenge existing assumptions* for backcasting) and showed how the application of these maxims can pay dividends for residential, commercial, and industrial water users.

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