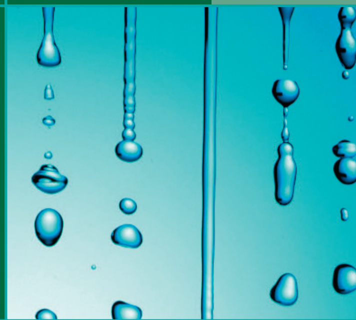
The Cooperative Research Centre for
Water Quality and Treatment

Costing for Sustainable Outcomes in Urban Water Systems

A Guidebook



Research Report 35

Costing for Sustainable Outcomes in Urban Water Systems

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A Guidebook

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Contents

Overview

New costing approaches are needed to deal with the changes inherent in sustainable urban water systems. Sustainable urban water systems encompass new technologies, new outputs and services, new scales, new management approaches, new risks, new business models, new regulatory arrangements, and new operating and institutional arrangements. Costing is a key decision making point. Existing costing approaches are not set up to deal with these changes, meaning that costing processes for more sustainable options vary within and between water authorities. That means options, projects, and organisations cannot be compared and benchmarked. More importantly though, it means there is a risk of investing in the wrong solutions. The objective of this guidebook is therefore to show how to cost to ensure sustainable urban water systems.

This guidebook is the final output of a collaborative research project led by the Institute for Sustainable Futures at the University of Technology Sydney. The project partners are the Collaborative Research Centre for Water Quality and Treatment, Hunter Water, Melbourne Water, Queensland Environment Protection Agency, South East Water, Sydney Water, and Yarra Valley Water.

The guidebook presents and applies a set of costing principles essential to sustainable urban water cost analysis that have been synthesised from recent research and practice. These costing principles are outlined above right.

THE COSTING PRINCIPLES:

1. USE APPROPRIATE COST PERSPECTIVES
2. PROVIDE WATER SERVICE OUTCOMES
3. THINK IN TERMS OF SYSTEMS
4. INCLUDE LIFE CYCLE COSTS
5. ASSESS ON THE BASIS OF INCREMENTAL COSTS
6. ACCOUNT FOR EXTERNALITIES
7. ACCOUNT FOR THE TIME VALUE OF MONEY
8. ACKNOWLEDGE AND MANAGE PRECISION AND UNCERTAINTY
9. REPORT TRANSPARENTLY

1.1. WHY IS COSTING CRITICAL FOR SUSTAINABLE OUTCOMES FROM WATER SYSTEMS?

Cost analysis is pivotal to many decisions about urban water infrastructures.

While considerations of cost alone will not assure sustainable outcomes, exploring least cost means of providing urban water service promotes economic efficiency and resource efficiency, both of which are core concepts in sustainability. Failing to focus on cost effectiveness when seeking sustainable outcomes can lead to solutions that meet environmental objectives at unnecessarily high financial cost and with significantly increased resource use intensity. For example, imagine a situation where a supply-demand gap is forecast. A range of responses are under consideration, including new supplies, recycling, and a new tier of water efficiency. A focus on least cost, or cost effectiveness, might suggest a focus on maximising water efficiency outcomes first, with concomitant reductions in environmental impact.

As well, promoting cost effective servicing directs investment towards those areas with the best potential to offset or avoid major augmentations of bulk supply.

Finally, the extent to which emerging reforms in the water industry, such as third party access and recycled water pricing, can promote sustainable outcomes is strongly dependent on the associated cost analyses.

1.2. WHY IS THIS GUIDEBOOK USEFUL FOR ME?

The local context determines what is the most sustainable urban water system: potential solutions need to be examined on their merits for a particular location. This guidebook is a structured process for doing just that. Water industry practitioners (including both engineers and economists) will find:

- clear guidance on what the essential costing principles are for sustainable urban water systems
- examples of how to apply them in practice, and
- checklists designed to help practitioners to adapt the principles to their particular projects and decisions.

The outcome for practitioners using this guidebook is defensible and transparent cost analyses that provide better returns on investment and more sustainable outcomes.

1.3. GUIDEBOOK STRUCTURE

To make the guidebook useful to both engineers and economists, it is set up to provide both breadth and depth about a core set of costing principles and how to apply them to promote sustainable urban water outcomes.

Section 2 outlines the basics of the urban water cycle and current drivers for sustainable outcomes.

Section 3 sets out the principles, and explains why each principle is important for costing for sustainable urban water outcomes, what the principle is, and what would happen if it were implemented.

Section 4 shows how to apply the principles through a four step process: framing the study, characterising the study, identifying and specifying costs and benefits, and analysing and reporting costs. A case study about an urban fringe development is woven through Section 4 to demonstrate the application of the principles. The case study is extended with 'what-if' analyses and text boxes to highlight alternatives and related ideas.

1.4. GUIDEBOOK SCOPE

This guidebook is designed to help practitioners identify more sustainable and least cost solutions when costing options and alternatives for sustainable urban water outcomes. The principles and processes outlined in this guidebook hold across the many dimensions that characterise such projects, including:

- Geographical, hydrological and social location and context
- Infrastructure scale (from large centralised to small, highly distributed systems)
- Populations served (from tens of households to tens of thousands of households)
- Water cycle elements affected (from single components e.g., rainwater tanks, to the whole water cycle)
- Project stage (from pre-feasibility to investment sign-off).

The principles and processes also hold across four broad opportunities where least cost studies can usefully inform investment decisions that lead towards sustainable outcomes:

- For infrastructure in new development and redevelopment areas (e.g., servicing plans or studies of alternative servicing options including total water cycle management, water sensitive urban design, third pipe reuse or decentralised reuse alternatives)
- For water conservation programs and similar targets (e.g., demand management, efficient water use, rainwater tanks and/or stormwater capture, effluent reuse targets)
- For new assets which enhance the existing system (e.g., upgrading a wastewater treatment plant from secondary to tertiary treatment, sewer overflow abatement works, supply augmentations)
- For significant asset replacement (e.g., water and sewer mains).

1.5. COST EFFECTIVENESS, NOT COST–BENEFIT

The scope of the guidebook is limited to questions about the relative cost effectiveness of a series of options. To be specific about the guidebook's scope, a distinction between cost benefit analysis and cost effectiveness analysis is necessary.

Cost benefit analysis (which is not the focus of this guidebook) involves the estimation of dollar values for all future costs and prospective benefits associated with a particular action, project, or policy. It attempts to answer the question 'can this action, project, or policy be judged to be economically beneficial' or 'do its total benefits outweigh its total costs?'

The outcome of a cost benefit analysis is expressed either as a net benefit or net cost, discounted back to a present value, or as the ratio of benefits to cost (Hanley and Spash, 1993). A ratio greater than one means the proposal can be considered economically or financially viable. The difficulty with cost benefit studies is in the estimation of dollar values for each and every benefit. This problem of valuing benefits is particularly acute for urban water projects because the provision of water services to urban populations is seen as a necessity, a government responsibility and a right for people within our community. It is also important to note that if only a single project is analysed, as is common with cost benefit analysis, a positive result fails to reveal the existence or otherwise of more cost effective alternatives.

In contrast, cost effectiveness analysis (which is the focus of this guidebook) compares alternative ways of meeting the same objective(s) (Hanley and Spash, 1993). It is concerned with the relative costs of meeting objectives rather than whether an alternative can be judged as being economically beneficial in its own right. There is no attempt to value the objectives themselves in dollar terms. In cost effectiveness analysis, the viability of a particular option can only be determined by reference to the range of possible alternatives. In terms of costing for sustainable outcomes, cost effectiveness analysis has the advantage that it can be used to identify the least cost means of providing specified urban water service(s) (e.g., enhanced wastewater management for an existing region) or of meeting a particular goal (e.g., a 20% reuse target for a utility by 2010).

For example, imagine a proposal to conserve potable supplies through non-potable reuse schemes in new development areas. A cost effectiveness analysis of such a proposal would compare the reuse scheme to other feasible alternatives that could either conserve or augment potable supply e.g., a demand management program, a new potable augmentation, rain tanks for new and existing homes, etc. In contrast, a cost benefit analysis would commonly consider only the non-potable reuse scheme for new development areas, and limit itself to the question of how the costs of this scheme compare to its benefits.

Life cycle costing (or whole of life costing) is also a form of cost effectiveness analysis. Life cycle costing responds to the fact that the costs associated with an option accrue over the whole life cycle of the asset, and therefore cost analysis should include acquisition or capital, installation, operation, maintenance, refurbishment, decommissioning, and disposal costs. It is important in costing for sustainable urban water outcomes because the distribution of costs across these life cycle elements can vary markedly between options and have significant financial impacts.

2

Background

2.1. URBAN WATER CYCLE BASICS: CONTEXTS AND DRIVERS

This section places the provision of urban water services in a broader perspective. Many readers of this guidebook will be familiar with the urban water cycle, the current local and national context for costing water services, and the current drivers for improving costing practice, including the impact of sustainability on the Australian water industry. This section is an introduction to these elements for those who are less familiar.

This section starts by placing urban water in the broader perspective of water and nutrient cycles. Next, it provides an overview of current urban water service provision in Australia. It then highlights the current issues and drivers for change in costing practices and how they relate to sustainable urban water outcomes.

2.1.1 THE WATER CYCLE

Australia has the lowest rainfall of any continent (other than Antarctica): the average annual rainfall is approximately 420 millimetres. The highest rainfall occurs along the tropical portion of the east coast, but only 11 per cent of the land area has a median annual rainfall over 800 millimetres, which is where most of the population lives. This natural water cycle is the basis for the urban water cycle that we have created within our cities and towns. The urban water cycle is a series of linked components. These components are explained in Figure 1 (over page) and below.

A brief explanation of the water cycle and its elements is a useful starting point for this guidebook. Historically, the various elements depicted in Figure 1 and explained below have been managed separately, sometimes by different organisations. Increasingly, a water cycle focus is emerging, which means that the connections between the elements are being seen as significant, and in need of management. For example, a dual reticulation scheme providing recycled water to a new development can save water from a dam and reduce the need for disposal of treated sewage.

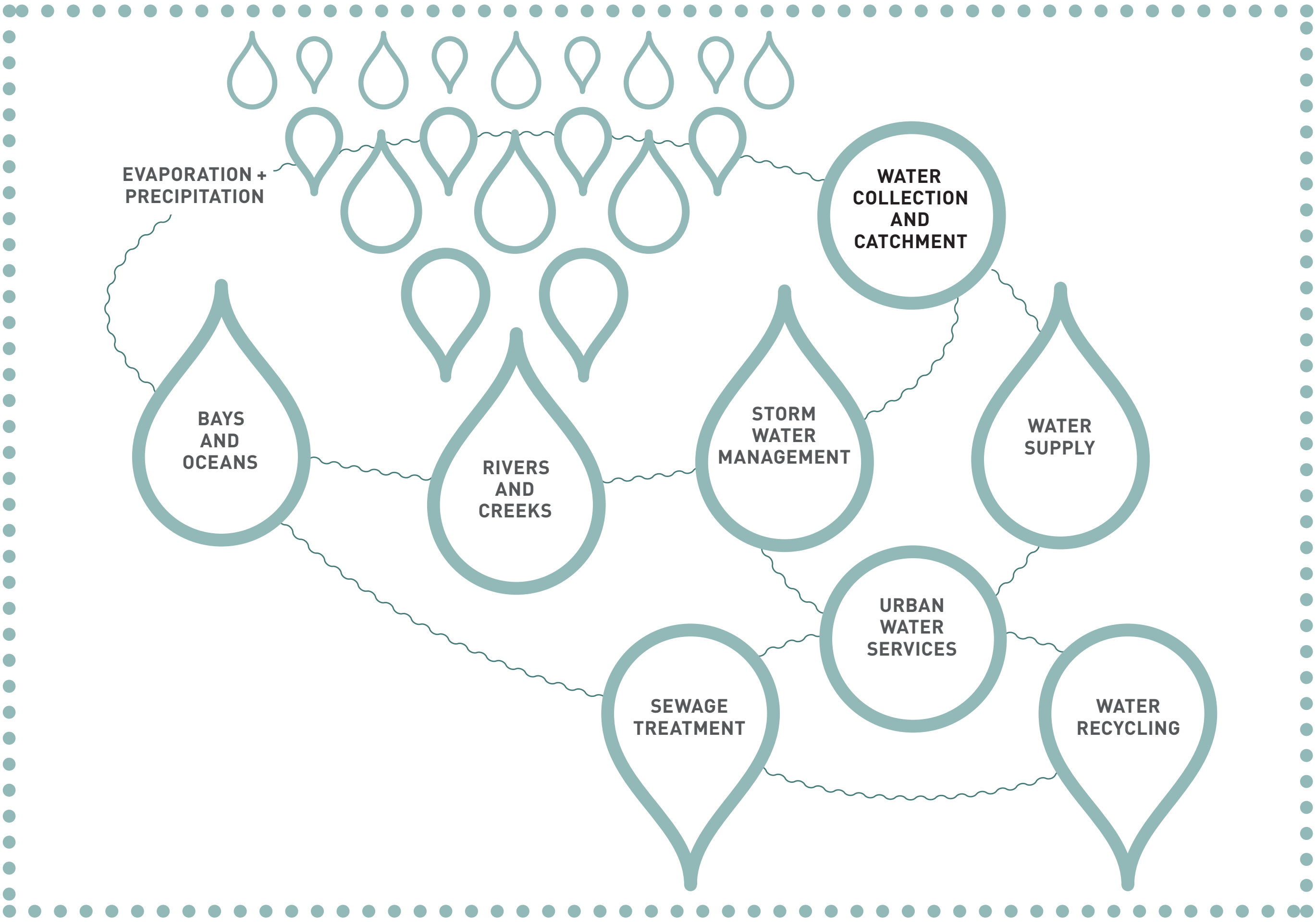
From a sustainability perspective, rivers and creeks, both upstream and downstream, are a critical part of the urban water system. Management of this part of the system encompasses pollution prevention from domestic and industrial sources, and protecting and improving rivers and creeks by controlling irrigation demands, stabilising beds and banks, preventing flooding, fencing stream frontage, removing willows and other weeds, planting trees and releasing water from reservoirs to ensure environmental flows.

As most Australian capital cities are located on the coast, bays and oceans are a critical element of Australia's urban water systems. A sustainable approach to managing the urban water system addresses the protection of bays and oceans (e.g., by building wetlands to reduce stormwater pollution), improving the quality of effluent discharged (e.g., by enhancing treatment techniques), and reducing the quantity of water removed and effluent produced (e.g., through water conservation programs).

Management of the urban water cycle currently starts with harvesting high quality water from largely uninhabited catchments. This water is stored in dams or reservoirs. As well as ensuring a source of supply during periods of low rainfall, storage assists purification. Sometimes groundwater bores are used to augment urban water supply, especially in smaller towns. Other alternative primary sources include desalinised water.

Water is supplied using an extensive network of pipes, pumping stations and treatment plants. Dam water is generally treated (filtered and/or disinfected) before it is distributed through the mains system.

FIGURE 1 THE URBAN WATER CYCLE



Ultimately, customers are concerned about the services they obtain from the water that enters their home, their industrial premises or their commercial buildings. Thus, urban water services include, for example, clean and tasteful drinking water, flushed toilets, cooled machinery, and a healthy garden.

Sewage and industrial waste collected by retail customers from homes and businesses is treated in sewage treatment plants and either disposed to the natural system of fresh and marine waterways, or recycled.

Stormwater, greywater (i.e. wastewater from laundries, showers, and basins and sometimes kitchens) and blackwater (i.e. wastewater from toilets) can be treated to make it suitable for a range of uses, e.g., toilet flushing, agricultural, horticultural and other businesses, irrigation of open spaces (e.g., golf courses) and potable reuse. Recycling technologies and the costs of implementing them are changing rapidly: the costs of recycled water are currently slightly higher than the cost of importing water, and lower than desalting sea water.

In urban areas, stormwater is generated when rain runs off roofs, roads, driveways, footpaths and other impervious or hard surfaces. In Australia, the stormwater and sewer systems are separate, and stormwater generally receives little or no treatment before it is discharged to waterways and the sea. Because both the quantity and quality of stormwater flows have the potential to degrade ecosystems (e.g., through scouring or extensive pollution with high organic and sediments loads as well as sudden discharges from flooded sewers and growing piles of litter and rubbish in drainage channels), stormwater management is a critical component of sustainable urban water management. Management options include building devices to retain and / or detain flows, and treat or remove pollutants.

2.1.2 THE CONTEXT AND DRIVERS FOR COSTING URBAN WATER

National policy

The Council of Australian Governments (CoAG) water reform agenda in 1994 proposed full cost recovery for water use across all states and territories. In 2003, CoAG renewed the water reform agenda through the National Water Initiative (NWI). By early 2006, all States had signed the NWI, committing them to implementing best practice water pricing based on full cost recovery principles and significant urban water reform, including a focus on creating water sensitive cities.

According to the NWI, best practice water pricing can promote economically efficient and sustainable use of water resources, water infrastructure assets, and government resources. It can also ensure sufficient revenue streams to allow efficient delivery of services. Furthermore, it can give effect to the principles of consumption-based pricing and full cost recovery.

Pricing for full cost recovery addresses water service provision, consumption-based pricing, cost recovery for water resource planning and management, and pricing to include externalities. Typically, in Australia, state/territory governments or independent pricing regulators set such prices.

The importance of understanding and estimating costs comes to the fore in the pricing of recycled water. The issue of recycled water pricing has the focus of many parties involved in the water industry. A recent study commissioned by the Water Services Association of Australia (Acil Tasman and GHD, 2004) proposes pricing within a band where the whole-of-system marginal cost of the recycling scheme defines the lower bound, and customer willingness to pay for recycled water defines the upper bound.

Governance arrangements

Governance arrangements relating to urban water systems vary by state, so there is a wide breadth of arrangements.

Generally, prices are set using the outcome of a regular review process between utilities and the economic regulator. Utilities project future demand and costs, and report on actual capital and operating expenditures. Independent advisers to the economic regulators review and question the assumptions underlying these projections and reports.

Third party access and recycled water pricing provide a strong incentive for reviewing the costing practice of utilities. Third party access in the water industry refers to private companies or other providers obtaining the right to use the utilities' network infrastructures. In Australia, access is likely to encourage competition in downstream product markets or downstream water markets (including retail supply). Given the excess capacity in most Australian systems, it is unlikely that parties will find it profitable to develop new water collection facilities. However, water pricing reforms to achieve full cost recovery may increase the feasibility of developing new water collection facilities in the future.

The funding of infrastructure development has changed considerably over time. Prior to the 1970s, water infrastructure was funded mainly through borrowings and general revenue. Governments and water authorities then introduced developer charges to finance the rapid urban development. The focus on developer charges was reinforced by subsequent government restrictions on external borrowings and, in the 1980s, by very high interest rates. In some states, developer charges differ between lots. In others, flat per-lot rates are levied. Private investment in water infrastructure is a relatively new concept, and is expected to increase rapidly and significantly.

Under Trade Practices legislation, utilities can be forced to grant third parties access to the network infrastructures. Accurate estimates of actual and avoided costs are an important component of assessing fair third party access charges.

The water utility

Utilities with responsibility for more than one element of the urban water system (see Figure 1) have internal drivers to change costing practices to account for and manage the connections between the elements.

Over the past decade, water resource strategies have been developed for most major urban regions in Australia. The more recent strategies have the explicit aim of balancing long-term supply and demand. Increasingly, Australian water utilities are adopting integrated resource planning as the framework for supply-demand planning (White et al., 2006). Integrated resource planning seeks to investigate both supply and demand side options to arrive at the least cost means of balancing the two (Swisher et al., 1997; Beecher, 1996). The idea of an end use focus is at the core of integrated resource planning. The term 'end use' refers to where the water is used (e.g., residential or commercial sector) and what it is used for (e.g., showering, cooling tower, etc.). Taking an end use approach opens up different ways of providing the same service, i.e., with a different quality or quantity of water. Costing supply and demand side approaches on an equal footing is an emerging challenge.

Costing decentralised or distributed systems is another emerging priority for water utilities. In some quarters, distributed systems are perceived as more expensive and costly than centralised systems. International experience suggests their total per-household economic costs are likely to be similar to or lower than centralised water systems (White, 2006). What is certain is that the costs of decentralised systems are distributed differently amongst stakeholders and over time, and the risks of decentralised systems will require new management approaches. Costing studies that consider both centralised and decentralised options need a process of equivalent analysis that can uncover the full costs for both kinds of systems.

Although utilities usually have internal costing guidelines and templates, problems can still arise. For example, when internal financial experts review a proposal, questions may reasonably arise about the clarity or appropriateness of assumptions or the range of costs included.

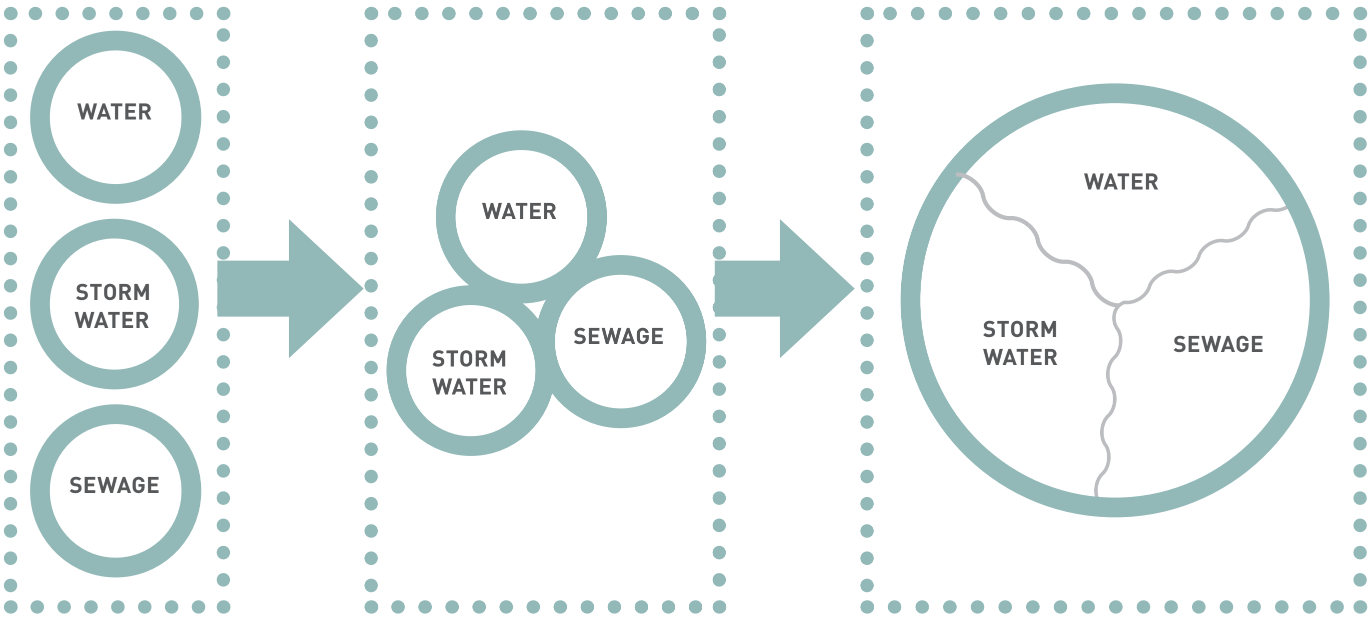
Computer models feature prominently in the costing process as undertaken by Australian utilities. The example of cost analysis for the replacement of water and sewer mains is regarded internationally as a quite refined form of asset management, even though the models are not yet robust on social costs and avoided costs. An example of a social cost is additional traffic time due to traffic restrictions while replacements are carried out.

Sustainability in the Australian water industry

Almost twenty years after the term was coined, sustainability is still a loose and contested concept that is subject to a wide range of interpretations and applications. Like other sectors, utilities have sought to understand the relevance of the concept to their business operations. Also like other sectors, the impacts of sustainability can be described in 'push' and 'pull' terms.

The sustainability push is exemplified in regulatory shifts, for example towards water conservation, or through the imposition of targets for water recycling, or through new planning instruments that require significant reductions in water demand from new homes, or more

FIGURE 2 SHIFTING RELATIONSHIPS BETWEEN THE THREE URBAN WATER CYCLE DOMAINS



generally requiring adherence to 'ecologically sustainable development' principles in a utility's enabling legislation.

The sustainability pull is a little harder to define, but no less strong in its impact. It is the impact of changing societal expectations, which results in increasing pressure to report on the sustainability of their operations, e.g., corporate social responsibility (CSR), socially responsible investment (SRI), etc. CSR is the voluntary actions that business can take, over and above compliance with minimum legal requirements, to address both its own competitive interests and the interests of wider society. SRI considers both the investor's financial needs and an investment's impact on society. The Global Reporting Initiative (GRI) is a management tool that helps businesses to identify and report on the economic, social, and environmental impacts of their operations – it is already 5 years since VicWater published their guidelines for implementing the GRI in water utilities (VicWater, 2002).

The Australian water industry, through the Water Services Association of Australia (WSAA), is developing a common methodology for evaluating the overall sustainability of alternative options for urban water systems (see Lundie et al., 2005). These include large-scale options for cities as well as configurations of water sensitive urban developments or single high rise developments. The sustainability framework developed identifies stakeholder involvement and iterative decision-making as critical to developing sustainable options for the water industry.

Putting the push and pull together, the result of sustainability for the water industry is the integration of previously separate domains of infrastructure and management. Historically, water supply, stormwater and wastewater infrastructures consisted of separate large-scale centralised pipe networks and large potable water and sewage treatment plants. The primary objectives of this infrastructure, which arose in the 19th century, were to provide and ensure hygiene, sanitation, flood and fire control, and urban water supply. In the last decade or two, the new driver of environmental protection was 'added on' to these systems, with the effect of moving the three domains closer together, whilst retaining their separateness. Now, demographic, climatic and societal trends are pushing these conventional systems to their limits. Emerging approaches integrate the three domains seamlessly (see Figure 2), and require different approaches to thinking about what kinds of services are offered, who manages them, and who pays for them. Inclusion of these different approaches in decision-making requires new understandings of costs, and costing processes so that well-informed choices between such new options and conventional options may be made. The most sustainable option for a particular context could stand alone, or be fully integrated, or be somewhere in between. These new understandings of costs and costing processes are the focus of the remainder of this guidebook.

3

What are the essential costing principles?

In this section, we identify and outline the essential costing principles for sustainable urban water outcomes. For each principle, we explain here what it is, why it is important to sustainable urban water cost analysis, what happens if it is effectively implemented in a costing study and what the risks are if it is excluded. In Section 4, we explain how to apply the principles, and demonstrate their application through the case study, 'Steve's story'.

THE ESSENTIAL COSTING PRINCIPLES ARE SUMMARISED BELOW:

1. USE APPROPRIATE COST PERSPECTIVES Cost perspective(s) are considered and specified. Multiple cost perspectives may be needed (e.g., utility, customer, developer). The 'whole-of-society' perspective is critical for promoting sustainable outcomes.

2. PROVIDE WATER SERVICE OUTCOMES Analysis takes a service focus. Options are defined and compared on the basis of water service outcomes (e.g. removing faecal matter or cleaning clothes), rather than an assumed volume required.

3. THINK IN TERMS OF SYSTEMS System boundaries are defined, consistently applied, and appropriately holistic for the question at hand.

4. INCLUDE LIFE CYCLE COSTS Asset lives are fully accounted for. This involves applying a common period of analysis, staging options to meet demand, including all capital and operational costs and ensuring the implications of varying asset lifecycles are covered by replacements or residuals.

5. ASSESS ON THE BASIS OF INCREMENTAL COST Options are assessed on incremental cost wherein a base case is specified ('business as usual' or 'without project' outcome) and both costs and avoided costs (or benefits) relative to the base case are accounted for. This includes avoidable operating costs and capital augmentations that could be delayed or become unnecessary within existing urban water systems.

6. ACCOUNT FOR EXTERNALITIES The interface between tangible costs and externalities is taken into account. Externalities are identified and incorporated into the study either as dollar values, system limits, or through qualitative means.

7. ACCOUNT FOR THE TIME VALUE OF MONEY The time value of money is fully accounted for with costs reported as being in a particular year and compared on net present value.

8. ACKNOWLEDGE AND MANAGE PRECISION AND UNCERTAINTY Uncertainty, risk, and a lack of accuracy and precision are inevitable. A good costing study acknowledges and manages them explicitly.

9. REPORT TRANSPARENTLY Reporting is transparent. The analysis and results are summarised in a coherent and traceable form.

3.1. USE APPROPRIATE COST PERSPECTIVES

COST PERSPECTIVE(S) ARE CONSIDERED AND SPECIFIED. MULTIPLE COST PERSPECTIVES MAY BE NEEDED (E.G., UTILITY, CUSTOMER, DEVELOPER). THE 'WHOLE-OF-SOCIETY' PERSPECTIVE IS CRITICAL FOR PROMOTING SUSTAINABLE OUTCOMES.

3.1.1 WHAT ARE COST PERSPECTIVES?

The fundamental dimensions of cost analysis are who pays, how much they pay and when they pay. 'Who pays' relates to the difference between economic and financial analyses, and is addressed in this guidebook through the concept of 'cost perspective'. The terms 'economic analysis' and 'financial analysis' have various meanings. Below, we explain what we mean by these terms in this guidebook.

Both economic and financial analyses are assessments of cost (and benefits, including avoided costs) in dollar terms. They differ critically in that financial analysis is conducted from the perspective of a single party (e.g., the water utility, land developer) and is used to address the commercial viability of a project. Economic analysis in comparison seeks to determine the impact of the project on the economy or society as a whole (Herrington, 2005). Financial and economic analyses therefore include different costs and benefits.

Economic analysis aims to determine whether our decisions and actions are the best possible in the circumstances. Analysis from this 'whole-of-society' cost perspective has a crucial role in identifying more sustainable outcomes. It is therefore a focus for this guidebook as it is recognised that many agencies may not currently incorporate a societal perspective in their options analysis. Cost effectiveness analysis from the 'whole-of-society' perspective includes costs and benefits accruing to all key parties (e.g., the water utility, developer, customers) as well as society more generally. Externalities are accounted for (see Section 3.6) and transfer payments excluded. Transfer payments, such as the price of potable water supply to customers or developer changes, represent exchanges between the key parties. A cost to one party is a benefit to another. These payments are not included in the economic analysis.

Financial analysis is conducted from the commercial perspective of a single party (e.g., the water utility, land developer). It includes only those costs directly attributable to the commercial entity in question and is used to determine the commercial viability of a project. Financial analysis can take various forms and address questions of project funding as well as project costs. This guidebook describes only the simplest form of financial analysis for a project: a cost breakdown from the various stakeholder cost perspectives.

3.1.2 WHY ARE COST PERSPECTIVES IMPORTANT?

The cost perspectives chosen determine what costs are included and therefore the outcomes of a cost analysis. Decisions about what to build or which programs to run need to consider what is least cost for society as a whole i.e. the 'whole-of-society' cost perspective. This is because the provision of urban water services is usually a government responsibility provided for by regulated monopolies that in Australia are usually government-owned. Least cost for society as a whole may not be least cost for the water utility. Both financial and economic analyses are therefore important in the assessment of water infrastructure developments (Qld Treasury, 2000) and should include, as a minimum, analyses from a whole-of-society perspective and the utility cost perspective.

3.1.3 WHAT HAPPENS IF COST PERSPECTIVES ARE INCLUDED?

For urban water, sustainable outcomes are promoted by identifying the least cost to society because analysis from a whole-of-society cost perspective identifies economically-efficient and resource-efficient means of service provision.

Analysis that is limited to the cost perspective of a utility runs the risk of missing the best opportunities to deliver in economic, social, and/or environmental terms. For example, a utility evaluating supply-demand options may be advised against investing in efficiency in favour of investing in supply, because the financial analysis highlights the contrast between reduced revenue from efficiency, and the costs and increased revenue associated with increased supply. However, analysis of these two options from a whole-of-society cost perspective usually shows that investing in efficiency has a lower overall cost to society than augmenting supply (White and Fane, 2002). Utilities use whole-of-society cost perspective analyses to underpin submissions to regulators for water price increases, based on the need to remain financially viable whilst simultaneously delivering better environmental and economic outcomes.

Analysis of an array of financial cost perspectives shows how the costs and benefits of options are shared between the stakeholders, and provides a basis for negotiation between the parties on how to pursue the least cost solution.

3.2.
PROVIDE WATER SERVICE OUTCOMES

ANALYSIS TAKES A SERVICE FOCUS. OPTIONS ARE DEFINED AND COMPARED ON THE BASIS OF WATER SERVICE OUTCOMES (E.G. REMOVING FAECAL MATTER OR CLEANING CLOTHES), RATHER THAN AN ASSUMED VOLUME REQUIRED.

3.2.1
WHAT IS A SERVICE FOCUS?

Conventional business thinking takes an output focus, and is concerned with supplying a commodity. Emerging business thinking, particularly in the sustainable business arena, takes an outcome focus instead, and is concerned with supplying a service (Dunphy et al., 2003)

This shift in thinking is revolutionising many industry sectors, and is providing significant gains in economic, social, and environmental outcomes, whilst simultaneously improving financial performance. For example, Fuji Xerox shifted from selling photocopiers to 'document service' (Dunphy et al., 2003). That is, they realised that their customers wanted to photocopy documents, not own a photocopier. Rather than designing machines for short lifetimes and frequent disposal so that they could sell more machines, Fuji Xerox shifted to designing for long lifetimes and ease of reuse and/or upgrading. This shift reduced costs, improved efficiencies, and drastically reduced material inputs, processing and waste production, providing significant environmental improvements. The lesson here is that shifting to a service focus opens up many different paths for achieving the same outcome.

For sustainable urban water, a service focus has three dimensions:

- dissociating the scale of the infrastructure from the scale of the demand i.e. while increasing water demand from a city can be seen as a single large requirement, it is in fact made up of many individual demands from households and businesses. This new demand could be met with a new, centralised supply such as a single desalination plant, or new, highly distributed supplies such as rain tanks in all new houses, or new, distributed supplies such as suburb-scale sewer mining and reuse schemes.

- focusing on the outcome rather than the capacity or volume i.e. most urban water services can be delivered with less water volume. Taking an outcome or end use approach to building up demand projections means that demand side options that take the potential of efficient fixtures and appliances and behaviours into account can be considered alongside supply options.

- matching the water quality with the service required i.e. most urban water services such as garden watering or toilet flushing can be delivered by less than potable quality water. The water quality should be fit for purpose.

3.2.2
WHY IS A SERVICE FOCUS IMPORTANT?

A cost analysis that seeks sustainable urban water outcomes must, by definition, be costing options that have the potential to deliver these outcomes. A service focus opens up the kinds of options under consideration, and therefore is likely to result in improved environmental, societal, and economic outcomes. That is, options for assessment will consider a range of infrastructure scales, a range of water use efficiencies, and a range of water qualities.

A service focus allows the analyst to see their study within the bigger picture of the provision of new or improved urban water services to the community. A focus on the service outcomes also encourages linkages between decisions across an urban water system.

3.2.3
WHAT HAPPENS IF A SERVICE FOCUS IS USED?

Cost analysis based on a service focus will broaden the range of options being considered. For example, in a study initially focused on options for increasing a particular system capacity, a service focus includes options that reduce the capacity requirement e.g., indoor water use efficiency and work to minimise infiltrating and ingress into sewers in wet weather could be considered alongside a sewer pump station upgrade.

A service focus may also result in distributed systems being proposed. For example, small scale recycling, from in-building greywater systems to community scale cluster reuse schemes, has the potential to meet increasing demands as they occur, potentially resulting in lower financial risk and more effective investment.

Focusing on service outcomes also makes linkages apparent between specific decisions at different points in an urban water system. For example, imagine a new development that will increase the burden on an existing sewage treatment plant. A costing study on sewage treatment plant upgrade options could be linked to decisions about whether the new development that is generating the sewage will be serviced with recycled water.

Not all studies will be structured to compare alternatives that provide the same service outcome. In studies where alternatives provide non-equivalent services, two approaches are possible. The first is to 'normalise' the service outcomes by finding a common metric of comparison. A prime example is to use unit costs to compare a range of demand management and supply options on differing scale in terms of 'dollars per kiloliter' conserved or supplied. (See '*Metrics of Unit Cost*' Box on page 18 for discussion of appropriate unit cost metrics).

A second approach, if no common metric is possible, is to estimate the value of the services and include in dollar terms. For example, a study to identify the least cost means of meeting a recycling target of say 20% of wastewater collected by 2010 will involve widely varying outcomes. Similarly, a study to determine the most cost effective means of disposing of effluent from a sewage treatment plant could include an option based on productive reuse. In such studies, there is a need to quantify the difference in dollar values between the different service outcomes e.g., one alternative provides effluent disposal and the second provides effluent disposal and a commercially valuable crop.

Taking a service perspective to cost analysis can therefore require a shift in the basis for comparison, and means paying close attention to system boundaries (see Section 3.3), avoided costs (see Section 3.5), and the timing of costs (see Sections 3.4 and 3.7).

3.3. THINK IN TERMS OF SYSTEMS

SYSTEM BOUNDARIES ARE DEFINED, CONSISTENTLY APPLIED, AND APPROPRIATELY HOLISTIC FOR THE QUESTION AT HAND.

3.3.1 WHAT ARE SYSTEMS AND SYSTEMS THINKING?

Urban water infrastructure is a complex system. A system is a set of 'things' connected, associated, or interdependent, that together form a complex unity. 'Systems thinking' is a conceptual framework that clarifies patterns in a system: it helps decision-makers work out how to manage systems effectively (Checkland, 1981; Senge, 1990).

Complex systems can be a bit of a vicious circle – they are difficult to understand, so predicting their behaviour is difficult, which makes them difficult to understand. For example, water demand can be thought of as a complex system. It is a function of unpredictable interactions between technologies and behaviours. This is why, for example, Melbourne's per capita demand increased in 2006 despite significant investment in water efficiency programs.

To make things manageable, we need to break complex systems apart. The trouble is that we then tend to think of the parts as separate, unrelated things, which means that the consequences of changes to one part of the system tend to go unnoticed for other parts of the system. For example, significant improvements in water efficiency in existing areas could lead to sewerage blockages because of insufficient grades or increased deterioration of sewerage systems because of longer residence times.

A key feature of many systems is that their parts are coupled in a non-linear fashion, which again makes predicting their behaviour difficult. Non-linear behaviour of systems is caused by positive and negative feedbacks from the factors that define the system. For example, for urban water systems, improved water use behaviour resulting from the educative component of installing appliances that are more efficient is a positive feedback, whereas increased demand for outdoor water use in a drought is a negative feedback.

Non-linear interactions result in system thresholds or 'tipping points', which are the maximum stress levels that a system can endure without change for the worse. For example, the new concept of effective impervious area (Walsh et al., 2004) in stormwater management operates in this way – below a certain point of hydraulic connectedness (or effective impervious area), urban streams can cope with the impacts of urbanisation. Above that limit, a non-linear response sets in, and streams rapidly degrade. The value of the limit for a particular waterway is determined by many unrelated factors, such as the local geography, hydrology, soils, climate, and development.

We tend to define things according to our experience. That means that we tend to define systems and their parts according to what we know, and so we are likely to miss less familiar things, for example, a hydrologist might be focused on the quantity and rates of flow in urban stormwater events, but an ecologist might be focused on the quality implications of these. The upshot is that it is probable that our sustainable urban water systems are incompletely defined, with unclear and/or inconsistent boundaries. Making our assumptions explicit is therefore a critical first step. Getting the physical underpinnings right is also important, so water balance models are part of the starting point for implementing a systems approach.

3.3.2
WHY IS A SYSTEMS APPROACH IMPORTANT?

Sustainability seeks outcomes that are environmentally, socially, and economically desirable and feasible. This requires understanding how environmental, social, and economic systems interact, so a systems approach is consistent with the goal of sustainable urban water outcomes. For cost analyses, a systems approach is essential because the system, the system boundaries, and system environment determine:

- which options and whose cost perspectives should be considered e.g., a stormwater expert might focus on recycling stormwater through raintanks and aquifer storage and recycling to meet water conservation targets for a site. However by considering the water supply, wastewater and stormwater for the site as a system, the opportunities for conservation through water efficiency and effluent recycling would become apparent.

- the constraints that limit the operation of the system e.g., the existing potable supply around an infill development will have a limited capacity. This constraint may mean that only major potable conservation, such as a combination of efficiency plus recycling for toilet and outdoor plus rain tanks for hot water, can avoid the need for upgrade to the local distribution network.

- the externalities imposed by the operation of the system, e.g., the significance of stormwater and effluent releases from a new development will be further increased if these flows impact an estuary with a marine park and/or major oyster industry.

3.3.3
WHAT HAPPENS IF A SYSTEMS APPROACH IS USED?

In the urban water context, a systems approach ensures that all relevant parts of the water supply chain (supply, wastewater, stormwater) receive adequate attention in a given cost analysis. It also provides a framework for understanding interactions at different scales (the allotment, subdivision/suburb and city/region).

A systems understanding of urban water helps create linkages between what initially appear to be unrelated studies and decisions.

A systems approach will also identify boundary issues, constraints, and externalities, and facilitate decisions about how to deal with them e.g., through qualitative assessment; by imposing limits on alternative system configurations; or by costing externalities. (see Section 3.6)

Finally, a systems approach is essential for identifying avoided costs (see Section 3.5).

3.4.
INCLUDE LIFE CYCLE COSTS

ASSET LIVES ARE FULLY ACCOUNTED FOR. THIS INVOLVES APPLYING A COMMON PERIOD OF ANALYSIS, STAGING OPTIONS TO MEET DEMAND, INCLUDING ALL CAPITAL AND OPERATIONAL COSTS AND ENSURING THE IMPLICATIONS OF VARYING ASSET LIFECYCLES ARE COVERED BY REPLACEMENTS OR RESIDUALS.

3.4.1
WHAT ARE LIFE CYCLE COSTS?

Life cycle costs, sometimes known as 'whole of life costs', represent all the costs associated with a given 'asset'. This includes acquisition, installation, operation, maintenance, refurbishment and disposal (NSW Treasury, 1997). The Australian Standard AS/NZS 4536 (1999) provides a generic definition of a life cycle cost as:

"The sum of the acquisition cost and ownership cost of a product over its life cycle"

The life cycle cost of infrastructure, product or program includes all capital, operating and decommissioning costs and is usually represented as a present value in order to account for the costs occurring over time (see Section 3.7 below on accounting for the time value of money).

When comparing options that can be expected to last for different periods of time, life cycle costs should then include the cost of replacement and/or include the residual value of long lived assets at the end of the analysis period. For example, if efficient washing machines are compared to raintanks as means of water conservation, then the fact that the raintank might be expected to last for 50 years while the washing machines would need replacement on average after 10 years should be reflected in the calculation of life cycle costs. Likewise those components that will need to be replaced or refurbished on a regular basis over the life time of an asset need to be accounted for. For example, the pump in a rain tank used for toilet flushing and garden watering could be expected to need replacing every 15 or so years.

When comparing costs, applying a common period of analysis to all options is an important aspect of life cycle costing. This is particularly true with costing for sustainable urban water outcomes because options such as water efficient appliances and onsite wastewater treatment will have significantly different life cycles to conventional centralised water infrastructures. The period of analysis should also be long enough to reflect a concern for sustainable outcomes.

3.4.2
WHY IS LIFE CYCLE COSTING IMPORTANT?

Options based on different scales of infrastructure, different water volumes, and different water qualities (see Section 3.2) can have significantly different asset lifetimes, cost breakdowns between capital and operating, and staging. These temporal differences have a significant effect on the overall cost of alternatives.

For example, small-scale wastewater systems can have a lower capital cost than large-scale systems, and are also readily implemented in stages that more closely reflect service demand changes (Pinkham et al., 2004). Capital expenditure on distributed systems is then both lower and will occur in several lumps over the life of the infrastructure, rather than as one lump sum up front for more centralised approaches. The operating costs of small-scale systems however, are commonly higher than equivalent centralised systems.

Accounting for these differences through consistent and appropriate treatment is essential when comparing such options.

3.4.3
WHAT HAPPENS IF LIFE CYCLE COSTS ARE ACCOUNTED FOR?

If life cycle costs are accounted for, the implications of different infrastructure scales (reflected in e.g., staging and differences in the longevity of assets capital and operating cost profiles), and different service outcomes (reflected in e.g., water volumes and qualities) will be accounted for in the analysis.

Alternatives that are compared on the basis of life cycle costs will include acquisition or capital, installation, operation, maintenance, refurbishment and replacement costs. End of life cycle issues will be accounted for, including asset replacement and residual values. The common period of analysis used for all alternatives should be long enough to cover the lifetimes of common urban water assets and show the need for asset replacement with short lived assets. A period of analysis of 50 years is therefore recommended. Industry practice is typically much shorter periods of analysis, so availability of forecast data or other constraints may not allow such a long time period of analysis. In such cases the residual values of assets become a more important factor and these will need to be estimated.

3.5.
ASSESS ON THE BASIS OF INCREMENTAL COST

3.5.1
WHAT IS INCREMENTAL COST?

The term 'incremental cost' has various meanings. In this guidebook, we use it to refer to the assessment

OPTIONS ARE ASSESSED ON THE BASIS OF INCREMENTAL COST WHEREIN A BASE CASE IS SPECIFIED ('BUSINESS AS USUAL' OR 'WITHOUT PROJECT' OUTCOME) AND BOTH COSTS AND AVOIDED COSTS (OR BENEFITS) RELATIVE TO THE BASE CASE ARE ACCOUNTED FOR. THIS INCLUDES AVOIDABLE OPERATING COSTS AND CAPITAL AUGMENTATIONS THAT COULD BE DELAYED OR BECOME UNNECESSARY WITHIN EXISTING URBAN WATER SYSTEMS.

of alternatives based on the difference between the alternative and a base case. Least cost alternatives are those with the lowest incremental difference or 'least cost' relative to this base case. In many cases alternatives will have a lower cost than the base case and so the incremental cost will be negative.

In simple terms, there are two ways to compare alternatives. Either compare the 'full costs' of alternatives relative to the existing system as it currently stands, or focus on the difference between the cost of alternatives and a base case representing 'business as usual' for the urban water system. While we are interested in the absolute cost of each proposal, it is the incremental difference in cost compared to the base case that is the critical point for comparison.

A focus on 'incremental costs' when comparing urban water alternatives acknowledges the existence of potential for avoided costs within most existing urban water systems. These avoided costs are those costs that would be incurred if a proposal did not go ahead. This covers deferred costs that would result from delaying an upgrade in the existing system, and completely avoidable costs (both operating expenditure and planned capital augmentation) that are redundant with a given option in place (IPART, 2006).

Estimating avoided costs requires a robust understanding of the base case, i.e. the business as usual, or 'do nothing' or 'do nothing differently'alternative that would have occurred without the proposal. For example, if a water efficiency program is implemented, then a reduced volume of water is sourced, treated, distributed, used, collected, treated, and disposed or reused. This means reduced operating costs. Where augmentations are deferred or shelved, it also means reduced capital costs. In the case of a major recycled water scheme, avoided costs could accrue from the deferral of potable supply headwork augmentation, in the potable water distribution network through downsizing, through reductions in reticulated water volumes, and in the existing effluent treatment system if disposal was constrained. Two caveats here are the need to consider other drivers of system standards, such as fire fighting capacity, and the surety that cost reduction will not be proportional to volume reduction (because asset sizing, and hence costs, usually depend on demand peaks rather than average levels).

3.5.2
WHY IS INCREMENTAL COST IMPORTANT?

Incremental cost is the most appropriate metric for comparing urban water options because most studies consider options that are in some way additional (or incremental) to an existing urban water system. In all such cases, the effect an option has on the future costs of the existing system needs therefore to be taken into account in the assessment of that option.

Analysis of the 'incremental cost' of alternatives, where costs and avoided costs are both fully accounted for, will therefore identify which alternative was the least cost.

3.5.3
WHAT HAPPENS IF INCREMENTAL COST IS USED?

From a set of alternatives, the one with the lowest incremental cost will be the most cost effective. Comparisons based on incremental cost include not just all the costs incurred if an option is implemented but also all those costs within the existing urban water system that would be deferred or permanently avoided.

Most studies will include some avoided costs, usually those adequately represented by system-wide averages (e.g., average water treatment operating costs). Highlighting site specific sustainable solutions will only occur if all local avoided costs are included in the analysis. This means considering the characteristics of the local surrounding urban water system, such as an existing, highly constrained, local supply reservoir that requires augmentation to cope with proposed infill development.

Site-specific avoided costs are a function of existing local network constraints, local regulatory requirements, local growth scenarios, and local design goals. This means for example, that while rain tanks may seem expensive forms of water supply when analysed on a whole of system basis, in specific locations with constrained local supplies and/or site specific stormwater goals, rain tanks may form a least cost solution.

Regulatory requirements, in general, play an important role in shaping incremental costs. An example of how legislation requiring water conservation in new developments changes the operating environment of water utilities and has a significant effect on the base case and therefore the incremental cost is shown in Text Box Four on page 65.

Text Box One Metrics of Unit Cost

A variety of metrics are used by practitioners to estimate unit costs of water supplied or conserved. These different techniques can give significantly different unit costs for the same option and will not necessarily rank options in the same order. Three of the most commonly encountered are:

i. annualised unit cost (Menke and Woodwell, 1990);

ii. present value per total volume saved or supplied (Dziegielewski et al., 1993);

iii. average incremental cost (AIC) or levelised cost (Herrington, 2005).

One common approach used in Australia and the US for demand management options in particular is annualised unit cost (Beatty et al., 2004). Menke and Woodwell (1990) use a derivative of this method. The annualised unit cost method lends itself to a simple analysis with the unit cost for water derived from the annualised cost of the option divided by the yield per year. The main drawback with the annualised unit cost method is that only a single figure for yearly water supply or conservation can be incorporated into the calculation. This makes it difficult to account for options whose yield changes over time. This difficulty becomes apparent when one considers the wide range of options that fit into this category of changing actual yield over time. For example, options such as measures to regulate minimum efficiency levels for new appliances have a yield that grows over time – what figure should be chosen for the denominator? Likewise with bulk supply, because only a single figure can be used, the tendency is to include the total potential yield from the option rather than the actual yield of the expended supply over time. For this reason annualised unit costs of large scale bulk supply options are often particularly low. Being based on annualised costs, the method also provides a future value for the cost of water rather than the more standard present value.

Dziegielewski et al. (1993) recommends option unit costs where the NPV of cost and avoided cost is divided by the total volume of water conserved over the life of the program or some other defined period. The California Urban Water Conservation Council (2000) advocate this approach also. However, with this metric, the unit cost of an option and potentially its relative ranking will be dependent on the time period chosen for the analysis, particularly for short periods of analysis. Option unit costs will also look low when compared to the marginal cost of supply because of the lack of discounting of water.

To overcome the disadvantages with the other metrics, this guidebook recommends the use of average incremental cost (AIC) or levelised cost as a metric of unit cost. This metric calculates the unit cost of water supply by taking the NPV of costs for an option over the NPV of water saved or supplied by that option (Herrington, 2005; Fane et al., 2003). Unlike the other unit cost metrics, AIC allows smaller scale water efficiency options to be compared to large-scale supply options on an equivalent basis. Further, the metric is directly comparable to the marginal cost of water supply, which is usually estimated by the AIC formula and is therefore the standard for developing supply demand strategies in the UK (UKWIR/ Environment Agency, 2002).

A commonly raised issue with AIC is difficulty in understanding the discounting of water volumes. As Beatty et al. (2004) have noted, the technique also favours water supplied or saved in earlier years because water is discounted along with dollars. It is important to remember that none of the unit cost metrics provide a perfect ranking of options that can then be considered the least cost response. In some cases it may make sense to calculate multiple metrics. In choosing a metric it should be remembered that the goal is to use that metric to inform a comparison of options.

3.6. ACCOUNT FOR EXTERNALITIES

THE INTERFACE BETWEEN TANGIBLE COSTS AND EXTERNALITIES IS TAKEN INTO ACCOUNT. EXTERNALITIES ARE IDENTIFIED AND INCORPORATED INTO THE STUDY EITHER AS DOLLAR VALUES, SYSTEM LIMITS, OR THROUGH QUALITATIVE MEANS.

3.6.1 WHAT ARE EXTERNALITIES?

'Externalities' is an often-used and sometimes abused term, and yet we increasingly turn to it when seeking sustainable urban water outcomes.

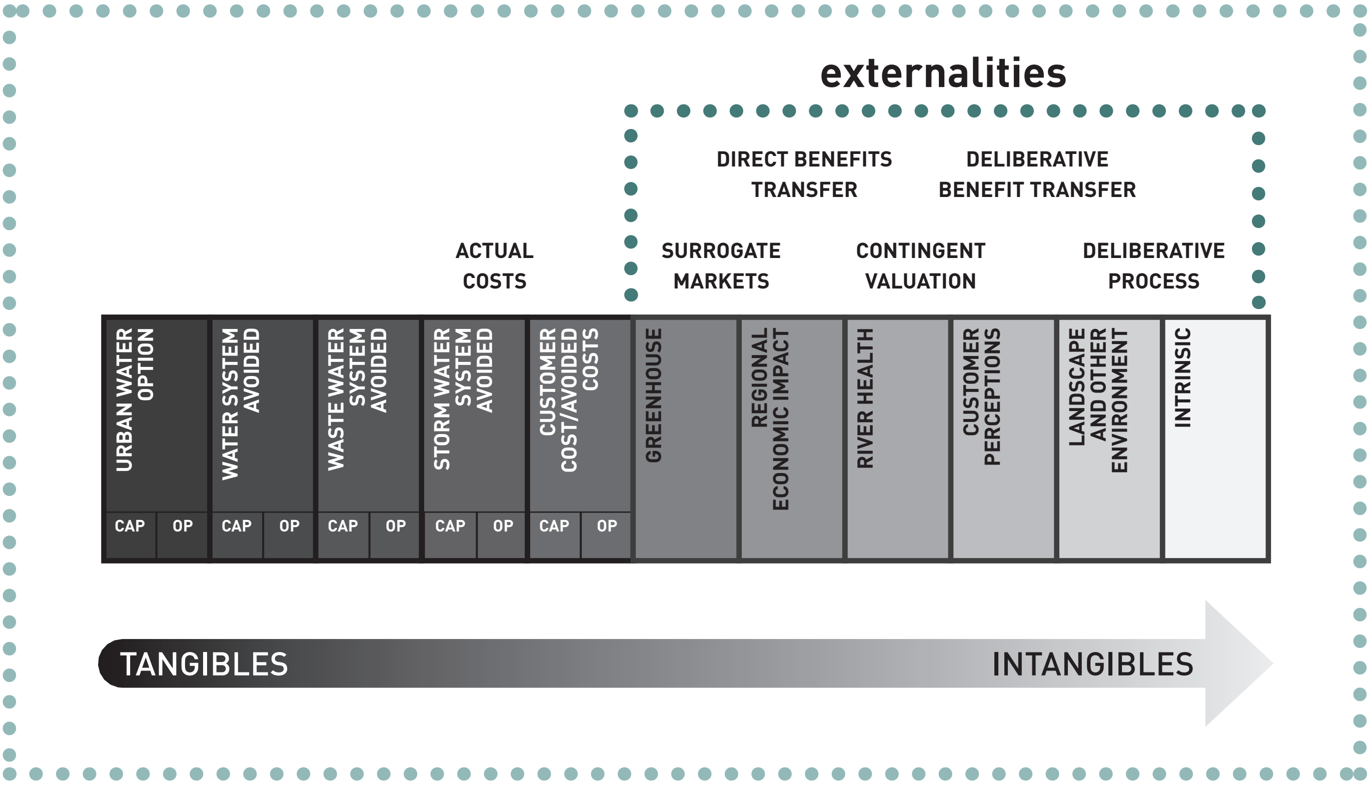
The basic idea is that from a whole-of-society perspective, important impacts go beyond the actual and avoided costs to key stakeholders. These further impacts need to be determined, and their treatment specified. In this way, the limits of costing need to be defined.

In strict economic parlance, an externality is any impact (cost or benefit) that is not taken into account in an individual's or business's decision to undertake the activity that affects another **economic agent.** For example, the positive externality from a wetland in a new, water-sensitive designed suburb is the bird watching opportunities that are created, rather than the bird habitat.

In common usage, externalities refer to all environmental or social impacts that are usually excluded from cost analyses e.g., declining river health because of increased extraction and disposal of inadequately treated sewage.

In considering externalities for the Australian water industry, Bowers & Young (2000) take a somewhat wide definition: 'externalities are a subset of non-market effects on the welfare of third parties and the environment, that arise from water use.' Bowers and Young also proposed tangibility as the basis of a framework for valuing externalities in urban water. They defined tangible externalities as impacts on production (such as fisheries, agriculture, and manufacturing) and property damage. It would be possible to place a dollar value on these tangible externalities through

FIGURE 3 SPECTRUM OF COSTS AND AVOIDED COSTS



various methods. Possible valuation methods can be grouped as methods based on market prices, surrogate or proxy market methods and survey-based methods (Qld Government, 2003).

Part-tangible externalities include impacts on recreation and amenity. Intangible externalities include impacts on wildlife, biodiversity, and human health. Bowers and Young propose lumping all intangible externalities together, and dealing with them through specifying goals and limits for receiving water quality. The definition of tangibility or otherwise is a personal judgement e.g., human health can be monetised, and regularly is in the insurance industry, and at the same time, ethical considerations and personal value stances hold some of us back from this approach.

A similar approach is to see the costs and externalities for urban water in a spectrum from the tangible to the intangible (see Figure 3).

So what approaches can we use to bring externalities into our accounting processes?

We can choose either to keep externality assessment separate from costing analyses, holding them alongside, or we can move them in (i.e. internalise) to our costing analyses. There are three possible approaches for internalising externalities into a cost analysis for urban water: (i) by monetising impacts directly, (ii) by imposing goals or limits on the options considered, or (iii) by qualitative assessment followed by scenario analysis.

- **Direct monetisation:** we can use surrogate markets to attribute proxy values to externalities, and include directly in cost analyses e.g., greenhouse gas emissions can be valued using market prices from carbon trading schemes.

- **Goals and Limits:** we can set (sustainability) goals or objectives for a development that ensure all options target the same outcome, and/or we can set (regulatory) limits e.g., to control nutrient levels discharged to local watercourses or by purchasing green electricity avoid greenhouse gas emissions.

Text Box Two Identifying and Valuing Urban Water Externalities

Identifying the significant externalities that may result from a particular urban water proposal is the first step in the process of accounting for externalities in a cost analysis. Externalities can be identified though various means including reference to policy documents such as catchment plans or blueprints and utility sustainability or environmental reports. There is also an international literature on criteria for sustainable urban water that may assist in identifying externalities (for example Lundin et al., 1999; Balkema et al., 2002; or Ashley et al., 2004). Australian sources include Bowers & Young (2000); Lundie et al., (2005) and Van Bueren and Hatton MacDonald (2004). The latter categorise water externalities depending on whether they have a direct or indirect impact on people and ecosystems; and which stage of water provision activity they are generated by (i.e., catchment management activities, extraction, storage, use, distribution, disposal).

In many situations a workshop where the externalities associated with a proposal or set of options are ‘mapped’ and prioritised by a stakeholder group can be a practical approach to externality identification. A range of stakeholders can be invited and asked to nominate the most significant externalities from their perspectives. Depending on the situation identified, externalities can then be grouped and prioritised via a deliberative process.

Identifying the externalities is a process that is closely aligned with defining the system under study, the system boundaries and the system environment. By taking a systems approach to the cost analysis, externalities often become apparent.

Valuing externalities can be complex and should be approached with caution. The rapidly changing approach across the globe to the cost of carbon is a useful case in point. The average market value of a ton of CO_2 in 2005-06 was around \$20 - \$25. However, the 2006 UK Stern Review on the economics of climate change calculated a discounted present value social cost (or damage cost) of 5-6 times that, at around \$110 per ton of CO_2. In the future, the cost of carbon emissions will almost certainly rise steeply as strict abatement targets are legislated. At

- **Qualitative assessments:** we can define (sustainability) criteria, design appropriately deliberative or participatory processes to rank each option's performance against each criterion, and use the criteria assessments to develop alternative scenario approaches that we compare on net present value or help explore different risks and risk trade-offs.

While analysis of alternative scenarios may be used in major cost analysis studies such as the development of a supply-demand strategy for a metropolitan region, for smaller studies, such an approach to externalities would not be warranted. Qualitative assessment will however remain the primary means by which externalities that we choose to hold outside our cost analysis are then assessed by a decision maker.

3.6.2 WHY ARE EXTERNALITIES IMPORTANT?

Many impacts of changes to the urban water system, especially environmental and social impacts, are typically excluded in a costing analysis. This is because the impacts themselves are difficult to assess: they range from tangible to intangible and from readily monetisable to non-monetisable. Even though categorisation and monetisation of externalities remain onerous, the identification of these impacts is a critical first step.

3.6.3 WHAT HAPPENS IF EXTERNALITIES ARE INCLUDED?

Once further impacts are identified, they can be matched with an appropriate (either more or less quantitative) valuation method and decision making process. This ensures that the degree of sustainability of different options is at least noted, and at best, accounted for.

best then, even for this most 'commodified' of externalities, wide-ranging sensitivity analyses are necessary, with careful consideration about whether discounting is reasonable or appropriate.

For valuing externalities in general, the best outcomes arise from processes that match the context of the decision to be made with appropriate (e.g., narrow or broad, informative or deliberative) participatory processes and the appropriate methodology (e.g., benefits transfer, contingent valuation, citizen's jury). The point is that valuations made in a particular circumstance may have limited transferability i.e. careful consideration of their reliability in other contexts is necessary. That said, there are some well-established externalities databases, including ENVALUE (http://www.epa.nsw.gov.au/envalue/), Environmental Valuation Reference Inventory (EVRI) (http://www.evri.ca), and ValueBase (http://www.beijer.kva.swe/valuebase.htm)

3.7. ACCOUNT FOR THE TIME VALUE OF MONEY

THE TIME VALUE OF MONEY IS FULLYACCOUNTED FOR WITH COSTS REPORTED AS BEING IN A PARTICULAR YEAR AND COMPARED ON NET PRESENT VALUE.

3.7.1 WHAT IS THE TIME VALUE OF MONEY?

The time value of money is a key concept in cost analysis because it addresses the fact that the value of money is not constant over time: costs or benefits expected to arise in the future have a lower worth in 'present value' terms than costs and benefits that arise today. This is why dollar values must always be reported with a year attached.

In economic analysis, the convention is to report costs and benefits in terms of their net present value (NPV). That is, to account for the time value of money by discounting the future stream of costs, avoided costs, and other benefits back to the present. A net present value calculation is simply compound interest in reverse. Compound interest calculates the increased value of a deposit placed in a bank account at some point in the future; discounting determines the present value of a particular cost or benefit identified at a known time in the future. Net present value is preferred as the method to use for comparing urban water alternatives because it provides a dollar value that is comparable to currently known costs and benefits in the present. Accordingly NPV is the standard metric used by governments and other agencies to evaluate and compare projects across sectors.

Discount rates reflect various factors including cost of capital. A typical discount rate for government infrastructure projects in Australia is 7% (real). NSW Treasury (1997) recommends applying a range of rates (4%, 7%, 10%) for infrastructure investments. In the USA, state revolving loans are the primary source of capital for water infrastructure, so discount rates are typically around 2-3% (Etnier, 2005).

Because discount rates represent factors that can be expected to vary between individuals and organisations, discount rates can also be expected to differ between financial and economic analysis. Public discount rates used in economic analysis can be expected to be lower than private discount rates and the individual financial perspectives can be expected to alter discount rates.

Similarly, some analysts use different discount rates to account for the perceived level of risk for different options. For example, more speculative benefits commonly have a higher discount rate applied. This conflates two quite separate concepts, and reduces the transparency of a cost analysis. A better approach is to deal with risk independently of the time value of money (see Section 3.8 below on managing uncertainty).

Engineering economics approaches to cost evaluation also account for the time value of money. These methods are more closely aligned to financial analyses as they are structured in terms of the return on investment. One such mechanism, annualised costs, is commonly used to assess urban water investments. It considers the cost of borrowed capital as a yearly capital cost estimated in the same manner as a fixed loan paid off with interest, and treats the interest rate as equivalent to the discount rate. A disadvantage of this approach is that the annualised cost estimates represent future values rather than present values which means they can not be compared directly to current costs and benefits.

In practical terms, NPV is conducted by doing a cash flow analysis, where costs and avoided costs are presented at the times at which they would fall.

3.7.2
WHY IS THE TIME VALUE OF MONEY IMPORTANT?

The time value of money is often misunderstood and sometimes misrepresented. It is critical to include it coherently and transparently because discounting has a significant impact on the results of cost analyses. Costs should only be directly compared if they represent values in the same year (including the present).

Different options will have different timing in terms of costs and benefits. Accounting for these differences through consistent and appropriate treatment of the time value of money is essential when comparing such options.

3.7.3
WHAT HAPPENS IF THE TIME VALUE OF MONEY IS ACCOUNTED FOR?

If the time value of money is adequately accounted for, the results of the cost analysis (preferably reported as net present values) can be meaningfully compared to known costs and benefits. The period of analysis would be long enough to reflect a concern for sustainable outcomes, and would be consistently applied across all options. The discount rate would be stated and appropriate to the cost perspectives and the terms of the analysis.

Further, whether the analysis has been conducted in real or nominal terms will also have been stated. Analyses in real terms are more common and specify all costs in constant terms relative to a base year and do not include a nominal increase to cost in order to account for expected inflation. Analyses in nominal terms incorporate costs that are estimated at their future values. It is important that a single analysis is conducted on either real or nominal terms and not a mixture of the two. Real discount rates can be expected to be lower than nominal discount rates that incorporate inflation.

3.8.
ACKNOWLEDGE AND MANAGE PRECISION AND UNCERTAINTY

> UNCERTAINTY, RISK, AND A LACK OF ACCURACY AND PRECISION ARE INEVITABLE. A GOOD COSTING STUDY ACKNOWLEDGES AND MANAGES THEM EXPLICITLY.

3.8.1
WHAT ARE RISK AND UNCERTAINTY?

Urban water systems are stochastic i.e. they exhibit randomness and unpredictability, and we will never have complete knowledge about them and their behaviour. Yet, planners need to plan, so we find ways to manage the inherent risks and uncertainties.

The concepts of risk and uncertainty appear similar in nature, but there are fundamental differences (Green, 2003). Risk applies to situations where probabilities can be assigned, whereas uncertainty is present in situations where probabilities cannot be assigned. That is, risk is quantifiable uncertainty, whether numbers or descriptors are used.

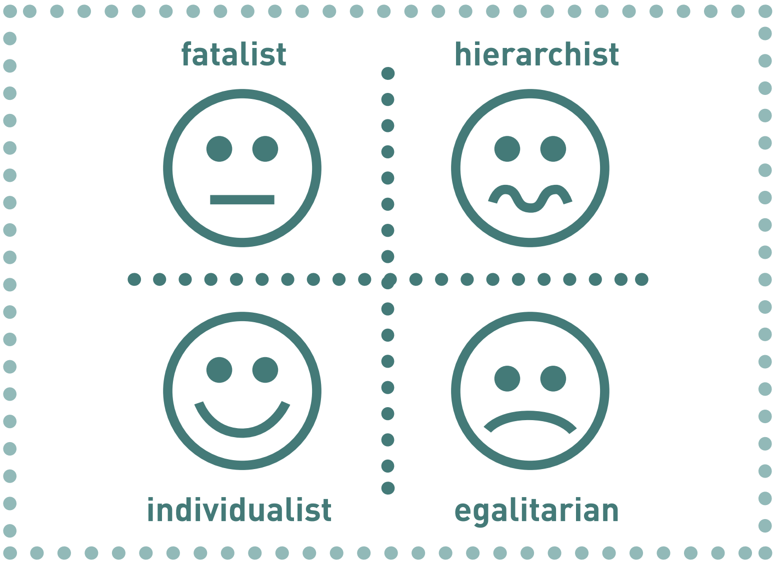
Risk perception is an inherently subjective assessment of the probability of a specified event happening, and our level of concern with the consequences of the event. Several decades of psychological work have been devoted to understanding perceived risk. Two theories dominate the field: the psychometric paradigm and cultural theory. The psychometric paradigm, developed by quantitative psychologists and decision scientists, assumes that many of the wide arrays of mitigating factors in risk perception can be quantified. This is the usual approach in urban water planning. Text Box Three explains the two most common probabilistic techniques for quantifying risk.

In contrast, the cultural theory perspective developed by sociologists and anthropologists sees risk perception as a delicate balancing act undertaken by an individual using their particular experience as the filter (Thompson et al., 2000) (see Figure 4).

According to Thompson et al., an 'individualist' believes nature is benign and resilient, whereas 'egalitarians' hold the view that nature is fragile, intricately connected, and ephemeral. 'Hierarchists' believe in a controllable world, so nature is stable until pushed beyond identifiable limits. 'Fatalists' find neither rhyme nor reason in nature or people. By way of example, imagine a community facing a prolonged drought and a rapidly decreasing remaining supply in the local dam. An egalitarian might suggest immediate investment in a large pipeline for intercatchment transfer. An individualist might prefer an approach of living within the means of the catchment, so their preferred interventions might be focused on investing in efficient and effective water use. A hierarchist might want to consider the economic and environmental costs and benefits of both before making a recommendation, and the fatalists were probably out fishing at the time.

FIGURE 4 RISK PERCEPTION FILTERS

(After Thompson et al., 2000)



The implications for sustainable urban water systems are that the policy, intervention, and technological space need to be broad enough to encompass a wide range of risk and uncertainty perceptions, in both probabilistic and humanistic terms.

Meanwhile, the precautionary principle states that where this is a possibility of serious or irreversible harm to the environment, protective action should be taken in advance of scientific proof of harm.

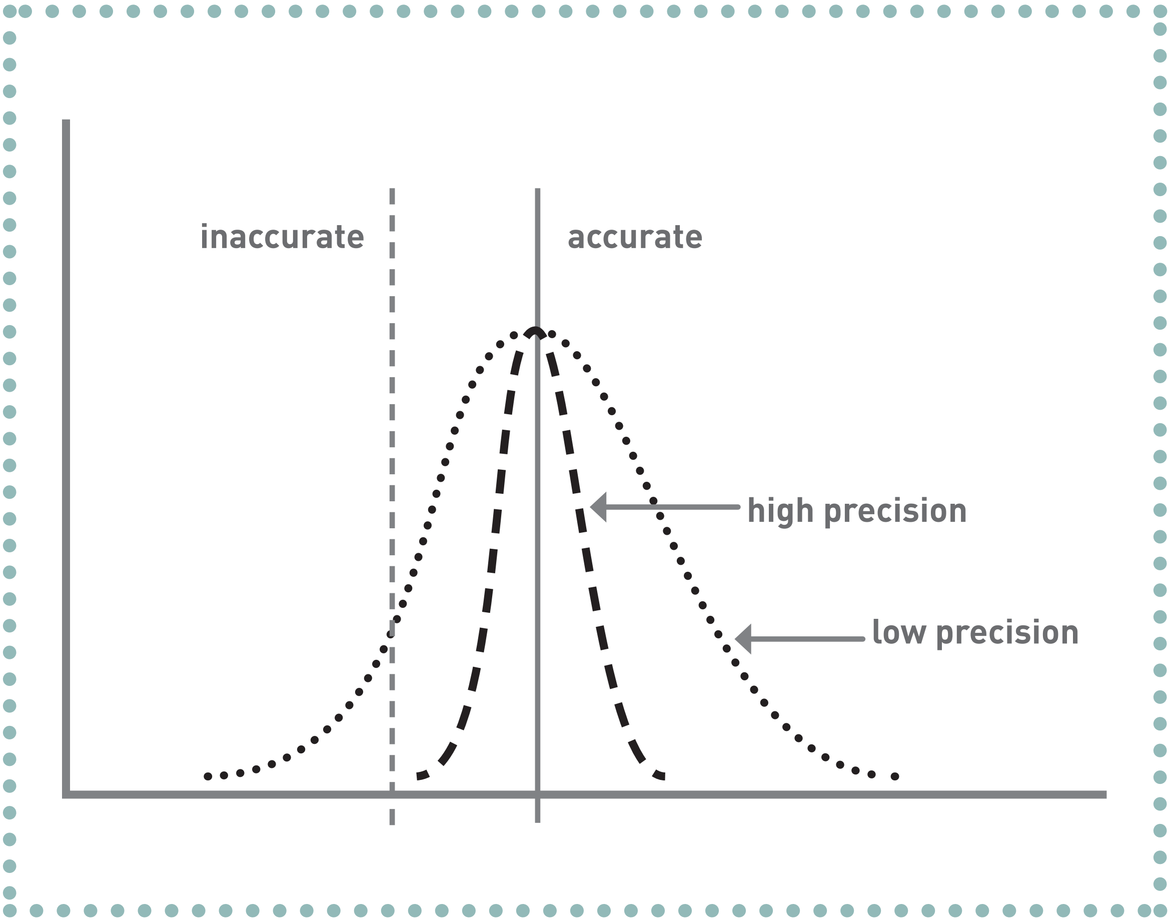
3.8.2
WHAT ARE ACCURACY AND PRECISION?

Accuracy and precision are often misunderstood and misused. Accuracy relates to whether an estimate is correct i.e. the extent of agreement between an estimate and the true value of some thing. Precision is a measure of the certainty of an estimate. As Figure 5 shows, a narrow distribution is more precise than a broad distribution.

We use errors to denote the level of certainty in our estimates. Errors in data propagate through calculations in particular ways that need to be accounted for so that our final cost estimates have a degree of validity that reflects reality.

Sensitivity analysis sets out to determine the sensitivity of an outcome to changes in its determining parameters. If small changes in parameters result in large changes in outcomes (e.g., a small shift in population projection results in a large shift in the cost of sewage infrastructure), then the outcome is said to be 'highly sensitive'. To manage this sensitivity, we can attempt to either determine the key parameter with a high degree of accuracy and precision, or devise other means of reaching the outcome, i.e. alternative options, that reduce the sensitivity.

FIGURE 5 ACCURACY AND PRECISION



3.8.3
WHY IS UNCERTAINTY IMPORTANT?

Uncertainty and risk are a fact; all data contain inherent uncertainty and errors.

Uncertainty and risk are important considerations for any analysis, including the analysis of costs involved with alternative urban water systems. Because, by definition, we have little or no experience with new urban water systems, the uncertainty around these systems is higher. They will also have qualitatively different risks and risk profiles (Fane et al., 2005). That is, uncertainty and risk are omnipresent. Our challenge is to work out adequate ways of dealing with them.

Making assumptions explicit, being reasonable and defensible about the magnitude of uncertainty in costing assumptions, and therefore about the significance of differences between cost estimates, are cornerstones of best practice. Variations in key data that impact differently on options, e.g., projections, need to be explicitly investigated e.g., through sensitivity analyses.

Different levels of certainty are acceptable for different decision stages and scales of expenditure. The decision stage determines the type of uncertainty analysis and the acceptable level of contingency.

One way of managing uncertainty is to assign appropriate levels of contingency to costs, either to specific cost elements, or to the cost analysis as a whole. Acceptable contingency (in percentage terms) typically decreases with the scale of infrastructure and with increasing specificity of decisions (e.g., contingencies are clearer at the construction stage than at conceptual design).

3.8.4
WHAT HAPPENS UNCERTAINTY IS DEALT WITH?

Uncertainties are noted, risk profiles and levels of certainty are mapped, and some risks will be quantified through the process of explicitly managing uncertainty. Decisions are defensible because errors and uncertainty have been brought through the calculations appropriately.

Text Box Three Probabilistic Techniques

Monte Carlo simulation
The most well known probabilistic technique for numerical risk assessment is Monte Carlo simulation (Janssen et al., 1992). Monte Carlo simulation allows the key variables and parameters in an equation or model (e.g., a water balance and costing model) to be defined as ranges or probability density functions. The simulation is then a process of repeatedly generating values for each of the key variables based on these predefined probability densities and recording the outputs from the model. The outputs are termed probability density functions. The 'sampling' process that occurs when a Monte Carlo simulation is run will also take account of any specified correlations between the variables. Relatively easy to use software applications exist (e.g., RISK by Palisade Software).

Bayesian approach
It is usually impossible to empirically obtain probabilistic information about many of the key variables in an equation or model. As a consequence, the more subjectivist or Bayesian approach to probability analyses has also been widely adopted (UKWIR/Environment Agency, 2002). The Bayesian basis for the probability of an event is the degree of belief one has that an event will occur given all current information. Thus, the Bayesian approach treats the probability as a function of both the extent and the state of available information. This implies that there is no single probability of an event, and that different decision makers can 'hold' different probabilities for the same event, depending on various factors, including their particular worldview and how well-informed they are. As a consequence, decision makers no longer need sharply distinguish between risk and uncertainty and can make their own assessment of the estimated probabilities associated with a variable.

3.9. TRANSPARENT REPORTING

REPORTING HAS TRANSPARENCY. THE ANALYSIS AND RESULTS ARE SUMMARISED IN A COHERENT AND TRACEABLE FORM.

3.9.1 WHAT IS TRANSPARENT REPORTING?

Transparent reporting seeks to summarise and detail the analysis in a coherent, traceable form. It provides details of the assumptions, which form the basis of recommendations. Key uncertainties are highlighted and the results of sensitivities are provided. The appropriate level of detail and justification will depend on the report's audience. Even for a brief report, however, it is important to capture the key assumptions and uncertainty, and to be explicit about how they impact on the recommendations.

Ideally, a transparent report should be simple to interpret, systematic and contain enough information that someone else would be able to repeat the analysis and get compatible results. To achieve this, it may be necessary to capture more detailed information elsewhere, in an appendix for instance.

3.9.2 WHY IS TRANSPARENT REPORTING IMPORTANT?

Transparency is important for the credibility of the costing study. Explicitly setting out assumptions also facilitates communication of the significance of apparent cost differences between alternatives.

Explicit definition of system boundaries and stating what impacts have been considered significant and retained outside the study facilitates the assessment of costs in the context of other criteria. This means different configurations are being compared on a common basis.

Transparency in reporting and decision making is also a cornerstone of corporate social responsibility, an increasingly widely held expectation in society, which is often found in the enabling legislation for water authorities.

3.9.3 WHAT HAPPENS IF REPORTING IS TRANSPARENT?

Recommendations based on costing will be consistent with the stage of decision making, scale of project, and level of uncertainty in estimates.

A transparent, comprehensible report will be clear about the study objectives, system boundaries, base case, the costs and avoided costs or benefits included, assumptions underlying the water balance, the treatment of externalities, sensitivities to key economic parameters such as discount rate, and the implications of all of these for the recommendations made.

Desalination plans shelved

Here's a case study on cost analysis of options and alternative configurations for sustainable urban water in the 'Bridgewater' region.

'Desalination plans shelved' ran the headlines. In the train on his way to work, Steve skimmed the front page article and the commentaries further on in the paper. The article reported that independent experts had determined there should be enough capacity from a combination of recycling and water efficiency to meet the demands of the increased population forecast for the next 30 years. Between that and the public outcry, the politicians had decided to shelve plans for a desalination plant to bridge the gap.

'Yeah, right,' thought Steve, 'so the city's gonna grow, but water use isn't!'

It was Steve's first day back at work. Last week he was at the annual national conference for the water industry. As he stared out the train window, he was thinking about what the CEO at Flinders Water had said in his speech, about why he reckoned sustainability makes good business sense, and how Flinders is having a go at new ways of doing this whole water cycle thing of water, sewage and stormwater together. Steve's been going to these national water conferences for decades. Sustainability has been talked about for quite a few years now. But somehow, something was different last week. The talk seemed to have moved from why sustainability is too hard, to why sustainability makes sense.

Steve is a senior planner at Bass Water. His division has just been restructured: his new role is to manage the planning for the whole northeast sector, including both greenfield and infill sites. He's got a new boss too, who is interested in innovative things as long as the cost benefit argument stacks up.

'Maybe it's time to think about what this sustainability thing might mean for us,' thought Steve. 'But new ways of doing things usually cost more, and cost has to be the bottom line for all our decisions here. Hang on a minute though – that American guy at the conference reckoned that distributed wastewater systems cost less than centralised systems. Maybe we could use the new development planned for the northeast as a trial? Or at least find out about other ways of doing things and see what they really cost?' he mused. >>

What are the options?

Later that morning, Steve is sitting with his boss, Sally, talking about the desalination plant decision, the shift at the conference, and what it means for their planning processes. 'Look,' said Sally, 'I understand that desal is really energy intensive, and this drought might be connected to climate change, so emitting even more greenhouse gases probably won't help, but we've got to be 110% certain that our supply meets demand.'

'Sure,' says Steve. 'But what about if we use the northeast sector to have a look at these new ways of doing things? At least include them in the options analysis? There must be something in it for Flinders to be so gung-ho.'

'It'll increase the cost of the options study, I guess.' Sally's brow furrowed. 'And what about the operational risks of these new technologies? We don't want to be guinea pigs for any of this stuff.'

'No, we don't,' said Steve. 'But we also don't want to miss out on good ideas, and the options study is a tiny fraction of the cost of the infrastructure – it's the place where it makes the most sense for us to find out about what these things really cost.'

Steve waited while Sally tapped her fingers on the desk. 'OK. You write me a memo, explaining why this'll be good for Bass, what it'll cost us in the options study, how we'll go about it, and what it'll do for us. I'll take it to the next Senior Executive Meeting, and we'll see what they say.' >>

Bridgewater options study approved

Steve wrote the memo, Sally signed it off, and the Executive agreed to invest the extra dollars in a broader options study for the Bridgewater region of the northeast sector. It had an existing community of 16,500, and the State planning department had slated it for another 24,000 over the next 25 years. And, there was enough lead time to broaden the scope of the options – it wasn't the next cab off the rank. The executive wanted to see a report from Steve on the process and the outcomes within 2 months. >>

The sustainable costing guidelines

Even though Steve was chuffed that the exec had agreed, he wasn't at all sure about how to go about a different kind of options study. That weekend he called his golfing mate, Geoff, in part to tee up a game, and in part for ideas. Geoff retired last year – he'd been a senior economist with the State's pricing regulator, then ran his own strategic planning business consulting back to government.

'So, the exec gave me the go-ahead for a broader options study for Bridgewater.'

'Good on you,' Geoff grinned, 'that'll keep you out of mischief'.

'I'm thinking it's gonna cause me plenty of mischief actually.' Steve grimaced. 'Got any ideas for how I go about something like this?'

'Maybe.' said Geoff. 'Try getting onto Erik over at the State Environment Agency – I remember him saying something about a sustainable costing guidebook they were writing – maybe he'd let you have a copy of it.' continued next page >>

The water crisis continues across

4 How are the principles applied?

This section describes the general process of conducting a cost analysis of options and alternative configurations for sustainable urban water in a given location. It explains how you carry out the four stages in a costing study:

1. Framing the study
2. Characterising the study
3. Identifying and specifying costs and avoided costs
4. Analysing and reporting incremental cost

This process represents the key costing principles in practice.

Within each stage, sequential steps are set out in the order in which a cost analysis might progress. In practice, you should expect to iterate between the steps within a stage, and to revisit earlier stages. You should also expect some variation in applying the process between individual studies, based on the type of cost analysis, the context of the analysis, the scale of the development and the stage of planning.

Along with the explanation of how to apply the principles, each subsection has an instalment of Steve's story, showing in detail how the ideas can be applied. White panels and a report icon are used within Steve's story to indicate sections of the report he has to prepare for the senior executive team. There are also some additional text boxes that provide more details and different examples.

This indicates a part of Steve's report to the executive

At the end of each stage, a summary checklist highlights key actions.

1 FRAMING THE STUDY

- Define the objectives
- Describe the system
- Adopt a specific cost perspective/s
- Define key economic parameters
- Determine the treatment of externalities

2 CHARACTERISING THE STUDY

- Develop a water balance model
- Specify a base case
- Define a broad range of options and develop alternative system configurations

3 IDENTIFYING AND SPECIFYING COSTS AND AVOIDED COSTS

- Specify costs to include
- Specify avoided costs and benefits to include
- Specify and quantify externalities

4 ANALYSING AND REPORTING INCREMENTAL COSTS

- Compare options using discouted cash flow analysis
- Consider uncertainty; conduct sensitivity analysis
- Document the analysis

STEVE'S STORY STUDY OBJECTIVES

Erik came good with the guidebook, and Steve had already had a flick through it. He figured he might as well start at the beginning, and work his way through.

The first thing it said to do was to be clear about the objectives and drivers for the options study, so he had a go at drafting them up. He figured the key things to include were something about integrating all three bits of the water cycle, something about sustainability, and a focus on costing options. He started the process of capturing all the elements for his report back to the executive:

BRIDGEWATER OPTIONS STUDY OBJECTIVE:
Investigate and cost a wide range of sustainable options for providing water, wastewater and stormwater services to Bridgewater Downs (a new growth area adjacent to existing small township of Bridgewater, located on the outskirts of Bass' major metropolitan area).

The guidebook said that drivers were important because they influence what kind of options get included, so Steve had a go at the drivers too. 'The first thing is the desal decision,' Steve thought to himself. 'Most of the so-called 'new' potable water used at Bridgewater will have to be saved elsewhere in the Bass metropolitan region, so that puts strong pressure on for water conservation and recycling. Then there's the nutrient issue in the bay. And those new stormwater guidelines that the SEA* has been talking about for some time now... Maybe I'll call Erik again, and get him to explain them to me.'

....

Steve met Erik at the SEA offices. Erik explained the main differences in the new guidelines:

'So, basically, the old stormwater guidelines had a one size fits all approach, and focused on keeping pollutants out of waterways – stuff like litter, total suspended solids, total phosphorous, oil and grease etcetera. That was much better than no attention to pollutants, which is what we had before, but it didn't always make sense, and even when it did, it didn't necessarily lead to better urban streams. So, the new guidelines pick up on what we now know is important – and mainly, that's the frequency and intensity of rainfall events. So now, we're asking people to think about this idea of 'Effective Impervious Area', which has to do with the connectedness of pipes and channels in the catchment. For Bridgewater Downs, that means thinking about on-site detention systems, bio-retention swales, maybe even overland flow. And, the other big shift is that the actual goals vary based on the receiving environment. For Bridgewater Downs, you've got local bush land, the river and the estuary, things that need high level protection, so you'll need goals that reflect that.'

'You'll need to work closely with Bridgewater Council on this – Michael is the Team Leader for Catchments and Planning there. He's really keen on environmental things, in fact the whole area is, and he's given us good feedback on the new guidelines. He's pushing the Council to make them mandatory in the approvals process for all new developments. But his budgets are pretty stretched, like all councils, so he'll be looking to you and the developers to do the right thing. You should also know that Bridgewater Council are a bit hot under the collar about failing septic systems - there's a couple of new Councillors who want to see the whole area sewered.'

Steve added some more elements for his report back to the executive:

DRIVERS FOR THE BRIDGEWATER OPTIONS COST STUDY:

1. Minimise potable water demand: Without desalination, the metro demand-supply strategy relies on reducing the call on existing dams, which will require extensive water efficiency and water recycling.
2. Minimise water quality impacts: the river and the bay are already under nutrient stress.
3. Meet new stormwater guidelines: The State Environment Agency (SEA) has released the draft guidelines for comment. Bridgewater Council will likely incorporate them into the approvals process for all new developments.

*State Environmental Agency

Step 1

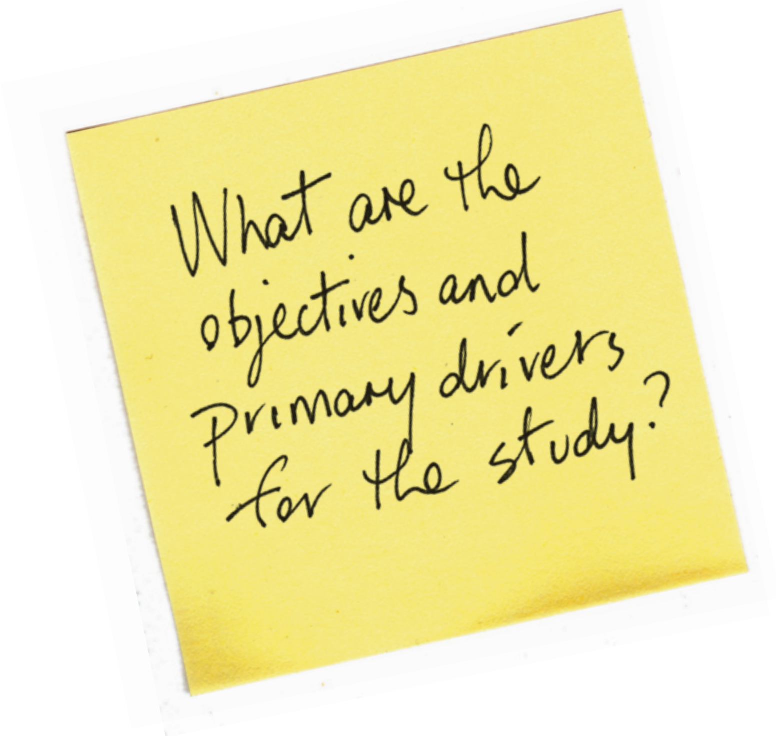
4.1.
FRAMING THE STUDY

The first stage of a costing study is to set out the objectives, describe the system, including the site and service needs, determine which cost perspectives are relevant and determine key economic parameters. In the course of 'framing' the study, you, the analyst, are clarifying "what is the question this study is designed to answer?"

4.1.1
DEFINE THE STUDY OBJECTIVES

Why?
The objectives and primary drivers for the study directly affect both the nature of options considered and the grounds for comparison between them. Clear articulation of the study objectives will help to both direct the analyst and to communicate the rationale for the study to others.

How?
Firstly, you need to specify the actual question or problem at hand. In doing this, explore the range of other drivers, conditions and constraints that influence this issue. These might include regulations, company policy, standards or risk mitigation. Then, keeping Principle 2 (*Provide water service outcomes*) in mind, formulate clear and achievable objectives for the study.



For example, a study could compare alternatives for servicing a new development area. The driver for the study could be to meet a consumption goal (e.g., 50% reduction on average) as well as relevant stormwater goals (e.g., targets for effective impervious area, peak flow attenuation and extended detention) in a new residential development area. Naturally, all alternatives would need to work within the existing health and environmental regulations. An appropriate study objective under this circumstance is 'to compare alternative infrastructure configurations that can provide all water supply, wastewater and stormwater services'.

Another example would be a study comparing demand management and source substitution options as means of meeting a water conservation target. The driver for the study is a conservation target and presumably the need to contain growth in potable water demand in the context of the regions supply-demand balance. An appropriate study objective would be 'to compare options for cost effectively providing water conservation and potential to save potable supplies in the target year'.

Sometimes it will be appropriate to involve other stakeholders in defining study objectives e.g., a water authority might collaborate with a local government authority and state agencies to determine the most sustainable servicing strategies for a new release area.

STEVE'S STORY SYSTEM UNDER STUDY

BRIDGEWATER DOWNS COSTING OPTIONS STUDY

The system under study is the urban water system required to provide water supply, wastewater and stormwater services to the population in the proposed development area over the next 50 years and beyond. It has the following characteristics:

- Will grow to 8000 hh* detached residential homes and 125 commercial/light industrial lots (assumes large warehouse type lots of 6000 m^2) and public open space (19 ha irrigated) over time;
- Has a projected rate of growth of 330 hh/yr over 25 years, but needs to be flexible to allow the developers' preferred rate of 500 hh/yr over 16 years; and
- Has a final projected population of approximately 22,500 in 2032 based on occupancy projections.

The context or system environment includes ecological, physical, and social elements, each of which is explained in detail below.

The Bridgewater Downs development site has a total area of 790 ha, encompassing residential (500 ha), commercial (100 ha), and public open space (190 ha, of which 19 ha will be irrigated).

The local ecosystems surrounding the development site include intact and partially cleared native bush land and a river that is part of an estuary. These ecosystems are relevant to the urban water system because they are impacted by stormwater and effluent releases.

The 'catchment' or hydrological context for the site is that it drains to a river that drains to an estuary. Ecological experts have determined that the river is in moderate to poor condition.

The estuary has experienced a build-up of nutrients in recent years, so SEA licensing on nutrient disposal is becoming increasingly stringent. The average rainfall is 650 mm/yr.

The new development will be supplied with potable water from metropolitan supplies that are highly constrained.

At a local level, the Bridgewater supply zone has some excess capacity but will need a significant upgrade in the base case.

In the base case, the new development is connected to the sewage treatment plant servicing the existing development, which must therefore be upgraded.

Existing stormwater management systems in Bridgewater are minimal – some streets are kerbed and channelled.

The existing land use in the area of the new development is primarily agricultural activities (e.g., market gardens and poultry farms) on small acreage lots, serviced by on-site sewage systems, many of which are thought to be failing. Stormwater runoff likely contains fertiliser, manure, and pesticides.

The location is on the outskirts of our major metropolitan area, and is adjacent to the existing township of Bridgewater with a population of 16,500 in 5500 hh. Some local residents work nearby, many commute into the city.

*hh = household

4.1.2
DESCRIBE THE SYSTEM UNDER STUDY

Why?
Detailing the urban water system provides the basis for comparing alternative system configurations.

Defining the system boundaries and system context enables identification and pro-active management of relevant 'boundary issues', such as what costs to include and which impacts to account for.

Any project must always be part of a larger urban water system. Describing how the project connects to the rest of the urban water system is critical to being able to identify linkages, different potential solutions, and opportunities to capture synergies between the three domains of the water cycle (water, wastewater, and stormwater). The detail of this linkage will be an advantage later on when specifying avoided cost items as part of the base-case (see '*Specify a base case*' on page 45).

Having clear boundaries also puts you in a good position to determine the types of externalities that will be considered and those that will not – there is more on this once you reach the step '*Determine the treatment of externalities*' on page 37.

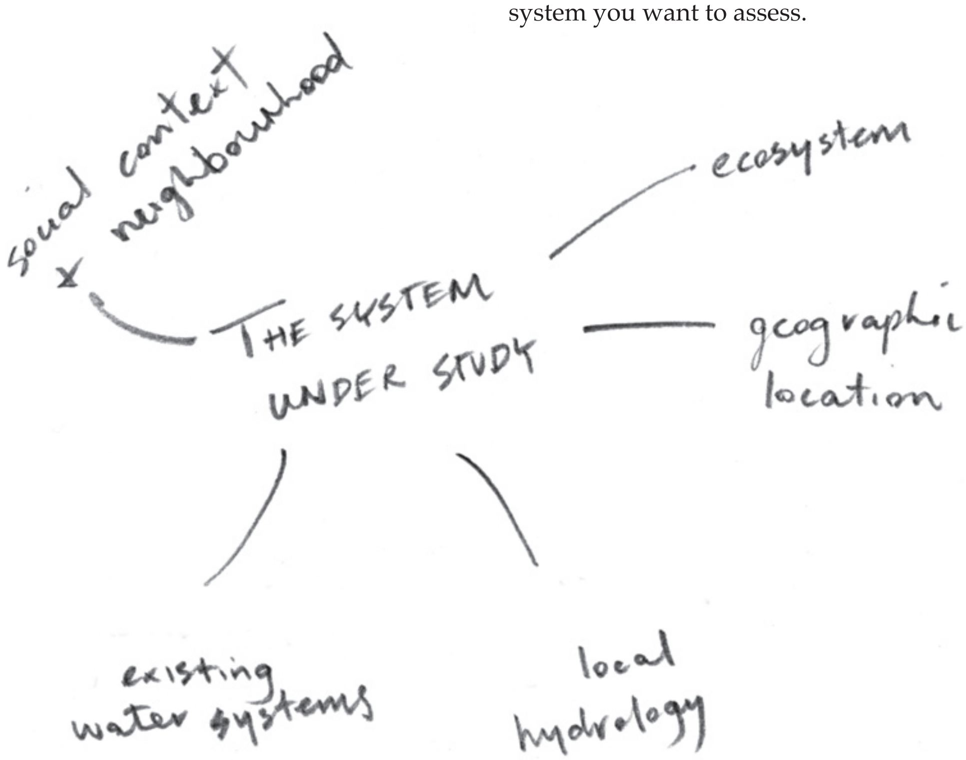
How?
You need to describe both the system that is being studied and the system setting, its surroundings.

Describing the system means detailing all the components required on the site to provide the actual water supply and/or wastewater and/or stormwater services required. It also includes detailing site and demographic characteristics as these directly influence the services requirements. This system definition should be consistent with the study objectives.

Describing the system setting or context includes detailing the following:

- ecosystem and/or geographical location
- physical location within which the urban water system functions (local contexts) i.e. relationship to local hydrology and existing urban water systems
- social context and neighbourhood setting
- existing government commitments and decisions

Based on these two descriptions, and keeping in mind Principle 3 (*Think in terms of systems*), determine very clearly the boundaries of the system you want to assess.



STEVE'S STORY COST PERSPECTIVE

Geoff called Steve to ask how the Bridgewater Downs study was going.

'OK,' replied Steve, 'the thing I'm thinking about at the moment is this idea of cost perspectives. The guidebook talks about the need to look at things from a 'whole-of-society' angle. I'm not sure how that's gonna wash with Bass Water executives or Treasury for that matter.'

'Actually, it might be easier than you think,' replied Geoff. 'When I worked at the pricing regulator, I saw other utilities use that to argue for price increments at the same time as investing in efficiency – they showed that using less water was the best thing for society and the environment: it costs less, and uses less energy and chemicals and so forth. But it also means a drop in revenue to the utilities. So, the utilities use a 'whole-of-society' perspective to show demand management is the most cost effective option, and then do an analysis from the perspective of just their own business to show the price rise they need to remain financially viable.'

'But how does that work for a new development like Bridgewater Downs?' asked Steve.

'Well, you'd need to include all the major players for a start – for a new development, that'd be the developer as well as your customers and Bass Water. You might want to have a think about whether you're going to treat all your customers the same way. Are the people who buy in to Bridgewater Downs going to pay for any of these new ideas?'

Steve looked perplexed. 'I dunno. I guess I hadn't thought about that. Don't the developers just pass on all their costs to the customers anyway?'

'Yeah, but if you're thinking about on-site options, like rain tanks and the like, you need to think about how that might happen in practice - will the new owners buy and install them independently? Or will the developers supply them? Or will Bass Water do it?' Geoff asked. 'Whatever you decide, you need to include all the costs associated with each option, so you'll need to include all the groups who might have a major cost or benefit, as well as the overall perspective of whole-of-society.'

COST PERSPECTIVES FOR BRIDGEWATER DOWNS STUDY

Analyses will be undertaken from a range of perspectives, including whole-of-society, utility (Bass Water), developer, and customer.

4.1.3
ADOPT A SPECIFIC COST PERSPECTIVE/S

Why?
For urban water, sustainable outcomes are promoted by identifying the least cost to society as a whole because this represents the economically- and resource-efficient means of service provision. Analysis of various cost perspectives shows how the costs of options are shared between the stakeholders, which opens the door for negotiation between the parties on how to pursue the least cost solution.

How?
The choice of cost perspective should be made keeping in mind Principle 1 (*Use appropriate cost perspectives*). In almost all cases, your study should take a whole-of-society cost perspective. An exception to this rule is an analysis intended **solely to address** a question of commercial viability. In addition, if an objective of the study is an understanding of distributional questions (i.e. 'who pays' and who benefits'), then you might need to specify further cost perspectives in addition to the whole-of-society perspective.

Since taking a whole-of-society perspective means you will be including costs to all significant parties, at this point in the process you need to articulate who they are. Likely parties include the water supply authority (bulk and/or retail), the wastewater authority, the developer, the customer and local government.

STEVE'S STORY DETERMINE KEY ECONOMIC PARAMETERS

So I thought I might pick your brains a bit more on these cost things, waddyareckon?' Steve asked hopefully. 'Lucky for you we're playing 18 holes,' Geoff smiled. 'Thanks mate – it's my shout at the 19th,' said Steve, relieved.

'The guidebook says you've gotta make decisions about a bunch of parameters. They reckon net present value is the best option for cost comparison, because it's the simplest way to take account of the time value of money. What do you think?'

'Well, it is pretty much the standard in the water industry,' said Geoff.

'Yeah.' Steve agreed. 'It's got some problems, but it is the thing that everybody's familiar with, so I guess I'll go ahead and use that, at least for the financials. Sally and the executive will be happy with that. And then, on the timeframe, because some of these options are gonna have very different replacement schedules, this study needs to take into account what happens in the long term, so I was planning on using a 50 year period, at the usual Treasury discount rate of 7%.'

'Sure – no-one's gonna baulk at that.'

'Then there's this idea about unit cost,' Steve continued. 'Sally said that incremental cost is what the metro planning guys are using in their analysis, so she thinks we'd better report that, too."

'Sounds good.' Geoff said.

'Trouble is,' said Steve, 'I don't get it. I just don't see how you can discount water – water is a physical quantity – a litre today is exactly the same as a litre tomorrow, so discounting it makes no sense at all to me.'

'So long as you think of the water as a physical thing, it is confusing,' explained Geoff. 'But if you think of the water as the benefit that you get for the cost that you pay, then it starts to make sense. The calculation is actually exactly the same as the average incremental cost formula used to calculate the marginal cost of supply – you just take the NPV of costs over the NPV of benefits, which is the water you can expect the option to supply or conserve over time."

Geoff continued as they walked down the last fairway, 'Pragmatically, ranking options on levelised cost allows you to identify the least cost demand-supply strategy, which is what you need to supply Sally with.'

'And actually, now I think about it, there's another good reason to use incremental cost. You know how you've been on about small-scale options lately?' Geoff reminded Steve.

'The American guy's presentation was pretty convincing – if 60 million people are using these systems in the richest country on the planet, there's gotta be something in it,' replied Steve.

'Well, unlike the other unit cost metrics, incremental cost is the only one that lets you compare options of different scales on a fair basis. That means you can compare things like smaller scale water efficiency options with big new supply augmentations – could be handy for this study, huh?' prompted Geoff.

'I'm still not sure I get it, but at least I get the idea that it's a useful thing to do,' resolved Steve. 'Now, what'll you have to drink?'

KEY ECONOMIC PARAMETERS FOR BRIDGEWATER DOWNS OPTIONS STUDY:

Compare options on the basis of net present value and average incremental cost or levelised cost.

Use a 50 year period of analysis, and a discount rate of 7% in real terms.

4.1.4
DEFINE KEY ECONOMIC PARAMETERS

Why?

The choice of key economic parameters shapes both the inputs and outcomes of the study. Clarity in their definition, therefore, renders the analysis transparent and internally consistent.

How?

Specify metrics for cost comparison

In line with Principles 5 (*Assess on the basis of incremental cost*) and 7 (*Account for the time value of money*) cost comparisons should be reported as present values or net present values (NPV). If you adopt alternative discounted cash flow approaches, this should be stated clearly, together with the implications for comparison of costs to NPV figures.

Many studies will also require options to be compared in terms of unit costs. These may be, for example, unit costs of water supplied or dollar per unit of pollutant reduced. In such cases you will need to specify the metric of unit cost to use for options comparison. In line with Principle 5, this guidebook recommends using Average Incremental Cost (AIC) or levelised cost for calculating the unit cost of water (see Text Box One '*Metrics of unit cost*' on page 18).

Determine an appropriate period of analysis

Costing for sustainable outcomes should take a life cycle view of assets and asset costs, as proposed by Principle 4 (*Include life cycle costs*). This means including all capital and operating expenditure associated with the option over the period of analysis including allowances for maintenance, replacement, etc. For this reason, you must use the same period of analysis for all alternatives. Often, cost analyses are conducted over a 20 or 30 year timeframe – this is too short to account adequately for the different lifetimes of assets – a better period is 50-100 years. Alternatively, if a shorter period of analysis has to be used for other reasons, then be sure to account carefully for differences in residual values.

Decide on an appropriate discount rate

Keeping in mind Principle 7 (*Account for the time value of money*), you will need to choose a discount rate. You will also need to nominate whether the discount rate is real or nominal because this affects the value of the costs you include in you analysis. If you do the analysis in nominal dollars, make sure your discount rate includes a provision for inflation.

In many cases, discount rates are prescribed. If not, when deciding on an appropriate discount rate consider also the cost perspective you have established. As described under Principle 7, the public or 'whole-of-society' discount rates can differ for the private discount rates applied in financial analysis by specific parties (e.g. developers).

STEVE'S STORY TREATMENT OF EXTERNALITIES

Externalities seem to be a real buzz word just now, thought Steve to himself. He had prepared a draft list of the potential externalities for the water side of the new development at Bridgewater Downs, and called a meeting of Bridgewater Council and the SEA to talk them through. Erik and Michael were due to arrive any minute. Steve had also invited Peter, a Director at MFP Engineering, because he'd mentioned them at various talks in recent years. Steve was keen to see if the others agreed with his list, and was looking forward to picking their brains about how to deal with these externalities.

After an hour, they had agreement on the list of significant externalities. Erik had convinced the others that biodiversity should be separate from nutrients and sediments because there were quantity-related impacts as well as quality:

- Energy-related greenhouse gas emissions
- Biodiversity impacts on local ecosystems
- Increased nutrient and sediment loads to receiving waters
- Perceived public health risk due to effluent reuse and rain tanks
- Positive public perception of reuse and raintanks, including restriction-free supply for outdoor water use

'I guess I always thought of externalities as negative things, but it makes sense that you can have positive ones too, like that last one about restriction-free supplies.' mused Steve.

Steve reckoned the greenhouse gas emissions at least started out being straightforward enough – he should be able to estimate the energy use of each option. He wasn't yet sure what to report though. There seemed to be lots of options: the total energy usage over the period of analysis; the total energy usage up to build-out; some kind of average energy use per year (but what year would you use?); or maybe you could normalise it against households or maybe against kilolitres. But how would that work for the greenhouse gases you avoid with an efficient showerhead? Maybe the best approach was to use an actual dollar value. He'd heard about carbon markets, but didn't really know what that meant or how they worked. He figured he could probably find out though.

'Hey,' said Michael, as he read the guidebook, 'If the biodiversity and sediment impacts are mostly stormwater related, then wouldn't having the new guidelines in place be a way of dealing with them through this idea of limits?'

'Could be – it doesn't cover the nutrients issue, but I guess we can group the externalities in whatever way makes sense,' said Erik.

'I think what that means is that I need to make sure that all the options meet the new stormwater guidelines, and then I've effectively dealt with the externalities of biodiversity and sediment impacts – yes?' asked Steve. The others agreed.

'And then how about if I just report the total nutrients exported to the river from each option?' asked Steve.

'That doesn't seem right,' said Peter. 'The options that include reuse or recycling are still putting nutrients back out into the environment, just not directly into the river.'

'But isn't that mostly going to be public open space irrigation? I guess it depends on the level of treatment, but I would have thought most of the nutrients in recycled water will either be taken up by the grass, or held up in the soil. And anyway, wouldn't they reduce the amount of fertiliser used by Bridgewater Council?' asked Erik.

continued over page →

4.1.5 DETERMINE THE TREATMENT OF EXTERNALITIES

Why?

Explicitly determining the treatment of significant externalities provides an opportunity to change the conventional practice of leaving them out of costs analysis. Instead, it promotes transparent decision-making about how they may be justifiably dealt with.

How?

Firstly, with reference to the system boundaries and study objectives developed in previous steps, identify the externalities that need to be accounted for in the analysis. A good way to identify these is to think about what impacts will have a major effect, and/or will vary in a significant way between options. Refer to Principle 6 (*Account for externalities* on page 19) for descriptions of an externality.

While some obvious externalities of concern should be readily identifiable (refer to Text Box Two '*Identifying and valuing urban water externalities*' on page 20 for potential sources), you may need to revisit the process of identifying externalities once the options included in the study are established (see '*Define a broad range of options and develop alternative system configurations*' on page 49).

Once you have established your list, you will need to decide which externalities you intend to include within the cost analysis. The main thing is that you are explicit and clear about how each impact is dealt with, regardless of whether it is included or excluded in the cost analysis. You will likely need to involve others in deciding how each externality is best dealt with for a particular analysis.

As described under Principle 6, (*Account for externalities*) there are three possibilities for how to deal with each externality.

The first option is to bring the externality inside the cost analysis by monetising it directly. This is easiest for externalities that are particularly significant, readily quantifiable and for which markets already exist such as greenhouse emissions or nutrient run-off to Port Phillip Bay. For externalities that don't meet all of these criteria, it is much harder. This is the reason cost studies tend to include only one or two externalities as monetary values.

For many studies, however, quantification and monetising any externalities may not be feasible within the budget or timeframe allowed for the costing analysis. If this is the case for your study, you might consider incorporating particularly critical externalities as system limits or goals e.g., through a site-specific goal limiting the acceptable level of nutrients released to waterways. This represents the second option. In effect, it is another way to bring the externality inside the cost analysis, because the costs of the measures required to meet the limits or goals are then included in the analysis. If you do introduce a limit into your analysis, you will need to support this assumption with a reasoned explanation. Ideally, you will also plan to show what the outcome of the analysis would be without this limit in place.

The final option is to keep the externality outside the cost analysis. In this situation, the best practice approach is to clearly document what the excluded externalities are and where possible the extent to which they differ between alternatives. It is also important to determine how these excluded externalities will be incorporated in the decision making process at a later stage e.g., assess them alongside costs through an appropriately designed participatory process.

STEVE'S STORY TREATMENT OF EXTERNALITIES

→ continued from previous page

How about this for an idea then - maybe a better approach is to report the mass of nutrients leaving the Bridgewater Downs system, regardless of where they go?,' proposed Steve. The others nodded.

'OK, good. Now, what about the public health impacts. Couldn't we just use a similar approach as for the stormwater impacts, and say that we'll limit those out by making sure that all options meet the new national guidelines for recycled water use?' asked Steve.

'I know the health department has had studies done that estimate the microbial risk from raintanks and recycled water, and I've seen some studies from the US that put a dollar value on a crook tummy, but that seems like too much detail for this study,' said Erik.

Steve nodded, and thought to himself that the best way to do this would be to add the new water quality guidelines to the drivers for the whole options study.

Peter said, 'Some externalities, like that last one about public perceptions of recycled water and rainwater, can be either positive or negative, depending on the person, and depending on when you ask them. I reckon that attitudes towards these things are changing, but they're changing in both directions. It seems to me that you could undertake a whole other study about that, but it's beyond the scope of what you need here. So, I reckon the best approach is the third one – just note it in the report.'

'I'm glad you said that,' smiled Steve.

SIGNIFICANT EXTERNALITIES FOR BRIDGEWATER DOWNS & THEIR TREATMENT:

Externalities and treatments collaboratively determined by Bass Water, the State Environmental Agency (SEA), and Bridgewater Council representatives.

1. **Monetise:**
   - Energy-related greenhouse gas emissions: Based on carbon market values

2. **Include in all alternative configurations by mandating limits:**
   - Biodiversity impacts on local ecosystems: require all options to meet new stormwater guidelines
   - Increased sediment loads to receiving waters: require all options to meet new stormwater guidelines
   - Public health risk due to effluent reuse and rain tanks: require all options to meet new national recycled water guidelines

3. **Retain outside the analysis:**
   - Increased nutrient loads to receiving waters: report nutrient loads leaving the actual system under study
   - Public perception of reuse and raintanks, including restriction-free supply for outdoor water use: beyond scope, note in report

4.1.6 KEY ACTION CHECKLIST

At this point, you as the analyst should be able to answer 'What exactly is the problem that I am designing solutions to solve?'

KEY ACTION CHECKLIST: FRAMING THE STUDY

- ○ CLEAR AND ACHIEVABLE OBJECTIVES HAVE BEEN FORMULATED
- ○ CHARACTERISTICS OF THE SYSTEM BEING ASSESSED HAVE BEEN DESCRIBED
- ○ THE BOUNDARY BETWEEN THE SYSTEM AND ITS CONTEXT HAS BEEN CLEARLY DRAWN INCLUDING THE RELATIONSHIPS TO EXISITING WATER SYSTEMS
- ○ THE COST PERSPECTIVE(S) HAS/HAVE BEEN CHOSEN, SETTING EXACTLY WHOSE COSTS WILL BE CONSIDERED
- ○ NPV AND/OR AVERAGE INCREMENTAL COST HAS BEEN CONFIRMED AS THE METRIC FOR ANALYSIS OR ALTERNATIVES HAVE BEEN JUSTIFIED
- ○ THE PERIOD OF ANALYSIS HAS BEEN CLEARLY DEFINED AND IS INFORMED BY INFRASTRUCTURE LIFE CYCLES
- ○ AN APPROPRIATE DISCOUNT RATE CONSISTENT WITH THE CHOSEN COST PERSPECTIVE HAS BEEN DEFINED
- ○ THE EXTERNALITIES TO BE INCLUDED AND EXCLUDED FROM THE ANALYSIS HAVE BEEN DECIDED
- ○ EACH EXTERNALITY HAS BEEN ALLOCATED AN APPROPRIATE TREATMENT METHOD

STEVE'S STORY DEVELOP WATER BALANCE MODEL

Steve was thinking about the system boundary for his study. He had been thinking that it was just the new development. But with the drivers about demand management and recycling, and the objective of lowest cost, Steve realised that there were opportunities with the existing Bridgewater community that should be included.

REVISITING AND EXPANDING THE SYSTEM BOUNDARY:
The system boundary now includes both the existing township of Bridgewater, and the new development at Bridgewater Downs, so that options for both communities can be included in the costing study.

Steve got approval for an internal project, and asked the Bass Water planning department to prepare a water balance model for the existing township of Bridgewater and the new development at Bridgewater Downs.

Because he wanted to analyse efficiency options, the terms of reference he wrote required that the model take an end use approach. For residential water use, that meant separate water use categories of toilets, showers, dishwashers, clothes washers, hand basins, kitchens, and outdoor water use. Steve's colleagues in the planning section at Bass Water told him that for commercial water use, the available data was not so good, so he might as well use aggregate figures. Public open space irrigation was a separate category. For each sector and end use, the model had to be able to account for different levels of water use efficiency and different sources of supply to end uses. Steve also asked the planners to calculate the net present value of water flows over time, so that he would be ready to do the levelised cost calculations later on.

Steve specified a 50 year period of analysis water balance model to reflect the study period.

Demand projections over time were based on household occupancy and growth rate, with a base case of 330 new households per annum. The planners chose a slowly decreasing occupancy rate, after a review of ABS 2001 Census data on similar suburbs, and in line with projected trends. The planners used a daily raintank model with 30 years of local daily rainfall data to determine the proportion of demand that raintanks of various sizes could meet.

The planners supplied Steve with a short report on the end use model:

The water balance model developed for Bridgewater Downs takes an 'end use' approach (e.g., toilets, showers etc). Demand is derived from the water use of technologies (e.g., flowrate, wash or flush volume), their usage and the ownership (i.e. how many, what kind). An end use model can account for different water use efficiencies of technologies such as showerheads and dual flush toilets. It can also account for the source of water supplied (rainwater, recycled, etc.). Dry weather wastewater flows can also be estimated.

The residential end use assumptions given in Tables 1 and 2 represent the best available information in 2006. continued over page →

TABLE 1 RESIDENTIAL END USE DATA – TECHNOLOGY

End Use	Efficient	Non-Efficient New	Non-Efficient Existing
Toilets	3.75 L/flush[1]	5 L/flush[1]	7.6 L/flush[1]
Showers	6.7 L/min[1]	7.5 L/min[1]	9.5 L/min[1]
Dishwasher	10 L/use[2]	20 L/use[3]	30 L/use[3]
Clotheswasher	71 L/load[1]	125 L/load[3]	143 L/load [3]
Hand basin	4.9 L/min[1]	4.9 L/min[1]	4.9 L/min[1]
Kitchen sink	19.4 L/min[1]	19.4 L/min[1]	19.4 L/min[1]
Baths	120 L/bath[1]	120 L/bath[1]	120 L/bath[1]
Outdoor	16.3 L/min[1]	16.3L/min[1]	16.3 L/min[1]
Cleaning	15 L/min[1]	15 L/min[1]	15 L/min[1]

Step 2

4.2. CHARACTERISING THE STUDY

The second stage in a costing study involves the detail of characterising the study objectives and the system under study within a spreadsheet or other form of 'bookkeeping' environment. This characterisation also extends to the options considered and alternative system configurations developed.

4.2.1 DEVELOP A WATER BALANCE MODEL

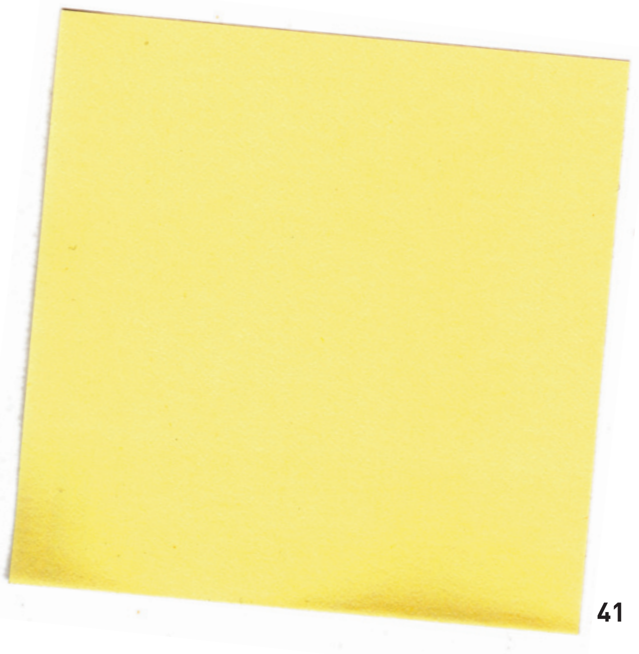
Why?
Developing a computer model of the physical water balance is critical to determining which options will be needed at which times to meet the objectives of the study. It is also essential for providing the ability to compare alternative system configurations.

How?
The purpose of a water balance model is to account for water flows onto and off the site, and how they vary for the options being considered. This provides a fundamental basis for comparison in the cost analysis. As a result, you will need to keep in mind the study objectives, the system definition and likely options to be considered when developing your water balance model. You can either develop your own model in a spreadsheet environment, or use one of the templates available e.g., MUSIC, Aquacycle. Your water balance model should reflect the objectives, and so should vary between studies. You may need to account for the total water demand (including both potable and non-potable components), as well as wastewater produced and stormwater flows.

In keeping with Principle 2 (*Provide water service outcomes)* ideally the model will have an end use basis and account for the fact that demand for services and therefore service outcomes will need to be projected to change annually. Since the model forms the basis for cost analysis, providing outputs in a yearly time step will be important.

For studies in the more detailed planning stage, significant hydraulic modelling of alternatives is commonly required to set design parameters (stormwater detention, pipe sizes etc). This hydraulic modelling, with time steps of days, hours or minutes, will usually be a separate exercise, which is used to inform the annual system water balance model. For example, a rain tank model based on at least daily rainfall data from a rain gauge near the site should be used to determine the proportion of demand that a raintank on that site can be expected to meet.

The outputs of the water balance model should show the implications of staging and different technology life cycles, because these are important in the cost analysis. The model should be set up so that options can be staged within alternative system configurations to meet expected demand for urban water services over time, and to enable sensitivity testing. One example is the changing number of residences in a new development area over the period of the analysis, and the associated differences in growth rates.



STEVE'S STORY DEVELOP WATER BALANCE MODEL

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TABLE 2 END USE DATA – USAGE

End Use	Residential	Commercial
Toilets	3.8 Flush/cap/d[1]	3 flush/staff/d[6]
Showers	6.3 mins/cap/d[1]	0.07 min/staff/d[6]
Dishwasher	1.044 load/hh/d[1,4]	0.7 load/office/day[6]
Clotheswasher	0.6 load/hh/day[5]	
Hand Basin	1.25 min/hh/d[6]	0.75 min/staff/d[6]
Kitchen Sink	0.75 min/hh/d[6]	1.25 min/staff/d[6]
Toilet Leakage	0.00438 L/hh/day[1]	
Baths	0.063 use/hh/day[1]	
Outdoor	6.6 mins/hh/d[1]	

REFERENCES
1 Roberts, Peter (2004)
2 sydneywater.com.au (2006)
3 Australian Greenhouse Office (2003)
4 Trewin, Dennis 2004,
5 ACNielson (1999, 2000)
6 Institute for Sustainable Futures (in-house estimate)

TABLE 3 BRIDGEWATER DOWNS MODEL EXTRACT: RESIDENTIAL END USE CALCULATION

		2,007	2,008	2,009	2,010	2,011	2,012	2,013	2,014
	Occupancy	3.012	3.006	3.000	2.994	2.988	2.982	2.976	2.970
	Households New	-	330	660	990	1,320	1,650	1,980	2,310
	Households Existing	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
	Commercial New	-	4	8	12	16	20	24	28
	Public Outdoor Area m2		35,000	35,000	35,000	35,000	35,000	35,000	35,000
	All figures in kL/year								
Efficient	Toilets	-	5,160	10,299	15,417	20,515	25,592	30,648	35,684
Efficient	Showers	-	15,283	30,505	45,666	60,766	75,805	90,783	105,700
Efficient	Dishwasher	-	1,258	2,515	3,773	5,030	6,288	7,545	8,803
Efficient	Clotheswasher	-	5,131	10,262	15,394	20,525	25,656	30,787	35,918
Efficient	Hand Basin	-	443	885	1,328	1,771	2,213	2,656	3,099
Efficient	KitchenSink	-	1,753	3,505	5,258	7,010	8,763	10,515	12,268
Efficient	Toilet Leakage	-	1	1	2	2	3	3	4
Efficient	Baths	-	911	1,821	2,732	3,642	4,553	5,464	6,374
Efficient	Outdoor	-	12,958	25,916	38,874	51,832	64,790	77,748	90,706
Efficient	Hot Water	-	12,920	25,806	38,656	51,472	64,254	77,000	89,712
Non-Efficient	Toilets	-	6,879	13,731	20,556	27,353	34,122	40,864	47,579
Non-Efficient	Showers	-	17,108	34,148	51,119	68,022	84,857	101,623	118,321
Non-Efficient	Dishwasher	-	2,515	5,030	7,545	10,060	12,575	15,090	17,605
Non-Efficient	Clotheswasher	-	9,034	18,068	27,101	36,135	45,169	54,203	63,236
Non-Efficient	Hand Basin	-	443	885	1,328	1,771	2,213	2,656	3,099
Non-Efficient	KitchenSink	-	1,753	3,505	5,258	7,010	8,763	10,515	12,268
Non-Efficient	Toilet Leakage	-	1	1	2	2	3	3	4
Non-Efficient	Baths	-	911	1,821	2,732	3,642	4,553	5,464	6,374
Non-Efficient	Outdoor	-	12,958	25,916	38,874	51,832	64,790	77,748	90,706
Non-Efficient	Hot Water	-	16,350	32,660	48,932	65,165	81,359	97,514	113,630
Public Outdoor	Irrigation	-	61,320	61,320	61,320	61,320	61,320	61,320	61,320

→ An end use approach allows the water balance to account for changes in demographics and technologies such as showerheads or dual flush toilets. The resulting differences in the water balance provide a way of comparing the water use at the same development given different levels of water efficiency. The simple equation applied in the calculation is:

End use water consumption = Technology x Usage x Ownership

The end use demands for the site are then brought together in the water balance as shown in Table 4. The Present Value (PV) calculations for water are included for use in calculating the average incremental costs (or levelised) costs of options.

TABLE 4 EXTRACT FROM BASE CASE WATER BALANCE

		Demand (kL/yr)	PV	2,007	2,008	2,009	2,010	2,011	2,012	2,013	2,014
New Residential	Efficient	Demand Total		-	-	-	-	-	-	-	-
		Rainwater 1 used		-	-	-	-	-	-	-	-
		Rainwater 2 used		-	-	-	-	-	-	-	-
		Recycling Demand		-	-	-	-	-	-	-	-
		Wastewater		-	-	-	-	-	-	-	-
		Reticulated used		-	-	-	-	-	-	-	-
	Non-Efficient	Demand Total		-	51,600	103,105	154,514	205,827	257,044	308,166	359,192
		Rainwater 1 used		-	-	-	-	-	-	-	-
		Rainwater 2 used		-	-	-	-	-	-	-	-
		Recycling Demand		-	-	-	-	-	-	-	-
		Wastewater		-	38,642	77,189	115,640	153,995	192,254	230,418	268,486
		Reticulated used	8,299,511	-	51,600	103,105	154,514	205,827	257,044	308,166	359,192
Existing Residential	Demand Mngmnt	Demand Total		-	-	-	-	-	-	-	-
		Rainwater 1 used		-	-	-	-	-	-	-	-
		Rainwater 2 used		-	-	-	-	-	-	-	-
		Wastewater		-	-	-	-	-	-	-	-
		Reticulated used		-	-	-	-	-	-	-	-
	Non-Efficient	Demand Total		1,039,371	1,038,303	1,037,234	1,036,165	1,035,096	1,034,028	1,032,959	1,031,890
		Rainwater 1 used		-	-	-	-	-	-	-	-
		Rainwater 2 used		-	-	-	-	-	-	-	-
		Wastewater		823,405	822,336	821,267	820,198	819,130	818,061	816,992	815,923
		Reticulated used	14,123,411	1,039,371	1,038,303	1,037,234	1,036,165	1,035,096	1,034,028	1,032,959	1,031,890
New Commercial	Efficient	Demand Total		-	-	-	-	-	-	-	-
		Wastewater		-	-	-	-	-	-	-	-
	Non-Efficient	Demand Total		-	7,710	15,420	23,130	30,840	38,550	46,260	53,970
		Wastewater		-	7,710	15,420	23,130	30,840	38,550	46,260	53,970
Public Outdoor		Demand Total		-	61,320	61,320	61,320	61,320	61,320	61,320	61,320
		Stormwater		-	-	-	-	-	-	-	-
		Recycling		-	-	-	-	-	-	-	-
		Reticulated used	1,736,319	-	61,320	61,320	61,320	61,320	61,320	61,320	61,320

STEVE'S STORY SPECIFY THE BASE CASE

With the expanded system boundary, Steve set about defining and specifying the base case.

'We said meeting stormwater guidelines is part of the base case,' remembered Steve, ' So I guess I'll need to look at water sensitive urban design elements, like swales, infiltration trenches, basins, and so on.'

First, Steve prepared a table of the costs of all the base case items for water, wastewater, and stormwater, on the site, and noted the assumptions that went with it:

TABLE 5 BASE CASE COST ITEMS WITHIN BRIDGEWATER DOWNS SYSTEM

Cost Description	Actual Costs 2006 $	Units
Potable reticulation and on-site plumbing	$4500	$/lot
Water using fittings and fixtures	$2000	$/lot
New reservoir	$5M	
Electricity for hot water	$3	$/kL
Gravity sewering	$5500	$/lot
New wastewater mains	$6.8M	
STP upgrade *	$18M	
O&M for STP	$0.4	$/kL
WSUD around each allotment	$2000	$/lot
WSUD for the development	$2500	$/lot
O&M on WSUD	$250	$/lot/yr

*Tertiary plant for 6 ML/day average sewer flow (25,000p) including sludge management and high nutrient removal

New and existing customers serviced by existing STP. The STP requires upgrade in both capacity and quality to tertiary. Other large capital works are sewer mains (9km) within new development, and additional sewer main (1km) from new development to STP as well as a new potable reservoir for the development.

'Now,' thought Steve, 'how do I work out what this means off the site? If I have a look at the base case water balance, that should hopefully tell me?'.

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4.2.2 SPECIFY A BASE CASE

Why?

Specification of a base case is fundamental to the assessment of alternatives on the basis of incremental cost (Principle 5). As alternatives need to be compared against a common reference point, a well-defined base case is essential for a consistent cost analysis, particularly since alternatives may provide significant savings to some elements of the base case e.g., avoiding mains duplication. That is, the base case functions as the starting point for analysis of alternatives.

How?

Specifying your base case means describing the situation that would occur if a 'do nothing' or 'do nothing differently' approach were taken i.e., specifying the system configuration that a minimalist conventional approach would take. You then use the water balance model to model the base case.

If sustainability regulations are in place, then these development controls should be incorporated within the base case. In NSW, for example, BASIX is now mandatory for new residential developments. A study of alternatives for servicing a new suburb in NSW would therefore incorporate BASIX into the base case. This would usually be via having a base case with water efficiency and rain tanks supplying toilet flushing and outdoor water use. See Text Box Four '*Change the Base Case – Change the Incremental Cost*' on page 65 which shows the impact of including BASIX on the incremental cost of alternatives.

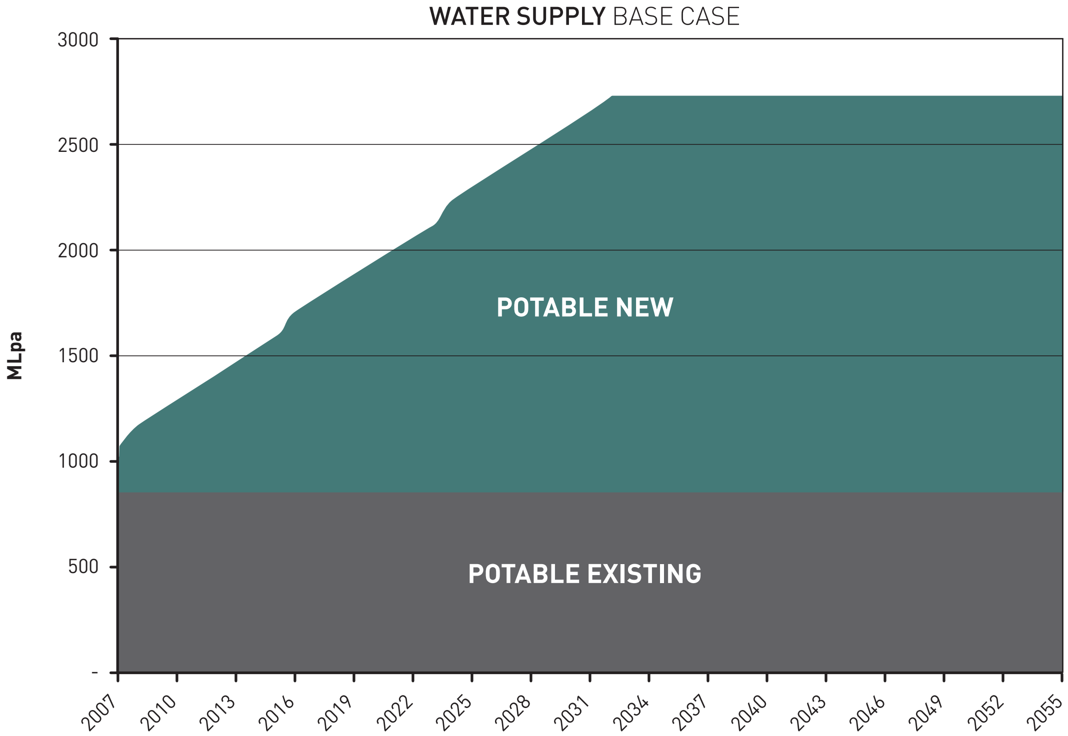
In specifying the base case, the main thing is to identify and specify all actual cost items associated with the project. Then, the avoided costs associated with each alternative configuration can be readily identified (see *'Specify avoided costs and benefits to include'* on page 55). Therefore, you need to identify all the costs that would occur as a result of the development, both within the project area (e.g., gravity sewers, reticulation), and outside the proposed project area (e.g., reservoir duplication).

For those cost items outside the project area, the costs to include will cover two important aspects: the operating costs of the current supply, and wastewater and capacity upgrades in the surrounding urban water system. Capacity upgrades can be either local, such as main duplications or sewer pump stations to service the area, or system wide augmentations represented by marginal cost of supply and the like. Your base case should list all flow-on cost implications in the wider urban water system of your project.

You will also need to consider what type of options you will be including in the study and what costs might be avoided due to these options. Options may provide reductions in potable water demand, or peak demands, or wastewater volumes, or peak storm flows etc. For example, if one option incorporates water use efficiency that also saves hot water (such as AAA rated shower heads), then the customers' impacts for water heating should be specified in the base case. Two specifications will be necessary – the costs and the energy use. Savings on the customers' electricity bills form part of the cost analysis, and the savings on energy related greenhouse emissions forms part of the treatment of externalities (regardless of whether you have decided to incorporate these in the cost analysis).

STEVE'S STORY SPECIFY THE BASE CASE

FIGURE 6 BRIDGEWATER DOWNS OPTIONS STUDY: BASE CASE PROJECTED WATER SUPPLY



→ 'Hmmm. The base case would see potable demand in the Bridgewater supply zone climb to about 2.7 GL per yr from the current 1GL per year or so. That means duplicating mains. And then there's the whole thing about marginal cost of supply – I'm not sure what value to use – think I might give a Geoff a call,' decided Steve.

'So what do I use for the marginal cost of supply now the desal plant is off?' asked Steve.

Geoff replied, 'I guess the Metro demand-supply plan guys will need to work that one out.'

'But don't I need to include it in my study?' asked Steve.

'Yeah, you do. Hang on and let me have a think. Your study is feeding into the Metro plan so .... Oh, I know - it's easy - just use the short run marginal cost. You remember – that's just the water supply opex.'

Geoff continued, 'You see, if your study was not feeding into demand-supply planning then you would use the long run marginal cost figure, which is the short run marginal cost plus the 'marginal capacity cost' to cover the cost of the next lump of supply capacity. But because the Metro plan is trying to work out the next lumps of 'supply capacity', you should just use the short run. Does that all make sense?'

'Yep, thanks mate,' said Steve, 'I reckon we're moving into a time where Metro supply-demand plans will be constantly under review. So that would mean that most studies should include only the short run marginal costs in their analysis and reporting, right? Then studies would just report their net costs and the water savings, so all sorts of alternatives could be compared.'

'You got it,' agreed Geoff.

If both new and existing customers use only metropolitan water supply, this will require duplication of a 10km main into Bridgewater.

TABLE 6 BASE CASE COST ITEMS OFF SITE (I.E. OUTSIDE BRIDGEWATER DOWNS SYSTEM)

Cost Description	Actual Costs 2006 $	Units
Water main duplication	$8M	
Marginal cost of supply (Short run)	$0.3	$/kL

STEVE'S STORY OPTIONS CONSIDERED AND ALTERNATIVE SYSTEMS DEVELOPED

When Steve set out to define a set of options for Bridgewater Downs and Bridgewater, he realised that some options could be undertaken together. So he defined options as specific actions, and used the term 'alternative configurations' to denote different sets of options. As well as a demand management program for the existing township, Steve also considered a wide range of options for the new development, including demand management for water efficiency, a range of other new sources, and different combinations of sources and demands. The options considered are:

- Enhanced water use efficiency in new residential and new commercial. This includes ultra efficient 4.5/3 litre toilets, AAA rated showerheads, 5A rated washing machines.
- Rain tanks plumbed to either toilet and garden or residential hot water
- Small scale recycling with dual reticulation back to new residential
- Large scale recycling via upgrade of existing sewage treatment plant and dual reticulation for new residential and public open space irrigation
- Aquifer storage and recovery (ASR) for public open space irrigation
- Demand management program within the existing town of Bridgewater. Free to customer retrofit program offered to all householders. Includes showerhead, leakage 'tune up', plumber visit, tap aerators and toilet replacement all 'free'. (Assumed uptake rates of 80% for the retrofit with 40% accepting the free 4.5/3 toilets on offer).

Steve thought about whether to include some kind of on-site systems for sewerage, like the American example at the conference, of interceptor tanks on lots, small bore sewers, local secondary or tertiary treatment, and recycling. He was worried about the local Council's stance on the failing septic systems they had already. In the end, he decided to include it because the whole purpose of this options study was to check out alternatives. Even though Bass Water would be unlikely to implement this on such a large scale first time around, Steve reasoned it was worth starting the process of finding out about them. He also decided to give that option a name that wouldn't attract the attention of the Councillors, so he called it 'small scale recycling'.

Using his six options, Steve put together five alternative configurations with a focus on water and sewer. Each alternative configuration was combined with initiatives to meet limits imposed by the new stormwater guidelines.

Steve then developed these configurations within the water balance model to estimate the savings in potable water, relative to the base case for the new development, and put together a summary of the options, the configurations, and the water balance model outcomes, and assumptions in the modelling for his report to the executive.

continued over page →

TABLE 7 OPTIONS, ALTERNATIVE CONFIGURATIONS, AND WATER BALANCE IMPLICATIONS

Options	Configurations 1	2	3	4	5
Efficiency for new residential + new commercial customers	√	√	√	√	√
4.5kL raintanks for all new residential toilet + garden water use		√			
Small scale recycling for new residential toilet + garden water uses*			√		
Aquifer storage + recovery (ASR) for irrigation of public open space (includes a large wetland for stormwater capture + treatment)			√		
Large scale dual reticulation from upgrade of existing sewage treatment plant to all new residential toilet + garden water uses, + public open space irrigation				√	√
3kL rain tanks for all new residential hot water					√
Potable water savings in new development (%)	13%	33%	51%	53%	71%
Demand management program within the existing town of Bridgewater					
Potable water savings compared to base case – new + existing development (%)	13%	25%	36%	38%	49%

* Small scale recycling is based on a modern STEP system - an interceptor tank on each lot for primary settling. Effluent is then pumped to a small treatment plant (for 500 households) by a small bore sewer where it is treated to a tertiary level. It is then micro-filtered, disinfected and returned to households for toilet flushing and outdoor use.

4.2.3 DEFINE A BROAD RANGE OF OPTIONS AND DEVELOP ALTERNATIVE SYSTEM CONFIGURATIONS

Why?
Broadening the range of options considered in a study increases the likelihood of identifying a low cost and a more sustainable solution.

How?
You should consider the full range of available options that could meet the objectives of the study. Conventional options based on centralised urban water systems need to be represented in your study, as well as some of the 'less than usual' suspects. For the latter, keep Principle 2 (*Provide water service outcomes*) in mind, and consider options that provide the same service but with reduced water used (e.g., efficiency) or with different quality of supply (e.g., options that reuse wastewater or capture and (re)use roof water or stormwater). On the wastewater side, appropriate small-scale reuse options will reduce wastewater capacity requirements downstream and should be considered.

Depending on the study objectives, possible options include:

- Water efficient fittings and appliances
- Rain tanks
- Large scale dual reticulation
- Cluster wastewater systems (200-1000 household) based on small bore sewers
- In-building blackwater or greywater reuse
- Onsite wastewater treatment and reuse
- Aquifer storage and retrieval
- Onsite detention and retention stormwater systems.

Once a set of options has been specified, you then bring different sets of them together to create alternative system configurations within your water balance model to meet the study objectives.

Alternative system configurations should be developed based on the water balance with an appropriate level of contingency for factors such as expected populations. Your water balance model will need to be able to account for the implications of different scales, including staging and technology life times of different infrastructures (e.g., distributed and centralised).

You will need to ensure the alternative system configurations of the options are specified to a similar level of detail as the base case. As with the base case, remember to stage the options over time to meet the changes in expected demand for water services.

STEVE'S STORY OPTIONS CONSIDERED AND ALTERNATIVE SYSTEMS DEVELOPED

FIGURE 7 BRIDGEWATER DOWNS OPTIONS STUDY: SMALL SCALE RECYCLING CONFIGURATION PROJECTED WATER DEMAND

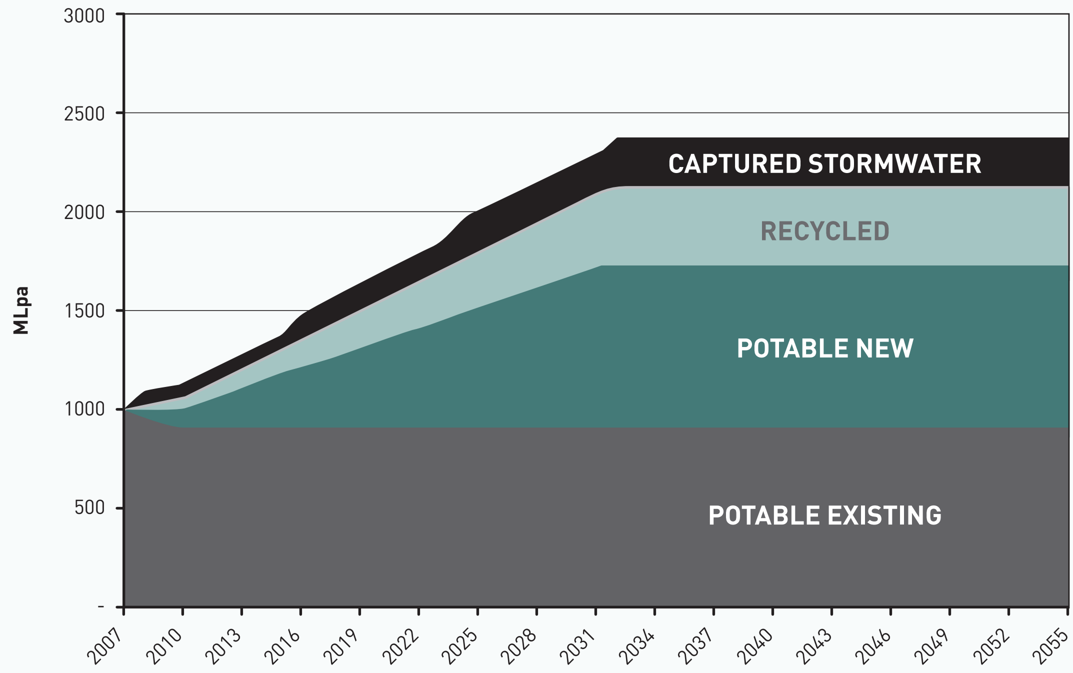
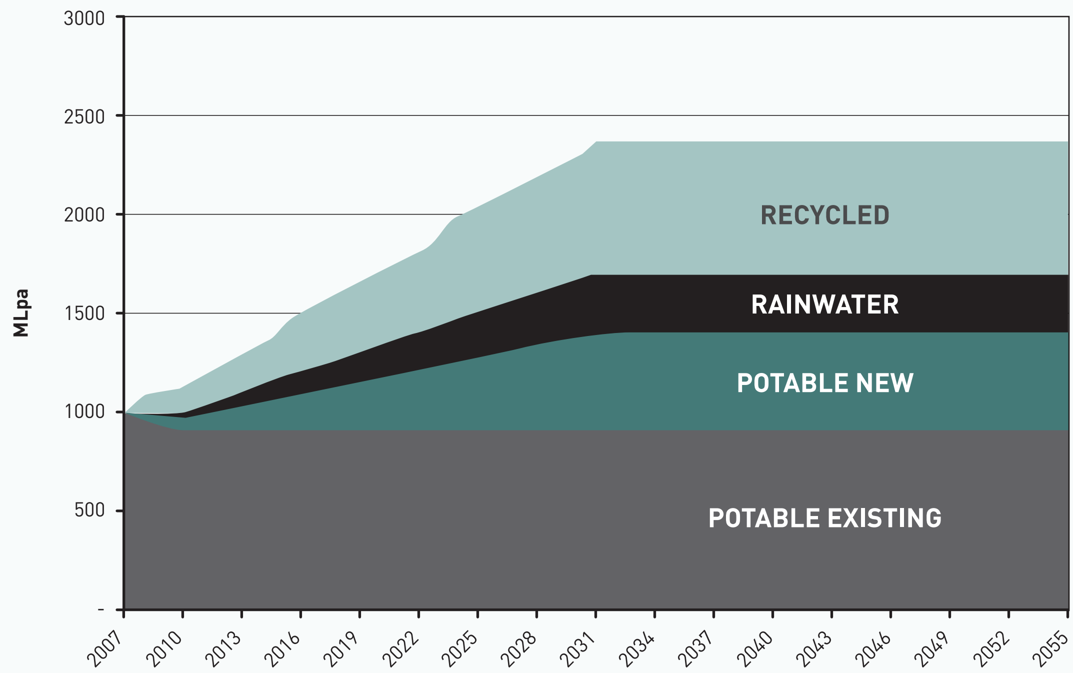


FIGURE 8 BRIDGEWATER DOWNS OPTIONS STUDY: LARGE SCALE RECYCLING AND RAINTANK CONFIGURATION PROJECTED WATER DEMAND



→ The analysis above shows that significant potable water savings are possible across the various configurations. When an expanded system boundary is used i.e. including both Bridgewater and Bridgewater Downs, the overall water savings decrease in percentage terms, but increase in absolute terms, because all configurations include the effect of demand management in the existing community.

A critical question is the availability of rainwater and recycled water i.e. the match between supply and demand.

A daily rainfall raintank model was used to determine the security of supply from the raintanks options. Assuming 4.5kl tank, roof catchment area of 100m^2, toilet demand of 45 l/d, outdoor demand of 110 l/d on average, skewed to summer, the tank met 78% of demand. Assuming a 3kl tank, roof catchment area of 100m^2, and 110 l/d hot water demand, the tank met 95% of demand.

Accounting for the summer peak in outdoor demand, the small scale recycling option met 90% of demand, while the large scale option met 100%, because effluent is sourced from both the new and the existing development.

The water balance model can disaggregate water supply by source. Two configurations are shown by way of example. Firstly, the small scale recycling example shows an overall decrease in demand of around 400MLpa, compared with the base case, at buildout. The impact of the Bridgewater demand management option is clear in the decrease in existing potable demand. The step increases in public open space demand are also clear. The ASR system will supply the public open space irrigation demand, which is about 10% of the total demand at 2380 MLpa. The recycled water for toilets and residential outdoor comprises around 17% of the total demand at 395 MLpa.

Comparing the small scale recycling configuration with the large scale recycling plus raintank hot water configuration, the enhanced potable water savings are clear. The new potable demand is reduced by a further 20% (440 MLpa), and recycling is able to supply around 680 MLpa, or just under 30% of the total demand.

KEY ACTION CHECKLIST:
CHARACTERISING THE STUDY

- ○ A WATER BALANCE MODEL PROJECTING DEMAND FOR URBAN WATER SERVICES ON AN ANNUAL BASIS HAS BEEN DEVELOPED
- ○ AS REQUIRED, DETAILED HYDRAULIC MODELLING OF DESIGN PARAMETERS (STORMWATER DETENTION, PIPE SIZES, RAIN TANKS ETC) HAS BEEN COMPLETED.
- ○ A BASE CASE HAS BEEN DEVELOPED WITHIN THE WATER BALANCE MODEL
- ○ ALL POTENTIAL COST ITEMS ASSOCIATED WITH THE BASE CASE HAVE BEEN COMPREHENSIVELY LISTED
- ○ A BROAD SET OF OPTIONS HAS BEEN DEFINED, AND BROUGHT TOGETHER IN A NUMBER OF ALTERNATIVE SYSTEM CONFIGURATIONS.
- ○ WATER BALANCES FOR ALTERNATIVE SYSTEM CONFIGURATIONS HAVE BEEN MODELLED.
- ○ EACH ALTERNATIVE SYSTEM CONFIGURATION MEETS WATER SERVICE REQUIREMENTS AND FURTHER STUDY OBJECTIVES.

STEVE'S STORY SPECIFY ACTUAL COSTS

Steve was starting to pull together a database of actual costs for each option, organised according to the configuration and the party responsible for the cost.

TABLE 8 OPTION COSTS SPECIFIED FOR BRIDGEWATER DOWNS

Configurations to which costs apply	Whose Cost	Cost Description	Actual Costs 2006 $	Units
1, 2, 3, 4, 5	D	Efficient fixtures (4.5/3L Toilet)	100	$/lot
1, 2, 3, 4, 5	C	Efficient appliances	200	$/lot
2	D	4.5kL raintank installed	3,500	$/hh
3	D	STEP and small bore sewer	5,000	$/hh
3	D	2ML/day wastewater treatment plant	1.75M	$
3, 4, 5	D	Dual reticulation	2,000	$/hh
3	D	150ML/yr ASR site - bores and pumps	200,000	$/site
3	D	Wetland for stormwater capture	1M	$
4, 5	D	Dual reticulation mains	1,000	$/hh
4,5	U	Upgrade STP to recycled water class A	8M	$
5	D	3.0kL raintank installed	2,500	$/hh
1, 2, 3, 4, 5	U	DM management program in existing	50,000	$
1, 2, 3, 4, 5	U	Standard retrofit of existing house (shower, taps, leaks	180	$/hh
1, 2, 3, 4, 5	U	Retrofit 4.5/3 litre toilets	400	$/ hh
2, 5	C	Raintank pump operating expenditure	0.3	$/kL
2, 5	C	Raintank inspection and maintenance	50	$/hh/yr
2, 5	C	Raintank pump replacement every 15yrs	500	$/hh
3	U	Small bore system including WWTPO&M	375	$/hh
3	C	STEP pump opex	25	$/hh
3	LG	ASR site - bores and pumps	0.1	$/kL
4,5	U	Upgrade STP to recycled water class A	200	$/ML
Transfer payment costs				
1, 2, 3, 4, 5	U	Price of water for reduced sales/purchases	1	$/kL
3, 4, 5	C	Price of recycled water	0.7	$/kL

All cost estimates are in 2006$. A margin of error +/-10% will be tested for all costs.
U: utility; D: developer; C: customer; LG: local government

The basic assumptions in allocating these costs is that developers are responsible for all infrastructure, fittings, and appliances within the new development site, including raintanks, dual plumbing and reticulation, small scale sewage treatment plants, and ASR capital expenditure. Customers are responsible for the costs of maintenance of systems on their lot, such as rain tanks and interceptor tanks. Bass Water is responsible for costs associated with implementing demand management programs in the existing area, and for upgrades to infrastructure required by the base case, such as increasing the capacity and standard of the existing sewage treatment plant. Land purchase costs for infrastructure are not included because although land requirements vary significantly between options, Bass Water has adequate land holdings in the area.

Transfer payments are introduced for the financial analysis from utility and customer perspectives. These payments are the price of potable and recycled water as charged to the customer. The price of potable water is a 'cost' to the utility in the form of foregone revenue for alternatives that save potable water relative to the base case. The price of recycled water is the corresponding cost to the customer for some of this water.

Importantly, by definition, transfer payments are excluded from the analysis from the whole-of-society cost perspective.

There are other transfer payments, including developer charges and customer wastewater charges. However, because both of these are currently flat fee arrangements for Bass Water, they do not vary between the base case and the alternatives and so do not show up in the analysis.

Step 3

4.3. IDENTIFYING AND SPECIFYING COSTS AND AVOIDED COSTS

The third stage in a cost analysis for sustainable water outcomes involves the identification and specification of actual costs, avoided costs, and externalities associated with each option under consideration. This stage of the process also involves determining who will incur or receive the various costs, the timing of costs, and the level of contingency or uncertainty associated with the data used.

4.3.1 SPECIFY COSTS TO INCLUDE

Why?
A meaningful cost analysis is only possible once all the actual costs associated with each option have been clearly specified.

How?
As described above, each alternative system configuration is comprised of various options. To specify costs, you focus on each individual option in turn and identify the costs associated with it, including both capital and operating costs. The outputs from your water balance model will help here with, for example, sizing of components, timing of upgrades, etc.

Aligned with Principle 5 (*Assess on the basis of incremental cost*), you should measure costs relative to the base case - if there is no difference, there is no cost. Further, in general, only future costs should be included in the analysis. If the money has already been spent, it is a sunk cost, and you should exclude it from the analysis. The only exemption is in the case of specific assets, such as existing land holdings, that are already owned and if not used for a project could be sold or used for another purpose. In these cases the potential 'value' of these assets for their alternative purpose should be included as a cost in the analysis

As well as magnitude, costs have three further dimensions that need to be specified. Firstly, who will incur the cost; secondly, when the cost will be incurred; and thirdly, your level of certainty in the cost estimate.

For costing studies of urban water, 'who will pay for particular costs?' is an important question that you need to ask for each cost element. The value of assigning costs (and avoided costs) to particular parties is illustrated in Steve's story, where the costs are reanalysed from the perspective of the utility, developer and customer.

Considering 'who pays' in relation to individual options can act as a trigger to remember costs that might otherwise have been forgotten, for example, the operation and maintenance costs of rain tanks that fall to the consumer are easy to miss in a cost analysis that fails to think about different cost perspectives.

In line with Principle 7 (*Account for the time value of money*), all cost estimates are time dependent and all costs are considered to exist in a given year. As part of framing your analysis you should have already established your intent to conduct the analysis in real or nominal terms and accounted for this in the discount rate (see '*Define key economic parameters*' on page 35). Costs then should be specified as either real or nominal. Real and nominal costs cannot be mixed. Real costs are specified in constant dollar terms and exclude a nominal increase due to inflation if incurred in later years.

If the analysis is in real terms (as is most common), you may still need to adjust some cost estimates from older sources to the current/constant year. This involves re-estimating costs accounting for any increase that has occurred since that time. This is particularly important when using older studies for your cost data or when cost estimating manuals are several years out of date. When finalised, costs should be described as being of a certain year e.g., the estimated cost of an ASR pump is $45,000 (2006 $).

You should specify the level of uncertainty in your cost estimates (see Principle 8 '*Acknowledge and manage precision and uncertainty*'). A common approach is to allow for a fixed contingency margin on capital and another on operating costs. Both of these vary with the stage of design. Of course, different options have different risks and different levels of certainty in estimates, and so should have different contingency estimates. Uncertainty in cost estimates can also be expressed using appropriate significant figures or error bands. At this point in the analysis, all you need to do is to record any contingency included and the margin of error. Keep in mind that different levels of certainty will be acceptable for different decision stages and scales of expenditure.

Many utilities and consulting organisations will have cost estimating manuals as a primary source of cost data. Not all analysts will have this resource and so may need to look at previous studies or contact technology distributors to source costs.

STEVE'S STORY SPECIFY AVOIDED COSTS

By considering the base case costs previously determined, Steve was able to identify which could be completely avoided and which could be reduced through downsizing the infrastructure required.

Steve worked through each of the alternative configurations separating the costs into those that were fully avoided and those that could be reduced, producing tables and explanations for his report.

TABLE 9 FULLY AVOIDED COSTS SPECIFIED FOR BRIDGEWATER DEVELOPMENT

Configurations to which avoided costs apply	Whose Avoided Cost	Avoided Cost Description	Avoided Costs 2006 $	Units
1, 2, 3, 4, 5	U	Marginal cost of supply (Short run)	0.3	$/kL
1, 2, 3, 4, 5	C	Electricity for hot water	3.0	$/kL
1, 2, 3, 4, 5	U	O&M for sewage treatment plant	0.4	$/kL
3	D	Gravity sewering	5500	$/lot
3	D	New wastewater mains	6.8M	$
3	U	Existing STP upgrade	18M	$
5	U	Main duplication	8M	$

TABLE 10 DOWNSIZING AVOIDED COSTS SPECIFIED FOR BRIDGEWATER DEVELOPMENT

Configurations to which avoided costs apply	Whose Avoided Cost	Avoided Cost Description	Base Case Cost 2006 $	Revised Cost 2006 $	Units
2,5	D	Stormwater at allotment scale	2000	1000	$/lot
3	D	Stormwater at development scale	2500	2000	$/lot
3,4	U	Mains duplication	8M	6M	$
3, 4, 5	U	New reservoir	5M	3M	$

AVOIDED COSTS

Configuration 1 (Efficiency only) would give marginal cost of supply savings to Bass Water and hot water energy cost savings to customers.

Configuration 2 (4.5kL Raintanks for outdoor and toilet) provides savings to the developer because of reduced need for stormwater elements at the allotment scale.

Configuration 3 (Small scale recycling and ASR) avoids all the base case sewerage costs (gravity sewering, sewerage mains, and upgrade of existing STP). The ASR component abrogates much of the base case development scale costs for stormwater management to meet the new guidelines.

All configurations with recycled water would have lower peak day potable demands, so the size of the new supply reservoir can be downgraded. Further, the supply main duplication can be completely avoided with configuration 5 (recycled water and raintanks for hot water) and downsized with the other recycled water options.

These downsizings are not possible with the rain tank only configuration because unlike the recycled water, the raintank supply is not secure (i.e. there will be peak days when there is no water in the rain tanks).

It should be noted that there can be no down-sizing of the potable reticulation network within the new development as it is sized for fire-fighting requirements (local fire-fighters are yet to be convinced to use recycled water). →

4.3.2 SPECIFY AVOIDED COSTS AND BENEFITS TO INCLUDE

Why?
Clear specification of system wide and local-area avoided costs and other benefits ensures their inclusion in the cost analysis. Sustainable urban water initiatives, e.g., rain tanks or in-building reuse schemes, often cost more than the base case for a particular site but also save money elsewhere in the urban water system, for example by deferring an upgrade and/or augmentation in the sewage collection and treatment system. You are looking for these savings in this step.

How?
When you identify avoided costs, you will need to consider both individual options and the alternative system configuration developed in the previous stage. You will also need to consider capital costs (e.g., changes in timing of augmentations, staging, downsizing etc.), operating costs (e.g., marginal reductions due to reductions in the volumes of water or sewage treated, distributed or collected or disposed), and perhaps even decommissioning costs.

Working your way methodically through each individual option in turn will help identify certain avoided costs, particularly savings in operating cost associated with supplying urban water services under the base case. The example of AAA rated showerheads saving customers' hot water costs, illustrates this. Similarly, all options that reduce wastewater volumes (water efficiency or on-site effluent reuse) will avoid some of the operating costs of wastewater treatment.

If you then consider the alternative system configuration, you may identify capital cost implications within the surrounding urban water system. For instance, some configurations may mean various planned capital augmentations could be downsized, deferred or completely averted. You should look to identify costs associated with both local area augmentation (local pump stations, mains) and system wide implications (the marginal cost of water supply and depending on location, wastewater treatment).

As with actual costs, avoided costs represent a change relative to the base case and as you consider the options and system configurations in detail, you will likely need to return to the base case specification to include extra costs there.

Also in the same manner as actual costs, for all avoided cost estimates you will need to specify 'who benefits', the level of contingency, and the timing.

Some changes in the operating environment of water utilities have a significant effect on the base case. A common example just now is the introduction of new legislation that specifies extensive reductions in water use in all new homes (see *Text Box Four* on page 65).

TRANSFER PAYMENTS

As with the avoided cost specification, transfer payments need to be specified for the financial analyses from the various cost perspectives. These are reduced potable water bills, which are a benefit to customers and increased recycled water sales, which are a benefit to the utility. The transfer payments are a function of the volumes of potable and recycled water supplied, and so differ between configurations.

TABLE 11 TRANSFER PAYMENTS BETWEEN PARTIES IN THE BRIDGEWATER DOWNS DEVELOPMENT

Configurations to which charges apply	Who benefits from change in charges	Charge Description	Base Case Cost 2006 $	Units
1, 2, 3, 4, 5	C	Price of water for reduced sales/purchases	1	$/kL
3, 4, 5	U	Price of recycled water for increased sales/purchases	0.7	$/kL

STEVE'S STORY SPECIFY EXTERNALITIES

Steve had decided that the best way to deal with greenhouse gas emissions was to go with an actual dollar value. Geoff advised him to simply have a look on the web at the European Carbon Market (www.carbonpoint.com.uk) and take an average of the trade values over the last 12 months. He came up with a figure of $25/ton of carbon dioxide.

The next step was to estimate the greenhouse gas emissions associated with each option and each configuration, and go through a process a bit like with avoided costs. Steve realised he needed to build an energy balance model – like the water balance model. Steve put together another little database, and the key assumptions for his report.

TABLE 12 ENERGY BALANCE AND GREENHOUSE ASSUMPTIONS

Option / Configuration / Element	Value	Units
Rain tank pump	3	kWhr/kL
Large scale recycling	2	kWhr/kL
Small scale recycling	3	kWhr/kL
ASR	0.5	kWhr/kL
Potable supply	0.3	kWhr/kL
Sewage collection and treatment	0.5	kWhr/kL
Hot water by customer *	30	kWhr/kL
Energy related emissions	1	ton CO_2/MWhr
Value of greenhouse emissions	25	$/ton CO_2

* This figure assumes all hot water is heated using electricity from Bass grid.

These energy intensity figures are rough estimates from a variety of sources.

These energy use figures are linked to the water balance for each configuration. The incremental energy is then estimated relative to the base case. An extract from the energy balance model is provided below for Configuration 5 (Large scale recycling plus rain tanks for hot water) to show how this was done.

TABLE 13 EXTRACT FROM ENERGY BALANCE MODEL FOR CONFIGURATION 5

Energy (MWhr) **Additional**	**PV**	**2,007**	**2,008**	**2,009**	**2,010**	**2,011**	**2,012**	**2,013**	**2,014**
Rain tank pump	5483	-	37	74	110	147	183	219	256
Large scale recycling	8737	-	159	195	231	267	303	339	375
Small scale recycling	-	-	-	-	-	-	-	-	-
ASR	-	-	-	-	-	-	-	-	-
sub -total	14219	-	196	269	341	414	487	559	631
Conventional									
Potable supply	4732	303	300	297	294	300	306	311	317
Sewer and WWT	7484	343	362	380	398	417	435	453	471
hot water by customer	184323	9,406	9,783	10,158	10,533	10,907	11,279	11,651	12,021
total	210758								
Base case									
Potable supply	7,424	312	348	365	383	400	417	435	452
Sewer and WWT	9,074	412	434	457	480	502	524	547	569
Customers hot water	200,992	9,509	9,988	10,467	10,944	11,420	11,895	12,368	12,841
total	217490								
Net	**6732**								

To convert the present value of energy use to a dollar value, a conversion figure between MWhr and tons of carbon dioxide is required. For electricity generation in eastern Australia, this figure is roughly one. So, the value of the greenhouse emissions is simply calculated by the equation:

(PV Energy Use MWhr) x tons CO_2/MWhr x $/ton CO_2 = 6732 x 1 x 25 = $168,300

→

4.3.3 SPECIFY AND QUANTIFY EXTERNALITIES

Why?

Historically, externalities have been ignored. Sustainable water outcomes require us to acknowledge externalities, and to be clear about how we are treating them. In this step, you will quantify the extent of the externalities you have decided to include within the cost analysis.

How?

Earlier in the analysis ('*Determine the treatment of externalities*' on page 37), you determined which externalities were deemed significant to your costing study, and how they were to be treated.

In this step, you need to specify which of your externalities are relevant to which options, and quantify those externalities that are to be incorporated in the analysis as monetary values.

If you have decided not to monetise externalities, this step will simply involve specifying which externalities are relevant to which options and to what extent. Those externalities you have decided not to monetise should be treated separately, and require explicit reporting in the documentation of the cost analysis for sustainable water outcomes (See '*Document the analysis*' on page 71).

Externalities to which dollar values are to be assigned need first to be quantified i.e. you will need to estimate the scale and timing of the impact. Analogous to the cost analysis, externalities can be estimated in absolute terms or as an incremental value relative to the base case.

Greenhouse gas emissions are probably the most commonly included externality value in cost analyses of urban water. In a similar way to specifying costs and avoided costs, in relation to the water balance of various alternatives, this requires a quantification of energy use and energy savings by the alternative system configurations. From this energy balance, you can infer the scale of greenhouse implications based on the source of the energy use, and then assign monetary values to the projected emissions. This process is demonstrated in 'Steve's story'.

STEVE'S STORY SPECIFY EXTERNALITIES

→The greenhouse gas emissions avoided over a 50 year period for the alternative configurations are shown below in Table 14

TABLE 14 PROJECTED GHG EMISSIONS AVOIDED OVER 50 YEARS

Configuration	Avoided CO_2 equivalent	
Config 1 (Efficiency & DM)	108	MT
Config 2 (Efficiency, Raintanks &DM)	72	MT
Config 3 (Efficiency, Small-scale recycling &DM)	79	MT
Config 4 (Efficiency, Large-scale recycling &DM)	63	MT
Config 5 (Efficiency, Large-scale recycling, raintanks for HW & DM)	32	MT

KEY ACTION CHECKLIST:
IDENITIFYING AND SPECIFYING COSTS AND AVOIDED COSTS

- ○ ALL COSTS ASSOCIATED WITH EACH OPTION HAVE BEEN SPECIFIED
- ○ ALL AVOIDED COSTS ASSOCIATED WITH EACH OPTION HAVE BEEN SPECIFIED
- ○ ALL COSTS AND AVOIDED COSTS HAVE BEEN ADJUSTED TO THE CORRECT YEAR (WHETHER REAL OR NOMINAL) AND SPECIFIED IN TERMS OF A SPECIFIC YEAR I.E. $15,000 IN 2006 DOLLARS
- ○ ALL COSTS AND AVOIDED COSTS INCLUDE ANSWERS TO THE QUESTION 'WHO PAYS?' OR 'WHO BENEFITS?'
- ○ ALL COSTS AND AVOIDED COSTS HAVE APPROPRIATE LEVEL OF CONTINGENCY/UNCERTAINTY SPECIFIED
- ○ SIGNIFICANT EXTERNALITIES ASSOCIATED WITH EACH OPTION HAVE BEEN SPECIFIED
- ○ ESTIMATIONS OF MONETARY VALUES HAVE BEEN MADE FOR QUANTIFIABLE EXTERNALITIES

STEVE'S STORY ANALYSING AND REPORTING INCREMENTAL COSTS

Steve could see the story starting to come together. He reckoned he had all the pieces of the jigsaw ready to go. He built a cost model to bring it all together, and prepared the next section of his report for the executive.

COSTING THE OPTIONS AND CONFIGURATIONS

A cost model was developed. The table below is an extract from the cost model, showing costs and avoided costs by party. Some salient features are explained below.

TABLE 15 EXTRACT SHOWING COST PARTITIONING FOR CONFIGURATION 3 (SMALL SCALE RECYCLING AND ASR)

line			NPV	2007	2008	2009
	Developer					
1	**Costs**					
2	E	Efficient fittings Res	$800,000	$33,000	$33,000	$33,000
3	E	Efficient fittings Non Res	$12,500	$500	$500	$500
4	SSR	Recycling reticulation	$16,000,000	$660,000	$660,000	$660,000
5	SSR	STEP and small bore sewer	$40,000,000	$1,650,000	$1,650,000	$1,650,000
6	SSR	Small scale wastewater treatment	$28,000,000	$1,750,000	$-	$1,750,000
7	ASR	ASR CAPEX	$1,800,000	$200,000	$-	$-
8	ASR	wetlands	$1,000,000	$1,000,000		
9	**Avoided**					
10	SSR	Avoided WSUD in development	$4,000,000	$165,000	$165,000	$165,000
11	SSR	Avoided Gravity Sewer	$44,000,000	$1,815,000	$1,815,000	$1,815,000
12	SSR	Avoided WW mains	$6,800,000	$6,800,000		
13	**Utility**					
14	**Costs**					
15	DM	Cost for program	$1,722,000	$430,500	$430,500	$430,500
16	SSR	STEP + small WWT O & M Costs	$115,125,000	$-	$123,750	$247,500
17	**Avoided**					
18		Avoided water OPEX	$11,717,030	$9,540	$45,034	$62,132
19		Avoided WWT OPEX	$20,066,880	$54,417	$72,939	$91,461
20	SSR	Avoided WWT upgrade	$18,000,000	$18,000,000		
21	SSR	downsize supply main	$2,000,000	$2,000,000		
22	SSR	downsize reservior	$2,000,000	$2,000,000		
23	**Customer**					
24	**Costs**					
25	E	Extra cost of eff appliances	$1,600,000	0	$66,000	$66,000
26	SSR	STEP Opex Costs	$3,675,000	$-	$8,250	$16,500
27	**Avoided**					
28	E	Avoided cost of hot water	$4,829,423	$10,282	$20,564	$30,846
29	DM	Avoided cost of hot water	$3,942,133	$127,166	$127,166	$127,166
30	**Council**					
31	**Costs**					
32	ASR	ASR OPEX	$220,752	$-	$3,066	$3,066
33	**Transfers**					
34		Price of potable	$19,390,081	$31,801	$150,113	$207,106
35		Price of recycling	$10,612,494	$-	$11,408	$22,815

Step 4

4.4.
ANALYSING AND REPORTING INCREMENTAL COSTS

4.4.1
COMPARE CONFIGURATIONS AND OPTIONS USING DISCOUNTED CASH FLOW ANALYSIS

Why?
The aim of this cost analysis process for sustainable water outcomes is to compare the costs and benefits of alternative configurations. In this step, you bring together all the specified costs into a net present value to do just that, in line with the cost perspectives you adopted, and your chosen period of analysis and discount rate

How?
The analysis of costs will be in line with Principle 5 (*Assess on the basis of incremental cost*) and Principle 7 (*Account for the time value of money*) with alternative system configurations compared in terms of the present value of costs relative to the base case.

To conduct the analysis you need to develop a cost model: a basic spreadsheet is usually sufficient. In most cases, this model will be an extension of the water balance model developed earlier.

For each alternative system configuration, you will need to include the costs, avoided costs and monetised externalities you have already specified, now scheduled in a manner that is consistent with the water balance. Cost scheduling should be as realistic as practical, accounting for option staging and the time required to build options. An obvious example is that if a system configuration includes a new sewage treatment plant, then this plant will have to be in place before sewage volumes can flow to it.

The costing model should also link to changes in the water balance, for example, each year, potable water saved relative to the base case should come through into the cost model as an avoided cost.

Once option costs and benefits have been scheduled over time, you can calculate net present value.

Costs should be analysed from the cost perspectives you determined previously. For example, the utility cost perspective will bring together all utility costs and avoided costs.

The whole-of-society perspective is a little more complex than other perspectives. To build it up you will need to include the costs from each of the significant parties (water authority, developer, and customer perspectives) and include externalities. The main difference with analyses from individual cost perspectives is that you will also need to make sure to exclude payments passing between major agents (e.g., customer bills and developer contributions).

You should pay attention to the period of analysis, and make sure it is consistent across all configurations. You should also make sure the contingency/uncertainty associated with a particular cost is carried through all the calculations associated with that cost.

→ Configuration costs have been sequenced over time so that infrastructure will be available to meet demand. In all cases, infrastructure is assumed to be built the year before it is first used. The first households are expected in the new development in 2008.

Centralised infrastructure such as the wetland for ASR (line 8) must therefore be built in the first year. In contrast, decentralised infrastructure can be spread over time. For example, line 6 shows small-scale sewage treatment plants built in 2007 and 2009 (also 2010, 2012, 2013 etc) these correspond to the rate of growth in the development (330 households per year). In all, 16 small WWT plants will be built over time. Network infrastructure such as recycled water reticulation (line 4) can also be built as the development occurs.

Line 15 shows the demand management program in the existing community running over 4 years. Operating costs (lines 16, 18, 19 and 26) and the price of potable and recycled water (lines 34 and 35) are linked directly to the water balance.

FULLY COSTED BASE CASE
A full costing of the base case provides a starting point for the incremental cost comparisons of alternative configurations and allows the results to be considered in both absolute and relative terms.

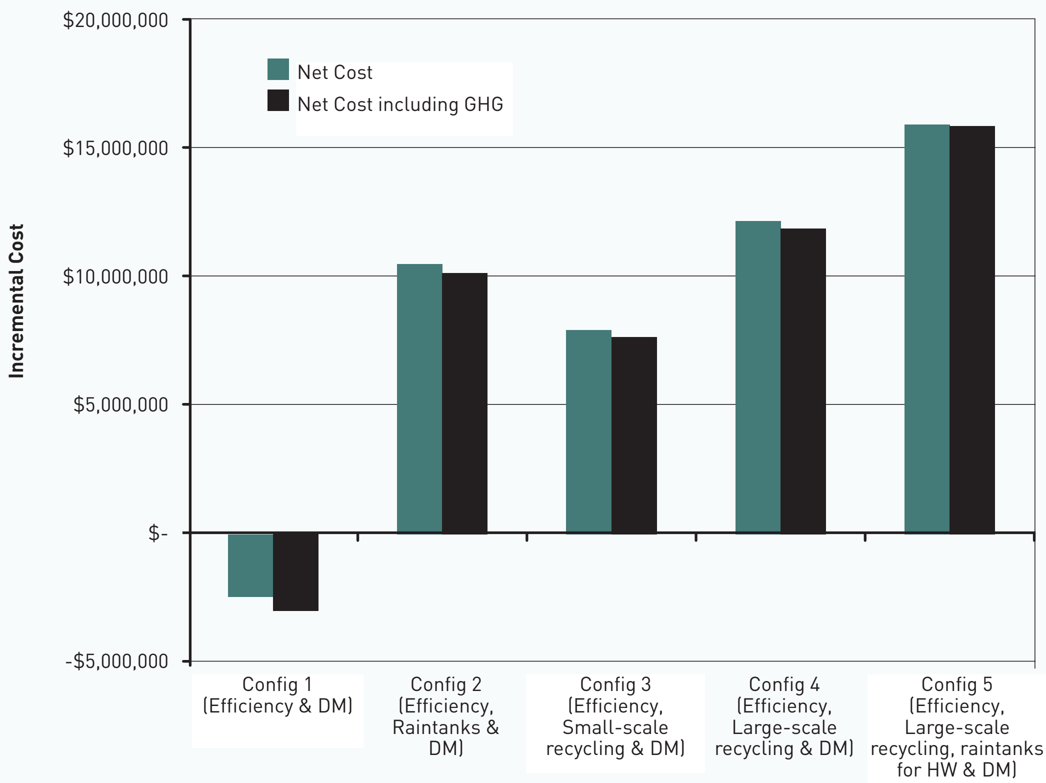
The base case for Bridgewater Downs is expected to cost $114.8M (2006$) excluding the cost of hotwater to customers ($22M).

STEVE'S STORY ANALYSING AND REPORTING INCREMENTAL COST

INCREMENTAL COSTS OF ALTERNATIVE CONFIGURATIONS

The results of the cost analysis for Bridgewater Downs are shown below. All configurations include demand management in the existing community, and provisions to meet the new stormwater and recycling guidelines. The cost analyses include all costs and avoided costs relative to the base case. That is, the graph shows the incremental costs of each configuration, relative to the base case, including and excluding the value of greenhouse gas emissions associated with each configuration.

FIGURE 9 INCREMENTAL COSTS OF ALTERNATIVE CONFIGURATIONS



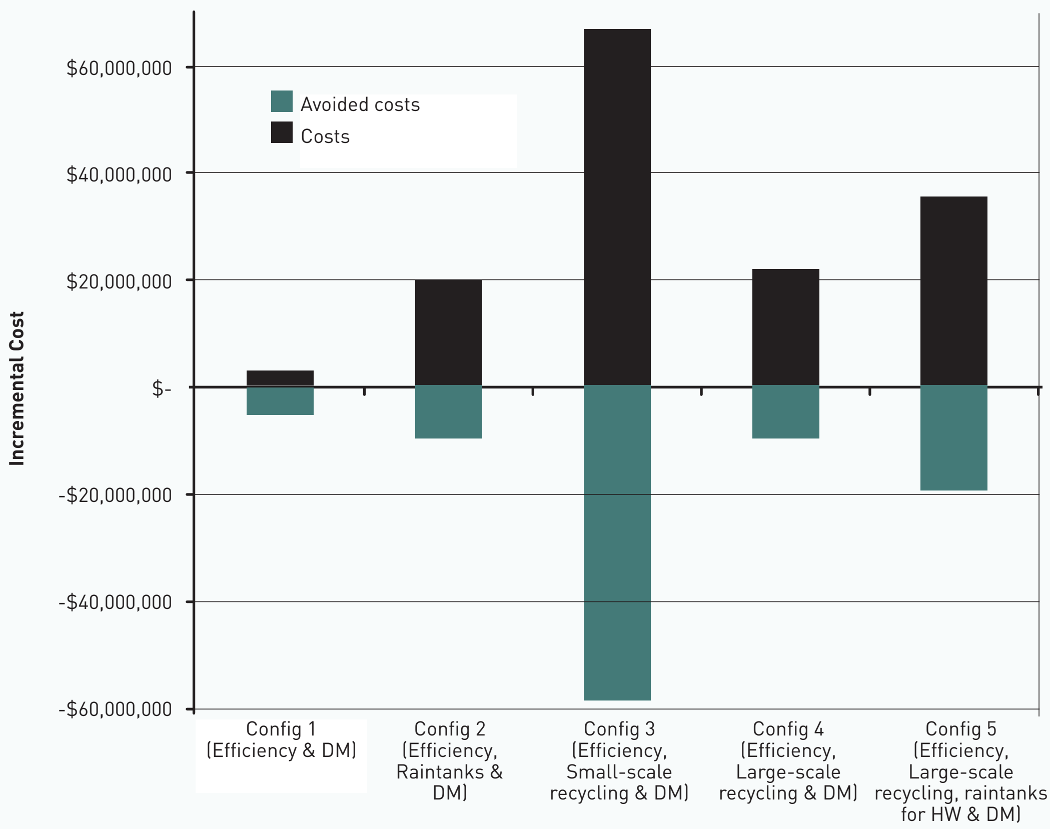
The results show that only Configuration 1 (Efficiency & DM) costs less than base case and all other alternatives are an incremental cost above the base case.

The small scale recycling configuration has the lowest incremental cost of the remaining configurations.

The results also show that including greenhouse gas (GHG) emissions at a value of $25/ton of CO_2 has a small impact. The most significant source of greenhouse gas avoidance is the customer energy savings associated with reduced hot water use through efficient showerheads. Net GHG impacts from other options are small.

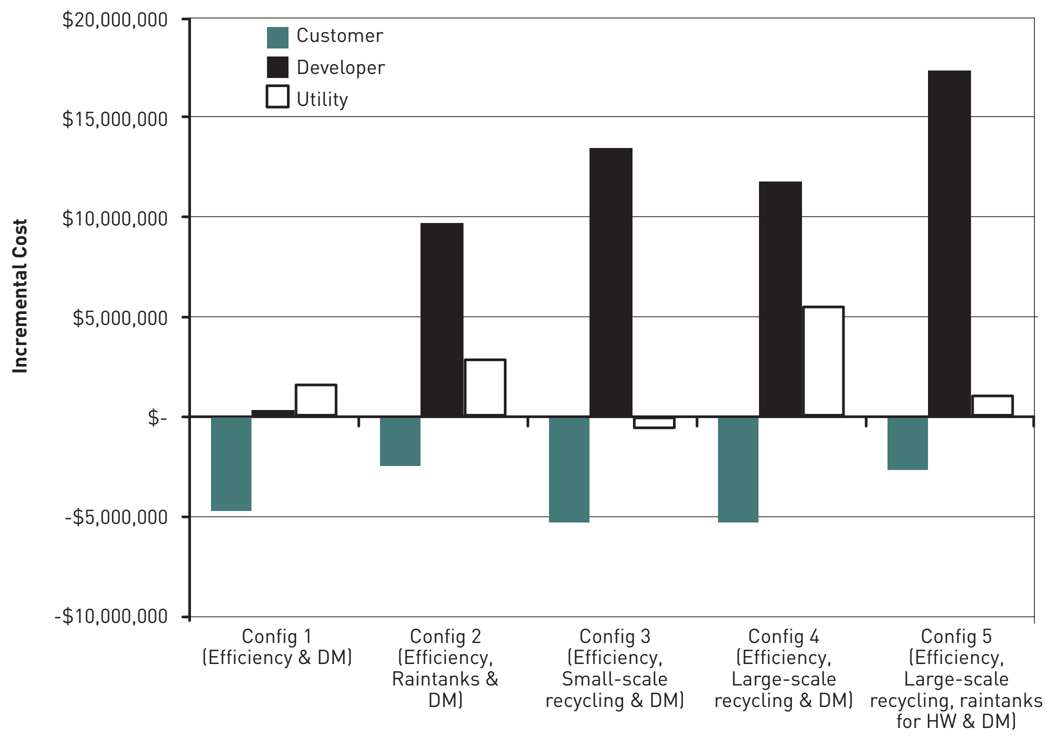
FULL COSTS OF ALTERNATIVE CONFIGURATIONS
Another way to analyse the costs is to consider both the costs and avoided costs associated with each alternative configuration, relative to the base case. The figure below shows the results of this analysis. Note the change in scale in the vertical axis from the previous figure. Two things are evident here. Firstly, this figure shows that the additional costs (i.e. the increase in cost relative to the base case) for Configuration 2 (raintanks only) are slightly lower than any other of the configurations with alternative sources. Secondly, although Configuration 3 (small scale recycling and ASR) has high additional costs, the additional avoided costs are also high, so the incremental costs over the base case are lowest for this alternative, of all the source substitution alternatives.

FIGURE 10 COSTS AND AVOIDED COSTS OF ALTERNATIVE CONFIGURATIONS, INCLUDING GHG



STEVE'S STORY ANALYSING AND REPORTING INCREMENTAL COST

FIGURE 11 INCREMENTAL COSTS OF ALTERNATIVE CONFIGURATIONS (INCLUDING DEMAND MANAGEMENT IN THE EXISTING COMMUNITY, MEETING STORMWATER GOALS) FROM THE DEVELOPER, CUSTOMER AND BASS WATER COST PERSPECTIVES



This figure shows the incremental costs apportioned to the major cost perspectives of the Bass Water, the developer, and our customers. These incremental costs include transfer payments in the form of the price of potable and recycled water.

In all configurations, the customers have reduced costs. In all source substitution configurations (2 – 5), developers experience increased costs because we assume they take responsibility for meeting the costs associated with infrastructure within the development.

Interestingly the small scale recycling configuration is slightly financially beneficial to the utility relative to the base case. This is even after the foregone revenue from water sales are accounted for. The reason for this is that small scale recycling shifts the capital cost of sewage treatment from the utility onto the developer.

This analysis raises the question of whether, to what extent, and how, to redistribute costs and benefits when different configurations are considered.

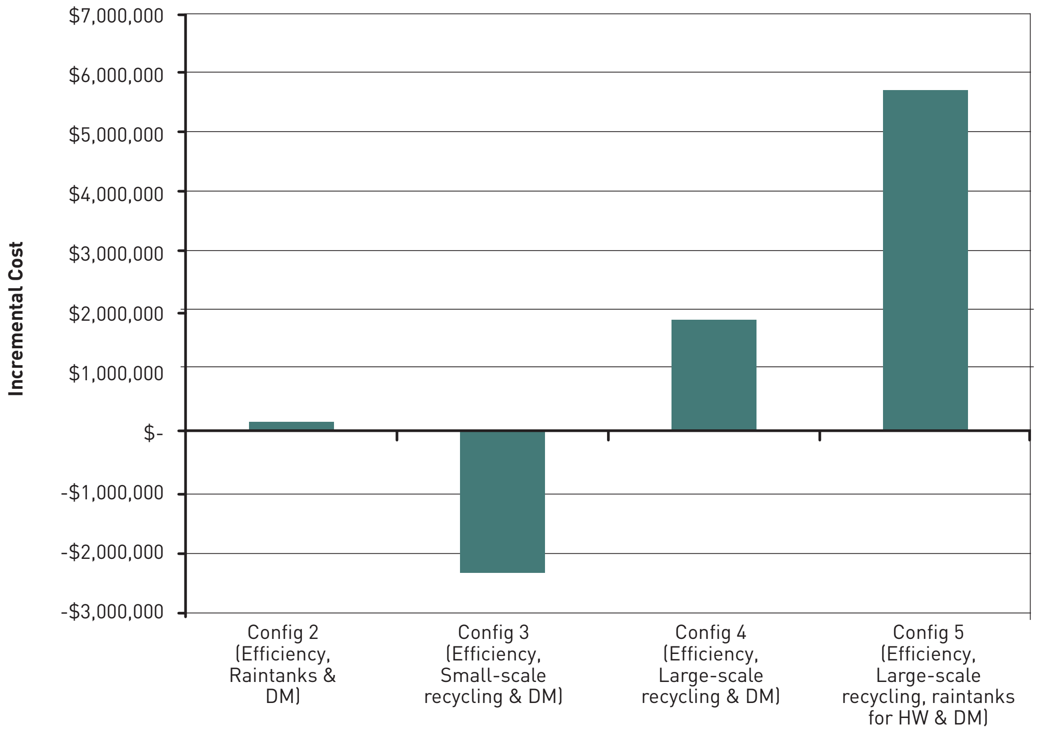
Text Box Four
Change the Base Case – Change the Incremental Cost

Incremental costs are assessed relative to a base case. In Steve's story, the base case definition assumed that while there was a strong driver towards conservation of potable supplies there was no Government regulation enforcing a level of the water conservation within new developments. In NSW, the recent introduction of BASIX (Building Sustainability Index) means that all new freestanding residential dwellings built in NSW must reduce water consumption by 40% compared to current household averages.

This State Government regulation effectively means that new developments without access to a dual reticulated secondary supply must have water efficiency measures and rain tanks for toilets and gardens to gain planning approval. In NSW, rain tanks and efficiency measures should therefore be considered as base case for new residences. Regulation such as BASIX that significantly changes the base case will have a major impact on the incremental cost of alternatives. This is illustrated in Figure 12 below where the incremental costs of the three recycled water configurations in Steve's story are assessed against a base case which includes BASIX. In this situation, the costs look quite different because the rain tanks become avoided costs. The figure illustrates how the same costs with an altered base case can appear to tell a different story; in this case that the small-scale recycling option represents a lower cost than the base case.

FIGURE 12 COMPARISON OF INCREMENTAL COST OF ALTERATIVE CONFIGURATIONS WITH AND WITHOUT BASIX REGULATION (WITH DEMAND MANAGEMENT (DM) IN EXISTING COMMUNITY AND MEETING STORMWATER GOALS)

If Steve were conducting his study with BASIX in place, he would also need to account for this in the water saving results he reported, so he could report only savings beyond those expected from BASIX.



STEVE'S STORY UNCERTAINTY AND SENSITIVITY ANALYSIS

Steve continues to make his way through the guidebook. Now that he's done the cost analysis he needs to do a sensitivity analysis. His boss, Sally, is worried about Bass Water not being a guinea pig, and is concerned about how risky the cost estimates are for new servicing arrangements. Steve knows Sally and the executive will be looking closely at this part of his report. Steve has heard about Monte Carlo analysis, but he doesn't really know what it means – another question for Geoff, but there's no golf this weekend because the cricket season has started for Steve's son. Instead, Geoff joins Steve at the game.

'So, what's the difference between Monte Carlo simulations and what I can do by hand in a spreadsheet?' Steve asked while they watched his son batting.

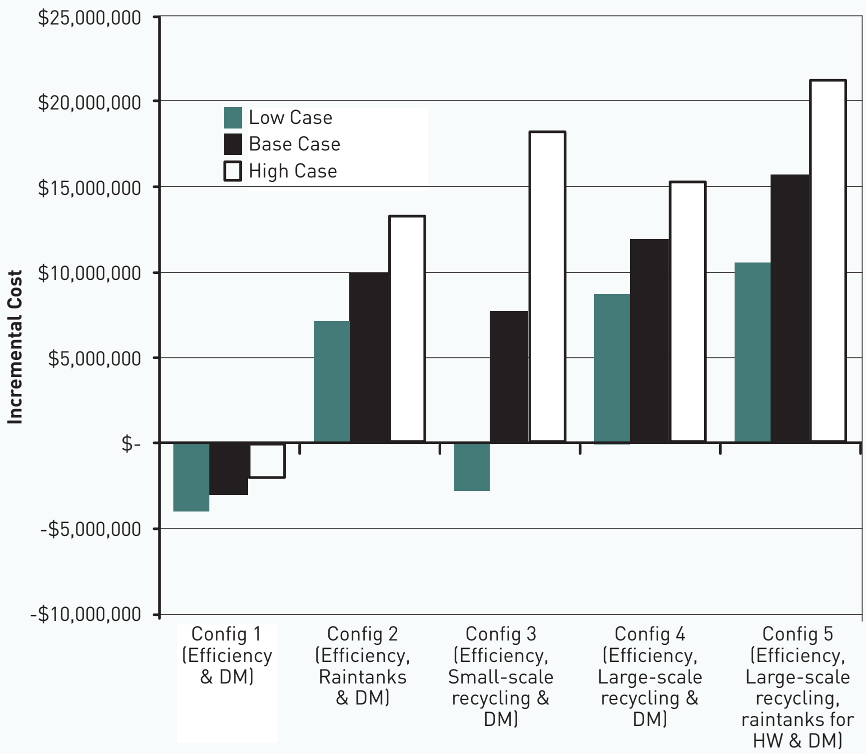
'In a spreadsheet, what they usually do is look at the impact of increasing or decreasing the important variables.' Geoff explained, 'and you might do that for just a few variables. If you're being really systematic, then you might look at combinations of changes in key variables – say what if the population increases more rapidly and the drought doesn't break. Basically, Monte Carlo does a similar thing, in a more sophisticated way. So instead of specifying values, you specify the probability of a range of values for a key variable. You can also specify how key variables affect each other. So the output is a bit more complex. For what you're doing, and the stage you're at, I reckon simply testing different figures in a spreadsheet is better because it's easier to see how your big assumptions play out.'

UNCERTAINTY AND SENSITIVITY ANALYSIS.
In a costing study such as this, there are many unknowns. Sensitivity analyses are the best means of dealing with these. This section reports on sensitivity analyses conducted across all configurations for the key parameters of cost estimates, growth rate and discount rate.

SENSITIVITY FOR COST UNCERTAINTIES.
Cost and avoided cost estimates, including estimates for GHG, were tested at +/-10%.

FIGURE 13 SENSITIVITY TO COST AND AVOIDED COST ESTIMATES (+/-10%): INCREMENTAL COST OF ALTERNATIVES (WITH DM IN EXISTING AND SW GOALS) INCLUDING GHG

This figure shows that uncertainties increase as they propagate through the calculations. For example, uncertainties in costs are added to uncertainties in avoided costs. The small-scale recycling shows the highest variability because this configuration has both high costs and high avoided costs relative to the base case. This is in part an artefact of an incremental approach. That is, all other configurations are contingent on large investments made as part of the base case. Configuration 3 invests in alternative infrastructure, and avoids some base case investment, so that the incremental costs of Configuration 3 relative to the base case are lower than the three other infrastructure-based configurations (see Figure 9), but the actual costs are higher, relative to the base case (see Figure 10). This is because the base case includes a significant upgrade to the existing STP. Configuration 3 avoids this upgrade. This issue is explored further in the sensitivity analysis. If this analysis were done on total costs, the differences between configurations would be less marked. →



4.4.2
CONSIDER UNCERTAINTY AND CONDUCT SENSITIVITY ANALYSIS

Why?
All projections into the future are to some degree uncertain. Variations in projections can have a significant impact on outcomes and will affect different system configurations in different ways. These effects need to be investigated and reported.

How?
Uncertainty can be managed within cost studies through various methods for risk and sensitivity analysis (see Principle 8 '*Acknowledge and manage precision and uncertainty*'. Different levels of certainty are acceptable for different decision stages and scales of expenditure, and each organisation will have its own policies and practices in this regard. There is no 'one size fits all' approach to managing uncertainty.

Regardless of the approach you take, you will need to consider uncertainties in your:

- cost estimates
- water balance model
- cost parameters (e.g., discount rate, period of analysis, etc.).

You will also need to be aware of the impact of your system boundary on the analysis.

Below, we explain how to deal with these uncertainties.

Ideally, your cost specifications included some indication of the precision of your estimates. Costs with large magnitude and / or a high degree of uncertainty are your target for further analysis.

In the water balance model, identify which variables are key to the cost outcomes. Likely candidates include changes in population or housing growth, uptake rates of programs (e.g., rebates for front loading washing machines), technology (e.g., legislation to mandate 4A toilets), or impact of climate change on local rainfall patterns.

A particularly important sensitivity analysis will be the discount rate. Discount rate can have a large impact of the results of a cost analysis of urban water, particularly if the timing of significant costs varies between alternatives, as is likely when you are comparing more and less centralised options.

Once you have decided which variables represent key uncertainties, conduct a sensitivity analysis. The simplest way to do this is to assess the relative changes in outcomes depending on your best guess of the high and low extremes of each key variable. Do sensitivities for high and low figures, and report error bands. There are more complex methods as well (see *Text Box Three* on page 31). Match the method to the decision.

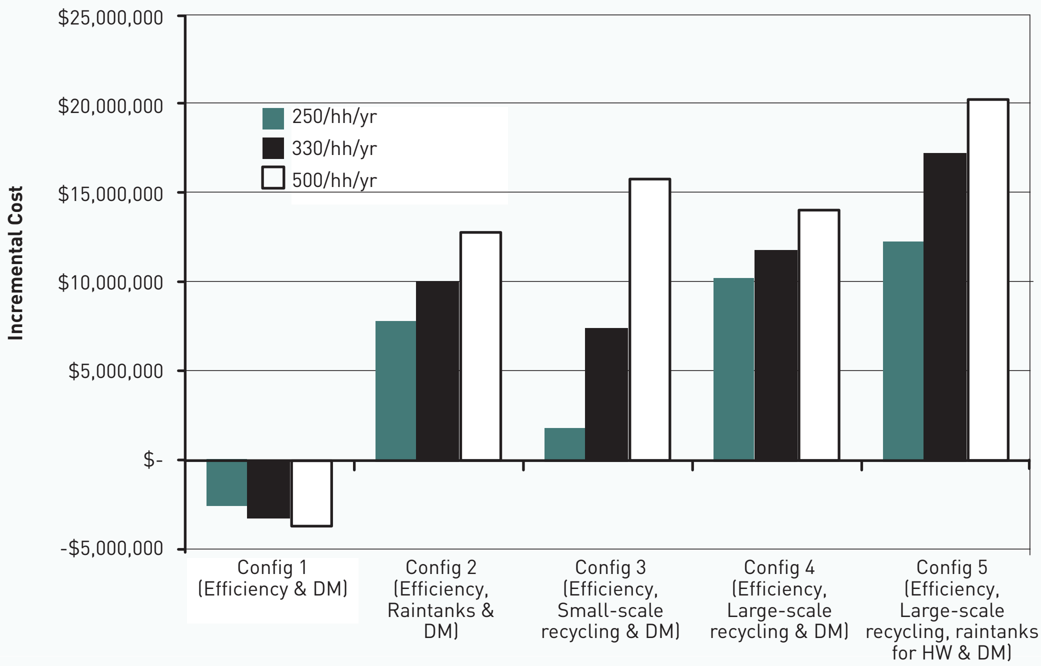
Making assumptions explicit, being reasonable and defensible about the magnitude of uncertainty in costing assumptions, and therefore about the significance of differences between cost estimates, are cornerstones of good practice.

STEVE'S STORY UNCERTAINTY AND SENSITIVITY ANALYSIS

→ The ranking of configurations is the same in the optimistic case, and changes in the pessimistic case, where configuration 3 ranks above configurations 2 and 4 on incremental cost. This too is an artifact of the boundary of analysis and using a percentage approach to contigency.

SENSITIVITY TO GROWTH RATE UNCERTAINTIES
The model was tested with slower (250hh/yr) and faster (500hh/yr) growth rates. The number of commercial lots and the area of public open space was assumed to correspond to household growth. In all configurations, costs were rescheduled to account for changing growth.

FIGURE 14 SENSITIVITY TO CHANGE IN GROWTH RATE OF AREA 250HH/YR TO 500HH/YR: NET COST OF ALTERNATIVE INCLUDING GHG

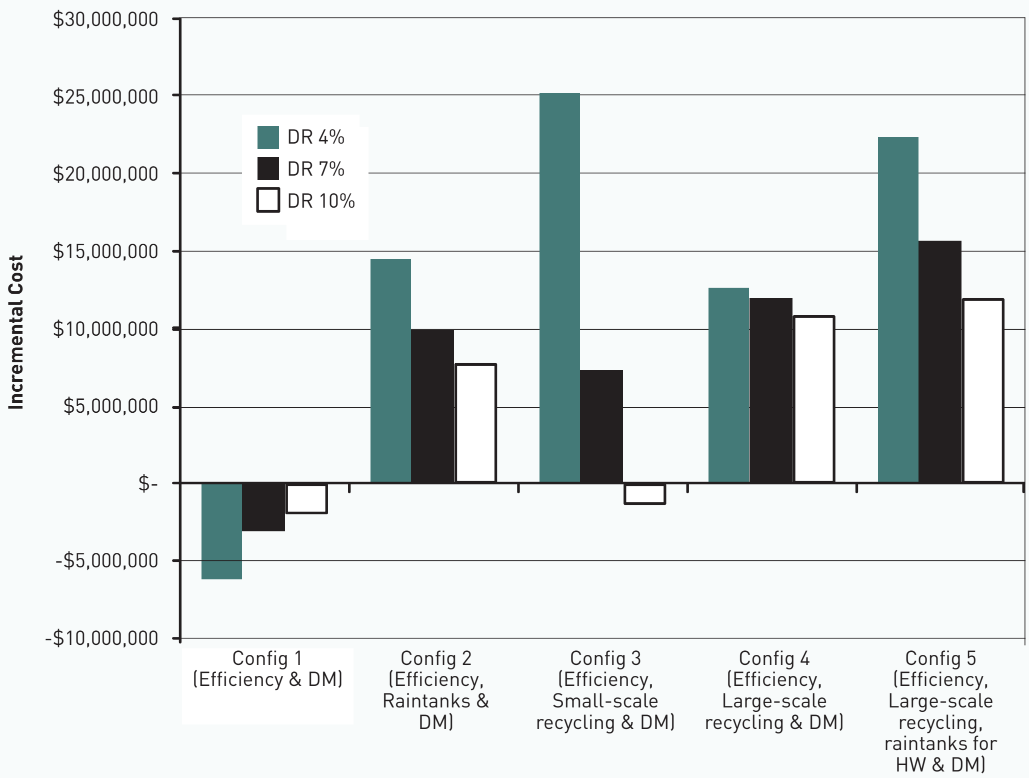


The graph shows the impact on incremental cost of changes in growth rate. For Configurations 1, 2, 4, and 5, the differences are primarily in transfer payments i.e. more or less potable and recycled water bought and sold. The primary capital cost that varies over time is relatively small: the provision of raintanks in Configurations 2 and 5. For Configuration 3, there are significant differences in capital expenditure (the provision of sewerage infrastructure), so the impact of growth rate changes is strongest here. For a slower growth rate, the ranking of configurations stays the same, and in fact, Configuration 3 improves substantially relative to the other configurations. This is because investment in sewage treatment in Configuration 3 is matched to demand, so a slower growth rate slows this investment, resulting in a lower present value. For increased growth rate, the opposite occurs. That is, the benefits of matching growth rate with investment are reduced for Configuration 3, so its present value, represented here by incremental cost, increases beyond that of configurations 2 and 4.

This demonstrates an important sensitivity of distributed systems that manifests as a contingency that needs to be actively managed. Distributed systems represent a lower risk of over-investment should growth rates be slower than expected, and the economic benefits of distributed systems decrease if growth rates increase substantially. The corollary risk in centralised systems is the impact on the return on investment period. That is, a slower growth rate with lower sales means a longer period to recoup investments.

SENSITIVITY TO DISCOUNT RATE

FIGURE 15 SENSITIVITY TO DISCOUNT RATE: NET COST OF ALTERNATIVES (WITH DM IN EXISTING AND SW GOALS) INCLUDING GHG



The final sensitivity test is for the key economic parameter of discount rate. The original analysis used the standard Treasury figure of 7%. Here, this is compared with 4% and 10%.

The small scale recycling configuration is most starkly affected by discount rate. This is because this configuration involves less up front costs but more costs into the future than any other configuration, as explained above. So, reducing the discount rate strengthens the future costs' impact on the NPV, and so the ranking of options changes. The opposite effect occurs when the discount rate is increased i.e. future costs have a lower impact on the NPV, so costs in general go down, and particularly so for Configuration 3.

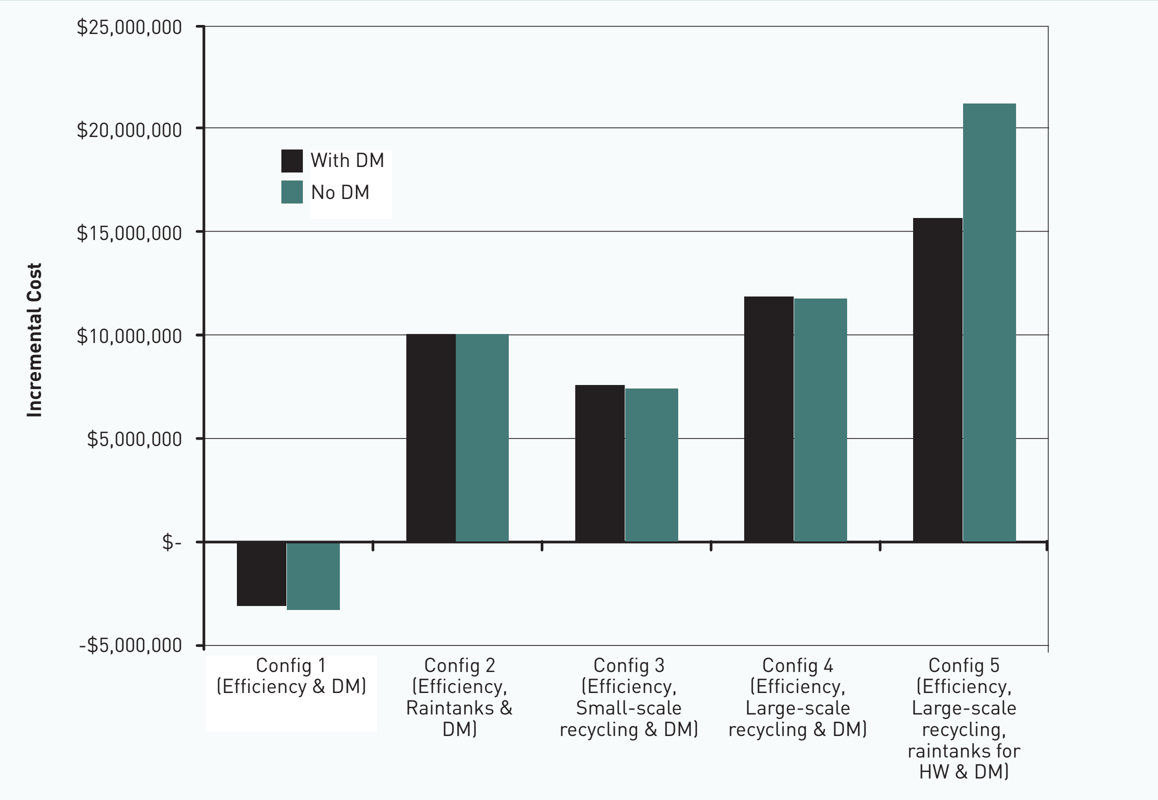
STEVE'S STORY DOCUMENT THE ANALYSIS

Steve's report for Sally and the executive is nearly complete - it'll be considered at the next executive meeting in a fortnight. Now that he's got all the models in place, he wants to go back to the initial assumptions, and check that they were reasonable and defensible. The guidebook talks a lot about system boundaries, and the big choice for the Bridgewater study is whether to include the existing community or not. The other big assumption that Steve keeps wondering about is around externalities. With his SEA and Council mates, they decide to internalise the biodiversity and pollutant externalities via new stormwater guidelines. Steve is pretty certain that the executive will want to know what that means, so his report should cover it.

ANALYSING THE IMPLICATIONS OF INCLUDING THE EXISTING TOWN WITHIN SYSTEM BOUNDARY

Much of the infrastructure is shared by Bridgewater and Bridgewater Downs, so initiatives in one location can have a strong impact on the other. The analysis in this section focuses on the impact of the proposed demand management program in the existing community on the incremental costs for each configuration. Figure 16 shows that for Configurations 1 to 4, dropping the DM program in the existing town has little impact on the incremental cost. That is, the avoided costs arising from the DM program are similar to its implementation costs. For Configuration 5 however, the lack of a DM program means that duplication of the mains supply can no longer be avoided, so there is a significant increase in net costs without the DM program.

FIGURE 16 NET COST OF ALTERNATIVE CONFIGURATIONS WITH AND WITHOUT DM IN EXISTING TOWN (INCLUDES STORMWATER GOALS AND GHG EXTERNALITIES)



4.4.3 DOCUMENT THE ANALYSIS

Why?

Transparency in analysis and decision-making is a primary requirement for private and public organisations adhering to the principles of corporate social responsibility. Moreover, the need for transparency is increasingly noted in enabling legislation for utilities, and expected by the public. It also ensures better engagement and increased trust from stakeholders.

How?

You will need to summarise and report on your cost analysis in a coherent, traceable form. It will be important firstly to consider the audience(s) of the report and the appropriate level of detail and justification for this audience. For large or complex projects, it may be prudent to have interim reports and opportunities for stakeholder consultation to avoid any perception of information overload toward the end of the project.

Where a brief report is required or appropriate, it will be important to capture further detailed information (such as the assumptions behind cost estimates) elsewhere, perhaps in the spreadsheet models, or in an appendix that documents the input assumptions and the analysis, including sensitivities, step by step.

Ideally, someone else should be able to go through your cost analysis and identify where all the estimates came from.

A clear representation of the base case is extremely important and will form the foundation of a transparent, comprehensible report. Since the concept of avoided costs is sometimes difficult to communicate, clearly specifying these "costs" in the base case will enable quicker comprehension of their inclusion as benefits for particular alternative configurations.

It is also important to be transparent about both the level of uncertainty within the analysis and how key uncertainties have been treated. This includes detail of which sensitivities have been tested and where uncertainties remain. It will often be appropriate to show results of key sensitivity analyses.

Recommendations on the basis of the cost analysis need to be consistent with the stage of decision-making, scale of project, and level of uncertainty remaining in estimates.

Other elements of the analysis to document include:

- Your study objectives
- Your system boundaries
- Your chosen time period of analysis and discount rate
- The source/s of your assumptions underlying the water balance
- Your sources for cost estimates
- How (and sometimes why) you treated externalities that were monetised and included
- All those externalities (by option or system configuration) that you considered were significant, and that you left outside the cost analysis.

STEVE'S STORY DOCUMENT THE ANALYSIS

ANALYSING THE IMPLICATIONS OF INTERNALISING EXTERNALITIES VIA STORMWATER LIMITS

The forthcoming shift in stormwater regulations provides a useful driver and mechanism for internalising the externalities associated with biodiversity and sediments. This analysis examines the impact of this decision.

We estimate that standard stormwater for the development would cost about $1000 per lot less than WSUD. This translates into a cost of about $3.8M. The additional cost of WSUD elements is shown in Figure 17. Configurations are compared to a base case that does not account for stormwater limits.

FIGURE 17 NET COST OF ALTERNATIVE CONFIGURATIONS WITH AND WITHOUT STORMWATER GOALS (INCLUDES DM IN EXISTING TOWN AND GHG)

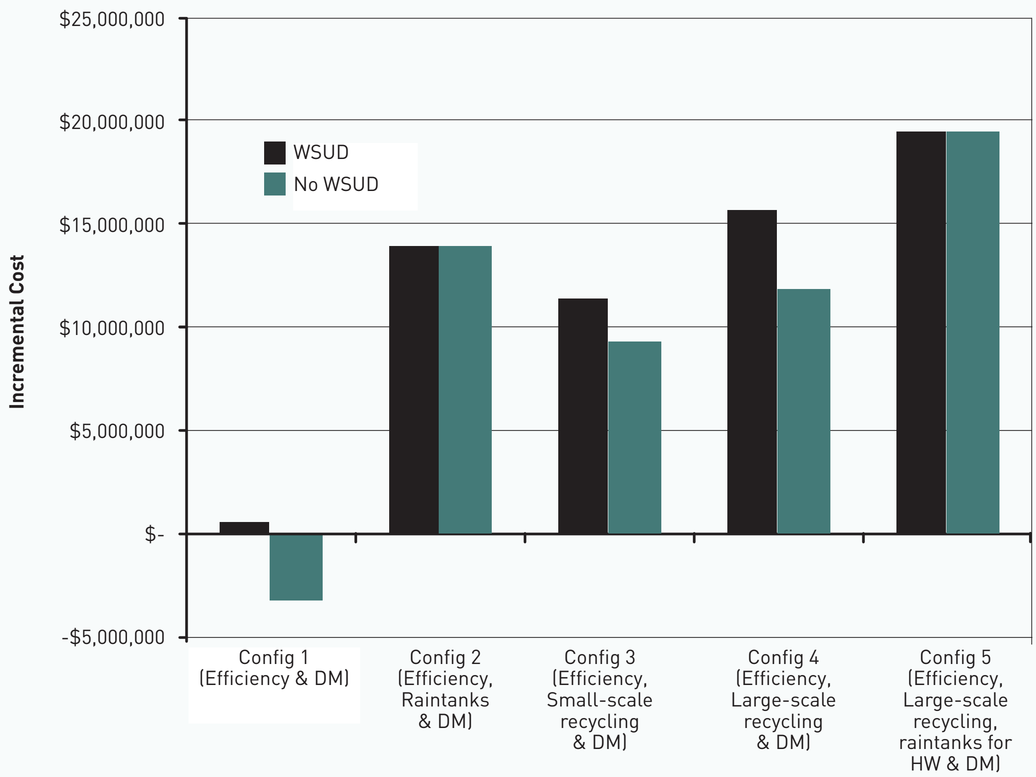


Figure 17 shows that the impact of implementing WSUD to meet stormwater limits is highly variable. For configurations with rain tanks (Configuration 2) and/or large wetlands for aquifer storage and recovery (Configuration 5) already in place, there is no cost impost. Configurations 1 and 4 had no WSUD elements, so the difference is the full cost of WSUD ($3.8M). These are significant shifts here. Configuration 1 goes from an incremental benefit of $3.2M to a cost of around $600 000.
For Configuration 5, the cost increases by about 25%.

DOCUMENT EXTERNALITIES LEFT OUTSIDE THE COST ANALYSIS

Steve and his colleagues from SEA and Council identified nutrient loads from effluent releases as a significant externality. These were nutrient loads and effluent releases. Putting dollar values on these is not straight forward, so they decided to exclude them from the cost analysis. Steve and his colleagues still wanted to demonstrate how the alternative configurations have different impacts in these externalities, so instead of a cost analysis, Steve undertook a pollutant load analysis, focusing on the mass of nitrogen and phosphorus released to the environs.

Nutrient loads released into the environment are an important externality that is difficult to quantify in dollar terms. Instead, a pollutant load analysis was completed. The location of nutrient release to the environment changes with configuration. For example, in Configuration 1, nutrients are primarily released to waterways, but in Configuration 3, the releases are mostly to land through residential watering. The pollutant load analysis was based on the following assumptions:

Treatment level (mg/L)

	Secondary	Tertiary
Nitrogen	15	10
Phosphorus	10	1

TABLE 16 PROPORTION OF BASE CASE NUTRIENT LOADS AND EFFLUENT RELEASE

Configuration	ML/yr released to environment	N kg/yr released to environment	P kg/yr released to environment
Base case	1,950	19,500	1,950
Config 1 (Efficiency & DM)	1,600	15,980	1,600
Config 2 (Efficiency, Raintanks &DM)	1,600	15,980	1,600
Config 3 (Efficiency, Small-scale recycling &DM)	1,200	15,450	7,370
Config 4 (Efficiency, Large-scale recycling &DM)	1,160	11,590	1,160
Config 5 (Efficiency, Large-scale recycling, raintanks for HW & DM)	1,160	11,590	1,160

The table shows that the most important result is that Configuration 3 (efficiency, DM in the existing community, and small-scale recycling) releases a significantly increased phosphorus load, relative to the base case. This is because in this configuration the STP for the existing Bridgewater community is not upgraded as would be required in all other configurations including the base case.

STEVE'S STORY DOCUMENT THE ANALYSIS

INPUTS TO THE SUPPLY DEMAND STRATEGY

Because the metro water strategy is under review again, Sally has asked Steve to explicitly include a section in his report for the executive that shows the implications of the Bridgewater study options. The metro water strategy is a 25 year plan but with a longer period of analysis. Steve needs to report water conservation in the target year of 2031 and the average incremental cost in 2006$.

Firstly, the metro planners need to know what the total annual water savings will be in 2031, at the end of their 25 year strategy, for each alternative configuration. Steve knows water savings can be reported in various ways – cumulative, actual annual, annual average, etc. Because water planning is linked to a particular point in time, and because Bridgewater's water savings for the alternatives will change over time, as, for example, populations grow, Steve reasons that reporting the water saved in the final year of analysis is a useful approach.

Bridgewater and Bridgewater Downs options have substantially different impacts on the metro strategy. This section shows the water volumes conserved in the year 2031, the average incremental costs associated with these, and the potable water savings in the new residential servicing arrangements. Table 17 shows the volume not required from the existing water reticulation system in 2031.

TABLE 17 WATER VOLUME CONSERVED IN THE YEAR 2031 (I.E. NOT CUMULATIVE)

	GL conserved in 2031
Efficiency + DM in existing	0.4
Efficiency Raintanks + DM in existing	0.75
Efficiency Recycling (small scale) + DM in existing	1.04
Efficiency Recycling (large scale)+ DM in existing	1.09
Efficiency Recycling (large scale) Raintanks (hot water only)+ DM in existing	1.39

Secondly, the AIC or levelised costs. Note that these are for options not the alternative configurations, and that these cost are highly context dependent.

TABLE 18 NET AIC (LEVELISED COSTS) OF WATER CONSERVATION

		$/kL
Efficiency in new development	-$	2.4
DM in existing	$	0.1
Raintanks	$	6.1
Small scale recycling	$	2.6
Large scale recycling	$	3.4
Raintanks for hot water	$	2.0

The average incremental cost results show that:

- Efficiency in the new development represents an incremental avoided cost of $2.40/kL. This means that despite the extra cost of water efficiency appliances and toilet ($300/hh), there is a significant net saving of over two dollars for each kilolitre saved by efficiency in the new development area.
- DM in the existing development has an incremental cost of $0.1/kL. Here the cost of over $300/hh on average is mostly offset by savings on the marginal cost of water supply and wastewater treatment.
- Raintanks alone have an incremental cost of $6.10/kL.
- Dual reticulated recycling for residential has an incremental cost of between $2.6 and $3.4 /kL in the new Bridgewater development (dependent on whether recycling is small or large-scale).
- Rain tanks for hot water alone have an incremental cost of only $2.0/kL. This is because a significant avoided cost becomes available (the supply main duplication) once this degree of water saving has been avoided. (Without this avoided cost, the incremental cost of a rain tank for hot water could be more than for toilets and garden).

The option unit costs presented here are site specific to the situation set out in the Bridgewater case study. This is because these costs are incremental and account for avoided costs.
The total water savings and cost information from the Bridgewater example are both context dependent.

More generic information that might be of interest for the Metro supply demand plan is the level of demand reduction that can be expected from new detached residential developments across the metro area (not including public open space, the proportion of which will vary). These savings are set out in Table 19.

TABLE 19 POTABLE SAVING IN NEW RESIDENTIAL

	Potable water saved
Residential efficiency	17%
Residential efficiency & Raintanks	44%
Residential efficiency & Small-scale recycling	48%
Residential efficiency & Large-scale recycling	52%
Residential efficiency, Large-scale recycling & Raintanks (hot water only)	76%

STEVE'S STORY DOCUMENT THE ANALYSIS

CONCLUSIONS AND RECOMMENDATIONS

1) Water use efficiency in the existing development has a significant net benefit

2) A demand management program in the existing development is highly cost effective in its own right and opens up the possibility for cost savings for 'more sustainable' configurations in the new development.

3) The small scale recycling configuration has a significant nutrient externality. It conserves a similar volume of water to the large scale recycling, but at considerably lower unit cost. The uncertainty in the sensitivity analyses is in part an artefact of an incremental approach, so it may be worth repeating the sensitivity analyses using total costs for all configurations.

4) Large scale recycling (Configurations 4 and 5) look more cost effective than rain-tanks (Configurations 2) as a means of conserving potable supplies.

5) If large scale recycling can be shown to be cost effective in the context of the metro plan, then Configuration 5 with rain tanks for hot water is more cost effective than Configuration 4 alone. Configuration 5 represents only a small increase in cost to the utility but a significant increase for the developer.

KEY ACTION CHECKLIST:
ANALYSING AND REPORTING INCREMENTAL COSTS

- ○ A COSTING MODEL HAS BEEN CREATED SCHEDULING THE COSTS AND AVOIDED COSTS FOR EACH OPTIONS AND/OR ALTERNATIVE CONFIGURATIONS
- ○ MONETISED EXTERNALITIES HAVE BEEN ESTIMATED AND INCLUDED INTO THE COSTS ANALYSIS
- ○ OPTIONS AND/OR ALTERNATIVE CONFIGURATIONS HAVE BEEN COMPARED USING THE SELECTED COST METRIC(S) (I.E. NPV) AND FROM THE CHOSEN COST PERSPECTIVE(S)
- ○ THE UNCERTAINTY WITHIN VARIABLES THAT HAVE A SIGNIFICANT INFLUENCE HAS BEEN CONSIDERED
- ○ SENSITIVITY ANALYSIS ON CHOSEN VARIABLES HAS BEEN CONDUCTED
- ○ ALL FOUR STAGES OF THE COSTS ANALYSIS PROCESS HAVE BEEN CLEARLY DOCUMENTED
- ○ THOSE EXTERNALITIES IDENTIFIED AS OUTSIDE OF THE ANALYSIS ARE ALSO CLEARLY DOCUMENTED.
- ○ THE COSTS ANALYSIS HAS BEEN SUMMARISED TO AN APPROPRIATE LEVEL OF DETAIL FOR KEY AUDIENCE(S)
- ○ RECOMMENDATIONS HAVE BEEN MADE THAT ARE CONSISTENT WITH THE STAGE OF DECISION-MAKING, SCALE OF PROJECT, AND LEVELS OF UNCERTAINTY WITHIN THE RESULTS

5

So what? Now what?

After a cost analysis has been completed and the report has been written, then what?

In a costing study of urban water, the least cost alternative will rarely be exactly the same as the solution that is implemented. What is important is to retain the general objective of delivering urban water services to society at least cost and greatest resource efficiency – that is what will help us move towards sustainable urban water outcomes. The way to achieve this is simple: use the least cost alternative as the point of comparison for developments towards the final decision. The cost implications of decisions to move away from least cost servicing are then explicit.

Movement from the least cost alternative to a decision to go ahead with a different solution will be based on varying criteria in each situation e.g., organisational constraints in relation to certain technologies or stakeholder decisions to pursue what they consider to be more marketable alternatives or lack of appropriate institutional arrangements to get the transfer payments right. Likewise, other forms of analysis might be used to inform movement to a preferred alternative e.g., risk analysis.

It is important to remember that the 'tangible' costs and benefits included in the results of the costing study are only a subset of all the impacts that differ between alternatives. If significant impacts have been excluded from the analysis, these should have been identified when the treatment of externalities was considered. Even when externalities have been internalised as dollar values or via imposed system limits, it is still possible that the total value of these externalities has not been captured. For example, there is a substantial difference between the carbon market valuation of greenhouse gas emissions, the cost not to produce those emissions in the first place, and the long term cost to society as a result of those same emissions. Such externalities should inform decisions about preferred alternatives.

In some cases, the results of a costing study will be used as an input to a multi criteria analysis. This can be a useful means of bringing together qualitative criteria and costs. However multi criteria analyses have a number of potential pitfalls. For, example if costs are simply included as one criteria via weighting against other criteria, this in effect places a dollar value on all the criteria. What is important is to retain a focus on the goal of achieving urban water servicing and the study objectives at least cost, and to design a robust deliberative process of stakeholders to identify and consider the criteria.

So what is the significance of costing for sustainable outcomes in urban water?

Cost analysis is a critical element of decision making about the shape of our urban water systems now, and how they might change in both the short and long term.

This guidebook has described a set of principles for costing which align with promoting sustainable outcomes from urban water. It sets out a structured costing methodology, and applies these principles to the practice of analysing the costs of a set of options and alternative configurations for delivering urban water services.

In summary, the elements that distinguish costing for sustainable outcomes in urban water from simple, good practice in cost analysis are:

- Analysis from a whole-of-society perspective, including full accounting for costs across the life cycle and all avoided costs;
- A holistic systems understanding of urban water and definition of the urban water system by the actual water services provided;
- Definition of the urban water system by the actual water services provided;
- Analysis of options on an appropriate unit cost basis; and

- A clear treatment of externalities and uncertainty, including specifying the extent to which these are dealt with inside the analysis.

While improving cost analysis alone does not assure sustainability, a focus on the least cost means of providing water services highlights what is more economically efficient and resource efficient. A focus on cost effectiveness when seeking sustainable outcomes also helps avoid high cost solutions which simply 'add-on' to conventional approaches.

Costing for sustainable outcomes means that a spectrum of options, from appropriately centralised to appropriately distributed, are proposed and assessed for a given context. In some cases the most sustainable solution may be a centralised option. In others, it may be a distributed option, or a mix of both, with, for example, better potential to match water quality and water uses, or to match the timing of infrastructure provision with the timing of changes in demand. Where alternative options are chosen as a result of the cost analysis, a decision to implement these infrastructures will need to account for the different risk profiles and management approaches and different institutional arrangements.

Applying the principles and practices in this guidebook will ease the inclusion of alternative strategies in utility planning because it will:

- facilitate comparisons between costing studies, both within and across organisations;
- reduce the uncertainty surrounding costing studies of non-conventional 'sustainable' options for urban water; and
- provide a much better basis for comparison with conventional options.

6

References

1. Acil Tasman, GHD (2004) Pricing for recycled water. Report for WSSA

2. Ashley R, D Blackwood, D Butler, P Jowitt (2004) Sustainable Water Services: A Procedural Guide. IWPA Publishing, London, UK

3. Balkema A., Preisig, R. Otterpohl, and F. Lambert (2002) Indicators for the sustainable assessment of wastewater treatement systems, Urban water vol. 4, p153-161

4. Beecher JA (1996) Avoided Costs: An Essential Concept for Integrated Resource Planning. J. Contemporary Water Research and Education (formerly Water Resources Update) 104:28

5. Bowers J, Young M (2000) Valuing Externalities: A Methodology for Urban Water Use. CSIRO Urban Water Program Folio 01/1323. 45 pp.

6. Checkland P (1981) Systems Thinking, Systems Practice. Wiley. Chichester

7. California Urban Water Conservation Council 2000 A guide to the data and methods for cost effectiveness analysis of urban water conservation best management practices. CUWCC, Sacramento CA

8. CPUC (California Public Utilities Commission) (2001) California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects.

9. Checkland P (1981) Systems Thinking, Systems Practice. Wiley. 330 pp.

10. Walsh, C.J., Leonard, A.W., Ladson, A.R. and Fletcher, T.D. (2004) Urban stormwater and the ecology of streams. Cooperative Research Centre for Freshwater Ecology and Cooperative Research Centre for Catchment Hydrology, Canberra.

11. Dunphy, Griffiths, Benn, (2003), Organizational Change for Corporate Sustainability, a guide for leaders and change agents of the future, Routledge, London

12. Dziegielewski B., Opitz E., Kiefer J. and Baumann D. 1993. Evaluating Urban Water Conservation Programs: A Procedures Manual, AWWA Carbondale IL, USA

13. Etnier C, Willetts J, Mitchell CA, Fane S, Johnstone DS (2005) Decentralized Wastewater System Reliability Analysis Handbook. . Project No. WU-HT-03-57. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by Stone Environmental, Inc., Montpelier, VT.

14. Fane S, J. Robinson, S. White, (2003), The Use of Levelised Cost in Comparing Supply and Demand Side Options, Wat Sci Tech: Water Supply: vol 3 No. 3

15. Fane, S., Willetts, J., Abeysuriya, K., Mitchell, C., Etnier, C., S. Johnstone, (2005), Decentralised wastewater systems an asset management approach WATER ASSET MANAGEMENT INTERNATIONAL, 1. 3

16. Green C (2003) Handbook of Water Economics. Principles and Practice. Wiley. 443 pp.

17. Hanley N, Spash CL. (1993) Cost-Benefit Analysis and the Environment. Edward Elgar Publishing. 278 pp.

18. Hatton MacDonald D (2003) Managing Externalities Using Price: Some Implications for Reticulated Water, Reuse Water and the Environment. Water Recycling Australia 2nd National Conference Brisbane, September 2003

19. Herrington P (2005) The Economics of Water Demand-Management. In: Butler D, Memon F. Water Demand Management. IWA Publishing. 384 pp.

20. Howe C, White S (1999) Integrated Resource Planning for Water and Waste Water: Sydney Case Studies. Water International 24(4):356-362

21. IPART (Independent Pricing and Regulatory Tribunal) (2006), Pricing arrangements for recycled water and sewer mining. Sydney Water Corporation, Hunter Water Corporation, Gosford City Council and Wyong Shire Council Draft Determinations Nos 8 and 9, APPENDIX C Guidelines for the calculation and treatmnet of avoided and deferred costs of recycled water.

22. Janssen PHM, Heuberger PSC, Sanders R (1992) UNCSAM 1.1: a Software Package for Sensitivity and Uncertainty Analysis (Manual). Report No. 959101004, National Institute of Public Health and Environmental Protection Bilthoven, The Netherlands

23. Lundie S, Ashbolt N, Livingston D, Lai E, Kärrman, Blaikie G, Anderson J (2005) Sustainability Framework. Methodology for Evaluating the Overall Sustainability of Urban Waster Systems. University of New South Wales, Centre for Water and Waste Technology. Prepared for WSAA. 171 pp.

24. Lundin, M., Molander, S. and Morrison, G.M. 1999 A set of indicators for the assessment of temporal variations in the sustainability of sanitary systems, Wat. Sci. Tech, vol. 39:5, p 235–242

25. Menke and Woodwell 1990 Water efficiency, report by the Rocky Mountain Institute

26. NSW Treasury (1997) Guidelines for Economic Appraisal. Office of Financial Management

27. Pinkham, R., Hurley, E., Watkins, K., Lovins, A., Magliaro, J., Etnier, C. and Nelson, V. (2004) Valuing Decentralised Wastewater Technologies: A Catalogue of Benefits, Costs, and Economic Analysis Techniques. Prepared by Rocky Mountain Institute for the U.S. Environmental Protection Agency.

28. Qld EPA 2003 Techniques for Environmental Economic Evaluation (http://www.epa.qld.gov.au/publications/p00710aa.pdf/Techniques_for_environmental_economic_evaluation.pdf)

29. Queensland Treasury (2000) Guidelines for Financial and Economic Evaluation of New Water Infrastructure in Queensland.

30. Senge, P., (1990), The Fifth Discipline Fieldbook. New York: Doubleday.

31. Standards Australia (1999) AS 4360:1999, Risk Management. Standards Association of Australia, Sydney, Australia

32. Standards Australia (1999) AS/NZS 4536:1999, Life cycle costing. Standards Association of Australia, Sydney, Australia

33. Swisher JN, Jannuzzi GdM, et al. (1997) Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment. Riso National Laboratory, Denmark, UNEP Collaborating Centre on Energy and Environment

34. Thompson M, R J Ellis, and A Wildavsky (1990) Cultural Theory as Political Science. Westview Boulder, Colorado.

35. UKWIR/Environment Agency (2002) The Economics of Balancing Supply & Demand (EBSD). Main Report. Report Ref. No. 02/WR/27/3. UK Water Industry Research, London. 55 pp.

36. US EPA (2000) Guidelines for Preparing Economic Analyses. EPA 240-R-00-003. Washington DC

37. Van Bueren and Hatton MacDonald (2004). Addressing water-related externalities: Issues for consideration. Water Policy Workshop convened by the Australian Agricultural and Resource Economics Society, 10th February 2004, Melbourne

38. VicWater (2002) Triple Bottom Line Reporting Guidelines, July 2002

39. Vickers A (2001) Handbook of Water Use and Conservation. WaterPlow. Amherst, MA. 446 pp.

40. White SB, Fane SA, Giurco D, Turner A (2006) Putting the economics in its place: decision making in an uncertain environment, Ninth biennial conference of the International Society of Ecological Economics on "Ecological Sustainability and Human Well-being" 15-18 December 2006, The India Habitat Centre, Lodi Estate, New Delhi

41. White SB, Fane SA (2002) Designing Cost Effective Water Demand Management Programs in Australia. Water Science and Technology 46(6-7):281-288

42. Wynne B (1992) Uncertainty and Environmental Learning: Reconceiving Science and Policy in the Preventive Paradigm. Global Environmental Change 2(2):111-127

43. Young M (2000) Managing Externalities: Opportunities to Improve Urban Water Use. CSIRO Urban Water Program Folio 01/1324. 29 pp.

7

Glossary

Cost perspective the accounting stance which defines the cost and benefits that are included in an analysis. Cost perspectives are either economic, indicating overall whether society will be better or worse off as a result of an action, or financial, indicating commercial viability for a particular commercial entity or defined group.

Costing (cost analysis) the process of bringing together the estimates of expected outlays and other monetised impacts to make an appraisal of a proposed project, option or scheme.

Sustainable Development development that uses, conserves, and enhances the community's resources so that ecological processes are maintained or enhanced and the total quality of life now and in the future can be improved.

Externality in strict economic parlance, externalities are those impacts on economic agents caused by economic activity which are not paid for in the market place. They can be either positive or negative. Externalities represent only a sub-set of non-monetised impacts and only those to 'economic agents'.

Greywater a combination of wastewater from the laundry, bathroom and kitchen.

Incremental cost the net additional cost corresponding to an option.

Intangible costs those impacts that are difficult to assess or place a monetary value on with any certainty.

Marginal cost of supply the net additional cost corresponding to an additional unit of output.

Monetised impact an impact for which a monetary value has been determined or estimated.

Non-monetised impact an impact that is significant in decision-making, but for which no monetary value has been determined.

Option a discrete behavioural measure, infrastructure, or system alternative that is considered within a study. An option exists with a range of other options that meet the study objectives by a variety of means.

Present value the value of the stream of future costs and benefits associated with that option, discounted to current monetary values based on a predetermined discount rate.

Recycled water treated stormwater, greywater or black water suitable for a range of uses, e.g., toilet flushing, irrigation, industrial processing or other suitable applications.

Residuals value remaining or impacts incurred after the end of the period of analysis.

Sustainable outcomes outcomes that contribute to sustainable development.

Sunk costs a cost that has been incurred and cannot be recovered.

System a system is a set or assemblage of 'things' connected, associated, or interdependent, so as to form a single unity.

Tangible costs direct outlays and directly avoided outlays, or actual capital and operating costs incurred or avoided.

Urban water system the system that provides water supply, wastewater and stormwater services to a city or town or a predominantly residential part thereof.

Abbreviations

ABC	Activity Based Costing
CAPEX	CAPital EXpenditures
CoAG	Council of Australian Governments
DSR	Development Servicing Plan
ESC	Essential Services Commission (VIC)
FCA	Full Cost Accounting
GHG	Greenhouse gas emissions
IPART	Independent Pricing and Regulatory Tribunal (NSW)
IRP	Integrated Resource Planning
IRR	Internal Rate of Return
LCP	Least Cost Planning
NPV	Net Present Value
NWI	National Water Initiative
OPEX	OPerational EXpenditures
PIR	Performance Improvement Review
PV	Present Value
RME	Responsible Management Entity
WSAA	Water Services Association of Australia

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