WA7090/6

A Framework for Valuing Water Demand Management: Tauranga City Council case study

Report 3 of 3

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About This Report

Title

A Framework for Valuing Water Demand Management: Tauranga City Council case study

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Reviewer

Abstract

This conceptual framework is the second part of a project which addressed the question, ‘why’ (would an organisation adopt WDM). To do this Beacon commissioned work from Market Economics in three parts: a literature review (WA7090/4), the creation of a comprehensive conceptual framework (WA7090/5) and a case study to test the framework utilising data from Tauranga City Council. Based on the application of the economic framework developed in the first two reports, it is estimated that as a result of implementing a water demand management approach, Tauranga City Council has delayed the implementation of the next major water supply infrastructure identified for the city’s water supply, by approximately 10 years with a net benefit to the community of $53.3 million in 2009 terms.

Reference

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Prologue

Beacon Pathway is dedicated to research that will generate sustainable homes and neighbourhoods by changing the way the Residential Built Environment in New Zealand is designed, built and modified. Established in May 2004, the consortium comprises Building Research, Fletcher Building, New Zealand Steel, Scion, and Waitakere City Council. Shareholder contributions are matched, dollar for dollar, by monies from the Foundation for Research, Science and Technology (FRST).

Beacon's vision is:

Creating homes and neighbourhoods
that work well into the future
and don't cost the Earth

This work, commissioned under the water research stream: the wise management of water in an urban environment is an important ingredient in Beacon's overall strategy. Over the past three years, Beacon's research has clearly demonstrated the value of water demand management, delaying new water sources, raising consciousness of resource limits, and making better use of existing infrastructure.[1]

Beacon's water research has successfully demonstrated the potential benefits of a water-efficient approach through analyses of the potential of packages of measures, and discussions and workshops with a range of Councils. This work made explicit the 'what' and the 'how' for water demand management (WDM), with the remaining question, 'why' (would an organisation adopt WDM) requiring research. It was clear that a rigorous economic analysis of the value of water demand management was needed to help councils and water authorities to illustrate the value of such an approach to decision-makers and communities.

To do this Beacon commissioned work from Market Economics in three parts:

- A literature review;
- The creation of a comprehensive conceptual framework; and,
- A case study to test the framework utilising data from Tauranga City Council.

This is the third of those pieces of work.

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[1] Refer reports on the Beacon website: www.beaconpathway.co.nz

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1 Executive Summary

Water Demand Management in Tauranga City

Based on an economic analysis commissioned by Beacon Pathway from Market Economics, it is estimated that as a result of implementing a water demand management approach, Tauranga City Council (TCC) has delayed the implementation of the next major water supply infrastructure identified for the city's water supply, by approximately 10 years with a net benefit to the community of $53.3 million in 2009 terms.

Tauranga was chosen for the case study as it was at the forefront of thinking in WDM. Not only had it installed meters in the face of some protest from its community, it also had a substantive education programme and was starting to investigate how it might develop its WDM programme even further. It was also a useful example to analyse as it is recognised as one of the particular areas in New Zealand where water supply is under increasing pressure from population growth.

The result stems from the first application of a framework that can help councils and other water authorities analyse the value of taking a demand management approach. The framework is used to value the net benefits arising from the TCC's work over the last decade in implementing WDM through the introduction of water metering and pricing and education programmes.

It is also important to note that this is not a complete valuation of the net benefits of WDM, as there are further categories of benefits that have been identified resulting from the implementation of water pricing and education programmes which have not been assessed in monetary terms. These additional benefits are:

- Increased satisfaction by Tauranga residents and ratepayers through the knowledge that there has been some preservation in the option and non-use values of water.
- Increased education and awareness of water-related issues and improved public relations.
- Potentially some savings to the recreational values of local streams.

Had it been possible to include these categories in the valuation methodology, it is very likely that an even higher net benefit would have been calculated.

Although the water demand and supply situation will vary across the country, and thus the results of this case study are not directly transferable to other case studies, it is expected that there is a high likelihood that similar results can be achieved through the implementation of WDM in other territorial authorities. Overall it is concluded that based on the outcomes of this case study, there is a strong value case for establishing investigations into other possible implementations of WDM throughout New Zealand.

Tauranga's positive response to the process of applying the framework and the outcome, reassured Beacon that the Framework has potential as a decision making tool for councils.

2 Introduction

2.1 Water Demand Management

It is clear that worldwide population growth, agricultural activities and industrial processes are placing ever-increasing pressure on water resources. Perhaps not surprisingly, this trend has also been accompanied by a growing interest in the use of water demand management (WDM) interventions as a means of helping to ensure that demands for water can be met by available water supply. Unlike the more traditional supply-side measures of water management, which aim to increase the capacity for the provision of water to end users, WDM interventions employ various techniques for conserving water and improving the efficient use of water by end users. Examples include the introduction of water metering and charging, initiatives to support retrofitting of houses with low flow showers and dual flush toilets, and the promotion of water saving education programmes for the public.

Increasingly the wider benefits of water demand management are also being recognised. In addition to the incremental savings granted to water providers as a result of not having to produce additional units of water; WDM can achieve substantial cost savings in wastewater management as less water is put through the system, provide savings in energy use and greenhouse gas emissions, and help to support the environment's provision of valuable ecosystem services.

Framework is also described in a summary form here, the primary purpose of this report is to explain the application of the framework to a specific case study. The case study chosen for analysis is the introduction of WDM interventions over the last decade by Tauranga City Council (TCC).

Method Used to Value WDM in Tauranga City

The value of having implemented two important aspects of WDM in Tauranga City are evaluated in this report by the application of a framework "Framework to Value Water Demand Management' (Smith and MacDonald, 2009) based on an economic cost-benefit approach. The researchers engaged with council officers who initially provided local data and then reviewed the outcome in a workshop. The workshop session was essential to get detailed feedback on both the framework and its application to this case study. The outcome is a rigorous analysis of the value to Tauranga city of implementing WDM.

Based on experience from the Tauranga case study it takes some time to gather the appropriate data, but the time taken well justified.

In order to undertake this analysis, it has been necessary to develop a set of assumptions or a 'scenario' around the effects that would have been felt in Tauranga City, had TCC chosen not to implement WDM. Essentially this has involved development of a set of water supply projections that would have occurred over time had WDM not been implemented in Tauranga, as well as an estimation of the capital and operational expenditures that would have been necessary to meet these water supply requirements. In this study the analysis has also been extended out to 2015, so that a fair assessment can be made of the benefits of delaying the implementation of the proposed Waiari water supply scheme.

A real attempt is made in this study to value all potential benefits and costs arising from the implementation of WDM in monetary terms. The categories of benefits and costs assessed consist of: (1) savings in operational and capital costs required for water supply (2) savings in operational costs for wastewater treatment; (3) loss in benefits received by consumers from water consumption; (4) increased provision of indirect use values through the reduction of water taken from ecosystems; and (5) reduced emissions of greenhouse gases. A variety of techniques are used to measure these benefits/costs, ranging from simple financial analyses over time, through to the application of ecological shadow prices for surface water and greenhouse gas emissions.

2.2 Water Demand Management in Tauranga City

In WDM-focussed workshops that Beacon organised in 2008, Tauranga City Council stood out as a city which was at the forefront of thinking in WDM. Not only had it installed meters in the face of some protest from its community, it also had a substantive education programme and was starting to investigate how it might develop its WDM programme even further.

The city was a useful one to analyse as it is recognised as one of the particular areas in New Zealand where water supply is under increasing pressure from population growth (Pricewaterhouse Coopers, 2004). These population pressures have occurred particularly as a result of the rapid population growth in the coastal areas of Mt Maunganui and Papamoa and are evidenced, for example, by the successive rounds of water restrictions put in place over the years 1992 to 1999. Notably, relatively high population growth is projected to continue for the city over the next 30 -50 years.

As early as 15 years ago, TCC started investigating options for a new water source to supplement the existing water supply schemes at Joyce and Oropi Roads. The Waiari Stream was thus identified as the next likely major water supply source for the city. At around the same time, however, TCC also began investigations into options for reducing water demand. As a result of this initiative, TCC has over the last decade implemented WDM through two core techniques or interventions: water pricing and education programmes.

The education programmes commenced around 1999, while in the meantime the Council also embarked on the infrastructure investments required to introduce water metering and pricing. The education programme included the issuing of dummy water bills to raise awareness of water consumption and equivalent volumetric charges that would accompany such usage, as well as school programmes. Even prior to the introduction of universal water metering, significant reductions in average per capita daily water consumption and average per capita peak consumption were noticed (see Figure 1). Significant further reductions were achieved when universal water charges were formally introduced in 2002. Water pricing along with continued investment in education appears to have continued to reduce water demands in the city, although over recent years there has been a levelling off of this trend. Overall it is estimated that as a result of implementing WDM, TCC has deferred investment in the Waiari water supply project plant by approximately 10 years.

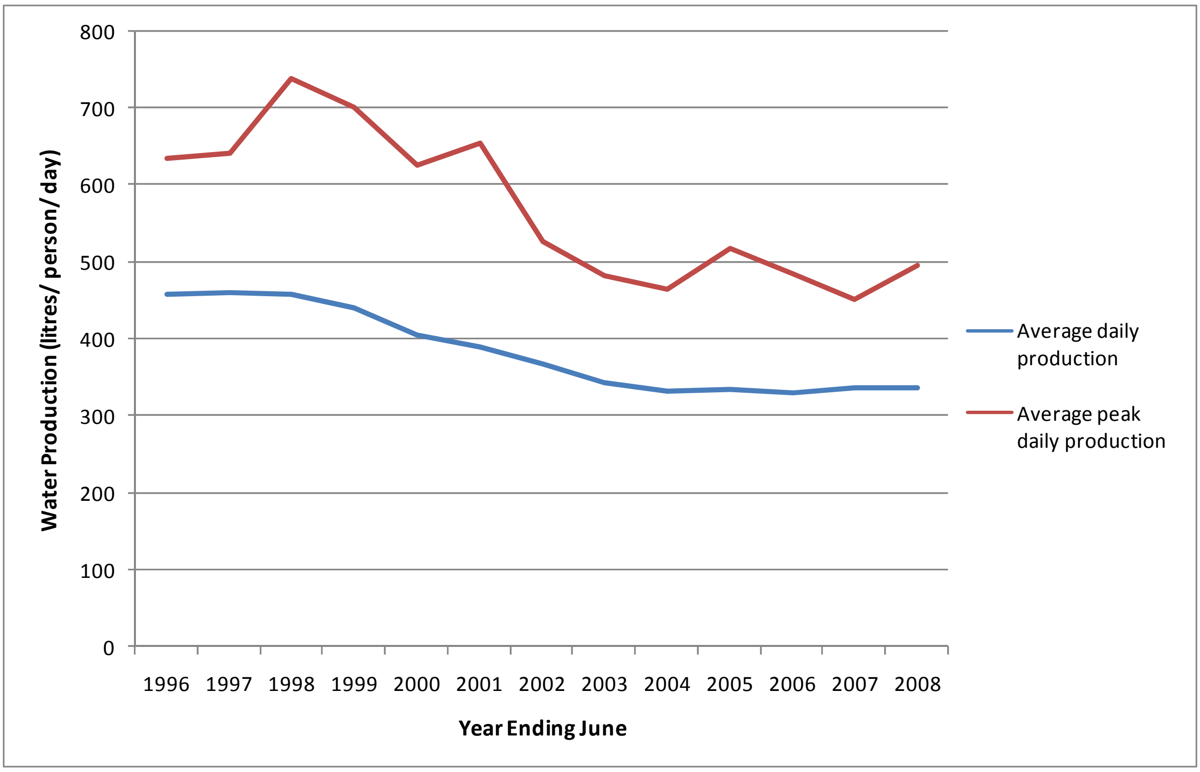

Figure 1: Tauranga City Average Water Production and Average Peak Water Production, 1996-08

3 A Framework for Valuing WDM

This section of the report briefly describes the framework that is applied for assessing the value of WDM implementation. For a more detailed explanation of the framework it is recommended that readers refer to Smith and McDonald (2009).

3.1 Cost-Benefit Analysis and Multi-Criteria Analysis

The application of a cost-benefit (or opportunity cost) analysis is implicit in most monetary valuation studies of alternative policies or projects (see, for example, Roberts et al. (2005) and Bentley et al. (2007)). The process involves: (a) identifying all project effects, beneficial and adverse (i.e. benefits and costs), (b) quantifying those effects in physical terms, and (c) where possible placing monetary values on the physical effects (Boland et al., 2009). The measured benefits and costs of alternative projects or courses of action can then be compared to see if, giving consideration to non-monetised impacts, each project alternative's benefits justify its costs. The method further provides a means of assessing which, among alternative options, delivers the greatest benefits net of costs.

While the theory behind cost-benefit may be relatively straight-forward, in practice this simplicity is easily lost in the many details of application. Among the key difficulties is the identification of all potential costs and benefits arising from a particular project.[2] In these regards it is important to note that the process will typically require an evaluation of effects that have not yet occurred (where we are evaluating future options), or effects that would have occurred had a project been undertaken in a different manner (where we are evaluating the benefits of an already implemented project). In both situations these effects can, however, never be certain (see also Section 2.2 below). Additionally there are a number of difficulties associated with placing monetary values on benefits and costs, particularly those types of benefits and costs which are not usually priced in economic markets. The environmental benefits arising out of different water supply and demand options are, for example, among the types of effects which are typically not subject to market pricing and for this reason often missing from cost-benefit analyses.

Although in this study an attempt has been made to value all benefits and costs where possible, it is recognised that there are some who are opposed to the idea of placing monetary values on environmental and other non-market benefits/costs. At one extreme is the view that reducing ecological processes to economic values simply reinstates the ascendancy of economic values over societal and ecological values. In contrast, others hold that there is a need to accurately

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[2] ***Because of the wide set of responsibilities on local authorities, it is deemed appropriate to evaluate water demand management proposals from a social welfare perspective. This perspective requires consideration of the wide range of costs and benefits affecting society as a whole. As an alternative, water demand management options could be evaluated from the perspective of opportunity costs to individual consumers or water suppliers. In this case, only the benefits and costs impacting on the individuals under consideration would be evaluated.***

account for the contributions of every aspect of the environment if we are to achieve a sustainable economy (Nordhaus, 2000), and the real issue is finding the appropriate methodology (see, for example, Hannon (2001)). In this paper the view is taken that, although the valuation of such effects may be difficult and subject to uncertainties, monetisation is nevertheless a worthwhile pursuit. Valuation enables analyses to be framed in a common and widely used metric, thus providing decision makers with a common reference for discussion. This is of particular utility to decision makers who, in an attempt to adequately assess environment and economy tradeoffs, often grapple for specifics to weight impacts and evaluate different outcomes. Additionally, the valuation of exercise is likely to stimulate further valuation debate. Undoubtedly, this will touch on issues such as, 'What is an appropriate value for environmental costs/benefits?' and 'Are there alternative or complementary frameworks that might better capture some of the more controversial aspects of monetary valuation?

Finally it is noted that even where the best possible attempt is made to quantify all benefits and costs in monetary terms, it is likely that there will still be some effects that will remain too difficult to monetise. For this reason cost-benefit analysis is often used as the first stage of a wider multi-criteria analysis which allows for the consideration of other possible effects which may be evaluated in a range of qualitative and quantitative forms (see, for example, Roberts et al (2005)).

3.2 Development of Scenarios

One of the key concepts underlying a cost-benefit exercise is that all valuations are relative. This means that in a valuation of a WDM intervention, we do not attempt to put a value on the intervention *per se*, but rather to compare the benefits and costs arising as a result of implementing WDM *in relation to an alternative situation(s)* where WDM is not implemented. Establishing the datasets that describe these alternative situations or 'scenarios' is an initial and critical step in any valuation exercise.

Specifically, in this report the benefits and costs of implementing WDM in Tauranga City are evaluated by comparing the situation against a baseline (or status-quo option) situation where WDM is not implemented. This has required the development of two distinct scenarios, referred to in this report as the 'WDM scenario' and the 'baseline scenario'. In developing these scenarios it has been necessary to set out a range of assumptions regarding (1) future outcomes both with and without WDM, and (2) outcomes that would have occurred in the past had the Council chosen to pursue a different water supply management pathway. It is important to note that two scenarios employed in the analysis are just two of a range of plausible scenarios that could occur. The details of these two scenarios are set out fully in Section 3.1.

3.3 Benefits and Costs of Water Demand Management

There are a range of potential benefits and costs that can be taken into account in the valuation of WDM interventions. Based on a literature survey, we have developed a list of the principal benefits and costs that would ideally be taken into account in a valuation exercise (refer to Table 1). A further explanation of these benefits and costs is provided below. Important to note is that the cost-benefit analysis is ultimately concerned with the relative *difference* in each benefit or cost between alternative scenarios (i.e. the net benefit of net cost).

While there has been an attempt to identify in Table 1 all principal benefits and costs likely to arise in relation to the implementation of WDM, there may be other benefits and costs which are not covered by the categories below. Table 1 does not, therefore, purport to be exhaustive and additional benefits and costs should be taken into account where possible.

Benefit/cost major	Reference		Details of Benefit/Cost	Code	Example of benefit/cost to assess
1 Financial Expenditures	a	Local authorities/ utility providers/ ratepayers	Expenditure on infrastructure and operating costs for water supply, less revenues received for supply	FU	(i) The introduction of demand management options slows growth in water demand below that originally forecast, thus avoiding or delaying expenditure on a planned new water supply reservoir and dam (ii) Costs to the Council of employing staff to administer a water charging scheme (iii) Additional funds received by the Council as a result of an increase in the unit charge for water (iv) Costs to the Council of establishing a fund to subsidize households in installing rain tanks
	b	Private and commercial consumers	Expenditure on water resources and the infrastructure/ technologies and operating costs required for obtaining water resources	FC	(i) Increase in water bills for households and businesses as a result of an increase in the unit rate charged by the Council for water (ii) Money outlays by households to install low-flow shower heads, rain tanks and variable flush toilets
	c	Local authorities/ utility providers/ ratepayers	Expenditure on energy required for water supply	FEU	(i) A reduction in water demand reduces the energy required for pumping water to supply households and businesses.
	d	Private and commercial consumers	Expenditure on energy required for obtaining water resources	FEC	(i) Reduction in water heating costs for households as a result of the installation of low-flow shower heads.
	e	Local authorities/ utility providers/ ratepayers	Expenditure on infrastructure and operating costs for stormwater treatment	FS	(i) The introduction of rainwater tanks delays Council expenditure on upgrading stormwater retention and treatment systems otherwise required.
	f	Local authorities/ utility providers/ ratepayers	Expenditure on infrastructure and operating costs for wastewater treatment	FW	(i) The introduction of a water efficiency education programme and water meters reduces the water consumption in households and, in turn, the water discharged to the wastewater system. This results in a decrease in wastewater treatment costs.
2 Water Related	a	Municipal consumers	Value obtained directly from consuming water resources	WM	(i) Households suffer a welfare loss through the introduction of a water meter and the subsequent reduction in water consumption. The reduction in welfare is associated with less water available for watering gardens, refilling swimming pools etc.
	b	Industrial consumers	Value obtained directly from consuming water resources	WI	(i) An increase in water pricing increases the operating costs for a a food manufacturing industry, thus reducing the level of profit recieved by the company.
	c	Agricultural consumers	Value obtained directly from consuming water resources	WA	(i) Increasing demand on aquifer water supply by a growing population is likely to constrain the amount of water available for irrigation in the future. The introduction of a demand management programme will however curtail future agriculture water shortages and thus increase the level of future agricultural output that can be obtained.
	d	Humankind	Recreational values provided by water bodies	WR	(i) Future water takes are likely to lead to low flows within a stream and this will cause the stream to become slow-flowing, stagnant and unsightly. The stream environment will therefore become less attractive and less suitable for recreational activities (e.g. hiking). The implementaiton of a demand management programme will reduce the severity of these adverse effects.
	e	Humankind	Indirect use values provided by water mainly as a result of its role in the functioning of ecosystems	WE	(i) Water takes from streams alters downstream flow regimes to estuaries. This, in turn, advesely effects the health of estuarine ecosystems and thus the level of services provided from these systems such as the provision of habitat for shell fish and fish. The implementation of demand management reduces these adverse effects through the reduction of stream water takes. (ii) The reduction in water takes from streams and aquifers through demand management increases surface water flow volumes. This acts to reduce the impacts of pesticides and faecal coliforms, high water temperatures and low oxygen on ecosystem health. Water abstracted downstream for stock feeding etc is therefore cleaner and more safe to use. (iii) A water demand management programme reduces the need to construct a new dam to maintain water supply. This dam would have limited the normal flow of aquatic organisms and natural sediment cycling procesess. (iv) Reduced water takes as a result of the implementation of a demand management programme will increase surface water volumes and thus act to dilute nitrates and other pollutants discharged to streams. This will help to improve the ability of the water body to assimilate further waste discharges.

	f	Humankind	Option and non-use values of water	WO	(i) Water demand management reduces the demand on an aquifer water supply. People feel satisfaction in knowing that this is preserving the option of using this water resource for an alternative use in the future. (ii) The introduction of a water demand management means that a new reservoir planned to meet meet water supply is no longer needed. People feel satisfaction in knowing that the stream in which the reservoir was to be located is preserved.
3 Resilience	a	Local authorities/ utility providers/ private and commercial consumers	Reduction in the risk of water shortages	RS	(i) A water demand management programme curtails future growth in water consumption thus helping to ensure that existing water supplies can meet demand, espeically during times of drought. This provides a sense of additional security to local consumers.
4 Energy and GHG Emissions Related	a	Humankind	Reduction in the indirect use values as a result of the adverse effects of greenhouse gas emissions on ecosystem functioning.	EE	(i) A reduction in household energy consumption as a result of an installation programme for low-flow shower heads reduces household energy consumption and, in turn, the amount of carbon dioxide produced from energy production. This has a positive effect for humankind by helping to maintain the climate system in its current state.
5 Education & Public Relations	a	Humankind	Promotion of public awareness of water demand issues and encouragement of water saving practices	ED	(i) The introduction of a retrofitting scheme for households creates a greater level of awareness of water demand issues, thus encouraging value changes and voluntary implementation of further water saving practices.
	b	Local authorities/ utility providers/ commercial consumers	Promotion of customer relations	PR	(i) The implementation of a demand management programme reflects positively on New Zealand companies, promoting greater international competitiveness and sales overseas (ii) Ratepayers feel a sense of pride in knowing that the Council is proactively seeking to reduce water consumption and this encourages a greater level of satisfaction among citizens

Table 1: Potential Benefits and Costs of Implementing a Water Demand Management Option

1) Financial Expenditures (components FU, FC, FEU, FEC, FS and FW)

The financial components of the valuation framework capture the money outlays by local authorities and other utility providers as well as water consumers in relation to the supply and consumption of water. [3] For local authorities and other utility providers, financial expenditures include capital outlays on water supply infrastructure, such as dam construction, pump stations, network pipes and so on, as well as operating costs such as the payment of wages and salaries to staff and the purchasing of substances for water purification (component FU). Where the water demand management option under investigation involves the implementation of a tax or charge on water consumers (or an increase in a tax/charge), the additional income generated may count as a reduction in financial costs for local authorities/utility providers associated with water supply. Also important to note is that the supply of water often requires the use of energy, for example electricity required for the operating pump stations. Although for emphasis these energy costs have been identified as a separate category in Table 1 (component FEU), the costs are simply one category among a number of operational costs that can be considered in a valuation exercise.

The implementation of water demand management options may also create financial obligations directly for consumers (component FC). Depending on the scenario, this may include financial outlays associated with purchasing and installing water saving devices (e.g. low flow shower heads, rainwater tanks, dual flush toilets, etc). If a water tax or charge is to be introduced or increased, there is also likely to be increases in water consumption costs for consumers. As with local authorities and other utility providers, differences in energy costs between the WDMS and

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[3] ***Where the financial costs under the baseline scenario are greater than under the WDMS, in other words the net financial costs are negative, technically speaking there is a benefit associated with implementing the WDMS. However, to avoid confusion on the basis that financial expenditures are usually referred to as 'costs,' we also refer to these components as costs in Table 1.***

baseline scenario should also be considered in the valuation if possible (component FEC). In these regards it is very common for water saving devices to produce synergistic effects in terms of energy consumption, particularly where hot water is saved.

The final two categories identified in the financial expenditures category (components FS and FW) cover possible changes in stormwater and wastewater management expenditure by local authorities or other utility providers as a result of implementing a water demand management option. In terms of stormwater, this cost is most likely to be relevant in a valuation exercise where the WDMS involves implementation of rainwater tanks. This is because in addition to conserving water, rainwater tanks offer stormwater management services which will potentially reduce the need for future expenditures on stormwater management. Similarly, savings in water consumed often have flow-on implications for wastewater. In most cases, costs of wastewater treatment will decline.

2) Water Related (components WM, WI, WA, WR, WE and WO)

The water related benefits identified in Table 1 are intended to cover the wide range of values provided by water to humankind, and importantly the changes that may occur to these values as a result of implementing a selected water demand management option. Following the Total Economic Valuation methodology (Pearce et al., 1989; Pearce and Turner, 1990; Perrings, 1995a, 1995b), we have separated the values attributable to an ecological resource such as water into use and non-use values. Use values are further categorised into direct-use (components WM, EI, WA and WR), indirect-use (component WE) and option values (component WO).

To begin, direct use values are those based on conscious use of a resource in consumption or production activities. Component WM covers the direct use values (benefits) received by municipal consumers through their use of water. These benefits cover a range of different kinds of residential water use such as bathing, drinking, cooking, watering of lawns and washing of cars. In some situations WDM interventions may be implemented with no real change in the level of benefits or utility provided by water. The best low flow shower heads, for example, are designed to reduce the level of water used when showering without reducing the utility of the experience for consumers. Other WDM interventions, however, will affect the total utility provided to residential consumers. Taxes or tariffs on water use, for example, which are specifically designed to induce water consumption through increased charges, will likely create a direct loss in the utility provided to consumers through water consumption. The next components in Table 1, components WI and WA, are very similar to component WM except that it is the changes in direct use values provided to industrial/commercial and agricultural water consumers respectively, as opposed to municipal water consumers, which are the focus. Finally, water levels in streams, lakes and reservoirs can directly affect the recreational benefits provided by these water bodies. Ideally, a valuation of a WDM intervention will therefore also consider the possible changes in recreational benefits provided by the water bodies relied on for water supply (Component WR).

In addition to the direct use values of water thus far described, water provides significant indirect-use values, predominantly through its role in ecological systems. These systems provide numerous beneficial ecosystem services to humankind. For example, water clearly has a significant role in the ecosystem services of waste treatment and assimilation. In addition, water has a critical role in the provision of habitat and life-support to wildlife, the provision of nutrient cycling and processing functions, and in helping to regulate climate.

Assessing the likely changes in indirect-use values provided by ecosystems as a result of the implementation of a water demand management option (component WE) is certainly among the most challenging aspects of the valuation of a WDM option. In these regards it can be noted that because ecosystems are complex, with each component of the system interconnected, it may be very difficult to isolate the functions (and hence value) provided by an individual component such as water in the provision of ecosystem services. A further complication is that although ecosystems are often shown to tolerate quite a substantial degree of stress while continuing to provide substantially the same level of functions, there is often a type of ‘critical point’ which, once reached, small increases in stress or damage will result in drastic changes to ecosystem functioning. Although we should always aim to take account of these factors in assessing the impacts of a WDM intervention, it is unlikely that any valuation framework could ever fully account for these complexities, especially when it is considered that water is constantly cycling in the earth system through a variety of ecosystems.

The final water-related benefit identified in Table 1 covers changes in option and non-use values provided by water (Component WO). Option values recognise that individuals who do not presently use a resource may still value the option of using that resource in the future. Thus actions that conserve resources and increase the possibility of using the resources in the future will result in a net benefit in terms of increased option values. Non-use values greatly expand the definition of value for ecological resources into social and cultural considerations. Non use values include existence values (value individuals place on the conservation of an environmental resource which will never be used personally or by future generations), bequest values (satisfaction in knowing that a resource has been preserved for use by future generations) and altruistic values (satisfaction in knowing that a resource has been preserved for use by others in the current generation). As with the last component, although the changes in benefits may be significant, it is in practice very difficult to ascribe an appropriate monetary value for these changes.

3) Resilience (RS)

Component RS is intended to cover changes in water reliability or security arising out of a demand management option. People value having water reliably available at desired quantities across seasons and years, such as may be necessary to avoid periodic water use restrictions during drought periods. Water reliability and security have received growing interest in light of the concerns and potential impacts associated with future climate change.

4) Energy and Greenhouse Gas Emissions Related (EE)

Component EE in Table 1 is closely aligned to Components FEU and FEC in that it addresses the impacts of changes in energy use occurring as a result of changes in water demand. However, whereas Components FEU and FEC focused on the financial costs of energy use, Component EE addresses the ecological costs of energy use in terms of the greenhouse gas emissions generated. As already described above, the worlds' ecosystems (and climatic systems) are complex, and deriving a method that will produce a fair and proper monetary value for impacts on these systems is an ambitious goal. Nevertheless it is considered that a complete valuation exercise would try to take some account of these impacts in the assessment of a water demand management option.

5) Education and Public Relations (ED, PR)

Taking part in water demand management implementation is itself a pedagogic tool which can engender awareness and discussion in relation to water demand issues. This may, itself, promote value changes and voluntary water savings elsewhere. Consideration of such benefits is the focus of component ED. Local authorities and utility providers that instigate water saving programmes will also potentially improve relationships with those members of the public/customers who derive satisfaction in knowing that water conservation is taking place (Component PR).

3.4 Aggregating Benefits and Costs

In its most simplistic formulation, the value (measured in current $) of a selected WDM intervention, V, is defined as, $V = NB - NC$ (1) where NB, the net benefits of the water demand management option, is calculated as the benefits likely to accrue with implementation of the water demand management, in other words the benefits under the water demand management (WDM) scenario,, less the benefits likely to accrue under the baseline scenario. Similarly, the net costs of the water demand management option, NC, are calculated as the costs likely to accrue with implementation of the water demand management option, less the costs likely to accrue under the baseline scenario. Importantly, all benefits and costs included in the calculation for Equation 1 will be assessed over the timeframe of the two scenarios. Ideally, the timeframe will be the lifetime of the WDM intervention in question, although this will not always be possible.

By incorporating benefits and costs identified in Section 2.3 above, Equation 1 can now be expanded to,

$$V = WM + WI + WA + WR + WE + WO + RS + ED + PR - (FU + FC + FEU + FEC + FS + FW + EE),$$

(3) where, on the benefits side, WM, WI and WA represent the direct use benefits obtained, from water consumption by residential, industrial and agricultural consumers respectively, WR is the recreational benefits obtained, WE represents the indirect use value of water derived as a result of its role in the provision of ecosystem services, WO is the sum of all option and non-use values, RS is the benefits obtained in terms of advancing resilience in water supply, and ED and PR are the benefits obtained in terms of promotion of education and customer relations respectively. Importantly all benefits must be measured in net terms, i.e. the benefits that are

likely to be obtained under the WDM scenario, less the benefits likely to be obtained under the baseline scenario. Where the benefits are greater under the baseline scenario than the WDMS, the net benefits will be negative. This is effectively the same as a net cost in the valuation exercise.

On the costs side of Equation 3, FU and FC represent respectively the financial costs to utility providers and consumers of water provision and water consumption. The next two terms, FEU and FEC, represent the financial costs to utility providers and water consumers of energy use associated with the provision and consumption of water. Finally, FS and FW represent the financial costs to utility providers associated with stormwater and wastewater management and EE represents the net ecological costs associated with energy use and greenhouse gas emissions.

As with benefits, all costs in Equations 3 and 4 are measured in net terms by taking the estimated costs under the WDM scenario, less the estimated costs under the baseline scenario.

3.5 The Principle of Present Value

The costs and benefits of a selected WDM intervention do not occur at a single point in time; they are a continuously varying stream of expenditures and benefits that extend over the lifetime of the project and potentially beyond. In order to deal with this temporal dimension of cost, practitioners of cost-benefit analysis therefore turn to the principle of present value. Essentially this involves translating all future (and possibly past) benefits and costs into present day terms by the application of discount rates. This procedure then allows for all costs and benefits to be aggregated over time to give a total estimate of the net value.

When discounting is applied to specific assets, such as pipes and water supply plants, it provides a means of taking into account the opportunity costs of capital investments. This approach is widely accepted and non-controversial. In the case of non-market goods and services, however, such as the environment, the use of discounting is justified on the basis that it accounts for the social rate of time preference (i.e. the tendency of people to place more importance on now than on the future). By implication, the higher the discount rate used, the lower the importance placed on future costs and benefits. This means, for example, that schemes with environmental benefits occurring well into the future are less likely to be favoured than those with near term benefits, even if the near term benefits are of a smaller magnitude. Similarly, it is possible that a higher net present value will be calculated for options which produce high future environmental costs, but which yield near-term benefits greater than alternative options yielding lower near-term benefits, but also lower future costs.

There is considerable literature on the subject of setting the discount rate. While it is typically recognised that the application of some discount rate is required, there is much debate regarding the appropriate discount rate to apply in different types of valuations and whether this rate should be the same for all benefits and costs evaluated. As a guide to setting the discount rate, it can be noted that a rate of 4.5% per annum is recommended in the UK Environmental Agency Water Resources Planning Guidelines (Bentley et al., 2007). In order to generate the results presented in this report, a discount rate of 5.0% has been applied, in line with TCC's internal guidelines. Given, however, that the results appear to be relatively sensitive to the discount rate applied it is recommended that a range of alternative discount rates are tested. A copy of the model used to calculate the value of WDM in the Tauranga case study has been supplied to TCC so that it may undertake this sensitivity analysis.

4 Scenarios for Tauranga City

4.1 Introduction

As described above, before we can assess the value of a given WDM intervention, we must first define (at least) two different scenarios, the comparison of which will form the basis of the valuation exercise. For the Tauranga City case study, the purpose of the valuation exercise is to evaluate the application of two specific WDM interventions: the introduction of water meters and water pricing and the introduction of water education. One of the scenarios (referred to as the 'WDM scenario') therefore covers the introduction of these interventions, along with the economic, social and environmental implications. The comparative scenario (referred to as the 'baseline scenario') is a hypothetical analysis of the implications that would have occurred had TCC chosen not to implement WDM, and instead followed more of a traditional approach of simply extending water supply infrastructure to meet growing demands. The most important assumptions employed in the development of each scenario are set out below:

4.2 Scenario Timeframes

Both the WDM scenario and the baseline scenario cover the period commencing 1 July 1999 and ending 31 June 2015. The 1999/00 financial year is chosen as the start point for the analysis on the basis that this is approximately the time that TCC introduced WDM, and further most of the financial data used for the analysis can be obtained in a consistent format back to this date.

Although it was initially intended that the case study would evaluate the benefits of the WDM interventions that had been introduced to date (i.e. just for the period 1 July 1999 to present), after some consideration it was decided that in order to achieve a balanced valuation, it would be necessary to extend both scenarios out to the year 2015. This conclusion relates primarily to the capital expenditures that are required for bringing online the Waiari water supply scheme. The introduction of WDM in Tauranga city has not resulted in the avoidance of the need to construct the Waiari scheme altogether, but rather delayed the introduction of the scheme by approximately 10 years. However, had the analysis covered only the financial years 1999/00 to 2008/09, the capital expenditures required for the Waiari scheme would have been captured in baseline scenario but not at all in the WDM scenario. Potentially this would have over-emphasised the benefits of implementing WDM. By extending both scenarios out to 2015, the introduction of Waiari is captured in both scenarios.

4.3 Peak Water Supply and Investment in the Waiari Scheme

As is explained in the report to the Projects and Services Committee of TCC (Hermens, 2008), the need for additional water supply from the Waiari scheme is triggered once the peak day demand of Tauranga City exceeds the treatment capacity of the existing treatment plants at 69,000m^3/day.

With the introduction of WDM, we know that peak water supply has not yet reached the trigger point of 69,000m^3/day. In the WDM scenario, the introduction of the Waiari scheme therefore occurs sometime in the future. Based on current population projections, TCC has estimated that peak water demand will necessitate the bringing on line of the Waiari Scheme sometime during the year 2014/15. This projection assumes that peak water demand will continue at about the same rates per person as occur presently. In developing this estimate a security 'buffer' of around 10% additional peak demand has also been included.

Had WDM not been introduced, the Waiari scheme would have been required to be introduced at an early stage. For the purposes of the Baseline scenario, it has been assumed that peak water supply would have remained relatively constant over the entire study period, at around 671 litres/person/day, had WDM not been introduced. This figure is based on the average of the peak water demand for the financial years 1995/96 to 1997/98. By then multiplying the assumed peak water demand per person by the population for each year, it is determined that under the Baseline scenario, the Waiari scheme would have been required sometime in the year 2005/06.

The capital expenditures required for the implementation of the Waiari scheme are set out in the latest Long Term Council Community Plan (LTCCP). In the LTCCP, however, it is assumed that the commencement of operation of the Waiari scheme can be delayed by a further 2 years (ie until 2017) by the introduction of further WDM interventions. As these further interventions are not included in this valuation exercise, it has been necessary for the WDM scenario to move the capital expenditures set out in the LTCCP forward in time so that they are completed by 20014/15. The total cost (in present day terms) of implementing the Waiari scheme is assumed to be the same under the Baseline scenario. However, due to shorter timeframes for construction under this scenario, it has been necessary to assume that the capital expenditures occur over fewer years when compared with the WDM scenario. For the Baseline scenario, it has also been assumed that the expenditures are evenly distributed across each year. In summary, the profile of the Waiari water supply scheme capital expenditures under the two scenarios is set out in Table 2.

Year Ending June	Expenditure under WDM Scenario ($2009 mil)	Expenditure under Baseline Scenario ($2009 mil)
2000	0.0	0.0
2001	0.0	13.9
2002	0.0	13.9
2003	0.0	13.9
2004	0.0	13.9
2005	0.0	13.9
2006	0.0	0.0
2007	0.0	0.0
2008	0.0	0.0
2009	0.0	0.0
2010	2.6	0.0
2011	5.5	0.0
2012	3.0	0.0
2013	17.6	0.0
2014	30.8	0.0
2015	10.1	0.0
Total	69.7	69.7

Table 2: Capital Expenditures Required for the Waiari Scheme, 2000-2015

4.4 Volume of Water Supplied and Wastewater Treated

The assumed total volume of water supplied for each year under each of the respective scenarios is an important factor in determining the results of the valuation exercise, as explained further in Section 4.0. For the purposes of the WDM scenario, the water supply figures out to 2007/08 are based on real water supply data extracted from the Council's database. For the remaining study years, i.e. 2008/09 to 2014/15, it is assumed that per capita water supply under the WDM scenario remains approximately constant with the 2007/08 level (i.e. 123m^3/person/year). Total growth in water supply for these years is thus directly proportional to population growth (see Figure 2).

As with peak water demand, the volume of water supplied per capita under the Baseline scenario is based on an average of the years 1995/96 to 1997/98 (i.e. 167m^3/person/year), and is assumed to stay relatively constant over the entire study period (see Figure 2).

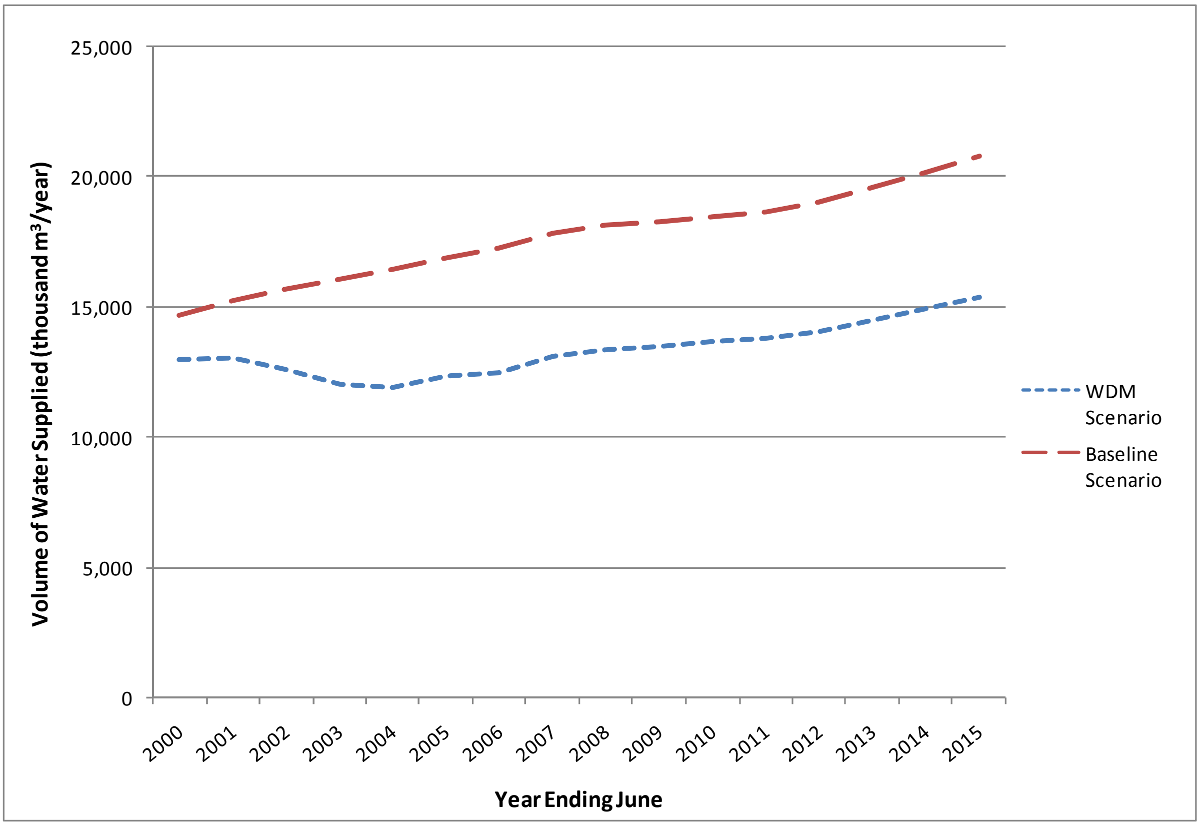

Figure 2: Volume of Water Supplied under the WDM and Baseline Scenarios, 2000-15

For the WDM scenario, real data has once again been used to establish the volume of wastewater treated for the first years of the study period (in this case 1999/00 to 2007/08). For the remaining years, the volume of wastewater required to be treated under the WDM scenario has been estimated by multiplying the assumed total volume of water supplied (as per above), by the figure 0.71. This figure is determined by taking the average ratio, for the years 1999/00 to 2007/08, of the total volume of wastewater treated to the total volume of water supplied. Similarly for the Baseline scenario, the total volume of wastewater treated is generated by simply multiplying the assumed volume of water supplied for each year by 0.71 (see Figure 3).

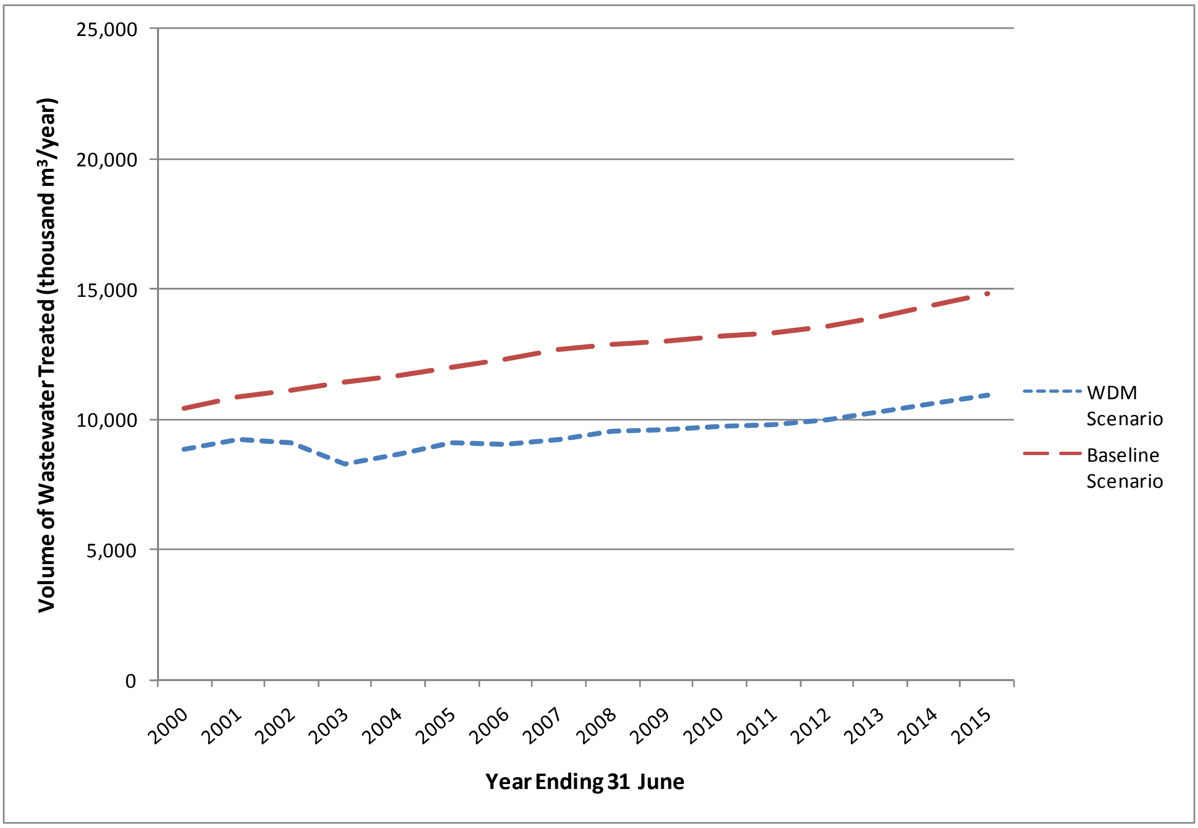

Figure 3: Volume of Wastewater Treated under the WDM and Baseline Scenarios, 2000-15

4.5 Other Water Supply Capital Expenditures

In addition to the capital costs required for the Waiari water supply scheme, the major differences in capital expenditures between the WDM and Baseline scenarios relate to the installation and renewal of water meters. With the introduction of water meter pricing, TCC was required to undertake relatively significant capital investment in the introduction of water meters throughout the city. These capital expenditures occurred over the financial years 1999/00 to 2004/05, and summed to a total of around $\$_{2009}$10.2 million.[4] The capital expenditures are included in the WDM scenario but not the Baseline scenario.

Similarly, the capital expenditures required for water meter renewals are included in the WDM scenario but not the Baseline scenario. For the years 2004/05 to 2008/09 the expenditures on water meter renewals (totalling $\$_{2009}$0.6 million[5]) are taken from real financial data supplied by TCC. For the remaining years expenditures on water meter renewals are estimated from the LTCCP budget (total of $\$_{2009}$3.2 million for the years 2009/00 to 2014/15).

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[4] ***The Capital Price Index – Machinery Plant and Equipment (refer to Appendix B) is used to translate all values to 2009 dollars.***

[5] ***See footnote 5.***

4.6 Water Supply and Wastewater Treatment Operational Expenditures

There are five categories of operational expenditures that differ between the WDM and Baseline scenarios: (a) expenditures on water education, (b) expenditures on water meter reading, (c) operational expenditures for water supply that vary according to the volume of water supplied (d) operational expenditures for wastewater treatment that vary according to the volume of wastewater produced, and (e) expenditures on electricity.

1) Education and Water Meter Reading Expenditure

For the WDM scenario, expenditures on water education and water meter reading over the period 1999/00 to 2008/09 are taken directly from Council data. For the remaining years of the WDM scenario, education and meter reading expenditures are assumed to grow at the same rate as population growth (see Figure 4). For the Baseline scenario, expenditures on water meter reading are assumed to be consistent with those of the WDM scenario for the first two years of the study. However, once the year 2001/02 is reached, the difference in operational costs for meter reading between the WDM and Baseline scenarios becomes substantial. This is associated with the introduction of universal water pricing. For the baseline scenario the expenditures on meter reading are assumed to continue to grow post 2000/01, but only at the rate equivalent to the population growth rate. Finally, in terms of education expenditures under the Baseline scenario, it is simply assumed that a nominal amount, equivalent to 10% of that contained in the WDM scenario, is spent each year.

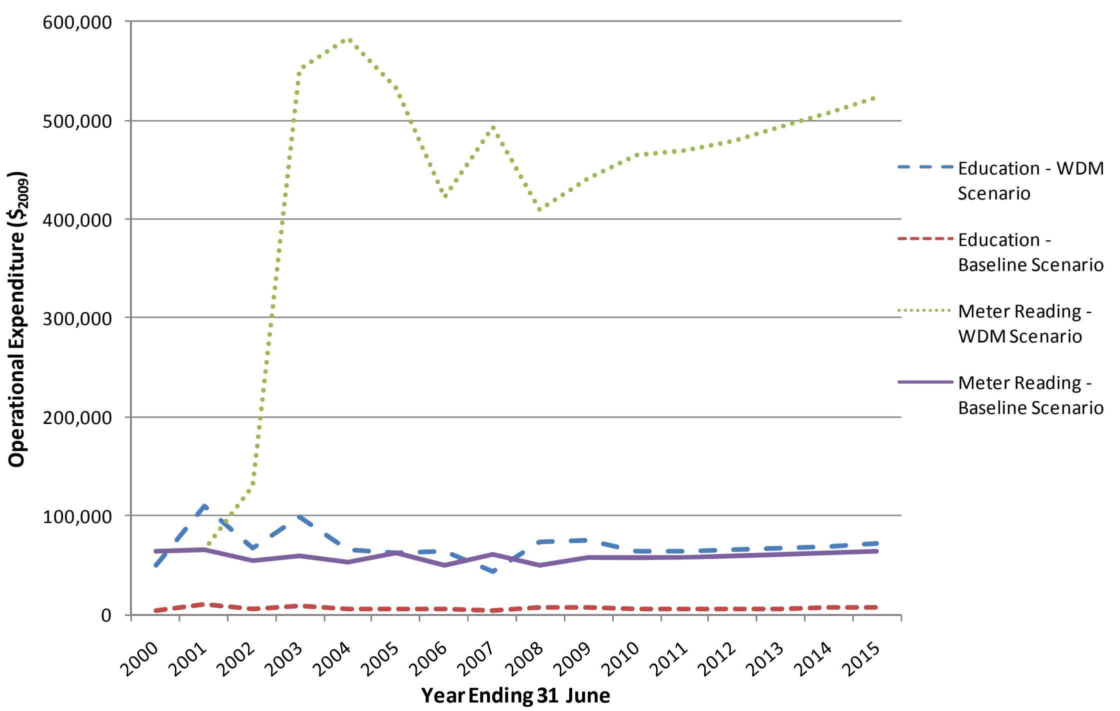

***Figure 4: Education and Meter Reading Expenditures under the WDM and Baseline Scenarios, 2000-2015*[6]**

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[6] *Expenditures are converted to 2009 dollars by application of the Producers' Price Index – Inputs Based for Electricity, Gas and Water (see appendix B).*

2) General Operational Expenditures for Water Supply and Wastewater Treatment

In addition differences in education and water meter reading expenditures, it is reasonable to assume that other operational expenditures will vary between the two scenarios as a result of different volumes of water supplied and wastewater treated. For example, the additional water required to be supplied under the Baseline scenario is likely to require additional expenditure on electricity for water treatment substances. Furthermore, where additional water is supplied, there is also likely to be additional wastewater generated. This means that additional maintenance of equipment will also be required for wastewater treatment.

In order to determine the difference in operational expenditures for water supply between the WDM and Baseline scenarios, a detailed breakdown of water supply operational expenditures was acquired from the Council's database for the years 1999/00 to 2005/06. Each expenditure category was then assigned a percentage that deemed is to be variable (i.e. will vary in proportion to the volume of water supplied) and a percentage that is non-variable (i.e. will not vary according to the volume of water supplied). Lab testing expenditures, for example, are assumed to be 100 percent variable, while repairs and maintenance of mechanical equipment are assumed to be 50% variable. For the years 1999/00 to 2005/06, the additional operational expenditures required under the Baseline scenario for a selected year t (O_t) were then calculated according to the formula, $O_t = \frac{VE_t}{WS_t^{WDM}}\left(WS_t^{Baseline} - WS_t^{WDM}\right)$ (1) where VE_t is the total value of all variable expenditures for year t, and WS_t^{WDM} is the total volume of water supplied for that same year under the WDM scenario, and $WS_t^{Baseline}$ is the total volume of water supplied under the Baseline scenario. For the year's post 2005/06, the fraction $\frac{VE_t}{WS_t^{WDM}}$ is assumed to remain constant at 0.10 $\$_{2006}/m^3$ (excluding electricity). This value is based on the data for the previous 2005/06 year.

3) Electricity

Electricity operational costs are given special attention in this study on the basis that (1) electricity is typically one of the most significant variable costs associated with water supply and wastewater treatment and (2) the use of electricity generates additional costs associated with the production of greenhouse gas emissions.

Data on electricity usage for water supply and wastewater treatment (kwh), along with the financial costs of electricity for water supply and wastewater treatment (current $) was provided by TCC for the years 2002/03 to 2008/09. For each year the amount of electricity used for water supply (kwh) was graphed against the total volume of water supplied for that year (m3), thus allowing for an estimate of the linear relationship between the variables to be established. This relationship, plus the assumed water supply requirements for each scenario (see Figure 2 above), was then used to estimate the total amount of electricity required under each scenario post 2008/09. Finally, the physical data on electricity usage was converted to estimates of electricity costs in constant 2009 dollar terms based on the 2008/09 ratio of electricity usage (kwh) to total cost of electricity ($). The electricity required for wastewater treatment and the costs of this electricity were calculated in an analogous manner to water supply.

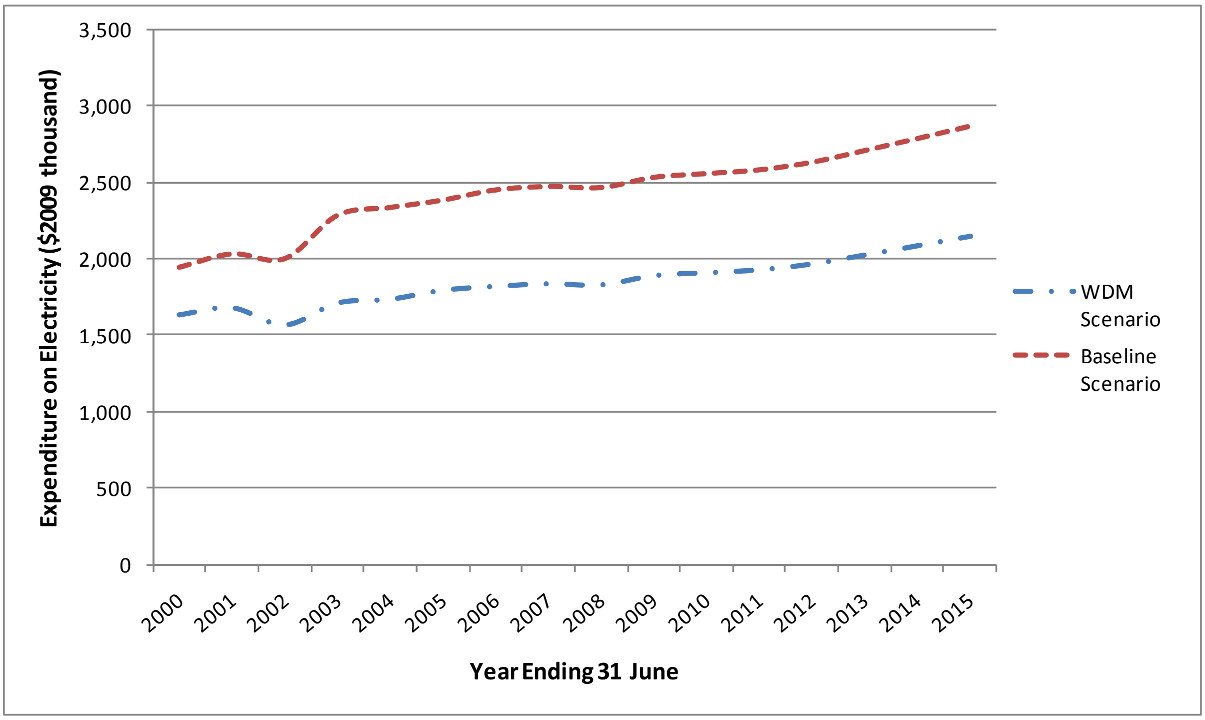

Figure 5: Total Expenditure on Electricity Required for Water Supply and Wastewater Treatment under the WDM and Baseline Scenarios, 2000- 2015

5 Methods Used to Value Each Benefit and Cost

Having set out the two comparative scenarios and the categories of benefits and costs to be assessed, this section is concerned with describing the methods used for valuing each benefit and cost in monetary terms. Although in this study there has been an attempt to assign monetary values to all potential benefit and cost categories included in Table 1, given time and budget constraints, it has simply not been possible to develop an appropriate method for all categories. The categories that remain unvalued in monetary terms are nevertheless important and should be given due consideration when reflecting on the net benefits of implementing WDM in Tauranga City. Further consideration can also be given in the future to the ways in which the methodology might be extended to cover the remaining categories.

5.1 Financial Expenditures (FU, FC, FEU, and FW)

The majority of the work required to evaluate the net financial benefits/costs associated with implementing WDM (components FU, FC, FEU, and FW) occurs in the setting of the two comparative scenarios. This is because as part of the development of these scenarios, expenditure profiles across time have been created for the different categories of operational and capital expenditure (see Section 3.0 above). It can also be noted that where necessary, all values from these profiles have been converted to current prices ($\$_{2009}$) through application of appropriate price deflators.

Now in order to determine the net benefit of implementing WDM for each of the financial components, we simply take the value of the likely financial expenditures under the Baseline scenario, less the value of the likely financial expenditures under the WDM scenario. In mathematical terms, the first financial expenditure component, FU, is therefore defined as,

$$\mathrm{FU} = \left(\mathrm{NPVC}^{\mathrm{BS}} - \mathrm{NPVC}^{\mathrm{WDM}}\right) + \left(\mathrm{NPVO}^{\mathrm{BS}} - \mathrm{NPVO}^{\mathrm{WDM}}\right) \qquad (4)$$

where $\mathrm{NPVC}^{\mathrm{BS}}$ and $\mathrm{NPVC}^{\mathrm{WDM}}$ are the net present value of capital expenditures on water supply by local authorities/ utility providers under the Baseline and WDM scenarios respectively, and $\mathrm{NPVO}^{\mathrm{WDMS}}$ and $\mathrm{NPVO}^{\mathrm{BS}}$ are the operating expenditures on water supply by local authorities/utility providers under the WDM and the Baseline scenarios respectively. The net present value (NPV) of each element is defined as the sum of the annual costs over the lifetime of the study, with future costs discounted. Equation (4) can thus be expanded to,

$$\mathrm{FU} = \sum_{t=1}^{n}\left(\mathrm{C}_t^{\mathrm{BS}} - \mathrm{C}_t^{\mathrm{WDM}}\right) g (1-r)^{t-1} + \left(\mathrm{O}_t^{\mathrm{BS}} - \mathrm{O}_t^{\mathrm{WDM}}\right) g (1-r)^{t-1} \qquad (5)$$

where t represents each year of the study ($t \in 1...n$); $\mathrm{C}_t^{\mathrm{BS}}$ and $\mathrm{C}_t^{\mathrm{WDM}}$ are the capital expenditures for year t under the Baseline and WDM scenarios respectively, similarly $\mathrm{O}_t^{\mathrm{BS}}$ and $\mathrm{O}_t^{\mathrm{WDM}}$ are the operating expenditures for year t under the Baseline and WDM scenarios; and r represents the annual average discount rate applied The equations for the other financial expenditures, FC,[7] FEU,

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[7] ***Interestingly, the financial costs to consumers (FC) balance out in this study to produce a net value of zero. This is because, while the costs of water for municipal and commercial***

and FW are derived in an analogous manner. In the case of financial expenditures on energy (FEU) and wastewater treatment (FW), however, no attempt has been made to assess differences in capital expenditures between the scenarios (i.e. capital expenditures are assumed to be the same).

5.2 Other Financial Components (FEC, FS)

This study has not attempted to include a value for either the change in expenditure for private and commercial consumers on energy supply (component FEC), or changes in expenditures relating to storm water treatment (component FS). Although it is possible that the WDM interventions in this study did result in some changes to consumer energy use, there is no information available upon which to assess the nature and magnitude of these changes. Additionally, the latter category of expenditure is considered to be not particularly relevant to the type of WDM interventions implemented in this case study. Changes in storm water treatment are more likely to arise, for example, with the implementation of WDM interventions such as rain tanks.

5.3 Water-Related Municipal and Industrial Direct Use Values (WM, WI)

5.3.1 Using Water Demand Functions and Price Elasticity to Estimate the Value of Water

The typical approach to estimating changes in direct use values received by municipal and commercial/industrial consumers accompanying a change in water pricing or water use is through the use of water demand functions. Only a brief description of this method is given here. Readers who are interested in learning more details may refer to commentators such as Gibbons (1986), Arbués et al. (2003) and Young (2005), as well as the larger framework report from which this case study is derived (Smith and McDonald, 2009).

In short, a water demand function specifies the relationship between the quantity of water consumed and the price of water, and is represented graphically by a demand curve. Consumers are hypothesized to adjust water consumption behaviour and, in the long-run, to modify water-using appliances in response to changes in water price. Water consumption thus varies inversely to price changes.

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consumers increases as a result of introducing water pricing (i.e. a net cost), these additional costs are transferred to the Council to help finance water supply (i.e. a net benefit). The simplest approach is therefore to exclude these payments, either as a cost to consumers or a benefit to the Council, in the analysis. Given, however, that consumers are ultimately responsible for the costs of water supply and wastewater treatment through ratepayer funds, any of the other net benefits or costs calculated for the Council (i.e. under components. FU, FEU and FW) should be considered as also relevant to consumer stakeholders.

An example of a demand function is provided in Figure 6 below. The curve represents the total quantity of water consumers are willing to purchase at a selected price. Notably as the quantity approaches zero, the slope of the curve tends towards vertical indicating that a small portion of the demand is for uses for which there are no substitutes and that are of great necessity to the user (Gibbons, 1986). The area under the demand curve represents the total willingness to pay (or value) of the water delivered to consumers.

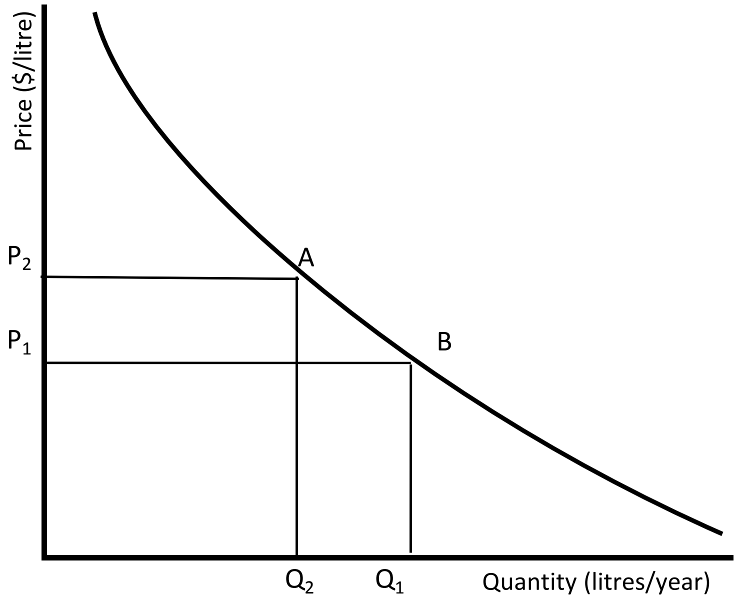

Figure 6: Municipal Water Demand Function

In order to explain the application of the demand curve to the assessment of a water demand management option,[8] let us assume, for example, that as a result of the implementation of an increase in water charges, the price to consumers for water consumption increases from P_1 (the baseline scenario) to P_2 (the WDM scenario). Based on the assumed demand curve in Figure 6, consumers will respond to the price change by adjusting consumption from Q_2 to Q_1. The difference in value received by consumers through water consumption is equal to the change in the area under the curve between the two scenarios, i.e. the area ABQ_1Q_2. In order to determine the change in direct use values of water as a result of implementing WDM, it is therefore necessary to determine a method for calculating the size of area ABQ_1Q_2.

In this study, reference is made to the concept of water ‘price elasticities’ in order to estimate the change in the area under the curve and thus the change in direct use values received by consumers. In summary, price elasticity, ε, is the relative change in the quantity demanded in relation to the relative change in price and is calculated according to the formula, $\varepsilon = \dfrac{\Delta Q / Q}{\Delta P / P}$ (6) where Q is the quantity of water consumed (m^3/person/day) and P is the price

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[8] ***Strictly speaking the curve is a marginal benefit curve, as opposed to a demand curve, as price rather than quantity is the dependent (y axis) variable.***

($\$/m^3$; see, for example, Samuelson and Nordhaus (1994)).[9] Now if it is assumed that the price elasticity is not equal to 1.0, the change in area under the demand curve for Figure 1 above (V) can be calculated as (Young and Gray, 1972), $V = \left(\frac{P_1 Q_2^{\frac{1}{\varepsilon}}}{1 - \frac{1}{\varepsilon}} \right) \left(Q_2^{1-\frac{1}{\varepsilon}} - Q_1^{1-\frac{1}{\varepsilon}} \right)$,(7) where ε represents the price elasticity of demand and all other variables are as specified above.[10]

Finally, given that V as defined above represents the change in municipal direct use values over just one year, the final step in the method is to estimate the total change in value over all years of the study, VM. Applying a discount rate this can be calculated as, $VM = \sum_{t=1}^{n} V_t (1-r)^{t-1}$ (8)

Where t represents each year of the study ($t \in 1...n$) and r represents the annual average discount rate applied.

5.3.2 Application to the WDM and Baseline Scenarios

A number of assumptions and additional steps are required in order to apply the method for assessing changes in direct use values, as specified above, to the assessment of the WDM and Baseline scenarios. These are summarised below.

1) Price Elasticity of Demand

Ideally, in applying equation 7 above, the price elasticity of demand, ε, would be derived specifically for Tauranga City from real information on water pricing and consumption. In this study it was however determined that, given the relatively little data available on different pricing and consumption variables, it was not possible to develop a sufficiently reliable estimate of Tauranga's price elasticity.[11] It is however noted that this is an area of research that could potentially be extended in the future.

It can also be noted that it would have been preferable to have analysed municipal and commercial uses of water separately. This is because the two types of demands are likely to

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[9] ***The demand for municipal water is generally expected to be rather inelastic (the absolute value of the price elasticity is less than 1.0). This means that a given change in price will lead to a less-than-proportional change in quantity used. This is because water has no substitutes for basic uses and also because water bills typically represent a small proportion of income (Arbués et al., 2003; Young, 2005).***

[10] ***Note that this equation assumes that a constant elasticity demand function applies to water demand. The validity of the constant elasticity assumption is likely to decrease, the larger the change in water consumption/price considered (Gibbons, 1986).***

[11] ***An estimation of price elasticity for Tauranga based on historic data is particularly complicated due to the simultaneous introduction of water pricing and water education. It is thus difficult to isolate the behaviour impacts of water pricing only on water demand.***

exhibit different patterns of response to price changes. In this study it was not, however, possible to separate all the necessary data required into municipal and commercial uses.
In order to calculate the results that are set out in Section 4 below, a default price elasticity of -0.34 was selected. This value is based on a review of international literature which suggests that the average price elasticity for municipal water use is around -0.36, while the average price elasticity for industrial water use is around -0.29 (Smith and McDonald, 2009). The final value of -0.34 was derived by a weighting 2/3rd towards municipal uses and 1/3rd toward industrial uses, so to reflect the approximate split of residential and commercial water consumption in the city.

2) Quantity of Water Consumed

The application of Equation 7 requires estimates of water consumed for the two different scenarios (variables Q_1 and Q_2) for each year of the analysis.[12] For the years 1999/00 to 2007/08, the volume of water consumed under the WDM scenario is taken from data on water sales supplied by TCC. For the years 2008/09 to 2014/15, it is assumed that under the WDM scenario, the volume of water consumed per person remains constant at that recorded for 2007/08.

For the purposes of assessing changes in direct use values, it has initially been assumed that the volume of water consumed under the Baseline scenario is the same as that under the WDM scenario for the first three years of the study, and thereafter remains constant at that recorded immediately prior to the introduction of universal water metering (i.e. 0.31m^3/person/day). Although it is reasonable to assume that water consumption under the Baseline scenario would have also been higher than the WDM scenario for first three years of the study, it was considered reasonable to exclude this change in water consumption from the assessment, as any reduction during this period would have occurred as a result of water education only rather than water pricing.[13] In summary therefore, it is only reductions in water consumption below that of 0.31m^3/person/day which are assessed in the calculation of changes in direct use values for consumers.[14]

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[12] Note that the volume of water consumed is distinct from the volume of water supplied, which is the water quantity variable required in the estimation of the majority of the other categories.

[13] The Council observed reductions in per capita water consumption immediately following the introduction of water education. It is expected that as a result of the initial awareness of water-related issues created by these education programmes, consumers would have first reduced consumption in those areas where very little effort was required (e.g. not leaving garden sprinklers going for long periods unnecessarily). It is expected that many of these actions would have resulted in no real loss to consumers in terms of the benefits received from water consumption.

[14] It should also be noted that education programmes continue throughout the study period under the WDM scenario. For the years post 2002/03, part of the reduction in water consumption is thus likely to be also attributable to education rather than water pricing. This effect could be viewed as altering the shape of the demand curve so that less water is

3) Water Consumed by Port Activities

As the consumption of water by the Port has in the past been subject to a different water pricing structure than other types of water consumption, the port consumption data should theoretically be separated from the rest of the city's consumption data and analysed separately. Although this has not been undertaken in this study, it is considered that this has generated a minimal impact on the results given that water consumed by the Port accounts for only about 1.5% of the total volume of water consumed.

5.4 Agriculture Direct Use Values (WA)

There has not been any evidence provided to suggest that there has been a significant change in the availability of, or benefits provided by, water use for agriculture purposes. This component of the framework has not been assessed as part of the case study.

5.5 Water-Related Indirect Use Values (WE)

To reiterate, the purpose of component WE is to include an assessment of the likely benefits of a water demand management programme in terms of supporting the provision of ecological services, such as dilution of wastewater, water purification and habitat for wildlife. It is anticipated that where such benefits arise out of a WDM option, it will typically be because the option contributes to maintaining or enhancing instream water flows. As described above, placing a value on these benefits is extremely challenging due to the complexity of ecological systems.

In this study, the value of indirect use benefits derived from the reduction of water taken from ecosystems is calculated as: $\mathrm{WI} = \sum_{t=1}^{n} \mathrm{ws}_t \, \mathrm{g} \mathrm{Veco} \mathrm{g} (1 - \mathrm{r})^{t-1}$ (10) where ws_t is the volume of water saved (in litres) through application of the water demand management option over year t (i.e. the difference between that used under the WDMS and the baseline scenario), Veco is the indirect use values provided by instream water ($\$_{2009}$/litre), and all other terms are as described above.

As a proxy for the indirect use values provided by instream water, Veco, we have relied on the ecological shadow price for surface water of $\$\mathrm{US}_{1994}0.16$ per tonne derived by Patterson (2002). This shadow price translates to approximately $376 per million litres in current NZ dollars.[15]

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demanded at each particular price. Alternatively, the effect can also be viewed as changing the value sets of consumers such that greater satisfaction is received from the option and non-use values of water. As neither of these effects have been taken incorporated in the valuation exercise, it could be argued that the assessment of loss of direct use values overstates the costs of implementing WDM.

[15] ***US dollars are converted to NZ dollars by application of the average US to NZ currency exchange rates for year ending June (see Appendix B). The value is also inflated from to current prices by application of the GDP Price Deflator (see Appendix B).***

Further details on the reasons for the selection of this shadow price as an appropriate proxy in the valuation of indirect use values are provided in Smith and McDonald (2009). To summarise, however, it is noted that, while Patterson's shadow price may be based on a highly aggregate model of global ecological processes, it is one of only very few studies in the literature that provide a per litre price for instream water. Interestingly, the shadow price derived by Patterson is also remarkably similar to that derived independently by Landry (1998), through an examination of the prices paid to protect instream flows for ecological purposes. As with other assumptions used in this study, the model provided to the Council provides an option for exploring the effect of alternative value estimates for instream water.

5.6 Resilience (RS)

Although we have not attempted to place a value on the benefits of resilience created through the implementation of WDM, it is noted that the literature suggests that municipal and industrial/commercial water users tend to value reliability/resilience of water supply quite highly (see, for example, Howe and Smith (1994)). There is also evidence that there has been quite substantial improvement in water supply resilience for Tauranga city since the implementation of WDM. In these regards it is observed that for a number of years prior to the implementation of WDM, the city experienced successive rounds of summer water use restrictions. These restrictions have, however, not been required since the introduction of WDM.

5.7 Energy and Greenhouse Gas Emissions (EE)

As described above, the purpose of this component of the framework is to incorporate an estimate of the costs of greenhouse gas (GHG) emissions arising out of changes in energy use between the WDMS and baseline scenarios. The changes in energy use between the two scenarios that are measured in this analysis are the differences in electricity requirements for water supply and wastewater treatment. As greenhouse gas emissions are released in the process of generating electricity, associated with these changes in energy are changes in the levels of 'indirect' greenhouse gas emissions for water supply and wastewater treatment.

Theoretically, the costs of greenhouse gas emissions can be included in the valuation exercise though application of the social cost of carbon (SCC). This is a measure of the full global cost today of an incremental unit of carbon dioxide (or equivalent amount of other greenhouse gases) emitted now, summing the full global cost of the damage it imposes over the whole of its time in the atmosphere (Price et al., 2007). Although the SCC is relatively straight forward in principle, in practice it is difficult to ascertain an appropriate value for the SCC because the amount of damage done (both now and in the future) by each incremental unit of carbon in the atmosphere will depend on the outcome of complex system interactions that will vary according to current and future concentrations of GHGs in the atmosphere. Concentrations of GHGs to the atmosphere are, in turn, influenced by emissions policies put in place, including the prices allocated to carbon emissions.

In this study, an estimate of the SCC has been made based on the findings of the Stern Review (Stern, 2006), which suggests that the optimum stabilisation goal requires the world to aim for atmospheric concentrations somewhere in the range of 450-550ppm (CO_2-e). The Stern Review calculates that this scenario implies a social cost of carbon of US\$30/tCO_2-e in 2000, which is equivalent to NZ$\$_{2009}$82/t$CO_2$-e.[16] Although there are other prices for carbon that could be derived based on different assessment of risks, emissions scenarios and other modelling assumptions, it is noted that the Stern estimate is probably the most widely referenced and frequently used in studies of this nature (see, for example, Price et al. (2007) and McDonald et al. (2009)).

It is further observed that the SCC is likely to increase over time because, as the concentration of carbon in the atmosphere and temperatures rise, an extra unit of carbon will do more damage at the margin the later it is emitted. To reflect the incremental damage of each unit of carbon as temperatures rise, the initial value for the SCC has therefore been up rated each year by a geometric growth rate. For the base model settings, this geometric rate is set at 2.0 percent per annum.

Overall, the costs of greenhouse gas emissions (EE) are calculated in this analysis as:

$$EE = \sum_{t=1}^{n} \left(e_t^{WDMS} - e_t^{BS}\right) \cdot ef \cdot Vemi \left(1+s\right)^{t-1} \cdot (1-r)^{t-1}, \qquad (11)$$

where e_t^{WDMS} and e_t^{BS} represent the amount of energy required (joules) by local authorities/utility providers/ratepayers for the supply of water and wastewater treatment during year t, under the WDMS and baseline scenarios respectively (see Section 3.6); ef is the average emissions factor for electricity (tonnes of CO_2-e per joule); Vemi is the SCC (NZ$\$_{2009}$81 per tonne of CO_2-e); and s is the rate of increase in the incremental damage of carbon (0.02 for the base model setting). Once again the term $(1-r)^{t-1}$ is used to discount future values, with r representing the selected annual average discount rate. The emission factor for electricity in New Zealand, ef, is assumed to remain constant throughout the study period at 56,100 tCO_2-e/PJ (Barber, 2009).

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[16] ***US dollars are converted to NZ dollars by application of the average US to NZ currency exchange rates for year ending June (see Appendix B). The value is also inflated from the year 2000 to current prices by application of the GDP Price Deflator (see Appendix B).***

5.8 Agriculture Use Values (WA), Recreational Values (WR), Option and Non-Use Values (WO), and Education and Public Relations (PR)

There are three remaining categories of benefits identified in Table 1 that have not yet been covered: (1) changes in recreational values, (2) changes in option and non-use values, and (3) education and public relation benefits. Although it is noted that each of these benefits is likely to arise in this study to some extent, it is very difficult to derive a suitable method for assessing such benefits. This is largely because we cannot easily apply value estimates derived from other studies/literature in the assessment of such values. Furthermore there is a lack of suitable data in this study upon which estimates of these benefits can be properly based. It is, however, noted that with additional budget and time available, further work could be undertaken to develop estimates of these benefits.

6 Results

Based on the scenarios set out in Section 3, and the methodology described in Section 4, this section of the report presents the results of the cost benefit analysis of the implementation of WDM in Tauranga City. All reported results are categorised according to the benefits and costs typology described in Section 2.3 above. For a full breakdown of the results by each benefit/cost category and year, readers may also refer to Appendix A.

6.1 Summary Results

Figure 7 below provides summary results for the calculation of the benefits and costs associated with the implementing WDM by Tauranga City over the period 2000 to 2015. Importantly, for all but one of the categories of effects assessed, the implementation of WDM is deemed to provide a net benefit. This means that the results occurring with implementation of WDM (i.e. under the WDM scenario) are expected to be more beneficial than those occurring without implementation of WDM (i.e. under the Baseline scenario).

If all of the financial benefits to TCC and households/ratepayers resulting from the implementation of WDM are added together (i.e. the reductions in operational and capital costs for water supply (FU and FC), reductions in electricity expenditure (FEU) and reductions in operational costs for wastewater treatment (FW)), the net benefit is calculated to be $\$_{2009}38.0$ million. This is a substantial financial saving, equivalent for example to around 55 percent of the currently estimated capital costs of implementing the Waiari Scheme (in net present value terms). On top of this, it is estimated that by reducing water takes from ecosystems (WE) and reducing electricity requirements for water supply and wastewater treatment (EE), the implementation of WDM provides further benefits to the value of $\$_{2009}27.6$ and $\$_{2009}1.4$ million respectively. In terms of costs, it is estimated that for this case study there is a loss of direct use benefits to water consumers of $\$_{2009}13.7$ million. Overall, summing all benefits and costs, the net benefits of implementing water pricing and water education in Tauranga City are strongly positive, estimated at some 53.3 million in total.

Figure 8 describes the way in which benefits and costs of implementing WDM are distributed across time. Not surprisingly, the category which includes capital expenditures on water supply (FU and FC) is the most dominant. In the early years of the study (i.e. 2001-2005), there are very substantial savings recorded for this category. This occurs because, with the implementation of WDM, the Wairi scheme is not yet required. These savings are, to some extent balanced at the end of the study period when the Waiari scheme is required to come on line under the WDM scenario. By comparison, the other types of benefits/costs assessed are relatively constant over the study period.

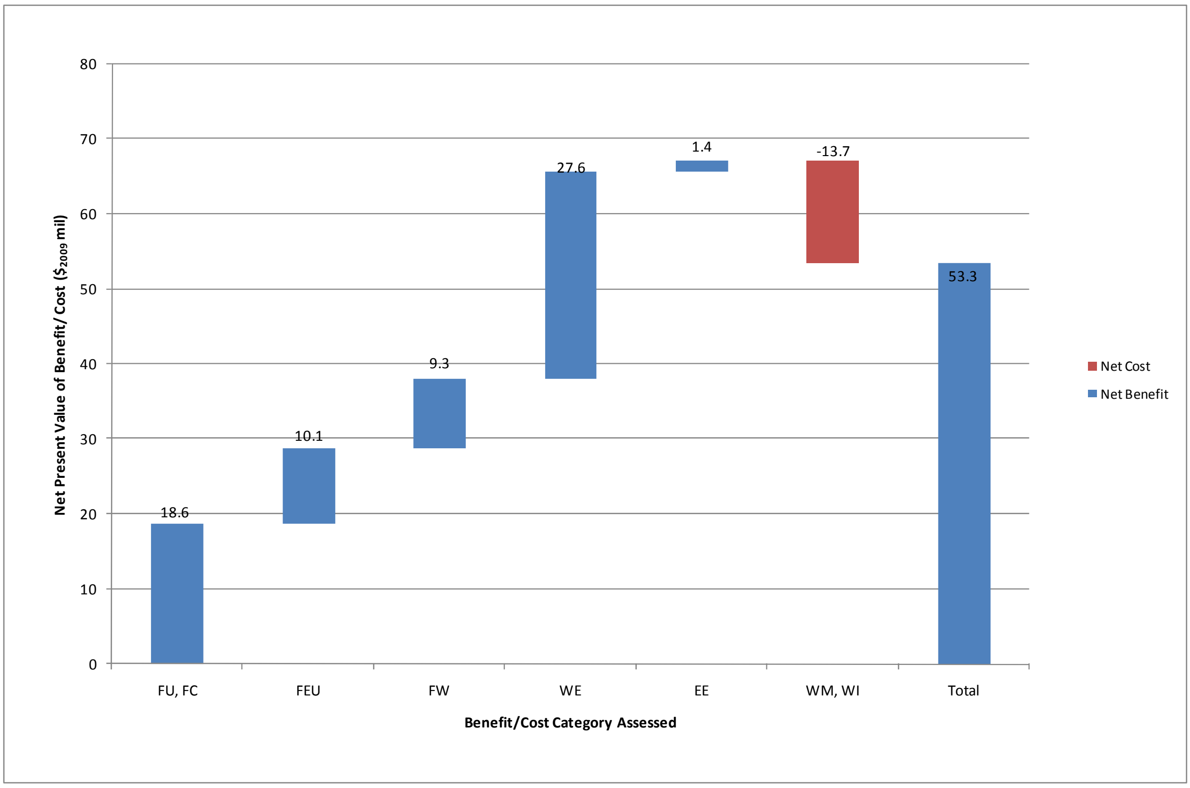

Figure 7: Total Net Present Value of Implementing Water Demand Management by Benefit/Cost Type for the Period 2000-15

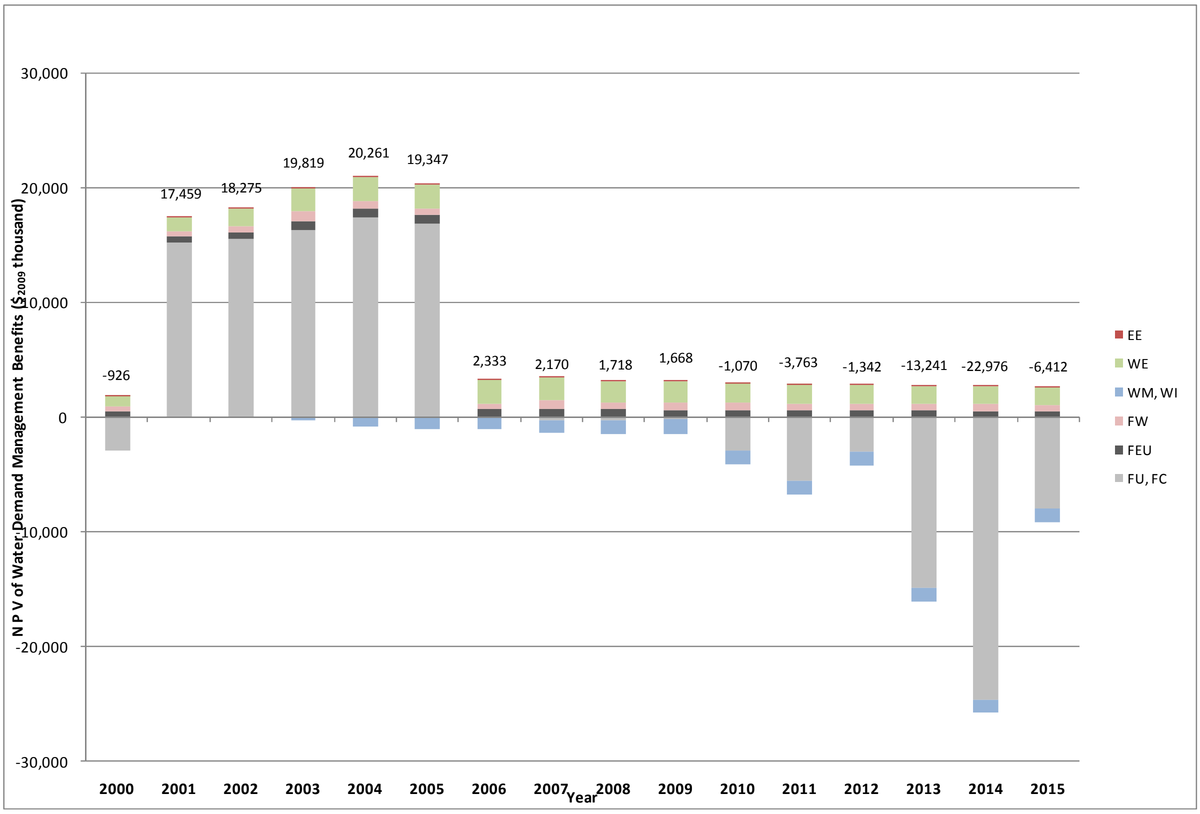

Figure 8: Net Present Value of Implementing Water Demand Management by Benefit Type and Year, 2000-2015

6.2 Results by Component

Financial Savings in Water Supply and Wastewater Treatment (FU, FC, FEU and FW).

As described above, the financial savings accruing to TCC and households/ratepayers resulting from the implementation of WDM in this case study are significant, calculated at 38.0 million. Figure 9 describes the breakdown of these saving across time, and according to the two categories of operational costs and capital costs. Interestingly, although the values for capital costs/savings are on a significantly larger scale compared with the operational costs, when summed across the whole of the study period, the results are fairly evenly split. It is estimated that in total, the net savings in terms of operational costs (including electricity) are 18.8 million, while the net savings in capital costs are 19.2 million.

In terms of operational costs, the most significant savings occur from the reduction in electricity required for water pumping/ treatment and wastewater pumping (just less than half of the total operational costs savings). Capital costs are more varied. As described above, in the early years of the study very high savings are recorded due to the delay in the implementation of the Wairi Scheme. It can however be noted that during these early years TCC was also required to invest in water meters throughout the city in order to implement water pricing, with the present value of this investment calculated around $\$_{2009}$10.2 million. Additional capital investment has also been required (and is assumed to continue to be required under the WDM scenario) for the ongoing renewal/maintenance of these water meters (NPV of $\$_{2009}$3.8 million). These additional capital costs required for the implementation of WDM act to reduce, to some extent, the very large savings that are otherwise generated from delaying the introduction of the new water treatment plant.

Overall it is considered that on the basis of the financial data alone, a strong value case is presented for the success of WDM in Tauranga city.

1) Loss in Benefits Received from Water Consumption(WM and WI)

As described above, this category covers the loss of benefits received by households and commercial water users as a direct result of reductions in water consumption. It is the only net cost calculated for this case study.

In per capita terms, the loss of water consumption benefits to consumers is calculated as being relatively small, with the maximum being $12.00/person/year for 2009. When summed over the entire population, this equates to a value of $\$_{2009}$1.3 million for 2009. As shown in Figure 10, post 2009 the estimated net costs start to decline. This occurs due to the influence of the discount rate in calculating the net present value of future costs.

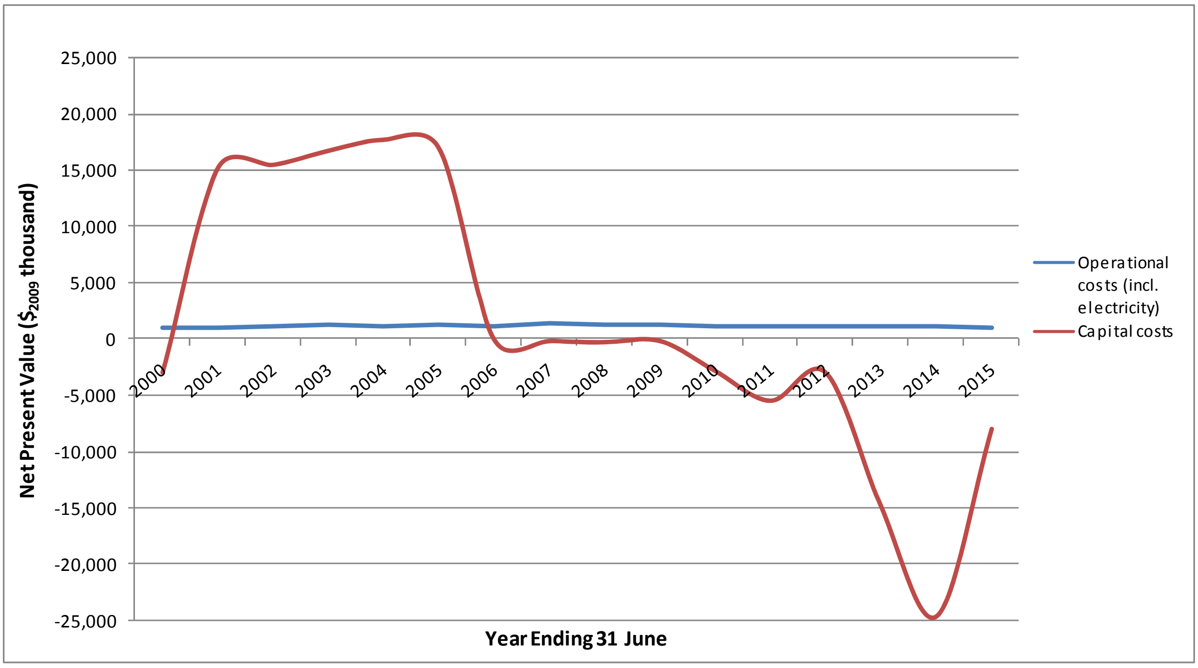

Figure 9: Net Present Value of Savings in Operational and Capital Costs for Water Supply and Wastewater Treatment as a Result of Implementing WDM, 2009-15

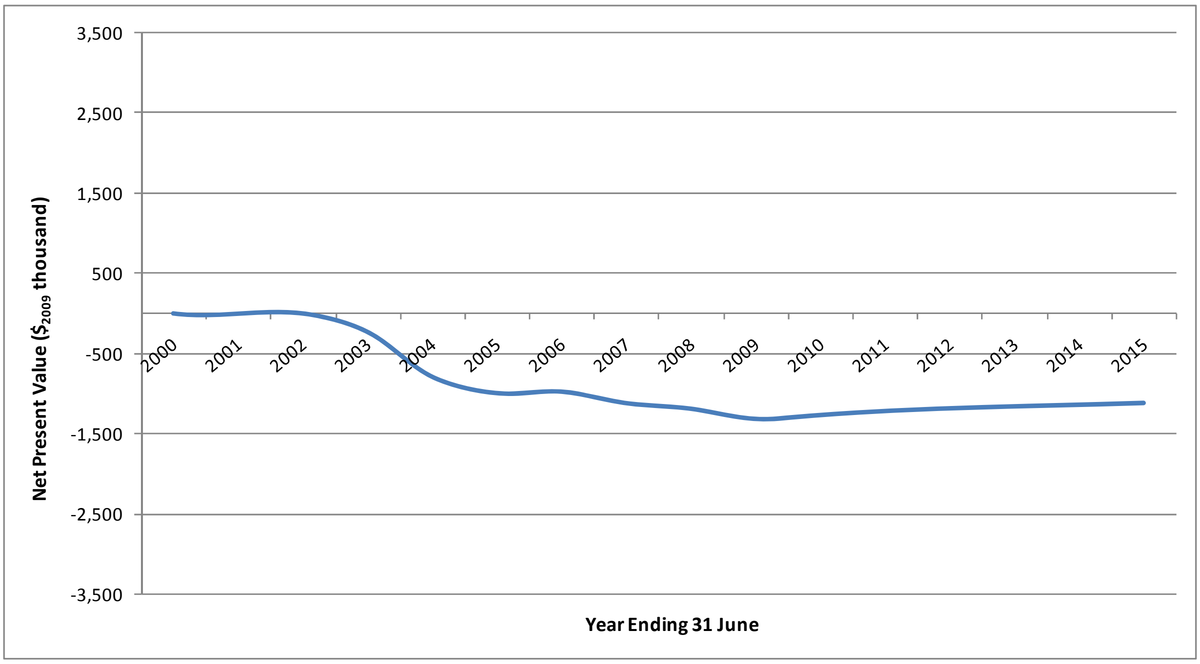

Figure 10: Net Present Value of Changes in Benefits Received from Water Consumption as a Result of Implementing WDM, 2009-15

2) Increased provision of indirect use values (WE)

Applying a shadow price of $\$_{2009}376$/ million litres of water, it is estimated that the reduction in water takes generated by implementing WDM will provide a net benefit of 27.6 million over the period 2000 to 2015. As shown in Figure 11, these benefits are calculated to be greatest in net present value terms over the years 2003 to 2009.

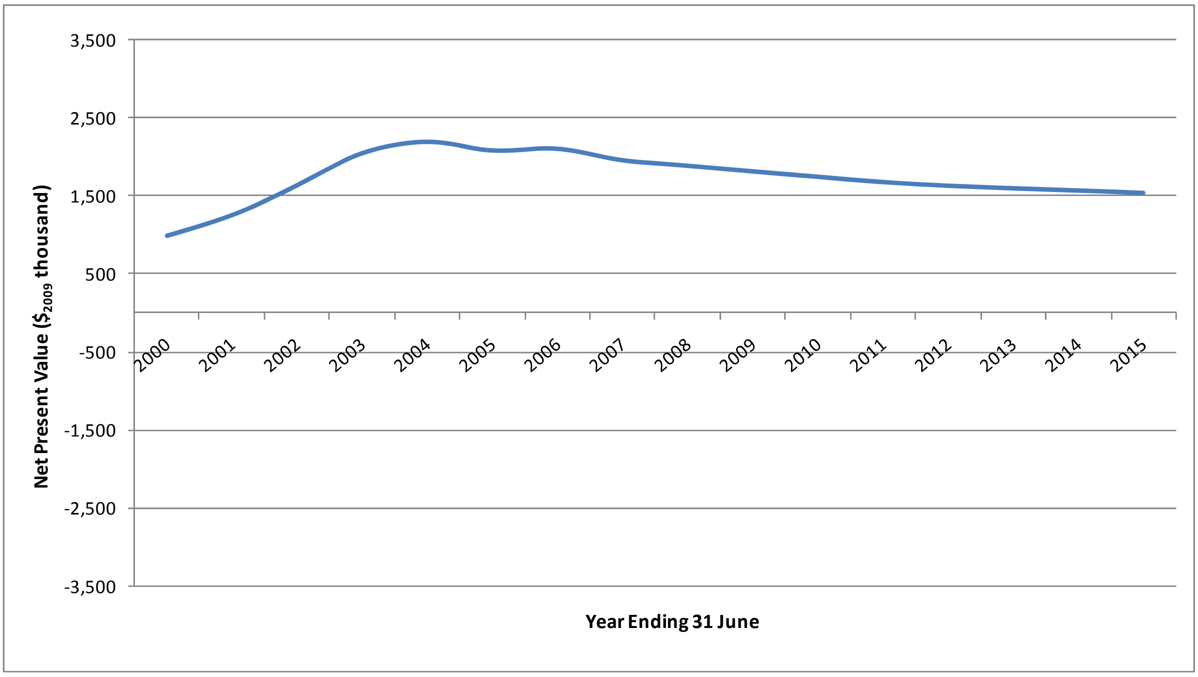

Figure 11: Net Present Value of Changes in Indirect Use Values Provided by Water as a Result of Implementing WDM, 2009-15

3) Benefits from reduced greenhouse gas emissions (EE)

As described above, the introduction of WDM is calculated to provide quite substantial financial savings to TCC and ratepayers in terms of reduced operational costs of electricity (around 10.1 million over the period 2000 to 2015). Associated with this reduction in electricity use are further savings in terms of reduced GHG emissions produced indirectly through water supply and wastewater treatment operations (a total of 1.4 million over the period 2000 to 2015; refer to Figure 12),

When calculating the extent of the reduction in GHG reductions, the GHG emission factor for NZ electricity production is critical. In these regards it can be noted that NZ's GHG emission factor for is relatively low when compared with that of other countries. In 2002, for example, the electricity CO_2 emission factor calculated for Australia and the UK were 0.92 and 0.45 t/Mwh respectively, compared with 0.16 t/Mwh for NZ (http://www.eia.doe.gov/). The low emission factor for NZ is a reflection of the relatively low use of fossil fuel combustion in the electricity production sector.

Overall, although the value of reduced greenhouse gas reductions calculated for this case study are not as significant as the values calculated for the other benefit/cost categories, it is nevertheless a clear benefit that results from the implementation of WDM. Reductions in greenhouse gas emissions are therefore one of a number of important considerations that should be taken into account when assessing the performance of WDM in Tauranga city and also the value case for implementing further WDM initiatives in the future.

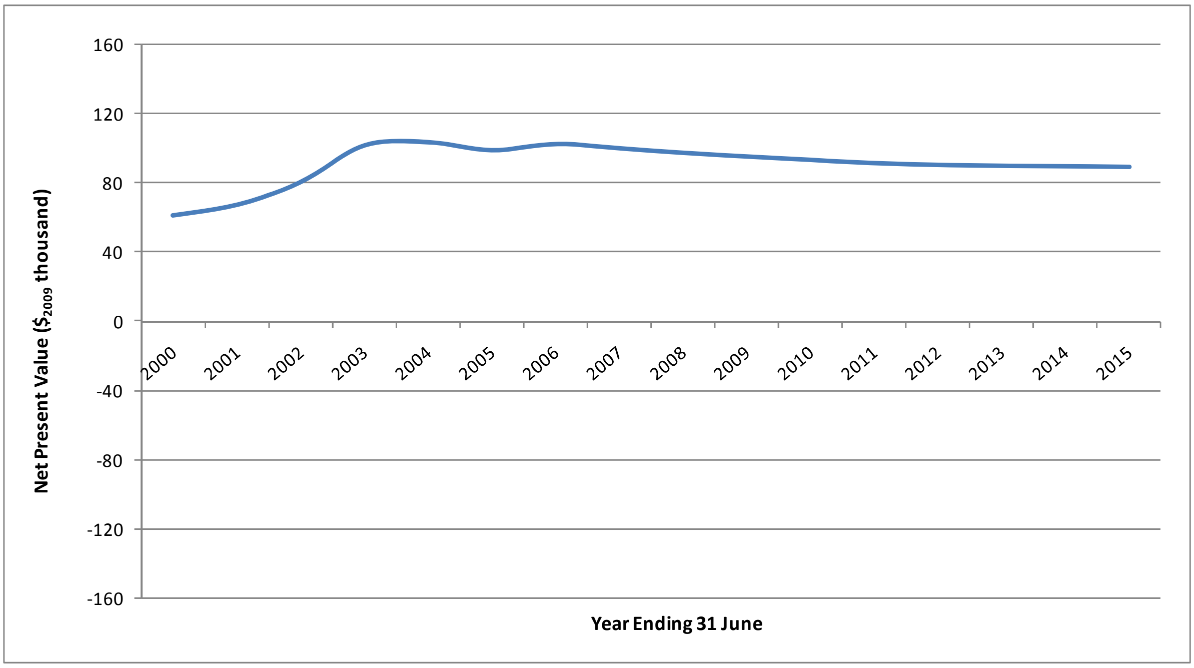

Figure 12: Net Present Value of Savings in Greenhouse Gas Emissions as a Result of Implementing WDM, 2009-15

7 Conclusion

This report presents the results of an investigation into the benefits and costs resulting from two major initiatives Tauranga City Council have put in place over the last decade to curb water demand throughout the city. These initiatives have consisted of the introduction of water metering and water pricing, and the promotion of water education programmes. Overall, the results of this study provide very clear evidence for the hypothesis that there are potentially very high benefits to be gained through the introduction of water demand management interventions.

In this study an attempt has been made to value all potential benefits and costs of implementing water demand management in monetary terms. The categories of benefits and costs assessed consist of (1) savings in operational (including electricity) and capital costs required for water supply and wastewater treatment (net benefit of $\$_{2009}$38.0 million); (2) loss in benefits received by consumers from water consumption (net cost of $\$_{2009}$13.7 million); (3) increased provision of indirect use values through the reduction of water taken from ecosystems (net benefit of $\$_{2009}$27.6 million); and (4) reduced emissions of greenhouse gases (net benefit of $\$_{2009}$1.4 million). Summing all benefits and costs for the period 2000 to 2015, it is calculated that the net benefit of implementing Tauranga's water supply initiatives is around $\$_{2009}$53.3 million. It is also important to note that this is not a complete valuation of the net benefits of water demand management, as there further categories of benefits that have been identified as resulting from the implementation of the water pricing and education programmes which have not been assessed in monetary terms. These additional benefits are (1) increased satisfaction by Tauranga residents and ratepayers through the knowledge that there has been some preservation in the option and non-use values of water; (2) increased education and awareness of water-related issues and improved public relations; and (3) some savings to the recreational values of local streams. Had it been possible to include these categories in the valuation methodology, it is very likely that a higher net benefit would be calculated for the implementation of water demand management.

Although the water demand and supply situation will vary across the country, and thus the results from this study are not directly transferable to other case studies, it is expected that there is a high likelihood that similar results can be achieved through the implementation of water demand management in other territorial authorities. Overall it is concluded that based on the outcomes of this case study, there is a strong value case for establishing investigations into possible implementation of other water demand management initiatives throughout New Zealand.

8 References

Arbués, F., Garcia-Valinas, M. and Martinez-Espineira, R. 2003. Estimation of residential water demand. A state-of-the-art review. Journal of Socio-Economics, 32, 81-102.

Barber, A. 2009. NZ Fuel and Electricity – Total Primary Energy Use, Carbon Dioxide and GHG Emission Factors. AgriLINK NZ Ltd, Christchurch. http://www.agrilink.co.nz/Portals/Agrilink/Files/FuelLCAEmissionFactors07.pdf

Bentley, J., Clarke, M.M Hooper, B., Lawson, R., Marshallsay, D., McDonald, A., Murray, D. and Waylen, C. 2007. A Framework for Valuing the Options for Managing Water Demand. UKWIR Report 07/WR/25/3. United Kingdom Water Industry Research Limited, London.

Boland, JJ., Flores, N. and Howe, C. 2009. The theory and practice of benefit-cost analysis. In Russel, C.S. and Baumann, D.D. The Evolution of Water Resource Planning and Decision Making. Edward Elgar Publishing Ltd, Cheltenham, UK.

Gibbons, D.C. 1986. The Economic Value of Water. Resources for the Future, Washington, D.C.

Gibbs, K.C. 1978. Price variable in residential demand models. Water Resources Research,14(2), 15-18.

Hannon, B. 2001. Ecological pricing and economic efficiency, Ecological Economics 36, 19-30.

Hermens, K. 2008. Waiari Water Supply Project – Investigations into Delaying Construction. Tauranga City Council, Tauranga.

Patterson, M.G. 2002. Ecological production based pricing of biosphere processes. Ecological Economics, 41, 457-478.

Pearce, D., Markandya, A. and Barbier, E.B. 1989. Blueprint for a Green Economy. Earthscan, London.

Pearce, D.W., and Turner, K. 1990. Economics of natural resources and the environment. Harvester Weatsheaf.

Perrings, C. 1995a. Biodiversity Loss: Economic and Ecological Issues. Cambridge University Press, Cambridge.

Perrings, C. 1995b. The Economic Value of Biodiversity. In V.H. Heywood, Global Biodiversity Assessment (pp 823-914). Cambridge University Press, Cambridge.

Pricewaterhouse Coopers. 2004. Ministry of Economic Development Infrastructure Stocktake: Infrastructure Audit. Ministry of Economic Development, Wellington.

Roberts, L., et al. 2005. Optimised Decision Making Guidelines: A sustainable approach to managing infrastructure. The NAMS Group, Wellington.

Smith, N.J. and McDonald, G.W. 2009. A Framework for Valuing Water Demand Management: Literature Review. Report WA7090/4 for Beacon Pathway Ltd.

Smith, N.J. and McDonald, G.W. 2009. A Framework for Valuing Water Demand Management: Conceptual Framework. Report WA7090/5 for Beacon Pathway Ltd.

Stern, N., 2006. Stern review: The economics of climate change. HM Treasury, 579 p. http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

Young, R.A. 2005. Determining the Economic Value of Water. Resources for the Future, Washington, D.C.

9. Appendix A: Detailed Results by Benefit Type and Year

Benefit/ Cost Category	Local authority/ household expenditures for water supply	Local authority expenditure on energy	Local authority expenditure on wastewater treatment	Value obtained from consuming water resources	Indirect use values provided by water	Costs of greenhouse gas emissions	Total
Benefit/ Cost Code	FU, FC	FEU	FW	WM	WE	EE	
2000	-2,873	491	406	0	988	61	**-926**
2001	15,212	528	402	0	1,250	67	**17,459**
2002	15,472	618	474	0	1,631	80	**18,275**
2003	16,304	772	833	-229	2,038	101	**19,819**
2004	17,356	768	640	-790	2,182	103	**20,261**
2005	16,843	719	612	-996	2,071	99	**19,347**
2006	-73	731	456	-977	2,093	102	**2,333**
2007	-241	702	782	-1,120	1,947	100	**2,170**
2008	-285	669	550	-1,190	1,877	97	**1,718**
2009	-206	642	649	-1,318	1,806	95	**1,668**
2010	-2,873	617	624	-1,267	1,737	93	**-1,070**
2011	-5,498	592	600	-1,219	1,671	91	**-3,763**
2012	-3,027	574	583	-1,184	1,623	90	**-1,342**
2013	-14,893	560	572	-1,162	1,592	90	**-13,241**
2014	-24,596	547	561	-1,140	1,562	89	**-22,976**
2015	-8,001	535	550	-1,118	1,532	89	**-6,412**
Total	**18,621**	**10,066**	**9,294**	**-13,709**	**27,600**	**1,449**	**53,321**

Table 3: Net Present Value of the Benefits of Implementing Water Demand Management by Benefit Type and Year, 2000-2015 ($$_{2009}$ thousand)

$^{+}$ Positive values represent a net benefit while negative values represent a net cost

10. Appendix B: US to NZ Exchange Rates and Price Deflators

Year	Exchange Rate (mid rate quoted to NZ$1)
1990	0.5825
1991	0.5770
1992	0.5423
1993	0.5397
1994	0.5915
1995	0.6696
1996	0.6761
1997	0.6876
1998	0.5101
1999	0.5327
2000	0.4699
2001	0.4148
2002	0.4897
2003	0.5809
2004	0.6293
2005	0.7085
2006	0.6190
2007	0.7559
2008	0.7607

Table 4: Average US to NZ Currency Exchange Rates for Year-Ending June, 1990-2008

Source: Reserve Bank of New Zealand, Reuters, NZFMA

Year	Purchasers' Price Index (PPI)
2000	948
2001	977
2002	1225
2003	1155
2004	1338
2005	1137
2006	1475
2007	1236
2008	1553
2009*	1360

*The index for the 2009 June Quarter is an estimate based on an extrapolation of the historic trend

Table 5: Average Purchasers' Price Index (Inputs Based) *for Year Ending June - Electricity, Gas and Water Supply, 2000-2009*

Source: Statistics New Zealand, Table PPI012AA

Year	Capital Price Index (CPI)
2000	1010
2001	1067
2002	1076
2003	1051
2004	1014
2005	998
2006	1001
2007	1025
2008	1033
2009*	1104

*The index for the 2009 June Quarter is an estimate based on an extrapolation of the historic trend

Table 6: Average Capital Price Index for Year Ending June – Machinery, Plant and Equipment, 2000-2009

Source: Statistics New Zealand, Table CEP007AA

Year	Purchasers' Price Index (PPI)
2000	951
2001	960
2002	1155
2003	1126
2004	1295
2005	1199
2006	1488
2007	1450
2008	1643
2009*	1622

*The index for the 2009 June Quarter is an estimate based on an extrapolation of the historic trend

Table 7: Average Purchasers' Price Index (Outputs Based) for Year Ending June – Electricity, Gas and Water Supply, 2000-2009

Source: Statistics New Zealand, Table PPI013AA

Year	GDP Deflator
2000	1043
2001	1089
2002	1116
2003	1119
2004	1157
2005	1191
2006	1210
2007	1249
2008	1308
2009*	1336

*The index for the 2009 June Quarter is an estimate based on an extrapolation of the historic trend

Table 8: Average GDP Deflator for Year Ending June, 2000-2009

Source: Statistics New Zealand, Table SNC042AA