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Water Demand Management: An economic framework to value with case study application

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About This Report

Title

Water Demand Management: An economic framework to value with case study application

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Abstract

This report synthesises three reports produced as a result of the development of a framework to value water demand management and its application to Tauranga City Council. It describes a brief literature review, and the development and of a framework. This was applied to a case study to demonstrate the potential value of water agencies adopting and implementing water efficiency measures. The case study result shows that in 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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1 Executive Summary

Proponents of taking a water demand management approach (WDM) – also known as a water efficiency approach - argue that it will produce environmental social, cultural and economic benefits. An analysis commissioned by Beacon Pathway from Market Economics Ltd has provided clear evidence for the hypothesis that the introduction of water demand management interventions will generate significant benefits for councils.

A brief literature review was carried out, and a framework was developed and applied to a case study, to demonstrate the potential value of water agencies adopting and implementing water efficiency measures. The case study result shows that in 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 education and awareness of water-related issues and improved public relations.
- Potentially some savings to the recreational values of local streams.
- 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.

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 transferrable 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. The very process of applying it helps councils understand the multiple values to be considered and it is expected the analysis and application of WDM will yield significant economic value.

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 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 research from Market Economics to develop and test a conceptual framework to value water demand management. The research is reported in three separate documents:

- Literature Review (WA7090/4)
- The Framework for Valuing Water Demand Management (WA7090/5)
- A Case Study: Tauranga City Council (WA7090/6)

This document is a synthesis of these three pieces of work. The original research reports are available from the Beacon website www.beaconpathway.co.nz .

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

3 Introduction

3.1 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, the installation of water tanks and the promotion of water saving education programmes for the public.

The literature on this subject indicates that increasingly the wider benefits of water demand management are also being recognised internationally. 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.

To demonstrate the economic value of taking a water demand management approach, a framework has been constructed, which is described in a summary form here, and applied 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).

3.2 Overview of framework

The approach is based on the comparison of two scenarios: no WDM vs WDM implemented. The scenarios are constructed with application of 'real' data for the current situation and modelled/predicted economic data for the other. The framework makes explicit a full range of benefits and costs related to water management (this is described in more detail in section 4).

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.

3.3 Case study: Tauranga City Council

Beacon's engagement with Tauranga City Council identified it as a good candidate for case study application of this approach. The key elements were: the city is recognised as an area where water supply is under increasing pressure from population growth; this growth is predigted to continue for next 30-40 years; has experienced successive rounds of water restrictions; has implemented water demand management policies such as residential water meters, a substantive education programme; and finally the council was starting to investigate how it might develop its WDM programme even further.

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, summarised below) 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.

While this analysis required Tauranga City officials to spend some time gathering data from many sources within the council, participants felt the outcome justified the investment.

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.

4 The framework for economic evaluation

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).

4.1 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
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-monetized 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.

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. 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.

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)).

4.2 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.

4.3 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.

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

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

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. [2] 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 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] 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.

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).

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).

4.4 Aggregating Benefits and Costs

In its most simplistic formulation, the value (measured in current $) of a selected WDM intervention, V, is defined as,

$$V = NB - NC \qquad (1)$$

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,

$$V = WM + WI + WA + WR + WE + WO + RS + ED + PR - (FU + FC + FEU + FEC + FS + FW + EE), \qquad (3)$$

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.

4.5 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.

5 Tauranga Case Study

5.1 Why Tauranga?

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.

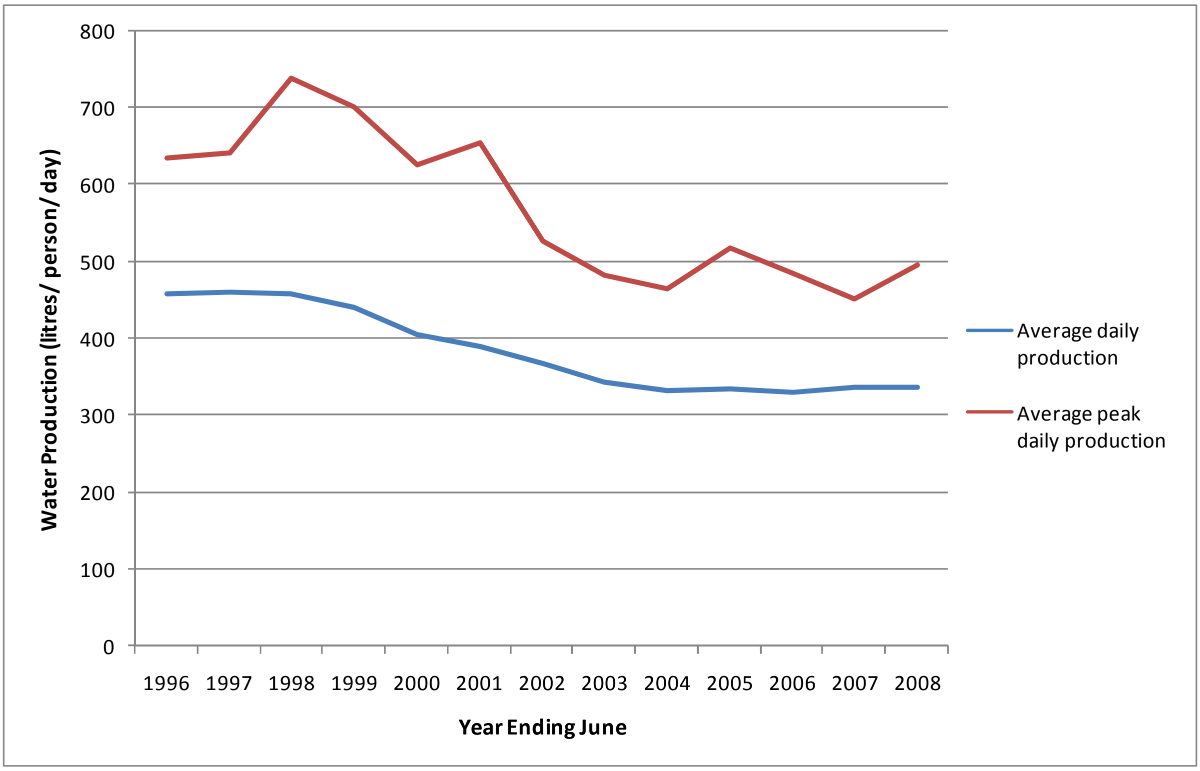

Figure 1: Tauranga City Average Water Production and Average Peak Water Production, 1996-2008

5.2 Scenarios for Tauranga City

5.2.1 ntroduction

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:

5.2.2 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.

5.2.3 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.

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

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

5.2.4 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).

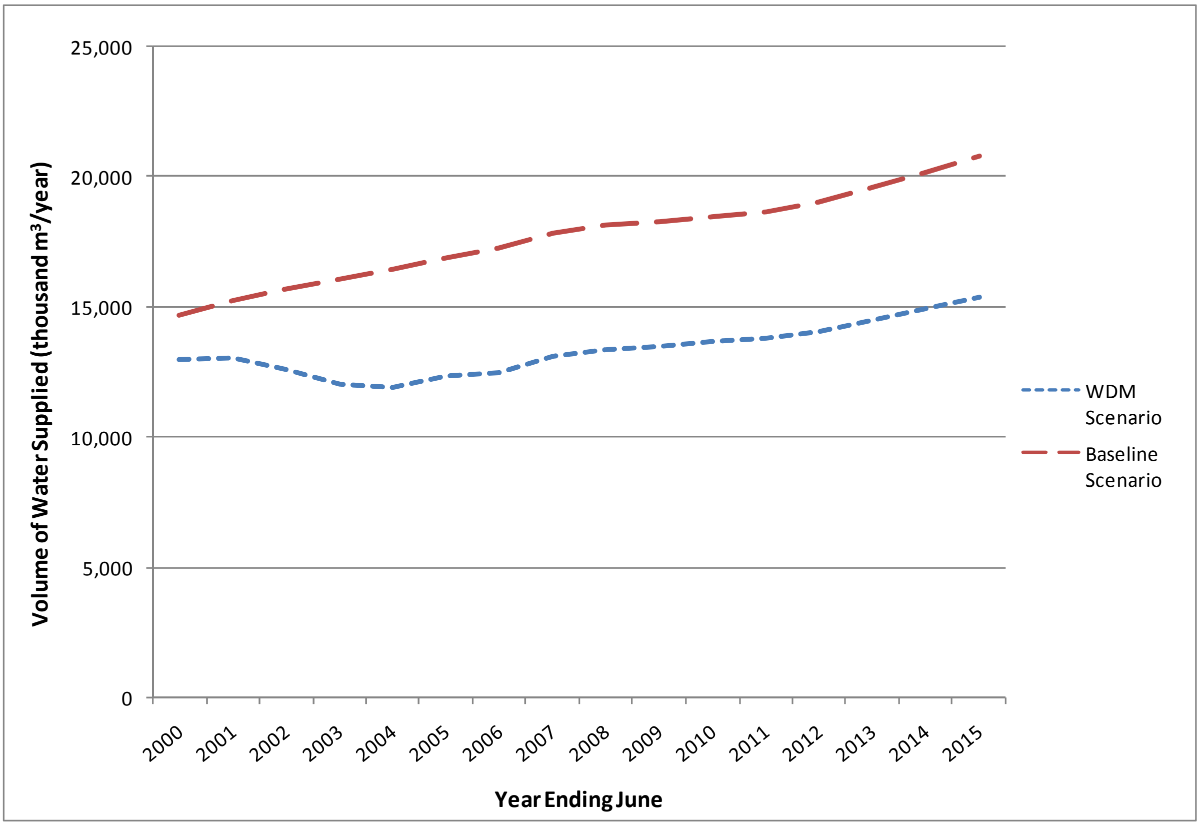

Figure 2: Volume of Water Supplied under the WDM and Baseline Scenarios, 2000-15

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).

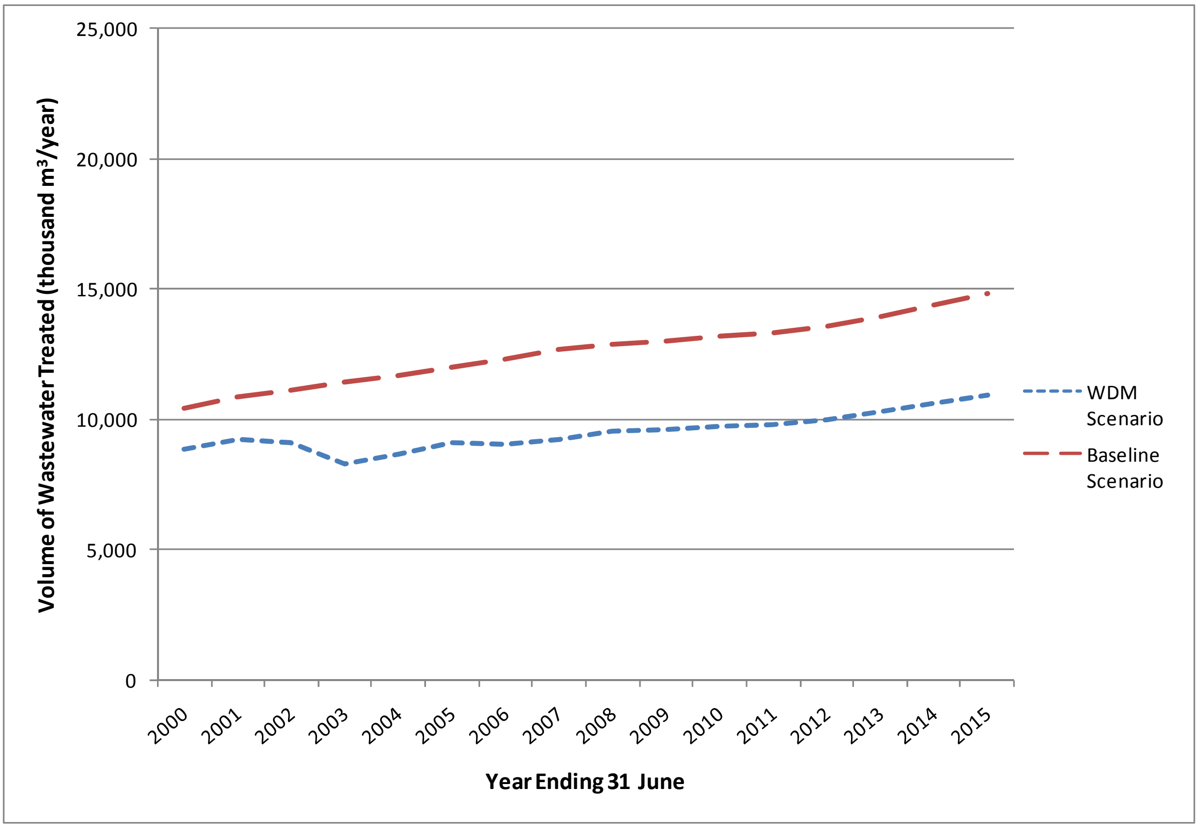

Figure 3: Volume of Wastewater Treated under the WDM and Baseline Scenarios, 2000-15

5.2.5 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.[3] 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[4]) 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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[3] *The Capital Price Index – Machinery Plant and Equipment (refer to Appendix B) is used to translate all values to 2009 dollars.*

[4] *See footnote 5.*

5.2.6 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.

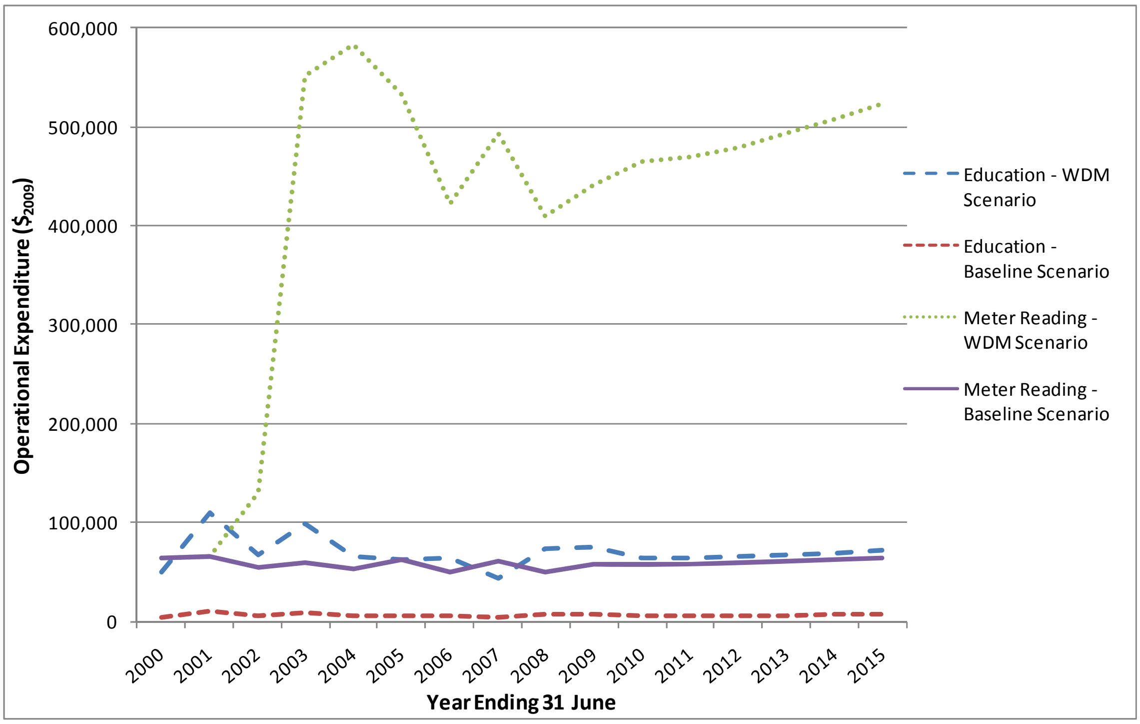

Figure 4: Education and Meter Reading Expenditures under the WDM and Baseline Scenarios, 2000-2015 [5]

[5] ***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,

$$O_t = \frac{VE_t}{WS_t^{WDM}}\left(WS_t^{Baseline} - WS_t^{WDM}\right) \qquad (1)$$

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 years 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.

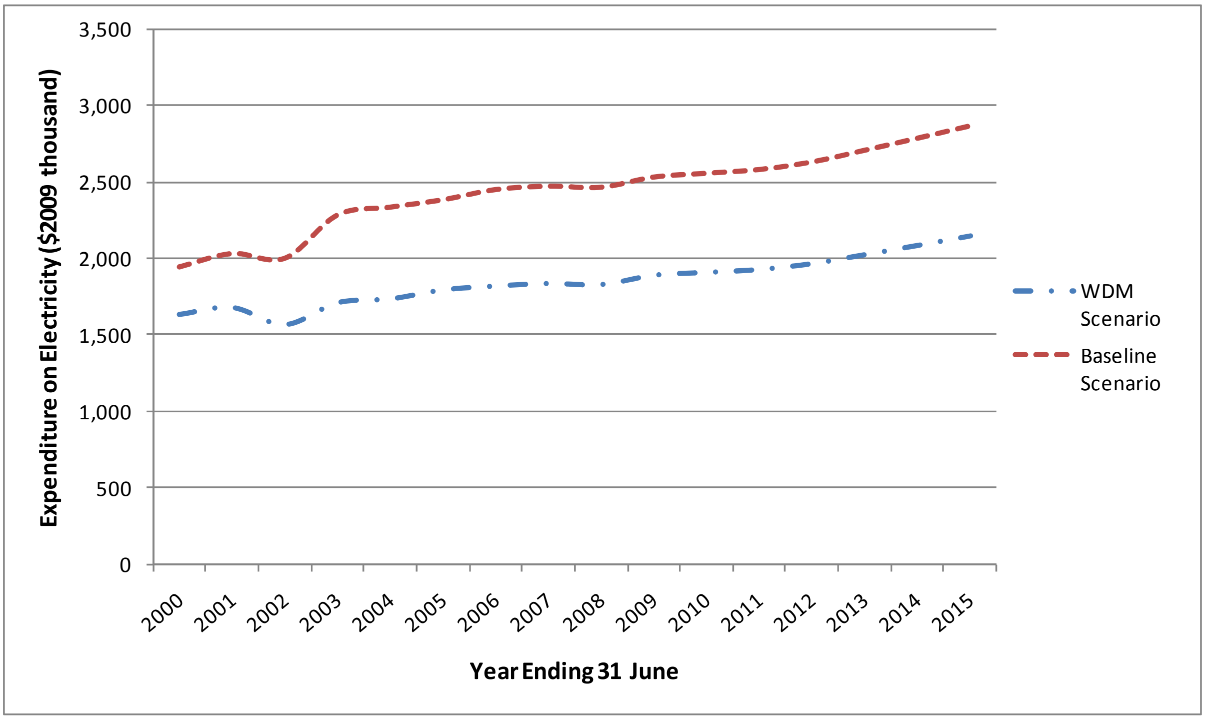

Figure 5: Total Expenditure on Electricity Required for Water Supply and Wastewater Treatment under the WDM and Baseline Scenarios, 2000- 2015

5.3 Summary Results for Tauranga

Based on the scenarios set out in section 5.2, 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.

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.

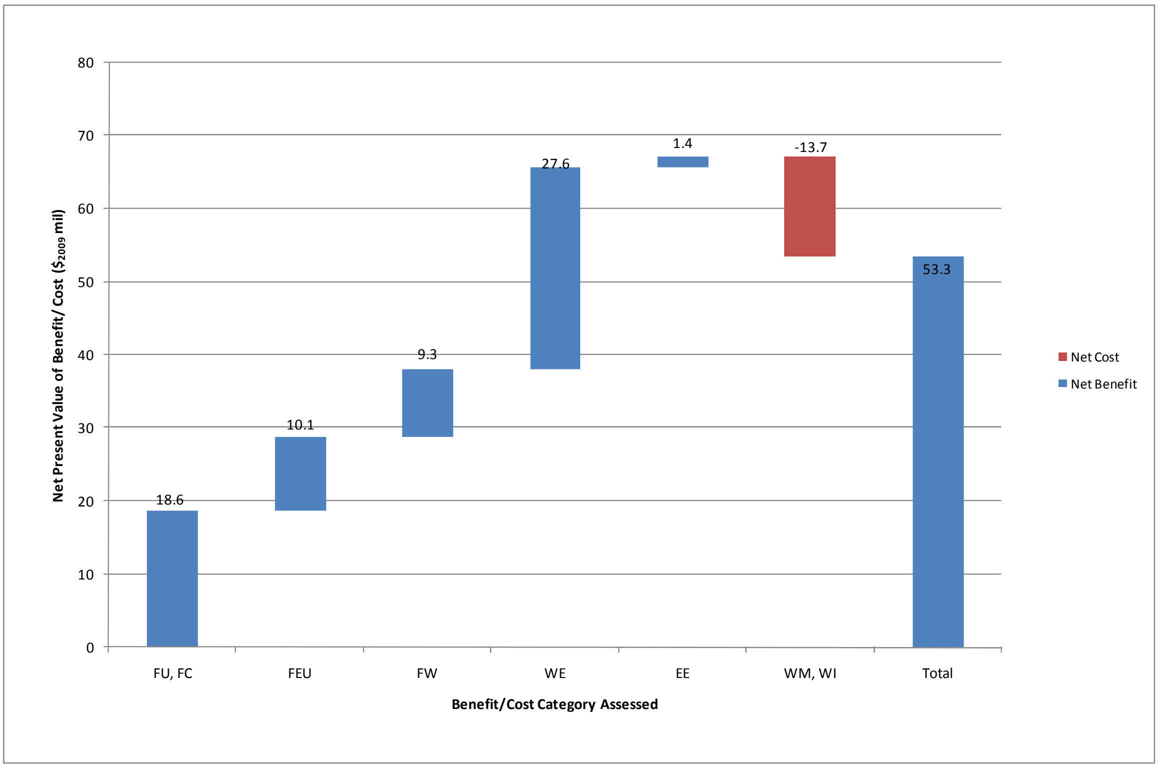

Figure 6: Total Net Present Value of Implementing Water Demand Management by Benefit/Cost Type for the Period 2000-15

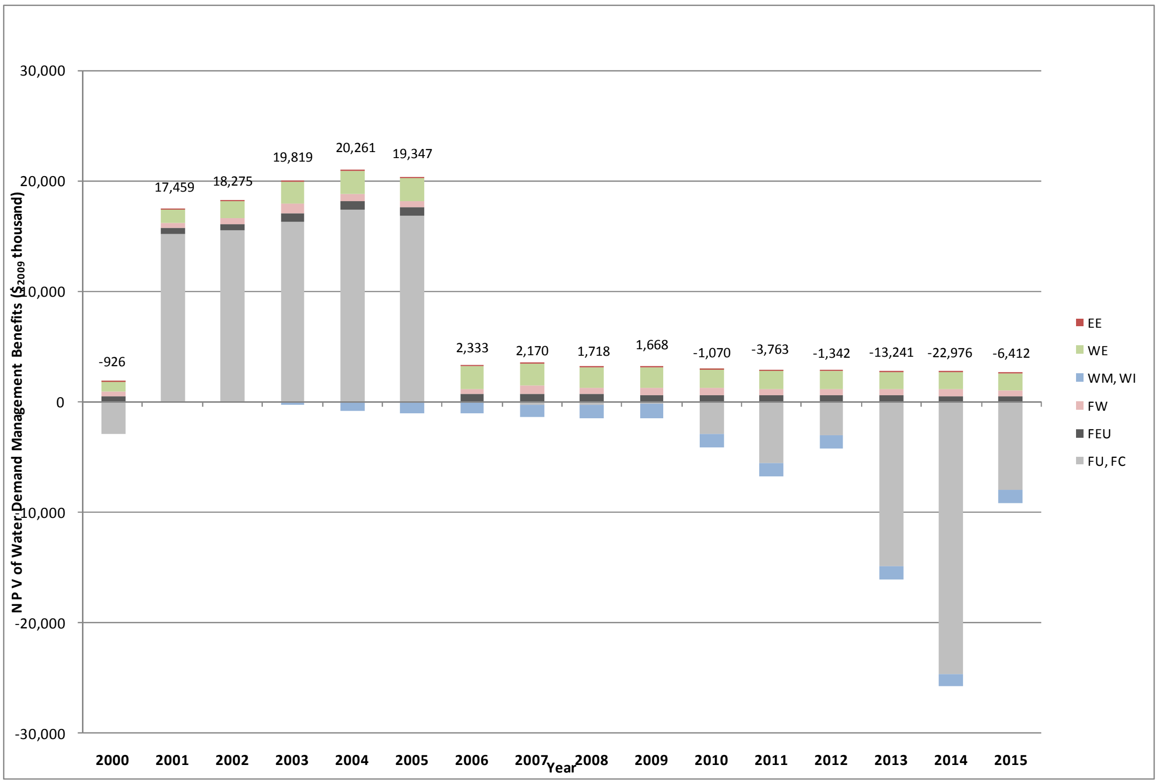

Figure 7: Net Present Value of Implementing Water Demand Management by Benefit Type and Year, 2000-2015

5.4 Results by Component

5.4.1 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 $200910.2 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 $20093.8 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.

5.4.2 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 $20091.3 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.

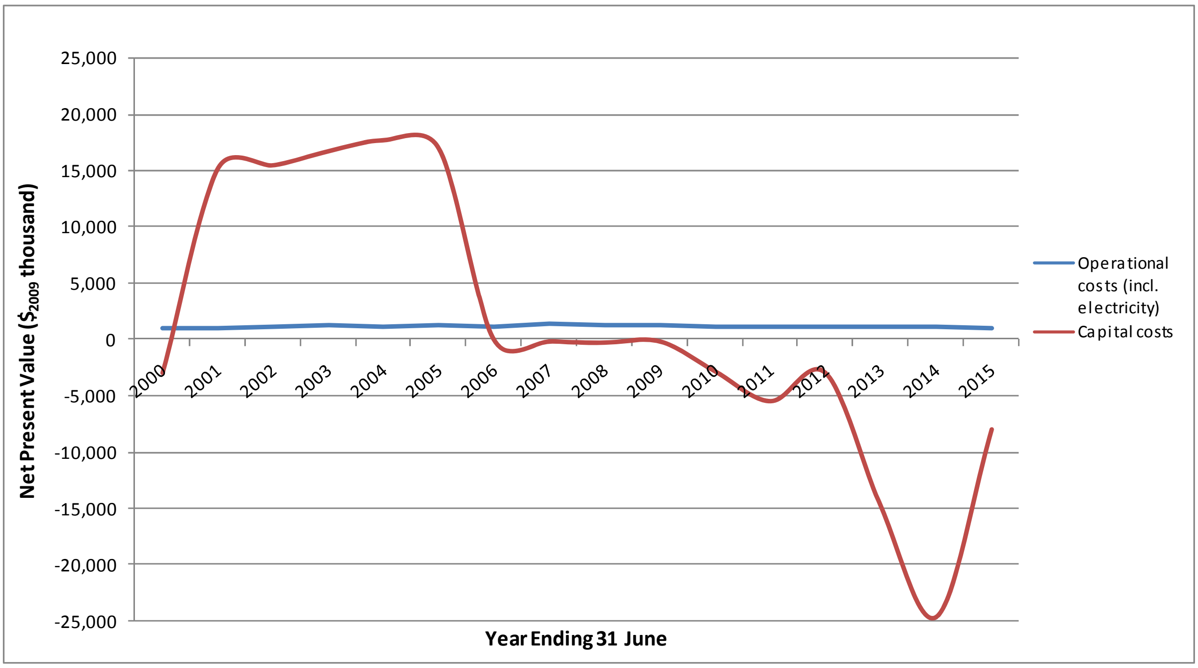

Figure 8:Net Present Value of Savings in Operational and Capital Costs for Water Supply and Wastewater Treatment as a Result of Implementing WDM, 2009-15

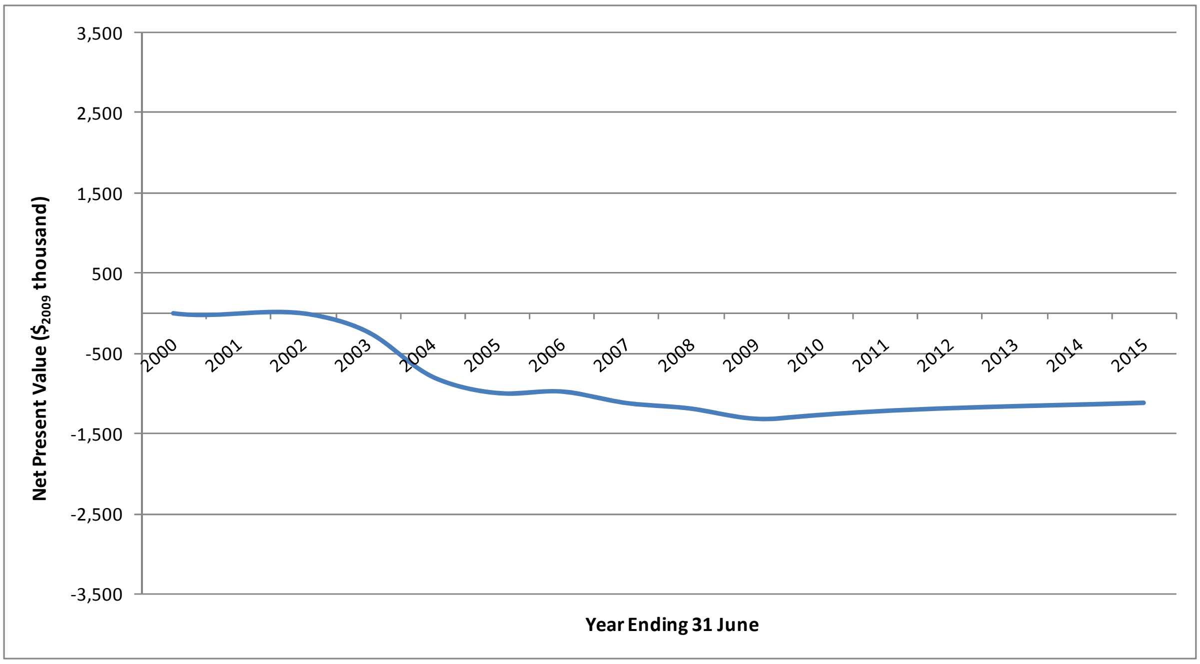

Figure 9: Net Present Value of Changes in Benefits Received from Water Consumption as a Result of Implementing WDM, 2009-15

5.4.3 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.

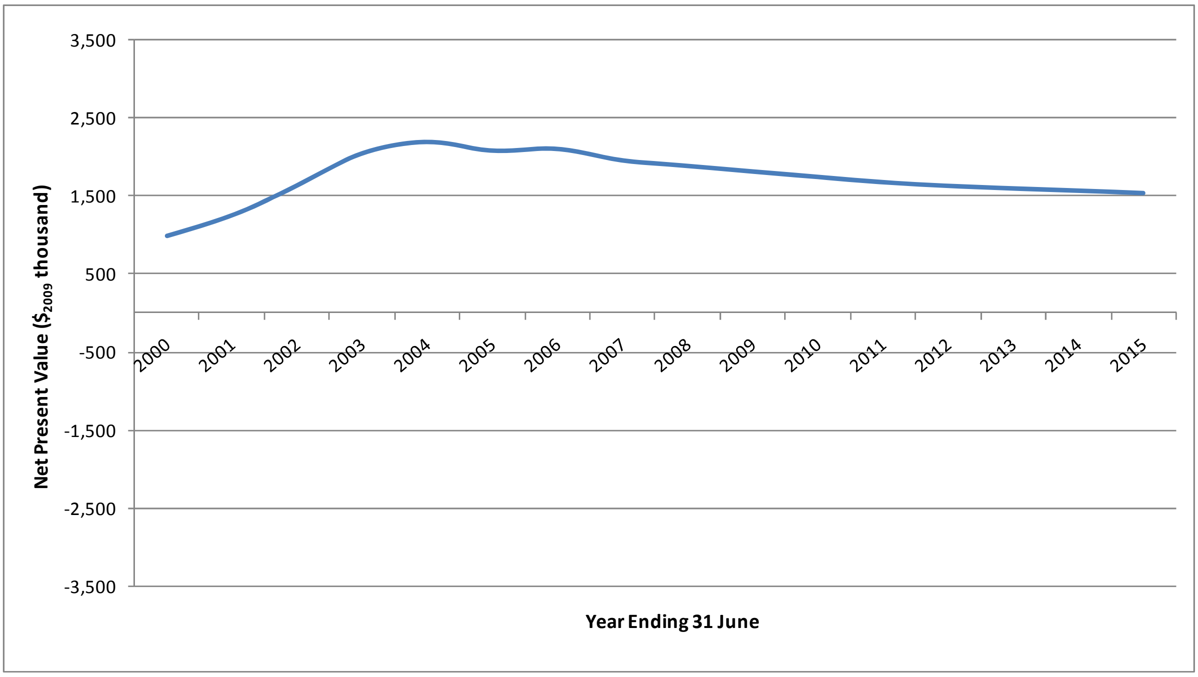

Figure 10: Net Present Value of Changes in Indirect Use Values Provided by Water as a Result of Implementing WDM, 2009-15

5.4.4 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.

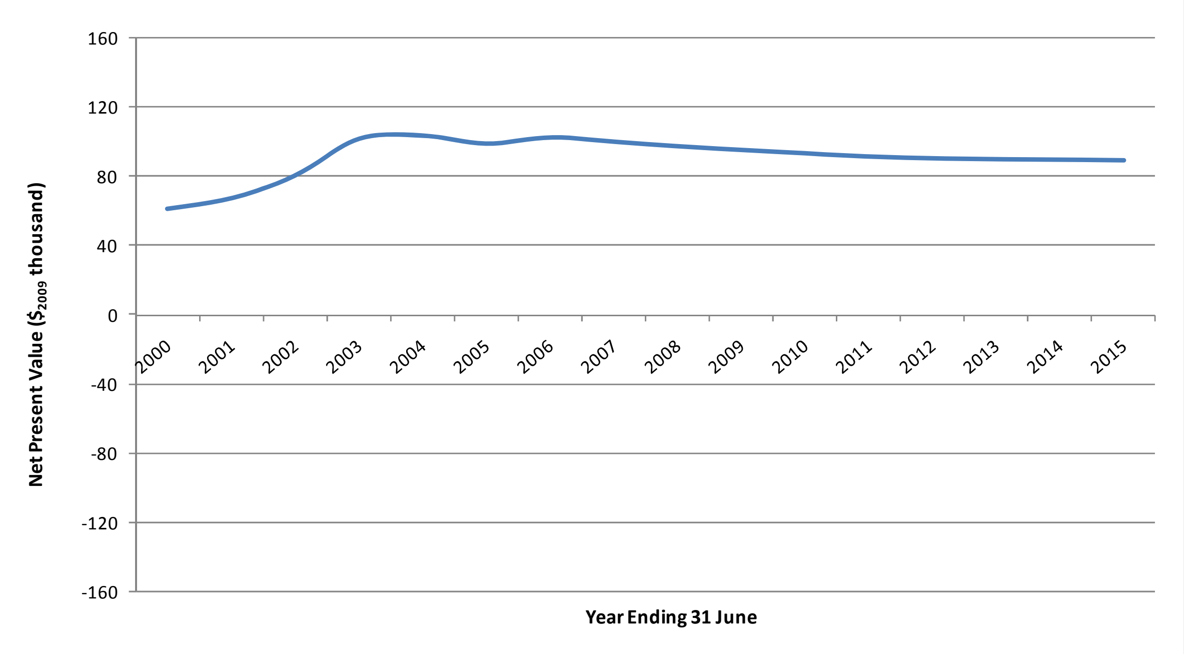

Figure 11: Net Present Value of Savings in Greenhouse Gas Emissions as a Result of Implementing WDM, 2009-15

6 Conclusions

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 water education programmes beginning in 1999, the introduction of water metering, and finally water pricing in 2002. Education has been ongoing and has developed and grown over time.

This research has provided evidence for the hypothesis that the introduction of water demand management interventions will generate significant benefits for councils.

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 transferrable 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.

The study provides the means to test the hypothesis and good evidence that the hypothesis is right: there has been significant benefit to Tauranga council and ratepayers from adoption of water demand management. As councils face increased pressure to reduce costs and better manage natural resources, this evaluative framework offers councils a robust means to assess their best approaches for better water management. The evidence from the analysis should provide a powerful value proposition to rate payers and other stakeholders for proposed policy changes to adopt water demand management approaches

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8 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**