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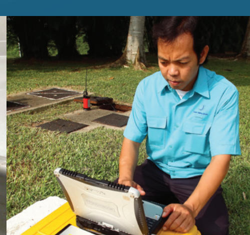
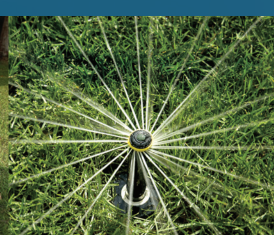
Preparing Urban Water Use Efficiency Plans

A BEST PRACTICE GUIDE

Lisa Maddaus, William Maddaus and Michelle Maddaus
Maddaus Water Management, Inc.

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About the authors

William (Bill) Maddaus, P.E., is a registered civil engineer with over 45 years of experience in water resource planning and management, Bill founded Maddaus Water Management (MWM) in 1995, an independent consulting practice. Through the company he founded, he offers technical assistance to water utilities in developing and evaluating water conservation programmes. MWM has completed over 300 projects in 19 years. Over the past five decades, Bill has established himself as an expert in urban water conservation. He co-authored the widely used Manual of Water Supply Practice, M52 'Water Conservation Programs - A Planning Manual' published in 2006 by the American Water Works Association (AWWA). Bill also wrote the Urban Drought Guidebook for the California Department of Water Resources in 1988. He also co-authored a handbook for the United Nations called 'Guide to Preparing Urban Water Efficiency Plans' in 2003. In addition, Bill led the effort to prepare Manual of Water Supply Practice M50 for AWWA called Water Resource Planning, first published in 2001. He updated this manual and a second edition was published in 2007. Bill was one of the original authors of the material for the AWWA Water Conservation for Small and Medium-Sized Utilities Handbook recently republished with the assistance of Deborah Green in 2009. From 1999–2002, he was chair of an AWWA national committee, Water Resource Planning and Management. Bill pioneered comprehensive conservation planning methods for water utilities, using cost-effectiveness analysis, and evaluating water savings from completed programmes. He has prepared over 200 water conservation planning studies for water agencies nationally and internationally. He has worked on five continents including projects and presentations in Thailand, China, New Zealand, Australia, South Africa, Jordan, Saudi Arabia, Spain, Russia, and Chile. Bill has a Bachelor of Science (B.S.) in Civil Engineering from University of California Berkeley, and a Master of Science (M.S.) in Civil Engineering from Massachusetts Institute of Technology (M.I.T).

Lisa Maddaus, P.E., is a senior water resources engineer with over 18 years of experience preparing water resources planning studies for urban water suppliers. Her focus is on integrated water resources planning, and her specialty is in conservation, drought and climate change planning. Lisa is currently on the Board of Directors for the California Urban Water Conservation Council and was formerly on staff as a Technical Adviser. Lisa has presented numerous papers on integrated water resource planning, water conservation, demand management and drought preparedness at the American Water Works Association (AWWA) national and International Water Association conferences and for the United Nations. Lisa is also the co-author of, United Nations Guide on Preparing Urban Water-Efficiency Plans and the AWWA Manual of Water Supply Practices, M52, Water Conservation Programs – A Planning Manual. Lisa was also a contributing author for the Drought Preparedness and Response Manual, AWWA Manual M60. Lisa supports the national AWWA Water Loss Control Committee and also served on the review committee for the recently updated AWWA Manual M36, Water Loss Control Programmes. Lisa has completed more than 150 conservation and drought planning studies and takes an especially pragmatic approach given her four years' experience with managing the Regional Water Authority's (RWA) Water Efficiency Programme in the Sacramento region in Northern California, United States. At RWA, Lisa helped the 22 water provider members fulfill best management practices for water conservation, as she was responsible for the daily management of a $2 million dollar budget. Lisa has supported planning efforts or presented internationally in Thailand, China, Chile, Spain and Kyrgyzstan. Lisa has a B.S. and M.S. in Civil and Environmental Engineering from the University of California, Davis.

Michelle Maddaus, P.E., is a registered civil engineer in California with 14 years of experience, specializing in conservation programmes and analysis and demand forecasting. Michelle's work efforts are focused on water conservation, climate change and the water-energy nexus. She is a very active member of the American Water Works Association and is their immediate past chair of the Climate Change Committee, a committee which she co-founded in 2008 and now has over 80 members internationally with most residing across the United States. In 2012, she received the OASIS (Outstanding, Achievement, Service and Initiative in Sustainability) of water resources award from AWWA for her efforts with the committee. Michelle is currently working with Lisa and Bill Maddaus on the update to the AWWA Manual Conservation and Planning M52 planned for completion in 2015. Michelle has been an active member of the California Urban Water Conservation Council's Research and Evaluation committee since 2004 and thorough knowledge of best management practices including requirements and technology for commercial, institutional and industrial (CII) customer surveys, landscape irrigation surveys, water budgets, water loss and automatic metering systems. Michelle has presented at numerous conferences including the IWA Efficient Conferences in Chile and Australia. Michelle has lived while studying in both England (University of Oxford) and Australia (University of New South Wales). Michelle later worked in Australia to help provide assistance and technical knowledge during their severe drought of 2006 working on water conserving measures. Michelle has been working on numerous conservation water saving analysis and water demand forecasting projects. Michelle has worked periodically over the past decade with the the San Francisco Public Utilities Commission and Bay Area Water Conservation Agency on a water demand and conservation programme design and technical analysis. Michelle was one of the three key modelers for the demand and conservation forecasts for the 28 wholesale customers. Michelle has conducted over 150 CII surveys and conducts trainings for CII audits including a recent workshop training along with Bill and Lisa for 24 attendees hosted by the Honolulu Board of Water Supply, Hawaii, United States in February 2012. Recently, Michelle was project manager for the Stanford University Landscape Study, which has been widely published and presented as a successful study of creating water budgets, and improving irrigation management practices using real-time metering technology on campus. Michelle has a B.S. in Civil and Environmental Engineering and a Masters in Business Administration from the University of California, Davis.

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The guide was possible through the efforts of the authors and the International Water Association Efficient Urban Water Management Specialty Group. In particular, we would like to acknowledge Mary Ann Dickinson, as Specialty Group Chair, for her boundless energy and dedication in supporting us with her feedback and input into the guide's content and sponsoring the Guide through connections with IWA Publishing. The authors would also like to acknowledge the past efforts of United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), notably Yuri Steklov, who supported a previous publication on this topic written by the authors.

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Foreword

Achieving efficient and sustainable water use is a critical international need. Many regions in the world are experiencing greater potable water scarcity due to the multiple pressures of growing populations, diminished water quality and climate change. Thankfully, there are opportunities for improving efficiency and stretching scarce potable water supplies: through better management of utility water supply and treatment systems, cost-effective reduction of network leakage, and adoption of consumer water conservation measures in homes and businesses. Greater water sustainability can be achieved in any community using the proven methods and programs that successfully reduce overall water use.

Based on a prior guide published by the United Nations and now out of print, this updated Guide provides current state-of-the-art counsel on planning urban water efficiency programs, designed to improve sustainable water use on a local and regional level. It is specifically targeted to urban water utility managers and their staff. Within the International Water Association (IWA), this kind of technical advice has been regularly featured as part of the *Efficient* Conferences, held every two years since 2001 in Spain, Chile, Korea, Australia, Jordan, and France, where successful water efficiency strategies have been explored, documented and showcased. Much progress has been made in this efficiency field; we have seen growth in both the number and the quality of utility water efficiency programs, not only in developed countries but also in low to moderate income countries where the need is often greatest.

The Guide's principal author deserves special thanks and recognition. William Maddaus has been a pioneer and expert in water efficiency planning since the 1970s, developing many of the methods for evaluating cost effectiveness that we use today. He brings a wealth of practical experience to this Guide from supporting water use efficiency and resource planning efforts on six continents, and co-authors Lisa and Michelle Maddaus are very competently following in his footsteps. I know that I speak for generations of water conservation professionals who are grateful for William's five decades of leadership on this important issue. We have all benefitted, and this Guide is yet one more example of his dedicated service to the utility community and his desire to promote the sustainability of our global water resources.

We are hoping at the IWA Specialist Group to develop more materials and manuals on water efficiency programs in the next several years. Please let us know if you have found this Guide useful, and what additional resources and assistance you might need. Our goal is to support global water efficiency efforts and to help communities worldwide maximize their precious water supplies for future generations.

Mary Ann Dickinson, Chair
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Preface

Growing demands on existing water resources, leading to increasing competition between agricultural, urban and industrial users, together with requirements for sustaining the aquatic environment for available water supplies, are focusing attention on the potential of water efficiency savings to alleviate this situation. In addition to providing water savings, improved water-use efficiency can deliver environmental benefits by reducing water withdrawals from sources as well as lowering wastewater discharges, thereby decreasing pollution loads in receiving oceans, rivers and streams. Efficient water use also helps to delay the need to invest in costly water supply and wastewater treatment facilities, thus reducing energy demand for pumping, treating and heating water.

This publication is for supporting decisions related to planning, investment and management in the water supply and sanitation sector. The publication also provides a flexible framework as a guide to preparing plans on the efficient use of water in the domestic, municipal and commercial sectors.

In a number of countries, regulations are already in force that requires water utilities to prepare water efficiency (i.e., water conservation) plans that consider potential water savings from the optimal use of existing water supplies. In those countries, the preparation of water-use efficiency plans is considered a precondition to the issue of permits to utilities for developing new supplies or expanding water or wastewater treatment facilities.

The United Nations' Plan of Implementation, adopted at the World Summit on Sustainable Development held at Johannesburg, South Africa in September 2002, reflected this expanding trend. It calls for, *inter alia*, the development of water efficiency plans by 2005, with support to developing countries, through actions at all levels to introduce measures for improving the efficiency of water infrastructure. The overall objective is to reduce real water losses and increase the recycling of water as well as introduce more efficient usage of water resources.

In 2003, in response to this call, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) prepared a publication, Guide to Preparing Urban Water-Use Efficiency Plans, Water Resources Series, No. 83. The publication was drafted by Mr. William Maddaus and Ms. Lisa Maddaus for the Environment and Sustainable Development Division of ESCAP. The publication was quickly sold out and not reprinted by the United Nations.

Given the Efficient Urban Water Management Specialist Group is currently one of the fastest growing membership sectors for the International Water Association, there recognition of the continued need to serve this group of planners and practitioners in preparing water use efficiency plans to guide decisions on determining priorities for implementation. The contents of this guide constitute an update of information from this previous publication undertaken by the United Nations.

Funding resources are always limited for repairing and replacing old infrastructure and/or building new infrastructure to serve growing demands as our world population increases and freshwater resources become scarcer. The least cost approach to serve existing and new customers is to maximize water use efficiency to its maximum practical extent.

This guide serves as framework to organize the planning process for planners. It begins with a basic overview of concepts and definitions in the Introduction. The next chapter focuses on what needs to be included in the plan to give planners a sense of the scope of the effort. The third chapter focuses on understanding the water supply situation and which sources may be effected by more efficient uses of these supply resources. The fourth chapter serves to define what the projected future need from the available water resources are using an analysis of existing water use and forecasting methods to estimate additional demands in the coming 2 to 3 decades. The fifth chapter steps the planner through the opportunity to be more efficient with water demands and selecting the goals and measures to mitigate future demand increases. The sixth chapter helps the planner screen the ideas to enhance existing or new water efficiency measures into a selection of measures to be further analyzed for cost effectiveness. The seventh chapter defines the methods for cost effectiveness to help the planner determine which measures may save the most water for the least cost and selecting which final measures to include in the Plan. The eighth chapter discusses the options to finance the programme. The ninth chapter presents ideas for engaging the community in the planning process and programme implementation. The final chapter discusses implementing the plan using the concept of an annual work plan and monitoring the success of the programme to reduce water demands or challenges encountered that may lead to revisions to the plan.

The guide is also supported by several appendices. The first appendix includes a glossary of terms. The second appendix provides a list of internet resources current as of the date of publication. The third appendix presents a list of example water use efficiency measures with descriptions for consideration in planning process described in Chapter 6. The fourth appendix includes further details on conducting cost effectiveness analysis described in Chapter 7. The fifth appendix offers an example checklist for reviewing customer water efficiency actions.

This guide also has a supplemental that is spreadsheet set up for simplistic benefit-cost calculations that may be downloaded from the IWA Efficient Urban Water Management Specialty Group web site: http://www.iwaefficient.com or from Maddaus Water Management: www.maddauswater.com.

Water-Use Efficiency Plans are commonly updated on a 3–5 year basis as new technologies and information becomes available and system conditions change (i.e., new sources of supply or revised demand forecasts). The philosophy of a 'living' document that can continuously be updated is important to ensure that water efficiency programmes stay focused on the overall goal to lower water demands.

Abbreviations

ADB	Asian Development Bank
APHA	American Public Health Association
ANQIP	Associacao National Paroa Qualidate nas Instudacoes Predieis
AUD	Australian Dollar
AWE	Alliance for Water Efficiency
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation (now WaterRF)
BMP	Best Management Practice
B.S.	Bachelor of Science University Degree
BWS	Honolulu Board of Water Supply
CARL	Current Annual Real Losses – performance indicator of real losses
CBSM	Community Based Social Marketing
CCF	100 cubic feet
CEO	Chief Executive Officer
CII	Commercial, Institutional and Industrial
cm	centimetres
Conn	Connection
CISRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CPUC	California Public Utilities Commission
CUWCC	California Urban Water Conservation Council
DMA	District Metered Area
DSM	Demand side management
DSS	Decision Support System (Model for DSM Least Cost Planning)
DRP	Drought Response Plan
EBMUD	East Bay Municipal Utility District
EEA	European Environment Agency
ELI	Environmental Law Institute
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FY	Fiscal Year
HB	House Bill (USA)
HET	High Efficiency Toilet
HOA	Homeowners Association
GHG	Greenhouse gases
GL	Gigalitres
GL/a	Gigalitres per acre
ILI	Infrastructure Leakage Index
IAPMO	International Association of Plumbing and Mechanical Officials
IPM	Integrated Pest Management
ISF	Institute for Sustainable Futures
IWA	International Water Association
IWM	Integrated Water Management
IWRMP	Integrated Water Resource Management Plan
IRWD	Irvine Ranch Water District
IRWM	Integrated Resource Water Management

Kl	Kilo litre
kPA	kilopascals
kWh	kilowatt hours
lcd	Litres per capita per day
led	Litres per employee per day
l	Litres
L_p	Total length of service connections from the edge of the street to the customer meter, in metres
L_m	Length of mains, in metres
lpd	Litres per day
m^3	Cubic metre
MBA	Masters of Business Administration
mg/l	Milligrams/litre
ml	millilitre
min	minute
MCDA	Multi-criteria Decision Analysis
MDB	Murry Darling Basin
MJ	Megajoule
ML	Megalitres
ML/a	Megalitres per acre
MLD	Million Litres per Day
ML/yr	Million Litres per year
mm	millimeters
MNF	Minimum night time flow
MOGA	Multi-objective Genetic Algorithm
M.S.	Masters of Science University Degree
MWELS	Mandatory Water Efficiency Labeling Scheme
MWA	Metropolitan Waterworks Authority (Bangkok, Thailand)
MWM	Maddaus Water Management
Nc	Number of Connections
NGO	Non-governmental Organization
NRW	Non-Revenue Water
NPV	Net Present Value
O&M	Operation and Maintenance
P.E.	Professional Engineer (registered license)
PRV	Pressure Reducing Valve
PSAs	Public Service Announcement
PUB	Public Utilities Board (Singapore)
PWS	Public Water System
QWC	Queensland Water Commission
RBMP	River Basin Management Plans
R	Rand (currency of South Africa)
RECs	Renewable Energy Credits
RIAL	Reuse for Industry, Agriculture and Landscaping (Project, Jordan)
ROI	Return on Investment
RWA	Regional Water Authority (Sacramento, California, United States)
RWEP	Regional Water Efficiency Program (Sacramento, California, United States)
SABESP	Comanhia de Saneamento Basico do Estado de Sao Paulo S.A.
SDWA	Safe Drinking Water Act (United States)
SEACI	South East Australia Climate Initiative
SEC	Singapore Environmental Council
STR	Sub-Tropical Ridge
SWC	Sydney Water Corporation
TWM	Total water management
UARL	Unavoidable average real losses
UCSC	University of California at Santa Cruz (California)
UN	United Nations
USA	United States of America
US$	United States Dollar
USAID	United States Agency for International Development
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
WaterRF	Water Research Foundation (formerly AWWARF)
WASH	Water, Sanitation and Hygiene
WDM	Water demand management
WEF	Water Efficiency Fund (Singapore)
WEF	Water Environment Federation
WEH	Water Efficient Home
WEP	Water efficiency programme
WET	Water efficiency team
WHO	World Health Organization
WOPs	Water Operator Partnerships
WSAA	Water Services Association of Australia
WWTP	Wastewater treatment plant

Chapter 1

Introduction

1.1 PURPOSE OF THIS PUBLICATION

This publication is intended to be of interest to a wide audience that includes (a) water and wastewater utility managers; (b) water and wastewater utility planners and engineers; (c) consultants to water and wastewater utilities; and (d) government regulators and policy makers. It is designed to assist those involved in carrying out the task of preparing a water-efficiency plan for a municipal water supply system as well as other experts who are interested in water efficiency. Following this Guide in developing such a plan will produce a water conservation plan offering the greatest possible benefits to be determined and implemented.

1.2 DEFINITION OF EFFICIENT WATER USE

In this publication, efficient water use, which is closely related to water management concepts such as demand management and water conservation, refers to action taken to reduce water use by a utility or customer. Actions by a water supply utility can include reducing water losses, metering customers and billing for usage in such a way that encourages efficiency. Actions by customers can include the use of more water-efficient fixtures, reducing the amount of water used for aesthetic irrigation (e.g., on gardens), improvement in water-use behavior or home appliances and fixtures, and installing water-efficient processing equipment in businesses and industry. Please see the Case Study 1 at the end of this chapter, titled **the Australian urban water industry recognizes the importance of water efficiency**.

This Guide is focused on long-term water efficiency for permanent changes in water use. Drought contingency or response planning is not included in this Guide. Some of the concepts presented within the Guide would also support drought planning efforts in a water supply shortage. Other definitions and terms used throughout this Guide are presented in Appendix 1.

1.3 BENEFITS OF WATER EFFICIENCY

The primary beneficiaries from water efficiency (not listed in any order of preference):

(a) water utility
(b) wastewater utility

(c) customers (community)
(d) environment
(e) energy utility
(f) climate change (reduction in green house gases (GHG)).
(g) other

The Guide will focus specifically on the benefits to the water utility from the perspective of a water utility planner. As the reader will find, considerations of the other beneficiaries may be discussed.

Both ‘quantifiable’ or measurable benefits and ‘non-quantifiable’ benefits are presented. Detailed description of methods for accounting for direct benefits (cost savings) from water efficiency programmes is presented in Chapter 7.

1.3.1 Summary of water utility benefits

The quantifiable benefits accruing to a water utility through the efficient use of water may include:

(a) A reduction in operation and maintenance expenses incurred by water and wastewater transmission and treatment facilities due to the lower use of energy for pumping and reduction in the use of treatment chemicals;
(b) Deferral or downsizing of capital facilities, as lowering the rate of increase in demand can postpone construction of new facilities or avoid a water supply or treatment capacity increment.

The types of capital water supply facilities most likely affected by water conservation include:

- Water storage reservoirs
- Raw water transmission facilities
- Water and wastewater treatment plants
- Treated water storage.

Water conservation can ‘expand’ or ‘stretch’ the capacity of treatment facilities, benefiting both the utility and the community (Box 1.1). The most significant long-term cost savings from efficient water management are achieved when utilities reduce the size of their planned treatment plants due to water conservation. Operation and maintenance costs and lower greenhouse gas emissions are also reduced on an ongoing basis.

The non-quantifiable benefits to a water utility may include:

- Enhanced stream flows (less withdrawal);
- Improved source water quality (less treatment required);
- Increased labor efficiency (focused efforts on most beneficial means to deliver water, e.g., less staff required to maintain expanded infrastructure); and
- Reduction in storm water flows from reduced irrigation run off.

A detailed description of benefits that may be derived from using water more efficiently is presented in Chapter 3.

1.3.2 Summary of wastewater utility benefits

Wastewater utilities can also benefit from reduced indoor water use resulting in reduced wastewater disposal. Their operation and maintenance costs can be reduced through lower use of energy for pumping and reduced chemical usage in wastewater collection, treatment and disposal. However, most wastewater capital facilities are designed for peak wet weather flow, which is not significantly affected by a reduction in water use as would be the case with dry weather flow. Wastewater disposal facilities involving land disposal are an exception to this rule, as lower flows will have an impact on such facilities. In the latter case, volume reduction through conservation means that the area of effluent holding ponds and other land requirements will be lessened, thus allowing savings on capital facilities costs.

BOX 1.1 EUROPEAN COMMISSION: A BLUEPRINT TO SAFEGUARD EUROPE'S WATER RESOURCES

'Water is essential for human life, nature and the economy. It is permanently renewed but it is also finite and cannot be made or replaced with other resources. Freshwater constitutes only about 2% of the water on the planet and competing demands may lead to an estimated 40% global water supply shortage by 2030. (2030 Water Resources Group, 2009).

The European Union (EU)'s water policy has been successful in helping to protect scarce water resources. The Blueprint to Safeguard Europe's Water Resources aims to tackle the obstacles which hamper action to safeguard Europe's water resources and is based on an extensive evaluation of the existing policy. The Blueprint is based on a wealth of information and analysis including the European Environment Agency (EEA) State of Water report, the Commission assessment of the Member States River Basin Management Plans (RBMPs) and Review of the Policy on Water Scarcity and Droughts, (European Commission, 2011a) and the Fitness Check of EU Freshwater Policy (European Commission, 2012). Moreover it is accompanied by an Impact Assessment.[1] The Blueprint is based on extensive public consultations both in the framework of its development and under the Fitness Check which has involved the general public, stakeholders, Member States as well as other EU institutions and bodies.[2] The Blueprint recognises that the aquatic environments differ greatly across the EU and therefore does not propose any one size fits all solution, in line with the principle of subsidiarity. It emphasises key themes which include: improving land use, addressing water pollution, increasing water efficiency and resilience, and improving governance by those involved in managing water resources.'

Source: Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions (2011), http://ec.europa.eu/environment/water/blueprint/index_en.htm (accessed July 29, 2013)

1.3.3 Summary of customer benefits

Benefits from increased water efficiency can also extend beyond the utility. Customers who save water may receive more reliable water service, lower water bills and, possibly, lower sewerage bills if sewerage service charges are based on water use. Customers who reduce hot water usage (e.g., from installing more efficient showerheads, washing machines, dishwashers, etc.) may also lower their energy bills. Lower demands on local rivers and streams can also provide improved source water quality for non-potable domestic uses (washing), aesthetics and improved recreational opportunities.

[1]Commission Staff Working Document–Impact Assessment, accompanying the Communication 'Blueprint to Safeguard Europe's Water Resources' which includes a full list of the studies that have fed into the Blueprint.

[2]European Parliament resolution of 3 July 2012 on 'The implementation of EU water legislation, ahead of a necessary overall approach to European water challenges'.

1.3.4 Summary of environmental benefits

The environment can benefit from lower withdrawals from water sources and lower wastewater discharges. In some cases, water conservation activities can provide environmental benefits such as:

- Higher stream flows for fish and other aquatic species;
- Higher lake levels for recreational purposes;
- Reduced impacts on water quality at a source; and
- Reduced wastewater discharge that has a positive impact on receiving waters.

Enhanced aquatic environments can also provide direct socio-economic benefits such as improved or return to fishing industry and improved public health benefits where body contact with impaired water ways is commonplace.

1.3.5 Summary of energy utility and other benefits

Water and/or wastewater utility facilities are often one of the larger consumers for a local energy utility (if a separate organization). Energy utilities will benefit from reductions in peak demand, customer energy savings, lower greenhouse gas emissions, and so on. Benefits also accrue to other organizations, including storm water utilities, from reduced runoff direct to local streams and rivers from excess irrigation that can contain pollutants including pesticides and fertilizers.

1.4 OBJECTIVES OF WATER-USE EFFICIENCY PLANNING

In addition to ensuring water availability, the reasons for conserving water include reducing the size of planned water treatment facilities or delaying the time when an expansion will be needed. This, therefore, reduces the need for capital outlay from utility revenue or seeking outside funding assistance.

Because some of the benefits of water conservation are independent of water availability or climate (e.g., benefits related to the deferral of water treatment plant expansion), ample water supply should not be used as a reason for exemption from water use efficiency planning requirements. General planning requirements can be designed for normal water supply conditions, with added requirements for critical water supply areas. Additional planning requirements and subsequent programme implementation could result in higher economic benefits and lessened environmental impacts from increased water use.

This publication shows readers how to evaluate these benefits and then compare the benefits realized to the costs involved in achieving them through a water-efficiency plan. It also provides guidelines on how to develop and implement all aspects of the plan.

1.5 WATER-USE EFFICIENCY PLANS AND FUNDING ASSISTANCE POLICIES

Plans are very useful tools, both for agencies in defining requirements for applying for funding assistance and an applying utility for documenting the needs. Plans form the basis for:

(a) Justifying a need for water-efficiency programme funding (areas of conservation that the utility cannot afford but which would benefit a water-short region);
(b) Confirmation of the necessity for water treatment plant expansion and/or upgrade;
(c) Identifying the opportunities for extending service lines for a larger number of citizens; and
(d) Avoid funding a new water supply source, conveyance and treatment facilities in order to meet escalating demands. Funding may be redirected to other priorities.

This publication provides a basis for preparing a water-use efficiency plan that can be incorporated into a water management policy as a prerequisite for grants or loans from governmental or non-governmental agencies. Many funding agencies now require a plan to ensure that their funds are used in an efficient manner. Although the language of the requirements typically allows for flexibility, it is reasonable to infer that utilities that plan and carry out water conservation will likely size their treatment plants and facilities more efficiently. Further, a utility may wish to demonstrate to potential funding agencies that it has done all it can reasonably do to make sure that the requested funds will be used in the most efficient manner. In such cases, it follows that utilities would be well advised to take an aggressive stand in preparing water-efficiency plans.

1.6 PUBLICATION OUTLINE

The Guide is divided into ten chapters that lead planners through the process of developing a water-efficiency plan. The chapters following this introductory chapter include:

Chapter 2 discusses the development of a water-efficiency plan and explains where the plan elements can be found in the publication.

Chapter 3 deals with assessing current and planned water supply sources, and describes typical sources of supply with the aim of assisting in the preparation of a sources inventory. Water quality and supply vulnerability are considered, while the effects of water efficiency on water and wastewater systems are documented, including the reduced operating costs and downsizing.

Chapter 4 assesses current and future water use. A methodology for evaluating current water use is proposed that includes a table on key characteristics of a service area. Another table is provided to assist in describing water use, which breaks water usage down into customer categories and compares current use with system safe yield and system capacity. A method of analysing historical use is presented and two methods of forecasting future use are explained with examples. One of the latter methods bases the forecasting on a constant per capita use while the second method involves projection by customer class.

Chapter 5 discusses the development of water-efficiency goals and describes a process for setting water goals for the water-efficiency plan. Certain questions are asked that help focus the efforts and, ways to express the goals are suggested. A public participation process is proposed for finalizing those goals, which involves a consensus-building process.

Chapter 6 considers different aspects of determining the feasibility of water-use efficiency measures. The chapter is divided into two parts. The first part describes water-efficiency measures that apply to a water utility, including system water audits, leak detection and repair. A new method of assessing water losses based on methods proposed by the International Water Association is described, as are different types of water tariffs that apply to metered customers such as water-pricing schemes designed to reduce water use. The second part describes water-efficiency measures that apply to domestic and non-domestic customers. A summary of available water efficient devices is tabulated and a comprehensive list of potential interior and exterior water-efficiency measures is presented in Appendix 3. A qualitative screening process is suggested to enable the planner to reduce the measures to be considered to a manageable number.

Chapter 7 evaluates the cost-effectiveness of measures. It describes how to make a benefit-cost analysis of potential water-efficiency measures and lists a step-by-step process. Benefits that should be quantified include those to the utility through downsizing and deferring capital facilities as well as reductions in operation and maintenance costs. A methodology is exemplified in tabular form, beginning with a procedure for estimating water savings. Estimating the costs of the measures and a process for quantifying agency benefits are explained, and the benefit-cost ratio calculation is demonstrated.

(Note: the reader is also referred to Appendix 4, which contains information and a website link to software for computing the benefit-cost ratio of an efficiency measure.)

Chapter 8 reviews the financing of water-use efficiency programmes. It describes funding sources for water-efficiency programmes, including pricing schemes and private funding as well as outside sources.

Chapter 9 discusses how citizens can participate in developing Plan goals, contribute to the list of efficiency measures being considered, better understand outcomes of the analysis and support the planned investment selected for the Plan. This chapter also explores the opportunities for building capacity by training of professionals, launching education and awareness programmes supported by community leaders, and use of social media to help engage the public in adopting water efficient practices and technologies proposed in the Plan.

Chapter 10 considers programme implementation and overcoming barriers to water-use efficiency. It describes the responsibility of the water-efficiency programme manager, from the preparation of a work plan to the completion of the plan, as well as those of other programme participants. Various obstacles are discussed, including the lack of data and knowledge about water-efficiency measures, and the lack of availability of long-range capital facility plans, and appropriate training and software. The publication is designed to assist users in overcoming many of these constraints.

Appendix 1 provides a glossary of key terms in water use efficiency. Appendix 2 presents internet resources. Appendix 3 provides example measures for consideration when performing the measures screening analysis described in Chapter 6. Appendix 4 illustrates more comprehensive details on cost effectiveness analysis and tools available including reference to a downloadable spreadsheet tool. Appendix 5 presents a sample checklist for use at a utility customer facility by either water utility surveyors and/or facility managers' review of basic water use efficiency practices and equipment measures.

Supplemental information to this Guide will be updated through the International Water Association's Efficient Urban Water Management Specialist Group website: http://www.iwahq.org (last accessed May 30, 2013). Online information includes the most up to date information related planning resources and spreadsheet tools available to perform assist with urban water use efficiency planning using cost effectiveness calculations.

CASE STUDY 1
The Australian Urban Water Industry Recognizes the Importance of Water Efficiency

Cilla Delacy, Water Services Association Australia, Melbourne, Australia

The Water Services Association of Australia has published Position Paper 5 'Using Water Wisely' in March 2013 (Water Services Association of Australia, 2013). The recent history of extremes of dry, rain and floods, and high temperatures is thought to be the continent's climate future. Australian customers and the community are seeking a robust and diverse approach to meet these extremes. Therefore, a combination of baseline investment in water efficiency (not wasting a drop) as well as developing new sources, particularly including those independent of rainfall, such as desalination and water recycling, is the key to a prosperous future.

'Using Water Wisely' concludes water efficiency is a major success story in Australia. Findings in this paper include:

- 'Many of the savings achieved through water conservation and efficiency programmes are now locked in, there is a new 'norm' for using water wisely

- Customers clearly view using water wisely as the no. 1 priority in doing their part to develop livable communities
- Water efficiency, desalination and water recycling, together with surface supplies, all form part of a diverse robust portfolio of water source options
- Providing customers with options and choice on how to reach water efficiency targets will be the focus of the future: 'water restrictions, except in emergencies, are a thing of the past (WASA, 2013).'
- Over 900,000 shower head replacements in Sydney and Melbourne metropolitan areas
- Water efficiency and energy efficiency go hand in hand and offer many benefits to customers
- Water efficiency can delay the need for water utilities to invest in expensive capital expenditure

'Using Water Wisely' documents success stories from several areas and provides references for more information. A snapshot of some of the water savings made from water efficiency programmes around Australia over the last 10 years is presented in the Table 1.1 below.

Table 1.1 Summary of Australian water efficiency programmes.

City/Town/Region	Annual water savings (ML)	Best performing programmes
Sydney	120,000	• Permanent Water Wise Rules • Leak management • Business water efficiency programmes
Perth	90,000	• Permanent water efficiency measures (2 day/week sprinkler roster) • Communications and water loss management programmes
Melbourne	60,000	• Showerhead exchanges • Watersmart rebate programme • waterMAP programme (non-domestic customers) • Target 155 Campaign
Adelaide	55,000	• Permanent Water Wise Rules • Domestic appliance rebate/exchange programs • Industrial, Commercial and public open space water efficiency programmes
Canberra	25,000	• Permanent water conservation measures • Communications, education and awareness raising programmes • Toilet and showerhead retrofit programmes • Large non-domestic customers demand management programme
Hunter region (NSW)	1058	Showerheads and tap retrofits
Ballarat	1000	Technical water efficiency programmes

Source: Water Services Association of Australia (2013).

Chapter 2

Developing a Water-Use Efficiency Plan

This chapter provides recommendations for the water utility planner on the content of water-use efficiency plans. The suggested annotated outline of a water-use efficiency plan serves as a structure for the Guide. Each section of the plan outline is discussed in subsequent chapters, which provide additional information on how to prepare the sections of the plan together with recommendations for tailoring water-use efficiency measures and the level of analysis to the size and/or capabilities of the water utility.

2.1 PLAN CONTENTS

Each plan should contain the following key components:

(a) A description of water supply source reliability with any anticipated changes in yield (Chapter 3);
(b) Projected future water use, preferably broken down by customer type or, in other words, customer class (Chapter 4);
(c) Explicit programme goals, both short term and long term (Chapter 5);
(d) Process used to select from a diverse list of efficiency measures for evaluation (Chapter 6);
(e) A cost-effectiveness analysis used as a part of the decision-making process (Chapter 7);
(f) Recommended efficiency measures, including explicitly defined implementation costs, scheduling and staffing (Chapter 7);
(g) Budget requirements with identified funding sources (Chapter 8);
(h) Involvement of the community in the planning process and also a plan for promoting education and awareness among citizens (Chapter 9);
(i) Implementation strategies with clarification of the roles of responsible parties (Chapter 10) and which will provide a process for monitoring and evaluating the actual savings achieved.

2.2 PLAN OUTLINE

A suggested outline for the water-use efficiency plan is given below with references to the relevant chapters of this publication.

- *Introduction and Summary*: Describe the reason for the plan and explain its goals. Describe the organization of the report and summarize the findings on the need to save water as well as opportunities to improve efficiency. Outline the public involvement process used. The introduction should clearly summarize the results of the cost-effectiveness analysis and the criteria for selecting efficiency measures. Briefly describe the measures to be implemented and their cost, benefits and schedule. Summarize the implementation plan including the roles of various participants, staffing needs, required annual budgets and source(s) of funding, plus monitoring and evaluation requirements.

- *Service Area, Climate and Demographics (see Chapter 3)*: Describe the service area and its climate (weather such as precipitation and temperature) and include a current map of the geographic boundaries of the service area. Provide current and projected population figures in five-year intervals for 20 years ahead (or more years) together with other demographic factors that affect water-use planning.
- *Water Supply Sources and Vulnerability (see Chapter 3)*: Identify and quantify existing and planned water supply sources. Describe the type of water treatment that is or will be required to produce potable water. Available information on non-potable water use that lowers demand for potable water should also be identified and quantified. Describe any known impacts to local water supplies or demands due to climate change.

Describe the reliability of water supply and its vulnerability to seasonal and climatic shortages by examining (a) an average water year; (b) a single dry year; and (c) multiple dry years. The Guidebook does not include drought contingency planning. In addition, describe the options for replacing any unreliable water supply source (i.e., not consistently available at all times when taking into account specific legal, environmental, water quality or weather-based climatic factors) with alternative sources or water demand management measures. This supply reliability analysis should check on variability due to potential climate change impacts.

- *Water Transfers/Exchanges (see Chapter 3)*: Describe opportunities for exchanges or transfers of raw or treated water with another utility on a short- or long-term basis.
- *Existing and Projected Water Use (see Chapter 4)*: This part of the plan should include:
  (a) Quantification of past and current water use (five-years at monthly intervals or best available information);
  (b) A projection of future water use at five-year intervals for the next 20 years or longer planning timeframe (i.e., using 50 years for water supply planning with climate change impacts considered) by the water-use sector or customer class if data are available from the water billing system. (Sectors could be defined as single-family, multi-family, commercial, industrial, institutional/government, landscape irrigation, sales to other agencies, saline water intrusion barrier/groundwater recharge/conjunctive use or any combination thereof, and agricultural use);
  (c) A baseline projection of the timing for necessary increases in the volume of water supply and water treatment capacity in the absence of additional water efficiency measures. This projection can include with and without climate change impacts to demand (i.e., variability in temperatures and/or shifts in precipitation patterns may result increased or decreased estimated demands). This baseline will later be compared to the projection with water use efficiency factored into the demand forecast.
- *Water Efficiency Goals (see Chapter 5)*: Describe the impetus of increased water efficiency. Based on the water-use profile and efficiency in the area concerned, identify opportunities for increasing water-use efficiency. Describe how the public and other interested parties have provided input to the goals. State the goals of the plan qualitatively and quantitatively.

- *Evaluation of Alternative Demand Management Measures (see Chapters 6 and 7)*: The objective of the evaluation is to provide the utility with specific justification for implementing chosen efficiency measures. (See Chapter 7 for a description of cost-effectiveness analysis methods and Appendix 4 for a more detailed discussion on the software that is provided for performing the analyses.) The evaluation should:
  (a) Identify possible efficiency measures. Describe water demand management measures that are currently being implemented or are scheduled for implementation, giving the starting dates, the affected customer classes, and the number of affected units (persons or accounts). Describe alternative implementation mechanisms for potential measures and the successes and challenges of existing measures;
  (b) Estimate, wherever possible, existing efficiency savings within the supplier's service area and the effect of such savings on the supplier's ability to further reduce demand;
  (c) Evaluate potential measures by taking into account the identified aspects:
    (i) Economic and non-economic factors, including environmental, social, health, customer impact and technological factors;
    (ii) A cost-benefit analysis that identifies total benefits and total costs directly to the utility (and descriptions for costs or cost-sharing provided for by other utilities such as wastewater, energy or stormwater);
    (iii) A description of funding available for implementing any planned water supply project that would provide water at a higher unit cost; and
    (iv) A description of the water supplier's legal authority to implement the measures and collaboration with other relevant agencies in implementation and cost sharing.
- *Detailed water shortage contingency analysis and drought/emergency action plan (including a copy of implementing law and/or ordinance)*: This is an optional section that a utility may decide is or is not necessary. Drought/emergency plans can very be useful in a crisis in cases of: (a) the onset of drought conditions; (b) a sudden natural disaster that damages water supply infrastructure; or (c) service interruption (e.g., a break in a water distribution main, power failure or treatment process malfunction). This issue is not covered in this Guide. The reader may reference other publications. The American Water Works Association (AWWA) published peer-reviewed guidance for planners on Manual of Practice, M60: Drought Preparedness and Response (AWWA, 2011). Another resource is the Water Shortage Contingency/Drought Planning Handbook (USBR, 2003) with example tables for a Water Shortage Contingency Plan provided by the United States Bureau of Reclamation. More information is provided at http://www.usbr.gov/mp/watershare/
- *Recommended Long-term Efficiency Plan (Chapter 8 and Chapter 9)*: A detailed description of the measures selected for the plan as well as their costs, benefits, and implementation schedule should be included. Include a description of the public awareness campaign that will accompany the programme to assist with successful implementation.
- *Implementation Plan (Chapters 8, 9 and 10)*: Provide projections for the required budget and staffing over the life of the plan together with the detailed annual budget for the first one to five years of the plan. Discuss the organizations and capacity building that will assist with the implementation of the plan. Discuss the monitoring and reporting that need to be carried out to ensure that the water efficiency goals are being met. Provide a resolution or other evidence of the official adoption of the plan by the utility together with a statement of intent to implement the plan.

2.3 PLAN UPDATES

The plan will require annual reviews and periodic updating, commonly done on two- to five-year cycles. The update will allow a water utility planner to (a) document demand reductions due to successful strategies; (b) revise demand forecasts; and (c) modify demand management measures that have not achieved the expected efficiency or add/discontinue measures. (Box 2.1)

BOX 2.1 POLICY GUIDELINES FOR WATER CONSERVATION PLANS IN THE UNITED STATES

A few countries have introduced requirements for submitting water conservation or water efficiency plans. Such requirements appear to be the most developed and widely applied in the United States of America, where the requirements vary for water efficiency plans depending on system size. The United States Safe Drinking Water Act of 1996 requires water conservation plans to address three categories of public water supply systems, that is, systems serving: (a) fewer than 3300 persons; (b) between 3300 and 10,000 persons; and (c) more than 10,000 persons. (Case Study 2)

These categories are referred to as small, medium and large-sized water utilities. In general, the majority of utilities are very small, serving less than 500 persons. In California, for example, 95 percent of the state's 7545 regulated utilities each serve more than 15 connections.[1] It has been recommended that all but the very small utilities should have a minimum level of water conservation programme. Utilities serving fewer than 500 persons could be exempted from the conservation planning requirement and small utilities could have reduced requirements. Because of the higher potential for water conservation savings, large utilities should be required to analyse water efficiency measures in addition to those in the minimum plan, and submit a formal water conservation plan.

One way that individual states can handle the utility size issue is to adopt the following guidelines:

- No plan required for utilities serving less than 500 persons.
- No plan required for systems serving 500 to 3300 persons unless in an area designated by the State as a 'critical water supply area.'
- A minimum plan/programme for systems serving between 3300 and 10,000 persons.
- A full conservation plan for systems serving more than 10,000 persons.

The above size distinctions could be reconsidered and applied at the end of the project planning period, for example, in 5 to 10 years, since growth may push the utility into a higher category.

Variations or exceptions in water management policies that require plans could be made for many reasons. Some policies target utilities with high per capita water use for special attention. This is done to focus on utilities that usually have a high Infrastructure Leakage Index (ILI). Utilities with a relatively high ILI, when compared to the norms, could be encouraged to prepare a plan to reduce ILI. The above criteria for systems serving more than 3300 persons could be modified to include the wording 'unless the ILI is above ___ (fill in appropriate value), in which case a full plan is required.'

In addition, as the market costs of implementing certain measures may change with technologies increasingly available at lower costs, the result could be more measures feasible for cost-effective

[1]2011 Annual Compliance Report, California Department of Public Health, Division of Drinking Water and Environmental Management, United States. There is quarterly reporting electronically that is in turn sent to the United States Environmental Protection Agency (USEPA). A Public Water System (PWS) is defined as a water system serving 15 or more service connections, or 25 or more users, for 60 or more days per year. http://www.cdph.ca.gov/certlic/drinkingwater/Documents/DWdocuments/2011/2011%20ACR.pdf (last accessed on May 30, 2013).

implementation. Moreover, some measures selected for implementation may have been unpopular with customers and strategies need to be modified. To avoid wasted effort on measures unsuitable or strongly distasteful for utility customers, having customer input into the planning process is critical for success of the water efficiency programme.

2.4 SUGGESTED PUBLIC PARTICIPATION IN PLAN PREPARATION

Any plan that is to be implemented will be more successful when there is some evidence that it has formally been adopted as policy and the official plan of the utility. For example, the preferred local approval process might include a resolution from the utility's directors adopting the plan at a public hearing. This should be done with proper notice and the holding of a public hearing, conducted during one of the regularly scheduled directors' meetings. This action will give utility customers and interested persons and groups the opportunity to review and comment on the proposed plan. The lead-time should be sufficient for the utility board of directors to review comments and consider changes to the proposed plan before its adoption. The adopted resolution should contain a statement of intent to implement the plan.

Detailed information on defining a public involvement strategy is provided in Chapter 9. Forms of public participation, such as a citizen's advisory committee that reviews progress (formulation and preparation), could be helpful in obtaining public participation and support for the plan adoption. Figure 2.1 presents an example schedule for the development of a comprehensive plan that includes both stakeholder involvement and formal adoption of the Plan.

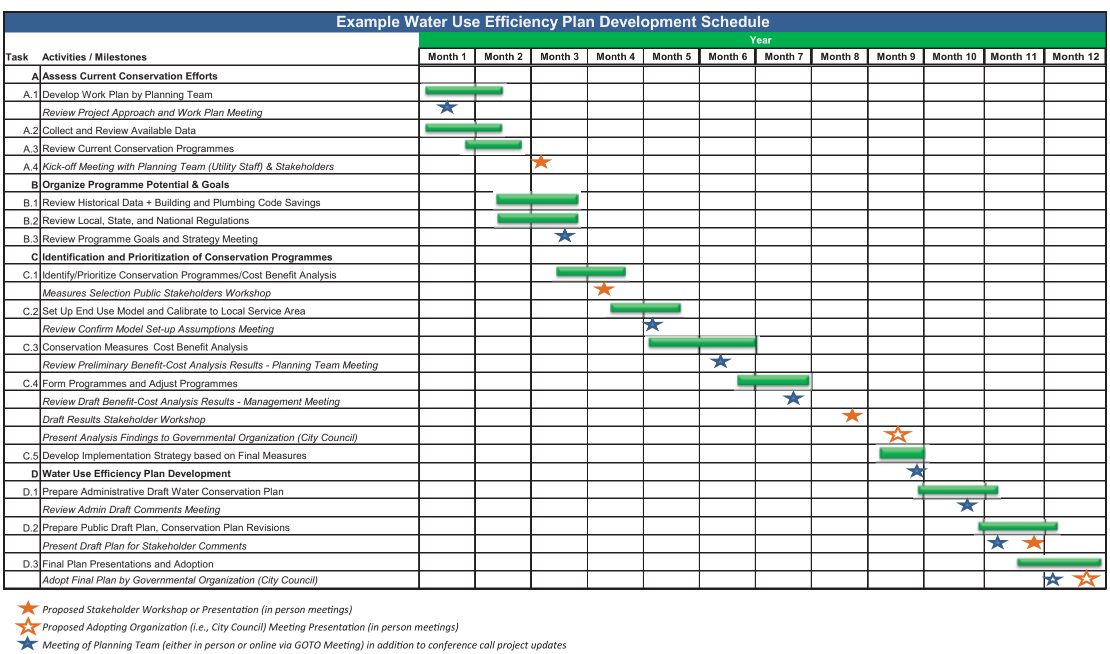


Figure 2.1 Example schedule for plan development including stakeholder involvement and plan adoption. *Source*: Maddaus Water Management (2013).

CASE STUDY 2

Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies in the United States

Bill Christiansen, Alliance for Water Efficiency, Chicago, Illinois, United States

The 1996 amendments to the Safe Drinking Water Act (SDWA) gave states the authority to require public water systems to submit water conservation plans in order to be eligible for grant or loan funding from a state fund. The amendments also required the Environmental Protection Agency to publish guidelines for preparing conservation plans (Public Law 104–182, 1996; Federal Register, 1998; and U.S. Environmental Protection Agency, 1998). With no overarching federal requirements, water conservation planning policies vary greatly throughout the United States and are completely absent in 22 states.

A 2012 report produced by the Alliance for Water Efficiency (AWE) and the Environmental Law Institute (ELI), *The Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies* (AWE & ELI, 2012), catalogued and analyzed water conservation policies in the United States. Data for each state are posted in the Alliance for Water Efficiency Resource Library and can be referenced for model policy examples (http://www.allianceforwaterefficiency.org/2012-state-information.aspx). Water conservation planning was a primary focus of the study and the results were quite diverse. Overall, 28 of the 50 states have some kind of requirement for water conservation plans and all are unique. Some states have water conservation planning requirements that are tied to the permitting process, other states incorporate planning with funding eligibility as is suggested in the SDWA, while others require all public water suppliers to submit regularly updated plans.

Table 2.1 States with strong conservation planning requirements by component.

Applicability	Authority to approve or reject	Updates	Framework	Implementation
California	Connecticut	Texas	California	California
Colorado	Colorado	Massachusetts	Texas	New Hampshire
Rhode Island	Kentucky	South Carolina		Oregon
Utah	Virginia			Texas
Washington				

The aforementioned study examined the nature of the planning requirements and applicability, state authority (or lack thereof) to reject plans, rules regarding plan updates, if the state has a framework for plans, and if implementation is required. Table 2.1 lists states with strong laws for the various components of conservation planning. There are additional states with notable laws, but the following represent the strongest examples. The five components listed in the table are all very important. Conservation planning requirements are most meaningful if they apply to a broad set of users, can be approved or rejected, must be regularly updated, and adhere to a robust framework. Implementation is also critical. Without rules enforcing implementation, a plan is just a plan.

Chapter 3

Assessing Current and Planned Water Supply Sources

This chapter guides the planner in assessing existing water supply sources for later comparison with current and future demand projections, to be developed as described in Chapter 4. In addition, it provides an important exercise in defining capacities and costs of both existing and planned water and wastewater facilities, including capital costs and operation and maintenance costs.

3.1 DEFINE WATER SUPPLY RELIABILITY AND CONSERVATION BENEFITS

Although defining water supply sources is a broad topic, for the purposes of water-use efficiency planning the best information available should be utilized. The best resource for information on water supplies to support water-use efficiency planning is commonly a utility's Integrated Water Resources Plan, if available. The American Water Works Association (AWWA) has a complete Manual of Water Supply Practice, M50, Water Resources Planning (AWWA, 2007) that describes Water Conservation as part of a portfolio of existing and planned future supplies. If an Integrated Water Resources Plan is not available, then determining this information can take between one and three weeks, depending on the complexity of the service area, climate variation, water quality issues, and the number and types of supply sources. When necessary, assumptions may be made since this exercise is for carrying out a cost effectiveness analysis of the demand management programme and not a full-scale water supply planning exercise.

The purposes for assessing water supplies within water efficiency planning context are:

(a) To enable the quantity of reliable water supply to be defined in order to identify potential shortfalls;
(b) To build an understanding of how long-term conservation and short-term droughts may rely on demand reduction; and
(c) To develop the database needed for evaluating potential benefits from conserving water supply.

The assessment describes the following factors that influence water supply:

- Service area boundaries
- Watershed boundaries
- Climatic (weather) conditions
- Water quantities in various sources of supply
- Water quality of sources, as may be impacted by current or planned water management practices

- Opportunities for water transfers and exchanges
- Conditions of the water conveyance, treatment and distribution system

Once water sources are quantified and future supply projects are defined, planners can establish the baseline for reliable water supply. When compared with estimated future demands, the projected shortfalls allow planners to quantify the water savings goals and cost savings (i.e., the benefits from developing fewer new supplies) from the demand management programme. Water savings goals and associated cost savings are key inputs into the cost-effectiveness analysis (see Chapter 7 for a more detailed description). Information on available software and additional references are provided in Appendix 4.

3.2 SERVICE AREA, WATERSHED AND SEASONAL CLIMATE

General descriptions of the characteristics of the utility service area help in assessing water sources. The service area can be defined in terms of the geographical boundary of the distribution system and locations of water intake, water treatment, wastewater treatment and discharge facilities. By specifying the locations of these facilities, planners can determine areas for potential environmental improvements through possible decreases in water withdrawal and wastewater discharges due to the demand management programme. The inclusion of maps depicting water service area boundaries and facilities in the water-use efficiency plan is especially useful. Demographic characteristics of the water service area are defined when quantifying current and future water demands (Chapter 4).

Watershed and groundwater basin characteristics need to be defined in order to determine the geographic area influenced by surface and/or groundwater resources use. Variations in historical precipitation records for the region concerned will provide insight into the flood and drought cycles that influence available water supplies. Aquifer recharge levels are also significant in determining the level of sustainable withdrawals from underlying aquifers. A summary description of historical climate conditions will suffice for this purpose. Planners may elect to depict this information in the form of graphical data charts on the amount of precipitation and/or groundwater recharge over time to indicate the corresponding frequency of historical drought conditions.

Local climatic conditions, such as drought frequency, will influence the number, type and feasibility of demand management measures selected (Chapter 6). For example, a long dry season without precipitation would be a constraint to rainwater harvesting for landscape watering needs because large amounts of water storage are required for that purpose.

3.3 CLIMATE CHANGE SHIFTS IN WATER SUPPLY AVAILABILITY

Climate change shifts should also be considered in terms of supply reliability to meet current and future demands. This can be achieved by reviewing historical shifts in surface water flows and other climate metrics to look at long range shifts in supply.

An example of observed shifts can be seen in long-run averages for Sacramento, California, United States in Figure 3.1. With reservoir storage, the flood control season of December through March has higher runoff, than the lower runoff from snowpack in the water supply storage season of April through July, which sees lower runoff from snowpack. This river system provides more than 30% of water supply for 23 million residents in Southern California and is a primary resource to a multi-billion dollar agricultural industry.

Box 3.1 describes an approach to forming water operator partnerships to address climate change.

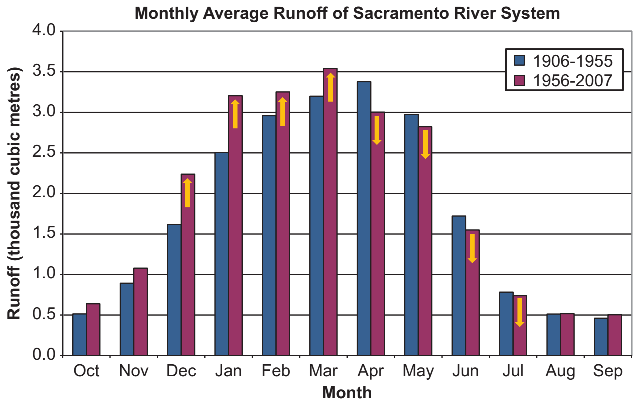


Figure 3.1 Climate change influence on Sacramento River system. *Source*: Personal communication, Michael L. Anderson, California Department of Water Resources, California, United States.

BOX 3.1 WATERLINKS AND USAID ECO-ASIA CLIMATE CHANGE INITIATIVE

In 2012, WaterLinks, together with United States Agency for International Developments (USAID's) Environmental Cooperation – Asia (ECO-Asia) project which was implemented by AECOM, completed two rapid assessments of water services providers to identify how they are preparing and/or responding to the likely impacts of climate change. One assessment involved 13 services providers in Asia and one in Australia while the other assessment engaged 20 water districts in the Philippines. The assessment presented elements of 'readiness' of participating services providers to adapt to and address climate change impacts; defined possible actions to improve their 'readiness'; identified capacity building needs; and documented good practices that contribute to building resilience against climate change impacts. The assessments included consultations and workshops involving services providers from Asia, Australia and the U.S. and followed a four-stage 'readiness' framework (see Figure 3.2).

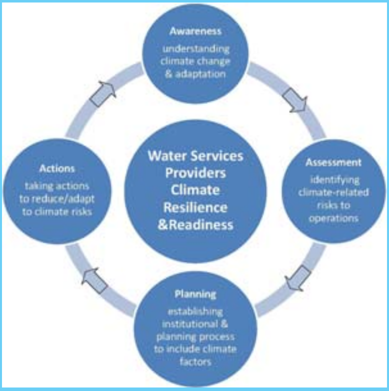


Figure 3.2 Framework for assessing readiness for climate change. *Source*: Waterlinks, 2012.

(*Continued*)

BOX 3.1 (*Continued*)

Key findings from both assessments were similar as follows:

(1) There is a general gap in local expertise, technology, and approach to better understand how climate change could affect water services delivery in urban centers and to plan for addressing climate change impacts and building adaptive capacities;
(2) Continued advocacy and engagement of various stakeholders – including the academic community, local and national government, policymakers, and communities – are critical to raise awareness of climate change and its impacts;
(3) Limited or lack of climate-related data, and associated know-how to distill useful information from those data, restrict water services providers from fully comprehending how climate change may impact their operations and sustainability of services delivery; and
(4) Learning from peers or other practitioners that have undertaken activities to become climate resilient is an ideal capacity building approach to plan and take action for addressing climate change impacts.

Source: WaterLinks (2013a).

3.4 SOURCES OF WATER SUPPLY

Each source of existing and planned water supply should be identified and quantified. Descriptions should also be provided of the water treatment that will be required to make the water potable. In addition, this is an important exercise in defining capacities and costs of existing and planned water and wastewater facilities, including both capital costs and operation and maintenance costs.

Sources of water supply are typically broken down as:

- Surface water
- Groundwater
- Recycled/reclaimed water
- Desalination water
- Other (rainwater harvesting and graywater systems).

3.4.1 Surface water

Where the source of supply is a surface water reservoir, analysing usable storage capacity and historical storage volumes will enable the available water supply to be assessed. Records of treatment plant production based on readings from production meters, if available, will provide data on historical water production. Design criteria for treatment plants can be used to assess unutilized capacity available for accommodating future growth.

If the source of water supply is a river, available information on stream depth from stream gauges converted to flows may be useful in quantifying variations in historical stream flows. If the water intake is unmetered then the water volume used can be estimated from pump characteristics and periodic electricity meter readings. The latter will indicate the period that the pump was running. The pump curve (available from the manufacturer) will indicate what flow was pumped, based on the pumping head for the installation.

New sources from surface water supplies, reservoirs or river diversions, should be identified in terms of production capacity and total capital construction costs as well as operation and maintenance costs, as such projects could be deferred or downsized due to the water demand management programme.

3.4.2 Groundwater

In the case of groundwater sources, the sustainability of available water supplies is directly related to the amount of water entering the groundwater basin as recharge compared to pumping rates. A reduction of overdraft (i.e., when groundwater pumping exceeds groundwater recharge) that extends the life of the groundwater supply source should be counted as a benefit from the demand management programme. This also provides an important exercise in defining capacities as well as costs of existing and planned water and wastewater facilities (including capital costs and operation and maintenance costs).

Recharge rates are typically quantified using peizometers adjacent to the pumping zone of supply wells. Alternatively, if a conjunctive water-use scheme is in place, where groundwater is mostly used in the high irrigation (dry) season when surface water flows are lower, it must be allowed to recharge aquifers during the wet (monsoon) season when higher surface water flows are used for irrigation. Recharge rates can be estimated by measuring water levels in supply wells during the low irrigation (less groundwater pumping) season.

Plans for new groundwater wells to increase supply capacity should include production capacity, capital costs, and operations and maintenance costs.

3.4.3 Recycled water and desalination

Access to seawater for desalination may be considered, if applicable. Existing or planned facilities for treating wastewater or seawater should be identified in terms of treatment capacity as well as capital for improvement, and operations and maintenance costs. Practically speaking, both recycled and desalinated water supplies are reliable sources of supply that are sustainable but they are very expensive (as much as 10 times more expensive on a volumetric (per cubic metre) basis than conserved water). These sources are easily quantified from designed capacity and metered production at treatment facilities. An example of treating and reusing wastewater as a source of water in is described in Case Study 3.

3.4.4 Other sources

In some cases, where water supplies are too low in pressure, unavailable on a day-to-day basis or are of poor quality, supplies are delivered by tanker trucks to supplement water utility output. Tanker truck records, interviews with operating personnel and community surveys can be used for quantification purposes.

Quantifying on-site graywater use and rainwater harvesting by specific customers requires a survey of water customers or another reporting mechanism, such as the number of systems sold or provided by the utility. Assumptions are commonly made on this aspect in cost-effectiveness analyses as this relatively small quantity of water provides relatively low cost savings. The exception to such assumptions is when local knowledge of the service area indicates participation by numerous customers in these activities, such as in some parts of rural Australia where over half of the water supply is provided by rainwater harvesting. Water savings from demand management measures are discussed in more detail in Chapter 6.

Availability of other supply sources, such as stored and treated urban storm water, varies due to local climatic conditions and water system designs. Quantified amounts and cost information are usually available from utility engineering departments.

3.4.5 Water sources quality

Quality problems need to be identified as they can have a major impact on the amount of supply produced as well as cause shifts in water management schemes. Particularly important are water quality variations that limit availability of water of suitable quality to meet peak demands. The treatment requirements for producing potable water from different sources should be noted. A useful reference could be a list of water quality 'constituents of concern' that are monitored and treated.[1]

Groundwater contamination due to natural or man-made causes, whether potential or existing, should be noted. If groundwater treatment is planned or required due to water quality concerns, details should be given of capacity, capital and operation and maintenance costs for new groundwater treatment facilities. Also of concern is the level of treatment provided for recycled or desalinated water as well as restrictions on its uses. If these sources are non-potable and used only for irrigation purposes, this should be taken into account as a factor in reducing peak demand for treated water during the irrigation season.

3.4.6 Water transfers/exchanges

Existing or planned agreements for meeting demands through (raw and/or treated) water exchanges or transfers under normal supply conditions or only in dry years on a short-term basis may form an important supplement to local sources. Water transfers can work both ways. In some cases, providers become suppliers to other agencies during dry periods, which count as an additional demand on the system. In other cases, providers receive water from other providers and that counts as additional supply. The provisions of these agreements should be understood as well as the cost of water supplied to, or received from, other providers.

Box 3.2 describes Singapore's experience in creating new sources of water.

BOX 3.2 SINGAPORE'S EXPERIENCE IN WATER MANAGEMENT

Approximately two thirds of Singapore's land area is used as water catchments. All major traditional surface water resources have been developed. Singapore has more than 1 million water accounts.

PUB, Singapore's national water agency, adopts a holistic and integrated approach in water management, from sourcing to the collection, purification and supply of drinking water, to the treatment of used water and its reclamation into ultra-clean, high-grade reclaimed water called NEWater, as well as the drainage of stormwater. To ensure an adequate and sustainable supply of water for Singapore, PUB has developed a diversified water supply strategy known as the Four National Taps. These are namely local catchment water, imported water from Malaysia, NEWater and desalinated water. Today, NEWater and desalinated water can meet 30% and 10% of Singapore's total water demand respectively. Additional information is available at http://www.pub.gov.sg

[1]An example of the constituents list that is maintained in the United States by the Environmental Protection Agency (USEPA) can be found at http://www.epa.gov. Water quality information, including drinking water testing requirements, can be found at http://water.epa.gov/drink/contaminants/index.cfm and in the publication, *Standard Methods for the Examination of Water and Wastewater*, 22nd Edition, 2012, American Public Health Association (APHA), American Water Works Association (AWWA) & Water Environment Federation (WEF), http://www.apha.org/media/

3.4.7 Water Treatment and Distribution System

The following aspects should be discussed:

- The capacity and conditions for, and costs of, maintaining an existing conveyance, treatment and distribution system in terms of system components' age, pumping energy and treatment chemicals required;
- Type of water supply delivery (piped, by truck, others);
- Routine operation and maintenance, the pipe replacement schedule, and the history of main breaks and leak repairs.

In addition, the system pressure should be documented. These are key data for assessing the quantity of treated water that will actually meet customer demand. If leakage reduction programmes, pressure management or other demand management measures are not in place, water conveyance and distribution losses may be viewed as limiting the water source supply.

3.5 SUPPLY VULNERABILITY

The capacity of each developed water supply project is not a guarantee that water will always be available in the amount historically withdrawn, particularly in the case of surface water sources. Assessing the vulnerability of water supplies is commonly done by comparing the 'safe yield' of water sources with projected demands. Safe yield is defined as the amount of water that can be reliably withdrawn under normal (average) annual hydrological conditions in developed supplies. This exercise allows planners to assess the amount of water that will be reliably available for use.

When supply capacity is compared to the average annual water demand or higher demand in dry years, then a shortfall may occur. The amount of shortfall with an acceptable level of risk to the community or the probability of not meeting demands can be determined from public opinion surveys. For example, such a survey could ask whether the community will tolerate a 25 percent shortfall every 10 years. If not, action should be taken to increase supply or reduce demand. Given the expense of developing water supplies for multiple dry years, it is common practice to accept some level of risk. During periods of shortage, a drought or shortage contingency plan can be implemented to reduce demand.

If it is apparent that climatic variations result in significant variations in surface water supplies and/or water quality issues are evident, and/or if the aquifer is in overdraft, the reliability of water supply during a single dry year and multiple dry years should be quantified. Plans to introduce alternative sources or water demand management measures may be applicable to any water supply that is not available at a consistent level of use (taking into account specific legal, environmental, water quality or climatic factors). This creates a basis for developing water efficiency programme goals (see Chapter 5).

Case Study 4 describes Melbourne's experience with responding to vulnerability and variability in water supplies due to a changing climate.

3.6 EFFECT OF WATER-USE EFFICIENCY ON WATER AND WASTEWATER SYSTEMS

Existing water systems are affected by reduced consumption in a variety of ways. A report on the topic, entitled *Impacts of Demand Reduction on Water Utilities*, was prepared. (Weber & Bishop, 1996). The report assessed the impact of water efficiency on a number of utilities in the United States by water source, whether surface water, groundwater, both, or purchased water. The report serves as an example for categorizing the impacts that are described in the following paragraphs.

3.6.1 Lowering water system operating costs and green house gases

Water efficiency will lower pumping energy required to acquire, treat and distribute water. The volumes of chemicals, such as chlorine, used to treat water on a flow basis are reduced. This, in turn, directly reduces operation and maintenance expenses. Table 3.1 shows an example of the average energy use for water delivery in the State of New York, US. The values are based on a survey completed in 2008 for the State of New York, United States of America and include costs for raw water pumping, treatment and finished water distribution. The same source also cites a national average of 370 kwh/ML for the same values, indicating water supply in New York is either more efficient or includes more gravity fed systems than average. Table 3.2 shows similar values with more detail on energy use by system components rom a report done for the State of California Public Utilities Commission. The utility planner can use their planned reduction in water use and from these tables the expected reduction in energy usage for the water system.

Table 3.1 Electric energy use by source water types in the state of New York, US.

Size category, persons served	Groundwater MJ/ML	Purchased water MJ/ML	Surface water MJ/ML
Less than 3000	882	684	1314
3000 to 50,000	972	576	954
50,000 to 100,000	774	NA	774
Greater than 100,000	1008	216	450

Source: New York State Energy Research and Development Authority (2008).

Table 3.2 Range in retail water electric energy intensities in state of California, US.

	MJ/ML		
	Low	High	Mid
Local supply energy intensity defaults			
Local surface water	145	1155	650
Groundwater	863	2785	1824
Brackish desalination	1348	1737	1542
Recycled water	1021	3248	2134
Seawater desalination	13,143	13,143	13,143
Local treatment energy intensity defaults			
Coag, flocc, filtration	42	435	239
Microfiltration	210	684	447
Disinfection (Ozone)	160	259	210
Water distribution energy intensity defaults			
Booster pumps			
Flat terrain	46	57	51
Moderate terrain	43	910	477
Hilly terrain	361	1499	930
Pressure system pumps	343	2447	1395

Source: GEI/Navigant Consulting (2010), Tables 4–6, p. 85.

3.6.2 Downsizing water systems

Demand management may allow new or expanded water facilities to be downsized or postponed, depending on how much impact water flows have on the designed capacity of the facility. Table 3.3 shows typical design criteria for water facilities that may be affected by reduced consumption. Reduction in the average daily water use reduces the amount of water that must be developed, or imported and stored, prior to treatment and use. Consumption reduction in peak day demand reduces the size of treatment plant expansion and amount of treated water storage needed. Water pipelines and pumping stations are designed to accommodate projected future peak hour flow rates. The peak hour flow is dependent on peak hour demands by customers plus required fire flows. The latter is based on the type of land use to be protected. Higher value land uses (such as commercial areas) require higher fire flows. Fire flows are not subject to demand management. The higher the fire flow component of the peak demand is, the less the impact of demand management on pipe sizes. In general, demand management has little impact on pipe sizes within water distribution systems.

Table 3.3 Effect of water efficiency on design criteria for water supply system elements.

System element	**Design criteria based on**			
	Average day consumption	**Peak day consumption**	**Peak hour consumption**	**Fire flow**
Source water acquisition	√			
Raw water storage	√			
Water pipelines			√	√
Water treatment plants		√		
Pumping stations			√	√
Treated water storage		√	√	

Source: Maddaus and Maddaus (2005).

3.6.3 Cost Saving on wastewater system operations

Wastewater systems offer similar operation and maintenance benefits from water-use efficiency improvements to those provided by water supply systems, that is, lower energy and chemical use. Most wastewater collection systems are designed to flow by gravity. Nevertheless, energy is required to lift wastewater into treatment plants and to process the waste. Disposal usually involves pumping treated wastewater to receiving waters or land disposal sites; these costs may be dependent on flow volume. Wastewater is chlorinated at least once during the treatment process, and sometimes de-chlorinated; use of these chemicals is flow dependent. The utility planner should recognize that wastewater treatment is much more energy intensive than water treatment, see Tables 3.4 and 3.5. Water efficiency will reduce the flow but not the waste load. Also primary treatment is much less energy intensive than secondary or tertiary/advanced treatment. The figures shown in Tables 3.4 and 3.5 should probably be reduced for application to water efficiency benefit calculations, depending upon the level of treatment provided and excluded from calculations, if wastewater is either not collected or not treated.

Table 3.4 Comparison electric energy use for facilities providing various levels of treatment for the state of New York, US.

Size category	Secondary treatment MJ/ML	Tertiary/advanced treatment MJ/ML	Percent increase for tertiary/advanced
Less than 3.8 MLD	3240	4896	52
3.8 to 19 MLD	1080	2124	97
19 to 75 MLD	1386	1872	34
75 to 285 MLD	1476	2088	42
Greater than 285 MLD	1008	NA	–

Source: New York State Energy Research and Development Authority (2008).

Table 3.5 Comparison electric energy use for facilities providing various levels of treatment for the state of California, US.

	MJ/ML		
Wastewater energy intensity defaults	**Low**	**High**	**Mid**
Wastewater Collection Pumps	2	433	218
Primary + Secondary	465	1545	1005
Primary + Secondary + Tertiary	1034	4315	2675
Microfiltration (incremental energy)	756	796	776
Reverse Osmosis (incremental energy)	1503	1519	1511
UV (incremental energy)	291	314	303

Source: GEI/Navigant Consulting (2010), Tables 4–6, p. 85.

3.6.4 Downsizing wastewater systems

Table 3.6 demonstrates the impacts of water-use efficiency, with resulting wastewater flow reduction, on the design of new facilities. Major benefits can be realized from disposal systems that are sized on a basis of the total volume to be disposed of (e.g., from a land disposal system). There is less impact on most other wastewater facilities because they are designed to accommodate peak wet weather flow, on which water efficiency improvements have little impact.

System elements	Design criteria basis		
	Average dry weather flow	**Peak wet weather flow**	**Solids loading**
Collection systems		√	
Interceptors		√	
Treatment plants		√	√
Disposal to receiving water		√	
Land disposal	√	√	

Source: Maddaus and Maddaus (2005).

CASE STUDY 3
USAID's Reclaimed Water Reuse for Industry, Agriculture and Landscaping Project, Jordan

CDM-Smith

There are few places where water is scarcer – or more valuable – than in Jordan. With an annual average rainfall of less than 20.3 cm and desert covering more than 75 percent of its area, in 1995, Jordan's demand for water exceeded its supply by 5678 ML/yr.

The USAID-sponsored, CDM Smith-implemented Reuse for Industry, Agriculture and Landscaping (RIAL) project sought to meet Jordan's water use challenges (particularly in the urban setting) and provide models for reuse application that could be replicated throughout Jordan. Addressing the needs of agricultural, industrial, and municipal water use, the project advanced Jordan toward its goal of 100-percent reuse of reclaimed water through practical projects and educational programmes. The project set examples that can be readily duplicated – and that provide immediate benefits, such as $USD millions in cost savings for businesses and new parks for urban citizens' enjoyment.

Four industries – textile, petroleum, beverage and fertilizer – were selected for improvements; these industries represented the major industrial sectors in Jordan. At the representative companies for each of these industries, the project team conducted pollution prevention and water stream efficiency audits, identified deficiencies, recommended and designed solutions to these deficiencies to maximize water use efficiency, assisted in implementing solutions, and disseminated lessons learned – both at these industries and throughout the industrial sector in Jordan.

Figure 3.3 The RIAL project initiated the usage of 'purple pipe' to indicate reclaimed water (above photo shows reclaimed water in urban landscaping activity – part of the RIAL project).

Some of the innovations that were achieved under the project included:

- The creation of the first privately-owned industrial wastewater treatment plant (WWTP), for the effluent reuse of industries at Al Hassan industrial park.
- The design and implementation of several urban landscape projects in Amman and Aqaba, which utilized color-coded (purple) pipes to indicate use of reclaimed water. These projects included training staff, of both the cities and other agencies, on the practices utilized in safe and effective reclaimed water reuse.

- Assistance to the Government of Jordan to standardize the use of purple pipes to indicate reclaimed water.
- Facilitated the creation of the reclaimed water reuse farmers association.
- Created two reclaimed water reuse knowledge centers: one at the Water Authority of Jordan, focused on reclaimed water reuse in agriculture, and one at the Ministry of Environment, focused on pollution prevention and reclaimed water reuse in industry.
- Conducted numerous conferences and workshops on reclaimed water reuse – exchanging knowledge and disseminating best practices.
- Design and implementation of three reclaimed water reuse agricultural demonstration sites:
  - At the Jordan University for Science and Technology, for research and educational purposes;
  - In Wadi Mousa, for farmers' income generation and training; and
  - In Aqaba, for pre-designed experiments and environmental monitoring, where many species of trees and plants were tested for reclaimed water reuse. In addition, underground irrigation was experimented with here, with the goal of maximizing water use efficiency by eliminating evaporation.

In 2008, the RIAL project won an IWA Project Innovation Honor Award in the Global category of Small Projects. While this first phase of the project was completed in 2008, the project is considered so influential that its successes are now being scaled-up in USAID's second phase of the project, which is scheduled to run through 2015.

Figure 3.4 Agricultural crops grown with reclaimed water – a part of the RIAL Project.

CASE STUDY 4
Managing for Changing Climate Conditions: The Experience of Melbourne, Australia 1997–2009

Bruce Rhodes, Melbourne Water, Melbourne, Australia

Note: Parts of this are an extract of a paper prepared and presented at the World Congress on Water and Energy, Dublin, Ireland, May 2012 (see Rhodes *et al.* 2012).

Introduction

Melbourne, the capital city of Victoria, is a city of over 4 million people in south-eastern Australia. Melbourne Water manages Melbourne's water supply system and main transfer network and treats and supplies drinking water to retail water companies and regional water authorities in the Melbourne region. Melbourne Water also removes and treats most of Melbourne's sewage, provides recycled water for non-drinking purposes and manages rivers and creeks and major drainage systems throughout the Port Phillip and Westernport Region. Melbourne Water is wholly owned by the Victorian Government and is governed by an independent Board of Directors. Melbourne Water provides bulk water supply and sewerage to services to three main retail water businesses City West Water, South East Water and Yarra Valley Water along with additional supplies to regional water authorities including Western Water, and Gippsland Water and irrigation supplies to Southern Rural Water.

Until December 2012, Melbourne's water supply was solely reliant on surface water supplies, and system storage capacity of 1,812,175 Megalitres (ML) provided water supply security for long duration drought events. However, between 1997 and 2009 inflows to Melbourne's water storages were 39% lower than the long term average, and remained below the long-term (1913–1996) average until 2011 (see Figure 3.5). Over this period storage volumes dropped from near capacity in late 1996 to a low of 25.6% in June 2009. Research undertaken by the South East Australia Climate Initiative (CSIRO, 2012) highlights a link between global warming and the recent rainfall decline in south east Australia. The experiences of managing through the extended shift in climatic conditions and the research have changed planning assumptions for Melbourne's water supply systems and the long term management and planning of water systems.

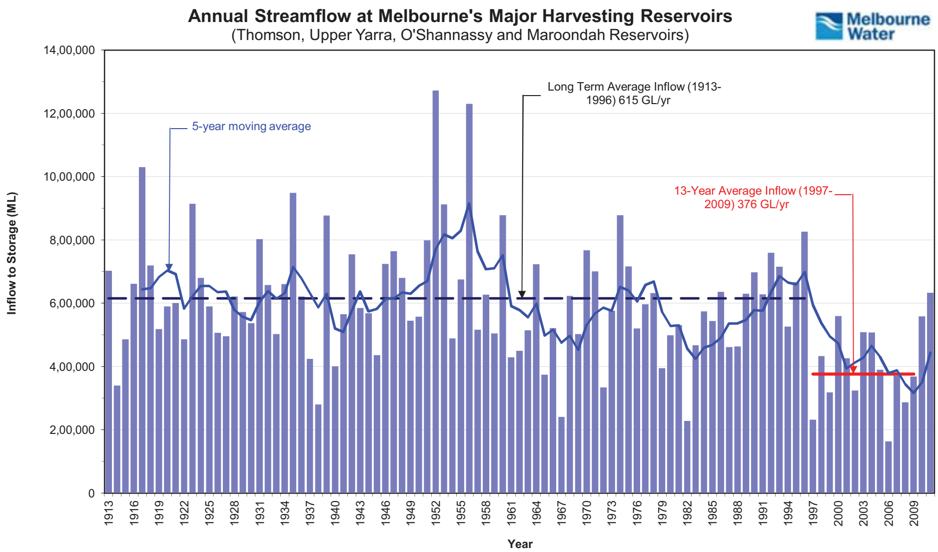


Figure 3.5 Annual streamflow at Melbourne's major water harvesting reservoirs 1913–2011.

The millennium drought

While Australia is known for its arid centre, Melbourne is largely temperate, with its climate dominated by the combined influences of the Pacific Ocean (i.e., El Niño & La Niña), the Indian Ocean and the Southern Ocean. The period 1997 to 2009 was characterised by:

- Average annual runoff rates consistently lower than the long term average.
- Strong El Niño events with lower rainfall during 1997/98, 2002/03 and 2006/07.

- Reductions in autumnal rainfall which impacted on catchment conditions and winter runoff volumes which are normally needed to replenish water storages.

In addition, several other severe climate events occurred over this period including:

- The highest recorded daily temperature of 46.4°C (7 February 2009) corresponding with the Black Saturday bushfires around Melbourne and in its catchments.
- The largest number of consecutive days above 43°C (January 2009).
- Six 1 in 100 year return period storm related urban flood events in the Melbourne area between 2002 and 2009.
- Victoria's wettest summer on record in 2010/11.
- Australia's hottest summer on record in 2012/13, with seven consecutive days (2–8 January 2013) average maximum daily temperature exceeding 39°C.

Between 1997 and 2009, the south east of Australia experiences the most severe rainfall deficit since the start of the 20th century (South Eastern Australian Climate Initiative, 2011). Across the Melbourne catchment area the 1997 to 2009 period was both the longest and the driest on record, highlighting the severity of the event which is referred to as the 'Millennium Drought'. While Melbourne has experienced other severe droughts notably in the 1960s and early 1980s, the severity and duration of the Millennium drought were placed considerable attention on the response and management of the event.

Melbourne's large storage capacity relative to inflow is a characteristic of Australian water supply systems, given the high annual streamflow variability compared to many other locations. The large carry over storage provides for secure supplies during extended dry periods, but security of supply can be compromised in periods when there are no high inflow periods to replenish storages.

During the Millennium Drought period Melbourne's water storages fell from capacity levels in October 1996 to 25.6% (453,227 ML) in June 2009. The Thomson Reservoir, which represents over 60% of total storage capacity and is the main drought reserve, dropped to a low of 16.2% (172,865 ML).

In 2010, the persistent drought conditions ended with the highest catchment rainfall and inflow since 1996. The summer of 2010/11 was wettest recorded in Victoria and resulted in severe floods over much of northern Victoria. It was also first time in Melbourne's history that storage volumes increased over the summer period and by September 2011 storage levels were at the highest point since November 2000.

Climate change and the millennium drought

In 2002 Melbourne Water and CSIRO undertook research on climate change projections for Melbourne's catchments. Included in the key findings of this study (Howe *et al.* 2005) was the expectation of lower average annual rainfall, and reductions in winter/spring rainfall and the potential for higher rainfall intensity during storm events. The reduction in mean streamflow for a severe climate change scenario was projected to fall by around 35% by the year 2050. In comparison, the observed 39% flow reductions have been more severe than those anticipated to occur under the severe 2050 climate change scenario, and bought into question the influence of climate change and variability in the severity and extent of the drought.

Hydrological analysis of the streamflow records available from 1913 showed the streamflow recorded at the main reservoirs for the period 1997–2006 was more severe than a 1 in 500-year return period (Tan & Rhodes, 2008). This was consistent with research undertaken for Murray Darling Basin, north of Melbourne's catchments, which showed that there is a 97.1% probability that the decadal rainfall recorded in 1998–2008 over the Murray Darling Basin (MDB) was the lowest since European settlement in Australia (Gergis *et al.* 2012). The corresponding streamflow deficit for the MDB was estimated to be around a 1 in 1500-year return period (Gallant & Gergis, 2011).

A major research initiative was undertaken into the causes and nature of climate variability and change in South Eastern Australia (South East Australia Climate Initiative (SEACI) http://www.seaci.org/) has shown a strong relationship between the rainfall decline in south-eastern Australia and the rise in intensity of the Sub Tropical Ridge (STR), the area of high pressure systems over the region. This strengthening of the STR is estimated to account for around 80% of the rainfall decline in south-eastern Australia. The STR has intensified with the increasing global surface temperatures and implies that the rainfall decline may have some link to global warming (CSIRO, 2012).

The research (CSIRO, 2012) also highlights that:

- The characteristics of the Millennium drought were 'outside' what would be expected based on natural variability as characterised by the instrumental record, and raises the possibility that there may have been a shift in the climate 'baseline'.
- Water resource managers need to ensure that their planning and management processes are robust and adaptive across a wide range of future climate and streamflow scenarios and are subject to regular review.

The backdrop of the experiences of the Millennium Drought, and the overlay of the research into the cause and nature have changed Melbourne's water management and planning directions and is discussed below.

Water conservation

As a result of falling water storages levels and continued low rainfall conditions Melbourne's water businesses and the Victorian Government water carried out a range of activities to increase water supplies and to reduce water demand. These activities were supported by an extensive range of community engagement, education and advertising programmes and were the most comprehensive and thorough water conservation programme implemented since the 1980s. Activities included:

- The introduction of new Permanent Water Savings Rules (State Government Victoria 2011) also provides a common sense set of rules for maintaining water use efficiency and includes the use of automatic watering systems only between the hours of 6 p.m. and 10 a.m.
- Mandatory water use restrictions (mainly affecting external water use). The Melbourne Drought Response Plan was first implemented between 2002 and 2005 and was continued between 2006 and 2012. The Drought Response Plan (DRP) provided the formal process for the introduction of a four stage water restriction policy across the metropolitan and surrounding areas. Details of the Drought Response Plan and water restriction schedules are available on each of the water company websites for City West Water, South East Water, Yarra Valley Water and Western Water.
- Reviews of water restriction schedules within the Drought Response Plan to accommodate variations required to reduce impacts such as on sports grounds.
- Domestic water use target campaign of 155 lcd at the height of the drought (Fitzgerald, 2009).
- Individual behaviour change programmes to demonstrate to people how to save water in homes.
- Specific business initiatives that engage key business stakeholders in water conservation programmes, such as cooling towers, non-domestic laundries, tennis clubs and workplace water conservation. The majority of the work in the non-domestic sector focussed on Melbourne's major water users with focus also given to open space, garden nurseries and so on, as these sectors were most impacted by water restriction schedules which impacted on outdoor water use.

- Low flow shower head exchange programmes. For example between 2006 and 2009 over 300,000 low flow shower roses were distributed by the retail water companies with an estimated net saving of over 3600 ML/yr (Rhodes, 2009).
- Industry programmes. This included Water Management Action Plans for all water users with greater than 10 ML/yr water usage.
- Supporting research studies to invest in innovative water conservation solutions.
- Government supported rebate programmes for water conservation items including rain water tanks, grey water systems, showerheads, and domestic water conservation audits.
- Public reporting of water storage and water use through websites, signage and regular media reporting including; weekly reporting of storage levels and water use during television news services.

These activities contributed to a considerable shift in water demand in Melbourne. Total water consumption fell from 423 litres/capita/day (lcd) in the 1990s to less than 240 lcd in recent years from 2010 to 2012 (i.e., a 44% reduction in per capita use), while domestic water consumption remained low at less than 160 lcd in 2012 under Stage 1 restrictions. Water savings over the period November 2002 to July 2011 were estimated to be in excess of 785,000 ML which is equivalent to about two years of restricted water demand and 43% of total storage capacity. The extended period of the Millennium drought combined with the focus on water conservation and efficiency has also meant that when water restrictions were eased in December 2012 and Permanent Water Savings Rules only applied, that per capita rates remained at levels lower than when restrictions were first introduced in 2002.

In addition to the water conservation initiatives a range of water supply activities were introduced, including:

- Diversification of supplies and introduction of non-climate dependent sources through construction of a 150,000 ML/yr desalination plant.
- Construction of an inter-basin transfer pipeline which can provide up to 75,000 ML/yr during periods of critical need.
- Increasing the operational range of reservoirs to access water at lower storage levels.
- Temporary revision of environmental flow obligations to enable additional water harvesting while monitoring and maintaining environmental health.
- Increased focus on Integrated Water Management (IWM) with greater integration of water recycling and stormwater harvesting into new developments to further supplement and diversify supplies (DSE, 2012).

Directions

Managing the shift in climate condition and for future climate and population uncertainty poses many challenges. During the millennium drought a combination of demand and supply side initiatives were implemented to maintain secure supplies. However a range of new directions are being implemented to further improve climate resiliency and support liveability objectives, including:

- Increased attention to Integrated Water Cycle Management, including water efficiency, water recycling and stormwater harvesting to provide source diversity and localized solutions and hence more resilient supplies while enhancing liveability. The Office of Living Victoria (http://www.livingvictoria.vic.gov.au/olv.html) has been established to drive coordination of urban wand water planning with an immediate focus on integrated water cycle planning, including the coordination and facilitation of the development for Integrated Water Cycle Plans for Melbourne's growth areas and inner Melbourne and examination of building controls to improve the water performance of new buildings, and the provision of water services through localised solutions (State Government Victoria, 2013).

- Improving decision support models to support Integrated Water Cycle Management across a range of spatial and temporal scales including local and decentralised water supply options.
- The shift in planning based on reliable streamflow and hydrologic stationarity (see Milly *et al.* 2008) to the introduction of a range of climate change scenarios drawn from downscaled climate change projections and observed 1997–2009 dry scenarios. These include scenarios drawn from climate projections for ‘wet’, ‘median’ and ‘dry’ climate conditions and include scenarios based on continuation of the hydrologic conditions observed between 1997 and 2009.
- An increased focus on optimisation of bulk water resources and environmental flows given the system augmentation and the need to balance long and short term costs and supply reliability. Multi Objective Genetic Algorithm (MOGA) optimisation methods supported by Multi-criteria Decision Analysis (MCDA) have been developed to support decisions to optimise cost and security of supply between multiple surface water sources and the more costly desalination sources (Kularathna *et al.* 2011).
- Development of an active adaptive water outlook and drought management and response processes (Melbourne Water, 2012).
- Maintaining a focus on climate change in the context of a variable climate, including; developing robust risk management methods, frameworks and tools to support climate adaptation and developing methods to integrate climate change with other uncertainties, such as population growth, demographic change and water use behaviour, while also balancing social, economic and environmental considerations.

Conclusion

The Millennium drought across South Eastern Australia highlighted the vulnerability of Melbourne’s surface water resources to rapid and severe climate-driven hydrological changes. Responses included diversification and augmentation of supplies including; an increased focus on Integrated Water Cycle Management, ongoing water conservation, a change in planning assumptions, the introduction of annual water outlook, climate change risk assessment and adaptation action planning.

Chapter 4

Assessing Current and Future Water Demands

A detailed understanding of current water use and an accurate forecast of future water demand are essential for making decisions about the nature and scope of a water conservation programme. In order to estimate water savings from potential conservation measures, water-use characteristics such as seasonal usage patterns and per capita use values can be evaluated based on the quality of data available. This chapter explains how to evaluate current water use and provides two methods for forecasting water use.

4.1 EVALUATING CURRENT WATER USE

Assessing current water use involves determining the characteristics of the water service area and defining current water use by type of demand.

4.1.1 Describing the service area

Table 4.1 can be used as a worksheet to characterize the water service area in ways that are useful to forecasting water use. The table includes sample numbers in order to demonstrate methodology. Population projections are usually available from local governments and/or regional planning agencies. Employment projections (i.e., the number of jobs and not employed residents) are usually available from the same planning agencies or from transportation planning agencies. Because transportation agencies forecast trips from home to work, they may have useful databases on the location and number of current and future jobs. A forecast of 20–30 years is usually adequate for water-use efficiency planning. Longer range demand forecasts may be useful for analyzing climate change scenarios.

4.1.2 Describing water use

Table 4.2 presents a worksheet that can be used to characterize existing water use. Sample numbers are shown in order to demonstrate the methods. Characterization includes:

(a) Average annual water production, which is the current total amount of water produced or withdrawn from a source and imported or pumped into the service area. If growth in water use has been low, the amount of water produced over the previous few years can be averaged; if not, water-use data for the last complete year on record should be used;

Table 4.1 An example of service area description.

Service area characteristic	Value
Current population (persons)	100,000
Future population (persons)	
In 5 years	110,000
In 10 years	120,000
In 20 years	135,000
Current number of domestic service connections	
Single-family	20,000
Multi-family	5,000
Total	25,000
Current number of non-domestic connections	
Commercial	3,000
Industrial	500
Institutional (public)	500
Total	4,000
Current employment (number of jobs)	60,000
Future employment (number of jobs)	
In 5 years	70,000
In 10 years	80,000
In 20 years	100,000

(b) Estimation of unmetered water use. If the water comes from a pumped source, use the following formula:

$$\text{Pumping volume} = \text{Pumping rate} \times \text{time of operation}$$

The time of operation can be estimated from the electricity meter readings.

(c) Water losses, which can be estimated by conducting a system water audit. Chapter 6 describes the assessment of water losses. The value entered in Table 4.2 should be the amount of water for which customers are not billed, whether or not it is metered. The water losses can be less than 10 percent in a relatively new, well-managed system, but more than 50 percent in a poorly-maintained or older system;

(d) Peak day ratio, which is the volume of the water produced on the day of highest water use divided by the amount of the water used on an average day (annual water use in million litres/365 days). Alternatively, the peak month ratio can be computed from production and/or billing data:

$$\text{Peak Day Ratio} = \frac{\text{Maximum Day Production}}{\text{Annual Average Daily Production}}$$

Table 4.2 An example of water use description.

Water-use characteristic	Value
Average annual water production	18,250 ML/yr
	50 MLD
Extent of metering	
Domestic	90 percent
Non-domestic	100 percent
Estimated unmetered use	2 MLD
Total metered water use	38 MLD
Water losses	10 MLD
as a share of water production	20 percent
Peak day water use	70 MLD
Peak day water use to average day water use ratio	1.4
Estimated seasonal use	
Month with lowest demand	February
Average demand in month with lowest demand	40 MLD
Non-seasonal water use	80 percent
Seasonal use	20 percent
Average water use by customer category	
Single-family domestic	15 MLD
Multi-family domestic	5 MLD
Commercial	10 MLD
Industrial	7.5 MLD
Institutional (public)	2.5 MLD
Water losses	10 MLD
Total	50 MLD
System supply safe yield	80 MLD
System capacity	60 MLD

(e) Estimated seasonal water use, which is the amount of water use that exceeds interior use. Interior or indoor water use is generally taken to be the lowest monthly (2 months if bimonthly billing cycle) water use pro-rated over a year. The formula for calculating seasonal use based on billing cycle, which is typically associated with outdoor use such as landscape (garden) watering, is:

$$\text{Seasonal water use percentage (Monthly)} = \frac{\text{Lowest month water use} \times 12 \times 100\,\text{percent}}{\text{Average annual water use}}$$

$$\text{Seasonal water use percentage} = \frac{\text{Lowest consecutive 2} - \text{month water use} \times 6 \times 100\ \text{percent}}{\text{Average annual water use}}$$

(f) Average water use by customer class. This information may or may not be available from customer billing records. Depending upon the categories used by the utility, complete Table 4.2 by expressing the results in million litres per day (MLD). In some cases, water-use data are only available in terms of meter size. The smallest meters are usually reserved for single-family homes (and some small businesses). Larger meters are used in apartment complexes, commercial establishments, schools and industries. Meter-size data can normally be utilized to categorize water use into domestic and non-domestic, unless multi-family units are the predominant type of domestic dwelling.

(g) Checking the accuracy of data. The following guidelines can be used to evaluate the distribution of water use for piped water systems:
   (i) Interior per capita domestic water use may be between 50 and 200 L per capita per day (lcd); per capita use is commonly higher in a single-family dwelling than in a multi-family unit;
   (ii) Exterior or outdoor per capita domestic water use varies from a small value (10–30 lcd) in multi-family buildings to an always larger value in single-family buildings (40–80 lcd);
   (iii) Commercial water use per employee can vary considerably but is often comparable to per capita interior domestic water use. However, it is expressed on a litre per employee/day (led) basis.

4.1.3 Analysing historical water use

In addition to completing Table 4.2, fluctuations in water use over the previous 3–5 years or an even longer period should be analysed. Changes occur in water use due to:

(a) Growth (or decline) in water accounts, industrial production or dwelling units of the population served;
(b) Number, value, and type of housing units that are constructed;
(c) Condition or health of the economy (unemployment rate);
(d) Cost of water supply;
(e) Climatic and weather conditions; and/or
(f) Conservation activities.

If historical annual water production, population, water accounts and rainfall are available for past years, then a trend graph can be constructed as presented in Figure 4.1. Population in the United States historically trended closely with production, which increased until the 1970s when water conservation technologies improved (i.e., lower volume for flushing toilets) and regulations were adopted. In California, three historic droughts were also experienced where restrictions drastically cut demand and then water use patterns returned to normal, though not a 100% return to levels observed prior to the droughts.

If monthly or bi-monthly water-use data are available, those data should be recorded on a table or spreadsheet, and a chart of water use versus time should be prepared. Next, divide total monthly water use by the number of accounts billed for each month. This will represent water use by a typical customer and show changes over time due to growth, climate (weather), water-use efficiency programmes or other reasons. Figure 4.2 provides an example of the seasonal fluctuations of water use by an average single-family dwelling in the United States in an area with a humid climate. Note that the water use almost doubles between the wet and dry seasons. A 12-month moving average (the average of the prior 12 months, computed each month) will show water-use trends.

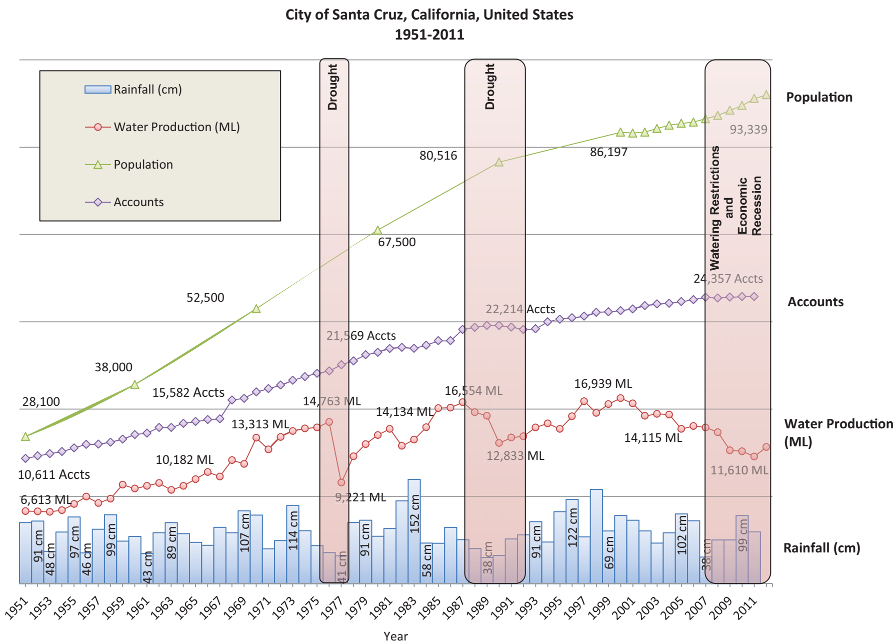


Figure 4.1 Historical annual water use in Santa Cruz, California, United States. *Source*: Personal communication with Toby Goddard (2013).

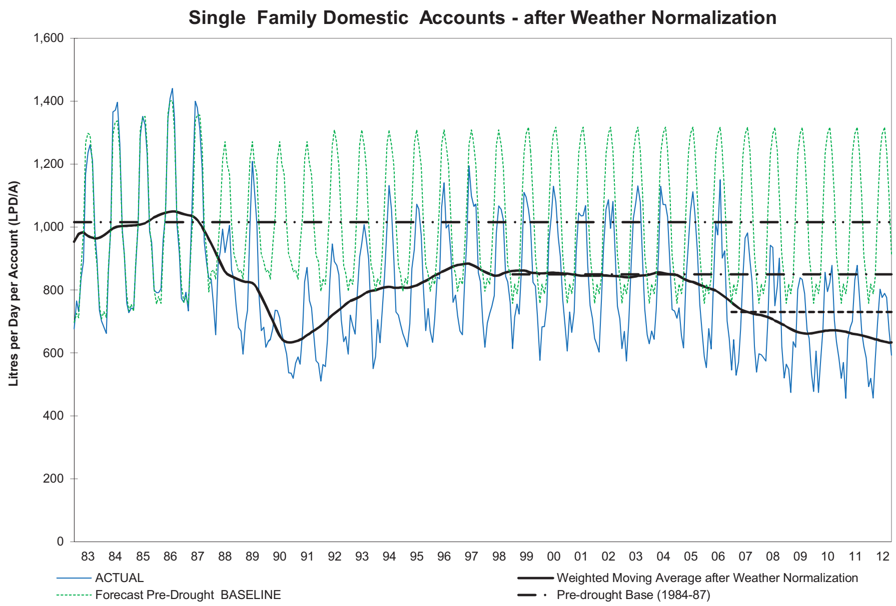


Figure 4.2 Seasonal water use by single-family residences in Santa Cruz, California, United States. *Source*: Personal communication with Toby Goddard (2013).

4.2 FORECASTING FUTURE WATER DEMAND

In addition to assessing current water use, a detailed forecast of water needs is crucial to proper planning and the evaluation of whether conservation will be beneficial in meeting part of the future demand. There are many reasons why water use can increase or decrease. The principal reasons include:

(a) Growth in population;
(b) Migration away from the service area;
(c) Declining household size or increases in the number of households;
(d) Increased or decreased employment;
(e) Increased or decreased industrial production;
(f) Economic growth or downturn; and/or
(g) Increased or decreased personal income.

Water use can also decrease, or increase at a slower rate, due to changes in the relative numbers of different types of customers (e.g., new homes with more or less irrigated landscaping) increasing numbers of persons living in a typical house, and conservation activities such as more water-efficient fixtures and appliances. For example, constructing more multi-family building units versus single-family homes will result in future population growth with lower water-use patterns, lower per capita demand and lower per account water use. Multi-family homes typically use less water than single family dwellings.

Figure 4.3 presents an example water demand forecast with and without effects of the United States plumbing code for a community in California with an estimated population growth of 183,100 in 2010 to 212,000 in 2035.

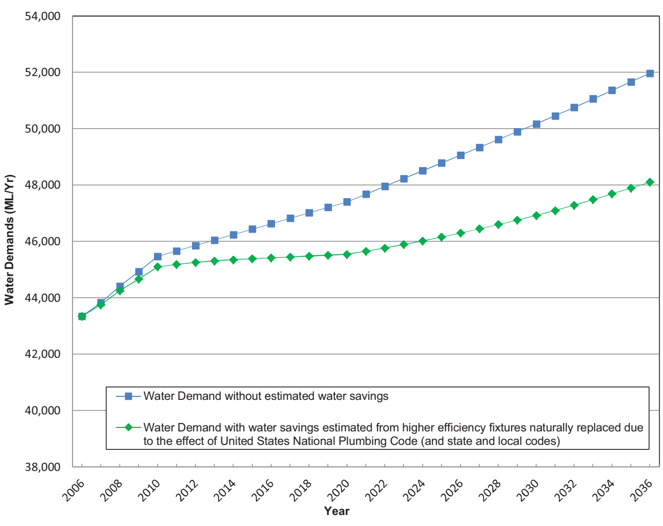


Figure 4.3 Example water demand forecast with and without water savings from United States plumbing codes. *Adapted from*: Maddaus Water Management (2011).

Two methods for forecasting water use, total per capita use and water use per account, are presented in Table 4.3. Other more sophisticated methods are available but the second method described here is usually adequate for conservation planning purposes. Table 4.3 includes the extension of the sample data given in Tables 4.1 and 4.3 in order to demonstrate the two methods.

Table 4.3 An example of forecasting future water demand.

Methods/parameters		Value
Method 1: Per Capita Water Use		
Average annual water use (production)		50 MLD
Current population served (persons)		100,000
Current per capita use		500 lcd
Population	In 5 years	110,000
	In 10 years	120,000
	In 20 years	135,000
Future water use	In 5 years	55 MLD
	In 10 years	60 MLD
	In 20 years	**67.5 MLD**
Peak day ratio		1.4
Peak day usage in 20 years		94.5 MLD
Method 2: Projection by Customer Class		
Step 1: Develop unit water use values		
Domestic	Total use	20 MLD
	Population (persons)	100,000
	Per capita use	200 lcd
Non-domestic use	Total use	20 MLD
	No. of employees (jobs)	60,000
	Per employee use	333 led
Step 2: Project future use		
Domestic		
Future population	In 5 years	110,000
	In 10 years	120,000
	In 20 years	135,000
Future domestic water use	In 5 years	22 MLD
	In 10 years	24 MLD
	In 20 years	27 MLD
Non-domestic use		
Future employment	In 5 years	70,000
	In 10 years	80,000
	In 20 years	100,000
Future non-domestic use	In 5 years	23.3 MLD
	In 10 years	26.6 MLD
	In 20 years	33.3 MLD

(*Continued*)

Table 4.3 An example of forecasting future water demand (*Continued*).

Methods/parameters		Value
Total future water use	In 5 years	45.3 MLD
	In 10 years	50.6 MLD
	In 20 years	60.3 MLD
Water losses in 20 years (as the current level)		20 percent 15.1 MLD
Total future water use in 20 years		**75.4 MLD**
Peak day ratio		1.4
Peak day usage in 20 years		105.6 MLD

4.2.1 Method 1 – total per capita water use

The simplest forecasting method assumes that growth in total water production will be directly proportional to population growth and that per capita water use will not change in the future. It directly links future demand to future population as:

$$\text{Future water use (MLD)} = \text{Current per capita water use (lcd)} \times \text{future population}$$

The experience of Singapore with declining per capita use is presented in Case Study 5. A projected future decline in per capita use may be considered when reviewing water demand forecasts. It is not customary to use a planned declined in per capita, and most common to use the current per capita demand for a baseline without conservation forecast. But as is shown in Figure 4.4 conservation impacts on demand can be factored in at the end of the planning process.

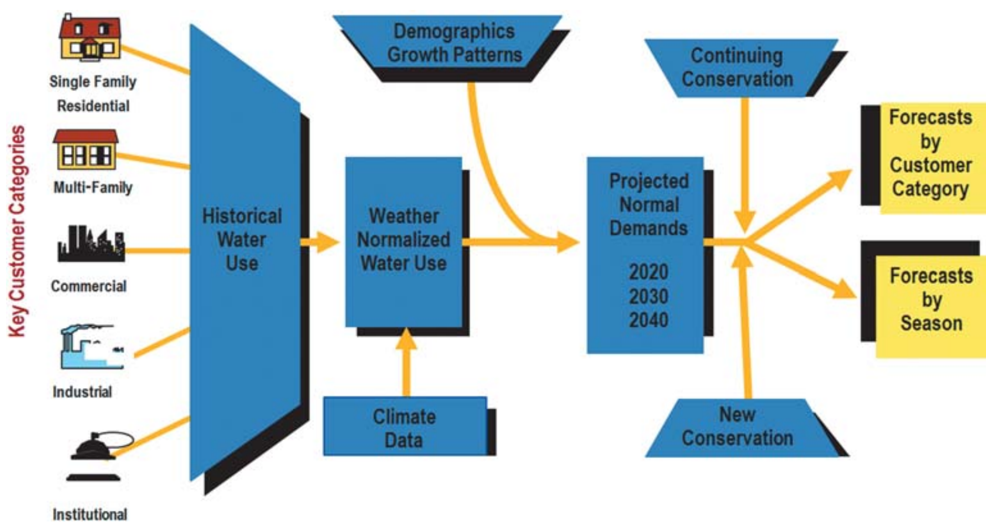


Figure 4.4 Overview of water-use projection process. *Source*: Maddaus, W. and Maddaus, L. (2006).

4.2.2 Method 2 – projection by customer class

Figure 4.4 gives an overview of demand forecasting by category of use. This method allows for different growth rates in different water-use categories. For example, if employment is growing faster than population, non-domestic water use may grow faster than domestic water use. This method is more sensitive than method 1; however, it does assume that per account water use does not change over time.

The second part of Table 4.3 can be used as a worksheet to develop a forecast by customer category. Per capita and per employee water-use values are developed for domestic and non-domestic use. If data are available for additional classes, such as single-family homes and multi-family dwellings, additional details can be included.

$$\text{Projected future water use by class} = \text{Use factor} \times \text{future population or employment}$$

The amount of water loss is added to total use by all the categories in order to find the total amount of water needed to be produced in future years. Water use can be further subdivided into interior use and exterior use (using seasonal distribution), which is helpful in analysing the water savings potential. Peak day use can be computed by applying the overall peak day factor, which is helpful to understanding the need for new or expanded water treatment facilities that apply peak day water use as a design criteria.

As illustrated in Table 4.3, where employment is growing faster than population, method 2 results in a significantly higher projected water use after 20 years than in method 1, that is, 75.4 MLD compared with 67.5 MLD. The difference in peak day use is even greater. Hence, method 2 is preferable where the data required to complete calculations are available.

4.3 USE OF DEMAND FORECASTS IN DEMAND MANAGEMENT PLANNING

The use of demand forecasts in demand management planning has been explained in this chapter. Such a forecast is needed in order to:

(a) Establish a baseline forecast – 'the no conservation case' to measure conservation performance against potential savings;
(b) Estimate water savings based on customer class projections separated into indoor and outdoor use (see Chapter 6);
(c) Estimate possible opportunities for capital project deferral or downsizing, using the 'with conservation' forecast (see Chapter 7).

CASE STUDY 5
Singapore's Water Demand Management Programme

Wai Cheng Wong, PUB, Singapore's national water agency

Increasing Water Demand

Water demand in Singapore is currently about 818 million litres a day (MLD), with domestic water consumption accounting for about 45% of total water use, while non-domestic consumption accounts for the remaining 55%. By 2060, total demand could almost double, with 70% coming from the non-domestic sector.

Water Demand Management

Through the Four National Taps, PUB has put in place a robust and sustainable water supply for Singapore. However, installing the infrastructure to supply water is only one half of the equation. As the population and economy continue to grow, Singapore needs to ensure that the demand for water does not rise at an unsustainable rate.

To achieve this, PUB is working with the community to change consumption habits. PUB endeavours to do this through a multi-pronged approach: pricing water correctly, facilitating programmes to encourage water conservation practices, and mandating standards for efficiency in water usage and related water fittings and appliances.

PUB has successfully reduced the per capita domestic water consumption from 165 L per day in 2003 to 152 L per day in 2012. PUB targets to further reduce per capita domestic water consumption to 147 L per day by 2020 and 140 L per day by 2030 as presented in Figure 4.5.

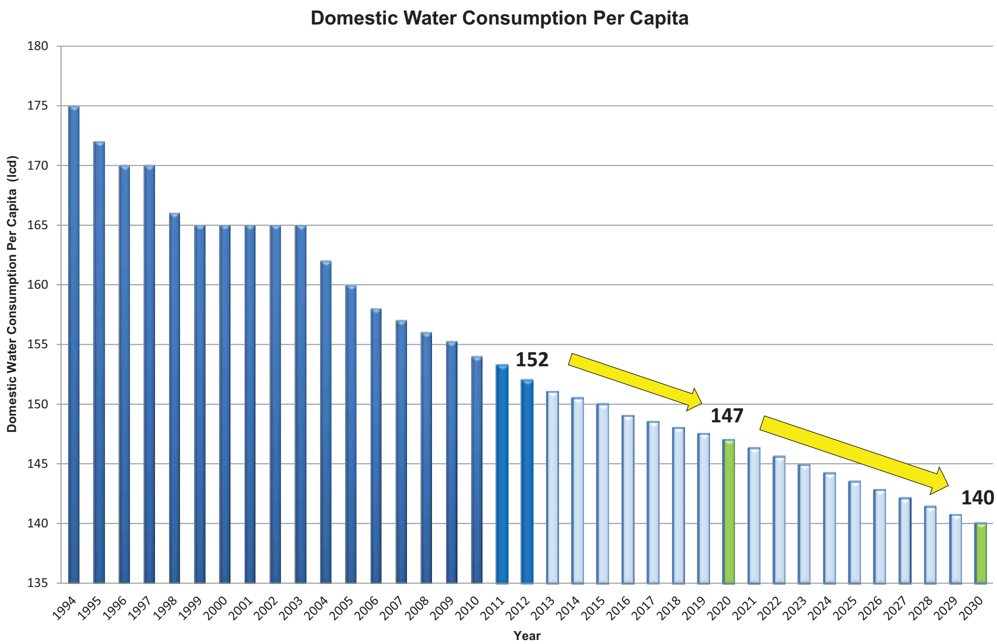


Figure 4.5 Historical and future projections of Per-capita consumption (Litres per capita per day). *Source*: PUB, Singapore's national water agency, (2013).

PUB also recognises that an efficient management of the transmission and distribution system from the water source to the customer tap is also important to minimise unnecessary loss of water or non-revenue water. This is achieved through an integrated water network management that emphasizes the use of good quality systems, active leak controls, accurate metering practices, strict legislation on illegal draw-offs and prompt response to customer feedback.

Chapter 5

Developing Water Use Efficiency Goals

In order to focus the programme design during the water efficiency planning process, it's imperative to have clear and concise goals for the programme. This chapter will review defining the overall water efficiency goals, developing a detailed profile of how customers have used water in recent years to assess additional conservation potential, and organize a database of past demand management activities. This chapter concludes with setting new goals for demand management as a supply alternative and involving the public in the goal setting process.

5.1 FRAME WATER USE EFFICIENCY NEEDS

Every utility through stewardship of its resources should strive for maximum practical water use efficiency. What is practical for a utility to implement varies. Common scenarios found may include:

- *High need*: identified where water is most scarce or supply is most vulnerable; limited service to population to be served in the near or long term;
- *Modest need*: where water service is of sufficient quantity and quality; or
- *Lesser need*: where water supply is in overabundance and population is migrating away from the area.

Before setting goals, planners need to:

- assess current water use by customers to the extent feasible and practical using available data and/or collecting new data;
- quantify the existing efforts by the utility based on evaluation of current demand management measures; and
- define new opportunities to meet unmet demands through other sources of supply.

Chapters 3 and 4 have defined water supply to utilities and demand characteristics. This information should aid planners in answering the questions posed in this chapter, which are aimed at establishing water-use efficiency goals. An overview of key supply and demand questions, which frame the discussion about goals and reasons for implementing water use efficiency programmes, are presented below.

5.1.1 Supply

- If you have a current or future projected water supply shortage or underserved population, is it limited to one part of the service area, or is it a system-wide shortage?
- Is the supply shortage primarily short-term (drought or an emergency shortage) or long-term (more than one year)? (Long-term shortages are the focus of this Guide.)
- Does the shortage exist or is it projected to occur in the future?
- What is the primary cause of the long-term supply shortage? Possibilities could include system leaks, inadequate water rights, pipeline delivery limitations, and inadequate water supply or treatment plant limitations.
- Does the supply shortage occur during peak demand periods each day, during the high-water use seasons of the year, or throughout the year?

5.1.2 Demand

- What type of demand reduction is estimated to have been achieved in the past?
- What quantity of real water losses may be recoverable (as a percent of total system input volume, also known as total production)?
- How much demand reduction might still be achievable from existing customers (retrofits) and new customers (new buildings)?
- What level of water-use reduction is needed? Typically, a reduction of 1 to 10 percent could be considered small, while 10 to 20 percent could be considered as medium, and 20 percent or more as large.
- When is the reduction needed?
- Is the need to reduce water use motivated by government regulations or in response to public or environmental concerns?
- What type of users (single family, multi-family, commercial, etc.) will be most affected?
- What categories of water use (domestic or non-domestic or irrigation) are growing the fastest?

5.2 ASSESSMENT OF WATER SAVINGS POTENTIAL FOR CUSTOMERS

Prior to assessing water-use efficiency methods for customers or setting goals, it is important to develop an understanding of how customers use water. Customer water-use patterns can be evaluated by analysing water billing records and seasonal patterns of use.

5.2.1 Assess water usage by customer category

Based on information extracted from water billing databases, pie charts of water usage by customer category can be developed (Figures 5.1–5.4). Domestic use could account for 60 to 70 percent of total consumption as shown by Figure 5.2, which represents water usage in a city of approximately 100,000 persons in Australia. Figure 5.2 is a demonstration of the usefulness of displaying data in this manner, which facilitates focusing water-use efficiency efforts on the largest sectors.

5.2.2 Estimate end uses

It is important to understand the end-use (i.e., use at the fixture, appliance) breakdown of demand in the domestic category as this category normally represents the highest consumption in urbanised areas. Figure 5.1 illustrates an end use breakdown for domestic customers in France.

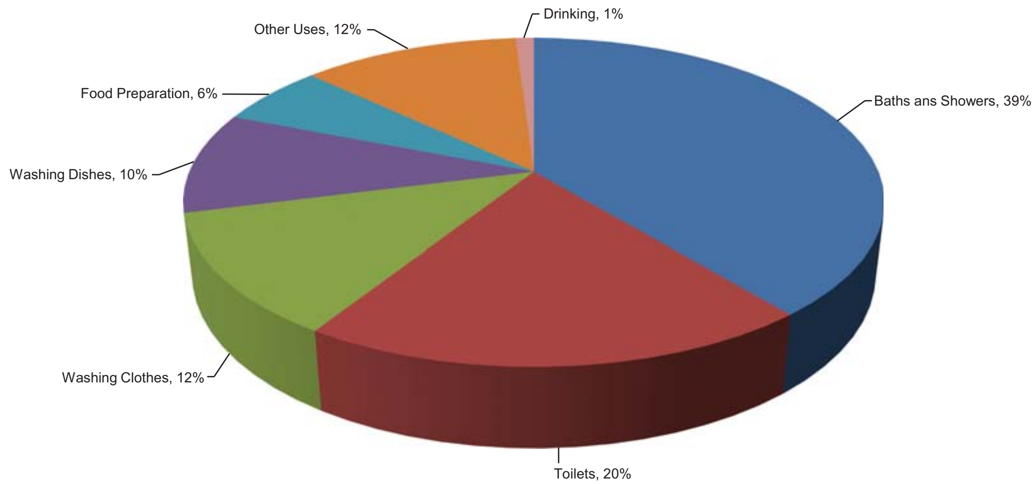


Figure 5.1 Domestic water consumption in France by usage category. *Source*: Personal communication, Bruno Nguyen, (2013) and review of information provided by Centre d'Information sur l'Eau (CIEAU) (2013).

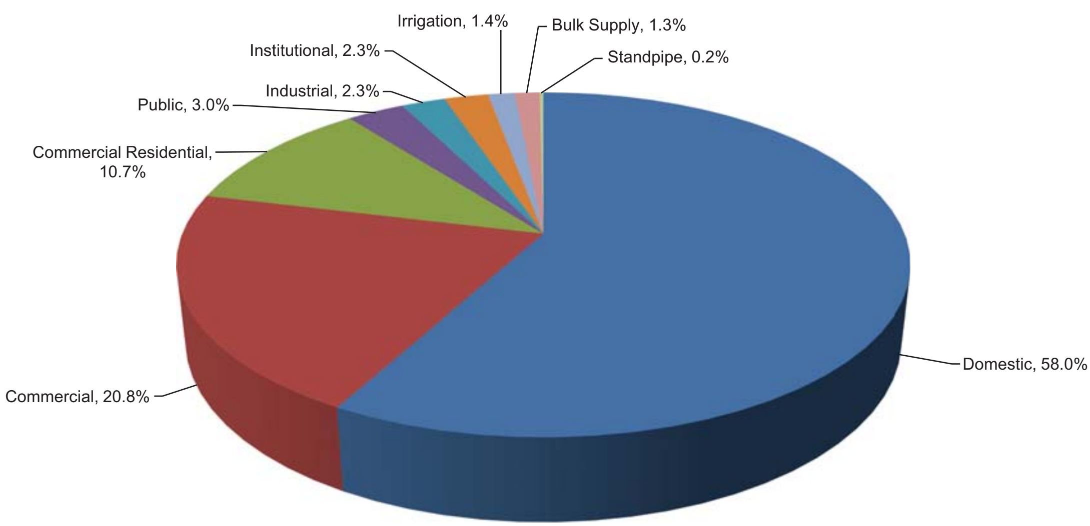


Figure 5.2 Annual water consumption by consumer category in Coffs Harbour, Australia. *Source*: Montgomery Watson Harza (2000).

Figures 5.3 and 5.4 provide a typical breakdown of domestic indoor and outdoor water uses. Figure 5.3 represents a typical water-use pattern for a middle-class family residing in a separate house, while Figure 5.4 shows a typical water-use pattern in a family residing in a separate house with a large irrigated garden.

The actual water use averages are normally expressed in terms of litres/connection/day. This information is used in calculating the costs and benefits of various water efficiency efforts.

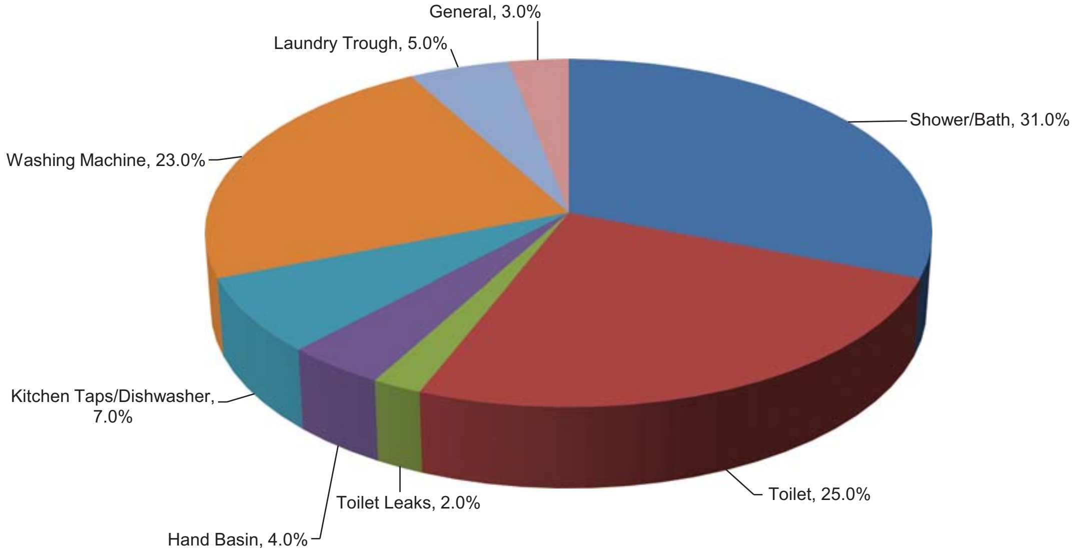


Figure 5.3 An example of domestic indoor water consumption in Australia. *Source*: Montgomery Watson Harza (2000).

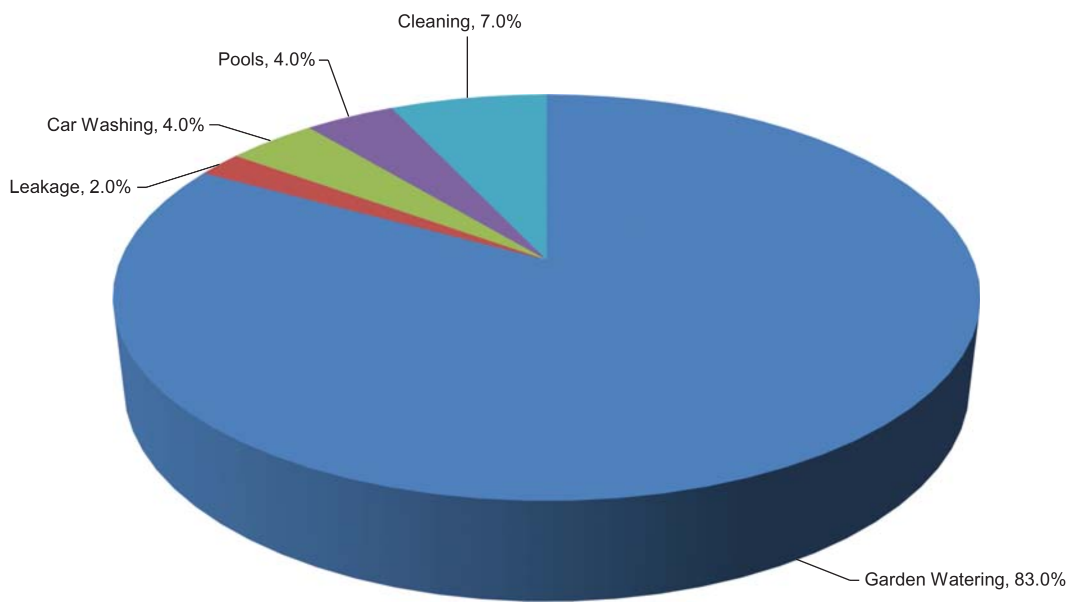


Figure 5.4 An example of domestic outdoor water consumption in Australia. *Source*: Montgomery Watson Harza (2000).

Care should be taken to use data from normal weather periods and a normal economy. Data collected from drought periods (including when watering restrictions were in place) or abnormally wet periods or during recessions should be avoided. If such data must be used then the data could be weather normalized and normalized with respect to economic variables, such as the unemployment rate, if temporarily high.

The following Figures 5.5–5.8 illustrate typical uses for common commercial customers in Singapore.

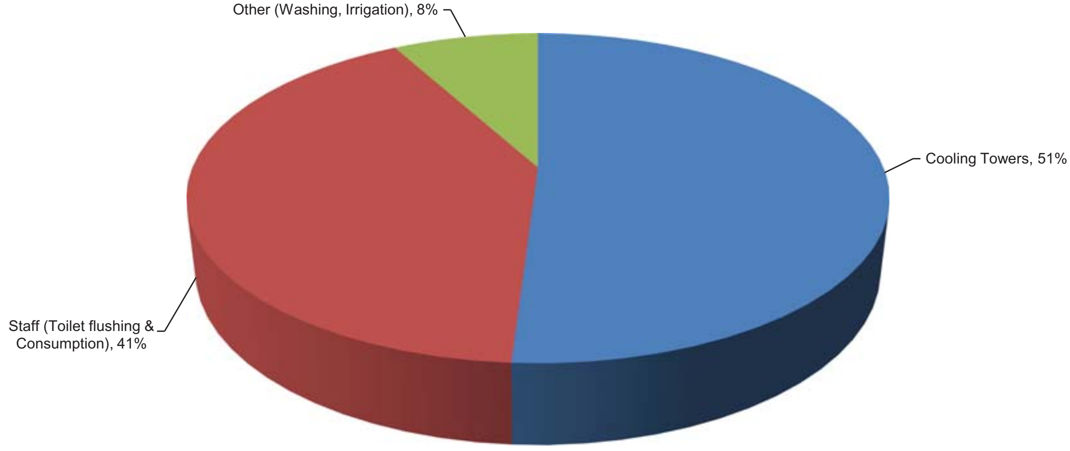


Figure 5.5 Example end uses for a commercial office building in Singapore, 2013. *Source*: PUB, Singapore's national water agency (2013).

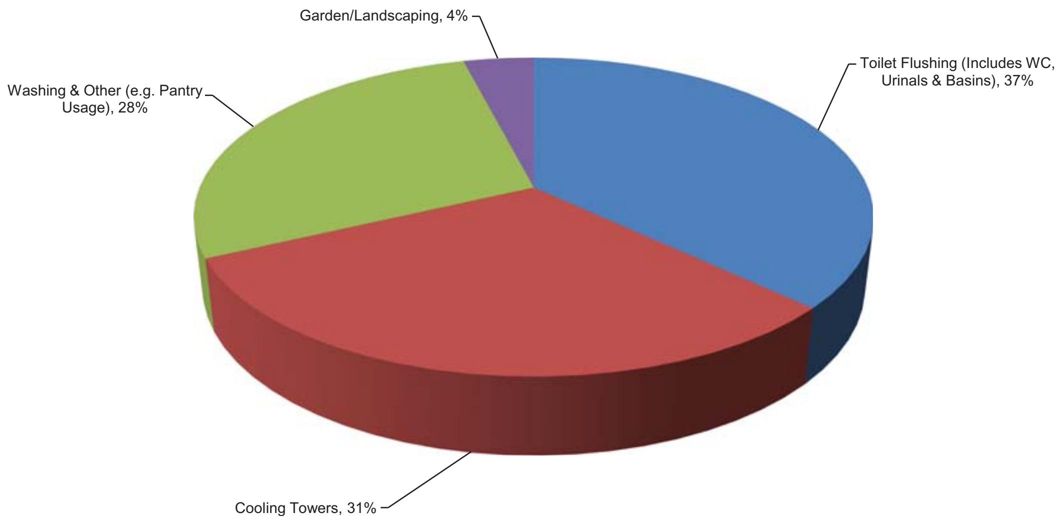


Figure 5.6 Example end uses for a Government office building in Singapore, 2013. *Source*: PUB, Singapore's national water agency (2013).

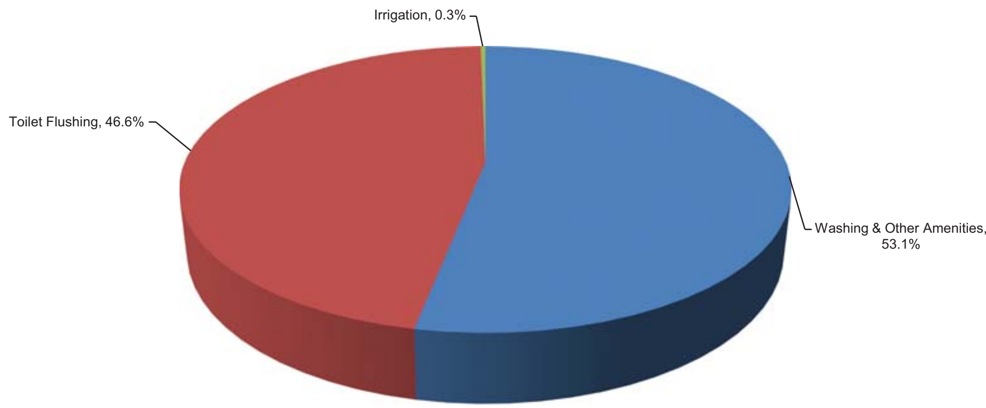


Figure 5.7 Example end uses for typical schools in Singapore, 2013. *Source*: PUB, Singapore's national water agency (2013).

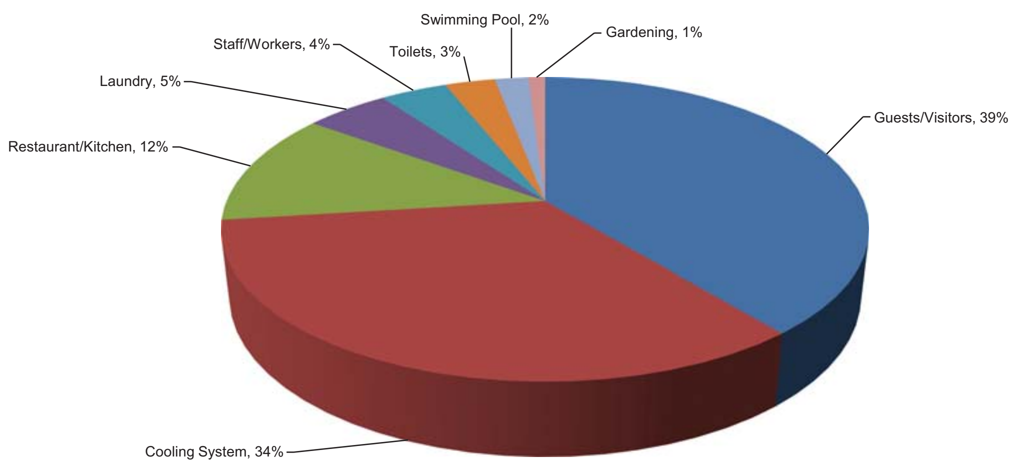


Figure 5.8 Example end uses for a hotel in Singapore in 2013. *Source*: PUB, Singapore's national water agency (2013).

5.2.3 Understanding water using behaviours to focus efficiency efforts

The efficiency effort needs to be focused in those areas where significant improvements can be made. Since it is not cost-effective to address all areas in which efficiency could possibly be implemented, only the largest customer categories and end uses within those categories are typically cost effective to be targeted. Alternatively, planners may target end uses that are more easily reduced (e.g., by the installation of new water efficient technology, or reduction of water losses). Appendix 3 lists potential efficiency measures adapted from the United States.

Water use behaviours have cultural and socioeconomic influences. An 'end use study' is useful to understanding how customers are using water in order to make decisions related to which programmes may have conservation potential. There is a broad spectrum of detail that these studies may have depending on the amount of time and budget available to conduct the review of end uses.

A basic review may be accomplished by developing an understanding of common water using practices in homes and local businesses. When seeking to understand water use patterns, it is important focus on the largest type of customers to get a sense of the 'average' type of use for that sector. It is also important to consider the range of types of users. A study of metered billing data on neighborhood or similar types of businesses would be most useful to this analysis.

End use studies have been done in various countries including the Australia, Singapore, Spain and the United States. Some examples were presented above and case studies are offered later in this chapter. The most rigorous approach to an end use study involves a detailed engineering study that can so far as data logging customers of specific types to better understand their water use patterns. These studies can be accomplished cost effectively by using statistical methods to determine a random sampling of customers. Two studies were completed previously by the American Water Works Association Research Foundation (WaterRF): *Residential End Uses of Water* (Mayer *et al*. 1999), and the *Commercial End Uses of Water* (Dziegielewski *et al.* 2000).

For developed or developing regions, most water demand comes from domestic use in homes. In 2006 through 2007, the State of California funded a research project to update and further research single family home use from the past WaterRF studies with the *California Single Family Home Water Use Efficiency Study* (Aquacraft Water Engineering and Management, 2011).

Two example case studies are presented below of how conservation potential was quantified to help define future opportunities for additional customer efficiency: Case Study 6: Rigorous Analysis Undertaken to Understand Potential for Water Use Efficiency, Santa Cruz, California, United States; and Case Study 7: Analysis of Non-Domestic Water End Uses in the Lower Hunter Valley, Australia.

5.3 DESCRIBE CURRENT DEMAND MANAGEMENT PROGRAMME

In assessing ways of reducing water demand, recent, current and planned water efficiency measures should be considered in two categories based on: (1) utility has full control to directly implement (frequently called utility-side measures); and (2) an action is required on the part of the customers to implement (customer-side measures).

First, actions taken by a utility to conserve water should be described, including estimated costs and effectiveness, such as:

- distribution system real physical loss reduction;
- reductions in apparent losses through addressing billing system errors or metering inaccuracies;
- water tariffs with increasing fees for higher use (frequently called inclining block tariffs); and
- metering all connections and charging based on use.

Second, customer efficiency measures should also be described, such as:

- promotion and awareness campaigns to educate customers on wise use of water;
- incentives or technical services to directly contact customers (i.e., surveys of customer properties to offer advice, or rebates on purchases of high efficiency equipment); and
- regulations or mandates on customers, manufacturers to push for high efficiency and/or improved quality of water using products.

The information collected may be best organized in tabular formats and/or spreadsheet format for future reference. For example, for customer measures consider the following key features:

- Programme title
- Date(s) conducted

- Targeted participants Targeted end uses
- Measure description
- Target implementation schedule (planned number per year)
- Actual numbers of distributed devices, audits, rebates and so on.
- Programme cost(s)
- Results of participants' surveys
- Evaluation of the amount of the water saved
- Savings due to water-use reduction (in local currency per million litres).

To the extent practical, water savings of past efforts should be quantified. Figure 5.9 illustrates a five-year historical period of water savings from various water use efficiency measures for the Melbourne, Australia area. Figure 5.10 presents the savings estimates for the Sydney Australia area.

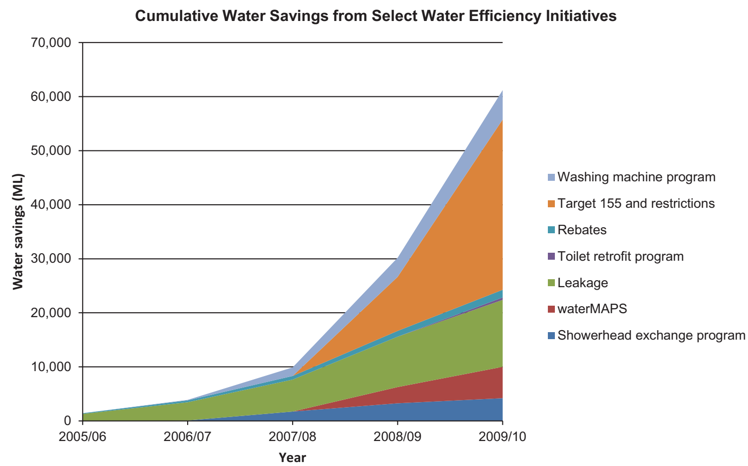


Figure 5.9 Cumulative water savings, Melbourne, Australia. *Source*: South East Water, Melbourne, Australia (2011).

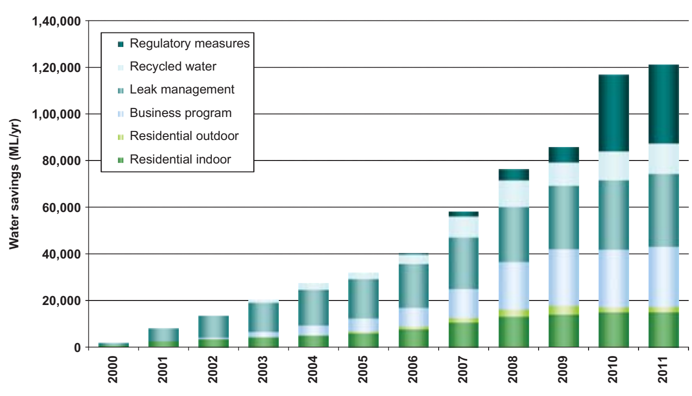


Figure 5.10 Cumulative water savings, Sydney, Australia. *Source*: Sydney Water Corporation, Australia (2012).

5.4 IDENTIFY POSSIBLE WATER SUPPLY OPTIONS FOR MEETING FUTURE DEMAND

In order to place the water-use efficiency programme goals in perspective, other ways of meeting the region's water needs should be described. Based on additional studies conducted by the utility, the following sources of water should be evaluated:

- New surface water supplies
- New groundwater supplies
- Reclaimed water
- Other sources

Useful information relevant to setting efficiency goals includes:

- The amount of water available (annual yield)
- Schedule of new water source development projects
- Possible environmental or other impacts of new water source development
- Cost of new supplies on a US$ dollar/million-litre basis

Development of the above sources represents an alternative to water efficiency programmes. Both options should be evaluated in an overall integrated water resources plan (IWRP), which is beyond the scope of this Guide. Planners will find more IWRP information in the American Water Works Association's *Water Resources Planning Manual*, M50, which was last published in 2007. (See Chapter 7 for additional information on how to evaluate the cost effectiveness of efficiency options.)

5.5 ESTABLISHMENT OF WATER EFFICIENCY GOALS

Goals are essential to planning water-use efficiency programmes. They provide benchmarks against which progress in reducing consumption can be measured. It is typically recommended that a water utility or local government that understands local issues set goals, as opposed to other government organizations such as regional, provincial, state or federal agencies. However, the supervising agencies may mandate water efficiency plans and play a monitoring role by ensuring the accountability of local governments through means such as regular reporting on water efficiency activities.

A water utility or local government agency may follow a three-step goal setting process:

(i) Set overall programme goals before preparing the plan in order to provide direction and focus;
(ii) After evaluating the proposed measures in terms of water savings and cost-effectiveness, select an overall programme of measures and overall water savings goal;
(iii) After developing the plan, set specific goals for each water-use efficiency measure in order to monitor implementation progress.

General overall goals can be expressed as:

(a) Total water savings at some point in the future, expressed as a percentage of total production and/or quantity of water saved;
(b) Annual average projected total per capita use (see Figure 5.11)
(c) Benefits realized, such as a capital project deferred or avoided and water made available for environmental purposes.

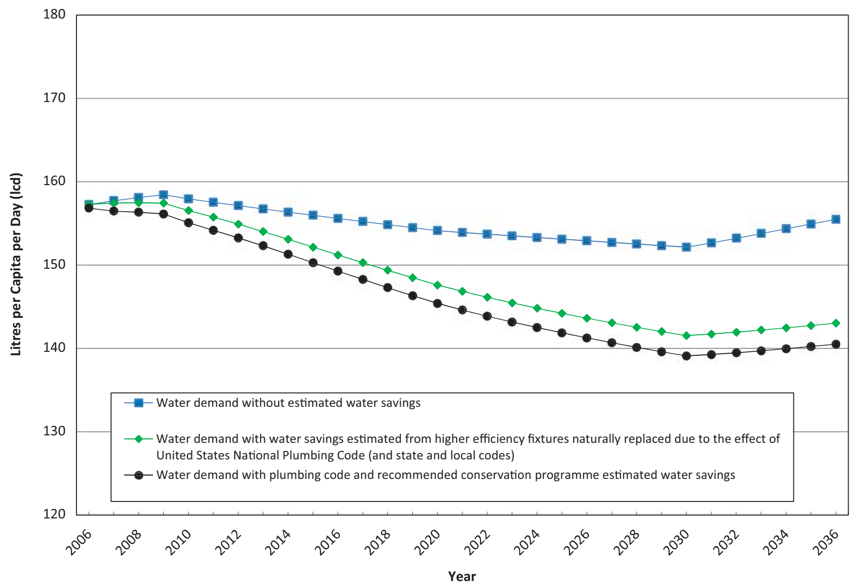


Figure 5.11 Example forecasted reduction in average per capita daily water use. *Source*: Maddaus Water Management (2013).

After the plan has been developed, specific water-use efficiency measurement goals can be expressed. Goals that measure implementation progress in terms of specific activities, such as the number of commercial (business) or annual water-use surveys (or audits), can also be useful in monitoring progress. This information is easier to acquire and track.

Customer satisfaction surveys can also be used to assess water use behaviour and customer response to the programme(s). Goals could include:

(a) Customers reached by, and/or participating in, one or more programmes;
(b) Number of installations, surveys or contacts completed; or
(c) Water savings for an efficiency measure.

Measuring progress against goals is useful in ensuring continued programme support and funding and, for local government, in ascertaining progress and showing that water is being used efficiently.

Reasonable goals for water savings are typically between 1–2 percent per year reduction in demand under average water year conditions (i.e., non-drought years). This is then projected to be total annual on the order of 10–20 percent savings in 10 years. In times of drought, restrictions can lead to 10–20 percent or more in a single year depending on the severity of the supply shortage. Figure 5.11 presents demand forecasts for the baseline water demand forecast with and without the United States National Plumbing Code and local regulations. Additionally, seven different scenarios were analyzed to determine the recommended set of water use efficiency measures to implement.

Most importantly, planners can use the results to modify goals or strategies where necessary. Water savings for some programmes (e.g., public information) cannot be quantified because the savings are usually small and overlap with other measures. Water savings from other hardware measures, such as plumbing fixture retrofits, are easier to quantify because reliable water savings data have been published.

Water savings are best approached on an individual measure basis (see Chapter 6). Statistical methods can be employed to calculate water savings. However, measuring such savings by reviewing total water production or sales records is difficult due to production fluctuations resulting from unrelated factors, including weather, uneven growth in new accounts, economic recessions and recoveries, changes in relative numbers of different types of accounts, changes in water/wastewater prices, and so on.

CASE STUDY 6

Rigorous Analysis Undertaken to Understand Potential for Water Use Efficiency, Santa Cruz, California, United States

Toby Goddard, City of Santa Cruz, California, United States

The City of Santa Cruz has a long history over the past 30 years of implementing water conservation measures. As a result, the City has taken a robust approach to analyzing its future water use efficiency potential.

The City currently serves 93,900 residents and 1395 MLD. Based on the coast of California, United States with small local reservoirs that are vulnerable to droughts, the City's Water Department needs to understand how customers use water wisely. As a result, the City has robust continuous tracking of data for which customers participate in which programmes. The City also has performed benchmarking studies to analyse remaining conservation potential in their service area. The City has one of the lowest per capita demands in the State of California (Figure 5.12). This is due both to their community effort to conserve and also that their customers have low irrigation demands with the cool summers along the coast of the Pacific Ocean.

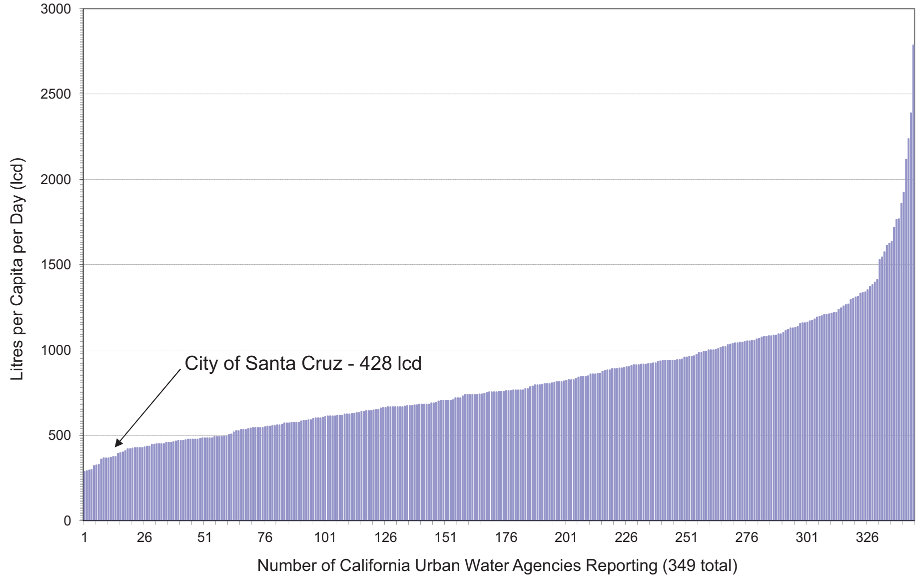


Figure 5.12 Statewide urban percent water use (10-year average). *Source*: California, United States Department of Water Resources, Urban Water Management Plans (2011).

Due the vulnerability of their supplies, the City is considering building a new desalination plant, which if approved would be very costly to local residents and businesses, currently estimated at US$115 million or about US$50 per person year. The community is asking the City how much water use efficiency is still feasible and reasonable to achieve. The City took several steps to answer this question:

- The City reviewed all their past efforts as seen in the schedule posted in Figure 5.13.
- The City also created maps to illustrate their efforts for each water use efficiency measure. Figure 5.14 presents an example of one map for all the properties that participated in their high efficiency clothes washer rebate incentive programmes between 2000 and 2012. This map was created using Geographical Information System mapping software and the database of customers that participated in the programme.
- The City demonstrated actual use versus possible savings from large irrigation properties. Figure 5.15 illustrates the results from outdoor landscape technical assistance programme where water budgets have been created and monitored via online internet software tools. This helps these customers to reduce demands by demonstrating in a clear report the difference between the actual irrigation water applied and the budget that was surveyed and set-up based on the type of plants, irrigation system equipment and the weather. There are currently 181 sites participating in the programme irrigating more than 153 hectares. In 2012, the estimated annual water savings was 1300 ML/yr.
- The City performed a very detailed and rigorous Baseline Survey to benchmark how much conservation has been achieved in various sectors of the community. The Baseline Survey findings are summarized in the table below.

Table 5.1 Results of city of Santa Cruz baseline survey.

Indoor water use characteristics by sector percentage of devices that are water efficient				
	Efficiency standard	**Single family domestic**	**Multifamily domestic**	**Commercial**
Toilets	<6 L/flush	90%	89%	96%
Showerheads	<9.5 L/min	92%	95%	95%
Bathroom Faucets	<8.3 L/min	90%	89%	Varies
Kitchen faucets	<6.8 L/min	71%	92%	63%
Clothes washers	<56 L per wash	63%	46%	52%

Source: WaterWise Consulting, Inc. (2013).

From this analysis, the City staff devised a summary of the potential for additional water use efficiency from various water conservation measures, both existing and new. Each measure is placed in the matrix based on a qualitative estimate of potential number of properties that could (or perceived would) remain to participate in the measure and a relative estimate of how much water would be saved per measure, see Figure 5.16. In other words, properties that have a high potential for both water savings and number of participating properties would be placed in the upper left hand side of the chart. And on the opposite end of the spectrum, the measures with low perceived water savings and number of properties that may participate are in the lower left. This is helpful when considering measures for selection in Chapter 6, and cost effectiveness evaluation for existing and new measure in Chapter 7.

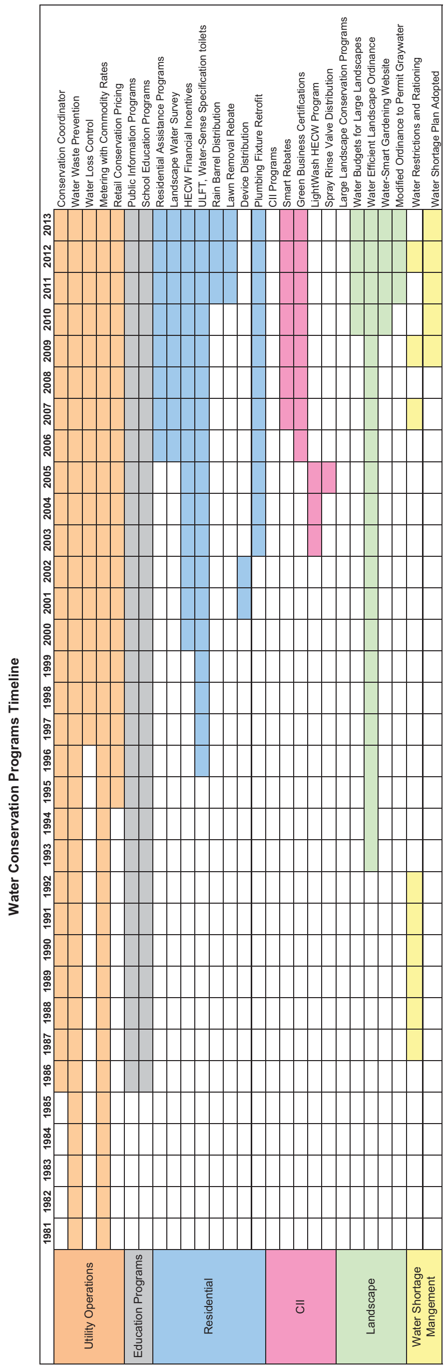


Figure 5.13 Timeline of past water conservation efforts by the City of Santa Cruz, California, United States.

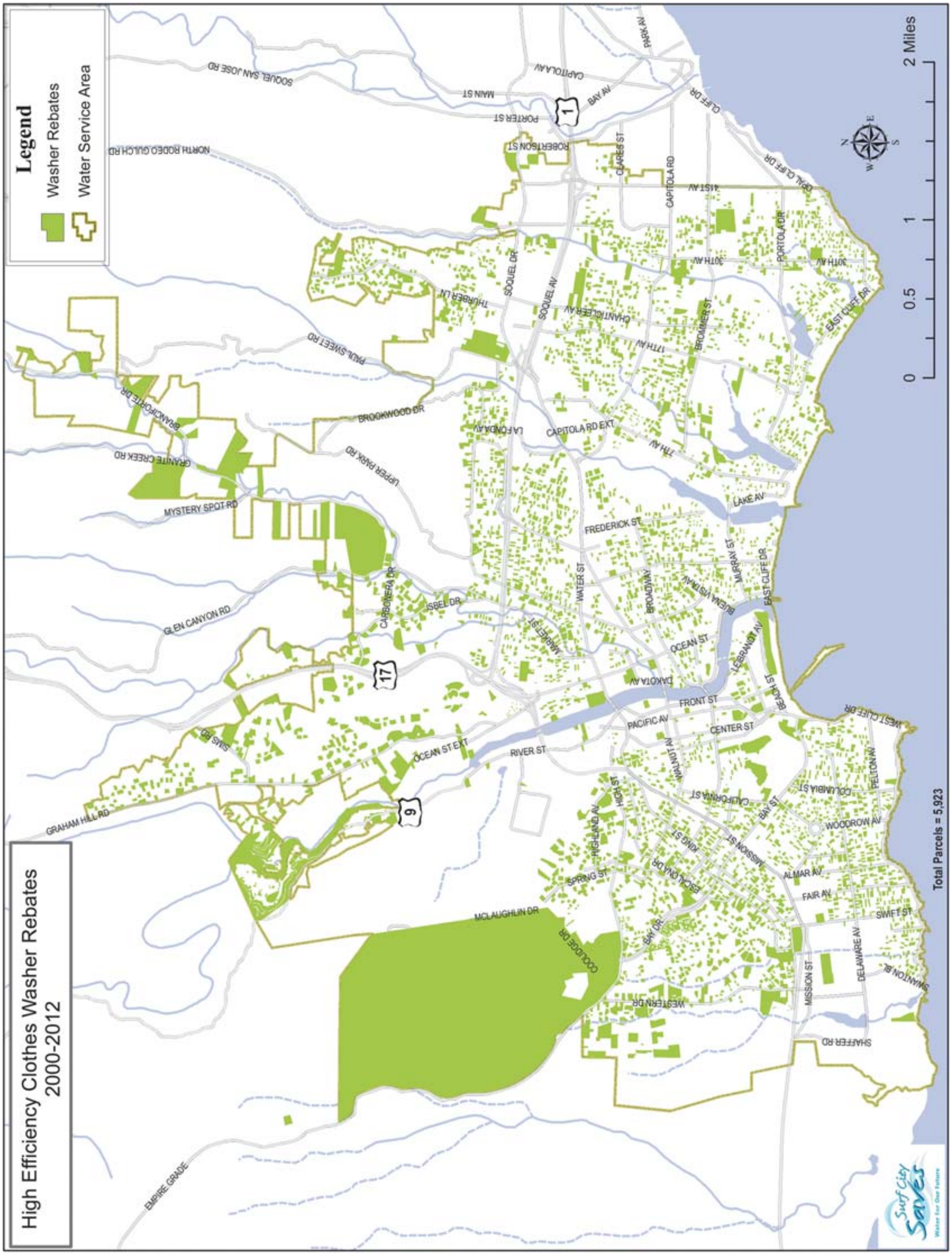
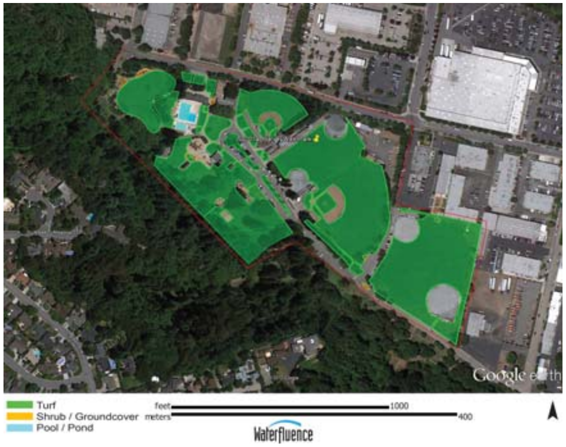


Figure 5.14 Map of domestic and commercial properties participating in high efficiency clothes washer incentive programme.



Landscape Water Use Report

March 2013
SiteID: SC-01a

Prepared For:

Site Name:	HarveyWestPark
Main Contact:	Meta Rhodeos
Landscape Firm:	
Other Contacts:	Dave Rosener

Acct# and Service Address:

027-02950-011; 0 Harvey West @ Dubois
027-02999-001; 300 Evergreen St
027-03400-011; 0 Harvey West Annex
027-03500-011; 0 Evergreen St
027-03505-011; 0 Harvey West Park
027-03520-011; 0 Harvey West Lit Lge

Site Description:

Measurement Method:	View Site Map
Measurement Date:	7/10/2012
Irrigated Turf Area (FT2):	576,180
Irrigated Other Area (FT2):	2,889
Pool/Pond Area (FT2):	5,180
Indoor Water Ccf/Bill:	0

SANTA CRUZ

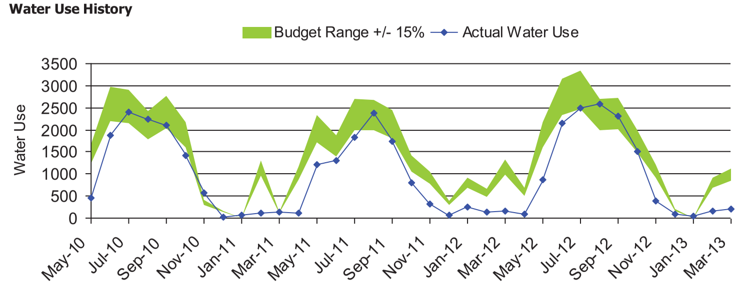
CITY OF SANTA CRUZ
HARVEY WEST PARK
809 CENTER ST RM 101
SANTA CRUZ CA 95060-3826

Site Percentile

88

100=top score

Water Use History



Savings Potential	Last Month	Last 12 Months	Last 24 Months	Last 36 Months
Over Water Ccf	0	298	360	815
Over Water %	0%	2%	2%	2%
Dollars Lost $	$0	$1,191	$1,439	$3,260

Read Date	Actual Water Ccf	Budget Water Ccf	Over Water Ccf	Over Water %	Weather ETo-Rain Inches
3/12/2013	205	984	0	0%	1.97
2/11/2013	156	802	0	0%	1.61
1/8/2013	54	0	54	100%	0.00
12/10/2012	88	185	0	0%	0.37
11/8/2012	385	1,064	0	0%	2.13
10/9/2012	1,502	1,739	0	0%	3.48
9/10/2012	2,317	2,373	0	0%	4.75
8/10/2012	2,592	2,348	244	9%	4.70
7/11/2012	2,486	2,898	0	0%	5.80
6/11/2012	2,158	2,743	0	0%	5.49
5/11/2012	865	1,881	0	0%	3.77
4/11/2012	96	591	0	0%	1.19

Messages

(800) 800-9519 Waterfluence Waterfluence.com

Figure 5.15 Landscape irrigation surveys and water budget programme success. *Source*: Waterfluence (2012).

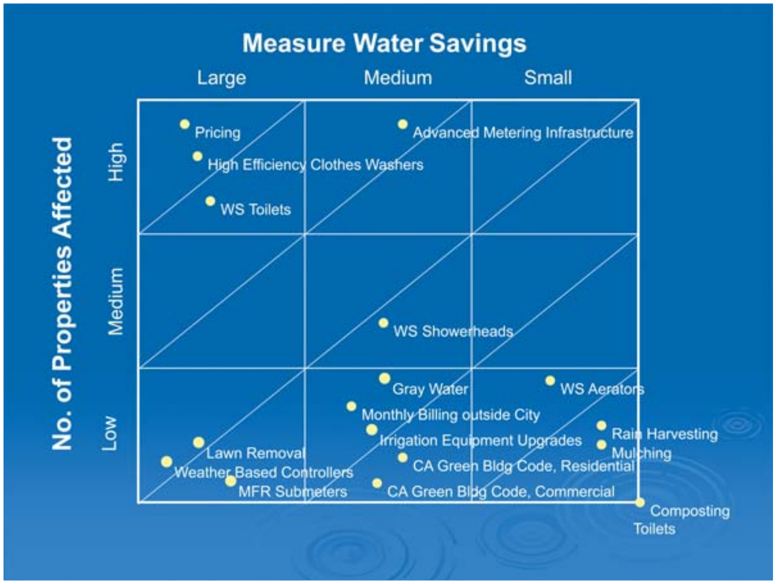


Figure 5.16 Summary of future water use efficiency potential for the City of Santa Cruz using comparison of number of properties and measure water savings. *Source*: Personal communication with Toby Goddard (2013).

CASE STUDY 7
Analysis of Non-Domestic Water End Uses in the Lower Hunter Valley, Australia

Stephen Askew, Hunter Water, Newcastle, New South Wales, Australia

Introduction

MWH Australia Pty Ltd was engaged by Hunter Water Corporation to review non-domestic customer water consumption and to develop profiles of how large non-domestic customers used water (Montgomery Watson Harza, 2012). The findings of the review were intended to prioritise water efficiency activities and ensure the most effective use of available funds on the utility and customer side.

Methodology

Non-domestic customers were categorised based on 2010/11 consumption data as forecast by Hunter Water:

- *Major Customers (>50 ML/yr);*
- *Large Customers (10–50 ML/yr); and*
- *Other Customers (<10 ML/yr).*

Major customers and large customers were further broken into sub sectors based on business activities. Major customers were surveyed using an online tool. An end use assessment was also undertaken for each customer sector.

Results of sector analysis

As previously stated, the water use breakdown for non-domestic customers was based on 2010/11 financial year data. Over 75% of non-domestic customers are commercial/industrial.

To identify the most significant target groups, all non-domestic customers were ranked in order of water consumption using 2010/11 billing data. Results of this analysis are shown in Figure 5.17 as a percentage of consumption.

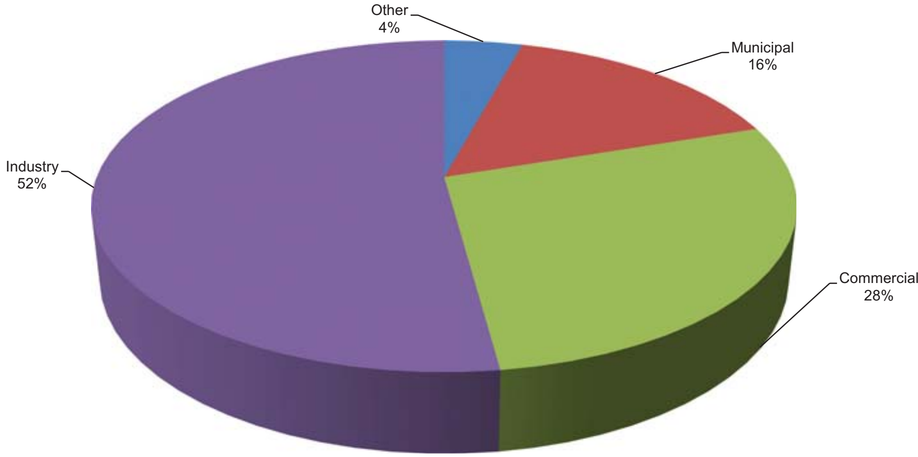


Figure 5.17 Non-domestic water consumption by sector (2010/2011). *Source*: Montgomery Watson Harza (2012).

Figure 5.18 shows that the top 200 customers (>10 ML/yr) consume approximately 70% of the total non-domestic consumption. Major customers make up approximately 50% of this consumption.

The account and average demand per account growth rates used in the Hunter Water demand forecast model (ISF, 2012) were adopted for each sector and individual major customer for use in the study.

Major customers

The 30 major customers were listed alongside their annual consumption (2010/2011), and assigned a sector and sub-sector. Major customers are generally targeted individually, as they are the highest water consumers and have diverse and unique end uses.

As part of this study each major customer (with consumption >50 ML/yr) was asked to complete an electronic survey on water efficiency so that a desktop audit could be conducted. The purpose of this desktop audit was to:

- More accurately define water end uses and potential targets for water efficiency audits;
- Determine current water conservation strategies employed by major uses;
- Gain a further understanding of potable and non-potable customer water consumption, as well as the potential for source substitution and reuse; and
- Assist with benchmarking the current water consumption of major users.

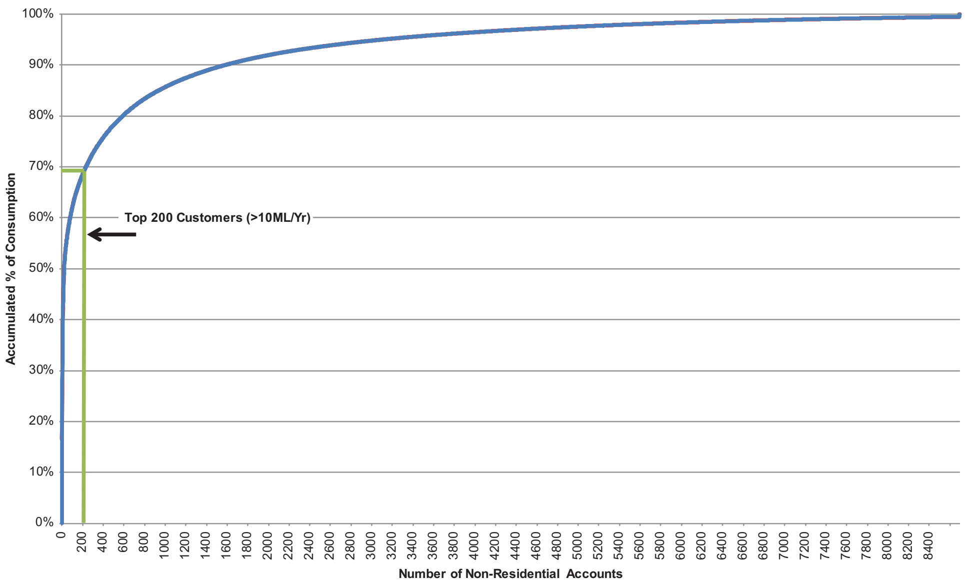


Figure 5.18 Non-domestic customers ranked by water use (all accounts). *Source*: Montgomery Watson Harza (2012).

Sub-sector analysis

Water use for major customers and large customers was further broken down into sub-sectors. Sub-sectors were defined based on the Hunter Water business type. Businesses with similar end uses (and customer categorisation from previous demand investigation studies) were grouped together. Customers were assessed individually before being assigned to a sector.

Figures 5.19 and 5.20 show the sub-sector breakdown.

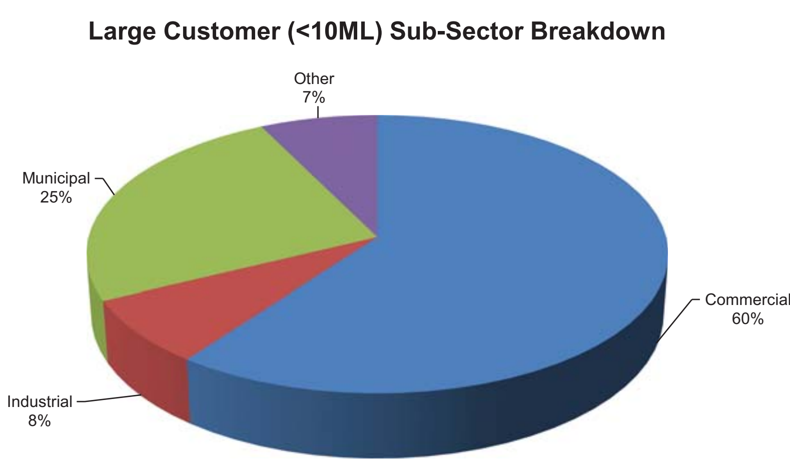


Figure 5.19 All large customers (including majors). *Source*: Montgomery Watson Harza (2012).

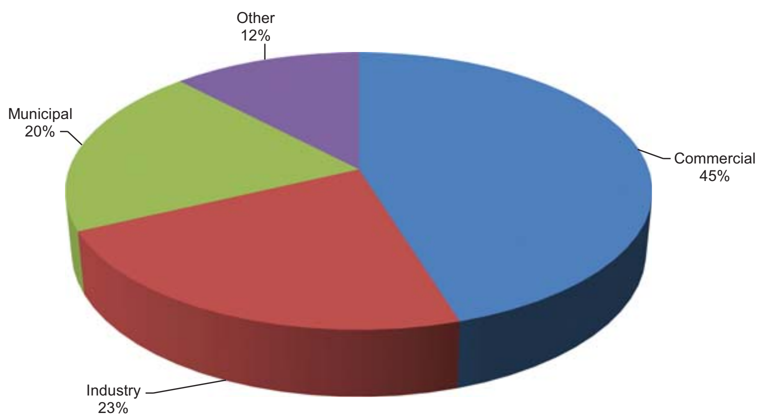


Figure 5.20 Large customers (excluding majors). *Source*: Montgomery Watson Harza (2012).

The large customer profile varies significantly from the total major and large customer profile (all customers >10 ML/yr), indicating that the industrial sub-sectors are primarily represented by the top 30 major customers. The large customers are made up of a broad range of sub-sectors with no significantly dominant groups. However, the dominant sector within this group is commercial, making up 45% of all large customers, followed by industrial with 23% and municipal with 20%.

Figure 5.21 shows both the large customer total consumption and average consumption per account for each sub-sector.

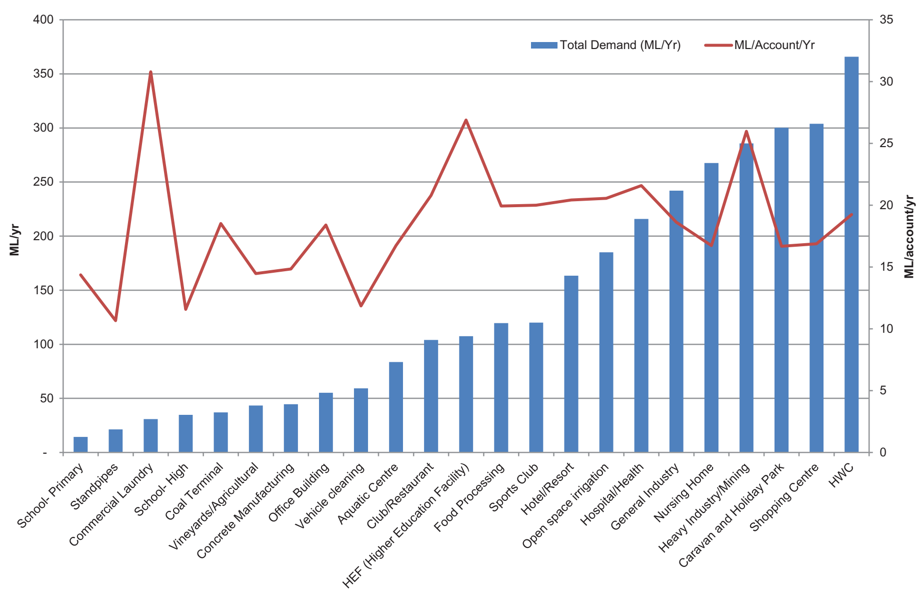


Figure 5.21 10–50 ML customers categorised for each sub-sector (2010/11). *Source*: Montgomery Watson Harza (2012).

The most important customer target groups were identified as:

- Heavy industry/mining – it has the second highest average consumption/account and makes up 9% of the total consumption.
- Shopping centres, caravan/holiday parks and nursing homes – these groups have high overall consumption.
- Clubs, hotels/resorts, open space irrigation and hospitals/health – these customers have a high average consumption per account and represent a significant proportion of the total consumption.

Benchmarking

A benchmarking assessment was undertaken for each major customer based on available information. The benchmark targets for each customer type were adopted from the Queensland Water Commission (QWC) Best Practice Toolkits which has been replaced by their 'ecoBiz Queensland' program (Queensland Department of Environment and Heritage Protction, 2013) and Prior case studies in the commercial and industrial sector such as *Meeting Australia's Water Challenges–Case Studies in Commercial and Industrial Water Savings* (WSAA, 2009) Commercial activity measures were sourced from customer survey results, follow up, websites and other available sources.

End use assessment

Evaluation of water efficiency programmes requires the identification and targeting of specific water end uses. Designing and tailoring demand management programmes can be improved by understanding not just which sectors are significant water users but where water is anticipated to be used within the sectors.

End use breakdowns were determined for each sector and sub sector based on the following:

- Previous experience in water conservation programmes;
- Available demand management research and previous water audits; and
- Results from the major customer survey.

The following non-domestic end uses were included in this analysis:

- Toilets and urinals
- Showers and basins
- Irrigation
- Kitchen uses
- Laundry
- General cleaning/wash-down
- Pool, spas and water based attractions
- Cooling
- Steam generation
- Process water
- Vehicle washing
- Medical processes
- Fire testing
- Leaks and losses
- Hunter Water/standpipes

Due to the specific nature of many industrial processes, it was difficult to accurately determine end uses for the industry sector and sub-sectors. The industry end use breakdowns assigned in this assessment are therefore only indicative of anticipated water usage and may vary considerably by individual customer.

Approximately 88 percent of the industrial sector is represented by major customers. These customers, both having unique end uses and the highest potential for water savings, would best be targeted by individual water management programmes, rather than sector or end use specific programmes. The end use assessment therefore focussed on $<$50 ML/yr customers (all customers excluding major customers).

The end use breakdown of $<$50 ML/yr customers showed that showers and basins, toilets and urinals, irrigation, cooling and general cleaning/wash down are dominant.

Chapter 6

Determining Feasibility of Water-Use Efficiency Measures

The key to determining the success of a water efficiency programme is a thorough evaluation of feasible water-use efficiency measures. As guidance on the range of options that are normally evaluated, this chapter identifies typical water-use efficiency measures that might be considered. Section 6.1 covers efficiency measures that utilities can undertake such as water loss reduction, metering, and water pricing. Section 6.2 considers the potential range of efficiency measures that can be implemented by customers. To streamline the evaluation, Section 6.3 proposes a method to screen measures down to a more manageable list for cost-effectiveness evaluation (presented in Chapter 7).

6.1 WATER DISTRIBUTION EFFICIENCY MEASURES FOR UTILITIES

Utility measures include aggressively reducing losses of water, installing water meters and setting up water pricing systems that encourage water efficiency.

6.1.1 Water system audits, leak detection and repair

The quantity of water lost between leaving the source and entering a customer's property is an important indicator of water distribution efficiency. With challenges to deliver consistent and continuous service to its customers, a primary focus on water loss control can help extend the capacity of existing systems to meet the needs of more customers in developing countries. There are direct financial benefits to utilities due to lower operation and maintenance cost as a result of successfully controlling water losses. In addition, enhanced surface water flows can also improve local rivers and streams due to reduced withdrawals from efficiency when more customers are served without constructing more infrastructure.

The amount of water lost can vary greatly from less than 10 percent in new, well-managed systems to more than 50 percent in older systems suffering from poor maintenance. Trends are also an important indicator, as rising water losses should trigger a proactive stance to address known water loss issues and if found economically feasible a full-scale comprehensive water loss control program should be implemented.

A leak-free water system is not technically or economically feasible, since water in a piped system is under pressure. Thus, a low level of water loss cannot be avoided, even in the most well maintained systems. New performance indicators have replaced a historically used term 'unaccounted-for water' (UFW), which often gives conflicting perceptions of the true success in controlling water losses. With this problem in mind, IWA originally developed and published a well-defined water audit methodology and an array of performance indicators in 2000. In 2006, IWA published a second edition of the *Manual of Best Practice: Performance Indicators for Water Supply Systems* (Alegre *et al*. 2006). In 2009, the American Water Works Association published the *Manual of Water Supply Practice, M36, Water Audits and Loss Control Programs* to adopt the same IWA methodology.

Figure 6.1 illustrates that percent of non-revenue water in some Asian cities is substantial.

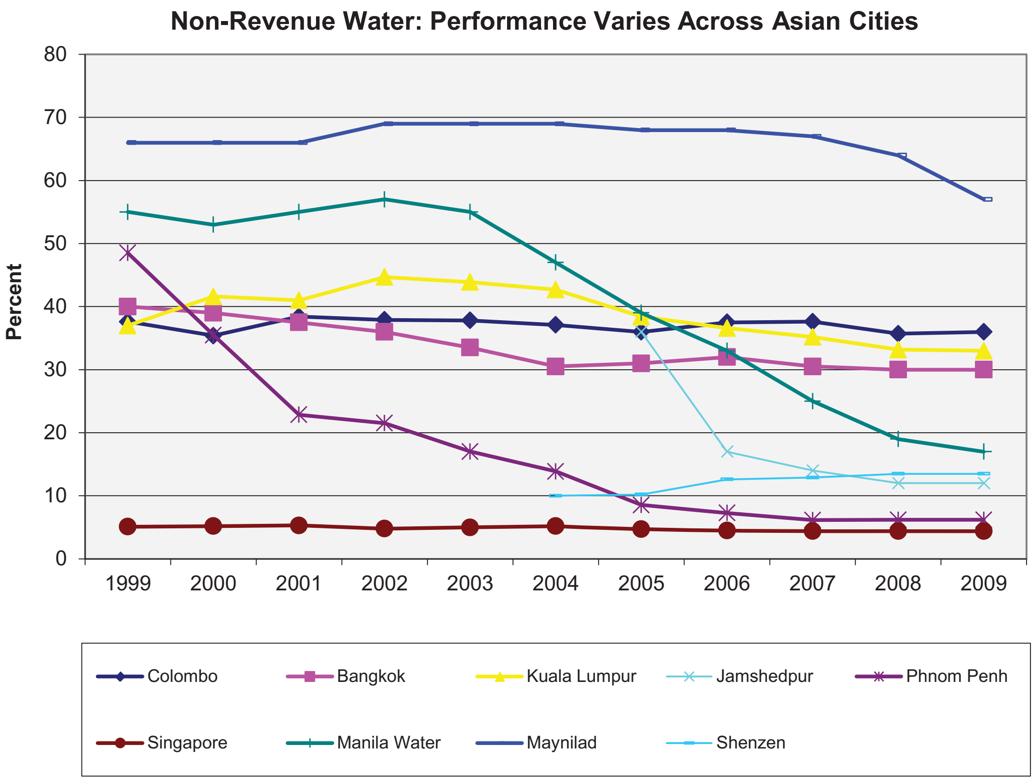


Figure 6.1 Water losses across Asian countries. *Source*: Personal communication with Roland Liemberger (2013). *Notes*: 1) Data of most utilities are unaudited and may be misleading; 2) Only some of the utilities have continuous supply – in all other cases NRW would be significantly higher when the system in its current condition would be supplied on a continuous basis; 3) The figures for Phnom Penh and Singapore are UFW. All others are NRW; 4) 2009 data are estimated.

As real water loss control programs including leak reduction measures are expensive, spending time on a careful water audit of the distribution system is a prudent first step. If the audit indicates that leak reduction activities are economical, then water utility maintenance staff should pursue them. Details necessary to gain a complete understanding on how to conduct an audit implement loss control strategies are available in the *Water Loss Control Manual* (Thornton *et al.*, 2008).

(a) Influences on real water losses

In each water supply system, several key local influences govern the magnitude of real losses and may place constraints on the ability of a water utility to control them. These influencing factors include:

- ✓ The number of service connections
- ✓ The location of the customer meter on the service connection
- ✓ The length of the mains
- ✓ The average operating pressure, when the system is pressurized
- ✓ The presence of surges
- ✓ The percentage of time per year for which the system is pressurized
- ✓ Infrastructure condition, materials, frequencies of leaks and burst pipes
- ✓ The type of soil and ground conditions, in so far as they influence the proportion of pipe leaks and bursts that show quickly on the surface

Table 6.1 shows how real losses are defined and determined. The terms in Table 6.1 are defined in Table 6.2, with the key parameter being real losses. The methodology for computing the real losses is explained in the IWA *Manual of Best Practice.*

Table 6.1 Components of water balance for a transmission or distribution system.

A	B	C	D	E
System input volume m^3/year	Authorized consumption (m^3/year)	Billed authorized consumption (m^3/year)	Billed metered consumption (including exported water)	Revenue water (m^3/year)
			Billed unmetered consumption[a]	
		Unbilled authorized consumption (m^3/year)	Unbilled metered consumption	Non-revenue water[b] (m^3/year)
			Unbilled unmetered consumption	
	Water losses (m^3/year)	Apparent losses (m^3/year)	Unauthorized consumption	
			Billing system inaccuracies	
			Metering inaccuracies	
		Real losses (m^3/year)	Leakage on transmission and/or distribution mains	
			Leakage and overflows at utility's storage tanks	
			Leakage on service connections up to point of customer metering	

Source: Alegre *et al.*, (2006)

[a] Difficulty may be experienced in completing the water balance with reasonable accuracy where a significant number of customers are not metered. In such cases, authorized unmetered consumption should be derived from a statistically significant number of individual connections of various categories, and/or by the measurement of inflows into discrete areas of uniform customer profile (with data adjusted for leakage and diurnal pressure variations, as appropriate).

[b] The term 'non-revenue water' has replaced 'unaccounted-for water,' which is no longer terminology used in standard industry practice to refer to water losses.

Table 6.2 Definition of terms for international standard water audit.

Term	Definition
System input	The volume input to that part of the water supply system to which the water balance calculation is related, allowing for known error in the measurement of the input value. Equal to water from own sources plus water imported.
Water supplied	System input minus water exported to other utilities.
Authorized consumption	Volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier; for domestic, industrial, commercial and institutional usage. (Note: Authorized consumption may include items such as fire-fighting and training, flushing of water mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, etc. These uses may be billed or unbilled, metered or unmetered.)
Water losses	The difference between system input and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as raw water mains, transmission or distribution systems, or individual zones.
Apparent losses	Such losses include all types of inaccuracies associated with customer metering, data archiving and billing, plus all unauthorized consumption (illegal use). (Note: Over-registration of customer meters leads to under-registration of real losses, while under-registration of customer meters leads to over-estimation of real losses.)
Real losses	Physical water losses from the pressurized system up to the point of measurement of customer usage. The annual volume lost through all types of leaks, bursts or breaks, and overflows from tanks/reservoirs. These losses depend on the frequency, flow rates and average duration of individual leaks, breaks and overflows. (Note: Although physical losses after the point of customer flow measurement or assumed consumption are excluded from the assessment of real losses, this does not necessarily mean that they are insignificant or unworthy of attention for demand management purposes.)
Revenue water	The components of system input that are billed and produce revenue (also known as billed authorized consumption). Equal to billed metered consumption plus billed unmetered consumption.
Non-revenue water	Those components of system input that are not billed or do not produce revenue. Equal to unbilled authorized consumption plus apparent losses plus real losses.
Unbilled authorized consumption	Those components of authorized consumption that are not billed or do not produce revenue. Equal to unbilled metered consumption plus unbilled unmetered consumption.

Source: Alegre *et al*., (2006)

(b) Technical performance indicators for real water losses

The IWA methodology focuses on one key technical indicator of real losses (CARL), which presents the annual volume of real losses divided by the number of service connections (Nc), allowing for the percentage of time for which the system is pressurized. This is shown as

$$\text{CARL} = \text{Current annual volume of real losses/Nc}$$

CARL is expressed as litres/service connection/day when the system is pressurized. In order to put the above number into international perspective and judge whether it is low or high, another computation is normally made to define what can be called unavoidable annual real losses (UARL). UARL can be calculated based on the equation

$$\text{UARL} = (A \times Lm/Nc + B + C \times Lp/Nc) \times P$$

where Lm = length of mains in metres, Lp = total length of service connections from the edge of the street to customer meters in metres, P = average pressure in metres and A, B, C = constants. The values of A, B, and C have been derived from statistical analysis of international data from 20 different countries and are published in IWA *Manual of Best Practice* together with example calculations.

Finally, a useful non-dimensional index of overall system condition and management, that is., an infrastructure leakage index (ILI), is derived as a ratio between the two above performance indicators, and is shown as

$$\text{ILI} = \text{CARL/UARL}$$

This ratio has been observed to be between 1.0 and 120.0 as presented in Figure 6.2. Well-managed systems in very good condition would be expected to have an ILI close to 1.0, with higher values for older systems containing infrastructure deficiencies that warrant action to reduce losses. Real Losses per connection per day should be used for target setting and monitoring of a utility's progress. Once a target is set, this can be evaluated for cost effectiveness similar to other water efficiency measures as discussed in Chapter 7.

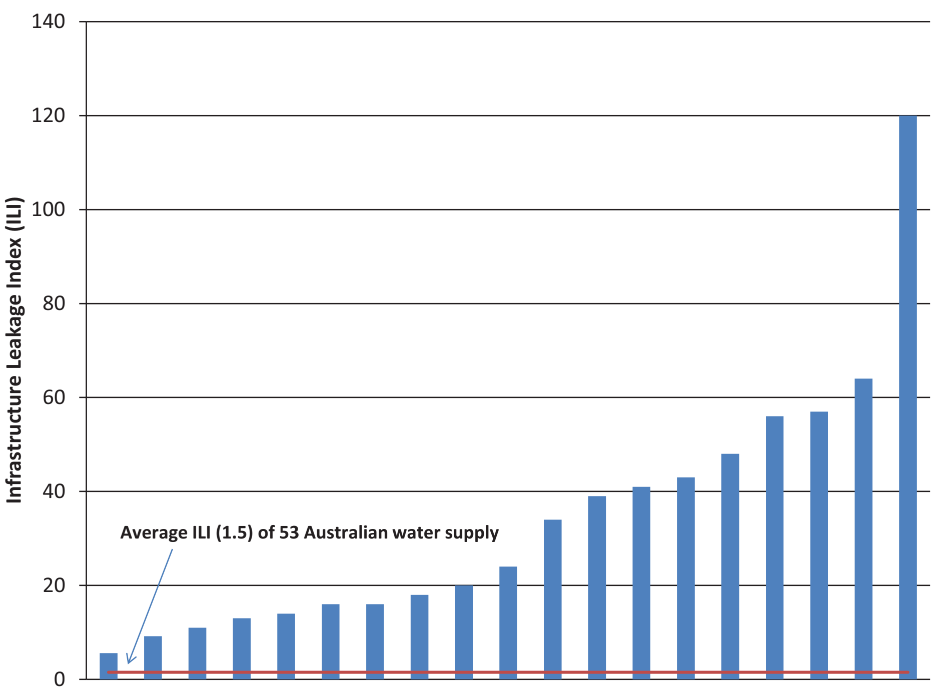


Figure 6.2 ILI Values from 19 indonesian water utilities (2006). *Source*: Asian Development Bank (2010a).

For more information, a number of reference and research project reports focused on benchmarking the successes and lessons learned from employing water loss control strategies have been published, including:

- Evaluating Water Loss and Planning Loss Reduction Strategies, Water Research Foundation (Fanner *et al.* 2007)
- Leakage Management Technologies, Water Research Foundation (Fanner *et al.* 2007)
- Leak Detection: Technology and Implementation, International Water Association (Hamilton & Charalambous 2013).
- IWA has a series of Water21 articles published by the IWA: Water Loss Specialist Group.

A basic tool for developing a water system balance is available online through the American Water Works Association: http://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx (last accessed April 18, 2013).

An example of a water loss reduction project is presented in Box 6.1.

BOX 6.1 SUCCESS IN REDUCING WATER LOSSES IN SOUTH AMERICA: BRAZIL APPARENT LOSS REDUCTION IN BRAZIL

Companhia de Saneamento Básico do Estado de São Paulo S.A (SABESP) is one of the largest water and sewage service providers in the world. It services a population greater than 25 million with 7.1 million service connections. SABESP eliminated significant Non Revenue Water (NRW) losses and dramatically increase total billable consumption by replacing inaccurate meters through:

- Hiring a local contractor, BBL, a Miya company to provide an innovative and turnkey solution that included analysis, engineering, design, supply, and installation of 26,490 new meters over a period of 36 months.
- Focusing on the high daily consumption of SABESP's large customers, where proper sizing and calibration of the meters was critical in order to achieve high accuracy and maximize revenues.

Performance-based Contract

Instead of using a standard Time + Materials method to calculate the value of the contract, a non-capital expenditure method using performance-payments was chosen. Project value was based on the average increase in billable consumption volume. The increase in volume was tied directly to the effects of resizing and flow profiling that the new meters provided.

Although the period of the contract was 36 months, the contract only awarded BBL, a Miya company, compensation for the first 12 months following each meter's replacement. After completion of the contract, SABESP continued to benefit from the additional gains that each new meter generated.

Results:

- Total volume of metered consumption increased by 20 million cubic meters over the 3 years contract duration
- Revenues increased by US$36 million.

Figure 6.3 Example of before and after meter replacement. *Source*: Miya Corporation. More examples are available through Miya Corporation: http://www.miya-water.com/our-experience/case-studies

6.1.2 Metering with tariffs based on volume of water use

The first step in accounting for water sold and setting up a water efficiency programme is to meter all customers and bill each customer's account according to their individual use of water. When billed, customers receive the direct financial benefit in the form of cost savings from using water more efficiently and lowering their use. Metering new homes and buildings during construction is straightforward and of minimal cost. Retrofitting homes and businesses later can be a time-consuming and costly venture. As unmetered customers are usually charged for water based on a simple fee for service (in other words, the exact same fee is charged in each billing period), it is difficult to obtain community support for paying what may be perceived as a higher price for water. This can create a cycle (see Figure 6.4) that is most challenging to break away from into a better managed water supply system.

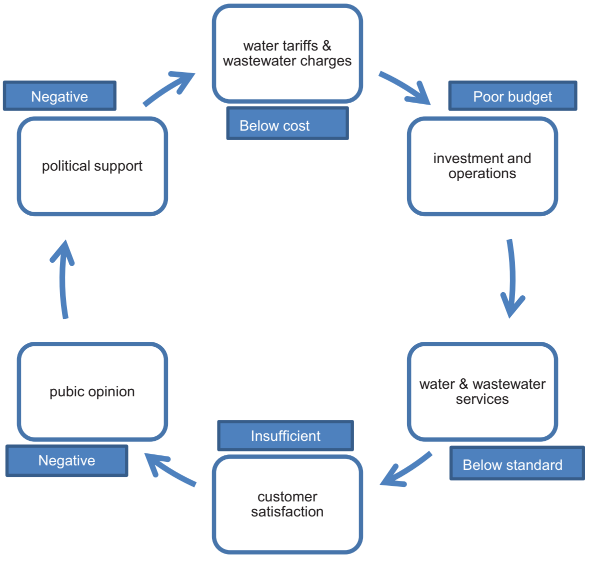


Figure 6.4 The Vicious Cycle in Water and Wastewater Systems Management. *Source*: Rudolph, K. (2009).

When existing unmetered connections are retrofitted with water meters and customers can be billed at a volumetric tariff (i.e., a tariff based on the volume of the water used), it is common to see the majority of users receiving lower bills since a small percentage of customers typically use the majority of the water supplied. Studies have shown that up to 75 percent of the water may be used by only 25 percent of the population and that the installation of water meters can reduce consumption by up to 20 percent. Installing meters for a currently unmetered community can take a number of years.

Non-promotional efficiency water pricing programmes

Using this measure, a water utility would modify its existing water (efficiency) tariff structure with the objective of reducing consumption to generate benefits, such as averting or delaying additions to water supply capacity for delivery or treatment. Traditional objectives in tariff structure design include (a) basing the tariffs on the costs to serve; (b) providing adequate and stable revenues; (c) providing fairness or equitability among customer classes and volume users; and (d) providing ease of implementation and administration. In developing countries, the collection rate of water bills must be factored into the tariff-setting process in order to prevent revenue shortfalls.

Efficiency tariffs provide a financial incentive for customers to reduce water use, usually by applying a surcharge on peak-month usage or by charging a higher unit tariff for water as the number of units used increases. Efficiency tariffs are often not based on historical costs to serve each customer group, and are thus considered by some customers to be unfair. It is therefore essential that efficiency tariffs be developed through a public process that assures acceptance of the purpose and design of the tariff structure. It is important that regardless of the efficiency tariff structure selected, greater control can be achieved from a combination of pricing with indoor and outdoor efficiency programmes than from pricing alone. Efficiency pricing as part of a broad demand management programme is the most logical approach. Types of non-promotional efficiency water tariffs include:

- A combination of low tariffs for baseline minimum water quantity (the same fixed charge every billing cycle for the baseline volume) and high volumetric charges for the amount that the customer uses above the baseline volume;
- Inclining tier tariffs with volume amounts (or blocks) where higher unit charges are triggered at higher levels of use to encourage efficiency;
- Seasonal tariffs or excess-use surcharges;
- Water budget based billing; or
- Marginal cost pricing.

In some cases, it is easier to envision what types of tariff structures do not encourage water efficiency:

- A declining block structure;
- A flat tariff structure (a fixed fee regardless of water use);
- A uniform tariff structure (the same low unit charge for water regardless of how much is used).

These types of tariff structures offer little incentive for customers to improve water-use efficiency. An overview of general recommendations on multi-tiered types of tariffs that do offer customers incentives is presented below.

It is often difficult to predict changes in water use due to changes in price. Definitions and methods for assessing the response to tariff changes, called price elasticity or inelasticity, are covered in numerous reference texts and need to be taken into consideration when deciding whether and how to implement water tariff changes. It is critical for planners to have an understanding of price elasticity concepts, since they may greatly influence the revenue generated and thus the financial situation of the utility if water efficient tariff structures are not applied correctly. However, as this aspect is not covered by this publication, the authors recommend the use of more in-depth reference material on the subject. Two important publications dealing with this topic are the *Water and Wastewater Finance and Pricing: A Comprehensive Guide, Third Edition* (Rafetlis, G. *et al*., 2005) and American Water Works Association, *Manual of Practice, M1, Principal of Rates, Fees and Charges, 6th Edition* (AWWA, 2012).

Multi-tiered tariffs

(a) Tariff structure

Multi-tiered tariffs involve water-use charges at two or more levels. Multi-tiered tariffs are common for single-family domestic customers, although, technically, can be used for all customer groups. Many utilities impose multi-tiered tariffs only for domestic customers who use consistent amounts of water over time (e.g., where annual water use per account remains the same from year to year). Using a tariff structure with a fixed (flat) charge and two or more volumetric blocks allows adjusting two- or three-tiered tariffs to achieve revenue neutrality within the volumetric charges, while maintaining the desired balance between the fixed and volume portions of the total revenue required to operate the water system. Revenue neutrality is not usually required but is an objective of sound financial management. In other words, even if the water tariffs are changed, the water utility should still collect the same total amount of money per year if their costs are the same.

(b) Two-tiered structure

In a two-tier tariff structure that aims at efficiency, the first tier (for domestic customers) is usually set to include a major portion (say, 80–90 percent) of non-discretionary interior use. The higher tariff for the second block then provides a small incentive to reduce interior water use. The second tier price is applied to all other uses above the level of interior use and usually identified from wet (low irrigation) seasonal usage patterns (in litres per account per billing cycle). The second tier is where the incentive to conserve water is provided. Numerous combinations of first- and second-tier prices exist that provide the desired level of revenue.

Most utilities use a 10–20 percent tariff difference between the two blocks, which simply serves as a reminder that using larger amounts of water has the added impact of higher charges. The reason for the nominal tariff difference is that the higher the second tier tariff, the lower the first tier tariff must be, if revenue neutrality is to be achieved and maintained. Revenue neutrality means that after the tariff change the same amount of revenue is collected as before, without considering the effects of the tariff changes. When the first tier is set at a very affordable tariff and the second tier is a tariff applied to, say, 80 percent or more of the total volume billed (expected revenue), there is no effective efficiency incentive. This is because two tier rates leave little opportunity to encourage water conservation by high users since most users are in the second tier and the first tier.

(c) Structures of three tiers or more

A tariff structure of three or more tiers provides an opportunity to directly address users of very high amounts of water. The higher (third, fourth) blocks are usually set at the levels of water use related to certain percentages of the total accounts (e.g., the top 10 or 20 percent) or the percentage of water use in those customer groups, with a view towards discouraging discretionary usage at these levels. Proponents of this type of tariff structure argue that this structure promotes economic efficiency by charging tariffs that more nearly reflect the costs of peaking to those who cause the need for peak capacity. A third or fourth tier gives an opportunity to charge more and encourage conservation by the high users.

The third and fourth tiers are generally set at 15–20 percent above the prior tier. Sometimes the top tier is set very high to discourage peak water use if meeting a peak demand is a particular problem (e.g., if a utility would have to build an expensive new water supply project or expand a water treatment plant). Given the selection of fixed percentage relationships between tiers, consistent revenue can be derived with adequate consideration to price responsiveness in the upper tiers, if applicable.

Seasonal tariffs

A seasonal tariff is commonly applied during the dry season to encourage efficient irrigation practices and relieve peak water demands. Seasonal tariffs can use either of the structures discussed above. The distinguishing feature is that the tariff in the dry or peak season can be (and usually is) different to that used in the wet season. In some cases, a multi-tier structure is used in the dry season and a single tier in the wet months. In other cases, multi-block tariffs are used during the entire year but with elevated tiered tariffs or surcharges in the dry season.

In still other instances, a three-tier structure is used with the same tariffs during the entire year. The logic of this alternative is that the tariffs are set such that the higher tiers are not effectively applied during the off-peak water demand months. Another variation of the seasonal tariffs is to apply the peak tariffs only to water used in the dry season that is in excess of wet season use, so that the consumer must consider the economics of the most discretionary water use. Proponents of these tariff structures argue that they discourage wasteful water use and promote efficiency.

Billing cycle

For water supply tariffs to form an effective deterrent to wasteful water use, it is not enough for the tariff structure to be designed to have an impact on the potentially wasteful customer categories; the deterrent prices must also be effectively communicated to customers so that informed choices can be made on whether or not to use the water. There are two important aspects with regard to the communications side of this equation:

(a) The shorter the billing cycle, the more frequent the reminder to customers of the cost of water. Where there is a chronic shortage of water, utilities can move to monthly meter reading and billing. During prolonged drought periods, monthly billing takes on even greater importance. Quarterly billing, in contrast, affords minimum communication with customers and defeats the purpose of efficiency tariffs. For example, a higher bill for the dry season might have been sent to customers during the wet season;

(b) The bill presented to water users should clearly show the amount and cost of water used in prior periods separately from wastewater, garbage collection and other charges.

Integration of efficiency and tariffs

Water prices should never be used as the prime mover for reduced water use, for the following reasons:

(a) In the case of interior water use, which is largely non-discretionary, many customers are unlikely to engage and persevere in water-saving habits such as shorter showers, fewer number of toilet flushes, larger laundry loads, and so on. The more efficient water-preserving approach is to install fixtures that will ensure water savings. It might be argued that higher water prices will prompt the use of efficient fixtures, but experience with attempts to reduce interior water use through pricing alone suggests that utility education programmes stressing the necessity for water savings and give-away/rebate programmes are more effective. In addition, it is difficult to increase water prices for interior water use and to maintain volumetric revenue neutrality. In other words, higher prices for interior water use are not realistic;

(b) In a two-tier tariff structure, there is little latitude for setting a high second-tier tariff without driving down the first-tier tariff or changing the balance between fixed and volumetric derived revenue. Consequently, in using a two-tier tariff structure, outside water use cannot be effectively addressed with tariffs, even with differentials for dry/wet-season use patterns. It is more effective to engage in efficiency programmes related to landscape design, irrigation methods and practices, and incentives for reductions in use, rather than to rely only on water pricing to obtain water-use efficiency improvements;

(c) By using a tariff structure of three or more tiers, the high end users can be targeted with penalty water tariffs for assumed wasteful water use. This can affect the top 5–10 percent of customers with the highest water usage tariffs. However, the majority of customers receive bills for unchanged or lower amounts. In the end there can be some conservation effect in the top tier but relatively little volume ends up being affected.

Recommended approach

Price should be an important factor in any comprehensive efficiency effort because of the broad-based support it gives to the overall efficiency programme. An 'efficiency tariff structure' should be multi-tiered, with preferably at least three tiers, because:

(a) Having a three-tier pricing structure provides a method that a water supply utility can use in times of crisis to manipulate, on a temporary basis, setting higher tariffs aimed at inducing large reductions in water use;

(b) An efficiency tariff structure provides a constant reminder to customers that water is a precious commodity, and that higher the amount of water used, the higher will be the water bill;

(c) Implementing an efficiency tariff structure should be accompanied by the shortest billing cycle practicable, and not longer than bi-monthly, so that the impact of recent water use and its cost can be adequately conveyed to customers.

6.2 WATER EFFICIENCY MEASURES FOR CUSTOMERS

How to determine the key opportunities for customers to be more efficient are reviewed in this Section.

6.2.1 Developing a list of alternative evaluation measures

As part of the evaluation of appropriate measures, compile a list of potential demand management measures that may be appropriate for the area. This process generally yields over 100 potential efficiency measures in the following typical customer categories: (a) domestic; (b) commercial; (c) industrial; (d) public (institutional); and (e) irrigation.

A measure is distinguished from a device that saves water or an overall programme by using the definitions listed below.

(a) Device

This is a physical item of hardware, such as a new showerhead or toilet, or specific action taken by individuals, such as commercial audits, that save water if the recommendations are implemented or carried out by a water utility or other group.

(b) Measure

This is a device plus a implementation method and possibly an incentive, such as a rebate or ordinance (regulation), targeted at a particular type of end user that, when implemented, will save water.

(c) Programme

This is a set of one or more measures targeted at one or more customer categories, and managed by a water utility as a separate project.

(d) Plan

A plan is a set of one or more programmes together with an estimated budget, schedule and staffing plan. In addition, planners can create a strategy or programme for a measure that puts devices or messages into the hands of customers and allows them to take action.

6.2.2 Water efficient devices, fixtures and fittings

(a) Codes and standards

There are various approaches to making existing and new buildings more water efficient. One method is to incorporate requirements for efficient plumbing fixtures and appliances into building codes. Efforts to develop an international code for energy efficiency led to the development of the International Plumbing Code as one of many standardized codes. A number of countries are at various stages of adopting the International Plumbing Code. Copies are available from the International Code Council at web site: http://www.iccsafe.org/Pages/default.aspx (last accessed April 18, 2013)

In the United States and in other countries local jurisdictions often adopt the plumbing and mechanical codes developed by the International Association of Plumbing and Mechanical Officials (IAPMO). Information is available at http://www.iapmo.org/pages/default.aspx (last accessed on June 2, 2013). In 2012 they published a Green Code Plumbing and Mechanical Code Supplement available at http://iapmomembership.org/index.php?page=shop.product_details&flypage=flypage_iapmo.tpl&product_id=4&category_id=6&option=com_virtuemart&Itemid=3 (last accessed on June 2, 2013).

This supplement incorporates many sustainability concepts including more aggressive water conservation than required by most local codes.

In the United States, most regulations on water efficiency that pertain to buildings are the result of efforts to make buildings more energy efficient. When the Federal Energy Policy Act was passed in 1992, the water-related provisions of the Act consolidated a patchwork of individual state regulations on water efficient fixtures and appliances. By requiring standard flow tariffs and flush volumes for manufacturing plumbing units, the Act controlled not only fixtures in new construction but also those in the replacement market. The specific requirements for manufactured fixtures are summarized in the Case Study at the end of this chapter. These provisions of the United States Energy Policy Act are available at http://www1.eere.energy.gov/buildings/appliance_standards (last accessed on April 18, 2013)

(b) Available devices and appliances

Available water efficient fittings and fixtures (together with other devices) have been researched and evaluated for cost, possible water efficiency value, and legal status if appropriate. Sources of information on devices and appliances include: (a) the *Handbook of Water Use and Conservation* by A. Vickers, published in 2001; (b) the *Memorandum of Understanding Regarding Urban Water Conservation in California* published by the California Urban Water Conservation Council in 2008, which contains a list of best management practices; and (c) *Best Management Practice (BMP) Cost and Savings Study* (Chestnutt, 2005).

Table 6.3 provides a summary of devices. Demand reductions and costs shown need to be checked against local water-use patterns and costs; however, an approximation should be given of the level of savings and costs that can be expected. Actual savings vary with household size, current devices or technology in use, portion of water used in the landscape area and so on.

Table 6.3 Example list of water efficient devices by category.

Device	Flow rating[a]	Estimated cost in the United States (US$)			Device life (years)[a]	Demand reduction (L/conn/d)[b]
		Purchase cost ($)	Installation cost ($)	Additional annual cost[a]($)		
Bathroom						
Ultra low-flow showerhead	6.8 L/min	10–90			5–10	40[c]
Low-flow showerhead	9.5 L/min	10–90			5–10	20[c]
High efficiency faucet	6 L/min	30–90	50		15–20	15
Flow flow control device	8.3 L/min	2			10	20
Low flow faucet aerator	8.3 L/min	5–10			5	5
Ultra low flow faucet aerator	1.9 L/min	5–10			5	20
Toilets						
Squat-pour toilets	1 L/flush	50	100		30–40	150[d]
Ultra high efficiency toilet	3 L/flush	150–300	200		30–40	125[d]
High efficiency toilet	5 L/flush	200–600	200		30–40	100[d]
Six-litre toilets	6 L/flush	100–300	200		30–40	90[d]
Dual flush toilets	6/3 L/flush	200–400	200		30–40	105[d]
Water dam devices	1 L/flush	5			5	10[d]
Composting toilets	0 L/flush	2000	500	200	20+	160[d]
Kitchen						
Kitchen faucet	6.8 L/min	40–300	50		10–15	10
Faucet aerator	8.3 L/min	5–10			5	3
Dishwasher (domestic)	18 L/wash	300–900	200		10–15	20
Laundry						
Faucet aerators	8.3 L/min	5–10			5	2
Efficient washing machines	56 L/wash	750–1100	100		10–15	60
General household						
On-demand or point-of-use hot water systems	24–35 L/min	900–1300	200–400		20+	15
Household pressure reducing device	414 kPa	50	200		20+	10
Greywater systems		>3000	>400		15–25	80

(*Continued*)

Table 6.3 Example list of water efficient devices by category (*Continued*).

Device	Flow rating[a]	Estimated cost in the United States (US$)			Device life (years)[a]	Demand reduction (L/conn/d)[b]
		Purchase cost ($)	Installation cost ($)	Additional annual cost[a] ($)		
Landscaping						
Drip systems		50–100	10–50		10	20
Micro-spray systems		50–100			10	10
Faucet timers		20–50	0–100		5–10	20
Rainwater tanks		1000[f]	4000		20+	40
Trigger shut-off valves on hoses		10–15			5	5
General commercial equipment (other than above measures)						
Waterless urinals	0 L	500	300	150–200[e]	20+	80[g,h]
Ultra high efficiency urinal	0.5 L/flush	300–500	100–400		20+	70[g,h]
Efficient urinal	1.9 L/flush	200–450	100–400		20+	60[g,h]
High efficiency flush valve toilet	5 L/flush	450–700	100–400		20+	800[g]
Dual flush toilets	6/3 L/flush	300–400	200–400		20+	100[g]

[a] Where applicable.
[b] Demand reduction is given in units litre per connection per day (Litre/conn/day). Assumed 2.5 persons per connection.
[c] Based on comparison with 11 litre/minute shower.
[d] Based on comparison with 13 litre flush.
[e] Based on 3–4 cartridges/year (at US$50/cartridge).
[f] A 550-litre tank with small elevated stand.
[g] Per device.
[h] Replacing 8-litre urinals & 13 litre toilets, assume10 flushes/day.

Several conservation survey type measures are illustrated in Figures 6.5–6.7.

Figure 6.5 Conducting a residential audit and checking shower flow rate. *Source*: Maddaus Water Management (1995).

Figure 6.6 Conducting a commercial water audit and checking toilet flush volume. *Source*: Maddaus Water Management (2005).

Figure 6.7 Recording data from a landscape water survey (catch can test) and entering data into a tablet computer to save time and increase accuracy. *Source*: Maddaus Water Management (2013).

6.3 MEASURE SCREENING PROCESS

The list of alternative measures is normally very long. Therefore, a screening process is useful for reducing the number of measures that need to be seriously considered. Each potential measure should be screened based on non-quantifiable criteria. These criteria could include:(a) technology/market maturity; (b) service area matching; (c) customer acceptance/equity; and (d) best available measure.

(a) Technology/market maturity

This criterion indicates whether the necessary technology is available commercially and supported by the local service industry. For example, a device may not pass the screening if it is not yet commercially available in the region.

(b) Service area match

This criterion seeks to distinguish the technology that is appropriate to an area's climate, type of end uses, building stock or cultural uses of water (lifestyle). For example, low water-use landscape measures for commercial sites may not be appropriate where customer water-use analysis indicates minimal irrigation in the service area.

(c) Customer acceptance/equity

If customers are unwilling or do not have the ability to implement measures, market penetration (and thus water savings) will be insignificant and probably not cost effective. Customer acceptance may be based on convenience, economics, perceived fairness, culturally acceptable practices, aesthetics or environmental values. Measures should also be equitable in the sense that one category of customers should not benefit while another category pays the costs without receiving the benefits.

(d) Best available measure

If a choice must be made between two or more measures of equal effectiveness for the same targeted end use, then the more appropriate measure (due to, e.g., ease of implementation or lower unit cost) will pass the screening.

The above criteria can be scored on a scale of 1 to 5, with 5 being the most acceptable. Measures with low scores should be eliminated from further consideration, while those with high scores can be passed onto the next evaluation phase (cost-effectiveness analysis).

6.3.1 Suggested menu of water efficiency measures

A list of more than 90 specific measures is provided in Appendix 3. The list can be used as a starting point, and planners can add or delete measures using the resources detailed above.

6.3.2 Example of a screening process

The example measures listed in Appendix 3 supports this chapter. Once planners have settled on their list of measures, then the measures can be rated on a scale of 1 to 5 as shown in Table 6.4. Generally, the measures should be eliminated if they score mostly 1 or 2. The screening is qualitative and subjective and should therefore be carried out jointly by the project team in order to achieve a consensus, since each team member is likely to interpret and score measures differently. The objective is to reduce the list to about 20 to 30 measures that pass the screening, (that is, they have relatively high scores). In general, each measure needs to have total score of 17 or more points in the total rating in order to pass the screen.

A measure screening workshop is often held with local stakeholders as presented in Figure 6.8.

Table 6.4 Example of the matrix for initial screening of water-use efficiency measures.

Device	Distribution method	Possible incentive	Screening criteria[a]				Total score	Pass[c]
			Technology/ market maturity	Service area match	Customer acceptance/ equity	Better measure available[b]		
Domestic interior								
Domestic water audits	Water utility to provide	Free. Optional retrofit kit.	4	5	4	5	18	Yes
Install retrofit kits	Water utility to offer with bill or through audit	Water utility installs	4	4	4	4	16	No
Retrofit-on-resale (regulation)	Water utility regulation	Enforcement	2	3	2	3	10	No
Showers								
Shower regulation	Water utility to pass a regulation	Enforcement	4	5	3	5	17	Yes
New fixed head	Customer purchase	Free; coupon	4	5	4	5	18	Yes

Source: Maddaus, W. and Maddaus, L. (2006) 'Manual of Practice M52, Water Conservation Programs – A Planning Manual', American Water Works Association.
[a]On a scale of 1 to 5, with 5 being the most acceptable.
[b]Compared to measures that target the same end use.
[c]Passes screening.

Figure 6.8 Conducting a Measure Screening Workshop. *Source*: Maddaus Water Management (2006).

CASE STUDY 8

Water Use Reduction in Public Schools, São Paulo, Brazil

Reviewed by Noa Uni, Global Marketing Director, Miya Water Corporation, Tel Aviv, Israel

Companhia de Saneamento Básico do Estado de São Paulo S.A (SABESP) is one of the largest water and sewage service providers in the world. It services a population greater than 25 million with 7.1 million service connections. The goal of the project was to reduce long-term water consumption among 671 public schools in the São Paulo Metropolitan Region by 10%. SABESP contracted with BBL, a Miya company for this project that was completed between August 2008 and May 2011. See Figures 6.9–6.11.

Figure 6.9 Original standard taps. *Source*: Miya Corporation.

Figure 6.10 Replacement of automatic shut-off toilets. *Source*: Miya Corporation.

Figure 6.11 Miya's experts visitng one of the schools in the program. *Source*: Miya Corporation.

Project description

Short-term reductions of water consumption were targeted through:

- High efficiency toilets
- Automatic taps
- Leak detection services and leak repairs
- Infrastructure maintenance

Long-term water savings were tied to a program of training the student bodies and school teaching staff in water awareness and water conservation techniques.

Water consumption reduction measures

- Engineering analysis:
  - Implementation and review of District Metered Area boundaries
  - Plumbing services inspection
  - Action plan for each school
- Pipe leak detection and repair
- Installation of low consumption toilets
- Refurbishing of toilets that were not replaced
- Automatic shut-off taps installed – thereby effectively eliminating waste water due to taps being left open.
- Monitoring and water consumption management

Training

- Teachers and school supervisors:
  - Water Conservation Techniques
  - Environmental issues
- Students:
  - Water usage and conservation
  - Responsible best practices and habits

Results

- Water consumption decreased by 30% within 12 months of the end of the project. The project therefore was three times more successful than the original goal, and this success was achieved almost immediately.
- Monthly averages of 123,514 m^3 of water was saved during the life of the project
- A major change in the attitude of the students, from indifference to responsible awareness occurred
- Return on Investment (ROI) was achieved within 15 months

More examples are available online: http://www.miya-water.com/our-experience/case-studies

CASE STUDY 9

National, State, and Local Municipal Codes and Regulations and Appliances and Plumbing Fixtures, United States

Maddaus Water Management

In the United States, there can be several layers of plumbing and appliance codes, national, state, and local. Below is such an example, from a water stressed area along the California coast.

National plumbing code

The United States Federal Energy Policy Act of 1992, as amended in 2005 requires only fixtures meeting the following standards can be installed in new buildings:

- Toilet – 6 litre/flush maximum
- Urinals – 3.75 litre/flush maximum
- Showerhead – 9.4 litre/min at 552 kPa
- Domestic Faucets – 8.25 litre/min at 414 kPa
- Public Restroom Faucets – 1.88 litre/min at 414 kPa psi
- Dishwashing pre-rinse spray valves – 6 litre/min at 414 kPa

Replacement of fixtures in existing buildings is also governed by the Federal Energy Policy Act that requires only devices with the specified level of efficiency (shown above) can be sold today The net result of the plumbing code is that new buildings will have more efficient fixtures and old inefficient fixtures will slowly be replaced with new more efficient models. The national plumbing code is an important piece of legislation and must be carefully taken into consideration when analyzing the overall water efficiency of any service area, especially a community significant indoor water demands.

In addition to the plumbing code, the United States Department of Energy regulates appliances such as domestic clothes washers and dishwashers. Regulations to make these appliances more energy efficient has driven manufacturers to dramatically reduce the amount of water these efficient machines use. Generally, front loading horizontal axis washing machines use 30 to 50 percent less water than conventional models (which are still available). Planners usually forecast a gradual transition to high efficiency clothes washers (using 71 litres or less) so that by the year 2020 this will be the only type of machines purchased. In addition to the industry becoming more efficient, rebate programs for washers have been successful in encouraging customers to buy more water efficient models. Given that machines last about 10–15 years or less eventually all machines in a given service area will be of this type.

More details can be found at: http://www1.eere.energy.gov/buildings/appliance_standards (accessed on April 18, 2013)

State plumbing code

An example of a state plumbing is California where the new Code of California Regulations Title 20 California State Law (Assembly Bill 715) requires High Efficiency Toilets with less than 4.8 lpf and High Efficiency Urinals with less than 1.875 lpf be exclusively sold in the state by 2014.

In addition, California adopted a new plumbing code called 'CalGreen' effective January 2011 that affects all new buildings and remodeling with a permit built after that date. This would impact all new buildings built in California going forward. After CalGreen was adopted at least one other Code body, IAPMO, adopted similar provisions in an updated code, see Green Building Supplement above. Table 6.5 summarizes these state requirements.

Table 6.5 CalGreen plumbing code requirements (State of California, United States).

Component	Effective date	Indoor fixtures included	Indoor requirement	Landscaping & irrigation requirements	Are the requirements mandatory?
Indoor	1/1/2011	Toilets, Showers, Lavatory & Kitchen faucets, Urinals	Achieve 20% savings overall below baseline	Not applicable	Yes
Outdoor	1/1/2011	Not Applicable	Not applicable	Provide weather adjusting irrigation controller	Yes
Indoor	1/1/2011	Submeter leased spaces	Only if building > 4,645 sq. m. & if leased space use > 380 lpd	Not applicable	Yes
		Toilets, Showers, Lavatory & Kitchen faucets, Metering Faucets, Urinals	Achieve 20% savings overall below baseline	Not applicable	Yes

(*Continued*)

Table 6.5 CalGreen plumbing code requirements (State of California, United States) (*Continued*).

Component	Effective date	Indoor fixtures included	Indoor requirement	Landscaping & irrigation requirements	Are the requirements mandatory?
Outdoor	1/1/2011	Not applicable		Provide water budget	>93 sq m. landscaped area
			Not applicable	Separate meter	As per Local ordinance
				Prescriptive landscaping requirements	>93 sq m. landscaped area
				Weather adjusting irrigation controller	Yes

[i] Effective date is 7/1/2011 for toilets.

Local county, city or utility municipal codes

A Municipal code can also contain water efficiency criteria that go over and above state and federal codes. One example of a Municipal Code in California is listed below:

- 4.8 litre per flush maximum toilets
- 0.47 litre per flush maximum urinals
- 5.63 litre per minute showerheads
- 1.875 litre per minute lavatory faucet aerators
- Hot water circulating pumps
- Clothes washers with water factors of no greater than 4.0

Adapted from: Maddaus Water Management (2013).

CASE STUDY 10

The Portuguese System of Certification and Labeling of Water Efficiency of Products, Associação Nacional Para a Qualidade Nas Instalações Prediais, Portugal

Reviewed by Noa Uni, Global Marketing Director, Miya Water Corporation, Tel Aviv, Israel

An efficient water cycle in buildings can be summarized by analogy with the 3R principle (used for waste) through a 5R principle: Reduce consumption, Reduce losses and wastes, Reuse water, Recycle water and Resort to alternative sources (rainwater, saltwater, etc.). Reducing consumption is the first priority, involving, in addition to consumer awareness, the promotion of efficient products.

With this objective in view, the ANQIP (Associação Nacional para a Qualidade nas Instalações Prediais) decided in 2008 to launch a voluntary certification and labeling system for water efficiency of products.

ANQIP (www.anqip.pt) is a Portuguese non-profit association, whose members include several universities, firms from the sector, water management authorities and self-employed technicians, whose basic aim is to promote water efficiency in buildings. This system was the first of its kind in Europe.

Figure 6.12 presents the labels used, where ‘A’ signifies the greatest efficiency and is considered ideal. The A+ and A ++ ratings are meant for special or regulated applications. The system also takes into account the user-friendliness and performance of the devices in question.

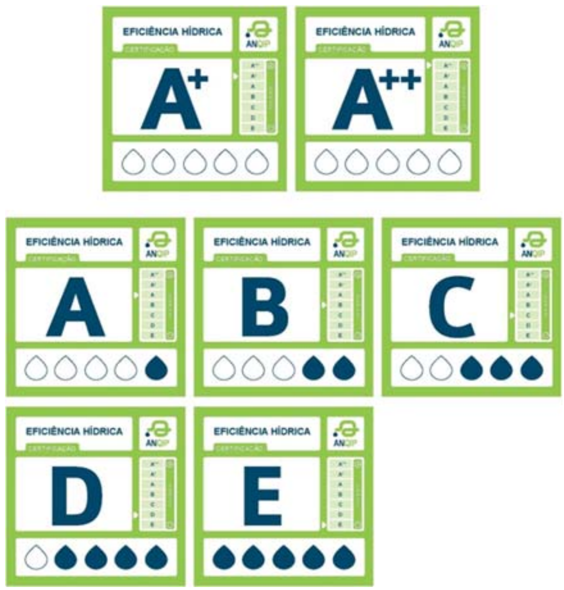


Figure 6.12 Portuguese water efficiency labels *(ETA 0803, ANQIP, 2008)*.

ANQIP has drawn up Technical Specifications (ETA) for different products so as to create and establish the necessary benchmark values to be assigned to each letter. These Technical Specifications also establish the certification testing conditions.

Firms signing up to the system will sign a protocol with ANQIP which will define the conditions under which they can issue and use the labels. ANQIP controls the process by randomly testing labeled products on the market, from time to time. These tests are performed by accredited laboratories or by laboratories which are recognized by the Association.

Table 6.6 presents the categories defined in the Technical Specification ETA 0804 for flushing cisterns. The use of low volumes is limited for technical and health reasons. The use of 4-litre flushing cisterns, for example, can lead to problems in the drainline transportation in Portugal. Therefore, their usage requires an alteration of the usual criteria of the design of the drainage system. Furthermore, it must be ascertained if the discharge volume is compatible with the characteristics of the toilet.

Based on these facts, ANQIP established low volume flushing cisterns belonging to water efficiency categories A+ or A++, but with the obligation that the label warn users of the need to ensure the performance of the system and compatibility of the drainage conditions in the building system (Figure 6.13).

Shower systems and showers represent over 30% of the daily average domestic water consumption volume in Portugal. At this level, efficiency reduces both water consumption and the consumption of energy required for the production of hot water. The classification of these devices considers the shower heads (showers), individually, and the shower taps equipped with a hose and a shower head or with a fixed shower head (shower systems).

Table 6.6 Water efficiency categories for the labeling of flushing cisterns *(ETA 0804, ANQIP, 2008).*

Nominal volume (Litres)	Type of flush	Water efficiency rating	Tolerance (maximum volume–complete flushing)	Tolerance (minimum volume for water-saving flushing)
4.0	Dual control	A++	4.0–4.5	2.0–3.0
5.0	Dual control	A+	4.5–5.5	3.0–4.0
6.0	**Dual control**	**A**	**6.0–6.5**	**3.0–4.0**
7.0	Dual control	B	7.0–7.5	3.0–4.0
9.0	Dual control	C	8.5–9.0	3.0–4.5
4.0	Interruptible	A+	4.0–4.5	–
5.0	Interruptible	A	4.5–5.5	–
6.0	Interruptible	B	6.0–6.5	–
7.0	Interruptible	C	7.0–7.5	–
9.0	Interruptible	D	8.5–9.0	–
4.0	Complete	A	4.0–4.5	–
5.0	Complete	B	4.5–5.5	–
6.0	Complete	C	6.0–6.5	–
7.0	Complete	D	7.0–7.5	–
9.0	Complete	E	8.5–9.0	–

Figure 6.13 Examples of water efficiency labels for low volume flushing cisterns, with special warnings *(ANQIP. ETA 0804, 2008).*

For shower systems and showers, the model implemented considers the ideal usage (letter A) to represent a water usage of between 5.0 (L/min) and 7 (L/min). The A and A+ labels applied to shower heads with a discharge which is 5 (L/min) or less must bear the indication 'Recommended for usage with thermostatic taps', due to the increased risk of scalding. Table 6.7 presents the various efficiency categories for showers and shower systems.

Table 6.7 Water efficiency ratings for the labeling of showers and shower systems *(ETA 0806, ANQIP, 2009).*

Discharge (Q) (L/min)	Showers	Shower systems	Shower system with a thermostatic tap or an eco-stop function	Shower system with a thermostatic tap and an eco-stop function
$Q \leq 5$	A+	A+	A++ (1)	A++ (1)
$5.0 < Q \leq 7.2$	A	A	A+	A++
$7.2 < Q \leq 9.0$	B	B	A	A+
$9.0 < Q \leq 15.0$	C	C	B	A
$15.0 < Q \leq 30.0$	D	D	C	B
$30.0 < Q$	E	E	D	C

Taps are the most common device, both in homes and in collective facilities. In an average home, there are at least 3 to 5 taps installed in the kitchen and bathrooms. In the case of bathroom taps (in homes), the model which is currently being studied considers ideal usage (label A) to be a level of water consumption of 2.0 (L/min). For kitchen taps, the model considers ideal usage (label A) to be a level of water consumption of 4.0 (L/min).

Kitchen taps with a discharge of under 4 litres per minute and bathroom taps with a discharge of under 2 litres per minute (in homes) must bear a label with an advisory note recommending that they be utilised only with an aerator or similar. Tables 6.8 and 6.9 presents the various efficiency categories for taps.

Table 6.8 Water efficiency ratings for the labeling of bathroom taps (in homes) *(ETA 0808, ANQIP, 2010).*

Discharge (L/min)	Bathroom taps	Bathroom taps with an aerator or an eco-stop function	Bathroom taps with an aerator and an eco-stop function
$Q \leq 2.0$	A	A+	A++
$2.0 < Q \leq 4.0$	B	A	A+
$4.0 < Q \leq 6.0$	C	B	A
$6.0 < Q \leq 8.0$	D	C	B
$8.0 < Q$	E	D	C

Table 6.9 Water efficiency ratings for the labeling of kitchen taps *(ETA 0808, ANQIP, 2010)*.

Discharge (L/min)	Bathroom taps	Bathroom taps with an aerator or an eco-stop function	Bathroom taps with an aerator and an eco-stop function
$Q \leq 2.0$	A	A+	A++
$2.0 < Q \leq 4.0$	B	A	A+
$4.0 < Q \leq 6.0$	C	B	A
$6.0 < Q \leq 8.0$	D	C	B
$8.0 < Q$	E	D	C

Over 70% of the companies operating on the Portuguese market have adopted the system and more than 300 products labeled are now available.
Source: Personal communication, Armando Silva-Afonso (2013).

CASE STUDY 11
An End-Use Study About the Comfort in the Use of Water Efficient Showerheads

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Nowadays, the use of efficient water using products is a matter of growing importance, due to the unsustainable use of the potable water at a global level. However, the reduction of flow in showers and taps could be sensitive to the users, in terms of comfort.

The comfort in the use of showers depends on several factors, but are not known, however, many studies on this issue. WaterSense, for example, considers essentially, as factors of comfort, the strength of the spray and the coverage of the spray, by setting the performance to be followed in each of these parameters on the basis of user data. Other studies refer comfort parameters such as the spray pattern (spray distribution), the water temperature (vertical temperature profile), the skin pressure (velocity of the spray), the effectiveness in washing away the soap and shampoo, the controllability, and so on.

In order to measure the effect of flow restrictors in existing showerheads, ANQIP (the Portuguese association for water efficiency in buildings) lead a study in a student residence at a University, looking to know the minimum flow for comfort, relating to gender of users and duration of the bath. As is evident, the results of this study cannot be extrapolated in general, as they are function of the type of existing showers and of its characteristics.

The study involved 16 persons, 8 males and 8 females, and each user was asked to record the flow that use commonly for showering (Q_{usual}) and to carry out a progressive reduction (around one liter per minute and per day) of the flow rate on subsequent days, until it finds a minimum value of comfort ($Q_{min.comf.}$). To this end it has been provided a simple flow meter. The data collected are summarized in Table 6.10.

The average values obtained are presented on Table 6.11. The more relevant conclusion of the study is the fact that, from a certain value, the duration of the shower increases with the reducing of the flow rate, what means that the reduction in the water volume used on the shower does not follow the reduction of the flow, so that the savings may not be as significant as expected, and also leading to the conclusion that, for each type of shower, exists probably a 'break point', that is, a point at which the flow rate reduction is not translated into water efficiency.

Table 6.10 ANQIP study data.

Person	Age	Sex	Q_{usual} (L/min)	Duration (min)	$Q_{min\cdot comf.}$ (L/min)	Duration (min)
1	22	F	11	4	7	5
2	23	F	10	15	5	13
3	22	F	10	9	6	8
4	24	F	9	10	5	12
5	21	F	8	7	4	8
6	20	F	9	8	6	7
7	19	F	10	5	7	6
8	23	F	10	8	7	10
9	20	M	11	5	8	6
10	22	M	12	4	7	6
11	23	M	10	6	6	5
12	21	M	9	7	6	6
13	19	M	10	5	7	7
14	22	M	11	8	9	7
15	24	M	8	4	6	7
16	23	M	10	6	7	9

Table 6.11 ANQIP study result.

		Q_{usual} (L/min)	Duration (min)	$Q_{min.conf.}$ (L/min)	Duration (min)
Averages	F	9625	825	5875	8625
	M	10,125	5625	7	6625

From the analysis of Table 6.11 it can be concluded that is the male that usually uses a higher flow in the shower and that also requires a greater flow of comfort. In terms of duration of the shower, the values are higher for females in any case. It may be noted (from Table 6.10) that, for female, the minimum average flow of comfort required in the shower was 4 L/min and, for males, was 6 L/min, although these values does not satisfy all individuals.

In terms of consumed volumes (flow x duration of showering) the Table 6.12 presents the usual volumes and the volumes of minimum comfort for each person. Looking at the Table it can be seen that the minimum and maximum usual volumes used by females are, respectively, 44 L and 150 L. In respect to the volumes of minimum comfort considered, the minimum value is 32 L and the maximum is 70 L.

Table 6.12 Volumes consumed in shower (usual and min. comfort).

Person	Age	Sex	V_{usual}	$V_{min.conf.}$	Person	Age	Sex	V_{usual}	$V_{min.conf.}$
1	22	F	44	35	9	20	M	55	48
2	23	F	150	65	10	22	M	48	42
3	22	F	90	48	11	23	M	60	30
4	24	F	90	60	12	21	M	63	36
5	21	F	56	32	13	19	M	50	49
6	20	F	72	42	14	22	M	88	63
7	19	F	50	42	15	24	M	32	42
8	23	F	80	70	16	23	M	60	63

Source: Personal Communication, Armando Silva Afonso (May 2013).

Linking these two analyses, it can be noted that it is the female who consume more water in showers. In any case, the reductions are significant because, in females, the average volumes fell from 80 L/shower for 50 L/shower (37.5% decrease) and, in males, decreased from 57 L/shower to 46 L/shower (reduction of about 20%). Overall, the usual shower corresponds to an average of 68.5 L/shower and the minimum comfort value corresponds to 48 L/shower, which translates into an effective reduction potential of 30%.

Linking these two analyzes, it can be noted that it is the female who consume more water in showers. In any case, the reductions are significant because, in females, the average volumes fell from 80 L/shower for 50 L/shower (37.5% decrease) and, in males, decreased from 57 L/shower to 46 L/shower (reduction of about 20%). Overall, the usual shower corresponds to an average of 68.5 L/shower and the minimum comfort value corresponds to 48 L/shower, which translates into an effective reduction potential of 30%.

Chapter 7

Evaluating Cost Effectiveness of Water Efficiency Measures

This chapter provides an overview of the basic methodology and key considerations for a cost-effectiveness evaluation of water efficiency measures, using a net present value benefit-cost analysis. The analysis is based on the benefits (cost savings) gained by the water utility being greater than the costs to the water efficiency programme. The following discussion highlights the central concepts and general methodology for conducting the evaluation to determine the optimal water efficiency measures.

Detailed instructions for a cost-effectiveness evaluation are provided in Appendix 4 and the software available to download to accompany this guidebook. The software contains a Microsoft Excel Workbook, which is programmed to perform a simplified benefit-cost analysis. After reading this chapter, it is suggested that planners explore the preparation of cost-effectiveness evaluations using the accompanying software.

7.1 APPROACH TO BENEFIT-COST ANALYSIS

The outcome of a cost-effectiveness evaluation of specific water efficiency measures will be quantified water savings and cost estimates for implementing an economically feasible water efficiency programme. This evaluation will help planners refine the water efficiency plan to the optimal design by identifying those measures that will provide the greatest benefit to the utility.

It is imperative that planners keep the overall water saving goals of the programme in mind when evaluating benefits and costs. Some measures may have highly favourable benefit-to-cost ratios (much greater than 1.0), but not very high estimated water savings. In other words, if measures are selected on an economic basis only, the programme may not be successful in achieving the water savings goals. The programme expenditures need to be for those measures that will have a benefit-to-cost ratio higher than 1.0 and which will meet the water savings targets.

Once the measures have been initially determined as feasible (as discussed in Chapter 6), the next critical step is to assess the benefits and costs to the utility from each measure. Planners must evaluate the economics of a proposed efficiency programme prior to undertaking implementation to ensure that the water efficiency plan is well designed. For an efficiency plan to be feasible, the total economic benefits (water supply and treatment costs due to water savings) must be greater than the total costs of implementing all of the efficiency measures.

Certain key measures, such as public information, are critical to the success of any plan and are included in the final water efficiency plan even though the implementation costs are often more than the quantifiable (direct) economic benefits (cost savings). In addition, information gained from evaluating the benefits and costs of the programme will assist in communicating the need for the programme to customers and policy/decision makers.

7.2 BASIS FOR BENEFIT-COST ANALYSIS

Having assessed the benefits and costs of a programme, a utility planner will be able to identify beneficial measures for implementation. Comparing economic impacts of different implementation strategies for the same measure will also help determine an economically feasible course of action when delivering these measures to customers. A benefit-cost analysis provides a direct comparison of the value of the water demand reduction from specific measures with that of the additional water supplies that would otherwise be needed (such as building a new water storage reservoir, increasing the existing system supply capacity, etc.) either to accommodate increases in demand or successfully manage long-term water supply shortages.

7.2.1 Responsibility of the efficiency programme manager

The duty of an efficiency programme manager is to focus the evaluation on the following key objectives or outcomes:

(a) **Provide detailed documentation and defensible, referenced data for costs and benefits**
This is a critical objective, as it will enable an efficiency programme manager to justify measures when questioned on the projected outcomes by policy/decision makers and the public. Some information may not be available or assumptions may have to be made about data; these should be noted and openly discussed with decision makers. These data gaps may possibly be filled with research from pilot programmes as the water efficiency programmes begin.

(b) **Ensure clarity and consistency in accounting perspective**
Benefits that are specific to the audience being evaluated need to be explained carefully and accurately (subject to data availability). Benefits to the water supply utility are compared only to the costs to that utility.

Benefits to the customers are compared only to the costs to those customers. Full societal costs are accounted for as costs accrued to the utility or customers, as appropriate.

If a financial incentive is to be given to customers, this is viewed as a benefit from the customer perspective. However, a subsidy provided to customers is a cost from the utility perspective. All details on what is considered a cost or benefit should be well documented.

(c) **Verify that customers have an interest in voluntary programmes or can have mandated participation in programmes being proposed**
One mistake can be copying a practice from another community and assuming that it will be equally or more successful in a different community without consideration of local demographics, community patterns of water use, or local laws and regulations that may need to be added or changed. If time permits a survey can be done or a small pilot program run to verify that the measure will work in the community. A ten step guide to creating a successful pilot project is provided in Chapter 9.

(d) **Establish a baseline water demand and a tracking mechanism for water efficiency activities that should be put in place prior to beginning the programme**
Reviewing what water demand reductions have occurred can be challenging, especially when a lack of records for the type of measure, number of installations or events, and dates are unavailable. This missing information leads to a lack of documented water savings and credibility of programme successes, and ultimately may lead to a curtailment in funding. In addition, if adjustments to the

programme are needed, analysis of this data will prove useful to making suggestions for improving the programme.

(e) **Provide adequate staffing for implementation, tracking and follow-on analysis for individual water efficiency measures**
Programmes with a mismatch between scope (number of measures) and the labor and resources required may be a key reason for any lack of success. Providing details (such as staff hours and costs of materials) concerning each measure will enable planners to determine whether measures will be highly successful in achieving anticipated water savings, or whether they will be underperforming (e.g., requiring more staff support or funding) or discontinuation.

7.2.2 Benefit-cost analysis methodology

The primary reason for undertaking an efficiency programme is to avoid, defer and/or downsize any future capital water supply project in addition to lowering a water supply utility's current operating (labour, energy, chemical) costs. Any of these cost savings will translate into a benefit from a utility perspective. Planners should be consistent in using conventions and assigning data to benefit or cost columns based on how they accrue to the water utility (cost or benefit). Estimated costs are based on the projected costs of implementing individual measures in the programme, including staff time. A detailed example of how to set up a benefit-cost evaluation is provided in Appendix 4.

Box 7.1 provides some suggestions for small and medium sized communities on how to approach benefit-cost analysis.

BOX 7.1 SIMPLE APPROACH TO ESTIMATING COST EFFECTIVENESS FOR SMALL COMMUNITIES

For very small to medium-sized water supply utilities (less than 10,000 connections to as many as 100,000 connections), a straightforward and basic approach to benefit-cost analysis may be adequate. A full-scale benefit-cost analysis will not be necessary for a successful programme. However, it is recommended that planners pursue a more detailed evaluation to enable better-informed decision-making, especially when significant levels of funding support are being requested.

A more informal comparison by a utility of the benefits and costs may be appropriate to making decisions. This streamlined evaluation may simply involve comparing a planned programme to another utility's programme with similar goals and objectives. This simple approach can help in formulating a budget by using the cost per person from the other utility multiplied by the population to be served. In other words, take the annual budget of a successful water efficiency programme and divide it by the corresponding service area population; then multiply the cost per person for the same planned efficiency measures by the service area population in order to determine an estimate for an annual budget request. For example, if a neighbouring utility has 50,000 connections and a successful school education programme for US$ 5,000 per year, a planner may make an estimate based on his water utility's connections of, say, 15,000 (15,000/50,000) × US$ 5,000 = US$ 1,500.

This simplified approach works well when the number and types of connections are similar. For example, if a neighbouring utility has several large industrial customers and many commercial connections, the focus of their programme may be on non-domestic efficiency measures. Therefore, it would not be good practice to compare that utility's efforts in domestic water efficiency measures to the service area of the utility making the evaluation, if the customers of the latter utility are domestic users.

Source: For more information, planners may review Water Conservation for Small and Medium Sized Utilities by Green and Maddaus (2010).

Many water utilities around the world use benefit-cost analyses to evaluate and select an efficiency programme best suited to meet local community needs and the water supply utility situation. A benefit-cost analysis requires local-specific data about water use and demographics. Figure 7.1 illustrates the basic methodology for benefit-cost analysis.

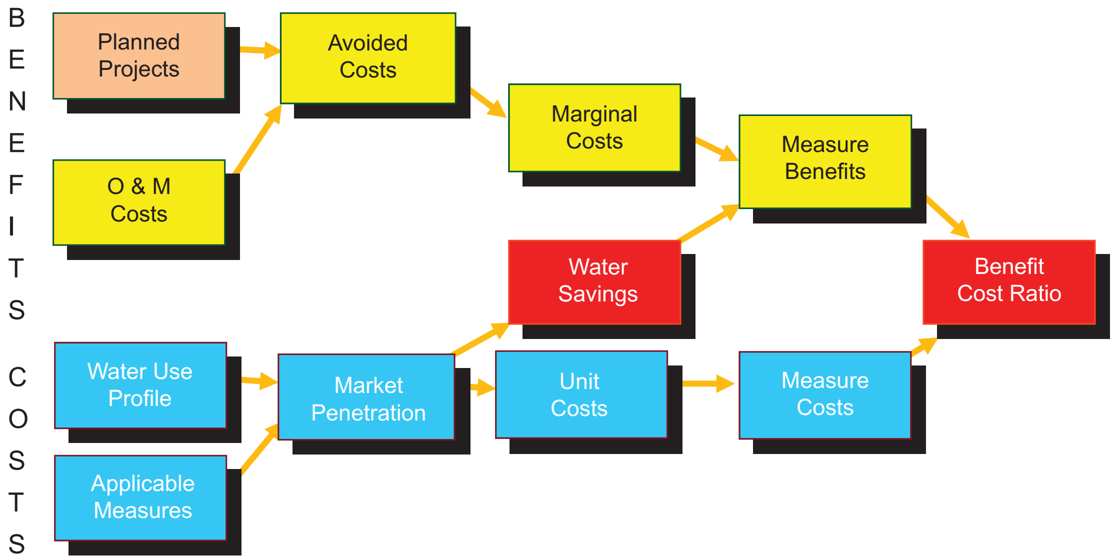

Figure 7.1 Benefit-cost analysis methodology. *Source:* Maddaus and Maddaus (2006).

Figure 7.2 can be explained by the following steps (which are further defined with formulas for actual calculations in Appendix 4:

(a) Collect the projected population growth from local, regional and provincial planning agencies, as this can be useful in forecasting water account growth (see Chapter 3);

(b) Develop a baseline projection of total water demand without taking into account efficiency. (Total demand may be estimated by multiplying the number of connections by type by the average domestic account usage and average business account usage etc.) Surveys may be conducted in order to estimate this information for the 'typical' customer's end uses if no other sources of information exist (common for utilities with non-metered connections) (see Chapter 4);

(c) Based on the categories of water use in a 'typical' account (also called a 'water use profile'), identify applicable water efficiency measures. For example, if small increases in demand are recorded in the dry season, this illustrates that minimal landscape irrigation occurs. A planner may then elect to focus measures on indoor water-efficient plumbing fixtures and appliances (see Chapter 6);

(d) For each measure, estimate the number of events (e.g., the number of fixtures or appliances replaced) that are projected to occur (can be expressed as the percentage of accounts that will implement the measure);

(e) Estimate the average day and peak day (high irrigation) water savings by multiplying the affected number of accounts by the measure's unit water savings (see Chapter 6);
(f) Estimate the costs of the measure by multiplying the number of accounts implementing the measure by the unit cost(s);
(g) Identify the different categories of benefits to be gained by the utility;
(h) Identify planned water supply or wastewater treatment capital projects that might be delayed or downsized by reduced water use and/or wastewater flow;
   (1) Determine the avoided costs (deferred or downsized expenditures) associated with the planned water supply or wastewater treatment projects;
   (2) Determine the operation and maintenance cost savings (energy, chemicals and labour) associated with reduced water use and wastewater flows;
(i) Combine the capital cost savings with the operation and maintenance cost savings (cost per unit volume; e.g., local currency per m^3);
(j) Compare total avoided costs to the marginal costs (cost per unit volume) of the next available water supply project;
(k) Use the water savings multiplied by marginal costs to compute the measure benefits (i.e., total cost savings);
(l) Compute the current value of timeframe of benefits and costs for each measure (see Appendix 4);
(m) Divide the benefits by the costs and express the result as a ratio from the utility's perspective;
(n) Identify the other benefits (cost savings to the utility) and costs of, for example, water, wastewater and energy to customers;
(o) Divide the benefits and costs, and express the result as a ratio for customers;
(p) Accept the measure if the benefit-cost ratio is greater than 1.0. Also, consider the benefit-cost ratio for customers together with non-quantified environmental, socio-economic and customer service relations factors;
(q) Make a final selection of the measures and combine them into one programme. Assess the overall programme benefits (the sum of water savings from all measures multiplied by the marginal cost of the next source of supply, the capital savings and operation and maintenance costs) divided by the total efficiency programme costs. Review to ensure that total water savings are in line with targeted goals. If the overall benefit cost ratio is above 1.0 and the defined water savings targets are met, the programme is most likely well designed.

7.3 KEY CONSIDERATIONS IN ESTIMATING BENEFITS AND COSTS

The major categories of benefits and costs from the water efficiency programme that accrue to the water utility are the result of both short-term and long-term cost savings. Reduced water production will allow the utility to save costs from:

- Reduced water purchases from wholesale water agencies;
- Reduced energy (and associated greenhouse gas emissions) from pumping (production, treatment, and distribution);
- Lower chemical use;
- Reduced or deferred costs of water treatment plant capital expansion;
- Reduced water storage costs; and
- Reduced wastewater processing costs.

An example of a water utility in the United States with recommended water conservation programme is shown on Figure 7.2. The graph depicts a lower water demand if the recommended conservation programme is implemented.

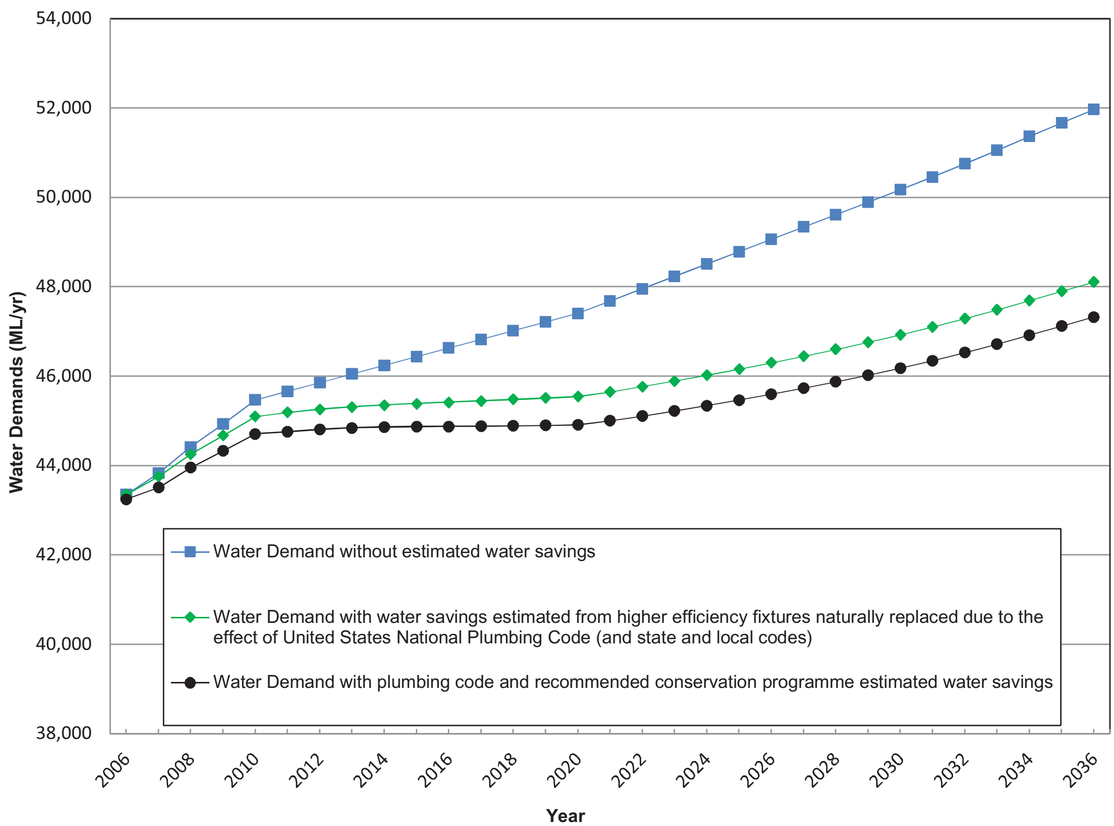

Figure 7.2 Example water demand forecast with recommended conservation programme. *Source:* Maddaus Water Management (2013).

7.3.1 Utility benefits (avoided costs)

Water utility cost savings can be significant. Given that the cost of water depends on the source(s) and treatment, cost savings are based on the marginal cost of the next available source of water per 1000 m^3. These benefits are based on combined short-term and long-term water savings as defined below:

(a) *Short-term savings*. These are savings unrelated to capital facilities and tend to result immediately from efficiency activities. They include reduced costs of treatment chemicals, energy input, and labour and materials required to handle reduced water production; and

(b) *Long-term savings*. These are savings associated with capital facilities (i.e., deferred, downsized or avoided water and wastewater facilities because of reduced demand) or reduced water purchases.

Information on the timing and sizing of capital facilities can often be found in the utility's capital facility plan, water supply plan, and/or water master plan. Water supply and treatment facilities are designed to meet water demands in a later period future year, typically 10–20 years in the future. Unfortunately, the capital facilities are sometimes identified just a few years in advance, and projections of needed facilities must be estimated from demand projections (based on population growth) to determine when the next capital project is needed and how much water supply capacity is still available.

Large water storage facilities such as water reservoirs are designed to meet average day demands in a critically dry year. Reduction in average day demands will defer or reduce the size of new water reservoirs.

Water treatment and distribution facilities such as water treatment plants, transmission pipelines, pumping stations and distribution storage tanks are designed to meet peak day demands. Demands increase on peak days due to hot, dry weather conditions. Reductions in peak day demands can be accomplished by reducing irrigation water, cooling-water use and evaporation from pools. Demand on peak days can also be reduced by programmes that reduce the indoor demands, but to a lesser extent. Reductions in peak day demand can allow the above-mentioned facilities to be deferred or downsized.

Figure 7.3 illustrates how water efficiency can affect the timing of capital facilities. In this case, a facility needed in 2035 could be delayed by about seven years. In the example shown, demand reduction would reduce peak-day demands by about 20 percent. The resultant cost savings (net current value) to the water supply utility is the difference in the present value of the costs associated with building the facility in 2042 instead of 2035.

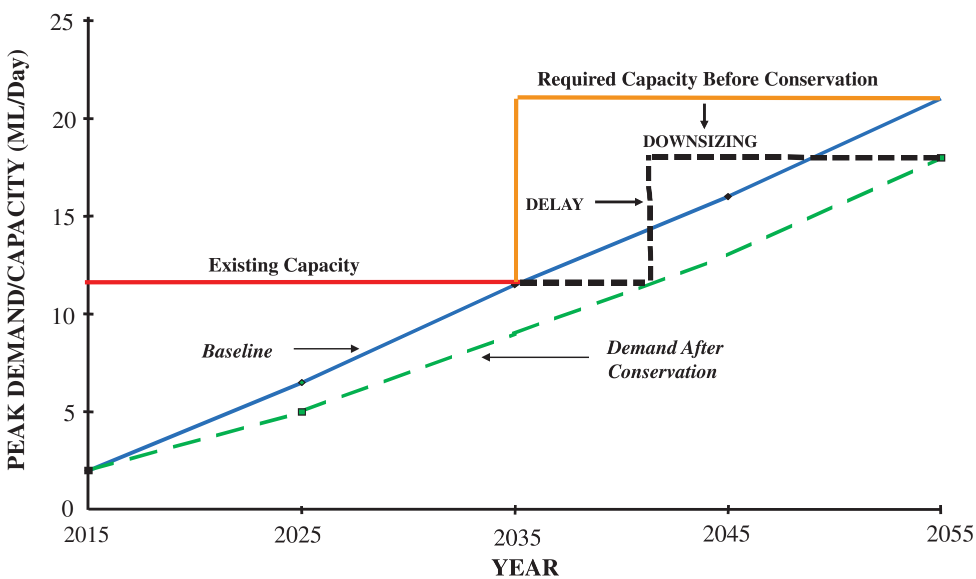

Figure 7.3 Delaying and/or downsizing a capital facility due to water demand reduction from efficiency measures. *Source:* Maddaus and Maddaus (2006).

Figure 7.4 illustrates an example from the Town of Cary, North Carolina, United States that shows that conservation can result in postponing a planned capital expansion project more than 30 years.

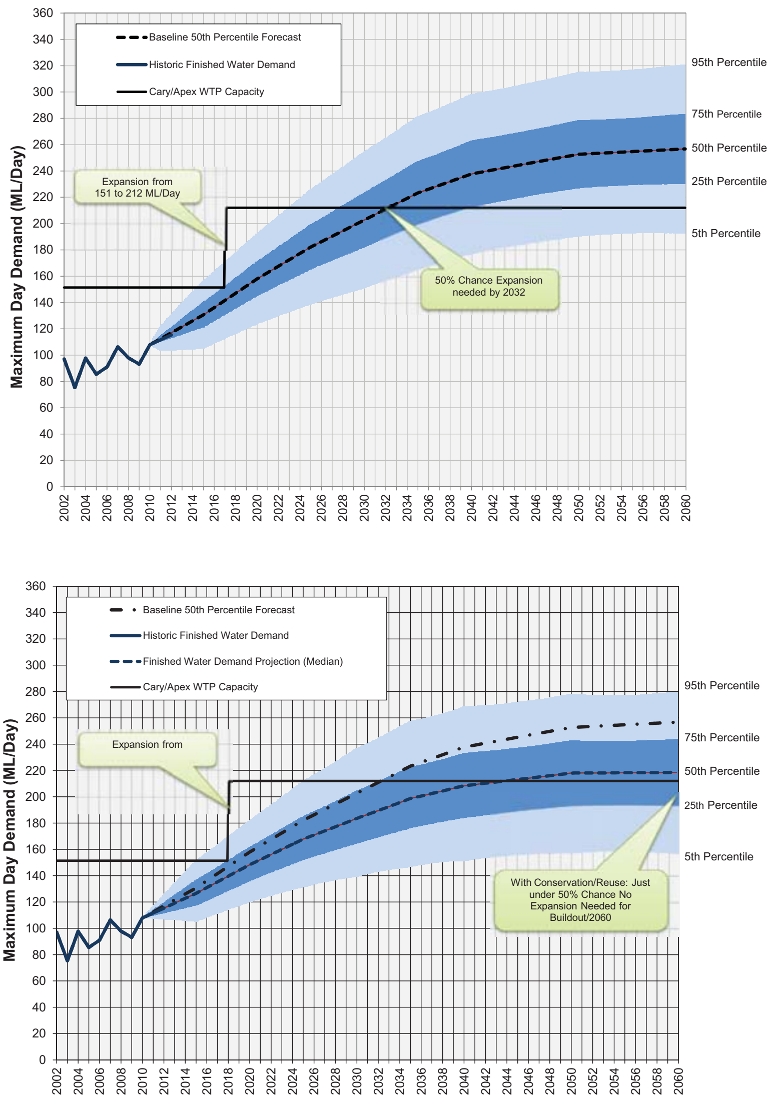

Figure 7.4 Example of delaying a capital facility due to planned water demand reduction from efficiency measures. No expansion needed to 2060 (bottom). *Source:* Goodwin (2013).

7.3.2 Utility costs

The costs of efficiency programmes fall into two broad categories:

(a) Implementation costs (paid by the water supply utility and, sometimes, customers) such as staff time, hardware costs, public and school education materials, and the cost of any monetary incentives that may be offered;

(b) The cost to the water supply utility from reduced revenues resulting from decreased demand, which should be viewed by planners as being exactly the same as if capital outlay was required to build new water supply projects. In other words, customer rates would need to be raised to build new projects; similarly, tariff adjustments over time are needed to cover projections in reduced revenues. The benefit is that the tariff adjustment for the efficiency programme is designed be less than a tariff adjustment to pay a new water supply project, assuming that measures and programme is selected that has a benefit-cost ratio higher than 1.0.

Other costs that accrue to other departments (or utilities) include staff time for planning and implementing efficiency measures or the installation and maintenance of water efficiency measures (e.g., plumbing fixture replacements, irrigation system improvements etc.).

Also of importance to the benefit-cost analysis are other non-economic impacts. Some of these are difficult to quantify. For example, water quality can be improved due to less run-off from irrigated landscapes that carry pesticides and fertilizers through storm water systems that discharge these contaminants directly into streams and rivers. It may be difficult to quantify to economic benefit of these water quality improvements, but they nonetheless should be analysed. These non-economic impacts should also be included when the analysis results are presented in a plan.

Figure 7.5 illustrates costs for conservation programs and how marginal returns change as more money is spent to achieve water savings. As the figure illustrates, the cost of the programme increases from the ‘current programme’to the ‘recommended programme’. Although the cost continues to increases, the water savings increase as well though at a slower rate. The decision on which programme is appropriate for each agency is dependent on many factors. Increasingly common, the decision on a recommended programme and level of funding for efficiency programmes may be impacted by the water conservation, energy or greenhouse gas reduction goals set forth in legislation, which is independent of the economic analysis.

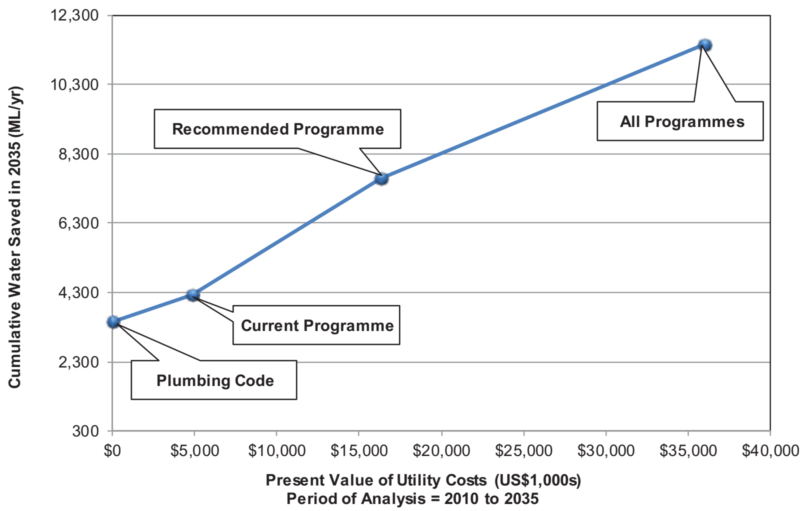

Figure 7.5 Example of present value of large utility programme cost versus water saved. *Source:* Maddaus Water Management (2013).

7.4 ESTIMATED CUSTOMER BENEFITS

Customer benefits and costs should also be considered; this aspect is discussed further in Appendix 4. If the water efficiency measure has a positive (greater than 1.0) benefit-cost ratio for the customer, then the customer may be more likely to implement the measure. While these impacts are not to be included in the benefit-cost analysis for the water supply utility, they should be recognized and discussed during the public review phase of efficiency planning such that utility incentives for conservation can be designed to be of benefit to the customer as well.

7.5 ESTIMATED OTHER BENEFITS AND COSTS

Other benefits and costs accrue to others beyond the water utility from the water efficiency measure. Other quantified benefits may include wastewater, energy or other social/environmental cost savings.

7.6 RE-EVALUATION OF PROGRAMME COST EFFECTIVENESS

Water utilities should track efforts concerning each measure in detail including staff time, costs and dates implemented. In addition, planners should carefully monitor changes in system demand and periodically (perhaps annually) re-evaluate water savings from selected or completed programmes based on metered records. At least 10% of the program budget should be reserved for post evaluation, revision of programs, and documentation of successes and failures, during and after their completion. Information from tracking efforts can be routinely used to recalculate the cost of water saved and compare that figure to original estimates. The cost of water saved can be expressed as cost per unit volume (1000 m^3) saved. More information on creating tracking and monitoring programme implementation is provided in Chapter 10.

In most cases, the programmes should continue until the costs, implementation rates, water savings or other factors change and result in the cost of water saved to rise above a predetermined threshold. The threshold could be the cost of meeting objectives or providing a new source of water supply by some other means. When a programme is no longer cost effective, it should be terminated and the resources placed elsewhere. Water supply utilities should always be given the flexibility to tailor and revise programmes to fit current local conditions.

7.7 EXAMPLE OF EVALUATING PROGRAMME COST EFFECTIVENESS

Tables 7.1 to 7.4 provide an example of a simplified benefit-cost analysis performed as a one-year test for a domestic water survey programme for domestic single-family homes. This is a shortened version of the example provided with the software provided via internet download for use together with Appendix 4.

For this survey, a trained water utility surveyor (or auditor) visits homes to conduct tests and recommend ways of saving water to the homeowner. In this example, it is assumed that 1000 homes are surveyed annually. Programme participants average 10 percent in water savings. The programme runs for 10 years. The savings from the measure is maintained for five years.

Each of the following tables represents one of the major components of a cost effectiveness analysis. The method determines the benefit-cost ratio for one year of implementation of the water efficiency measure (note that savings accrue for the useful life of the measure). Note that this example is only for utility costs and benefits. The major components of the benefit-cost analysis are summarized in the corresponding tables as follows: water utility savings, Table 7.1; water utility costs, Table 7.2; water utility benefits, Table 7.3; and benefit-cost ratio, Table 7.4.

Table 7.1 Domestic water survey programme: Water utility savings.

Measure: domestic water survey		**Value**
1. Total average single family-domestic water use, million litres/day		3.0
2. Number of single-family homes		10,000
3. Average water use per home, litres per day		300
4. Number of participants in the measure per year		1000
5. Programme length, years		10
6. Participant water savings	(a) Per cent savings	10
	(b) Estimated savings litres per day	30
	(c) Life of measure in years	5
7. Total savings after one year, litres per day (Line 4 × line 6b)		30,000
8. Total savings at end of life of the measure (5 years), litres per day (Line 7 × line 6c)		150,000
9. Total savings at end of programme (10 years), litres per day = Line 8		150,000
10. Annual savings decay after end of programme, litres per day/year = Line 8 ÷ by line 6c)		30,000
11. Lifetime savings[a] (25 years), million litres (see formula below)		54.54

$$^{a}\text{ Lifetime saving (ML)} = \frac{\text{Participant savings per day} \times 365 \times \text{number of participants per year}}{1\text{ million}} \times \frac{[1-(1-1/\text{life of measure})^{25}]}{1-(1-1/\text{life of measure})}$$

where

25 years = length of planning period chosen for analysis

Participant savings = litres per day

Life of measure = years

Table 7.2 Domestic water survey programme: Water utility costs.

Measure: domestic water survey		**Value**
1. Administration costs	(a) Staff hours	150
	(b) Hourly cost, US$/hour	50
	(c) Annual cost, US$/year Line 1a X 1b	7500
2. Field labor costs	(a) Staff hours	500
	(b) Hourly cost, US$/hour	30
	(c) Annual cost, US$/year Line 2a X 2b	15000
3. Materials costs	(a) Unit cost per participant	20
	(b) Number of participants/year	1,000
	(c) Annual cost, US$/year Line 3a X 3b	20,000
4. Total service area population		100,000

(*Continued*)

Table 7.2 Domestic water survey programme: Water utility costs (*Continued*).

Measure: domestic water survey		**Value**
5. Targeted population	Percentage	10
6. Targeted population	Number of customers contacted (assume 10 percent positive participation response)	10,000
7. Publicity costs	(a) Marketing cost, US$/year	3000
	(b) Advertising costs, US$/year	3000
	(c) Annual cost, US$/year Line 4a + 4b	6000
8. Evaluation and follow-up costs	(a) Labour and consultant, US$/year	5000
	(b) Annual cost, US$/year Line 5a	5000
9. Total costs (Line 1c + 2c + 3c + 4c + 5b)		53,500
10. Programme cost sharing (e.g., 25 percent grant funds, partnerships with wastewater, storm water or neighbouring water utilities)	Cost share from other organizations (assume 25 percent)	13,375
11. Net agency annual cost/year (Line 6 – line 7)		40,125

Table 7.3 Domestic water survey programme: Water utility benefits.

Measure: domestic water survey		**Value**
1. Next source of water		New reservoir
2. Average annual (discounted) avoided supply acquisition cost, US$/million litres		Not estimated
3. Average annual (discounted) avoided water treatment and distribution costs, US$/million litres		1050
4. Average annual (discounted) avoided wastewater capacity costs, US$/million litres		500
5. Avoided variable treatment and distribution costs (water + wastewater if measure reduces both, otherwise just water costs)		
5a. Chemical costs	(i) Total annual chemical costs, US$/year	60,000
	(ii) Annual fixed costs for chemicals, US$/year	10,000
	(iii) Avoided chemical costs, US$/year (Line 5a(1) – line 5a(2))	50,000
	(iv) Average annual treated water use, million litres	1095
	(v) Unit cost of chemicals, US$/million litres (Line 5a(3) ÷ by line 5a(4))	45.7
5b. Energy costs	(i) Total annual energy costs, US$/year	230,000
	(ii) Annual fixed costs for energy US$/year	70,000
	(iii) Annual energy costs not related to water production, US$/year	80,000
	(iv) Avoided energy costs, US$/year (Line 5b(1) – line 5b(2) – line 5b(3))	80,000
	(v) Average annual treated water use, million litres	1095
	(vi) Unit Cost of Energy, US$/million litres (Line 5b(4) ÷ by line 5b(5))	73.1

(*Continued*)

Table 7.3 Domestic water survey programme: Water utility benefits (*Continued*).

Measure: domestic water survey	Value
6. Avoided unit variable treatment and distribution costs, US$/million litres (Line 5a(5) + Line 5b(5))	118.8
7. Total average annual unit supply and treatment benefits, US$/million litres (Line 2 + line 3 + line 4 + line 6)	1,618.8

Note: Lines 2, 3 and 4 are discounted and converted to equivalent annual cost.

Table 7.4 Domestic water survey programme: benefit-cost ratio.

Measure: domestic water survey		Value
1. Present value of costs	(a) Total participants per year	1000
	(b) Total annual costs, US$/year (table 7.2)	53,500
	(c) Cost share from others, US$/year	13,375
	(d) Total programme (net) costs, US$/year	40,125
2. Present value of benefits	(a) Unit water supply and wastewater benefits, US$/million litres (table 7.3)	1618.80
	(c) Lifetime water savings, million litres (table 7.1)	54.54
	(d) Total water utility benefits, US$/year Line 2a × line 2b	88,300
Benefit-cost ratio (Line 2d ÷ by line 1d)		**2.2**
Benefit-cost ratio is greater than 1.0. Programme design for this measure is cost effective		

CASE STUDY 12
Sustainability Goals Achieved Through a Cost Effective Domestic Rain Barrel Education Programme, Honolulu Board of Water Supply, Hawaii, United States

Edited by Carolyn Sawai, Conservation Section Manager

The Honolulu Board of Water Supply (BWS) located on the island of Oahu, Hawaii teamed with Brown and Caldwell (BC) with the assistance of Maddaus Water Management to develop a comprehensive water conservation program that supports the BWS' mission of 'Water for Life, Ka Wai Ola.' Oahu is the most populated of the Hawaiian islands, where BWS serves more than 900,000 residents and metropolitan business community, with its mission focused on providing a safe and reliable water supply through balancing the three interdependent components of sustainability: resource, economic and organizational sustainability as illustrated in Figure 7.6.

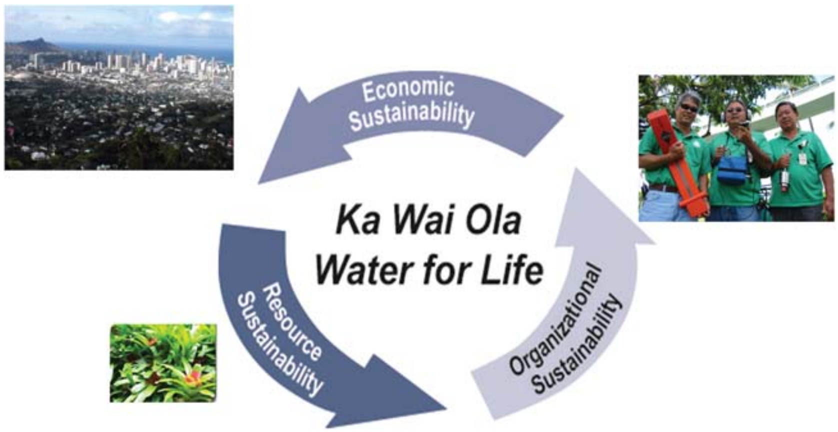

Figure 7.6 Board of Water Supply 'Water for Life, Ka Wai Ola' Program

Overall benefits from the BWS' water conservation program

By strengthening conservation efforts into the future, the BWS will continue receive numerous benefits including the following:

Resource sustainability

- *Maximize available freshwater sources*: The island of Oahu, Hawaii has finite limits on pumping from the freshwater aquifer and limited ability to use surface water sources to meet growing demands. The more efficient the existing demands become with the WCP being implemented, the less additional pumping of freshwater to meet new demands is required.
- *Minimize impacts of the next drought*: With leveraging water conservation to maintain the freshwater below the sustainable yield, BWS helps to recharge the aquifer. By banking more storage in the aquifer, BWS then mitigates the effects of future droughts when recharge is less plentiful and demands for higher withdrawals tend to increase. Overall strain on the aquifer in future droughts will depend on customer response to calls for curtailment due to dry conditions and how much storage is available to sustain Oahu's demand.

Economic sustainability

- *Allow for accelerated investment in rehabilitation and replacement programs under the Plan of Capital and Operating Needs*: The costs for all utility services are projected to increase; however, the costs will be lower than otherwise with conservation due to lower demands and less wear and tear on infrastructure. BWS will also be better able to afford increasing fiscal demands to rehabilitate and replace aging infrastructure by avoiding adding more costly supplies to meet future demands or savings from debt service to the extent projects can be delayed. Any reductions in lower demand are offset by lower fiscal requirements from the cost-effective conservation program that has been selected for implementation.

- *Utilize the least costly sources of supply*: Conservation is the cheapest source of water when offsetting the cost of pumping at US$146 per million litres (ML) produced when compared to the cost of the recommend conservation program at US$21 per ML produced.
- *Defer the need for desalination*: An option to produce water to meet potable demand from the planned 18.9 million litres per day (MLD) desalination plant in 2022 is an alternative planned in the WCP, and the energy cost associated with operations of the facility can be deferred through water conservation. The WCP is estimated to meet future demands of more than 18.9 MLD through 2035.

Social sustainability

- *Support the State Governor's and Mayor's sustainability initiatives*: The national trend in the United States is to minimize reliance on imported oil and use all resources more efficiently has been evolving and accelerating in recent years. Oahu has unique environmental resources and natural biodiversity that leads the island to flourish economically through tourism and other industry, and is wholly dependent on local residents and visitors respecting the need to live sustainably.
- *Meet each neighborhood's goals to protect watersheds*: The 'Ka Wai Ola – Water For Life' goals and sustainability management principles are infused in the goals, objectives and planned projects in the first three watershed management plans completed thus far and will also be included in the remaining five watershed management plans.
- *Strengthen the socioeconomic conditions of Oahu residents*: By maintaining more reasonable costs for water, energy, and sewer utility bills, local residents and businesses can better afford to reinvest in their community and have more dispensable income to support the local economy.

As a result, BWS' Program design developed with Brown and Caldwell and Maddaus Water Management is well rounded program that builds on all 5 key aspects of this island community's ability to be more efficient with their urban water supplies (Figure 7.7).

Figure 7.7 Five key aspects of conservation program design.

Specific benefits from the BWS' ongoing domestic rain barrel education program

- *Need for the Rain Barrel Program*: As part of the Water Conservation Program planning effort, BWS conducted a market penetration using a random phone survey and focus group study. The one of the key result of the study showed that more than 28% of BWS customers already used rain barrels at their homes. In addition, it showed more than a third of customers were not aware to use them and potentially more may consider installing rain barrels if they were more educated on their benefits. Figure 7.8 presents the outcomes of the survey question related to rain barrels.

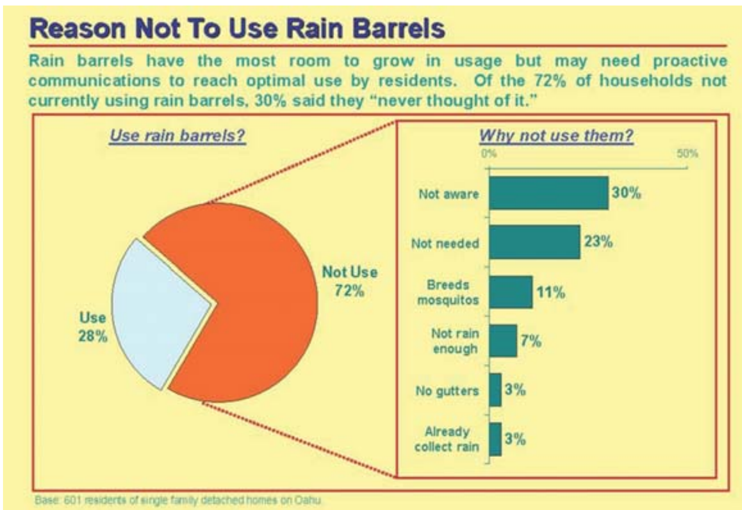

Figure 7.8 Customer telephone survey results on question for any reason not to use rain barrels.

- *Goal of the Program*: The Domestic Rain Barrel Program provides domestic homeowners an economical and convenient strategy to reduce outdoor water use. The long-term goal of the program is to encourage participants to expand their catchment system independently from the BWS in the future to maximize the rain water to meet their specific watering needs.
- *Educational Workshops and Resident Pick-up of Rain Barrels*: The program consists of quarterly workshops held at the BWS Demonstration Xeriscape Gardens (Figure 7.9) with the provision of one 208-litre recycled barrel, drilled and threaded with the appropriate fitting. The workshop consists of a one-hour session with question and answer periods and provides the participants instructions on proper placement, maintenance and integration of the barrel into their gutter and downspout system. Based on the successful pilot program in 2008 and 2009, Table 7.5 presents the number of workshops that have conducted through May 2013, as the program continues to be successful.
- *Popularity of the Program*: The program was initiated in August 2008 and has reached approximately 130 residents per year. Figure 7.10 shows BWS staff presenting to workshop attendees. Through 2012 about 500 rain barrels have been provided to BWS customers. Most workshops have a wait list for the next workshop (when more recycled barrels are available).

Figure 7.9 BWS demonstration 'Halawa' garden (Location of Educational Workshops and Native Plant Sales).

Table 7.5 Summary of domestic rain barrel implementation to date (as of May 2013).

Year	No. of Workshops per Calendar Year (Jan 1 – Dec 31)	Total No. of Attendees	Average Attendees per Workshop	Annual DSS Model Goal		Comments
				Single-Family Accounts	Multi-Family Accounts	
2008	2	34	17	N/A	N/A	A demonstration was given during a plant sale and only a few barrels were given away. This demonstration is not included in the 'no. of workshops' total.
2009	3	72	24	N/A	N/A	A demonstration was given during a plant sale and only a few barrels were given away. This demonstration is not included in the 'no. of workshops' total.
2010	5	105	21	N/A	N/A	
2011	4	100	25	152	7	Four workshops were held, from January through October 2011
2012	5	125	25	152	4	
2013	5 planned	150	25	152	4	2 workshops completed as of May 2013

Figure 7.10 Rain barrel education workshop presentation.

- *Customers Sharing Lessons Learned*: Many residents have shared back with BWS their experiences with the finished installation of the rain barrels. Figure 7.11 illustrates the finished installation at homes, and some have extended their systems to include more than the one barrel BWS provides. The program continues to be adjusted based on the feedback from customers.

Figure 7.11 BWS' customers' testimonals and examples of rain barrel finished home installations.

- *Cost of the Program*: Domestic rain barrels are estimated to save about 8000 litres per year per barrel (or 4 percent of the domestic irrigation demand) based on local rain patterns. The cost of the barrels to the BWS is limited to US$5 dollars per barrel (Table 7.6), since the barrels are donated and require a low level of effort for BWS staff to configure them to serve as rain barrels. Educational materials with clear instructions and diagrams on how to install and care for the barrel was developed by BWS staff and reproduced at minimal cost. Each customer that attends the workshop and receives one rain barrel is requested to pay US$ 35. Workshop attendees pay the fee even if they do not want to receive the rain barrel provided by BWS.
- *Quantifiable Benefits and Cost Effectiveness of the Program*: This program is nearly 100% cost reimbursed through the US$35 workshop fee, with only estimated US$5 non-reimbursable to

BWS. Given the nearly full cost recovery for this program, and assuming a 15-year life on the rain barrels, the calculated benefit for this conservation measures using the Decision Support System Model for Least Cost Planning (DSS Model) include:

- 5-yr program total barrels (one per acct) = 775
- Total annual water savings = 6.1 ML/yr
- Total lifetime savings (15-year life) = 91.5 ML
- Utility benefit to cost ratio = 3.1
- Discounted cost of conserved water/water saved (utility perspective) = US$28.80/ML
- Net present value (NPV) to the utility = US$47,000

More information is available through the Honolulu Board of Water Supply website: http://www.hbws.org (*last accessed: May 24, 2013*). Additional educational and resource materials are available from the American Rainwater Catchment Systems Association: http://www.arcsa.org (*last accessed: May 30, 2013*)

Table 7.6 Summary of domestic rain barrel program costs.

Item	Average Cost	Basis
BWS Labor (includes gas costs to BWS staff)	$15 per barrel	Picking up and unloading barrels, preparing barrels (rinsing and cleaning), drilling and threading barrels, providing workshops
Materials	$15 per barrel	
Barrels	Free	
Ball valve sets	$5 each	
Brass nipples	$5 each	
Hose to pipe adapters	$5 each	
Administrative and marketing cost	$5 per barrel	The 'hosting'group receives the $5 workshop fee. For BWS-provided workshops, the Friends for Halawa Garden receives the workshop fee. For outside workshops, the third party organization determines the fee they would like to charge. BWS recommends a fee of $5 per attendee for consistency. This $5 fee will cover costs associated with administration and marketing (e.g., printing materials, set up of the facility, etc.). The BWS does not charge a fee for instruction.
TOTAL COST	$35 per barrel	Each attendee pays the workshop fee, even if they do not pay for/receive a barrel.

Customer Testimonials

I am a resident of Honolulu (Kalihi Valley). I was fortunate in attending a BWS sponsored workshop. I am a container gardener and every part of my yard is green. I and my neighbors enjoy the greenery. I am trying to be more conscious about consumption/waste of Hawaii's potable water and this barrel helps me with the task of watering plants when there is no constant rain. I installed the barrel @ the front of my house to ensure adequate water for my common mango tree. The mangos this tree provides foster friendships with people from my community who walk or drive by. I am happy to share mangos for free since this fosters a better sense of Aloha & community. It is also the trick to avoid excessive rubbish waste. I look forward to expanding this system to accommodate vegetable growth in my back yard. I believe that at least two (2) more barrels would be needed to grow more food crops. Everyone should try this rain capture system! Mahalo (Thank You) to BWS for implementing this responsible community outreach program! (*Michelle Hill, Island of Oahu, Hawaii*)

I live in Central Oahu, Mililani Town. I installed the rain barrel on Feb 9th. As of today, Feb 21, my rain barrel has filled approximately 2.5 times. I have 6 down spouts on my roof which covers approximately 1600 square feet. The rain barrel is located in the rear of my home. I would like to install one in the front also. Other than installing an overflow outlet and enlarging the down spout inlet opening, installation was quite simple. (*Reagan Kanno, Island of Oahu, Hawaii*)

We live in Central Oahu in Upper Pearl City. As we live near the top of Waimano Home Rd, we receive a nice amount of rain. Our rain barrel almost never runs dry. In the dry summer months, we use the rain barrel to water our vegetable garden and rose garden. Depending upon the time of year and our usage, our barrel takes a few days to a few weeks to fill. We have saved quite a bit of money on our water bill since getting our first rain barrel. We liked it so much that we set up an old garbage can as a second rain barrel until we could locate and purchase more. Thanks for a fantastic program, HBWS! (*Heide Weber, Island of Oahu, Hawaii*)

CASE STUDY 13

Cost-effectiveness Analysis Non-domestic Water Efficiency in the Lower Hunter Valley, Australia

Stephen Askew, Hunter Water, Newcastle, New South Wales, Australia

Introduction

MWH Australia Pty Ltd was engaged to study non-domestic customers water consumption, assess existing water efficiency programs and develop new demand and drought management programs Montgomery Watson Harza (2012). This review suggested a suite of strategies to improve water efficiency and other water saving measures for industrial, commercial, municipal and other customers.

The findings of the review will help to prioritise water effeciency activities and ensure the most effective use of available funds in a climate of increased rainfall and constrained funding.

The following important points should be noted:

- Consumption forecasts were based on single year (2010/2011) and Hunter Water's data from previous baseline forecast modelling;
- The costs and savings associated with proposed programs are only estimates used for high level option comparison purposes only;
- Water end use breakdown assumptions used to estimate potential water savings were based on a limited number of available industry sources; and
- Supply-demand balances have not been assessed.

Methodology

Non-domestic customers were categorised based on 2010/11 consumption data as forecast by Hunter Water:

- *Major Customers (>50 ML/yr);*
- *Large Customers (10–50 ML/yr); and*
- *Other Customers (<10 ML/yr).*

Major customers and large customers were further broken into sub sectors based on business activities. Major customers were surveyed using an online tool. An end use assessment was also undertaken for each customer sector. Optimal program targets were identified based on each customer sector and the end use assessment.

Demand management programs were developed based on sectoral analysis, end use assessment, source substitution opportunities, review of national and international programs and analysis of existing Hunter Water programs. The end use modelling was also used to estimate water savings potential and levelised cost ($/kL saved) of individual programs. This approach allowed the most effective programs to be shortlisted for inclusion in the final strategy.

The outcomes of this analysis also provided important input into long term demand management forecasts.

Results

Results of the sector and sub sector analysis were presented in the Case Study 7 in Chapter 5 (Analysis of non-domestic water end uses in the Lower Hunter Valley, Australia).

The underlying assumption that high water users have the largest potential for savings at low relative cost was adopted to identify optimal programs.

Source Substitution

Source substitution programs have the potential to produce high potable water savings, particularly for major users. This study was a high level review only. It did not allow for the individual site conditions applicable to each source substitution opportunity. Conditions specific to each site include supply reliability, demand variability, contingency requirements and approvals. Hunter Water is conducting specific studies into source substitution opportunities for the lower Hunter region. The findings of these studies are not yet available and as such have not been incorporated into this paper.

The substitution of existing potable water usage is dependent on the quality, quantity and reliability of water required for the targeted end use. Source substitution and water recycling is governed by various national and state guidelines, as well as agreed levels of service and Hunter Water design standards.

Source substitution opportunities reviewed include:

- Rainwater harvesting;
- Stormwater harvesting;
- Groundwater;
- Recycled water;
- Greywater reuse; and
- Internal reuse.

Based on a potable versus non-potable high level end use assessment the source substitution potential for each customer type was estimated. It has been assumed that all non-potable end uses can be supplied through source substitution.

The following end uses have been considered as non-potable for this assessment:

- Irrigation;
- Toilets/urinals;
- General cleaning/wash-down;
- Laundry;
- Cooling;
- Steam generation; and
- Process water (non-food).

Approximately 55 percent of total non-domestic consumption is non-potable based on typical end use breakdowns.

Existing source substitution in the lower Hunter region includes both Hunter Water administered recycled water programs, as well as schemes implemented by individual customers such as rainwater harvesting and internal re-use.

The total non-potable annual demand volume is estimated as 13,000 ML/yr based on 55 percent of the total 2010/11 potable consumption (20,000 ML/yr) and existing recycled schemes (4500 ML/yr). The potential new scheme/s source substitution volume is estimated at 8500 ML/yr. Major customers make up 40 percent (1900 ML/yr) of the total potential source substitution savings. These customers would be most effectively targeted through large scale recycled water projects.

Demand Management Programs

A short list of non-domestic demand management programs was developed based on the following:

- Analysis of sectoral water use and the end uses within those sectors;
- Outcomes from the source substitution analysis;
- Review of national and international programs to understand common attributes of successful programs; and
- Review of current Hunter Water demand management programs to identify gaps and opportunities for new water efficiency programs and to optimise existing programs.

Evaluation of each shortlisted demand management program was undertaken using the correct DSS Model and considered the following:

- Potential water savings for each program;
- Assumed market penetration or 'uptake rate' of each program; and
- Assumed program implementation comparative costs to Hunter Water and the community. Net present value, annualised and levelised costs were included.

Estimated water savings are useful to help utility planners forecast the impact of programs on future water consumption. Savings usually develop slowly and reach full maturity after full market penetration has been achieved. This may occur five to ten years after implementation. Data that is required when forecasting water savings include locality specific data on baseline water use, demographics, market penetration, and unit water savings.

In order to assess the feasibility and cost effectiveness of each of the shortlisted programs, the costs of program implementation were estimated.

The proposed programs results are detailed in Table 7.7 in which programs are ranked by total community levelised cost. The evaluation assumed a discount rate of 7 percent.

Table 7.7 Individual program evaluation results.

Program	Average Water Savings (ML/yr)	Approximate Customer Payback Period (Years)[1]	Lead Time for Savings to be Realised
High pressure and trigger operated spray gun retrofit	75	0.2	1 months
Large customer audits (modified)	1635	0.9	>1 year
Hunter Water site audits	69	–	6–12 months
Water conservation toolkits	57	–	>1 year
Smart metering program	57	5.9	6 months
Cooling tower audit	55	3.2	6–12 months
Irrigation and landscape efficiency program (modified)	75	10.0	6–12 months
Hunter Business Water Savers Program (modified)	116	11.1	6–12 months
Pre-rinse spray retro-fits	10	0.8	1 months
Steam generation audit	18	6.6	6–12 months

Recommendations

Key findings from this study include:

(1) Major users (>50 ML/yr) represent the greatest potential for future water conservation efforts in the lower Hunter. Site based audits programs are the recommended approach for identifying cost-effective water conservation measures. The benefits of audits are expected to be maximised through subsidies and complemented with financial incentives for the customers;

(2) Source substitution efforts should focus on recycled water opportunities for major customers. These opportunities should be identified as part of the major customer audits;

(3) The recommended demand management programs to be included in the overall strategy are listed below. A total of ten programs have been selected:
   - Large customer audits (modified existing program);
   - Hunter Business Water Savers Program (modified existing program focused on amenities and all customers above 2 ML/yr);
   - Irrigation and landscape efficiency program (modified existing program);
   - High pressure and trigger operated spray gun retrofit;
   - Smart metering program;
   - Water conservation toolkits;
   - Hunter Water facilities audits;
   - Cooling tower audits;
   - Steam generation audits; and
   - Pre-rinse spray valve retro-fits.

(4) It is recommended that the water efficiency opportunities are reviewed every 4–5 years.

[1]Payback estimate assumes that all customer costs occur in the first year and that water savings achieved in the first year are ongoing. Assumes a water price of $2.08/kL for all customers. This is conservative as it does not consider the avoided cost of wastewater.

Chapter 8

Financing Water-Use Efficiency Programmes

A number of options exist for generating sufficient revenue or financing for a new or expanded water use efficiency programme. These include: (a) lowering operating costs through implementing efficiency measures (e.g., by reducing non-revenue water losses); (b) using capital facility budgets; (c) employing innovative water tariff pricing schemes; (d) utilizing private financing; and (e) using outside sources from other government agencies, national banks or international banks.

8.1 INFRASTRUCTURE COST SAVINGS

The least expensive way of increasing water supply can be the implementation of efficiency measures that save on current operating costs. As Chapter 7 shows, a planner may justify an expanded efficiency programme with more aggressive or costly measures, based on cost effectiveness of deferring or downsizing future capital projects. If these types of benefits are significant, financing with capital budget resources is legitimate. Capital projects are often financed by loans, bonds issued by a water utility, or from system connection fees collected from new developments. Since loans and bond issues often have restrictions on how the proceeds can be used, the use of system connection fees may be a possible option. These fees are collected to pay for capacity to serve new residential or commercial building developments. Because water efficiency is an alternative way of providing this new capacity (by reducing demand from existing and new customers), using such fees for efficiency is justified. One option is to use the revenue for capital-type efficiency projects, such as leak detection and repair, industrial recycling, toilet replacement and other long-life water efficiency equipment.

8.2 WATER TARIFF PRICING AND FEE-BASED FUNDING SCHEMES

The use of revenue collected from metered water-use charges is the conventional method of generating the money needed to pay for efficiency programmes. Typical water tariffs charge a fixed amount for the meter plus a constant charge per unit of consumption (uniform pricing). Innovative tariff structures have been used to generate the additional revenue for water efficiency, such as:

(a) *Inclining block tariffs (or rates) that charge more per unit as water use increases (see Chapter 6).* Normally designed to charge users of high amounts of water more per unit, the tariff structure generates higher revenues during hot, dry periods. Because water systems are sized to supply water during those peak demand periods, some utilities use inclining block tariffs to encourage efficiency. Just one additional step is needed to set slightly higher tariffs in order to generate extra revenue for funding efficiency programmes that help to reduce demand during peak periods. See the Irvine Ranch Water District Case Study in this Chapter.

(b) *Water tariff surcharges that add a small additional amount to the normal water charge*. This can be done seasonally or throughout the year. A surcharge during peak use periods will encourage water efficiency and generate additional revenue. A number of cities in the United States, for example, use this technique to encourage efficiency during peak use periods as well as fund efficiency programmes. The Albuquerque Bernalillo County Water Authority in New Mexico, United States has used a portion of the commodity charge for over 10 years to fund their water conservation programme (Albuquerque Bernalillo County Water Utility Authority, 2012).

There have also been cases where local initiatives have been funded based on self-elected fees being imposed. One example is student approved Carbon Fund for the University of Santa Cruz, California, United States, which is explained in a case study at the end of this chapter.

Another example is a Public Goods Charge that collected from each customer and is administered by the California Public Utilities Commission (CPUC). The fee is set based on energy utility's 3-year plan for energy efficiency programmes, where fees may also be applied to water use efficiency projects due to hot water and/or embedded energy savings. The CPUC also has a Water Action Plan (CPUC, October 2010) that includes goals to incorporate water conservation into the private water utility ratemaking process. More information is available online: http://www.cpuc.ca.gov. (last accessed on May 30, 2013).

8.3 PRIVATE FUNDING AND PERFORMANCE CONTRACTING

In areas where there is a shortfall in water system capacity, creative funding can be employed by landowners wanting to implement new land development. New land developers normally pay a routine fee or a meter charge for a new service account. The capacity charge for a new connection assumes that existing and future system capacity is available and that new projects are just buying a share of existing or planned capacity projects. Alternatively, where water capacity is inadequate, the amount of water needed to meet the needs of the entire project could be created by the implementation of efficiency measures as well as financing by the landowner (or developer). Although the two examples described below are taken from the United States, they could in general be applied worldwide:

- Water short communities of less than 10,000 connections along the West Coast of the United States (an arid area), such as the Morro Bay City, California, have required developers to retrofit a number of houses (about 10) with specified devices for each new house constructed. Normally the developer does not actually do the retrofit but rather pays a fee to the water utility, which then hires a contractor to do the project. Retrofitting could include replacing old showerheads, toilets and washing machines with new water-efficient plumbing fixtures and appliances.
- A land developer in northern California, United States (Shapell Homes) agreed to pay the local water utility (East Bay Municipal Utility District) US$8.5 million to develop 1400 residential homes. The development was just outside the water utility service area and the water utility planners maintained there was not enough water supply capacity at that time to annex the project to the service area. The developer also proposed a very low water-use project to minimize the utility fees, with fixtures beyond those required by local plumbing codes, such as high efficiency

toilets and efficient washing machines, which would be installed and recycled water used for landscape irrigation. The money collected from the developer was to be used by the water utility to conduct additional water efficiency programmes in the service area in order to generate the required capacity. The fee represented approximately 0.8 percent of the price of the new home and was considerably less than other fees paid to connect to the public water and sewer system. Projects considered included the most advanced technologies, called evapotranspiration[1] or weather adjusting irrigation controllers, apartment sub-meters on individual units and additional fixture rebates. As of 2013, the project has successfully developed approximately 1000 of the 1400 homes (the project had a long planned build out period) Maddaus *et al*. (2008).

Another technique used to generate capital to pay for water efficiency retrofits is called performance contracting or 'shared savings'. In essence, a private company will perform a water survey and identify potential water efficiency projects. Those with an attractive payback, based on utility bill savings or revenue recovery, will be financed by a third party. The performance fee schedule or loan is repaid using a portion of the savings from the reduced utility bills post retrofit or construction. Examples of firms that engage in this type of contracting include:

- Water Management Inc.'s Case Studies, http://www.watermgt.com (accessed on April 15, 2013)
- Water System Optimizations, Case Studies, www.wso.us (accessed on April 25, 2013)
- Miya Corporation, Case Studies, http://www.miya-water.com (accessed on April 25, 2013)
- Veritec Consulting, http://www.veritec.ca (accessed on April 25, 2013)
- Others

Another example is to use water tariff revenue to fund cost-effective projects by customers. Singapore PUB's Water Efficiency Fund, described as a case study in Chapter 10, is one example (PUB Singapore, 2010).

8.4 OUTSIDE SOURCES OF FUNDING

Funding from other government or international funding agencies may be available. Such a system could be developed in other countries by taking a portion of loan or grant money targeted at capital projects and using it for water efficiency projects where it can be shown that water efficiency is cost-effective.

International banking institutions are set up to fund projects that national, provincial or local governments are willing to sign on to repay, and a result are scoped based on requests received. If water use efficiency projects are not requested as part of the loan project applications and documents, then water use efficiency projects are not included. When water use efficiency projects are incorporated as part of the other larger infrastructure supply projects, then other sources of funding may include the Asian Development Bank (ADB), European Investment Bank, and the World Bank as well as international assistance agencies of the developed countries. Prior to the last 10 years, these agencies did not

[1]Evapotranspiration is the amount of water that a plant 'breathes' or releases into the atmosphere and which must be replaced by applying water from rainfall or irrigation to maintain plant health. A plant can commonly remain healthy down to 70 to 80 percent of evapotranspiration. The irrigation controllers receive local weather information via modem or satellite and update and change the irrigation schedule. More information is available on this programme from the California Department of Water Resources, which maintains a network of weather stations for providing data to agricultural and urban water users to enable them to adjust their irrigation schedules. Append web address for more information: http://wwwcimis.water.ca.gov/cimis/welcome.jsp (last accessed September 20, 2013).

separately fund water efficiency programmes with the exception of infrastructure rehabilitation projects. More recently, some targeted project funding has supported water system loss reduction and pressure management. Establishing water efficiency as a cost-effective alternative to infrastructure expansion should encourage funding agencies to sponsor water efficiency programmes that focus on the customer and not the water supply utility.

Mentoring and in-kind support between water utilities is also emerging through support by international funding agencies through the concept of Water Operator Partnerships (WOPs) or twinning. In Asia, both the ADB and the USAID through its Environmental Cooperation – Asia (ECO-Asia) project which was implemented by AECOM offer administration funds less than US$60,000 to cover expenses for mentoring between mentor and recipient partner utilities. More information on the ADB funded partnerships is provided below. A case study at the end of the chapter further describes the structure of the partnerships available through the USAID ECO-Asia Programme. ADB, USAID through ECO-Asia, and IWA established WaterLinks, a network that supports and promotes twinning partnerships between urban water services providers in Asia and the Pacific to build their capacities to enhance operational efficiencies that ultimately increase access to safe water and sustainable sanitations services (see www.waterlinks.org.)

BOX 8.1 ASIAN DEVELOPMENT BANK – WATER OPERATOR PARTNERSHIPS

'About 71 percent of people without access to improved sanitation and 56 percent of those who lack safe water live in Asia. Without these basic services, they face incredible health risks and suffer everyday indignity and inconvenience.

Water utilities, which have the critical responsibility of providing water supply and sanitation services to the region's 4 billion people, are at the forefront of efforts to rectify this common scenario. However, their task is hampered by numerous challenges, such as artificially low tariffs, staff incapacity, and insufficient budgets for infrastructure development.

To deliver sustained, world-class service, utilities need help from various partners. One key partner is their peers.'

Brief Overview of Water Operators Partnership Program (ADB, 2010b). http://www.adb.org/publications/water-operators-partnership-program

WATER BRIEF

Water Operators Partnership Program

ADB Photo Library (x4)

About 71% of people without access to improved sanitation and 56% of those who lack safe water live in Asia. Without these basic services, they face incredible health risks and suffer everyday indignity and inconvenience.

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To deliver sustained, world-class service, utilities need help from various partners. One key partner is their peers.

Partnering Operators

The Asian Development Bank (ADB) and the Global Water Partnership Program began collaborating in 2006 to implement the Water Operators Partnerships (WOPs) Program. The WOPs Program helps water utilities improve service coverage and delivery, financial sustainability, and other aspects of their performance.

The WOPs Program is part of a larger plan to achieve breakthroughs in vital areas of water supply and resources management and to attain the Millennium Development Goals. Announced by the United Nations Secretary-General's Advisory Board on Water and Sanitation (UNSGAB) in early 2006, the Hashimoto Action Plan called for breakthroughs in six key areas: water operator partnerships, financing, sanitation, monitoring and reports, integrated water resources management, and water disaster response. UNSGAB asked various regional development banks, including ADB, to assist in making the plan operational.

ADB implements the WOPs Program through Regional Technical Assistance (RETA 6396) financed by the Japan Special Fund, which was approved in April 2007.

Strategies for Operational Efficiency

To achieve its aims, the WOPs Program adopted key strategies with interlinked activities and outputs to ensure that targeted support is given to utilities. These strategies are as follows.

- **Formation of water utility networks.** These networks promote alliances, knowledge exchange, and capacity development among member water utilities. They also anchor all program activities designed to improve the operational and financial efficiency of members.
- **Continuous improvement and benchmarking.** This involves collecting, analyzing, and comparing key performance data of water and sanitation utilities and, on the basis of analysis, developing a strategy and work program to improve specific aspects of a utility's performance.
- **Twinning of water utilities.** Exemplary water utilities in the region are being tapped to help developing utilities enhance their skills and operational efficiency.

Asian Development Bank ADB

This chapter has the following case studies examples as different means of financing water efficiency programs or projects:

- Case Study 14 presents an innovative water tariff structure to encourage conservation by a utilities retail customers.
- Case Study 15 describes a public-private partnership funding for a non-revenue water program.
- Case Study 16 describes a successful self-funded project to save water on a college campus in California.
- Case Study 17 describes voter approved bond financing for water efficiency programs in Texas.
- Case Study 18 describes how partnerships can identify and prioritize projects in preparation for applying for funding during program implementation.

CASE STUDY 14
Allocation Based Tariff Structure to Support Water Efficiency Programme Funding, Irvine Ranch Water District, California, United States[2]

Fiona Sanchez, Assistant Director of Water Policy, Irvine Ranch Water District

Irvine Ranch Water District (IRWD) is a recognized leader in water use efficiency in the United States. Efforts have included intensive communication with the various customer groups and some of the first home water audits and ultra-low flush toilet retrofit programmes in California, culminated in the adoption of an allocation-based tiered tariff structure by the IRWD Board in 1991. The tariff structure is a foundational tool in IRWD's successful water use efficiency programmes, and has resulted in significant water use reductions. Secondary benefits include reductions in urban storm water runoff flows, energy savings and reduced greenhouse gas (GHG) emissions.

The tariff structure was instituted to promote the efficient use of water, and is designed to provide customers a significant economic incentive to use the proper amount of water required to serve indoor, landscape, commercial/industrial and institutional demands. This is accomplished by setting a customized 'allocation' for each customer account that is based upon a variety of factors such as: irrigated area, daily weather characteristics, number of residents, industrial or commercial business type, and other more unique characteristics such as the presence of a pool, livestock or specialized industrial equipment. Water is then sold to customers under a five tier structure based upon their monthly allocation which varies for landscape use relative to weather patterns. Customers using water within their allocation purchase water in the lower two tiers (including a below cost first tier) and are rewarded with very low water bills. Customers using in excess of their allocation also purchase water in one to three steeply ascending upper tiers, resulting in relatively high water bills and a strong pricing signal for excessive use. IRWD's fiscal year 2012–13 commodity tariffs for each of the five tiers are shown Table 8.1.

IRWD also assesses a monthly fixed charge based upon meter size. This fixed charge provides adequate funding for all operating costs other than the water commodity itself and the district's water use efficiency and related programmes. As such, IRWD enjoys revenue stability regardless of the amount of water sold or the degree of conservation experienced from customers' water use efficiency practices.

The tariff structure not only signals customers when they are over-using water, but also signals IRWD as to which customers need the greatest degree of attention. This two-way communication helps IRWD focus its financial and staff resources efficiently. Customer service is also emphasized. For example, billing

[2]Personal Communication, April 15, 2013, Fiona Sanchez, Assistant Director of Water Policy, Irvine Ranch Water District.

adjustments are provided for customers that have over-allocation use related to leaks if the customer shows evidence of the leak repair. In addition, customers that have habitual over-allocation use are contacted by IRWD staff and offered customer leak detection services, as well as water use efficiency education and assistance.

Table 8.1 IRWD's Water Tariffs 2012–2013.

Tier of tariff rate charges	Tariff per hundred cubic feet (CCF)*, 2012–2013	Use (As a percent of allocation)
Low volume discount	US$0.91	0–40%
Conservation Base	US$1.24	41–100%
Inefficient	US$2.76	101–150%
Excessive	US$4.70	151–200%
Wasteful	US$9.84	201% +

*CCF = Tariff is per unit of volume of water at 100 CCF or per 2,830 L of water.

Revenue from higher tier, over-allocation water use is 'reinvested' to fund tailored programmes and rebates for long-term improvements in water use efficiency and to support IRWD's urban runoff source control and treatment programmes. The tariff structure is designed to derive sufficient revenues from the over-allocation use tiers to completely fund these programmes. Because a substantial portion of water consumption in southern California is for outdoor irrigation, the tariff structure also helps control over-irrigation and the associated generation of pollutant-carrying dry weather runoff which flows into environmentally sensitive creek and estuary systems. The relationship between over-irrigation and urban runoff generation provides an appropriate role and nexus for IRWD's participation in urban runoff treatment and source control programmes. More information is available online at: http://www.irwd.com (last accessed on May 30, 2013.)

CASE STUDY 15
The Sebokeng and Evaton Advanced Pressure Management Project: A 5-Year Public Private Partnership, South Africa

Ronnie McKenzie et al. *2007*

Many water distribution systems in South Africa are deteriorating due to many years of neglect resulting in a serious maintenance backlog. Recent government legislation has introduced free basic water to all South Africans up to a limit of 6 Kl/month per property which in turn causes certain confusion regarding payment among many residents. These key issues and others have led to serious problems with service delivery specifically in the low income areas where the maintenance has been neglected for more than 30 years in some cases. The potential for support from the Private Sector has been highlighted at the highest levels within government as a possible solution to addressing the existing backlogs despite the fact that there are relatively few successful projects to support this view.

The project described in this case study is one of the largest Advanced Pressure Management projects in the world and was developed in the form of a 5-year Public Private Partnership which commenced in 2005 and concluded in July 2010.

Emfuleni Local Municipality is shown in Figure 8.1 and is located to the south of Johannesburg in the industrial heartland of South Africa. A separate water utility called Metsi-a-Lekoa was established several years ago to manage the supply of potable water to approximately 1.2 million residents of the Municipality of which 450,000 are located in the Sebokeng and Evaton areas. Water is supplied to Metsi-a-Lekoa from the local bulk water provider which is one of the largest providers of potable bulk water in the world.

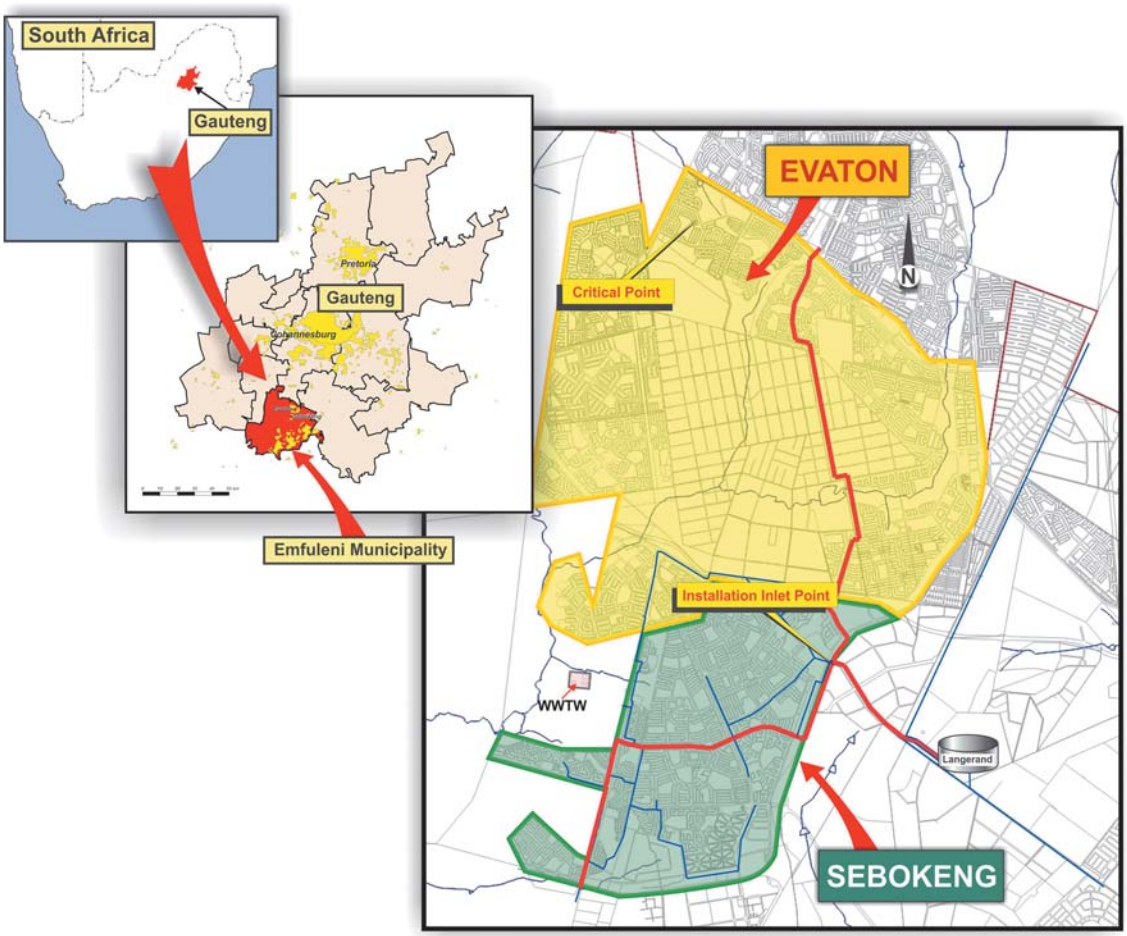


Figure 8.1 Location plan. *Source*: McKenzie *et al*. (2007).

The areas are predominantly low-income residential areas with approximately 70,000 household connections, each of which is supplied with an individual water supply as well as water borne sewage. The combination of low income coupled with high unemployment has resulted in a general deterioration of the internal plumbing fittings over a period of many years causing high levels of leakage. The leakage at the start of the project was known to be extremely high as indicated by a Minimum Night Flow in the order of 2800 m^3/hr as shown in Figure 8.2. This was one of the highest Minimum Night Flows recorded anywhere in the world and represents almost two Olympic sized swimming pools of water every hour during a period when demand for water should be minimal.

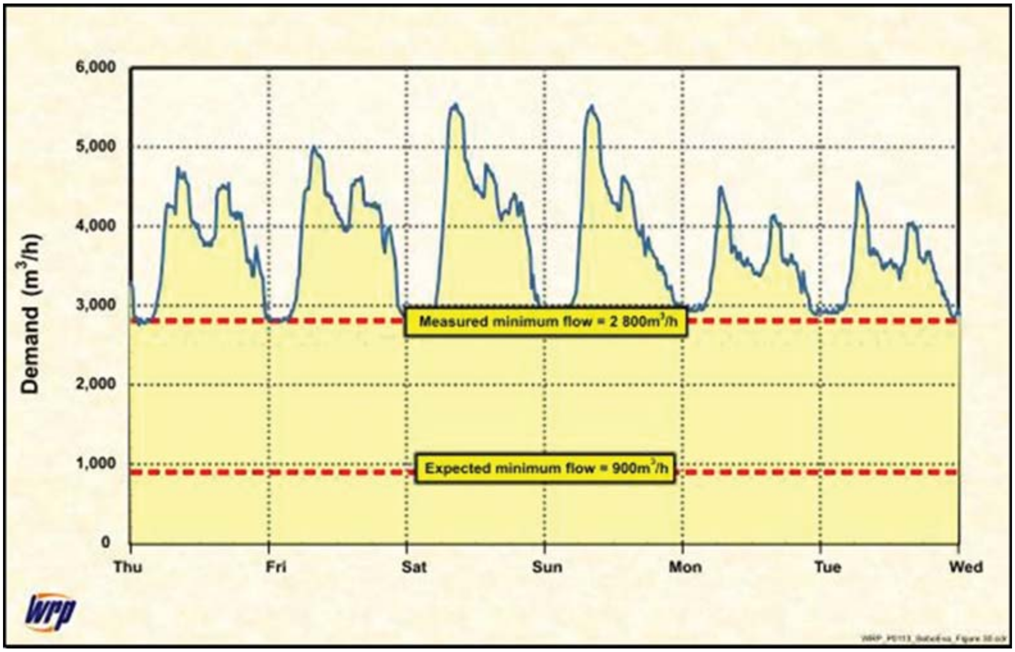


Figure 8.2 Initial water demands for a 6-day period entering Sebokeng and Evaton in July of 2003. *Source*: McKenzie *et al*. (2007).

The project was fully funded by the development team and the costs were recovered over the 5-year operational period through the recovery of a portion of the water savings achieved by the project.

The project cost approximately R10 million (US$1.5 million) to construct and operate over the 5-year period during which it achieved audited water savings of 50 million m^3. These savings represent over R150 million in (approx US$20 million) reduced water purchases by the local Municipality from the bulk water provider and the project had an effective pay-back of less than 2 months. The project team recovered approximately 15 percent of the total savings resulting in a pay-back to the development team of between 2 and 3 years.

Benefits of the project

The most obvious benefits from the project are clearly the savings in water purchases by the Municipality from the bulk water provider due to the reduced leakage in the Sebokeng and Evaton areas. The initial projected savings of approximately R20 million (±US$3.3 million) per year (Mckenzie and Wegelin, 2005) were in fact exceeded and after the first full year of operation the actual savings achieved were closer to R30 million (±US$4.5 million) as highlighted by Mckenzie and Wegelin (2006). The final audited savings achieved by the project are as shown in Table 8.2 and again graphically in Figure 8.3.

Table 8.2 Summary of water and financial savings for first 30 months of operation.

Year	Water use		Saving		
	Expected	Actual	M^3	Rands	US$
Months 1 to 6	18,721,000	14,614,000	4,107,000	11,499,600	1,691,118
Months 7 to 12	18,751,000	12,785,930	5,965,070	16,702,196	2,456,205
Months 13 to 18	19,403,000	13,886,451	5,516,549	16,218,654	2,316,951
Months 19 to 24	19,423,000	13,877,370	5,545,630	16,304,152	2,329,165
Months 25 to 30	20,086,000	15,269,040	4,816,960	14,788,067	2,112,581
Months 31 to 36	20,206,000	15,633,153	4,572,847	14,038,640	2,005,520
Months 37 to 42	20,769,000	15,870,850	4,898,150	15,918,988	1,768,776
Months 42 to 48	20,766,000	15,692,825	5,073,175	16,487,819	1,831,980
Months 49 to 54	21,452,000	16,479,970	4,972,030	16,159,098	1,901,070
Months 55 to 60	21,438,000	16,874,423	4,563,577	14,831,624	1,744,897
Total Months 1 to 60	201,015,000	150,984,012	50,030,988	152,948,838	20,158,263

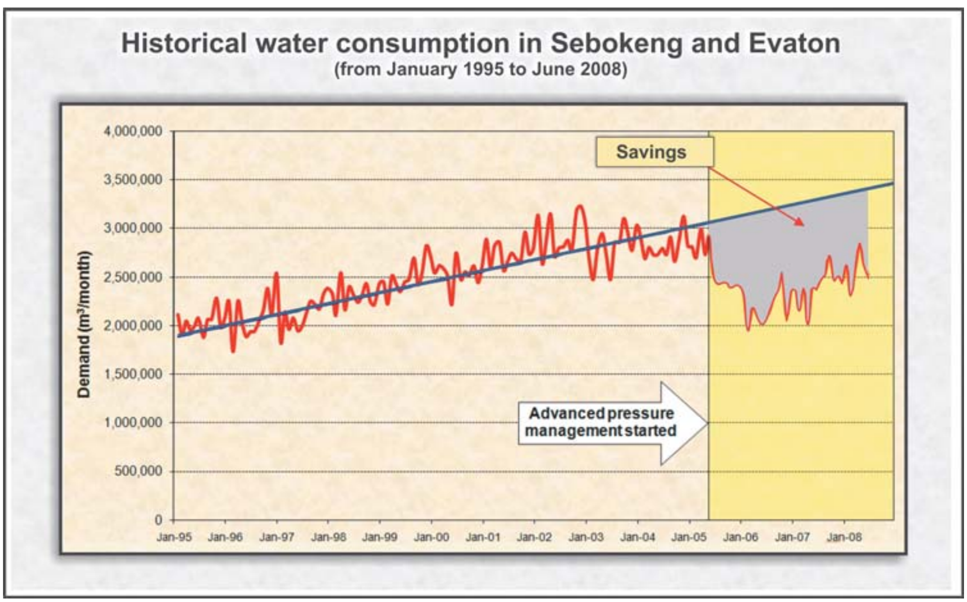


Figure 8.3 Historical water consumption in Sebokeng and Evaton areas for a 15 year period. *Source*: McKenzie *et al*. (2007).

The savings achieved by the project exceeded all expectations of both the Project Team as well as the Municipality and are the most obvious benefits to accrue from the project. After operating and managing the installation for two years, several other benefits also became apparent which were not initially anticipated. In particular the following benefits have been achieved each of which will be discussed in turn:

- Defer upgrading of infrastructure
- Identification of bottlenecks in the system and problem infrastructure;
- Identification of bulk meter errors;
- Catalyst for funding;
- Improved municipality status;
- Creation of National WDM fund;
- Catalyst for other WDM interventions;
- Sustainability of Savings.

In addition to the water savings, the project has achieved energy savings due to reduced pumping by the bulk water provider of more than 13,000 tonnes of CO^2 per annum representing 65,000 tonnes over the 5-year project period. This achievement was recognised by the award of the African Energy Award for 2010 for the best Energy Saving Demand Side Management Project in Africa.

This project is one of a few Water Demand Management (WDM) projects which has been accurately audited over the full 5-year period of the Public Private Partnership and demonstrates that such partnerships can be implemented involving relatively small projects and the savings achieved can be sustainable.

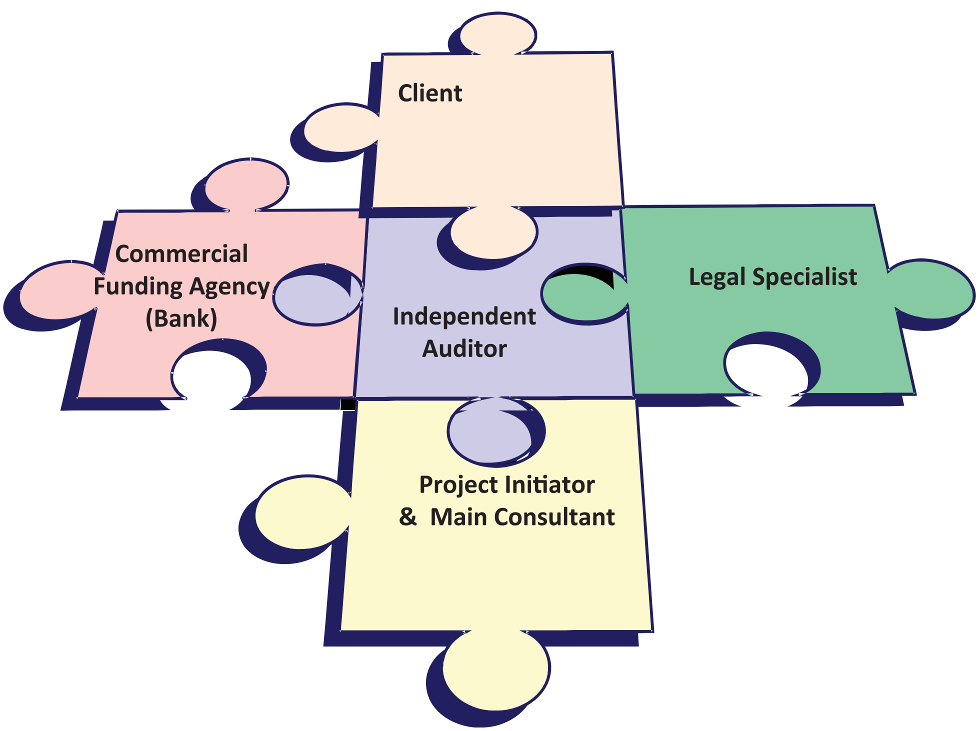


Figure 8.4 Key role players in the project. *Source*: McKenzie *et al*. (2007).

The Project Team included various key role players as indicated in Figure 8.4 listed as follows:

- The Client is Metsi-a-Lekoa which is the ring-fenced water utility formed by Emfuleni Local Municipality and was managed at the start of the project by CEO Mr Sam Shabalala.
- The funds required to complete the project were raised privately by WRP through Standard Bank.
- The establishment of the contract on which the project is based was funded and facilitated by the Municipal Infrastructure Investment Unit (MIIU) and Metsi-a-Lekoa.
- The consultants team comprised the Gauteng based WRP Pty Ltd in association with DMM. Additional specialist support was provided by various other sub-consultants including, structural design by Platinum Consultants, and support on the conceptual design by Coplan. In addition Mr Tim Waldron, the CEO of Wide Bay Water in Australia acted as a specialist reviewer. The main contractor for the project was WK Construction.

The project also involved a significant public participation and community awareness component which created over 100 employment opportunities at the peak and is considered one of the key factors resulting in the long-term success of the project.

CASE STUDY 16

Financing Through Self-Initiated Student Fund to Support Climate Change, Greenhouse Gases, Energy and Water Efficiency University of California Santa Cruz, United States

Edited by Dean Fitch, Senior Planner Physical Planning and Construction and Lacey Raaka, Sustainability Director, University of California, Santa Cruz

Students working together to funding efficiency projects

Climate Change is one of the biggest challenges facing society and the future of today's students. There is a clear scientific consensus that the danger to both humanity and the earth's ecosystems is very real. In response, communities around the world are working towards mitigating the severity of Climate Change. As an institution, University of California Santa Cruz (UCSC) must reduce its carbon footprint in accordance with federal law, state law, and UC system-wide policies. As a university UCSC is a signatory to the national American College and University President's Climate Commitment, as well as the regional Climate Action Compact with the city and county. As a community, individuals and groups within UCSC have shown a desire to reduce their negative impact on the climate through initiatives to reduce greenhouse gases and spread awareness.

An enterprising group of UCSC students created the Carbon Fund to diminish the campus's carbon footprint (through efficient water, energy and carbon projects) with environmentally friendly projects undertaken by staff, faculty and students. In 2006 UCSC students passed Measure 26, taxing themselves to buy Renewable Energy Certificates (RECs) in order to offset the climate impact of campus electricity purchases. The RECs were a point of pride and leverage for UCSC and its student body. In 2010 UCSC students changed the use of the funds through the passage of Measure 44. The Carbon Fund uses money raised by Measure 44, a student-approved ballot initiative that raises money through a US$3-per-quarter student fee. This created UCSC's Carbon Fund to be a new point of pride and leverage in reducing UCSC's carbon footprint. The Fund works towards recreating UCSC as an operationally carbon neutral campus while providing faculty with an opportunity for research and students with the tools they need to move towards a more sustainable future. The ideas for the projects can be submitted by the students with several different projects – the goal is to 'take their amazing ideas and bring them to life on the campus.' UCSC has obtained many awards including being recognized as one of US News and World Report's top 10 eco-friendly colleges.

2020 Water vision

To create, research, develop, and implement programmes and strategies that minimize potable water use on the UCSC campus. In 2020, UCSC's campus water demand is no more than 780 ML/Day (million gallons/year) (see Figure 8.8). Exploration, testing, and implementation of non-potable sources, for example, groundwater, rainwater, and reclaimed water, is supplying non-potable water campus-wide, and large scale outreach campaigns have effectively reduced personal water consumption.

Overarching goals:

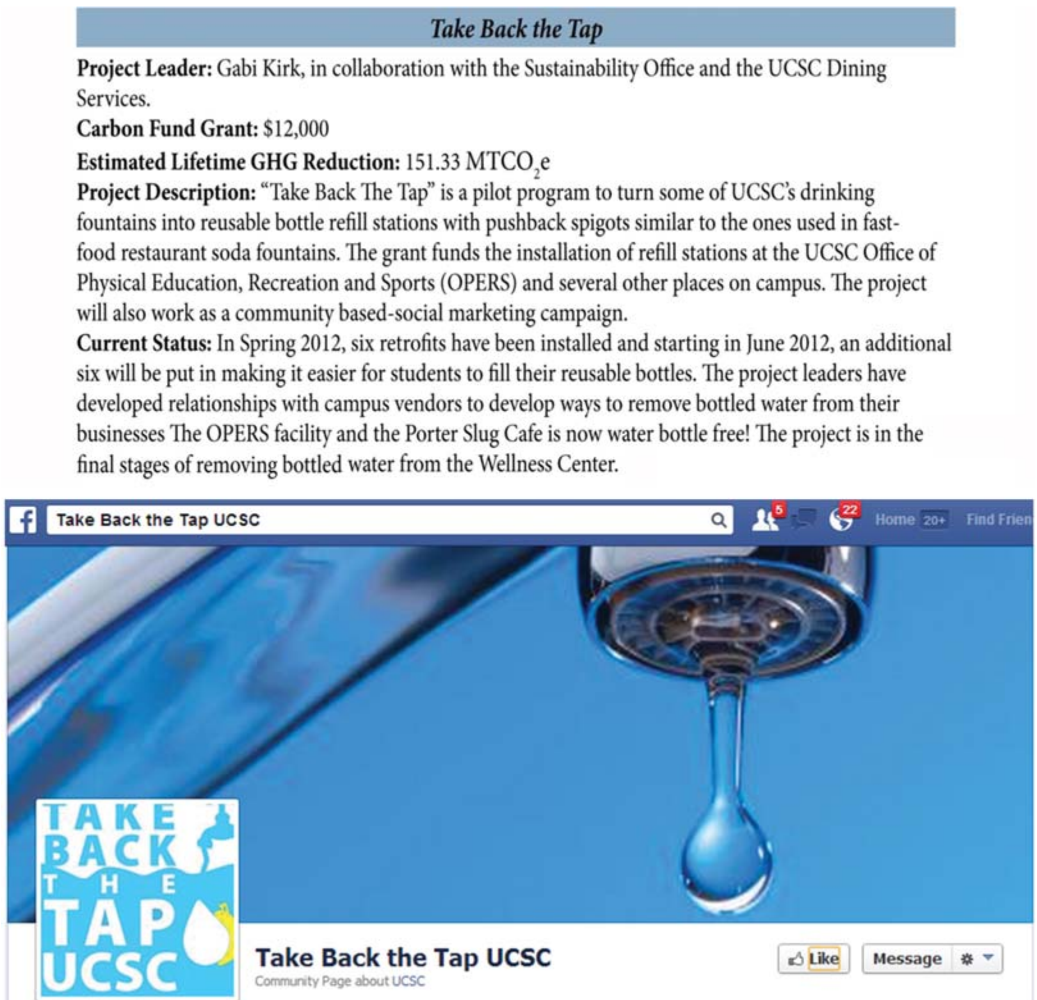
(1) Research, identify and apply new technologies and improvements that reduce campus water consumption and/or increase efficiency;
(2) Maintain the campus potable water demand at levels equivalent to or lower than 780 ML; and
(3) Implement effective educational campaigns to effect behavioral change and reduce water consumption.

Figure 8.5 UCSC student sustainability group.

Example projects

In its first year of operation 17 projects were funded for a total of US$200,000.

Through a combination of site modification and a water-relevant curriculum, UCSC undergrads Lucy Ferneyhough and Winfield Atherton are working collaboratively with the Natural Bridges Green Career School faculty (located off campus) and student body to reduce the school's demand for municipally distributed water. The project recently received a grant from the UCSC Carbon Fund, which will be used in the creation of a rain water harvesting system. Estimated annual savings is approximately 37,850 L of water.



Take Back the Tap

Project Leader: Gabi Kirk, in collaboration with the Sustainability Office and the UCSC Dining Services.

Carbon Fund Grant: $12,000

Estimated Lifetime GHG Reduction: 151.33 $MTCO_2e$

Project Description: "Take Back The Tap" is a pilot program to turn some of UCSC's drinking fountains into reusable bottle refill stations with pushback spigots similar to the ones used in fast-food restaurant soda fountains. The grant funds the installation of refill stations at the UCSC Office of Physical Education, Recreation and Sports (OPERS) and several other places on campus. The project will also work as a community based-social marketing campaign.

Current Status: In Spring 2012, six retrofits have been installed and starting in June 2012, an additional six will be put in making it easier for students to fill their reusable bottles. The project leaders have developed relationships with campus vendors to develop ways to remove bottled water from their businesses The OPERS facility and the Porter Slug Cafe is now water bottle free! The project is in the final stages of removing bottled water from the Wellness Center.

Figure 8.6 Example of student sustainability projects posted on 'take back the tap' facebook page. *Source*: UCSC via Facebook, 2013. Append web address for more information: https://www.facebook.com/pages/Take-Back-the-Tap-UCSC/253056658070353.

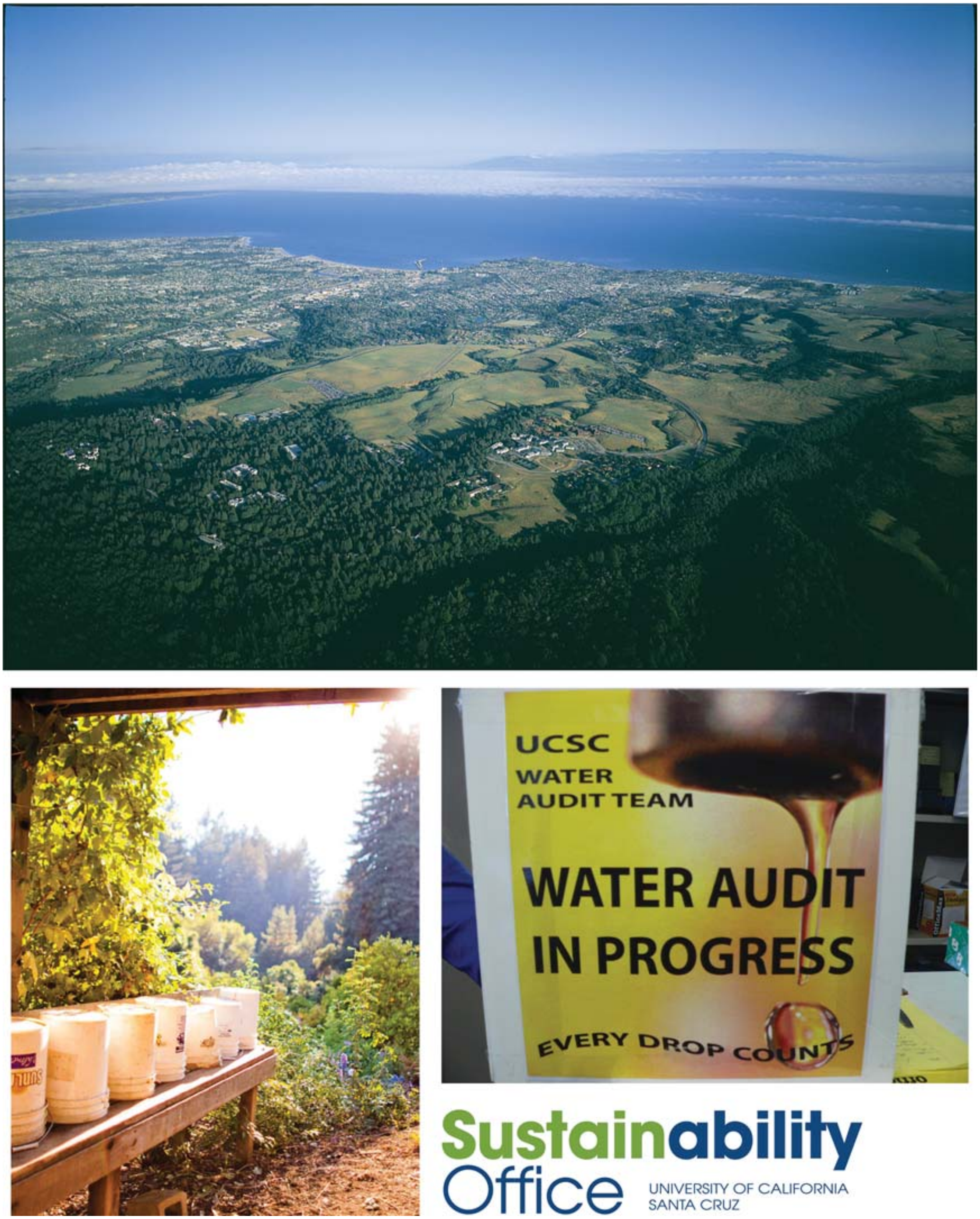


Figure 8.7 Campus wide initiative to reduce water, energy and green house gases.

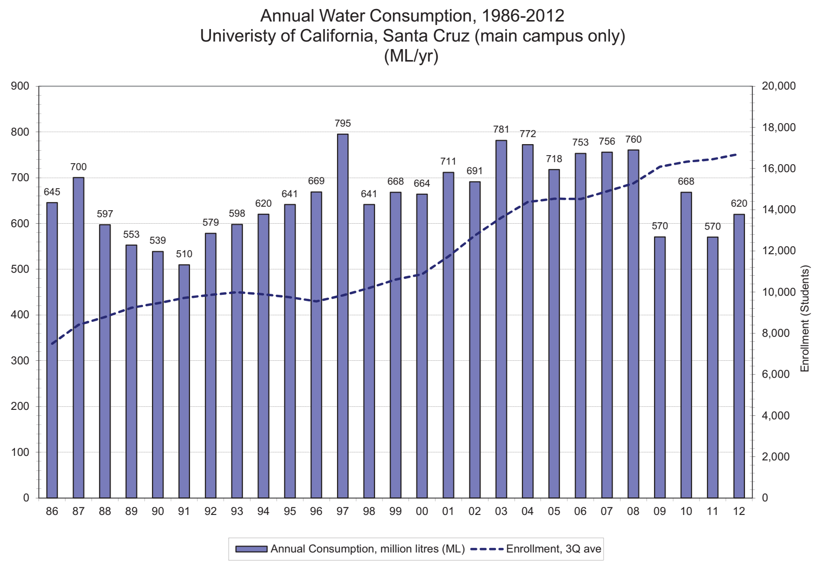


Figure 8.8 Campus water demand compared to student enrollment. *Source*: University of California, Santa Cruz, 2013.

CASE STUDY 17

Funding Water Use Efficiency Through Government Bond Financing, Texas, United States

Maddaus Water Management

In the United States, funds from some citizens voter-approved water bond finances may be used for certain water efficiency projects. For example:

- In May 2013, State of Texas Governor Rick Perry signed House Bill (HB) 4, which lays the foundation for meeting Texas' water future water needs. HB 4 provides for active, full-time governance at the Texas Water Development Board; creates a new funding mechanism to support water-supply project implementation over the next 50 years; and directs local, regional and state officials to prioritize projects to ensure efficient use of available resources. More than US$400 million of the US$2 Billion is for water efficiency projects. This is estimated to be the largest state financed initiative specifically for water use efficiency in United States history. Updates on the status of this major Texas initiative can be found on the Alliance for Water Efficiency web site, on the specific Texas page: http://www.allianceforwaterefficiency.org/Texas-Policy-Info-2012.aspx (last accessed on May 28, 2013).
- Between 1984 and 2006, California passed numerous water bond laws that included funding for water use efficiency programmes. Recent Integrated Resource Water Management (IRWM) Grant Programme Milestones include:
  - 2002 – Senate Bill 1672 creates the Integrated Regional Water Management Act to encourage local agencies to work cooperatively to manage local and imported water supplies to improve the quality, quantity, and reliability.

Figure 8.9 Governor from State of Texas, US signing new law, House Bill 4. *Source*: Office of the Governor, State of Texas, US (28 May 2013), http://governor.state.tx.us/news/press-release/18577/.

- November 2002 – California voters pass Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002, which provides US$500,000,000 (CWC §79560–79565) to fund competitive grants for projects consistent with an adopted IRWM plan.
- November 2006 – California voters pass Proposition 84, the Safe Drinking Water, Water Quality, and Supply, Flood Control, River and Coastal Protection Bond Act, which provides $1,000,000,000 (PRC §75001–75130) for IRWM Planning and Implementation.
- November 2006 – California voters pass Proposition 1E, the Disaster Preparedness and Flood Prevention Bond Act, which provides $300,000,000 (PRC §5096.800–5096.967) for IRWM Stormwater Flood Management.

- Although primarily for large capital projects, the bonds have provided up to US$20 million or more per year for water efficiency projects. In the past, typical water efficiency projects often involved concrete lining of irrigation canals, replacing leaking water mains.
- Administered by the California Department of Water Resources, water utilities must submit proposals to receive funding. Eligible water efficiency projects must build or buy something of a permanent nature (each product's useful life must be at least seven years) and have a benefit- cost ratio higher than 1.0. Eligible projects include: (a) system water audits, leak detection and repair; (b) installation of water meters; (c) distribution system pressure regulation; (d) large landscape irrigation equipment; (e) high efficiency washing machines; (f) toilets replacement; (g) commercial/industrial wastewater recycling; and (h) car-wash wastewater recycling. More information is available through the California Department of Water Resources: http://www.water.ca.gov (last accessed on April 25, 2013).

More information on state policy and funding initiatives throughout the United States is available through the Alliance for Water Efficiency: http://www.a4we.org (last accessed on May 28, 2013)

CASE STUDY 18
ECO-ASIA Water Operator Partnerships Based in Bangkok, Thailand

Reviewed by Arie Istandar, AECOM, WaterLinks.org, Bangkok, Thailand

Water operator partnerships (WOPs),[3] or twinning partnerships, are proven catalysts for improving how service providers can better deliver safe water and sustainable sanitation services. These sustained, peer-to-peer relationships draw on direct engagement and exchange of practical knowledge.

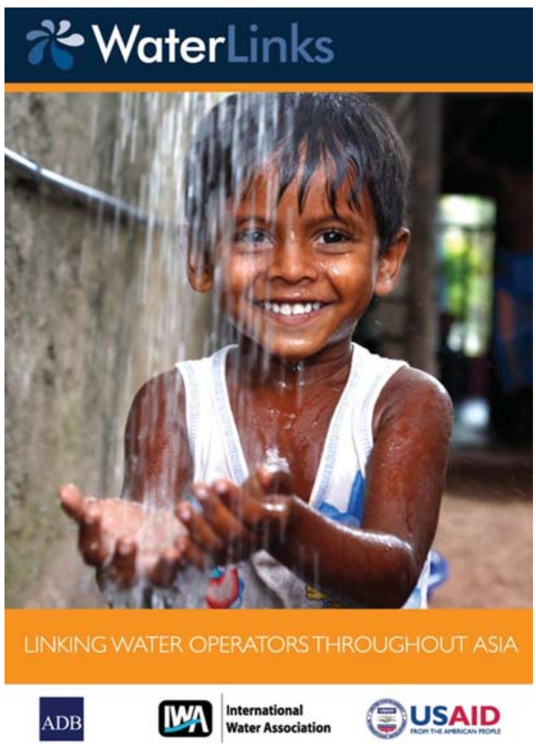


Figure 8.10 Benefits of water operators partnership programme: A small boy enjoys his new shower in small fishing community in Ngembo, Sri Lanka. *Source*: Luke Duggleby Photography for USAID.

[3]More information related to the Water Operators Partnership provided through WaterLinks is available online: http://www.waterlinks.org (last accessed on April 28, 2013) or at info@waterlinks.org

In a WOP, a 'mentor' partner works with its 'recipient' peer to identify and overcome service delivery challenges through a jointly defined work programme. Lasting 12–24 months, typical WOP programme activities include technical consultation, specialized on-the-job training, technology demonstrations, peer review of procedures and systems, and information exchange.

WOPs offer mutual benefits through cooperation. Recipients are able to improve operations and expand services by adopting new policies and practices, and building their skills and capabilities. Mentor partners also enhance their skills by applying knowledge in new settings, and achieve their sustainability goals. All partnerships under WaterLinks adhere to a set of principles and facilitation process to ensure consistency.

The WaterLinks Partnership Facilitation Process has 5 steps:

(1) *Identification*: finding candidate mentors and recipients for WOPs and their priorities, interests and needs.
(2) *Introduction*: introducing mentor and recipient partners to structure their partnership based on defined needs, priorities, capabilities and readiness to contribute resources. In this step, a Partnership Facilitator develops a concept on WOP arrangement and objectives and seeks agreement from both partners.
(3) *Establishment*: developing a joint WOP work plan and formalizing the partnership. Once agreement is confirmed, the Facilitator organizes a 3–5 day visit by the mentor to the recipient to allow the mentor to observe first-hand the recipient's local conditions and service delivery challenges, and assess overall capacity building needs. Based on this assessment, both partners and the facilitator discuss a joint work programme that will address the priority needs; has realistic targets and milestones over a 12–18 month period; and will achieve tangible results in terms of improved or expanded delivery of services. Both partners sign a partnership agreement to implement the work programme.
(4) *Implementation*: advancing defined activities according to the agreed work programme. The Facilitator when necessary helps manage, coordinate and monitor activity implementation. Near the completion of WOP work programme, the Facilitator supports WOP partners to prepare a report that summarizes each activity, results, lessons learned, outcomes as measured against objectives and performance indicators, and further needs for improvements or scale-up of new practices within the recipient's service area.
(5) *Replication*: promoting (1) replication of good practices and innovations between services providers at the regional and national levels and (2) scale-up of improvements within a provider's service area. Based on the WOP final report, WOP partners and the Facilitator jointly prepare a scale-up action plan, in which the facilitator will follow-up through a new or extended partnership.

More information on WOPs is available at: http://www.waterlinks.org.

Chapter 9

Community Involvement and Capacity Development in Water Use Efficiency

Without public support, efficiency programmes that rely on public participation for implementation will fail. The best way to develop public support is to involve the public from the beginning, starting with goal setting. The public can become involved in water efficiency programmes in several ways such as:

(a) Participating in the water efficiency planning process, including inputs on programme goals;
(b) Becoming aware of local water issues and the importance of saving water through information provided by water agencies;
(c) Participating in water efficiency programmes offered by local water utilities;
(d) Helping to educate others;
(e) Encouraging acceptance of the proposed measures by certain types of customers;
(f) Advising on the best way to target programmes;
(g) Building more interest in careers in the water industry and water efficiency;
(h) Enlisting support from non-governmental organizations to participate in water efficiency projects.

9.1 ENGAGING PUBLIC STAKEHOLDERS

Why involve the public in water efficiency planning process?

- *More legitimate* – given that the conclusions have been arrived at through an open, equitable and inclusive process that reflects the broad diversity of views within the community or region.
- *More informed* – citizens are apt to take action when water users are involved in the solution and understand how to save water in the community.
- *More participation* – citizens are more engaged in the implementation phase of the project when they have the opportunity to buy in during the planning phase of the project.
- *More funding support* – with more understanding by local leadership, then their support can lead to more monetary support for the programmes.

9.1.1 Developing a public participation strategy

It's critical to understanding public perceptions surrounding water when setting strategy. There are several helpful resources available including Public Communication: Perceptions and Early Communications Tools (Blankenship, 2010). The International Water Association's pending publication

Water Communications (Herve-Bazin, 2014) will focus on the critical issues of trust building within the community on issues surrounding water. The American Water Works Association Research Foundation (WaterRF formerly AWWARF) has previously developed helpful handbooks including *Public Involvement Strategies…Making it Work (CH2M-Hill, 2001),* which describes 11 steps to take in designing an effective programme for any water project. This step-by-step process to engaging in water professional in infrastructure projects has been adapted specifically to pertain to water use efficiency planning efforts.

Most of the steps are related to the research needed to form the foundations of an effective programme. The 11 steps are listed below, the first eight of which are related to developing the strategy:

(1) *Framing the problem*. Focus on issues and boundaries for why the water efficiency programme needs to succeed, be specific on goals and objectives for public involvement.
(2) *Identify the constraints*. Determine the issues that can be negotiated with the public and those that cannot, such as regulatory or political mandates, and spending limits.
(3) *Identify and describe decisions and planning milestones*. Develop a schedule that shows where the public will be able to provide input into decisions.
(4) *Identify potentially affected participants, or 'stakeholders,' who need to be involved*.
(5) *Determine vulnerability and 'must resolve' issues.* Focus efforts on those issues and groups that are likely to generate any conflict and prioritize as to the 'greatest' need for resolution and those that may proceed without resolution.
(6) *Determine the appropriate level of public involvement*. Establish what level of involvement is needed in order to engage stakeholders.
(7) *Select techniques.* By completing the first six steps, the planner can save time and money by selecting the most suitable public participation from many available techniques (see Section below). Focus on the right tool for where the input is needed in the planning process.
(8) *Finalize a public involvement strategy*. The planners should detail a schedule, budget and staffing requirements for carrying out the strategy designed.
(9) *Implement and monitor the strategy*. Periodic monitoring is necessary to ensure that:
 (a) The timeframe of the problem has not changed (i.e., continuing to plan for long-range water efficiency programme implementation in the midst of a drought crisis);
 (b) The issues remain valid and progress is continuing forward in an acceptable timeframe (9–12 months is typical to fully engage stakeholders and complete the technical planning process); and
 (c) The techniques being used are effective and stakeholders remain engaged.
(10) *Develop a consensus-based statement of goals*. To finalize this strategy session, the planners and stakeholders should issue a statement, based on the steps described above, that defines the agreed upon mission for the planning process, along with specific goals and objectives.
(11) *Manage change*. The process must be flexible enough to adapt to changes in schedule, political environment, staff or critical issues.

9.1.2 Identifying target audiences

Every planning process has a unique list of target audiences that should be involved. The following list is a starting point for identifying participants who should be included: citizens; elected officials; utility managers; policy makers; community leaders; environmental groups; special interest groups; economic development and business organizations; water supply and sanitation professionals; local and regional agencies; government regulatory agencies; recreational interests; landowners/land developers; neighbourhood and community associations; non-governmental organizations; religious leaders; large water users (industry or institutions); and the mass media. This list can be used to identify stakeholders and specific group representatives to be invited to participate.

9.1.3 Techniques for consensus building

A wide variety of consensus-building techniques exists. When the first seven steps listed above in Section 9.1.1 have been conducted and the stakeholders identified, the specific techniques can be selected. Available techniques include:

(a) *Public Meetings*. General assembly of any interested parties that provide informal and participatory forums, which can enhance a utility's relationship with its customers. However, consensus building does not usually occur at such a forum;
(b) *Citizen Advisory Committees*. Government appointed or invited community member committees which allow a broad range of stakeholder input on a regular basis throughout the duration of a project;
(c) *Workshops*. Forums which can provide a participatory process for exchanging ideas and information. Bringing interested parties together enables them to focus on specific issues and concerns as well as build a common understanding and potential for consensus;
(d) *Task Forces*. Such groups, which are more formalized and exclusive, are usually charged with the task of devising and recommending solutions to specific problems;
(e) *Professional or Scientific Panels*. Experts convened who can evaluate evidence regarding specific issues and make recommendations to decision makers, based on technical expertise;
(f) *Mediation*. The use of an experienced facilitator, approved by the participants, that aids in conflict resolution without making a ruling or binding parties to any particular course of action; and
(g) *Arbitration*. This is a formal procedure that requires that opposing parties be bound by the decisions of an impartial adjudicator. Arbitration can be used in conjunction with mediation, perhaps as a last resort when the achievement of a mediated consensus fails.

9.1.4 Tools for engaging the public for setting plan goals

There is a wide variety of tools that can be used in conjunction with, and as support for, the selected approach to involving stakeholders in the planning process. These tools include:

(a) *Participant surveys,* which can provide a knowledge basis by cataloging each participant's basic concerns and expectations. The surveys, which can be used to highlight divergent views that will need resolving on key issues, can be random telephone surveys of the general public, or one-on-one interviews with key stakeholders. Individual customers can be asked to detail what steps they have already taken to reduce consumption, and what programmes they are willing to participate in;
(b) *Issue or discussion papers,* which help to define the issues and provide a common basis of knowledge about an issue or set of issues. While such papers do not attempt to resolve issues, they can be the catalysts for educating and starting discussions with stakeholders. They can also help in deciding what measures can be undertaken to reduce water use and at what cost;
(c) *Policy statements.* These go further by committing participants to a specific position. Draft statements are circulated until consensus on a final version can be reached. They reinforce the outcome of the consensus-building process.

9.1.5 Guidelines for conducting a successful process

In addition to maintaining an honest and open participatory atmosphere, some general tips that can ensure success include:

- *Setting realistic goals*. Organizers and participants must bring realistic goals to the negotiation table, even though this process will not solve everyone's problems. It is important to remain focused on the key issues that require consensus and to avoid non-essential issues.
- *Optimize participation* by including only those stakeholders who need to be involved. Groups of 25 or less can be more efficient in making decisions and reaching a consensus.
- *Discourage hidden or disruptive agendas* (e.g., those of special interest groups). The process should stay focused on setting water-use efficiency goals.
- *Create access and openness*. Make resources, such as key staff, available during and between meetings. In addition, necessary information integral to the process should not be privileged.

Finally, using public participation in a consensus-driven goal is one of the key features of water-use efficiency plans. The public, which has a right to know the facts in advance, can offer good ideas that can lead to a better plan.

Many water resource projects could be controversial and the question on if the community can be more efficient with existing supplies is a frequent topic for discussion in a least cost planning approach to infrastructure planning. In some cases, water efficiency plans have been more successful in getting infrastructure plans funded and implemented because these plans used public input in determining the appropriate balance between water resource development, demand management through water use efficiency techniques and the environment.

9.2 BUILDING PUBLIC AWARENESS ON WATER CONSERVATION AND WATER EFFICIENCY

Information and promotion efforts happen at either a national, regional or local government level. There are occasions when multiple promotions are being conducted at the same time. Coordination is vital to the success of the program to have a clear and consistent message that can be heard and acted upon by local water consumers at their taps. Given the fiscal reality for utilities in both developing and developed countries, the behaviours leading to water users being the most efficient with local water supplies will be based on educated individuals making informed decisions.

9.2.1 Developing a public awareness program

Environmental Cooperation-Asia (ECO-Asia) with support from the United States Agency of International Development (USAID) has developed a 10-step tool-kit, including a Facilitator Guidebook and other support materials, that follows the international best practice for the design and implementation of water, sanitation and hygiene promotion programmes. The process begins with forming a core team to lead the effort and working through the step-by-step approach. The 10-steps are:

- Step 1: DEFINE the Problem, Potential Audiences, and Ideal Behaviors
- Step 2: GATHER Information
- Step 3: FOCUS on Feasible Behavior for One Audience and Problem
- Step 4: STRATEGIZE Long-term Change Goal, Objectives and Impact
- Step 5: PLAN Short-term Promotion Plan

- Step 6: CREATE Promotional Materials and Activities
- Step 7: PRETEST and Finalize Promotional Materials and Activities
- Step 8: IMPLEMENT the Promotion Campaign
- Step 9: MONITOR Promotion Process and Outcomes
- Step 10: EVALUATE Promotion Outcomes and Improve

This easy-to-use toolkit was developed for practitioners to use the Toolkit without consultation with experts. Access to the materials is available at no-cost through WaterLinks and available directly online: http://www.10step-toolkit.org/ (last accessed April 9, 2013). Scaling up the messages in times of drought is easier when an existing public awareness effort is on-going, and campaign themes and messages should evolve based on the outcomes of Step 10. The tool kit is demonstrated in Cambodia in Box 9.1.

BOX 9.1 EMPLOYING 10-STEP PROMOTION PROGRAM TOOLKIT, PHNOM PENH, CAMBODIA

The toolkit was used successfully in a field test in Phnom Penh, Cambodia, where the municipal government wanted to reduce the rates of waterborne diseases through changing the unhygienic behaviors of its citizens. As part of this effort, ECO-Asia facilitated a Water Operator Partnership between the City of Phnom Penh and the City of Iloilo, Philippines to develop an awareness campaign promoting the importance of good sanitation and hygiene practices, especially among children. Visits and technical exchanges between the staff at the two cities was instrumental in the development of promotion campaign messages and approaches to deliver the messages.

As part of their campaign, Phnom Penh created and disseminated school notebook covers and posters as daily reminders for school children of the need for better sanitation. The Municipality of Phnom Penh also organized Cambodia's first ever water, sanitation and hygiene (WASH) promotion day with over 1200 participants, including 500 students. The event included hand washing demonstrations, 'Love Clean Hands' t-shirt giveaways, and appearances by senior city officials. This campaign may also easily include best practices for being water efficient, for example, turning off the water when washing hands.

An example of a regional water conservation awareness program for 22 water utilities in northern California that used a design approach that followed these basic steps is provided at the end of this Chapter. As another example, the Alliance for Water Efficiency has developed a national public education program as described in Box 9.2.

9.2.2 Achieving social acceptance through cultural awareness and community based marketing

Establishing the need to be efficient with local supplies requires that the local citizens understand the benefits and specifically how to conserve water supplies through their actions. This understanding involves learning how modifying or adopting new individual water using behaviours can benefit their entire community. Tying in local slogans or messages can be powerful in terms of citizens identifying with local water efficiency initiatives.

With the advent of social media such as Facebook, Twitter and other online means of interconnecting local and global citizens, a new strategy has emerged to use these networks to share messages to 'subscribers' to local utility alerts or public awareness campaigns. Australian utilities have been at the forefront of leveraging these 'Community Based Social Marketing' tools to incentivize changing local water use behaviours. An example from Western Australia is provided in a case study at the end of this chapter.

BOX 9.2 NATIONAL PROMOTIONAL CAMPAIGN AND COMPREHENSIVE WATER EFFICIENCY WEBSITE DEVELOPED BY THE ALLIANCE FOR WATER EFFICIENCY

An example of a national promotional campaign developed by the Alliance for Water Efficiency includes a slogan, website, social media messaging and a bottle as collateral to promote the message 'Never Waste.' (Alliance for Water Efficiency, 2013)

The Alliance for Water Efficiency was formed in 2007 for the purpose of promoting the efficient and sustainable use of water. A non-profit organization, AWE serves as a voice for the long-term protection and wise use of water resources, especially drinking water resources. Headquartered in Chicago, AWE focuses on water efficiency programs and practices primarily in the US and Canada. However, AWE also works in other parts of the world, including Australia, Jordan, Italy, and the Philippines.

Figure 9.1 National promotional campaign in United States. *Source*: Alliance for Water Efficiency (2013).

The AWE website (Alliance for Water Efficiency, 2010) provides a comprehensive collection of conservation related information and documents. The site was originally launched in 2008 containing a Resource Library of detailed information on water efficiency products and programs, research papers, regular news reports, the 'Water Efficiency Watch' newsletter and a 'Legislative Watch' page. The site, updated daily, received over 8 million hits from more than 600,000 users in 2012, with over 550,000 documents downloaded – confirmation of the depth of information contained in the site and its relevance to users in the water resource community.

Source: Alliance for Water Efficiency (2013).

An example of artwork on the outside of a pressure reducing station is shown below and is used to help the residents in the neighbor value the facility, the equipment inside and ultimately understand the need to protect it from vandalism. An example of this strategy for community involvement to facilitate community acceptance is shown in case study at the end of this chapter for Khayelitsha, one of the largest townships, near Cape Town, South Africa.

Figure 9.2 Pressure Reducing Station Artwork 'Water is Precious' or 'Amanzi Axabisekile' in the local language Xhosa, photograph of Mr. Zolile Basholo. *Source*: Jaco de Bruyn (2013).

9.3 BUILDING COMMUNITY CAPACITY AND LEVERAGING NON-GOVERNMENTAL ORGANIZATIONS

There is a recognized need around the world to build more expertise in managing our water systems. As many utility workers are reaching retirement age, there is now a greater need than ever for succession planning such that workers are sufficiently skilled to successfully operate water systems in the future. Efficient water management extends beyond local utility workers, in that all careers that are water related from plumbers, landscapers and non-governmental organizations are all directly or indirectly water managers, and that can aid in making our resources more sustainable.

According to the United Nations, water operators provide approximately 90 percent of water and sanitation services worldwide. Water operators are essential to the achievement of the Millennium Development Goals and the realization of the Human Right to Water and Sanitation. It is therefore crucial to support utilities' capacity to improve the quality and the efficiency of their services (United Nations, 2013b).

Through the United Nations (UN) Water Family and partnerships, there are a wealth of open-source products and resources including publications, toolkits, experiences, training courses, knowledge that deserve to be put more directly at the disposition of operators. A primary goal of the Global Water Operators Partnership Alliance is to strengthen water operators' capacities, especially in poor countries and in regions with a lack of systematic exchange of know-how and expertise (United Nations, 2013a).

9.3.1 Engaging local professionals and trade organizations

There are or can be capacity built to implement water use efficiency through a local, national or international professional or trade organizations. Numerous internet links to these organizations is provided in Appendix 2.

Professional organizations are numerous. A few prominent international organizations include:

- International Water Association, Efficient Urban Water Management Specialist Group
- United Nations, UN-HABITAT Global Water Operators Partnership Alliance

- American Water Works Association, Water Conservation Division
- Alliance for Water Efficiency

Trade Organizations can include:

- Plumbers
- Landscape design or architects
- Landscape maintenance workers
- Gardening clubs

Many local trade and professional organizations are striving to help make our water resources more sustainable. Two unique organizational initiatives are the GreenPlumbers and Green Gardener programs. The GreenPlumbers program is described in the following box story and the Green Gardener program is described within the Regional Water Authority case study at the end of this chapter.

Box 9.3 describes the Green Plumbers programme started in Australia.

BOX 9.3 GREENPLUMBERS TRAINED ON MORE WATER EFFICIENT TECHNOLOGIES AND PRACTICES

GreenPlumbers is a global brand formed by the Master Plumbers & Mechanical Services Association in Australia in 2000, as a result of the severe drought that severely impaired water supplies in Australia for the last decade. The Green *Plumbers* curriculum was developed in conjunction with RMIT University (Melbourne) and the Australian Greenhouse Gas Office.

Green Plumbers is one of the Green Invest Group of companies. Green Invest is a publicly listed Australian Company on the Australian stock exchange (GNV). Green Invest has the vision of developing the world's leading environmental services and commodities company.

Green Invest Group of companies provide fully integrated sustainable environmental solutions ranging through:

- Carbon emission trading;
- Energy, water and transport audits and assessments;
- Training and education services to individuals businesses, organizations and community groups;
- Supply and installation/implementation of green technologies; and
- Implementing carbon offset programs and recommending energy efficiency initiatives.

Training rights for Green Plumbers in the United States and Canada are held by the International Association of Plumbing & Mechanical Officials (IAPMO), operated under the name Accredited Green Plumbers Training – not affiliated with Green Invest.

In 2000, the Master Plumbers and Mechanical Services Association of Australia (MPMSAA) identified the need to train Australia's plumbers in green technologies to combat the effects of climate change. The Green *Plumbers* program was established and is now recognized internationally as being at the forefront of training and the installation of water and energy saving products. In 2008 the commercial arm of Green *Plumbers* was acquired by Green Invest Ltd. Green *Plumbers* environmental training and licensing is now being implemented in Australia, the US, Canada, India, China, and New Zealand.

Source: Green Plumbers US (2013)

9.3.2 Role of non-governmental organizations

Local community initiatives have the ability to make positive ideas into reality through harnessing volunteer time and financial resources from among neighbors. Impassioned local leaders in the community have driven the organization of groups of individuals to become more water efficient. There has been a shifting focus towards NGOs training local citizens to leverage water efficient technologies such as repairing leaking appliances and plumbing fixtures.

Figure 9.3 The Jordanian Business Women Forum held seven training courses last year in Amman to train housewives on basic plumbing related to water pipes, taps and sinks in their homes (Namrouga, 2013). *Source*: Jordanian Business Women Forum.

An example of a NGO striving for a more sustainable use of our water resources is ECODES. The following box story describes their notorious programme supported through a partnership with local, regional and the European Union LIFE programme. Box 9.4 describes a model program in a city in Spain.

BOX 9.4 'WATER SAVING CITY', ZARAGOZA, SPAIN

In the year before the project was initiated by the *Fundación Ecología y Desarrollo,* there were 11 million Spaniards were undergoing daily water restrictions. There were serious inter-regional conflicts over this scarce commodity. In Zaragoza, a city of 700,000 residents in the north-east of Spain, as in other cities in Spain, a triple paradox was to emerge: rainfall was scarce and irregular, water was cheap, and it was being misused. February 1997 saw the beginning of the 'Zaragoza, the water-saving city' project. This aimed to promote a new water-saving consciousness through a more efficient management of this resource. It emphasised, above all, the importance of simple technological change to achieve a sustainable reduction in water consumption. The project was to issue a challenge to the city: to save 1000 million litres of domestic water consumption in one year. The project has shown that it is possible to deal with the shortage of water in cities, using a cheap, ecological, fast and contentious-free approach, by increasing efficiency in consumption. The most important lesson to be learned is that the shared responsibility between the main players (manufacturers, retailers, consumers, distributors, plumbers and so on.) has managed to create a new synergy which favours water-use efficiency.

A survey carried out in Zaragoza before the beginning of the campaign showed that about 60% of those questioned could not remember or were ignorant about water-saving strategies in the home.

(*Continued*)

BOX 9.4 (*Continued*)

With the successful implementation of raising the awareness of local inhabitants in 1997–1998, the following participation occurred:

- Plumbing and bathroom retail outlets collaborating in the campaign witnessed a 170 per cent rise in sales of their water-saving products.
- 168 educational establishments, 428 teachers and 70,000 students were directly participating in the campaign's Educational Programme;
- Over 140 establishments selling products related to domestic water consumption collaborated in the campaign. This figure means that 65 per cent of bathroom, ironmongery, plumbing, electrical household appliance and meter installation outlets were actively participating in the project.
- Three of the city's property developers have decided to install water-saving devices in their new homes.
- Over 128 large and small firms were collaborating in the campaign.
- 90 per cent of the media in Zaragoza were collaborating directly in the campaign.

The project had a budget of nearly US$668,000 (85 million pesetas). Just under 50 per cent of the financing is being provided by the European Union LIFE programme, with the rest being shared between the rest of the partners: the *Fundación Ecología y Desarrollo*, *Zaragoza City Council* and the *Aragón Regional Government*. Spanish and other cities around the world now have a successful model to follow for the most ecologically-sound method of facing up to water scarcity.

Source: ECODES (2013)

Another example of a local non-governmental organization, Generation Water, that has government funding and support from local water utilities, trains local students (ages 16–18) as part of a Water Infrastructure Academy on how to upgrade irrigation systems and is presented in the following Box 9.5.

BOX 9.5 TRAINING STUDENTS TO BE WATER MANAGERS BY GENERATION WATER, CALIFORNIA, UNITED STATES

Operating as the Infrastructure Academy in its first few years, Generation Water offered environmental education courses through high schools and colleges. In 2009, Generation Water was created to provide employment opportunities for students to do hands-on, environmental work. In 2010, Generation Water was awarded the State of California's US$2.5 million Green Innovation Challenge and since then, has worked with water agencies, large landscape property managers, and homeowners to save them water, time, and money. The two main purposes are to:

(1) To restore landscape to its natural beauty while living within our water resources.
(2) To prepare the next generation with the technical and business skills necessary to lead the transition to a sustainable economy.

Generation Water has been recognized as a results-driven organization that is leading the way in transforming California to its natural landscape. Generation Water has:

- Conducted over 240 school water audits and irrigation surveys
- Located and inventoried over 350 irrigation controllers and 5,300 valves

(*Continued*)

BOX 9.5 (*Continued*)

- Cataloged over 25,000 sprinklers including 10,000 that were malfunctioning or broken
- Installed over 125 rain gardens
- Employed and trained over 250 youth and young adults

Generation Water's clients have included the Los Angeles Department of Water and Power, Los Angeles Unified School District, Metropolitan Water District, Upper San Gabriel Valley Municipal Water District, Baldwin Hills Conservancy, Suburban Water Systems, Park Water Company, the City of Santa Clarita, and others.

In 2012, Generation Water celebrates its five-year anniversary and currently operates as a social entrepreneurial organization focused on a triple bottom line:

(1) Environmental: Water saved and acres restored to sustainable landscape
(2) Social: Number of young adults trained and placed into career paths
(3) Economic: Economic value created

Source: Generation Water (2013)

9.3.3 Role of local community leaders and citizens

With a clear purpose and energized citizenry, communities can strive to be more water efficient at local water taps through distribution of devices, training and educating the community on more efficient technologies such that other neighbors can make better decisions. An example is sharing information from a key leader in the neighborhood or neighborhood groups related to how each has found ways to be more efficient, including specific details on what and how it was accomplished and what local resources were used (i.e., local stores or manufacturers).

It is also common for utilities to ask for local neighborhood leaders to act as ambassadors and watch over neighborhood areas and identify actions for the water utility to take. For example, utilities cannot continuously canvass its many kilometers of distribution pipe network and know where leaks are surfacing that need to be repaired. It is helpful to have specific communication channel set up to share this information like identified leaks with the utility. An example from the Philippines is provided in the following Box 9.6.

BOX 9.6 COMMUNITY ORGANIZATION TO REDUCE NRW IN MANILA, PHILIPPINES

In the east sector of Metro Manila, Manila Water Company, Inc. is organized into 247 territories, each headed by a territory manager who oversees anywhere from three to five District Metered Areas (DMAs). Each territory has from 1500 to 5000 connections. In addition, DMAs are broken up into meter reader units, with each meter reader having up to 200 connections to monitor and service.

Within the organizational setup, a DMA is a business unit. DMA managers must be entrepreneurial and meet business targets. This means that they can propose additional investment but must have a business plan to justify full-cost recovery and the profitability of the new pipe investment. The principal concern of a territory and DMA manager is to both reduce NRW and increase billable water.

The Manila Water structure is designed to allow DMAs to have a direct relationship with every customer within the metering area. Once the area's demographics reach a certain density or the character of the area changes, a DMA is reorganized or a new one formed.

(*Continued*)

BOX 9.6 (*Continued*)

Outside of the DMA managers and meter readers, a critical part of the structure is the identified kasanggas (street leaders) in the community. The DMA managers have to develop anywhere from five to seven (sometimes more) of these relationships in their areas. They help communicate problems on the ground and broadcast local plans and news to communities.

Source: Asian Development Bank and the Institute of Water Policy (2010c).

9.3.4 Gaining support from local institutions and universities

One area that has gained a lot of momentum for support of water efficiency is from local institutions and universities. The support has come on a variety of different campuses across the globe with student organizations and clubs supporting resource efficiency and sustainable practices, to courses and educational material provided by instructors and professors to train the global workforce. Individual universities can often have their own campus sustainability goals and initiatives to reduce water, energy and waste.

Stanford University located in Palo Alto, California has been working on water efficiency on campus since they published a Water Conservation, Reuse and Recycling Master Plan in 2003. Stanford University has been very successful over the past decade at reducing their potable water use through implementation of this Plan, as the campus has spent US$2 Million on campus efficiency retrofits including replacing over 15,000 water fixtures (toilets, urinals, faucets, showers, ice machines, spray valves, laboratory steam sterilizer upgrades, landscape irrigation equipment upgrades and more). The campus exceeded their goal to reduce water use 20 percent while the campus increased total campus building square footage and added students. Their website includes information about their water efficient retrofit projects and a copy of their original master plan: http://lbre.stanford.edu/sem/water_efficiency (last accessed April 29, 2013). (See Box 9.7 below.)

BOX 9.7 RECOMMENDED STEPS FOR PILOT PROJECTS, STANFORD UNIVERSITY, CALIFORNIA, US

Stanford University has provided a list of the steps they recommend for a successful university pilot project (which may be considered applicable to utilities).

(1) Define the goal(s) of the pilot project with the Water Efficiency team; this may include sponsors and participants, depending on the situation and project.
(2) Identify interdisciplinary working team with skills needed for the project (e.g., mechanical engineer, building or department liaison, contractor(s), vendor(s), etc.)
(3) Verify the goal(s) are still important to the team. Ask or answer any questions about the project objectives so that expectations are clear: why are we doing this project? How will the outcomes benefit the agency/company/group/team? Once the results are in what change can be made?
(4) Define roles and responsibilities, schedule, information/data needs, the 'process' for the project. It is best to document this information between the parties in a 'internal contract' to that there is a record for all parties on the agreements and plan for the project financing and what is to be done.

(*Continued*)

BOX 9.7 (*Continued*)

(5) Identify the following:
  (a) Length of the pilot project study (for indoor equipment, fixtures, typically requires at least 6 months; for irrigation projects 12 months is more realistic)
  (b) Costs and funding for the pilot. It is important to note those funds are provided for a project to a department **after** it is completed and invoices have been submitted. There have been a variety of problems with providing up front funds to a department before the project was completed and is not recommended.

(6) Complete 'internal contract' with group lead from group benefiting from pilot study (the recipient of funding, equipment, and data). This contract and documentation formalizes the process, roles, and responsibilities.

(7) Identify major tasks and schedule initial site visit with 'Water Efficiency Team'. During this step the team can review steps #4 and #5.

(8) Keep track of schedule, task completion, and team commitments by scheduling regular 'communication'. Typically this communication is every 2 to 4 weeks.

(9) Perform site visit with team at completion of the project, obtain invoices paid, review paperwork, any warrantees or documentation needed for the project **before** issuing the funds.

(10) Provide dollar funding to the project. Clearly document items that were installed in the final paperwork.

(11) Consider developing a 'fact sheet' about the pilot project success, track water use after the project is completed (post retrofit water use), document lessons learned. Provide the information about the pilot project on the internet so others can benefit from the project experience.

Source: Personal Communication, Marty Laporte (2013).

Starting in 2012 an organized group focused on water efficiency called the 'College Water Efficiency Group' was started in California in the United States. The university campuses in the United States use a very significant volume of water per day for not only instruction by research (e.g., laboratories conducting daily experiments can be water intensive to clean all the laboratory equipment and glassware). In the state of California, there are over 220 large universities that have 4 million students and faculty on campus on a daily basis (4 million students and faculty represent approximately 10 percent of the total state population or 1 in 10 people are on a university campus on a daily basis).

The voluntary group has over 70 members representing a diverse number of entities, including water and energy utilities, who have all come together with the common goal to work on projects and improve water use on university campuses. The benefit of a diverse group is collaboration for funding, ability to do large scale projects, generate new ideas and share successful ways to implement projects to obtain real water savings. As of July 2013 the current members represent the following entities:

- Over 40 large Public / Private Universities from four different state territories within the United States
- Over 20 Water and Energy Utilities
- Organizations such as California Urban Water Conservation Council, Water Reuse Association (focused on commercial/industrial water reuse), Alliance for Water Efficiency
- Water and Energy Consultants

The group meets every other month via phone to share lessons learned as they work on 'implementation' of efficiency projects. The current group projects include the following efforts:

(1) Create list of successful projects completed at each campus (list will allow sharing and knowledge transfer from previous successes)
(2) 10 Steps to the Pilot Project (the campuses are considering doing multiple pilot projects).
(3) Water-Energy Nexus (conduct projects that create benefits of both water and energy savings)
(4) Non-Potable Uses on Campus (use of recycled water to reduce potable water needs)
(5) Sharing of policies that are in place in order to encourage water efficiency (e.g., campus goal to reduce campus water use 20 per cent)
(6) Review Technology to Minimizing Water Loss

This group, and others like the water operators partnerships, serves as examples of how synergy can be created among collaborative individuals and organizations. These groups once formed can quickly become highly valued for innovative idea sharing that allows for more success in efficient uses of water.

CASE STUDY 19
Stakeholder Participation in Water Sector Planning, Jiangsu Province, China
Reviewed by Arie Istandar, AECOM, WaterLinks.org, Bangkok, Thailand

'Leveraging stakeholder participation can be an effective means for strengthening water services delivery in China. Stakeholder participation is relatively new to the sector in China. As participating governmental agencies, water companies, research institutes, communities and even citizens become more effective in testing and deploying new approaches for stakeholder involvement, new governance and operational systems will be adopted by cities and water services providers. In Asia, USAID implements regional water and sanitation activities through the Environmental Cooperation-Asia (ECO-Asia) Water and Sanitation Program and under WaterLinks.

ECO-Asia develops and implements activities that demonstrate innovative strategies for expanding and improving access to safe water and sustainable sanitation. From 2008 to 2009, ECO-Asia implemented five activities in China related to strengthening the good governance of water and sanitation services. These projects included:

- Stakeholder Participation in Water Sector Planning
  - Stakeholder demand surveys and focus groups to support water service expansion in Jiangsu Province; Guidelines for participatory planning for water service projects in Jiangsu Province; and

   - Stakeholder surveys and focus groups to support sanitation decision-making in Yunnan Province;
- Customer Feedback Systems via Twinning Partnerships through WaterLinks
   - Customer service and customer water quality monitoring in Shenzhen, Guangdong Province; and
   - Customer water quality monitoring and service delivery in Yancheng, Jiangsu Province.

This report summarizes and analyzes the experiences of these pilot projects, and evaluates the potential of each activity for scale-up in China. It provides a series of conclusions and recommendations on further strengthening public participation and good governance.'

Source: Personal communication, *Arie Istandar (2013) and WaterLinks (2013b)*

CASE STUDY 20
Public Involvement Through Education and Outreach Programs Regional Water Authority, Sacramento Region, California, United States

Amy Marie Talbot, Program Manager, Regional Water Authority, California, United States

The Regional Water Efficiency Program (RWEP) is designed to capture the economies-of-scale for the joint operations of 20 water utilities in the Sacramento, California, United States area to meet California Urban Water Conservation Council Best Management Practice implementation commitments. The RWEP 'Be Water Smart' Program involves public outreach, professional and school education and various incentive programs[2] for a jointly funded business plan with a Fiscal Year 2013 budget of US$532,000 (including annual per-connection basis by the subscribing 20 water agency members) with US$206,000 in funding to support the 'Blue Thumb' outreach campaign (Figure 9.4).[3]

The 'Blue Thumb' outreach campaign focuses on reducing the outdoor irrigation demands of more than 1.8 million local citizens. The campaign specifically targets domestic outdoor use as it represents 65 per cent of an average household's total water use in the Sacramento region. The two primary goals of the campaign are to help residential water customers understand the need to use water efficiently outdoors and to undertake key water-efficient behaviors most likely to reduce outdoor water use. The 'Blue Thumb' campaign includes four key messages:

(1) Tune up your sprinkler system every spring.
(2) Check your sprinkler system every month for problems.
(3) Repair water-wasting problems within 48 hours.
(4) Schedule your sprinkler timer to water according to the weather.

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[2]The RWEP Program also includes a supplemental budget of approximately US$1.1 million dollars that incorporates grant and cost-sharing activities as well as in-kind partnership agreements with the regional wastewater and local energy service providers.

[3]The RWEP operates on a fiscal year (FY) basis. Budget figures in above text refer to FY 2013 from July 1, 2012 to June 30, 2013. The RWEP water agency member dues totaled US$400,000. Budget figures vary from year to year based on water agency member dues, available grants funding and other factors.

Figure 9.4 Public awareness ‘Blue Thumb’ outreach campaign promotional materials.

To communicate these primary messages across the Sacramento Region the ‘Blue Thumb’ campaign includes the following strategies:

- Call for ‘Blue Thumb’ pledges from residents to make an action- based commitment to reduce their outdoor water use. Every resident that signs a pledge receives a pair of ‘Blue Thumb’ garden gloves, an irrigation system maintenance tool, or gardening knee pad to remind them of their pledge when gardening or watering their landscape.
- Distribution of ‘Blue Thumb’ logo to each member service area for inclusion on water bills, newsletters, individual agency websites and other outreach avenues.
- Distribution of media public service announcements featuring the campaign’s signature ‘sprinkler dance’ and water savings tips through advertisement purchases on prominent region-wide television and radio stations.
- Development of the coordinating ‘Blue Thumb’ campaign website (BeWaterSmart.info) with new material including ‘how to’ videos and ‘check lists’ to help residents tune up and check their sprinkler systems at home, volunteer blog contributors by local landscape professionals and residents, low water use plant guides, and local water provider rebate information.
- Promotion of ‘Blue Thumb’ messages and pledge at local community events such as the University of California Cooperative Extension’s Harvest Day, partnerships with community leaders such as the Sacramento Kings (Figure 9.5), the region’s professional basketball team and other public relations opportunities such as support from the city of Sacramento’s Mayor, Kevin Johnson.
- Outreach via social media such as Facebook, Twitter and email blasts. RWA partners also provide social media postings on their respective pages. For example, Slamson, the Sacramento Kings mascot, posted on Facebook before and after several targeted games where RWA staff had planned attendance.
- Targeted online web advertisement purchases promoting signing up online for the ‘Blue Thumb’ pledge with unique prizes such as a signed Sacramento King’s jersey and River Cats tickets, Sacramento’s local baseball team.
- Integration of ‘Blue Thumb’ outreach campaign through media, event, and programmatic participation of partners including California’s Save Our Water campaign, the California Department of Water Resources and Association of California Water Agencies’ ‘Water Awareness Month’ in May, the United States Environmental Planning Agency’s WaterSense Program and Fix a Leak Week, Creek Week and Earth Day among others.

Public Awareness Campaign Celebrity Spokesperson:

Kevin Johnson, Former Professional Basketball Player & Mayor of City of Sacramento, California, United States

(Population 465,000)

Figure 9.5 Public awareness 'Blue Thumb' outreach campaign celebrity spokesperson.

The Regional Water Authority's Fiscal Year 2013 planned budget for the 'Blue Thumb' outreach campaign was US$151,000. Additional funding was obtained through state grant programs from the California Department of Water Resources and internal program funds for a total budget of US$206,000. Table 9.1 shows the Blue Thumb Fiscal Year 2013 Budget Summary by strategy.

Table 9.1 Summary of Blue Thumb fiscal year 2013 budget.

Strategy	Funding amount	Percentage of total 'Blue Thumb' program funding (US$206,000)
Advertising Purchases (TV/Radio)	US$30,000	15%
Public Service Announcement (PSA) Development	US$56,000	27%
PSA Distribution	US$10,000	5%
Website Additions	US$16,000	8%
Water Provider Outreach Tools and Training	US$3000	1%
Partnership and Campaign Launch with Sacramento Kings	US$27,000	13%
Partnership and Campaign Launch Event with River Cats	US$25,000	12%
Social Media	US$7000	3%
Media Outreach	US$6000	3%
Blue Thumb Events Team	US$10,000	5%
Collateral Items	US$10,000	5%
Program Management	US$6000	3%
TOTAL	US$206,000	100%

The results of the 'Blue Thumb' outreach campaign strategies include[4]:

- 3000 Blue Thumb Pledges
- 117,308 (BeWaterSmart.info) web site visits with nearly 3 times more visits in 2012 than 2011

[4]All numbers are from 2010–2012 except the number of pledges that includes data only from 2012. (Talbot 2013).

- 51,771 unique website visitors with nearly 4 times more unique visitors in 2012 than 2011
- 12.6 million impressions from ads
- US$117,350 in added value from Public Service Announcements (PSAs)
  - TV: 520 airplays on 9 stations (US$61,000 value)
  - Radio: 805 airplays on 20 stations (US$56,000 value)
- 23 guest blog entries
- 33 media stories
- 6 awards
  - 2013, Short-term Public Relations Campaign Category, Silver CAPPIE Award, Sacramento Public Relations Association, Water Spots: RWA Student Video Contest.
  - 2012, Continuing Public Relations Program Category, Gold CAPPIE Award, Sacramento Public Relations Association, 'Blue Thumb' Campaign.
  - 2012, New Media—Blog Category, Silver CAPPIE Award, Sacramento Public Relations Association, 'Blue Thumb' Blog.
  - 2012, Overall Communications Program Category, Crystal Award, International Association of Business Communicators, 'Blue Thumb' Campaign.
  - 2012, Social Media Category, Crystal Award, International Association of Business Communicators, 'Blue Thumb' Campaign.
  - 2012, Campaigns/Programs: Marketing/Communications Category, Award of Distinction, California Association of Public Information Officials, 'Blue Thumb' Campaign.

In coordination with the 'Blue Thumb' outreach campaign, the RWA also implements the Blue Thumb Neighbors Program. This Program is designed to operate on a community scale to inspire residents to adopt River-Friendly landscaping practices (River-friendly Landscaping practices are described in more detail in the Professional Green Gardner section). Blue Thumb Neighbors, which is offered free of charge to participants, uses community-based social marketing techniques to encourage learning and behavior change. These techniques include: working with local community influencers and leaders who serve as advocates; asking participants to pledge to participate; and making that pledge public. The Program also offers engaging education and incentives such as an at-home consultation on efficient watering conducted by local water providers; comprehensive resource kits; three fun, classroom-style workshops on sustainable landscape design, efficient watering and low-water use plants; and a hands-on workshop (called a 'Blue Thumb Garden Party') during which participants improve a neighbour's front yard while learning sustainable landscaping practices.

Figure 9.6 Public awareness 'Blue Thumb' outreach campaign neighborhood 'Garden Party' workshop.

The RWEP water agency members have the opportunity to nominate neigborhoods in their service areas to participate in the Program. RWA staff and partners choose one neighbourhood per year to participate in the Program. In the 2012 Blue Thumb Neighbors Program, there were 58 participating households with 75–90 people at each classroom workshop for a neighborhood in Carmichael Water District. Typically Blue Thumb Neighbors Program costs around US$20,000 per neighbourhood for all activities described above.

The RWEP Program also provides educational opportunities for both professionals and school-aged children. The Green Gardeners Training Program is targeted to landscape professionals and landscape managers in the Sacramento region. Since 2009, RWA in partnership with Ecolandscape California (Ecolandscape California, 2013) has managed and implemented this popular program which combines cutting-edge technology with ecologically-responsible landscape maintenance practices. The qualified Green Gardener conscientiously adheres to the River-Friendly Landscape Guidelines (River-Friendly Landscaping, 2013) and will have successfully completed 10 weeks of intensive training examining complex subjects such as:

- River Friendly Principles
- Soil Health
- Integrated Pest Management (IPM)
- Right Plant in the Right Place
- Fertilizer Management and Lawn Care
- Water Efficient Irrigation
- Pruning for Plant Health
- Mulches and Compost

Green Gardeners are qualified to help their clients save money, conserve water, and sustain healthy landscapes. Training includes:

- Completing a minimum of 20 hours of in-class instruction.
- Completing all homework assignments.
- Passing a written final exam.
- Attending 80% of the classes.
- Having a valid business license *and/or* are an employee or owner of a company with a valid Contractor's license from the California Contractors State Licensing Board.

From 2009–2012, the Green Gardener Training Program has hosted nine 10-week training classes and graduated 211 Green Gardeners. Each 10-week Training Program costs approximately US$10,000 for labor and materials. Green Gardener contact information is featured on RWA's BeWaterSmart.info website for residents throughout the region to find out more information about water efficient landscapes.

The RWEP also allocates US$31,000 each year toward school education to implement a video contest (9th–12th grade) and distribute water-related classroom curriculum and materials (kindergarden-8th grade). In partnership with Sacramento's regional newspaper, The Sacramento Bee and their Media in Education program (The Sacramento Bee 2013), RWA hosts a Water Spots Video Contest. The video contest is geared toward high school students and challenges students to use the 'Blue Thumb' Program's key messages in a fun and interesting way. Students submit a 30-second public service announcement using 'Blue Thumb' messages, logos, and other provided visuals. In 2012, the contest received 90 videos from 49 teachers, covering 1,700 students throughout the Sacramento region. The videos were evaluated and narrowed down to 11 finalists by a panel of celebrity judges including representatives from the Tahoe Film Commission, the Nature Conservancy, the Sierra Club, News 10, KOVR 13 and Kevin Johnson, the Mayor of Sacramento. Three videos were chosen as the 'Judges Choice' for 1st, 2nd, and 3rd place and both the winning students and teacher received cash prizes.

Figure 9.7 'Green Gardener' programme promotional poster.

The 11 finalist videos were also posted online through the Sacramento Bee website for the public to vote online for their favorite video(s). For the 2012 contest, the finalists' videos received over 16,000 online votes. The finalist video with the highest number of online votes was chosen for the 'People's Choice' award and both student and teacher also received cash prizes. All the finalist videos including the Judges and People's Choice videos were played on the jumbotron at a River Cats game, Sacramento's local baseball team. Outreach for the Water Spots Video Contest was achieved through a variety of avenues including newspaper ads, direct teacher contact, links on various partner websites, the distribution of 40,000 bill stuffers through The Sacramento Bee's outreach list, email blasts and other promotional pieces (Figure 9.8).

Figure 9.8 Public awareness ‘Blue Thumb’ water spots video contest winners.

For both the outreach and education components of the ‘Be Water Smart’ program, RWA relies on strategic partnerships with community leaders and the use of social and traditional media to distribute the ‘Blue Thumb’ messages. It is through these partnerships and creative and innovative marketing strategies that RWEP Program continues to be successful.

Source: Personal communication, *Amy Marie Talbot (May 21, 2013). Regional Water Authority, Sacramento, California, United States*.

CASE STUDY 21
Regional Integrated Water Efficiency Program, Western Australia
Meredith Blias, Perth Water Corporation, Australia

The Water Corporation has delivered four very successful and cost effective large scale water efficiency projects as part of the Regional Integrated Water Efficiency Program in regional Western Australia (East Pilbara, West Pilbara, Kimberley, Great Southern and Goldfields). The Four Projects included:

– Community Based Social Marketing (CBSM) designed to educate and motivate customers;
– Retrofits of water efficient fixtures, reprogramming and/or replacement of irrigation controllers, data logging of water use to identify improvements, irrigation reprogramming for non-residential customers;
– Leak detection and repair of the Corporation’s mains network; and
– A smart metering trial (Goldfields region) to improve system operations, to identify water conservation opportunities and to improve customer relations.

The Corporation and the Australian Government jointly funded this program to the tune of AUD$18 million. These regions have been facing challenges in water security and supply, and in growth in demand. Overall, the program has delivered 97 percent of targeted savings (i.e., 4.3 GL/yr) at 77 percent of the budgeted cost. It also received a Savewater! Award. From an economic prespective the unit cost for each project by region has been evaluated and presented in Table 9.2. All of these unit costs in the Pilbara compare favourably to the current average LRMC for water (AUD$7.50), although the unit costs do not include ongoing expenditure by the Water Corporation onthese projects or any expenditure required by the participants. The outstanding performer has been the retrofits of commercial showerheads followed by the replacement and/or reprogramming of the residential irrigation controllers. The CBSM programs were not as successful due to the lower than expected take up partly because of the transient workforce in Pilbara.

Table 9.2 Summary of investments in the regional integrated water efficiency program in Western Australia (AUD$).

Project	Kimberley	West Pilbara	East Pilbara	Great Southern	Goldfields
Community based social marketing	$3.82	$5.36	$4.39	$4.10	
Res irrigation	$0.32	$0.22	$0.24		
Non-res irrigation	$1.01	$0.66	$1.13		
Retrofits					
Commercial showerheads	$0.09	$0.02	$0.06	$0.03	
Residential showers	$0.68	$0.68	$0.68	$0.56	
Toilets	$1.98	$1.98	$1.98	$1.68	
Aerators	$1.27	$1.27	$1.27	$1.18	
Leaks in taps/cisterns – commercial	$2.38	$2.70	$2.41	$1.98	
Leaks in taps/cisterns residential	$2.51	$2.51	$2.51	$1.99	
Urinals	$0.25	$0.30	$0.57	$0.37	
Data logging	$0.31	$0.31	$0.36	$0.40	
Industrial efficiencies*		$0.13–0.44	$1.03		
Leak detection and repair	$0.36	$1.44	$0.46	$1.02	$1.54

*Note: excludes cost to customer.
Source: Personal Communication, Meredith Blias (May 20, 2013). Perth Water Corporation, Australia.

Chapter 10

Approaches for Programme Implementation

The implementation of efficiency programmes requires a dedicated staff and budget, plus several other positive aspects such as willing customer participants. This chapter describes the components of a successful efficiency programme and explains what can be done to overcome constraints to improvements in water-use efficiency.

10.1 IMPLEMENTATION

Once a water use efficiency plan has been developed, the programme will need to begin the implementation phase with a manager to champion the execution of revised or new work plan.

10.1.1 Responsibilities of an efficiency programme manager

The responsibilities of an efficiency programme manager are, initially, to develop the long-range efficiency plan, and then organize and direct the various measures that the efficiency programme comprises. This begins with preparing a work plan that defines the schedule and budget for each task identified as being necessary to carry out the plan. In a small utility, the efficiency manager will work part-time on efficiency and be responsible for carrying out most tasks. In larger utilities, managers will have the option of assigning other staff to individual tasks while they coordinate the overall programme.

10.1.2 Developing a work plan

Implementation can be a long, slow process, similar to planning, designing and building capital facilities. A 10-year time horizon for full water savings benefits to develop from implementation may often be appropriate, while efficiency measures take about three to four years to become fully operational. An annual work plan is helpful to set the details of measures to be implemented in an individual year, staff level needs, and planned budgets. The following guidelines may help utilities with implementation:

- Establish clear lines of communication for staff and management
- Obtain the necessary funding for selected measures
- Decide whether to hire staff or contractors for each measure
- Hire or assign staff to coordinate each measure
- Design the individual measure start-ups

- Advertise the measures to the target participants
- Involve elected officials in the launching of each measure
- Publicize the success of each measure
- Collect data on implementation (partnerships, costs, etc.)
- Evaluate the cost-effectiveness of each measure
- Update the efficiency plan every two to five years.

Examples of implementation tasks for specific measures may include:

- The development of a public information and in-school education programme
- Setting up and conducting speakers' groups with volunteer or paid presentations about the water efficiency programme
- Disseminating information and conducting public education activities
- Supervising retrofit device distribution
- Overseeing the utility water loss control and leak reduction programme
- Revising local laws, codes or ordinances to require the installation of water-saving fixtures
- The development of incentives to encourage efficiency, including appropriate water pricing and rebates
- Coordinating with programmes run by neighbouring water supply utilities.

Three case studies at the end of this Chapter present more details and examples for implementation program approaches: (1) leakage reduction; (2) domestic programmes; and (3) commercial, institutional and industrial programes.

10.1.3 Responsibility of programme participants

In addition to the efficiency programme manager, other individuals and groups may be involved in programme implementation. These persons/groups and their roles include:

(a) The water utility manager, who approves the final efficiency plan and authorizes budget and staffing requests. The manager will also extend formal requests for participation on a water efficiency advisory committee, if desired;

(b) The water utility Board of Directors, whose members may be publicly elected, is often supportive of efficiency programmes as such programmes are popular with customers and public interest groups. The efficiency programme manager should use all possible opportunities for presenting success stories at board meetings to advocate the authorization of additional programmes and funding;

(c) The water efficiency advisory committee. Medium-sized and large utilities often have an advisory committee, the role of which is to review and comment on plans, potential measures and implementation strategies;

(d) Consultants, who are sometimes used to develop efficiency plans, advise on the implementation of measures, and evaluate water savings and cost-effectiveness resulting from completed measures;

(e) Contractors, who are sometimes hired to conduct programmes;

(f) Public information specialist. Special skills are required to handle the programme aspects related to publicity and public education. The task can be implemented in-house or contracted to a public relations company; and

(g) Participants. The programme will not succeed without the participation of targeted customers. They need to be encouraged, with an offer that is too attractive to decline, to participate in making the changes in order to achieve efficiency. Education, regulations and incentives such

Table 10.1 Sample of 3 year Implementation Plan for Single Family Domestic Customers (US$).

	Programme length	Year 1 per unit equipment & installation cost	Subsequent years per unit equipment & installation cost	Inspection, rebate processing, marketing and admin cost	Start up budget	Program year 1		Subsequent years		Total estimated activities	Total estimated budget
						Estimated schedule of activities	Estimated annual budget	Estimated schedule of activities	Estimated annual budget		
Single-family Domestic Toilets	3 Years*	$250	$250	15%	$10,000	3000	$862,500	5000	$920,000	8000	$1,792,500
Single-family Domestic Showerheads	3 Years*	$40	$40	15%	$10,000	3000	$138,000	5000	$172,500	8000	$320,500
Single-family Domestic Faucet Aerators	3 Years*	$5	$5	15%	$10,000	4000	$23,000	9500	$54,625	13,500	$87,625

Source: Maddaus Water Management (2012).

as rebates can all convince customers that they should participate. Table 10.1 provides a sample 3-year implementation activities goals and budget for a smaller utility targeting single family residential homes.

10.2 OVERCOMING CONSTRAINTS

During both the planning and the implementation phase constraints may arise. Suggestions for overcoming challenges is included in the following section.

10.2.1 Lack of data

The following best available data are needed to enable efficiency plans to be prepared:

- Demographic data (population and employment) and projections
- Monthly water production data
- The number of water accounts by customer class
- Monthly water sales (usage) data by customer class
- Planned changes to the water system (capital improvement projects, annexations, new planned customers or new water intensive industries that may change your future customers)

If certain types of data are not available or are inadequate then estimates must be used. Data gaps can be filled by using data from similar water utilities or research projects. Figures 10.1–10.3 shows how water is generally used in single-family homes in the Australia and the United States. Outdoor use (primarily for landscape irrigation) is highly variable and depends on rainfall and temperatures during the growing season. (Similar data from Australia are presented in Chapter 5).

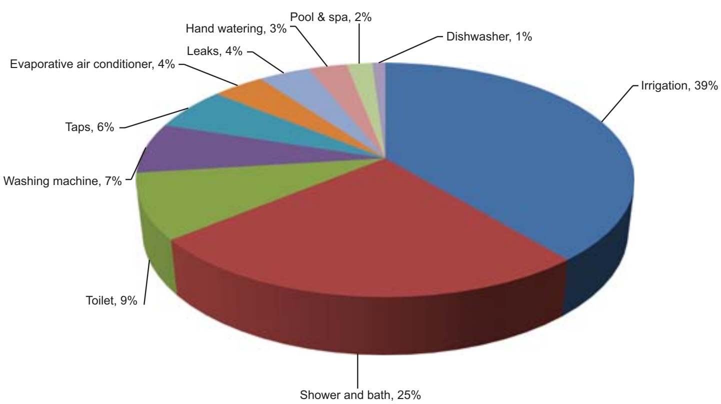

Figure 10.1 Average domestic end uses by area, Perth, Australia. *Source*: WSAA (2013).

If data of this type is not yet available, end uses could be estimated in the absence of local data based on estimate of litres per household per day and how effective various efficiency measures will be in reducing water use in existing and/or new homes. Breakdown of end uses presented in Figures 10.1–10.3 may help inform these estimates by illustrating the typical uses in the home in a developed country.

Table 10.2 presents World Health Organisation (WHO) requirements for level of service for domestic water use to meet human health and sanitation needs. Figure 10.4 illustrates the average per capita water use of listed countries.

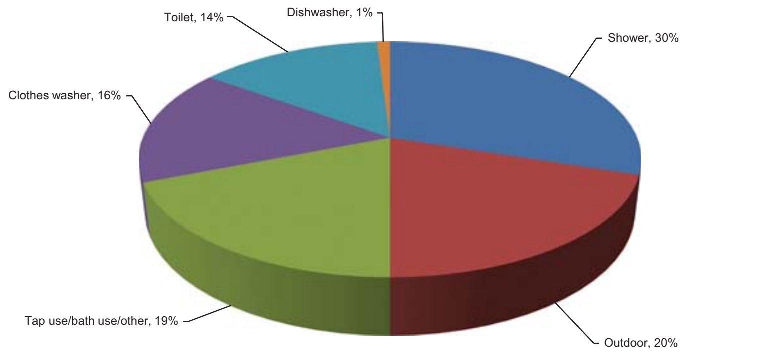

Figure 10.2 Average domestic end uses by area, Melbourne, Australia. *Source*: WSAA (2013).

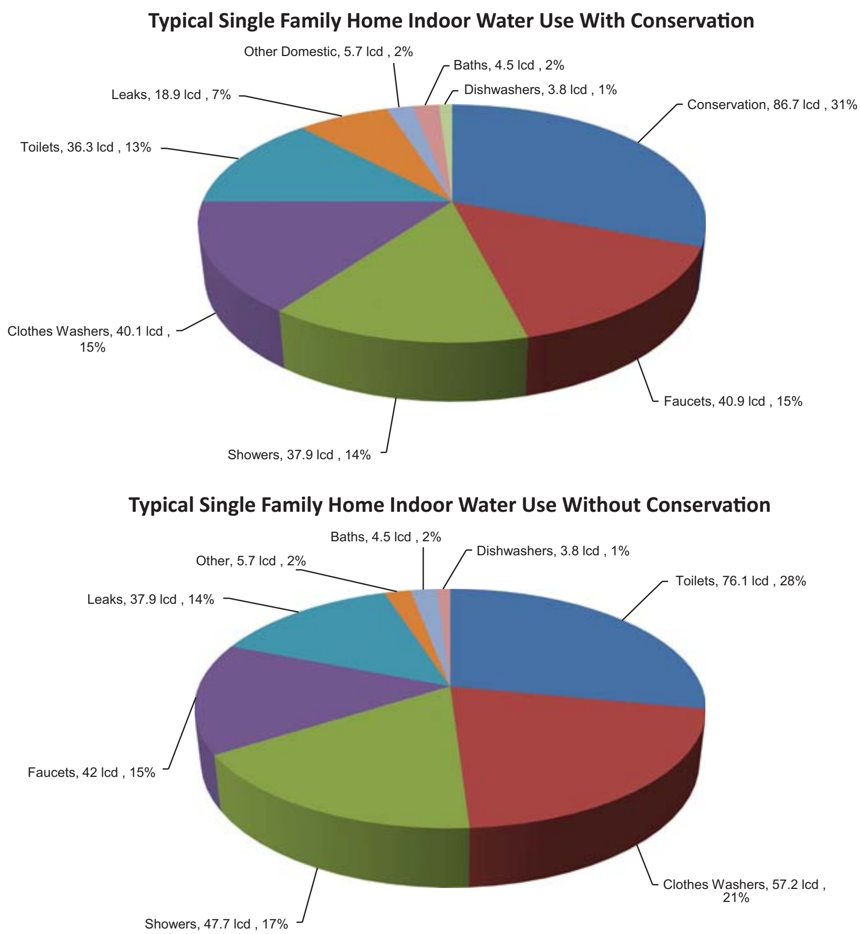

Figure 10.3 Average indoor end uses of water in single-family homes in the United States. *Source*: American Water Works Association (1999).

Table 10.2 Summary of requirement for water service level to promote heatlh.

Service level	Access measure	Needs met	Level of health concern
No access (quantity collected often below 5 lcd)	More than 1,000 m or 30 minutes total collection time	Consumption–cannot be assured Hygiene–not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 lcd)	Between 100 and 1000 m or 5 to 30 minutes collection time	Consumption–should be assured Hygiene–hand washing and basic food hygiene possible, laundry/bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 lcd)	Water delivered through one tap on-plot (or within 100 m or 5 minutes total collection time)	Consumption–assured Hygiene–all basic personal and food hygiene assured, laundry and bathing should also be assured	Low
Optimal access (average quantity 100 lcd above)	Water supplied through multiple taps continuously	Consumption–all needs met Hygiene–all needs should be met	Very low

Source: Howard and Bartram (2003).

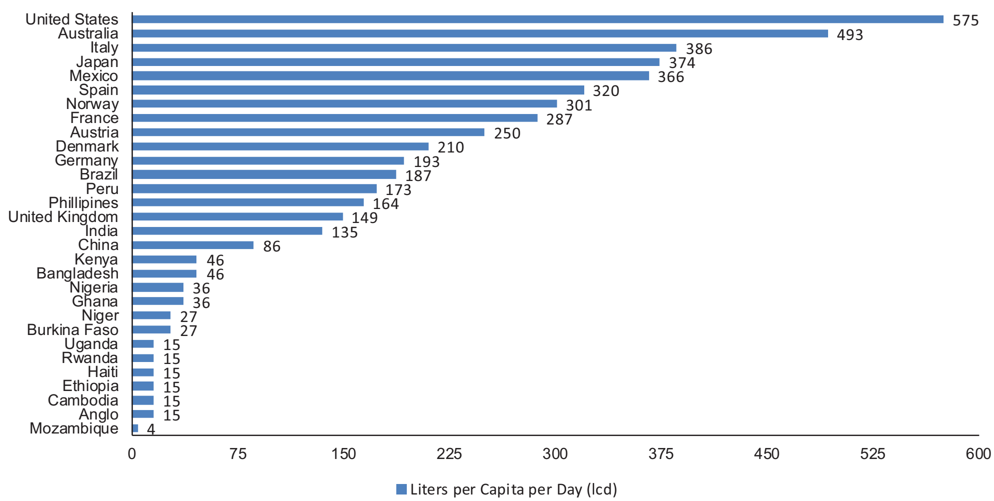

Figure 10.4 Water use (litres) per capita per day in 2002 for listed countries. *Source*: United Nations Development Program (2006).

The Human Development Reports prepared by the United Nations Development Programme documents that some countries do not have adequate access to reliable water supplies for human health needs. The first goal of these countries is to extend service. Being more efficient with existing supplies, such as reducing non-revenue water, is part of the solution.

10.2.2 Knowledge of efficiency measures

Water efficiency planners are often hampered by a general lack of knowledge about water-saving devices and measures. For more information on measures than the table of example measures presented in Appendix 3, good sources of information are the efficiency plans of agencies that have an efficiency programme as well as Internet sites of water supply utilities that are active in the efficiency field. Guidebooks and manuals have been written on the topic and they can serve as a resource for those new to the field. Many new professionals start by accessing information from local and regional information networks. A wealth of information is available on the Alliance for Water Efficiency web site (http://www.a4we.org). For a list of internet resources see Appendix 2.

10.2.3 Availability of long-range capital facility plans

Deferring or downsizing capital projects is a major source of potential benefits for the efficiency programme. Unfortunately, the cost-benefit analysis is often hindered by the lack of long-term water supply capital facility plans (giving types of projects and cost estimates), and may be adversely affected if water use is reduced. Some government oversight agencies require that water supply plans list future capital facility projects, the schedule and cost estimates, and water efficiency programme measures be formulated to qualify for government financing.

If water use is growing and will exceed the capacity of supply sources and/or water treatment and distribution facilities, capital expansion projects will be needed. If the plans do not cover the normal efficiency planning period (usually 20 years), the costs of these unplanned facilities should be estimated. Supply projects are normally designed to provide for growth over a 10- to 20-year period. Similarly, expansion of water treatment projects is designed for growth over approximately 10 years, for which the cost of the facilities can be estimated. For example, water treatment plants in the United States cost between US$1 million and US$2 million for a capacity of 3875 m^3 per day.

10.3 PROGRAMME MONITORING AND EVALUATION

An efficiency programme should be regarded as dynamic. Changes to the programme should be expected, based on how well the programme meets the objectives developed according to the guidelines provided in Chapter 5. Observations concerning the water supply situation, growth projections, customer participation and satisfaction, and water savings achieved should be made. The water efficiency industry is changing rapidly, and the programme should be reviewed periodically (e.g., once a year prior to planning the following year's budget expenditures) in order to take advantage of new methods for saving water.

Two types of programme follow-up actions need to be carried out:

(a) The water supply utility must keep good records of the impact that the efficiency programme is having (i.e., the measurement of water savings). Water-use data before, during and after the implementation of a measure are essential to evaluating water savings;
(b) The water supply utility should monitor how well the programme is performing and whether it is achieving its programme goals (and which may subsequently need to be revised).

10.3.1 Measuring water savings

The direct measurement of water savings is time-consuming and may be difficult for a small or medium-sized water supply utility to perform. The potential exists for leveraging analysis of end of uses of water saving studies performed by neighboring larger utility programmes may be used during planning for smaller utilities.

There are two fundamental types of studies: science-based through applied research testing and field based studies analysing real customer participant data.

For field studies, various comparative statistical tests can be used on a sampling of water use history for pre-programme customer's usage and post-programme participants. The literature provides ample examples of how to perform such an analysis. The main recommendation is to save data on specific accounts that participated in a program and associated historical water meter readings for at minimum several years, as this will enable such analyses to be made. Future analysis can be performed on calculated savings results with careful attention to potential influencing factors are taken into account. Some influencing factors that may be controlled for or at least acknowledged in the study tests might be:

- weather normalization;
- type of participant matched to appropriate control group (e.g., random sample of high water users matched to high water use participants);
- if the study objective was volunteer or required action by the customer;
- if changes in account occurred signifying changes in users and patterns of usage;
- changes in the type of incentive over the study period;
- whether the device was customer or professionally installed;
- if multiple types of equipment was used on the same property at the same time;
- if a pre- and post-audit (inspection) was performed;
- any change in water rates or other economic conditions, and so on.

A number of studies are described by the United State Bureau of Reclamation in their review of past studies: *Summary of Smart Controller Water Savings Studies, Literature Review of Water Savings Studies for Weather and Soil Moisture Based Landscape Irrigation Control Devices* (U.S. Department of the Interior Bureau of Reclamation, 2008).

For science based studies, control sites are carefully designed to allow for comparative tests. Landscape water demand may be calculated in studies by one of two methods: (1) using soil moisture, precipitation and irrigation measurements; or (2) based on net potential evaporation (ET) from weather station data. In order to obtain accurate verification of irrigation water savings, testing protocols are often used. The Irrigation Association has a Smart Water Application Technology programme that has established testing protocols. This is available at: http://www.irrigation.org/swat/ (last accessed on September 29, 2013).

There is a broad diversity of types of both water use efficiency devices and practices that use field and science-based studies to provide lessons learned for water use efficiency implementation. An example of a science-based study is presented at the end of this chapter that attempts to answer a common question related to if there are water quality hazards associated with using rainwater harvesting systems.

10.3.2 Other techniques for measuring effectiveness

Public surveys are a good way to make rapid and inexpensive measurements of customer satisfaction and participation rates. Customer surveys can be used to collect specific data on water savings for later use in calculating the overall impact of the programme. Public surveys conducted by telephone typically consist of 10 to 20 questions. The cost will depend upon the number of people contacted and the degree of data manipulation required. In the United States, the cost of such a survey is approximately US$10,000. The cost of a mail survey can be lower but participation rates are small, generally in the order of 3 percent, so a large mail circulation is necessary in order to achieve a significant sample size.

In summary, the questions that should be periodically asked are:

- Are the programme goals being achieved? If not, why not?
- Is public response positive? If not, why not?
- Are the specific efficiency measures contained in the programme effective? If not, why not?

If negative responses are received to any for these questions, consider revising the programme by:

- Evaluating alternative efficiency measures;
- Modifying existing measures to increase participation;
- Focusing efforts on other potential water-saving ideas instead of areas that are not showing expected savings.

10.4 UTILIZATION OF THE EFFICIENCY NETWORKS

Learning from the experiences of other water supply utilities is the starting point for most new water efficiency managers. Forming partnerships with other water supply utilities in the area that may already be involved in efficiency is a good opportunity to maximize available resources. Neighbouring water supply utilities may be able to provide invaluable 'how-to' information as well as data on actual water savings and customer participation, which are needed to calculate costs and benefits of specific measures. A coordinated regional effort among those utilities with a common desire to implement water efficiency programmes offers the following advantages:

- Achieving greater public visibility programmes
- Avoiding duplication of effort
- Providing regional consistency (important in regulatory programmes)
- Reduced costs for common programmes such as public education

Appendix 2 contains a detailed listing of other water efficiency-oriented web sites of water utilities worldwide. These web sites are good places to learn about new efficiency programmes being operated by other water supply utilities. Examples of useful networks include:

(a) Alliance for Water Efficiency, an international non-profit organization dedicated to the efficient and sustainable use of water (http://www.aw4e.org);
(b) California Urban Water Conservation Council, which is dedicated to furthering water efficiency in the State of California (http://www.cuwcc.org and http://www.h2ouse.org);
(c) California Department of Water Resources, Office of Water Efficiency (http://www.water.ca.gov);
(d) American Water Works Association, which sells useful water conservation publications and hosts annual technical conferences on sustainable water management conference which includes the topic of water conservation (see http://www.awwa.org/resources-tools/water-knowledge/water-conservation.aspx);
(e) United Kingdom Demand Management Centre (http://www.environment-agency.gov.uk/savewater);
(f) Singapore, which provides a good example from Asia (http://www.pub.gov.sg/efficiency).
(g) The Water Services Association of Australia (https://www.wsaa.asn.au)

Four case studies follow that describe successfully implemented conservation programs including:

- Case Study 22: Leakage Reduction through Pressure Management in Khayelitsha: Western Cape, South Africa.

- Case Study 23: Implementation Approaches to Domestic Water Use Reduction.
- Case Study 24: Implementation Approaches to Commercial, Industrial, Institutional water use reduction.
- Case Study 25: Control of Water Quality in a Supply System with Rainwater Harvesting for Garden Watering, Portugal.

CASE STUDY 22
Leakage Reduction Through Pressure Management in Khayelitsha: Western Cape, South Africa

McKenzie R., Mostert H. and Wegelin W. (2003)

Introduction

Khayelitsha is one of the largest townships in South Africa and is located approximately 20 km from Cape Town on the Cape Flats (a large flat sandy area at or near sea level). There are approximately 43,000 serviced sites with both internal water supply and water borne sewage while there are a further 27,000 low-cost housing units which are supplied from communal standpipes supporting a population of approximately 450,000.

Khayelitsha is supplied with potable water from Blackheath Reservoir situated at an elevation of 110 m through two large water mains supplying the area at an average pressure of approximately 80 m (8 Bar). A 1065 mm main supplies water from the north while a second 450 mm diameter pipe supplies the area from the west as can be seen in Figure 10.5.

Figure 10.5 Location Map for Khayelitsha.

At the beginning of the new millennium, the water supplied to Khayelitsha was measured to be almost 22 million m^3/a. The level of leakage was estimated from the night-time water use to be almost three-quarters of the water supplied to the area. The Minimum Night Flow (MNF) was measured to be in excess of 1600 m^3/hr. which is sufficient to fill an Olympic sized swimming pool every hour. From the analysis of the minimum night flows as well as the night-time sewage flows, it was established that most of the water supplied to the area was being returned to the sewer system through household leakage.

The Khayelitsha Pressure Management Project was therefore proposed in 2001 to improve the level of service to the Khayelitsha community by reducing the excessive water pressure and pressure fluctuations in the reticulation system. The high pressures and associated fluctuations over the past 20 years have caused serious damage to the internal plumbing fittings with the result that household leakage accounted for more than 80% of the non-revenue water supplied to the area. Such leakage results in very high water consumption in most properties and high levels of non-payment since the customers cannot afford to pay for new taps and toilet fittings let alone the high water bills. By reducing the pressure, it is possible to reduce such leakage and at the same time provide a better level of service to the consumers.

The approach used in the Khayelitsha installation is both simple and innovative and the savings achieved have exceeded both the Utility's and the Project Teams' most optimistic expectations. Local labour was used throughout the project and the community support was a key factor in the successful implementation of the project. The City of Cape Town Administration fully supported the proposal and endorsed the findings of the Project Team. They agreed to proceed immediately with a small-scale pilot project in Zone C of Khayelitsha (see Figure 10.5) which was commissioned in January 2001 at minimal cost. The pilot installation was a great success and clearly demonstrated the benefits that can be achieved through pressure management in Khayelitsha. The savings through leakage reduction from the Pilot Project were estimated in March 2001 to provide a payback of less than 6 months. As a result of these findings, the City of Cape Town Administration quickly approved the commissioning of a full-scale project which commenced in June 2001 and was completed in February 2002.

Project implementation

Having agreed on the approach and the conceptual design for the two PRV installations, the most difficult stage of the project was the construction of the chambers and the installation of the mechanical equipment. Most of the problems encountered were anticipated to a large degree although the following did cause some problems:

- Shortly after the start of the project (July and August 2001), the area was hit by severe storms resulting in the wettest two months since records began back in the 1870's. This problem was further aggravated by the sandy soil which had to be fully dewatered before any excavations could take place.
- The Utility was unable to stem the flow of water in the pipelines due to leakage at the upstream valves with the result that the pipeline could not be drained. This in turn caused serious problems for the mechanical contractor who had to weld on new pipe flanges after cutting into the pipes. It was only through world-class welders working under the most atrocious conditions that it was at all possible to commission the installation.

As a result of these problems and others, several major on-the-spot design changes had to be implemented which involved quick action by both the Structural Engineer as well as the overall Project Manager. Despite the problems, the water supply to Khayelitsha was maintained (albeit at a lower level of service) throughout the cut-in period and no serious complaints were received from the consumers. Some details of the 1065 mm diameter installation are shown in Figures 10.6 and 10.7 from which the size and complexity of the project can be seen.

Figure 10.6 Excavating and de-watering the site for the 1065 mm chamber.

Figure 10.7 Internal view of a portion of the 1065 mm diameter chamber.

Figure 10.6 shows the problems encountered with the high water table and wet conditions during construction which necessitated the use of a de-watering system since the bottom of the chamber is more than 6 m below ground level. A blank flange plate can also be seen which indicates the location of the water main. Figure 10.7 shows some of the pipe details inside the chamber including the valves, meters, strainers and controllers.

Results from the project

When motivating the project to the Utility, the Project Team took great care not to over-emphasise the likely savings and not to create unrealistic expectations on the part of the Utility. A one-year pay-back was indicated to the Utility with the proviso that the savings could be higher depending on the level to which the pressures can be lowered. Despite many rounds of network analysis and so on, the true situation can only be established through actual implementation and it is therefore very difficult to make accurate predictions for a project of this nature.

Another key issue addressed during this project was the accurate auditing of the savings in such a manner that there can be no doubt in the minds of either the Project Team or the Utility. Such auditing is often overlooked as an unnecessary luxury with the result that many Water Demand Management projects cannot be judged properly since claims of large savings made by the Consultant are often not shared by the Utility. In the case of the Khayelitsha project, the savings were monitored by the Utility and there is no doubt that the figures quoted in this case study are factual.

The first phase of pressure management involved the installation of the new pipes and pressure reducing valves (PRV) with the pressure reduced under fixed outlet pressure control: that is, the pressure reduced throughout the whole day using standard PRV pressure reduction without any additional reduction from the controllers. The savings achieved for this condition are depicted in Figure 10.8 from which it can be seen that the average daily flow was reduced to 1800 m^3/hr with a Minimum Night Flow of 1200 m^3/hr. The annual reduction in demand was estimated to be on the order of 6 million m^3/yr.

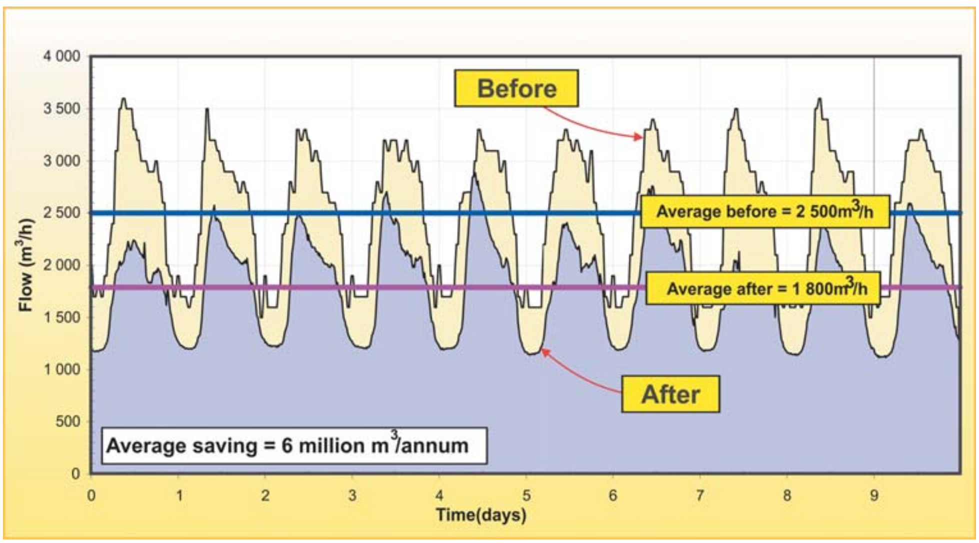

Figure 10.8 Inflow to Khayelitsha from fixed outlet pressure control.

The second phase of the pressure control involved using the electronic controllers to provide further pressure reduction during periods of low demand. This form of pressure control is termed Advanced Pressure Control and requires considerable experience and care to ensure that it is implemented properly. The results from this stage of the project are shown in Figure 10.9 from which it can be seen that the Minimum Night Flow was lowered by an additional 450 m^3/hr to 750 m^3/hr with the average daily flow dropping by a further 300 m^3/hr to 1500 m^3/hr The total annual savings achieved through the use of the Time-Modulated Pressure Control are estimated to be in the order of 9 million m^3/yr or 40% of the water originally supplied to the area.

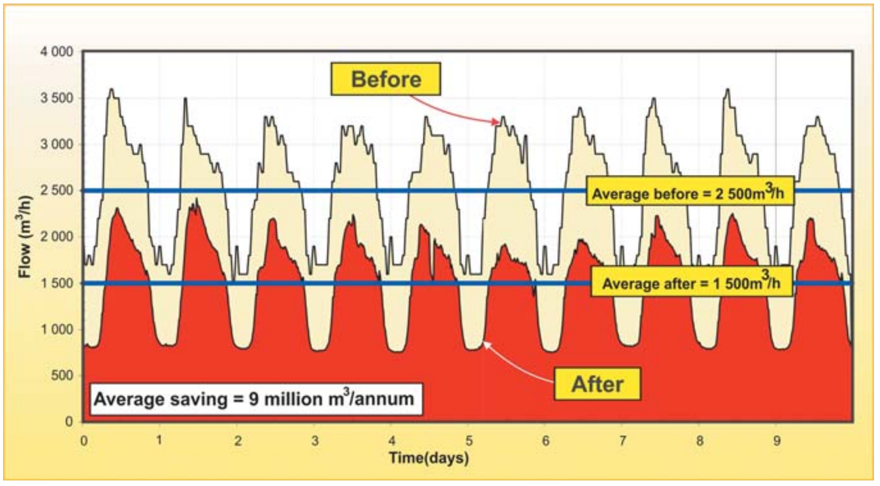

Figure 10.9 Savings achieved from the fixed outlet pressure control.

It is important to note that at no time during the pressure management activities, was the pressure at any point in the system lowered below the minimum level experienced during normal peak demand periods.

Local community involvement

One of the main problems often experienced with a project of this nature is the possible negative reaction from the local community resulting in theft and/or vandalism of the installation. This is particularly relevant in projects influencing the water supply to communities. If the actions being undertaken are perceived to have a negative influence on the overall level of service to the community, the project is destined for failure no-matter how much effort is spent trying to remedy the situation. This potential problem was taken very seriously by the Project Team and Utility from the inception of the project. The community was involved at each stage of the construction and was continually informed of progress and possible water shortages through continuous liaison with the Community Liaison Officer. All labour used on the project was sourced locally whenever possible and organised through the local labour forum to avoid any complaints of favoritism or nepotism (see Figure 10.10). It was through such measures that the project was constructed and commissioned within the confines of a low-cost housing area without one incidence of vandalism or theft.

Another interesting feature of this project is the overall design and appearance of the chamber. Engineers are not renowned for their flair and imagination when it comes to the design of concrete valve chambers and a concrete 'shoe-box' is often favoured without windows or any weak points where entrance can be gained. In the case of this project, however, considerable effort was taken to provide a valve chamber that was both economical from a cost perspective but also aesthetic in as much as a simple box design can be. An Architect was approached for assistance and the end result is clearly evident from the completed chamber as shown in Figures 10.10 and 10.11.

Figure 10.10 Local community painting the 1065 mm diameter chamber.

Figure 10.11 Completed chamber in Khayelitsha.

Summary and conclusions

The Khayelitsha Pressure Management project was initiated directly as a result of various submissions made to Council by the Project Team who provided sufficient motivation and evidence to support the investment of almost US$0.3 million into the project. Without the enthusiastic support of the Project Team and Council staff from the City of Cape Town, it is unlikely that the project would have been approved by the politicians or accountants within Council.

Although there are already several advanced pressure control installations in South Africa, this project is by far the largest and most significant to be undertaken in the country. It is the first time in South Africa that an attempt has been made to reduce the pressure over such a large area (24 km^2) from a single installation and the actual savings achieved are amongst the highest in the world from such an installation.

The approach used in the Khayelitsha installation is both simple and innovative and the savings achieved have exceeded both the Utility's and the Project Teams' most optimistic expectations. Despite the fact that the installation is situated within a squatter/informal area, there was no theft, vandalism or intimidation of any form. This can be attributed to the close liaison between the Council, Project Team and the Local Community who are all working together with a common goal of reducing wastage.

From the Utility's perspective, the Khayelitsha project shows not only Technical Excellence but also a true regard for the community and the environment. The project itself initially saved in excess of 9 million m^3/a representing a financial saving of more than US$2.7 million per year at current 2002 water rates – that is a 2 month pay-back. To place these figures in perspective, the proposed Berg River Scheme (recently approved to augment water supplies to Cape Town) and associated transfer works were estimated at 2002 prices to cost approximately US$200 million. This new scheme will provide a safe yield of almost 80 million m^3/a. The Khayelitsha installation is already saving 11% of the yield from the Berg River Scheme at less than 0.2% of the cost. As a result of the savings already achieved, the proposed US$3.6 million extension to the Zandvleit Sewage Treatment Works was postponed for at least two years and possibly indefinitely.

CASE STUDY 23
Implementation Approaches to Domestic Water Use Reduction

Maddaus Water Management

Incentive programs

Most water utilities start with a modest domestic water conservation program, usually beginning with a public education program. As the program matures incentive programs are offered. Here are several examples of 'mature' programs.

Sydney water's domestic water efficiency program (Sydney Water, 2013)

In 2011–2012 Sydney Water expanded the former WaterFix Program to provide customers with a choice of services to suit their individual needs. This new WaterFix service includes replacing showerheads, toilets and taps, and repairing leaks. Sydney Water offer's the new service to domestic customers at cost recovery rates. Sydney Water will continue to develop WaterFix as we learn from implementing the new service.

Recognising the increasing cost of living, Sydney Water is committed to supporting customers in hardship.

Sydney Water introduced PlumbAssist in 2011–2012, to help customers experiencing financial hardship to reduce their debt by identifying and addressing high water use and its causes. The service provides essential plumbing services and emergency plumbing work, if required, for customers who cannot afford it. Sydney Water elected to model their program after the successful San Antonio Texas a water utility in the United States, program 'Plumbers for People'. More information about the San Antonio program can be found at the following website: http://www.saws.org/

Estimates of water savings from PlumbAssist services provided in 2011–2012 are not yet able to be calculated. Sydney Water will analyse savings from this service in 2012–2013.

Sydney's new programs are delivered differently from the more general programs of the past. The new approach is to offer cost-recovery programs tailored to individual customer's needs, rather than implementing large-scale programs that result in across the board price increases.

Government Agency (EBMUD's) 2013 Domestic Conservation Rebate and Services Program (East Bay Municipal Utility District, 2013)

EBMUD's water conservation incentives and services will help a customer make their home more water-efficient. A WaterSmart home:

- saves water and energy
- saves money on utility and landscape maintenance bills
- reduces waste
- reduces pollution from irrigation runoff
- reduces greenhouse gas emissions from water pumping and heating

Services and Tools include:

- WaterSmart Home Survey Kit EBMUD's WaterSmart Home Survey Kit can help customers find and fix leaks, and check water flow rates.
- On-Site Home Water Surveys. EBMUD's free on-site indoor and landscape water use surveys provide customized information on how to save water and money.

Incentives:

- High-Efficiency Toilet Rebates. Get up to US$100 when you upgrade your old toilet.
- High-Efficiency Clothes Washer Rebates. Get US$100 for installing a high-efficiency clothes washer.
- Lawn Conversion & Irrigation Upgrade Rebates. Get up to US$2500 for converting lawns and upgrading irrigation equipment at single-family homes and multi-family residences of 4 units of less.
- Multi-Family Submeter Retrofit Incentives. Get up to US$250 for installation of sub-meters. This program is for qualified multi-family property owners and homeowners associations (HOAs).
- Mulch Discount Coupons. Mulching your garden reduces the need to water. Get discount coupons on bag or bulk purchases of mulch at retailers throughout the East Bay.
- Free Water-Saving Devices. High-efficiency showerheads, faucet aerators, and other water-saving devices are available free of charge to eligible EBMUD customers.

Public Involvement:

- EBMUD events, workshops, and classes keep customers up to date on the latest water-efficient ideas, practices, and technologies.

- Water Conservation Publications. Water conservation 'how-to' publications, school materials, EBMUD's Water Conservation Master Plan, and award-winning gardening book *Plants and Landscapes for Summer-Dry Climates*.
- Lose Your Lawn the San Francisco Bay-Friendly Way. Visit Bay-Friendly Landscaping and Gardening for useful information about sheet mulching and converting lawns to sustainable landscaping.
- Organizations and Community Resources. Links to EBMUD's water conservation partners, cooperating organizations, and other key community resources.
- Research & Development. Comprehensive studies, reports, and information on emerging technologies and methodologies within the water conservation field.
- Report Water Waste. Customers can call EBMUD to let them know about any water waste in a customer area.

EBMUD provides a WaterSmart Center - A central resource center for services and incentives for home and business, publications, workshops and events, and more. More information is available online: http://www.ebmud.com (last accessed on April 12, 2013)

PUB Singapore's initiative to promote water efficiency in the domestic sector

To raise awareness and enhance the capability of domestic customers to improve their water efficiency, PUB conducts extensive community outreach efforts in water conservation. Initiated in 2006, the 10-Litre Challenge is PUB's umbrella programme to encourage households to reduce daily water consumption. In addition, PUB also carries out a series of public outreach initiatives to enhance water conservation awareness.

10-litre challenge

In order to encourage the public to play a part in reducing the domestic water consumption, in 2006 PUB embarked on an initiative called the '10 Litre Challenge' to challenge every Singaporean to save 10 Litres of water a day. Together with Singapore Environment Council (SEC), a NGO, PUB has set up a dedicated 10-Litres Challenge website to host the challenge, as well as share information on useful water conservation tips. Projects launched under the 10-Litres Challenge include the enhanced Water Efficient Homes (WEH) and Mandatory Water Efficiency Labeling Scheme, amongst others.

Water efficient homes programme (PUB Singapore, 2011)

Water Efficient Homes (WEH) is a programme to help residents save water at home and cut down on their water bills. The programme encourages residents to install water-saving devices and practice good water conservation habits. As part of the programme, PUB officers visit households in Singapore to install free-of-charge water saving devices such as thimbles.

The WEH programme was launched in Feb 2003 and rolled out to all constituencies in the country by 2006. 40 percent of households have installed water saving devices in this exercise. Participating households have saved up to 5 percent of their monthly water consumption. Starting from 2007, PUB has enhanced the programme by re-visiting households with higher water consumption. Figure 10.12 presents the faucet aerator installation kit and actual installation.

Figure 10.12 Example of installation of water efficient devices in homes (PUB Singapore, 2013).

Mandatory water efficiency labeling

The Mandatory Water Efficiency Labeling Scheme (MWELS) was introduced in 2009 to help consumers make more informed purchasing decisions and encourage suppliers to introduce more water efficient products into the market. As part of the scheme, suppliers are required to label the water efficiency of their appliances on all displays, packaging and advertisements. MWELS covers taps, mixers, urinals and dual-flush low capacity flushing cisterns, and washing machines. In addition, suppliers are also encouraged to label the water efficiency of their showerheads under the voluntary water efficiency labeling scheme.

Water conservation awareness programme (PUB Singapore, 2013)

As part of ongoing efforts to get Singaporeans to use water wisely, PUB rolls out initiatives targeted at different audiences to remind them about the importance of making water conservation a way of life. These initiatives leverage on the mass media and social media platforms, as well as direct outreach to schools to reinforce the water conservation message.

As 50 percent of the water usage at home goes to showers and washing in the kitchen sink, PUB's awareness efforts focus on these two most water-consuming activities - by encouraging the public to take shorter showers and not wash dishes under a running tap. One of the initiatives, introduced in 2013, is the 'Time to Save' programme, where PUB's mascot Water Wally takes the lead in reminding students and adults to keep showers under 5 minutes. This initiative reaches out to all primary schools in Singapore where participating students will be given a timer and an activity booklet to track their shower timings for a week. They also take on the roles of junior water advocates by encouraging their parents to take shorter showers and spread water conservation tips to their neighbours.

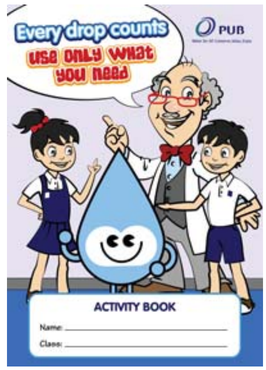

Figure 10.13 Example of school education outreach materials.

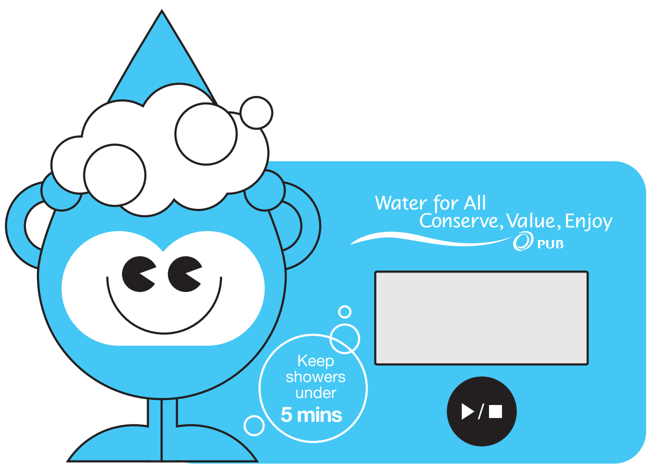

Figure 10.14 Example of public education online video.

Singapore's World Water Day–Record 35,000 people come together to spread the message of water conservation

The World Water Day, a worldwide celebration to mark the importance of freshwater and the sustainable management of this precious resource, is one of the platforms that PUB leverages on to spread the water conservation message. Singapore's annual celebrations of this event is supported by various community partners, who together with PUB, help spread the message through activities held at the major waterways and reservoirs in the island. In 2013, for instance, Singapore's World Water Day celebrations rallied 35,000 people who took part in a myriad of activities to promote awareness of the importance of water conservation.

CASE STUDY 24
Implementation Approaches to Commercial, Industrial, and Institutional Water Use Reduction

Maddaus Water Management

(1) Regulatory Approach–Require Water Management Plans

In most cities the breakdown of non-domestic customers shows there are many using small amounts of water and far fewer using large amounts. This is why many non-domestic water efficiency programs target individual larger users achieving outstanding results. In Australia two areas are using a similar approach.

- The waterMAP program in Melbourne requires all non-domestic customers that use over 10 ML per annum to develop a water management plan (waterMAP). In order to work with this diverse range of customers each water retailer employed key customer managers who personally engaged with customers and provided site specific advice. Assistance provided included site audits, retrofits, co-funded grants, workshops and most importantly personal engagement that resulted in the development of good working relationships. This program for approximately 1,300 customers resulted in water savings of over 17 GL over a 4 year period (WASA 2013). In addition to programs for large water using customers a number of specific programs have been developed and rolled out that address businesses such as hotels, Asian restaurants, cafes, laundries and sports grounds.
- The Queensland Water Commission requires similar plans for non-domestic customers using more than 10 ML/yr. The plan must include (Queensland Department of Environmental and Resource Management 2010):
  - Source of water
  - Current water use annual and seasonal
  - A water use inventory using sub meters
  - Calculation of a unit baseline use, ML/yr per unit of commercial activity and compare to national benchmarks where available
  - A comparison of existing fixtures to current standards
  - A program to identify and fix leaks
  - Assessment of cost-effectiveness of conservation measures including payback
  - Recommended action plan to achieve water savings

  These plans must be submitted to the water service provider for approval. There are penalties for non-compliance and annual reporting is required.

  Results of this program show a water use reduction of 70 percent for large customers (>20 ML/yr) (Montgomery Watson Harza 2012).

(2) Incentive Programs–Offer Technical Assistance and Rebates

Sydney water's every drop counts business program

For ten years ending in 2009 Sydney Water targeted customers using over 50 ML/yr and included:

- Free water audits to those customers who signed a memorandum of understanding committing them to implement identified water conservation opportunities if the return on investment met agreed criteria.
- For a time Sydney water offered low interest loans to assist with capital funding of conservation projects.

- By 2010–11 over 400 large businesses had participated in the program. Water savings have been estimated to be 22,577 ML/yr (Sydney Water, 2013).

East Bay Municipal Utility District's (EBMUD's) 2013 commercial conservation rebate and services program

EBMUD's Water conservation incentives and services can help a business more water-efficient, save water and energy, and lower landscape maintenance and utility bills. Included in the program offering are (East Bay Municipal Utility District, 2013):

- Free on-site water use surveys are tailored to the business, industry, or institution and designed to help them be more water wise and cost effective.
- A business or institution may qualify for rebates up to US$100 per toilet on the purchase of WaterSmart High-Efficient Toilets (HET).
- Businesses can save water, energy, and money with a high-efficiency clothes washer rebate of up to US$125 per qualifying washer.
- A business or institution may be eligible for a customized rebate on the purchase of any equipment or hardware change that improves water efficiency.
- A business can get up to US$20,000 for converting lawns and upgrading irrigation equipment at commercial sites and multi-family residences of 5 or more units
- Information, surveys and rebates for all large-landscape customers in the EBMUD service area.
- For a limited time, EBMUD will replace high-water use spray nozzle(s) with water-efficient models that can save you water and money. For restaurants, institutions, and commercial facilities.
- A business or institution may qualify for rebates up to US$150 on the purchase of a WaterSmart High-Efficient Water Broom.
- A business can get a WaterSmart certification, an award program. EBMUD staff complete a water use assessment, recommend cost-effective water saving measures and provide resources for implementing water-efficiency upgrades. Those businesses who install the cost-effective measures receive the award.

PUB Singapore's water efficiency management plan and water efficiency fund

To facilitate implementation of water efficiency projects for non-domestic customers, Singapore's national water agency, PUB set up a Water Efficiency Fund (WEF) in 2007 to co-fund projects that yield at least 10 percent reduction in water consumption within an organization (PUB Singapore 2010) .

The eligibility criteria for applicants are as follows:

- Companies with monthly water consumption of more than 1000 m^3. Individual companies with monthly consumption each of less than 1000 m^3 can choose to apply for this fund collectively for example, associations and groups of commercial enterprises. Project should yield at least 10 percent reduction of water consumption
- In addition to criteria 1, for industries in which recycling is already a norm for example, wafer fabs, WEF will only be given to the company if it puts in place a system that conserves water at a rate at least 10 percent higher than the norm in its industry.
- Organisations which intend to organise community-wide campaigns to promote water conservation can also apply for WEF.

CASE STUDY 25
Control of Water Quality in a Supply System with Rainwater Harvesting for Garden Watering, Portugal

Armando Silva-Afonso, Professor, Associação Nacional para a Qualidade nas Instalaçães Prediais, Portugal

Water scarcity affects one in three people on every continent of the globe. The situation is getting worse as needs for water rise along with population growth, urbanization and increases in household and industrial uses. Water scarcity encourages people to store water in their homes. This can increase the risk of household water contamination and provide breeding grounds for mosquitoes – which are carriers of dengue fever, malaria and other diseases.

That is already a reality that will suffer a change, for worse, in a few decades, according to the International Panel for Climate Changes. The next years will become crucial for the management of water and sustainability. The installation of collection, storage and reuse of pluvial waters systems, constitutes a particularly important solution for the sustainable use of the water, in countries with hydric stress, like Portugal.

In this perspective, ANQIP (the Portuguese association for water efficiency in buildings) developed a study to evaluate rainwater quality and safety, from a groundwater storage tank of an elementary recent installation, used for gardening, with a sprinkler irrigation system. That elementary system was adapted at the installations of the Order of the Engineers, in Coimbra (Portugal), for the storage of rain water in a watering hole of pluvial waters, for posterior use in the systems of irrigation of the garden (Figure 10.15). The main objective of the system is the conservation of an alternative water reserve during the period of low rainfall rate, which in Mediterranean countries like Portugal is about 3 months, corresponding to the hot season.

Figure 10.15 The sprinkler system.

The rainwater is collected from the roof surfaces, with an elementary parapet gutter system, connected to the storage tank with simple stacks. There is no filter or water first flush diversion. At the cement storage tank, with the maximum capacity of 50 m^3, under the floor, with no light, the water stays as long as possible, depending of the consumption for the garden, without any treatment.

The major purpose of monitoring control was the evaluation of water quality, by essential chemical, physical and microbiological parameters, in particular *Legionnella*. Sampling was conducted in two parts of the system, particularly in the storage tank and sprinklers, since they are the most critical locations in the facility.

The parameters were chosen according to the applicable legal values for irrigation water and surface water, considering the specified in the Portuguese regulations and European directives. An analytical plan was established with two batteries of tests with ranges of parameters and different frequencies:

Level 1 – Monthly complete analysis (physic-chemical and microbiological), allowing an assessment not only of the characteristics of rainwater but also those arising from precipitation over the coverage areas with eventual contamination, and from the collection (Table 10.3);

Table 10.3 Level 1 and level 2 control plan parameters.

Parameters	Units	Frequency (level 1)	Frequency (level 2)
Temperature	°C		
pH	–		
Color	Hz		Weekly or if justifiable
Turbidity	NTU		
Conductivity	μS/cm		
Dissolved oxygen	mg/l		
COD	mg/l		
BOD	mg/l		
Hardness	mg/l		
Chlorides	mg/l	First characterization analysis and then monthly	
Ammonium	mg/l		
Nitrites	mg/l		
Nitrates	mg/l		
Sulphate	mg/l		
Suspended solids	mg/l		Weekly or if justifiable
Total solids	mg/l		
Zinc	mg/l		
Iron	mg/l		
Chromium	mg/l		
Lead	mg/l		
Total coliforms	NMP/100 ml		Weekly or if justifiable
Heat-resistant coliforms	NMP/100 ml		
Legionella pneumophila	NMP/100 ml		

Level 2 – Weekly analysis of the main physic-chemical and microbiological contaminants control, to allow the characterization of the profile quality changes, as a function of storage time. (Table 10.3);
Level 3 – If the results determine an eventual need of disinfection procedures, or water treatment, this level will introduce one new methodology for monitoring and control.

Table 10.4 Level 1 Monthly sample analytical results.

	Analysis Level 1					
	July 06		**September 08**		**MRV_1***	**MRV_2***
Parameter/Unity	**Tank**	**Sprinkler**	**Tank**	**Sprinkler**		
Total coliforms (UFC/100 ml)	1	0	0	Insufficient water for operation of the sprinklers		50
Fecal coliforms (UFC/100 ml)	0	0	0		100	20
Temperature (oC)	23,5	22,8	23,1			22
Turbidity (NTU)	2,77	1,20	4			
pH (E. Sorensen)	7,57	7,81	7,92		6,5–8,4	6,5–8,5
Conductivity (µS/cm)	130	135	153			3
Color (mg PtCo/L)	<5	<5	<5			10
Dissolved oxygen (%)	75,1	99,2	84,9			70
Chemical oxygen demand COD (mg O_2/L)	<10	< 10	<10			–
Biochemical oxygen Demand–BOD (mg O_2/L)	<3	<3	<3			3
Total Hardness (mg $CaCO_3$/L)	35,0	37,0	34,5			
Ammonium (mg NH_4/L)	<0,050	<0,050	<0,050			0,05
Nitrate (mg NO_3/L)	2,2	1,2	1,8		50	25
Chloride (mg CL-/L)	9,7	<4	<4		70	200
Nitrite (mg NO_2/L)	<0,020	<0,020	<0,020			
Sulfate (mg SO_4/L)	8,7	6,2	6,7		575	150
Total Suspended Solids (mg/L)	<3	<3	<3		60	25
Total Solids (mg/L)	74	75	94			
Zinc (µg Zn/L)	1,6 × 102	<10	<10		2	0,5
Iron (µg Fe/L)	4,6 × 102	27	<10			
Cadmium (µg Cd/L)	<1,0	<1,0	<1,0		0,01	0,001
Lead (µg Pb/L)	<5	<5	<5		5	–
Legionella Pneumophila (UFC/100 ml)	Not detected	Not detected	Not detected			

MRV_1 * – Maximum Recommended Values for irrigation water, in accordance with Portuguese regulation
MRV_2 * – Maximum Recommended Values for water for human consumption, according to European legislation

Whereas the storage of water will be made for a period exceeding 30 days, it is essential to ensure quality control, through an analysis plan as part of a Water Safety Plan. The implementation of the urban building is a risk factor due to the proximity of wooded areas and a green spot, with significant pollen and particles deposition, and the permanence of birds.

Some of the analytical values determined are shown in Table 10.4 for the monthly monitoring and Table 10.5 for the weekly control.

During the sampling period occurred short periods of rainfall that had no meaning in refilling of the tank, resulting in the absence of water for operation of the irrigation system. So the last sample corresponding to the sprinklers was not available.

	Analysis level 2									
	July 14		**July 20**		**July 28**		**August 04**		**September 21**	
Parameter (Unity)	**Tank**	**Sprink.**	**Tank**	**Sprink.**	**Tank**	**Sprink.**	**Tank**	**Sprink.**	**Tank**	**Sprink.**
Total coliforms (UFC/100 ml)	1	0	0	0	0	0	0	0	10	Insufficient water for operation of the sprinklers
Fecal coliforms (UFC/100 ml)	0	0	0	0	0	0	0	0	0	
Temperature (°C)	23,8	22,2	22,8	23,4	24,4	24,4	23,7	23,7	25,7	
Turbidity (NTU)	0,74	0,55	1,95	1,65	1,98	1,98	12,5	3,72	1,22	
pH (E. Sorensen)	8,16	8,55	8,73	8,66	8,64	8,64	7,85	7,8	8,03	
Conductivity (μS/cm)	140	139	139	139	140	140	139	146	163	
Color (mg PtCo/L)	<5	<5	<5	<5	–	–	5	<5	<5	
Dissolved oxygen (%)	75,9	78,2	59	75,2	–	–	–	–	77,7	
Total suspended Solids (mg/L)	<3	<3	<10	<10	–	–	–	–	<3	
Total Solids (mg/L)	68	69	90	87	–	–	87	100	114,5	

As we can compared, all the analytical values are below the indicated limits, according to the global characterization of rainwater. Considering the absence of any filtration or disinfection system is relevant the quality confirmed. Note that being a new tank of cement, without any special cleaning or disinfecting, that justify uncharacteristic values of water, resulting from the materials, but without any expression or significance.
Source: Armando Baptista da Silva Afonso, (2013).

Appendix 1

Glossary of Key Terms

Adaptive plants – non-indigenous plants that easily adapt to the climate and thus require little or no supplemental irrigation once established.
Adjusted water budget – an amount of water used to maintain a landscape that is based on area and ET rate.
Appliance – a water using device such as a washing machine
Audit (end-use) – a systematic accounting of water uses conducted to identify opportunities for improved efficiency.
Baseline – an established value or trend used for comparison when conditions are altered.
Benefit-cost ratio – benefits and costs measured in terms of money and expressed as a ratio, with benefits divided by costs; typically used as an evaluation tool for different water efficiency measures and programs.
Best management practice (BMP) – a set of practices, measures or procedures that are beneficial, empirically proven, cost effective, and widely accepted by the professional community.
Block-rate pricing – a method of charging for water based on the volume used. As more water is used, the price increases (or decreases) through a series of blocks. These pricing structures are designed to encourage efficient use of a resource.
Catch-can test – a measurement of precipitation from a sprinkler system in which water is collected in graduated containers (catch-cans) placed at evenly spaced intervals for a specific period of time.
Central irrigation control – a computerized system that programs sprinkler clocks from a centralized location using a computer.
Closed loop cooling tower – water-conserving cooling tower system in which water used for cooling is recycled through a piping system that cools the water; the water is cooled as air exchanges heat with the pipes.
Codes and Standards – a set of requirements governing the design and performance of water using fixtures or devices, adopted by a nationally or internationally recognized code setting or standard setting organization.
Conservation pricing – water rate structures that increase the price of water as more water is used with the goal of encouraging more efficient use.
Consumptive use (evapotranspiration) – combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow, or intercepted precipitation. Also called crop requirement, crop irrigation requirement, and consumptive use requirement.
Continuous flow system – the continuous use, by an industry, of deionized water to remove contaminants from products and equipment.

Cooling tower makeup – water added to the recirculating cooling tower water stream to compensate for water evaporation losses.
Cooling-water – water typically used to cool heat-generating equipment or to condense gases in a thermodynamic cycle.
Cooling-water blow down – procedure used to reduce total dissolved solids by removing a portion of low quality recirculating water.
Cool-season grass – turf grass varieties that are typically not damaged by sub-freezing temperatures. Includes bluegrass, Kentucky bluegrass, perennial rye grass, red fescue, and tall fescue.
Decreasing block rate – pricing that reflects per-unit costs of production and delivery that go down as customers consume more water.
Demand management – the practice of systematically reducing water use for a broad spectrum of utility customers through efficiency measures and conservation, often as an alternative to purchasing new water or expanding water treatment facilities.
Demand scheduling – method of irrigation scheduling whereby water is delivered to users as needed and which may vary in flow rate, frequency and duration. Considered a flexible form of scheduling.
Device – a water using piece of equipment that uses or regulates the flow of water such as a faucet.
Discount rate – a value used to annualize costs or bring a future cost to today's cost, often defined to be the cost of borrowed money minus the inflation rate, expressed as a percent.
Distribution efficiency – measure of the uniformity of irrigation water distribution over a field.
Drawdown – the depth (from the top of the well) to the water in a well when the pump is operating. The water level typically drops when the pump is running.
Dual-flush toilet – a toilet designed to use a lower volume of water to flush liquid wastes and a higher volume of water to flush solid wastes.
Early closure flapper – a toilet flapper valve that closes sooner than normal to reduce the volume of water flushed.
Effective precipitation – the total depth of rainfall minus the volume lost to evaporation and leaching during a specific time period.
Efficiency – a level of water use performance that minimizes water waste
Established landscape – a landscape that has been in place for an extended period of time where the roots of the plants are well developed.
Evapotranspiration (ET) – water lost from the surface of soils and plants through the processes of evaporation and transpiration combined.
Evapotranspiration rate – a measure of the amount of water required to maximize plant growth. This measure is calculated from climatic conditions and factors such as temperature, solar radiation, humidity, wind, time of year, precipitation, and so on.
Faucet aerator – a device that can be installed in a sink to reduce water flow rate by adding air to the water.
Faucet restrictor – a device inserted into a faucet that forces water through a smaller orifice for the purpose of reducing the flow rate.
Fixture – a water using piece of equipment that uses or regulates the flow of water such as a faucet.
Flood irrigation – a method of irrigating where water is applied from field ditches onto land that has no guide preparation such as furrows, borders or corrugations.
Flow restrictor – a washer-like disk that fits inside a faucet or showerhead and reduces the water flow rate.
Flushometer toilet – a tankless toilet with the flush valve attached to a pressurized water supply pipe. These toilets are typically found in large institutional and commercial buildings such as schools, airports, office buildings, and so on.

Gauging station – specific location on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.

Gravity flow – a water system that relies on gravity to provide the pressure required to deliver the water. Consists of a water source located at a higher elevation than the water delivery points.

Gravity-flush toilet – the standard tank style of toilet that uses water (at standard gravitational pressure) to perform flushing functions.

Graywater – domestic wastewater composed of wash water from kitchen sinks, bathroom sinks and tubs, clothes washers, and laundry tubs that can be used for non-potable purposes such as irrigation.

Green building – a new or retrofitted building meeting certain efficiency standards with respect to water and energy.

Green industry – the industry that includes design, maintenance, installation, and management of landscapes.

Groundwater mining (overdraft) – pumping of groundwater for irrigation or other uses, at rates faster than the rate at which the groundwater is being recharged.

High efficiency device – a device that achieves a specific function at the lowest water use possible.

High efficiency toilet – a toilet that uses 4.8 liters of water per flush or less.

High water-use landscape – a landscape made up of plants, turf and features that requires 50 to 80% of the reference evapotranspiration to maintain optimal appearance.

Increasing block rate – pricing that reduces water use by structuring water rates to increase per-unit charges as the amount used increases.

Incremental cost – the additional cost associated with adding a specific amount (increment) of capacity to a water supply.

Infrastructure Leakage Index (ILI) – A dimensionless ratio of the estimated amount of non-revenue water in a system divided by the theoretical minimum for that system (calculated from formulas)

Integrated resource planning – a planning process emphasizing least-cost principles and balanced consideration of supply and demand management options for meeting water needs.

Irrigation audit – an on-site evaluation of an irrigation system to assess its water-use efficiency as measured by distribution uniformity, irrigation schedule, and other factors.

Irrigation districts – special units of local government that control the bulk of surface water supplies in the western United States.

Irrigation efficiency – the ratio of the average depth of irrigation water that is beneficially used to the average depth of irrigation water applied, expressed as a percent. Beneficial uses include satisfying the soil water deficit and any leaching requirement to remove salts from the root zone.

Irrigation plan – a 2-D drawing/plan that illustrates the layout of an irrigation system.

Isolation valve – a valve used for isolating all or part of an irrigation system for repairs, maintenance, or wet season shut-down Common types of isolation valves are the ball valve, butterfly valve, and gate valve.

Kilowatt-hour – 1000 watts of power for one hour, a measure of energy.

Landscape area – the total area on a property that contains landscaping elements. Usually equivalent to the total area minus the building footprint and paved driveways and paths.

Landscape water requirement – a measure of the supplemental water required to maintain the optimum health and appearance of landscape plants and features.

Lifeline rate – a minimum, sometimes subsidized water rate created to help meet basic human needs.

Low-flow faucet – a faucet that uses no more than 9.5 litres per minute at 80 pounds of pressure per square inch.

Low-flow plumbing – plumbing equipment that uses less water than was considered standard according to the United States Energy Policy Act of 1992. Must be only type of plumbing sold after January 1, 1994, as amended in 2006.

Low-flow showerhead – A showerhead that requires 9.5 litres of water per minute or less.

Low-flush toilet – a toilet that requires six litres of water per flush or less.
Low-volume urinal – a urinal that uses no more than 3 litres per flush.
Low water-use landscape – use of plants that are appropriate to an area's climate and growing conditions.
Low water-use plants – plants that require less than 30 per cent of reference ET to maintain optimum health and appearance.
Marginal-cost pricing – a rate design method where prices reflect the costs associated with producing the next increment of supply.
Matched precipitation rate – an equal rate of water delivery from sprinkler heads with varying arc patterns within an irrigation circuit. Matched precipitation rates are central to achieving uniform distribution or irrigation water.
Measure – a water saving device combined with a distribution or installation method or incentive (rebate).
Mega joule – one million joules, measure of unit energy.
Metering – use of metering equipment that can provide essential data for charging fees based on actual customer use.
Net present value – the present value of benefits minus the present value of costs.
Non-consumptive water use – water withdrawn for use but not consumed and thus returned to the source.
Non-residential water use – water use by industrial, commercial, institutional, public, and agricultural users.
Peak day ratio – a dimensionless ratio of the water produced and distributed on the highest day of the year divided by the average daily value for the same parameter.
Peak/off-peak rates – rates charged in accordance with the most and least popular hours of water use during the day.
Per capita (person) use – the amount of water used by one person during one 24 hour period. Typically expressed as litres per capita per day (lpcd).
Permanent wilting point – soil water content below which plants cannot readily obtain water and permanently wilt. Sometimes called permanent wilting percentage.
Plan – A document that describes a recommended course of action for implementing a conservation programme
Precipitation rate – the amount of water applied by a sprinkler system in a specific unit of time.
Present value – the cost of a future expenditure discounted to today's costs.
Pressure loss – loss in water pressure caused by friction of water against the inner walls of pipe or system components.
Pressure reducer – a component designed to reduce water pressure in supply system pipe or irrigation lines.
Pressurized-tank toilet – a toilet that flushes by using pressure from the waterline entering a pressurized plastic vessel inside the tank.
Price elasticity of demand – a measure of the responsiveness of customer water use to changes in the price of water; measured by the percentage change in price.
Pricing/rate structure – System used by water utility managers to charge customers for water usage.
Pricing signals – rate structures that encourage water conservation by customers.
Programme – A set of conservation measures planned to be implemented together.
Rain sensor – a device that automatically shuts off an irrigation system after a set amount of precipitation falls.
Recharge – the addition of water to the groundwater supply by natural or artificial means.
Recirculating cooling water – recycling cooling water to greatly reduce water use by using the same water to perform several cooling operations.
Reclaimed (recycled) water – wastewater that is treated and reused to supplement water supplies.
Reference evapotranspiration – the evapotranspiration of a broad expanse of adequately watered cool-season grass 4-6 inches in height. A standard measurement for determining maximum water allowances for plants so that regional differences in climate can be accommodated.

Residential End Uses of Water Study (REUWS) – the Residential End Uses of Water study published by the American Water Works Association Research Foundation in 1999. www.awwa.org
Retrofit – replacement of existing equipment with equipment that uses less water.
Return flow – that portion of the water diverted from a stream that finds its way back to the stream channel, either as surface or underground flow.
Reverse osmosis – common process used to produce deionized water from municipal water.
Seasonal rate structure – water rate structure that bills all water consumed during the dry season or peak season at a higher rate than during the other seasons.
Self-closing faucet – a faucet that automatically shuts off the water flow after a designated amount of time, usually a few seconds.
Simple payback period – the length of time over which the cost savings associated with a conservation measure must accrue to equal the cost of implementing the measure.
Simple water budget – a water budget that is the product of reference evapotranspiration, irrigated area, and a conversion factor.
Softening – the removal of calcium and magnesium ions from water.
Soil moisture sensor – a device placed in the ground at the plant root zone depth to measure the amount of water in the soil. Soil moisture sensors are also used to control irrigation and signal whether watering is required or not.
Source protection – protection of a water source, ranging from simple sanitary surveys of a watershed to the development and implementation of complex land use controls, in an effort to avoid water contamination.
Spray head – a sprinkler nozzle that delivers water in a fixed spray pattern.
Sprinkler heads – devices that distribute water over a given area for irrigation (or to put out fires). The primary purpose of sprinklers, however, is to get golfers wet on cold mornings.
Standard – a performance specification for water using device or fixture.
Static water pressure – water pressure as measured when the water is not moving. The 'not moving' part is critical, if the water is moving it isn't 'static'... When measuring static water pressure all the water outlets on the pipe must be closed. So if you're measuring the static pressure at a house you connect the pressure gauge, then take the reading while all the faucets, the ice maker, and so on., are turned off.
Sub-metering – use of separate meters to indicate individual water use in apartments, condominiums, and trailer homes, while the entire complex of units continues to be metered by the main supplier.
Subsurface irrigation – applying irrigation water below the ground surface either by raising the water table within or near the root zone, or by use of a buried perforated or porous pipe system that discharges directly into the root zone.
Supplemental irrigation – the application of water to a landscape to supplement natural phenomena.
Surface water supply – water supplied from a stream, lake, or reservoir.
Tiered pricing – increasing block-rate pricing.
Time-of-day pricing – pricing that charges users relatively higher prices during utilities' peak use periods.
Toilet dam – a flexible rectangular device placed across the bottom of a toilet tank to reduce the amount of water used per flush.
Toilet displacement device – a toilet retrofit device (such as a dam, bag, bottle, or rock) used to displace water in the toilet tank in order to reduce the volume required for flushing.
Toilet flapper – the valve that controls flushing in a gravity-tank toilet.
Under-irrigation – the difference between the water stored in a plant root zone during irrigation and the amount needed to refill the root zone to field capacity.
Uniform rate – a pricing structure in which the price per unit of water is constant, regardless of the amount use.

United States Safe Drinking Water Act (SDWA) – federal drinking water quality legislation administered by the U.S. Environmental Protection Agency. www.epa.gov

Variable charge – the portion of a water bill that varies with water use; also known as a commodity charge.

Water audit/survey – an on-site survey and assessment of water-using hardware, fixtures, equipment, landscaping, irrigation systems, and management practices to determine the efficiency of water use and to develop recommendations for improving water use efficiency.

Water budget – the amount of water required to maintain plants in a landscape; a method of establishing water efficiency standards by prescribing limits on water applications to landscapes.

Water closet – another name for a toilet

Water conservation incentive – an effort designed to promote customer awareness about reducing water use and motivate customers to adopt specific conservation measures.

Water demand – water requirements for a particular purpose, as for irrigation, drinking, toilet flushing, bathing, clothes washing, and so on.

Water efficiency – accomplishment of a function, task, process, or result with the minimal amount of water feasible; an indicator of the relationship between the amount of water required for a particular purpose and the quantity of water used or delivered.

Water efficiency measure – a specific tool or practice that results in more efficient water use and thus reduces water demand.

Water efficiency standard – criterion creating maximum or acceptable levels of water use.

Water efficient landscape – a landscape that minimizes water demand through design, installation, and management.

Water feature – a pool, fountain, water sculpture, waterfall, or other decorative element that includes water. Many water features recycle water thus reducing consumption.

Water right – under the riparian system, a legally protected claim to take possession of water occurring in a natural waterway and to divert that water for beneficial use; under the prior appropriation system, a property or legal claim to withdraw a specified amount of water in a specified time frame for beneficial use.

Water table – in an unconfined aquifer, the top of the saturated zone; the level at which a well penetrates the top of an unconfined aquifer.

Water transfers – selling or exchanging water or water rights among individuals or agencies.

Water-use efficiency – employing water-saving practices to reduce costs and to slow the depletion of the water supply to ensure future water availability.

Weather Adjusting Irrigation Controller – an electronic device that adjusts irrigation station run times and watering days with changes in the weather.

Wetlands – lands including swamps, marshes, bogs, and similar areas such as wet meadows, river overflows, mud flats, and natural ponds. An area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.

Xeriscape™ – a trademarked term denoting landscaping that involves the selection, placement, and care of low-water-use and native ground cover, turf, plants, shrubs, and trees. Xeriscape is based on seven principles: proper planning and design, soil analysis and improvement, practical turf areas, appropriate plant selection, efficient irrigation, mulching, and appropriate maintenance.

Appendix 2

Internet Resources for Water Efficiency

Web sites of various organizations contain general information on water efficiency methods and techniques as well as links to other sites. Web sites of water utilities provide examples of specific programmes offered and a way of contacting utility conservation staff.

Note: The web sites listed below are current as of 2013 and direct the reader to the water efficiency portion of an overall web site. Addresses may have changed and if any of the following contacts do not yield the expected web site, use an Internet search engine to locate it from the name of the organization or utility.

Organizations including a focus on water efficiency

International Water Association
http://www.iawq.org.uk/
Alliance for Water Efficiency
http://www.allianceforwaterefficiency.org/
UNESCAP
http://www.unescap.org/
Asian Development Bank
http://www.adb.org
Malaysian Water Association
http://www.mwa.org.my/
WaterLinks,
http://www.waterlinks.org
Water for People
http://www.water4people.org/
Environment Agency, United Kingdom
http://www.environment-agency.gov.uk/
Water UK
http://www.water.org.uk/index.php
United Kingdom Demand Management Centre, UK
www.environment-agency.gov.uk/savewater

Environment Canada, Canada.
http://www.ec.gc.ca/water/en/manage/effic/e_weff.htm
Wai Care Auckland, New Zealand
https://www.waicare.org.nz
American Water Works Association, USA, Canada, Mexico
http://www.awwa.org/
California Urban Water Conservation Council, California, USA
http://www.cuwcc.org
Home Water Works Consumer Web Site, USA
http://home-water-works.org
Water Saver Home Website, USA
http://www.h2ouse.org
California Department of Water Resources, Office of Water Efficiency, California, USA
http://www.water.ca.gov/wateruseefficiency/

American National Standards Institute (standards)
http://www.ansi.org/
Bureau of Reclamation, United States Department of the Interior, USA
http://www.usbr.gov/waterconservation/
Water Education Foundation, USA
http://www.water-ed.org
The Irrigation Association, USA
http://www.irrigation.org/
Green Plumbers
http://www.greenplumbersusa.com/
Generation Water, USA
http://www.generationwater.org/
Water Services Association of Australia
https://www.wsaa.asn.au/pages/default.aspx
Institute for Sustainable Futures, Australia
http://www.isf.uts.edu.au/
CISRO, Australia
http://www.csiro.au/
Victoria State Government Department of Environment and Primary Industries
http://www.water.vic.gov.au/
Government of Western Australia Department of Water
http://www.water.wa.gov.au/
United Nations Development Program, Human Development Reports
http://hdr.undp.org/en/reports/
ANQIP (the Portuguese association for water efficiency in buildings)
www.anqip.pt

Water utilities by geography

Asian

Singapore Public Utilities Board, Singapore
http://www.pub.gov.sg

Environment Bureau, Hong Kong, China.
http://www.enb.gov.hk/en/
Water Services Department, China
http://www.wsd.gov.hk/
South East Asian Water Utilities Network
http://www.seawun.org/
Metropolitan Water Works Authority of Thailand
http://www.mwa.co.th/ewtadmin/ewt/mwa_internet_eng/main.php?filename=index
Wastewater Management Authority, Ministry of Natural Resources and Environment, Thailand
http://www.wma.or.th/
Kurita Water Industries, Japan
https://www.kurita.co.jp
Manila Water, Philippines
http://www.manilawater.com/

Australia

Melbourne Water
http://www.melbournewater.com.au
Sydney Water Corporation, Australia
http://www.sydneywater.com.au
Yarra Valley Water Corporation, Australia
http://www.yvw.com.au
South East Queensland Water (Seqwater), Australia
http://www.previous.seqwater.com.au/
Hunter Water Australia
http://www.hunterwater.com.au/
City West Water, Australia
https://www.citywestwater.com.au/
South East Water, Australia
http://www.sewl.com.au/
Western Water, Australia
http://www.westernwater.com.au/
Perth Water Corporation, Australia
http://www.watercorporation.com.au/

United Kingdom

Thames Water, United Kingdom
http://www.thameswater.co.uk/
Yorkshire Water, United Kingdom
http://www.yorkshirewater.com/
United Utilities, United Kingdom
http://www.unitedutilities.com/
Essex and Suffolk Water, United Kingdom
https://www.eswater.co.uk
Bristol Water, United Kingdom
http://www.bristolwater.co.uk

Europe

Veolia, France
http://www.veolia.com
Suez Environment, France
http://www.suez-environnement.com/
Lyonnaise des Eaux France
http://www.lyonnaise-des-eaux.fr
Eurawasser, Germany
http://www.eurawasser.de
Trencianska spolocnost, TVS, Slovakia
http://www.tvs.sk
Publiacqua, Italy
http://www.publiacqua.it
VAS Brno, Czech Republic
http://www.vastd.cz
Aguas de Barcelona, Spain
http://www.agbar.es
Aguas de Valencia
http://www.aguasdevalencia.es
Madrid, Spain
http://www.cyii.es/ente/
European Commission Blueprint to Safeguard Europe's Water Resources
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012DC0673:EN:NOT.

Latin America

National water utilities: Instituto Costarricense de Acueductos y Alcantarillados, Costa Rica
https://www.aya.go.cr/
ANDA, El Salvador
http://www.anda.gob.sv/
ENACAL, Nicaragua
http://www.enacal.com.ni
IDAAN, Panama
http://www.idaan.gob.pa/
Obras Sanitarias del Estado, Uruguay
http://www.ose.com.uy/

Africa / Middle East

Water Authority of Jordan
http://www.waj.gov.jo/
Cape Town, Western Cape, South Africa
http://www.capetown.gov.za/
Miya Water Corporation, Tel Aviv, Israel
http://www.miya-water.com/

North America

Bay Area Water Conservation and Supply Agency, California, USA
http://bawsca.org

Regional Water Authority, California, USA
http://www.rwah2o.org/
Tampa Bay Water, Florida, USA
http://www.tampabaywater.org
Town of Cary North Carolina, USA
http://www.townofcary.org
Cobb County, Georgia, USA
http://www.cobbwater.org
Denver Water, Colorado, USA
http://www.denverwater.org
East Bay Municipal Utility District, California, USA
http://www.ebmud.com
San Diego County Water Authority, California, USA
http://www.sdcwa.org/
City of Sacramento Department of Utilities, California, UCA
http://www.cityofsacramento.org/utilities/
City of Santa Cruz, California, USA
http://www.cityofsantacruz.com/index.aspx?page=389
Los Angeles Department of Water and Power, California, USA
http://www.ladwp.com
Marin Municipal Water District, California, USA
http://www.marinwater.org
Metropolitan Water District of Southern California, California, USA
http://www.mwd.dst.ca.us
Irvine Ranch Water District, California, USA
http://www.irwd.com/
Honolulu Board of Water Supply, Hawaii, USA
http://www.hbws.org
Massachusetts Water Resources Authority, Massachusetts, USA
http://www.mwra.state.ma.us
Metropolitan North Georgia Water Planning District, Atlanta, Georgia, USA
http://www.atlantaregional.com/environment/water/water-district
Seattle Public Utilities (City of Seattle), Washington, USA
http://www.ci.seattle.wa.us
Regional Water Providers Consortium, Portland, Oregon, USA
http://www.conserveh2o.org/
Washington Suburban Sanitary Commission, Maryland, USA
http://www.wssc.dst.md.us
San Antonio Texas, USA
http://www.saws.org/
Stanford University, Palo Alto, California, USA
http://lbre.stanford.edu
University of California, Santa Cruz, USA
http://www1.ucsc.edu/conserving_water/
American Water Works Company, USA
http://www.amwater.com/

City of Ottawa, Ontario, Canada.
http://ottawa.ca/en
Engineering Services, City of Vancouver, British Columbia, Canada.
http://vancouver.ca/home-property-development/water-and-sewer.aspx

Appendix 3

Example Water Use Efficiency Measures for Water Utilities

The following list provides descriptions of possible water efficiency measures in the United States. Information on how to screen this list to a reasonable number for cost effectiveness analysis is described in Chapter 6.

Equipment or Measure Type	Measure Name	Measure Description
Water Loss - System Audit	Conduct Annual System Water Use Audit	Maintain a thorough annual accounting of water production, sales by customer class and quantity of water produced but not sold (non-revenue water). In conjunction with system accounting, include audits that identify and quantify known legitimate uses of non-revenue water in order to determine remaining unaccounted for water losses. Goal would be to lower the Infrastructure Leakage Index (ILI) and non-revenue water every year by a pre-determined amount based on cost-effectiveness. These programmes typically pay for themselves based on savings in operational costs (and saved tariff revenue can be directed more to system repairs/replacement and other costs).
Water Loss - Apparent Los	Apparent Loss Reduction – Billing System and Meter Testing	Continuously analyze billing data for system errors and under-registering meters. Identify and quickly notify customers of apparent leaks. Address meter testing and repair/replacement to insure more accurate meter reads and revenue collection. Actions could include meter calibration and accelerated meter replacement.
Water Loss - Real Water Loss	Real Water Loss Reduction – Leak Repair and Reduce Background Losses with Main Replacement and Reuse of flushing water	Measure covers efforts to find and repair leaks in the distribution system to reduce real water loss. More aggressive actions could include installation of data loggers and proactive leak detection. Leak repairs would be handled by existing crews at no extra cost. Specific goals and methods to be developed by Utility. May include accelerated main and service line replacement. Enhanced real loss reduction may include more ambitious main replacement and active leak detection. Capture water from water main flushing and hydrant flow testing for reuse.
Water Loss - Pressure Regulation	Distribution System Pressure Regulation	Install additional pressure regulators in portions of distribution system to maintain pressure within limits so accounts do not receive excessive pressure. There is a high correlation between high water usage and high pressure, due to higher leakage, atomization of sprinklers and ease of using excessive water.
Advanced Meter Infrastructure (AMI)	Install AMI	Equip new cutomer meters with AMI and retrofit existing system with AMI meters and associated network capable of providing continuous consumption data to Utility offices. Improved identification of system and customer leaks is major conservation benefit. Some of costs of these systems are offset by operational efficiencies and reduced staffing, as regular meter reading and those for opening and closing accounts are accomplished without need for physical or drive-by meter reading. Also enables enhanced billing options and ability to monitor unauthorized usage (such as use/tampering with closed accounts or irrigation if time of day or days per week are regulated). Customer service is improved as staff can quickly access continuous usage records to address customer inquiries. Optional features include online customer access to their usage, which has been shown to improve accountability and reduce water use. A ten year change-out would be a reasonable objective.
Advanced Meter Infrastructure (AMI)	Targeted AMI to Irrigation or Large User Accounts	Require that larger or irrigation customers install such AMI meters as described above and possibly purchase means of viewing daily consumption by landscape/property managers, or business either through the Internet (if available) or separate device. The AMI system would, on demand, indicate to the customer and Utility where and how their water is used, facilitating water use reduction and prompt leak identification. This would require Utility to install an AMI system.
Water Tariffs	Tariff Structure Evaluation	Tariffs must meet Utility costs, but some features can improve customer accountability by better imposing cost impacts for high water usage. Tiered tariff structures are the most popular form of conservation tariffs, and can be very effective provided there are sufficient tiers (3 to 4 is recommended), and price differences between tiers is sufficient and tiers are placed at usage levels that appropriately reflect low, medium and high usage levels for the Utility. This measure would also require a tariff study.
Water Tariffs	Modification to or Implementation of Tiered Tariff Conservation Pricing	Consider introducing tiered tariffs or seasonal pricing for certain customer classes. Some utilities utilize percentages of average winter usage as the basis for individualized summer tiers. Multi-Family Domestic tiers could be based on number of housing units served by meters. This measure would require a tariff study and advanced billing system capabilities.
Water Tariffs	Establish Separate Pricing Structure for Irrigation Accounts	Implementing conservation-oriented pricing for dedicated irrigation customers would encourage more efficient irrigation practices. Would require a tariff study.
Water Tariffs	Water Budget Based Billing	Develop individualized monthly water budgets for all or a selected category of customers. Water budgets are linked to a tariff schedule where tariffs per unit of water increase when a customer goes above their budget, or decreases if they are below their budget. Budgets typically are based on such factors as the size of the irrigated area and often vary seasonally to reflect weather during the billing period. These tariffs have been shown to be effective in reducing landscape irrigation demand (AWWARF Reports). This measure would require tariff study and capable billing software.

Public Education	Conservation Print Media	Use a range of printed materials to raise awareness of conservation measures available to customers, including incentive programmes offered by Utility. This can include newsletters, bill stuffers, brochures (self-developed or purchased), working with local newspapers, signage at retailers, signs on public buses. Regional participation and development can help assure consistent message. Such programmes would continue indefinitely.
Public Education	Electronic Conservation Options / Web Site / Social Media	Provide variety of conservation information on utility web site, distribution of "videos." Also consider social media options such as cell phone apps, Facebook, interactive kiosk with view screen, etc.
Public Education	Speakers Bureau/ Event Participation	Conduct presentations at various venues, from radio and television to service organizations and focused groups. Have booths at relevant community events. Participate in local activities such as parades, etc.
Public Education	Media Campaign	Suggest a general media campaign with theme such as “Use Only What You Need” message like Denver Water's programme or a “Beat the Peak” message media campaign like Cary, North Carolina or Tucson Arizona “Beat the Peak”. Also considered a programme with outdoor landscape focused action like: “Take Control of your Controller” Campaign for a focused social media based campaign as a media campaign. Consider determining appropriate usage and media campaign message with marketing study/focus groups.
Public Education	Recognition Programmes for Water Savings by Residences & Apartments Programme	Sponsor an annual awards programme for residences and multi-family properties that significantly reduce water use. They would receive a plaque/recognition. This could include innovative customers that install compost toilets, gray-water, bio-swales and rainwater cisterns in an effort to maximize practical home water use efficiency.
Public Education	Recognition Programmes for Water Savings by Businesses	Sponsor an annual awards programme for businesses that significantly reduce water use. They would receive a plaque/recognition.
Public Education - Irrigation Focus	Outdoor Domestic focused Public Awareness Information Programme	Programmes could continue efforts including poster contests, speakers to community groups, conservation hotline, website, video loan, radio and television time, demonstration gardens and printed educational material such as bill inserts, etc. Could also consider increasing current Utility efforts possibly adding social media such as cell phone apps, Facebook, interactive kiosk with view screen, etc. Programme would continue indefinitely.
Public Education - Irrigation Focus	Efficient Outdoor Use Education and Training Programmes	Utility would offer, organize and sponsor a series of educational workshops or other means for educating homeowners, landscapers and contractors in efficient landscaping and irrigation principals. Utilize guest speakers, native demonstration gardens, incentives, such as a nursery plant coupon.
Public Education - Irrigation Focus	Train Landscape Maintenance Workers (Green Gardener Programme)	Utility would sponsor bilingual training for managers and workers in landscape maintenance methods that will save irrigation water. Model after Green Gardener Programme. Santa Barbara County Water Agency example: http://www.greengardener.org/. With some of these programmes, names of businesses that have obtained training are included in Utility publications and/or Web sites (as an incentive to participate).
Public Education - Irrigation Focus	Networking with Landscaping Industry	Meet with and become members in "Green Industry" organizations; partner with projects and outreach material development. Outreach to nurseries for information distribution, provide "water wise plant" signage, etc.
Public Education - Irrigation Focus	Landscape Water Calculator	Develop Landscape Watering Calculator and Watering Index, and actively market these. Consider cell phone application (cell phone app) with Watering Index, following up in person with large landscape customers on a frequent basis to encourage use of Watering Index.
Public Education - Irrigation Focus	Climate appropriate (Water Efficient) Demonstration Gardens	Donate or acquire a portion of public or private land to create a demonstration garden displaying living examples of low water-using gardens and landscaping. The Utility would provide signs and brochures to educate those people visiting the garden.
Public Education	Promote Green Buildings	Assign Staff a position to work with local Green Building associations, developers, designers, vendors to promote incorporating water efficiency into building design. Possibly work with other partner utilities or agencies energy / wastewater / storm water. Co-sponsor award programme.
Public Education	Schools Education Programmes	Work with local school districts to develop classroom programmes that they would embrace. Consider poster contests, etc. Some programmes would require dedicated utility staff to assist & present.
Submetering	Mobile Home Park Submetering	Require or provide a partial cost rebate to meter all remaining mobile home parks that are currently master metered but not separately metered.
Submetering	MF Submeter Incentive	Provide a rebate (per unit) to assist MF building owners installing submeters on each existing individual apartment or condominium unit.
Submetering	Require Multifamily Submetering for New Developments	Require the submetering of individual units in new multi-family, condos, townhouses, and mobile-home parks.

Indoor Plumbing Fixtures	Single Family Water Surveys	Indoor water surveys for existing single family domestic customers. Target those with high water use and provide a customized report to owner. May include give-away of efficient shower heads, aerators, and toilet devices. Usually combined with outdoor surveys (See Irrigation Measures).
Indoor Plumbing Fixtures	Multi-Family Water Surveys	Indoor water surveys for existing multifamily domestic customers (2 units or more). Target those with high water use and provided a customized report to owner. Usually combined with outdoor surveys (see Irrigation Measures) and sometimes with single family surveys.
Indoor Plumbing Fixtures	Real Customer Water Loss Reduction - Leak Repair and Plumbing Emergency Assistance	Customer leaks can go uncorrected at properties where owners are least able to pay costs of repair. These programmes may require that customer leaks be repaired, but either subsidize part of the repair and/or pay the cost with revolving funds that are paid back with water bills over time. May also include an option to replace inefficient plumbing fixtures at low-income residences.
Indoor Plumbing Fixtures	Pressure Reduction	Provide incentive to install pressure regulating valve on existing properties with pressure exceeding 80 psi.
Indoor Plumbing Fixtures	High Efficiency Faucet Aerator / Showerhead Giveaway	Utility would buy showerheads and faucet aerators in bulk and give them away at Utility office or community events.
Indoor Plumbing Fixtures	High Efficiency Toilet (HET) Rebates	Provide a rebate or voucher for the installation of a high efficiency toilet (HET).
Indoor Plumbing Fixtures	High Efficiency Urinal Rebates	Provide a rebate or voucher for the installation of a high efficiency urinals.
Indoor Plumbing Fixtures	High Efficiency Toilet and / or Urinal Bulk Purchase Programme	Utility would buy HETs or urinals in bulk and give them away or sell them at a discounted price for customers who want to replace a high flush toilet or high flush urinal.
Indoor Plumbing Fixtures	Plumber Initiated High Efficiency Toilet and / or Urinal Retrofit Programme	Utility would subsidize installation cost of a new HET/ urinals purchased by the utility. Licensed plumbers, pre-qualified by the Utility would solicit customers directly. Customers would get a new HET installed at a discounted price. Pattern after Sonoma County, California programme.
Indoor Plumbing Fixtures	Install High Efficiency Toilets, Showerheads, and Faucet Aerators in Domestic Buildings	Utility would subsidize installation cost of a new HET purchased by the utility. Licensed plumbers, pre-qualified by the Utility would solicit customers directly. Customers would get a new HET installed at a discounted price.
Indoor Plumbing Fixtures	Install High Efficiency Fixtures in Government Buildings	Provide rebates or grants to install high efficiency faucets, toilets, urinals and showerheads in local and state government facilities.
Indoor Plumbing Fixtures	Install High Efficiency Fixtures in Low Income Housing	Direct install type toilet replacement programme in in low income housing operated a government agency/housing authority.
Indoor Plumbing Fixtures	Install High Efficiency Toilets, Urinals, and Showerheads in Commercial Buildings	Consider direct install programme-type for installation of high efficiency fixtures in all or selected commercial or institutional buildings. Replacements would include high efficiency toilets, showerhead, and waterless or high efficiency urinals.
Indoor Plumbing Fixtures	Install sensor-activated faucets	Consider direct install programme, rebates or grants for installation of high efficiency sensor faucet fixtures in all or selected high-use commercial or institutional buildings.
Indoor Plumbing Fixtures	Toilet Retrofit At Time of Sale	Work with the real estate industry to require a certificate of compliance be submitted to the Utility that verifies that a plumber has inspected the property and efficient fixtures were either already there or were installed at time of sale.
Indoor Plumbing Fixtures	Require high efficiency urinals in new development	Require that new building be fitted with the highest efficiency urinals.
Indoor Plumbing Fixtures	Require Fixture Replacement by a Deadline	Utility would pass an ordinance that requires certain targeted sectors of businesses to bring fixtures up to efficient standard by a fixed date at their own expense.

Indoor Plumbing Fixtures	Garbage Disposal Removal	Encourage 1% of single family homeowners per year to remove garbage disposals. Could provide a rebate.
Hot Water on Demand	Require Hot Water on Demand / Structured Plumbing in New Developments	Work with developers to equip new homes or buildings with efficient hot water on demand systems such as structured plumbing systems. These systems use a pump placed under the sink to recycle water sitting in the hot water pipes to the water heater or to move the water heater into the center of the house and/or reduce hot water waiting times by having a an on-demand pump on a recirculation line.
Hot Water on Demand	Provide a Rebate for Hot Water on Demand Pump Systems	Provide a rebate to equip homes with efficient hot water on demand systems. These systems use a pump placed under the sink to recycle water sitting in the hot water pipes to reduce hot water waiting times by having a an on-demand pump on a recirculation line. Can be installed on kitchen sink or master bath, wherever hot water waiting times are more than 1/2 minute. Requires an electrical outlet under the sink, which is not common on older home bathrooms but is on kitchen sinks.
Clothes Washers	Domestic Clothes Washer Rebate	Provide a rebate for efficient washing machines to single family homes and apartment complexes that have common laundry rooms. It is assumed that the rebates would only offer the best available technology. Rebate could be modified to increase incentive for the most efficient washers.
Clothes Washers	High Efficiency Clothes Washer Rebate	Provide a rebate for the installation of a high efficiency commercial washer (HECW). Rebate amounts would reflect the incremental purchase cost. Programme is intended to be a market transformation measure and eventually would be stopped as efficient units reach saturation.
Clothes Washers	Require High Efficiency Clothes Washers in New Development	Require developers to install an efficient clothes washer (meeting certain water efficiency standards, such as litres/load), Building Department would be requested to ensure that an efficient washer was installed before new home or building occupancy. Verify that the Utility can enforce conditions of water service that may include efficiency standards for washing machines.
Dishwashers	Efficient Dishwasher Rebates	Provide a rebate to encourage homeowner to purchase an efficient dishwasher (meeting certain water efficiency standards, such as a limit on the litres/load) when replacing an existing dishwasher.
Dishwashers	Require Efficient Dishwashers in New Development	Require developers to install an efficient dishwasher (meeting certain water efficiency standards, such as litres/load).
Irrigation	Outdoor Water Surveys	Outdoor water surveys offered for existing customers. Normally those with high water use are targeted and provided a customized report on how to save water. Can be combined with indoor surveys or focused on certain customer classes. All single family and multi-family domestic would be eligible for free landscape water surveys upon request.
Irrigation	Outdoor Water Audit	Outdoor water audits offered for existing large landscape customers. Normally those with high water use are targeted and provided a customized report on how to save water. All large multi-family domestic, CII, and public irrigators of large landscapes would be eligible for free landscape water audits upon request. Tied to the Water Budget Programme.
Irrigation	Financial Incentives for Irrigation and Landscape Upgrades	For SF, MF, CII, and IRR customers with landscape, provide a Smart Landscape Rebate Programme with rebates for substantive landscape retrofits or installation of water efficient upgrades; Rebates contribute towards the purchase and installation of water-wise plants, compost, mulch and selected types of irrigation equipment upgrades. Rebate for domestic accounts and up to 50% more for commercial customers.
Irrigation	Landscape Conversion or Turf Removal	Provide an incentive for to remove turf and replace with low water use plants or permeable hardscape. Rebates are often capped at an upper limit dollar limit for single family residence.
Irrigation	Landscape Conversion or Turf Removal	Provide an incentive for to remove turf and replace with low water use plants or hardscape.
Irrigation	Artificial Turf Sports Fields	Provide a rebate as a cost share for customer wishing to install artificial grass on sports fields, parks, or golf courses.
Irrigation	Shade Tree Programme	Provide incentives and information to promote shade tree planting as a water conservation measure
Irrigation	Weather-Based Irrigation Controller Rebates	Provide a per station rebate up to a 50% cost-share for the purchase of a weather based irrigation controller. These controllers have on-site weather sensors or rely on a signal from a central weather station that modifies irrigation times at least weekly. Requires local irrigation contractors who are competent with these products, so may require sponsoring a training programme in association with this measure.
Irrigation	Require Weather Adjusting Smart Irrigation Controllers and / or Rain Sensors in New Development	Require developers for all properties of greater than four domestic units and all commercial development to install the weather based irrigation controllers. Some utilities offer rebates for rain sensors.

Irrigation	Rebate or Free Rain Sensors	Provide a rebate or free rain sensor shut-off device for existing irrigation controllers. These cancel scheduled sprinkling when sufficient rain has been received. This measure is most effective in areas with intermittent rain in peak watering seasons.
Irrigation	Require Rain Sensors	Require installation of rain sensor shut-off devices when installing new irrigation systems.
Irrigation	Rotating Sprinkler Nozzle Rebates	Provide rebates to replace standard spray sprinkler nozzles with rotating nozzles that have lower application rates.
Irrigation	Water Conserving Landscape and Irrigation Codes	Develop and enforce Water Efficient Landscape Design Standards. Standards specify that development projects subject to design review be landscaped according to climate appropriate principals, with appropriate turf ratios, plant selection, efficient irrigation systems and smart irrigation controllers. There are many examples that have demonstrated significant water savings. The ordinance could require certification of landscape professionals.
Irrigation	Require Irrigation Designers / Installers be Certified	Require design / installation of irrigation systems by trained/certified contractors.
Irrigation	Landscape irrigation restricted to designated days and times	Specify specific irrigation schedules, including which days and times watering is allowed. Would help with load balancing system demands with planning for water areas can water on what days. Consider water waste enforcement approach. For an example see the Southern Nevada Water Authority programme. http://www.snwa.com/consv/restrictions_landscape.html (last accessed on April 29, 2013).
Rainwater Catchment	Provide Rain Barrel Incentive	Provide incentive for installation of rain barrels. This could involve rebates or bulk purchase and giveaways of barrels plus workshops on proper installation and use of captured rain water for landscape irrigation. Pattern after Honolulu Board of Water Supply programme.
Rainwater Catchment	Provide Incentive for Large Rainwater Catchment Systems	Provide incentive for installation of large rainwater catchment systems. This could involve rebates, grants and other cost share methods. Might require simultaneous installation of water efficient landscaping to assure that amount of water collected is capable of lasting into the peak irrigation season.
Gray water	Gray water Retrofit SF	Provide a rebate to assist a certain percentage of single family homeowners per year to install gray water systems.
Gray water	Require Plumbing for Gray Water In New SF Development	Require builders of single family homes to provide plumbing for and/or install a gray water system in new homes.
Gray water	Rebate for Gray Water Systems In New CII Development	Provide a rebate for gray water systems in new CII development, in accordance with existing codes.
Gray Water	Recycle water for non-potable uses	Recycle lavatory sink water for toilet flushing.
Other Outdoor	Require or Rebate Swimming Pool Covers	Provide a rebate through pool equipment supply stores for purchase of a swimming pool cover.
Other Outdoor	Prohibit Water Waste and Practices	Adopt or modify ordinance that prohibits the waste of water defined as gutter flooding and failure to repair leaks in a timely manner.
CII Equipment	Top Water Users Programme (Top customers from each customer category)	Top water customers from each category would be offered a professional water survey that would evaluate ways for the business to save water and money. The surveys would be for large accounts such as hotels, restaurants, stores and schools.
CII Equipment	Customized Top Users Incentive Programme	After the free water use survey has been completed at site, the Utility will analyze the recommendations on the findings report that is provided and determine if site qualifies for a financial incentive. Financial incentives will be provided after analyzing the cost benefit ratio of each proposed project. Incentives are tailored to each individual site as each site has varying water savings potentials.
CII Equipment	CII Rebates to Replace Inefficient Equipment	Provide rebates for a standard list of water efficient equipment. Included would be x-ray machines, icemakers, air-cooled ice machines, steamers, washers, spray valves, efficient dishwashers, replace once through cooling, and add conductivity controller on cooling towers.
CII Equipment	Water Savings Performance Programme	Incentive is based on the potential for savings over 5 years. Eligible project costs include labor, hardware and up to 1 year of water management fees.
CII Equipment	Require Plan Review for new CII	Require plan reviews for water use efficiency for all new business customers.

CII Equipment	Promote Kitchen Spray Nozzles	Provide free 0.08 liter per second (or lower) spray nozzles and possibly free installation for the rinse and clean operation in restaurants and other commercial kitchens. Millions have been replaced in the U.S. as they are very cost-effective because the valve saves hot water.
CII Equipment	School Building Retrofit	School retrofit programme wherein school receives a grant to replace fixtures and upgrade irrigation systems.
CII Equipment	Focused Water Audits for Hotels/Motels	Proved free water audits to hotels and motels. Standardize on the types of services offered to reduce costs. Included would be bathrooms, kitchens, ice machines, laundry, landscaping, and irrigation systems and schedules.
CII Equipment	Hotels/Motels Retrofit w/Financial Assistance	Following a free water audit offer motels a rebate for equipment identified that would save water. Or provide a rebate schedule for certain efficient equipment such as air-cooled ice machines that motels could apply for without an audit.
CII Equipment	Rebates for Sub meters on Cooling Towers	Offer a rebate to buildings that install submeters to measure the make-up and bleed-off water of the facility cooling towers. Provide educational brochures and a phone contact of a knowledgeable person to provide conservation information.
CII Equipment	Rebates for Conductivity Controllers on Cooling Towers	Offer a rebate to buildings that install conductivity controllers to reduce bleed-off water of the facility cooling towers. Provide educational brochures and a phone contact of a knowledgeable person to provide conservation information.
CII Equipment	Cooling Tower Regulations	Prohibit discharge of cooling tower blow down unless the TDS of the water is at least a certain level (that would ensure 5-10 cycles of concentration).
CII Equipment	Dry Vacuum Pump	Provide a rebate to assist CII with installation of dry vacuum pumps.
Other	Low Impact New and Remodeled Development	Utility would require developers of new/remodeled sites to follow Low Impact Development concepts/standards/Best Management Practices for storm water and water conservation benefits. Encourage or require use of bio-retention facilities, rain water cisterns, gray water plumbing, etc.
Other	Prohibit Once through Cooling, Non-Recycling Fountains, Water Wasting Fixtures and Practices	Prohibit certain obvious wastes of water in new and existing facilities, such as those listed. Consider requiring retrofits of existing situations, allowing reasonable time for compliance.

Appendix 4

Guide to Making Benefit-Cost Calculations

INTRODUCTION

The guidelines given in this appendix explain details and provide formulae for estimating benefits and cost and the benefit-cost ratio. An overview of the fundamental concepts of cost effectiveness evaluation of water efficiency measures are presented in Chapter 7. The comprehensive approach described below includes present value analysis to evaluate the costs and benefits of a long-term water efficiency measure. An overall programme benefit-cost ratio may be determined by using a weighted average of benefit-cost ratios of individual measures based on the amount of water saved.

Planners can use the software tools available for download that corresponds to the information provided in this Guide to perform many of the simplified benefit-cost calculations for one efficiency measure at a time. The guidance provided in this appendix will assist in creating a better understanding of the theory behind the calculations being performed and the preparation of input data for the spreadsheet software tool. The tool is available for download at: www.iwaefficient.com or www.maddauswater.com.

A. Choosing an accounting perspective

The first step in evaluating benefits and costs is to determine the perspective of the accounting to which those benefits or costs accrue. There are three basic perspectives: (a) the water utility; (b) water utility customers (as targeted by the applicable measure); and (c) society as a whole (social and environmental benefits). In other words, the planner must (a) establish the basis for who receives the benefit and/or and pays the costs, and (b) be consistent in the perspectives to have an accurate analysis.

B. Calculating benefits in terms of water savings

To calculate estimated water savings, the baseline water use must first be determined for the group of users targeted (e.g., use by residential customers). Water savings resulting from efficiency measures will depend on (a) the reduction in water use as a result of implementing the measure and (b) the degree of coverage that the measure can achieve (also known as "market penetration").

The expected water reduction in water use, E, from a given measure for a particular user group is calculated as:

$$E = R \times MP$$

where *R* equals reduction in water use as a result of the measure, expressed as a fraction of 1. The fractional water use, *R*, for the year of interest can be estimated by the formula:

$$R = S/W$$

where *S* equals annual estimated water savings expected from the measure, (lpd), *W* equals average water use without the efficiency measure in place (lpd), for the year of interest, and *MP* equals the percentage of customer market penetration (coverage) of the measure, within the group of water users under consideration, for the year of interest (also called the installation rate). For mandatory measures (e.g., plumbing efficiency standards), the *MP* factor is considered as 100 percent. For voluntary measures, the *MP* factor is much lower. One resource for estimating this value is from the experience of other utilities. Another approach is to set a value for *MP* based on the desired coverage for the programme. For example, the water utility may decide that a customer market penetration of 20 percent is the goal for implementation of the measure (e.g., residential home water surveys), and the efficiency programme will therefore be designed to achieve that goal. Thus, in this example, the *MP* factor is 20 percent or 0.20.

For example, if the fractional reduction in water use resulting from installing water efficient showerheads is 0.094, the estimated customer market penetration (or coverage) is 100 percent, and if mandatory national plumbing efficiency standards are in place and well enforced, then the overall percentage reduction will be:

$$E = 0.094 \times 1.0 = 0.094 \ (or \ 9.4\%)$$

The following formula may be used to estimate how effective a specific efficiency measure may be in a given year:

$$EWS = R \times MP \times B$$

where *EWS* equals the estimated reduction in water use as a result of the measure, in million litres per year for the year of interest, and *B* equals the baseline annual water use for the targeted group of users (or total water use, if detailed information not available) without conservation in place, million litres per year.

To design for maximum effectiveness, the expected impact of each efficiency measure should be assessed individually and then combined for an estimate of total expected water savings for all measures in the water efficiency programme. The expected water savings can be estimated by multiplying by *B*, and expected reduction for each efficiency measure by *E*. For example, if the baseline water use (without conservation) for the users' group of interest is 1000 million litres year, then the reduction in water use from the installation of water efficient showerheads is:

$$EWS = 0.094 \times 1.0 \times 1000\,ML/yr = 94\,ML/yr$$

C. Determining the benefits of efficiency measures

Savings to the water utility result from cost savings (the benefits from implementing efficiency measures that achieve the water savings). The three principal ways that cost savings can be achieved include (a) reduced water purchases (if the water utility is a wholesale customer of another water purveyor), (b) reduced operation and maintenance expenses and (c) downsized, delayed or eliminated capital facilities. They are described below.

1. Cost savings from the reduced purchase of water

A straightforward calculation results in the average annual unit cost of purchased water from a wholesaler using the following expression:

$$\text{Unit cost of purchased water} = \frac{\text{Annual water purchase costs}}{\text{Units of water purchased per year}}$$

Planners can calculate the amount of cost savings by multiplying the unit cost of purchased water by the number of units of water saved as estimated from efficiency measures. An added level of detail can be used if a higher cost is charged in peak use period (e.g., the high irrigation or dry season) than the average cost during this period (typically a few months) divided by the number of units of purchased water over the same period. This unit cost of peak period purchased water may then be multiplied by the amount of water savings from efficiency measures aimed at making water reductions during that period (generally relevant to landscape irrigation efficiency measures).

2. Cost savings from reduced operation and maintenance expenses

Since reducing demand results in less water produced, efficiency measures can reduce expenses, depending on the amount of water produced, or variable costs for utility operations such as energy and chemical costs. In addition, some fixed costs may be associated with the variable costs of energy and chemical usage, and may be included if appropriate. Only the variable costs that are attributed to water efficiency activities are used in the cost savings shown below.

(a) Energy cost savings

To estimate the variable cost of energy, use the formula:

$$\text{Unit cost of energy} = \frac{\begin{array}{c}\text{(Annual energy bill)} - (12 \times \text{monthly fixed charges})\\ - \text{(Energy costs not related to water production)}\end{array}}{\text{Total number of units of water used annually, million litres per year}}$$

where energy costs not related to water production are those independent of actual water production, such as building heating, cooling, lighting and processing equipment. These costs should not be included unless water production is reduced to the extent that facilities (e.g., certain buildings or items of equipment) are not used, which would rarely be the case.

(b) Chemical cost savings

Cost savings are calculated by multiplying the unit cost of chemicals by the number of units of water saved per year due to an efficiency measure. In most cases, costs associated with chemicals are variable. The following formula can be used to calculate the variable cost of chemicals:

$$\text{Unit cost of chemicals} = \frac{\begin{array}{c}\text{(Annual chemicals bill)} - (12 \times \text{monthly fixed charges})\\ - \text{(chemicals costs not related to water production)}\end{array}}{\text{Total units of water used annually, million litres per year}}$$

Note: The benefits derived from reduced wastewater collection and treatment operations (energy and chemical savings) can be calculated in a similar manner. In addition, unit costs for other types of benefits may be added when calculating the environmental, customer or societal (social) benefits. The incorporation of environmental and social benefits, when evaluating a complete water efficiency programme as the demand management alternative compared to other water supply alternatives, is recommended. However, calculations for these types of benefits are outside the scope of this publication.

3. Cost savings from downsized, delayed or eliminated capital facilities

The following simplified formulae illustrate the calculation of cost savings in cases where a project is downsized or eliminated.

(a) Downsized

If the project is downsized:

$$\text{Cost savings} = \frac{(\text{Cost of original size in planned year})}{(i+1)^n} - \frac{(\text{Cost of reduced size in planned year})}{(i+1)^n}$$

(b) Delayed

If the project is delayed:

$$\text{Cost savings} = \frac{(\text{Cost in original year})}{(i+1)^n} - \frac{(\text{Cost in delayed year})}{(i+1)^n}$$

where n equals the number of years that the project is delayed, and i equals the interest rate (rate of return that could be earned by project funds).

(c) Eliminated

If the project is eliminated: Cost savings = construction cost, in present value (local currency rate at the time of calculation).

D. Determining the costs of efficiency measures

This section describes the two principal costs to the water utility for undertaking efficiency programmes, that is, direct costs for implementation, such as in-house staff costs and any contracted costs (where a private contractor performs some of the work), and reductions in water revenues.

1. Direct costs to the water utility

These costs may be defined as in-house (staff and measure unit) costs and contractor costs (if administrative and/or fieldwork is contracted out). Utility costs are typically considered the sum of the following costs:

$$\begin{aligned}\text{In-house costs} &= \text{Administrative costs} + \text{field labour costs} + \text{measure unit cost} \times \text{number of units}\\ &\quad + \text{publicity costs} + \text{evaluation and follow-up costs; and}\\ \text{Contractor costs} &= \text{Administrative costs} + \text{number of events (or sites)}\\ &\quad \times \text{unit cost per event (including programme unit costs)} + \text{(if applicable),}\\ &\quad \text{contractor costs for publicity or evaluation or follow-up}\end{aligned}$$

(a) Administrative costs

These include the costs of staff time required for overseeing field staff, contractors, consultants, or contracted field labour. Administrative costs will be higher when launching a new programme or large consultant contracts. Administrative costs are typically 5 up to 25 percent of the total programme costs.

(b) Field labour costs

Field labour costs (i.e., field labour hours × hourly rate) include the costs of staff time to conduct efficiency programme work in the field such as water audits/surveys, leak repairs and fixture installation, follow-up site visits, and door-to-door customer contacts.

(c) Unit costs of each measure

Many measures can be estimated on a unit cost basis or as a cost per participant. Examples include retrofit kits, water survey/audit programs, and rebate programmes. Small programmes typically have higher unit costs than larger programmes due to a smaller number of participants and the absence of bulk purchase discounts.

(d) Publicity costs

All programmes require a public outreach component to educate customers through local media, including radio and television spots, local newspaper advertisements, flyers, customer bill inserts, billboard and bus advertising, cinema advertisement slides, customer workshops and seminars, and special demonstrations (booths at community events). Larger utilities often employ public relations professionals to handle this aspect of their efficiency programme for maximum effect, but this is not necessary for smaller programs. Costs will be roughly proportional to the number of customers contacted.

(e) Evaluation and follow-up costs

Two types of follow-up activities are commonly undertaken by a utility: (a) keeping records of the impact of each conservation measure in order to quantify the water savings from these activities); and (b) monitoring how well the measures are performing through follow-up contact with participants in order to assess if programme goals are being achieved. Costs from these follow-up activities may include staff time, public surveys to assess customer participation and satisfaction, including changes from a baseline survey on attitudes, and market penetration studies (more common among larger utilities) to assess future means of improving implementation of the measure.

The best sources of information are the experiences of water utilities that have conducted similar programmes. Costs can be expressed on a unit basis (e.g., US dollars per dwelling unit or US dollars per survey/audit). They can then be transferred to another utility's service area, accounting for economies of scale (e.g., any bulk purchase discount or larger number of participants that would drive costs down) for different-sized programmes.

2. Costs of reduced water revenues

Reduced revenue only occurs in systems with metered water use that is billed by volume. Reduced revenue is of primary concern among water utility decision makers, and it should be assessed carefully and explained in detail. There are two primary viewpoints:

(a) Reduced revenues are seen as a capital saving since the water savings result in avoidance of capital costs that would otherwise be spent on expanding or building new facilities. In that sense, the lost revenue is viewed as a negative capital outlay and the cost of the efficiency programme may be "capitalized" or, in other words, paid for in the same way as for a water treatment plant; and

(b) Reduced revenues are treated as an efficiency programme cost. However, including this cost is not appropriate when performing a benefit-cost analysis. This is because the benefits from less capital expenditure for avoided increases in system capacity are offset by the "cost" of reduced revenues.

In the absence of the water efficiency programme, additional revenues would be needed to pay for the new capital expenditures.

There is a direct correlation between lower water use and lost revenue if water use is metered and charged on a per unit volume basis. Lost revenue may be estimated by multiplying the water savings by the retail value of the water. Generally, this reduction is small, predictable and occurs over a long period, allowing the water utility to incorporate the changes into budget forecasts. Generally, cost effective (a benefit-cost ratio above 1.0) efficiency programmes save 0.5 to 2 percent of annual water use and reduce water revenues by a similar amount per year over the life of the programme. Historically, this amount has been less than inflation in other water utility costs, while the reduction in variable production (energy, chemical and treatment) costs help to offset estimated revenue decreases. Periodic rate adjustments can recover the inflation in water utility costs in addition to recovering any lost revenue; therefore, the actual economic impact can be made insignificant.

E. Performing a benefit-cost analysis

So far, the focus has been on collecting information for calculating benefits and costs. The goal now is to combine this information into a formal benefit-cost analysis from the perspective of a water utility.

As described in this section, benefit-cost analysis will show planners, decision makers and the public whether the measures being proposed are economically efficient or, in other words, whether the benefits are greater than the costs. The larger the water savings and the smaller the costs of the measures, the more economically attractive the measures will be to the water utility.

Benefit-cost analysis requires careful attention to detail and is a central responsibility of planners at medium-sized and large utilities. Planners perform benefit-cost analysis in order to justify significant budgets or as part of an effective water supply planning process. Smaller utilities may elect to calculate the cost of water saved, as described below, and select measures based only on costs.

A benefit-cost ratio greater than 1.0 will not always be the final deciding factor. Some measures are implemented independent of an economic evaluation. A good example is public education programmes, which are often thought of as the "glue" that holds the efficiency programme together. When performing a financial assessment, public education is difficult to quantify in terms of direct water savings and, as a result, rarely has a positive benefit-cost ratio. However, public education programmes are critical components of a plan that is always included to assist in achieving success with all measures by building the conservation ethic in customers. Alternatively, a very attractive efficiency measure may be beyond the water utility's means, particularly in a case when significant upfront investments are needed to launch the programme and the cost savings are over the long term. In general, most utilities will fall into the range of being able to start small and build an efficiency programme over time that has a positive economic impact.

F. Determining the benefit-to-cost ratio using present value analysis

This is a standard means of analysing different alternatives, and numerous economics textbooks present several methods for estimating the costs and benefits of a potential alternative (in this case an efficiency measure). One resource is the report, *Cost Effectiveness Guidelines for Evaluation Urban Water Conservation: Best Management Practices (CUWCC, 2005)*,[1] last updated in 2005 by the California Urban Water Conservation Council. The report can be ordered via their web site at www.cuwcc.org.

[1]California Urban Water Conservation Council (2005), Cost Effectiveness Guidelines for Evaluation Urban Water Conservation: Best Management Practices.

As an overview, the method calculates the ratio of the present value (current US dollar values) of benefits to the present value of costs. If the ratio is greater than 1.0, then the benefits outweigh the costs and measure is considered feasible (or economically efficient). The following formula shows the basis for benefit to cost ratio:

$$\text{Benefit-cost ratio} = \frac{\dfrac{\text{Sum of benefits (US\$) in year } (t)}{(1+i)^t}}{\dfrac{\text{Sum of costs (US\$) in year } (t)}{(1+i)^t}}$$

where i equals selected interest rate, as a decimal (5 percent = 0.05), and t equals any given year that the programme incurs costs or produces benefits, to the end of the planning horizon (typically 20–30 years).

1. Estimating the cost of water saved: simplified approach

The cost of water saved is a useful indicator that is relatively easy to calculate. It is commonly expressed as US dollars (local currency exchange rate) per million litres. These are common denominations of new water supply and it is a simple comparison to see if efficiency measures are less expensive than new sources of supply. There is no standardized formula for calculating the cost of water saved, but the following is suggested:

$$\begin{array}{c}\text{Cost of water saved}\\ \text{(US \$ /million litres)}\end{array} = \frac{\text{Present value of total efficiency programme costs over planning period (US\$)}}{\text{Total volume of water saved over the planning period (million litres)}}$$

G. Determining a benefit-cost ratio for all efficiency measures combined into one programme

The total benefit-cost ratio of the entire water efficiency programme can be determined through the following steps:

(a) Multiply the benefit-cost ratio for each efficiency measure selected for the programme by the total water savings over the life of that efficiency measure;
(b) Add up all the weighted benefit-cost ratios of all measures (from (a) above);
(c) Add up all the water savings of the individual measures.
(**Note:** If multiple measures are aimed at the same type of end use of water (e.g., reductions in residential indoor water use), the reduction expected for each of these measures (represented as a fraction, R, as defined above) should be multiplied and not added together. The weighted reduction factor can then be converted back to total water savings in million litres by multiplying the weighted reduction factor by the baseline water use.)
(d) Divide the total of all weighted benefit-cost ratios (result of step (b) above) by the total amount of expected water savings (result of step (c) above) to determine the overall programme benefit-cost ratio.

Software to Download

As part of this guide, there is software available for download in metric and English units. The software can be accessed on the following websites: http://www.iwaefficient.com or http://www.maddauswater.com

Appendix 5

Sample Checklist for Water Saving Measures

Below is a list of possible water saving actions for each of the end use categories. Where you have identified an end use category as being relevant to your business it is recommended that each of the possible water saving measures indicated below are investigated. For some measures, further advice may be required from relevant service providers, technicians or specialists.

WEMP Water Saving Measures Checklist - Typical efficiency measures by end use

Below are a list of possible water saving actions for each of the end use categories provided in the Water Using Features Checklist. Where you have identified an end use category as being relevant to your business it is recommended that each of the possible water saving measures indicated below are investigated. For some measures, further advice may be required from relevant service providers, technicians or specialists. It is recommended that a completed copy of this checklist is submitted to your water service provider as part of your WEMP.

End Use Category	Equipment / Process		Possible Water Saving Measure Addressed (In the yellow box '√' if applicable or 'x' if not)	Notes/Action	Initial
1. Amenities	1.1 Toilets		Replace single flush toilets with water efficient dual flush model (6/3 L or 4.5/3 L)		
			Install water displacement device in cisterns		
			Replace cistern flapper valves on an annual basis		
			Instruct cleaners to report leaks		
			Display contact person and telephone number for reporting of faults/leaks		
	1.2 Urinals		Install water efficient models		
			Correctly position and orientate sensors to avoid false triggering		
			Check programming of controls to minimise 'flush' and increase 'delay' cycles		
			Schedule battery replacements for every one to two years if mains power is not feasible		
			Install waterless urinals (subject to metallic piping & drainage slope issues)		
	1.3 Basins		Install water efficient tapware		
			Consider 'self closing' (spring loaded) or sensor solenoid controlled models		
			Consider 'purpose fit' flow regulators (e.g., 1.7 L/min)		
	1.4 Showers		Install water efficient models		
			Provide four minute shower timers for use		
			Erect signs that remind users to keep their showers short		
			Consider timer flow control in sports centres and swimming pools		
			Use vandal proof fittings in high risk environments (e.g., swimming pools)		
			Install coin operated showers		
2. Kitchen	2.1 Trigger spray		Install water efficient trigger sprays		
			Use low flow/high pressure type (e.g., dishwasher pre rinse spray valve)		
	2.2 Dishwasher		Set rinse cycle to automatically stop on rack exit		
			Retrofit to re-use final rinse water for next pre wash		
			Check and replace missing water jets		
			Check and clean blocked water jets		
			Check and replace worn water jets		
			Ensure dish racks are suitable for the type of dishware		
			Train staff in correct method of rack loading		
			Instruct staff to fully load racks before dishwasher operation		
	2.3 Glass washer		Replace with water efficient model (re-use of final rinse water and low use per cycle)		
			Ensure rinse cycle automatically stops on rack exit		
			Check and replace missing water jets		
			Check and clean blocked water jets		
			Check and replace worn water jets		
			Ensure racks are suitable for the glassware		
			Train staff in correct method of rack loading		
			Instruct staff to fully load racks before glass washer operation		
	2.4 Ice machine		Use minimum flow rates for condenser cooling, as per operation manual		
			Re-use cooling water for non-potable applications		
			Replace water cooled equipment with air-cooled model		
			Identify and repair leaks		
	2.5 Hand washing basin		Install water efficient tapware		
			Fit long life jumper valves		
	2.6 Thawing of frozen food		Train staff to thaw frozen products in fridge overnight, avoiding the use of running water		
	2.7 Food washing		Train staff to wash food in containers or basins, avoiding the use of running water		
	2.8 Wok stoves & steamers		Replace water cooled wok stove(s) with waterless air-cooled models		
			Fit wok stove(s) with automatic cut-off spout		
			Replace water cooled steamers with air cooled model with automated make-up water control		
3. Irrigation	3.1 Gardens & lawns		Schedule and implement system leakage assessments		
			Repair existing leakages		
			Periodically use mulch and water crystals		
			Ensure manual timers have a maximum range of two hours		
			Fit automatic timers with rain sensors and/or soil moisture sensors		
			Replace plants with drought resistant varieties		
			Set mowers to a higher cut		
	3.2 Technical solutions		Sub-meter irrigation water supply line to monitor consumption and identify leakage		
			Set irrigation schedule for outside the hottest hours of the day		
			Aerate soil annually to allow greater water infiltration		
			Investigate use of alternative water sources		
			Consider local climate (and precipitation rates), soil type and plant species when setting watering schedules		
			Set a schedule for ongoing maintenance and system review		

End Use Category	Equipment / Process		Possible Water Saving Measure Addressed (In the yellow box '√' if applicable or 'x' if not)	Notes/Action	Initial
4. Cooling Tower	**4.1 General**		Consider Sydney Waters: '*Water conservation best practice guidelines for cooling towers in commercial buildings*'.		
			Investigate if cooling tower(s) can be shut off outside of normal hours		
			Investigate reuse of bleed water for other appropriate non-potable uses (e.g., toilet flushing)		
			Install anti-splash louvers or wind breaks if windy conditions exist		
			Consider installing sub-meters on both make-up and bleed lines		
			Where sub-meters are installed, implement weekly meter reading log sheets or equivalent		
			Undertake independent testing of cooling tower performance by technician/cooling tower service provider		
			Performance based contracts with cooling tower service providers relating to reducing water consumption while keeping scale, corrosion and fouling at an acceptable level		
			Set a schedule for ongoing maintenance and system review		
	4.2 Performance review		Identify and schedule for repair any air intake and exhaust duct leaks		
			Clean air inlets for possible debris		
			Identify and investigate any splashing (wet patches) around towers. Ensure water flow rates or fan speeds are not too high		
			Schedule repair and maintenance of any overflow pipe leakage or unusual flow		
			Investigate operation of make-up line ball float setting and bleed line control		
			Identify and repair any cracks or misalignment in drift eliminators		
			Ensure spray nozzles are correctly positioned and not blocked		
			Identify and repair tower casing, basins, connections and pump leaks		
			Check valve, hatch and panel seal conditions		
			Investigate the use of variable speed drives for cooling tower fan motors		
			Check conductivity controller and bleed conductivity sensor is cleaned and calibrated		
			If CoC is less than 5, check to confirm this cannot be lower based on the conductivity of the make-up water		
			Undertake full investigation if system water losses are found to be greater than 8% of make-up water		
5. Pool/Spa	**5.1 Backwash**		Eliminate 'scheduled' backwashing, use pressure readings to indicate action needed		
			Upgrade sand gravity type filters by replacing sand with Zeolite or replace with new pressure type		
			Install 'clear-view screen' in backwash discharge line to visually inspect water turbidity reducing unnecessary backwashing		
			Investigate re-use of backwash water for non-potable applications		
			Investigate water treatment plant (membranes and sterilisation) for re-use of backwash water as make-up		
	5.2 Rainwater tank		Install a rainwater tank(s) to provide alternative water supply for pool top up		
	5.3 Deck cleaning		Adopt mechanical cleaning methods such as brooms or mops as an alternate to using water		
			Ensure hand held hoses are fitted with trigger nozzles, water brooms or use high pressure cleaner		
			Prohibit use of fire hoses for washdown		
	5.4 Pool evaporation		Use pool cover when the pool is not in use		
			Consider using shade cloth over pools		
			Use screens or landscaping to reduce effects of prevailing wind		
			Investigate for leaks if water level drops more than 3 cm in a day		
	5.5 Pool make-up		Install a sub-meter on pool make-up supply line		
			Check make-up tank control valve regularly		
	5.6 Pool infrastructure		Take meter readings outside normal operating hours to check for leaks (zero flow testing)		
			Check pool shell for leaks		
			Check balance tank for leaks		
			Check supply and return piping for leaks		
6. Steam system	**6.1 Condensate re-use**		Set a schedule for ongoing maintenance and review of steam traps		
			Re-use condensate from boiler		
	6.2 Boiler use efficiency		Check condensate return system for leaks and ensure pipe insulation is sound		
			Consider replacing distributed high capacity thermal storage heat recovery systems with solar & gas		
			Install conductivity-based control system to maximise cycles of concentration		
			Check control settings for unnecessary operation		

End Use Category	Equipment / Process		Possible Water Saving Measure Addressed (In the yellow box '√' if applicable or 'x' if not)	Notes/Action	Initial
7. Process	**7.1 Cleaning**		Fit hand held hoses with trigger or twist action nozzle or use high pressure cleaning unit		
			Investigate installing automated Clean In Place (CIP) systems to replace manual cleaning		
			Check programming of existing CIP		
			Reuse final rinse from CIP as pre-wash in next CIP or other appropriate re-use		
			Investigate replacement of water cleaning with chemical and/or steam or pressure system		
	7.2 Water purification		Investigate re-use of reverse osmosis (RO) waste stream for non-potable applications		
			Program RO plant to maximise volume of water produced & minimise waste steam (brine)		
	7.3 Fire testing		Capture fire test water for re-use in fire test or other non-potable applications		
	7.4 Vacuum system		Consider replacing Liquid Ring Vacuum Pumps (LRVP) with 'dry' vacuum pumps		
			Re-use water from LRVP for non-potable applications (e.g., toilet flushing or irrigation)		
			Re-use wastewater from LRVP (i.e., feed back into the vacuum pump for a closed loop)		
	7.5 Spray nozzles		Replace worn or missing jets		
			Introduce a regular inspection regime		
			Replace high flow models with lower flow models		
			Replace nozzles with stainless steel versions for better wear resistance		
	7.6 Water cooled equipment		Capture cooling water for re-use in cooling or other non-potable water uses		
	7.7 Sterilisers		Ensure sterilisers are switched off at the end of operation (e.g., install shut of valves)		
			Set steriliser at the minimum possible flow rate		
	7.8 Chillers		Clean tubes regularly to maximise efficiency and reduce water use in cooling towers		
			Check system controls for unnecessary operation and hence unnecessary cooling tower operation		
			Reduce system heat load (e.g., lighting upgrade, insulation, window film) to save cooling tower water		
	7.9 Lubrication		Replace water as the medium for equipment lubrication		
			Check nozzles, retrofit low flow type (e.g., on lubrication lines)		
8. Laundry	**8.1 Equipment & practices**		Load machines to maximum capacity to minimise cycles of fixed water use		
			Check all automatic programs for water use optimisation (e.g., eliminate unnecessary rinse cycles)		
			Replace water inefficient top loaders with front loaders with high star rating		
	8.2 Wastewater		Capture final rinse water and re-use in the next pre wash cycle		
			Re-use wastewater for non-potable applications (e.g., toilet flushing or irrigation)		
			Install water treatment plant for re-use as make-up water in washing process		
	8.2 Cleaning		Fit hand held hoses with a trigger or twist action nozzle or use high pressure cleaning unit		
9. Laboratory	**9.1 Sterilisers & autoclaves**		Capture condensate for re-use in non-potable applications (e.g., toilet flushing or irrigation)		
			Install retrofit kits to increase water efficiency		
			Ensure operation only when required		
	9.2 Vacuum system		Consider replacing Liquid Ring Vacuum Pumps (LRVP) with 'dry' vacuum pumps		
			Re-use water from LRVP for non-potable applications (e.g., toilet flushing or irrigation)		
			Re-use wastewater from LRVP (i.e., feed back into the vacuumpump for a closed loop)		
	9.3 Lab taps		Install water efficient tapware		
			Consider 'self closing' (spring loaded) or sensor solenoid controlled models		
			Consider 'purpose fit' flow regulators (e.g., 1.7 L/min)		
10. Leakage	**10.1 Meter reading**		Conduct zero flow test out of business hours to ensure no leaks are present		
			Conduct regular meter readings, especially out of hours (including zero flow testing), to identify leakage		
			Consider installing a smart metering system with permanent data logging and auto reporting on all significant water end uses		
	10.2 Facility assessment		Implement ongoing program to check and monitor problem areas such as:		
			1. Nozzles		
			2. Tap jumper valve washers		
			3. Toilet flapper valves		
			4. Urinal automatic controls		
			5. Make-up water supply control valve		
			6. Steam traps and condensate return lines		
			7. Cooling towers		

Source: The State of Queensland, Department of Natural Resources and Mines (2013).

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Many communities are facing water scarcity in developing and developed countries alike. There are numerous publications and on-going research studies documenting the changes in our climate and potential for worsening shortages in our future. Meeting future potable water demands as communities continue to grow will rely heavily on using our existing water resources more efficiently.

Preparing Urban Water Use Efficiency Plans: A Best Practice Guide provides detailed approaches to developing and implementing water use efficiency plan. This book covers the broad spectrum of conservation planning for urban communities including achieving more efficiency from:

- Residential domestic uses
- Commercial and governmental facilities use
- Industrial uses
- Pricing
- Water loss control programmes

The steps in the Guide clearly outline and provide sample calculations to aid determining which water use efficiency activities are financially justifiable to undertake. The end result is a plan that policy decision makers can adopt and fund, and that water service provider staff can implement to help increase their community's water reliability. It includes numerous case studies and a Microsoft Excel based software tool to allow planners to evaluate the business case for implementing various water conservation activities.

This book is an essential resource for professionals in water and wastewater resources, particularly for planners and engineers. It is also a useful guide for postgraduate and undergraduate students.

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