ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

GUIDE TO PREPARING URBAN WATER-USE EFFICIENCY PLANS

WATER RESOURCES SERIES
No. 83

UNITED NATIONS

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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 water 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.

In a number of countries, regulations are already in force that require water utilities to prepare water efficiency (that is, 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 treatment facilities.

The Plan of Implementation, adopted at the World Summit on Sustainable Development held at Johannesburg, South Africa in September 2002, reflects 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 losses and increase the recycling of water as well as introduce more efficient usage of water resources.

In response to that call, the Economic and Social Commission for Asia and the Pacific (ESCAP) has prepared this publication on water-use efficiency planning. The contents of this publication constitute a source of information 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 residential, municipal and commercial sectors.

The ESCAP secretariat gratefully acknowledges the valuable contributions of William Maddaus and Lisa Maddaus, both of Maddaus Water Management, who authored the publication. The publication was reviewed, edited and finalized with the participation of Yuri Steklov of the Environment and Sustainable Development Division of the ESCAP secretariat.

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Abbreviations

AWWA	American Water Works Association
AWWRF	American Water Works Association Research Foundation
BMP	best management practice
ILI	international leakage index
IWA	International Water Association
TIRL	technical indicator of real losses
UARL	unavoidable average real losses
UAW	unaccounted-for-water
l	litre
l/c/d	litre per capita per day
l/e/d	litre per employee per day
Ml	million litres
Ml/d	million litres per day
m	metre
m^3	cubic metre
m^3/year	cubic metre per year
Nc	number of connections

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INTRODUCTION

A. 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, (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 the publication in developing such a plan will enable the water conservation plan offering the greatest possible benefits to be determined and implemented.

B. 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 (for example, on gardens), improvement in water-use behaviour, and installing water-efficient processing equipment in businesses and industry.

C. Benefits of water efficiency

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

(a) Water utility;

(b) Wastewater utility;

(c) Customers (community);

(d) Environment;

(e) Energy utility;

(f) Others.

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.

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 less use of treatment chemicals;

(b) The 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” the capacity of treatment facilities, benefiting both the utility and the community. The long-term cost savings from water management can only be achieved if utilities reduce the size of their planned treatment plants due to water conservation.

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.

3. Summary of customer benefits

Conservation benefits can also extend beyond the utility. Customers who save water may receive lower water bills and, possibly, lower sewerage bills if sewerage service charges are based on water use. Customers who reduce hot water usage (for example, from installing more efficient showerheads, washing machines, dishwashers, etc.) may also lower their energy bills.

4. Summary of environmental and other benefits

The environment can benefit by 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;
- Higher lake levels for recreational purposes;
- Reduced impacts on water quality at a source.

Energy utilities will benefit from reductions in peak demand, customer energy savings, lower greenhouse gas emissions, etc.

D. 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 (for example, benefits related to the deferral of water treatment plant expansion), ample water supply should not be used as a reason for exemption from water conservation 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.

E. 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;

(d) Avoiding the funding of a new water supply source, conveyance and treatment facilities in order to meet escalating demands.

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 be likely to 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.

F. Publication outline

The Guide is divided into eight chapters that lead planners through the process of developing a water efficiency plan. Chapter I discusses the development of a water efficiency plan and explains where the plan elements can be found in the publication.

Chapter II 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 III 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 IV 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 V considers different aspects of determining the feasibility of water-use efficiency measures. The chapter is divided into two parts. Part A 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 rates that apply to metered customers such as water-pricing schemes designed to reduce water use. Part B describes water-efficiency measures that apply to residential and non-residential customers. A summary of available water efficient devices is tabulated and a comprehensive list of potential interior and exterior water efficiency measures is presented by type of customer in annex II. A qualitative screening process is suggested to enable the planner to reduce the measures to be considered to a manageable number.

Chapter VI 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. (The reader is also referred to annex III, which contains software for computing the benefit-cost ratio of an efficiency measure).

Chapter VII 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 VIII 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 unavailability of long-range capital facility plans, and appropriate training and software. The publication is designed to assist users in overcoming many of these constraints.

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I. 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.

A. 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 II);

(b) Projected future water use, preferably broken down by customer type or, in other words, customer class (chapter III);

(c) Explicit programme goals, both short term and long term (chapter IV);

(d) Evaluated efficiency measures (chapter V);

(e) A cost-effectiveness analysis used as a part of the decision-making process (chapter VI);

(f) Recommended efficiency measures, including explicitly defined implementation costs, scheduling and staffing (chapter VI);

(g) Budget requirements with identified funding sources (chapter VII);

(h) Implementation strategies with clarification of the roles of responsible parties (chapter VIII).

B. Plan outline

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

1. 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. 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.

2. Service area, climate and demographics (chapter II)

Describe the service area and its climate 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 together with other demographic factors that affect water-use planning.

3. Water supply sources and vulnerability (chapter II)

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 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. However, this publication does not cover drought contingency planning. In addition, describe the options for replacing any unreliable water supply source (that is, not consistently available at all times when taking into account specific legal, environmental, water quality or climatic factors) with alternative sources or water demand management measures.

4. Water transfers/exchanges (chapter II)

Describe opportunities for exchanges or transfers of raw or treated water with another utility on a short- or long-term basis.

5. Existing and projected water use (chapter III)

This part of the plan should include:

(a) Quantification of past and current water use (for the last five years at monthly intervals);

(b) A projection of future water use at five-year intervals for the next 20 years (or provide the horizon for water supply planning) 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.

6. Water efficiency goals (chapter IV)

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.

7. Evaluation of alternative demand management measures (chapters V and VI)

The objective of the evaluation is to provide the utility with justification for implementing specific efficiency measures. (See chapter VI for a description of cost-effectiveness analysis and annex III 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;

(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 following 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;

   (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.

8. 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 (for example, a break in a water distribution main, power failure or treatment process malfunction). However, this issue is not covered in this Guide.

9. Recommended long-term efficiency plan (chapter VI)

A detailed description of the measures selected for the plan as well as their costs, benefits, and implementation schedule should be included.

10. Implementation plan (chapters VII and VIII)

Provide projections for the required budget and staffing over the life of the plan together with the estimated annual budget for the first five years 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.

C. 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/delete measures.

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 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 a success of the water efficiency programme.

D. Suggested public participation in plan preparation

Any plan that is to be implemented should include 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.

Other 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. Additional information on public involvement is provided in chapter IV with a discussion on how to select potential measures for further consideration.

Box 1. Policy requirements 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 conservation plans depending on system size. The United States Safe Drinking Water Act, 1996 requires water conservation plans to address three categories of public water supply systems, that is, systems serving: (a) fewer than 3,300 persons; (b) between 3,300 and 10,000 persons; and (c) more than 10,000 persons

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 per cent of the State’s 8,000 utilities each serve less than 500 persons. 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 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 3,300 persons unless in an area designated by the State as a “critical water supply area”;
- A minimum plan/programme for systems serving between 3,300 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 unaccounted for water (UAW) percentage. Medium-sized utilities with a relatively high UAW, when compared to the norms, could be encouraged to prepare a full plan to reduce UAW.

Box 2. Sydney Water Corporation uses least-cost planning to prioritize programmes

Sydney Water Corporation (SWC) uses least-cost planning as a framework to:

- Provide base data for evaluation of options;
- Shortlist programmes and initiatives for detailed evaluation;
- Evaluate cost effectiveness;
- Rank options in terms of a benefit-cost ratio.

A computer model calculates the “levelized cost”, which represents the cost to the community to achieve a certain level of water savings and is expressed in terms of A$/1,000 litres saved. Levelized costs comprise the ratio of discounted costs to discounted water savings, thus providing an economic ranking of the options.

Their current water efficiency programme is driven by regulatory requirements to reduce per capita water use by 25 per cent over 10 years. (See <http://www.ipart.nsw.gov.au> for regulatory requirements on SWC).

II. ASSESSING CURRENT AND FUTURE WATER SUPPLY SOURCES

A. Introduction

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 III. 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.

The purposes for assessing water supplies in this context are:

(a) To enable the quantity of reliable water supply to be defined in order to identify potential shortfalls;

(b) 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 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.

Although defining water supply sources is a broad topic, for the purposes of water-use efficiency planning the best information available should be utilized. 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.

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 (that is, 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 VI for a more detailed description). Software and additional references are provided in annex III.

B. Service area, watershed and 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 service area boundaries and facilities in the water-use efficiency plan is especially useful. Demographic characteristics of the service area are defined when quantifying current and future water demands (chapter III).

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 (see chapter V). For example, a long dry season without precipitation would be a constraint to rainwater harvesting for landscape watering needs because a large water storage volume is required for that purpose.

C. 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;
- Desalinated water;
- Other (rainwater harvesting and graywater systems).

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 from stream gauges 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 capital as well as operation and maintenance costs, as such projects could be deferred or downsized due to the water demand management programme.

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 (that is, 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 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. 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 per cubic metre basis than conserved water). These sources are easily quantified from designed capacity and metered production at treatment facilities.

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 customers to assess the number of such systems installed. 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 V.

Box 3. Singapore Public Utilities Board experience in using innovative water sources

Approximately half of Singapore's land area is used as water catchments. All major traditional surface water resources have been developed. Surface run-off is collected in 145 impounding reservoirs, piped to 19 raw water reservoirs, treated at nine treatment facilities, and then supplied via 15 storage or service reservoirs and a pipeline network of some 5,150 km. Singapore has more than 1 million water accounts. To augment local water supplies, Singapore imports water from Malaysia.

The Government is actively exploring alternative water supply sources. The Public Utilities Board (PUB) is to proceed with seawater desalination for potable water supplies, and will recover good-quality water (called NEWater) from secondary treated effluent for use by clean industries as an alternative to PUB potable water. However, the fact that water from such new sources will be more expensive highlights the importance of (a) comprehensive water demand management in controlling water demand growth, and (b) fully utilizing limited water resources. Additional information is available at <http://www.pub.gov.sg>.

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.

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

[1] An example of the compressive list that is maintained in the United States by the Environmental Protection Agency (EPA) can be found at <http://www.epa.gov>. Water quality information, including drinking water testing, can be found at <http://www.epa.gov/region4/water/drinkingwater/watertesting.htm> and in the publication, *Standard Methods for the Examination of Water and Wastewater*, twentieth edition, 1998, American Public Health Association, <http://www.apha.org/media/>.

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.

6. Water transfers/exchanges

Existing or planned agreements for meeting demands through (raw and/or treated) water exchanges or transfers either 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 counts 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.

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.

D. 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 per cent 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 IV).

E. Effect of water-use efficiency on water and wastewater systems

Existing water systems are affected by reduced consumption in a variety of ways. A recent report on the topic, entitled *Impacts of Demand Reduction on Water Utilities*, was produced by J. A. Weber and D. Bishop in 1996 for the American Water Works Association Research Foundation (AWWARF). 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.

1. Lowering water system operating costs

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 1 shows an example of the average energy use for water delivery and its significance in overall operation and maintenance costs.

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 2 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 1. Average energy output for water supply delivery

Type of water source	Energy use, kWh/1,000 litres	Electricity cost as % of total O & M costs	Electricity cost as % of total cost
Groundwater	0.3	18	7
Surface water	0.2	11	4
Purchased water	0.2	4	3

Source: Water Industry Database, American Water Works Association, 1991.

Table 2. Effect of reduced consumption 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: W. Maddaus, 1999, "Estimating the benefits from water efficiency" in proceedings of Conserve 99, Monterey, California, February 1999, American Water Works Association.

3. 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.

4. Downsizing wastewater systems

Table 3 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 (for example, 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.

Table 3. Effect of water-use efficiency on design criteria for wastewater system elements

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: W. Maddaus, 1999, "Estimating the benefits from water efficiency" in proceedings of Conserve 99, Monterey, California, February 1999, American Water Works Association.

III. 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 are required. This chapter explains how to evaluate current water use and provides two methods for forecasting water use.

A. Evaluating current water use

1. Describing the service area

Table 4 can be used as a worksheet to characterize the 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 (that is, 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 up to 20 years is usually adequate for water-use efficiency planning.

2. Describing water use

Table 5 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. 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 residential service connections		
	Single-family	20 000
	Multi-family	5 000
	Total	25 000
Current number of non-residential 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

Table 5. An example of water-use description

Water-use characteristic	Value
Average annual water production, Ml/year	18 250
Ml/d	50
Extent of metering	
Residential, per cent	90
Non-residential, per cent	100
Estimated unmetered use, Ml/d	2
Total metered water use, Ml/d	38
Water losses, Ml/d	10
as a share of water production, per cent	20
Peak day water use, Ml/d	70
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, Ml/d	40
Non-seasonal water use, per cent	80
Seasonal use, per cent	20
Average water use by customer category	
Single-family residential, Ml/d	15
Multi-family residence, Ml/day	5
Commercial, Ml/d	10
Industrial, Ml/d	7.5
Institutional (public), Ml/d	2.5
Water losses, Ml/d	10
Total, Ml/d	50
System supply safe yield, Ml/d	80
System capacity, Ml/d	60

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

Pumping volume = Pumping rate x time of operation

The time of operation can be estimated from the electricity meter readings (see chapter II);

(c) Water losses, which can be estimated by conducting a system water audit. Chapter V describes the assessment of water losses. The value entered in table 5 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 per cent in a relatively new, well-managed system, but more than 50 per cent in a poorly-managed, 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). Alternatively, the peak month ratio can be computed from production and/or billing data;

(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 water use pro-rated over a year. The formula for calculating seasonal use, which is typically associated with outdoor use such as landscape (garden) watering, is:

Seasonal water use percentage

$$= \frac{1 \text{ low month water use} \times 12 \times 100}{\text{Average annual water use}}$$

(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 5 by expressing the results in million litres per day (Ml/d). 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 residential and non-residential, unless multi-family units are the predominant type of residential dwelling;

(g) Checking the reasonableness of data. The following guidelines can be used to evaluate the distribution of water use:

   (i) Interior per capita residential water use may be between 50 and 200 litres per capita per day (l/c/d); per capita use is always higher in a single-family dwelling than in a multi-family unit;

   (ii) Exterior or outdoor per capita residential water use varies from a small value (10-30 l/c/d) in multi-family buildings to an always larger value in single-family buildings (40-80 l/c/d);

   (iii) Commercial water use per employee can vary considerably but is often comparable to per capita interior residential water use. However, it is expressed on a litre per employee/day (l/e/d) basis.

3. Analysing historical water use

In addition to completing table 5, 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) The number, value, and type of housing units that are constructed;

(c) The condition or health of the economy;

(d) The cost of water supply;

(e) Climatic and weather conditions;

(f) Conservation activities.

If historical monthly water-use data are available, those data should be recorded on a 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, water-use efficiency programmes or other reasons. Figure I provides an example of the seasonal fluctuations of water use by a 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.

B. 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. The principal reasons include:

(a) Growth in population;

(b) Declining household size or increases in the number of households;

(c) Added employment;

(d) Increased industrial production;

(e) Economic growth;

(f) Increased 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 (for example, new homes with more irrigated landscaping) increasing numbers of persons living in a typical house, and conservation activities such as more water-efficient

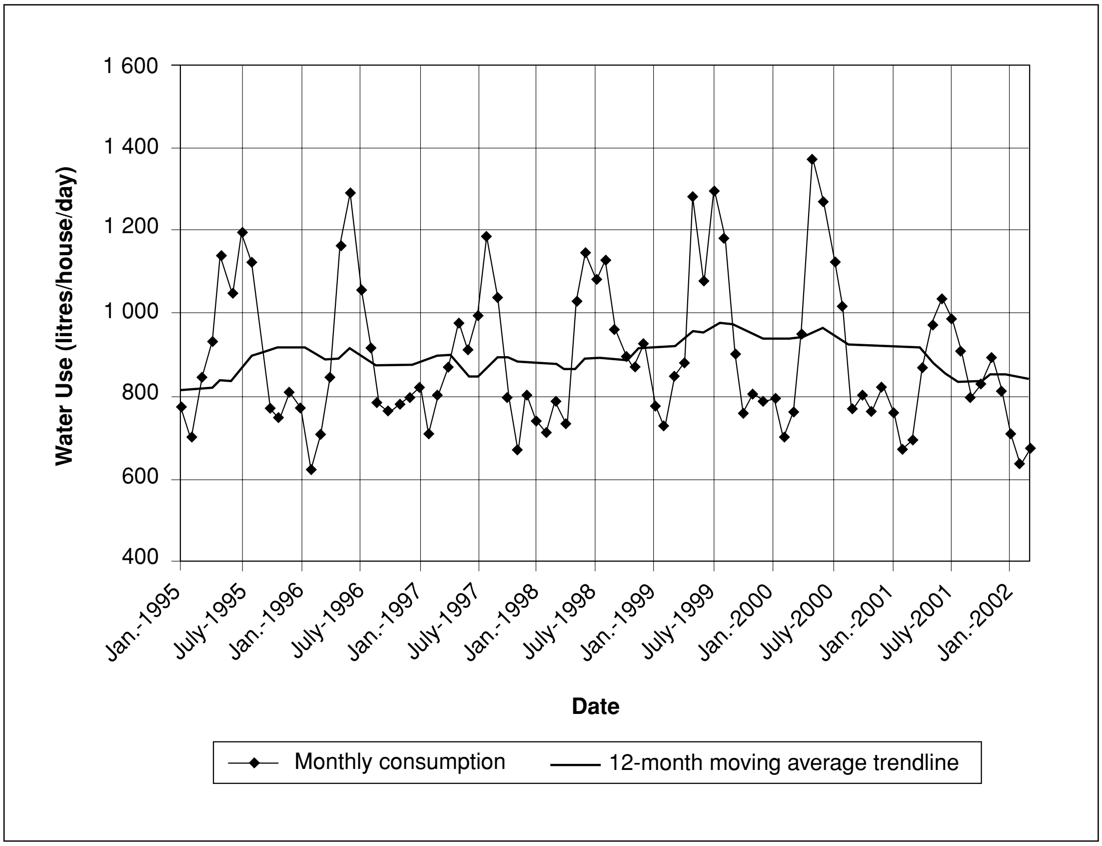


Figure I. Water use by single-family residences in a humid area, Atlanta, Georgia, United States

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 per account water use.

Two methods for forecasting water use, total per capita use and water use per account, are presented in table 6. Other more sophisticated methods are available but the second method described here is usually adequate for conservation planning purposes. Table 6 includes the extension of the sample data given in tables 4 and 5 in order to demonstrate the two methods.

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:

Future water use (Ml/d) = Current per capita water use (l/c/d) x future population

2. Method 2 – projection by customer class

Figure II 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-residential water use may grow faster than residential 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 6 can be used as a worksheet to develop a forecast by customer category. Per capita and per employee water-use values are developed for residential and non-residential use. If data are available for additional classes, such as single-family homes and multi-family dwellings, additional details can be included.

Projected future water use by class = Use factor x future population or employment

The amount of water losses is added to total use by all the categories in order to find the total amount of water needed to be produced in future

Table 6. An example of forecasting future water demand

Methods/parameters		Value
Method 1: Per capita water use		
Average annual water use (production) Ml/d		50
Current population served (persons)		100 000
Current per capita use, l/c/d		500
Population	In 5 years	110 000
	In 10 years	120 000
	In 20 years	135 000
Future water use, Ml/d	In 5 years	55
	In 10 years	60
	In 20 years	67.5
Peak day ratio		1.4
Peak day usage in 20 years, Ml/d		94.5
Method 2: Projection by customer class		
Step 1: Develop unit water use values		
Residential	Total use (Ml/d)	20
	Population (persons)	100 000
	Per capita use (l/c/d)	200
Non-residential use	Total use (Ml/d)	20
	No. of employees (jobs)	60 000
	Per employee use (l/e/d)	333
Step 2: Project future use		
Residential		
Future population	In 5 years	110 000
	In 10 years	120 000
	In 20 years	135 000
Future residential water use, Ml/d	In 5 years	22
	In 10years	24
	In 20 years	27
Non-residential use		
Future employment	In 5 years	70 000
	In 10 years	80 000
	In 20 years	100 000
Future non-residential use, Ml/d	In 5 years	23.3
	In 10 years	26.6
	In 20 years	33.3
Total future water use, Ml/d	In 5 years	45.3
	In 10 years	50.6
	In 20 years	60.3
Water losses in 20 years (as the current level), per cent		20
	Ml/d	15.1
Total future water use in 20 years, Ml/d		75.4
Peak day ratio		1.4
Peak day usage in 20 years, Ml/d		105.6

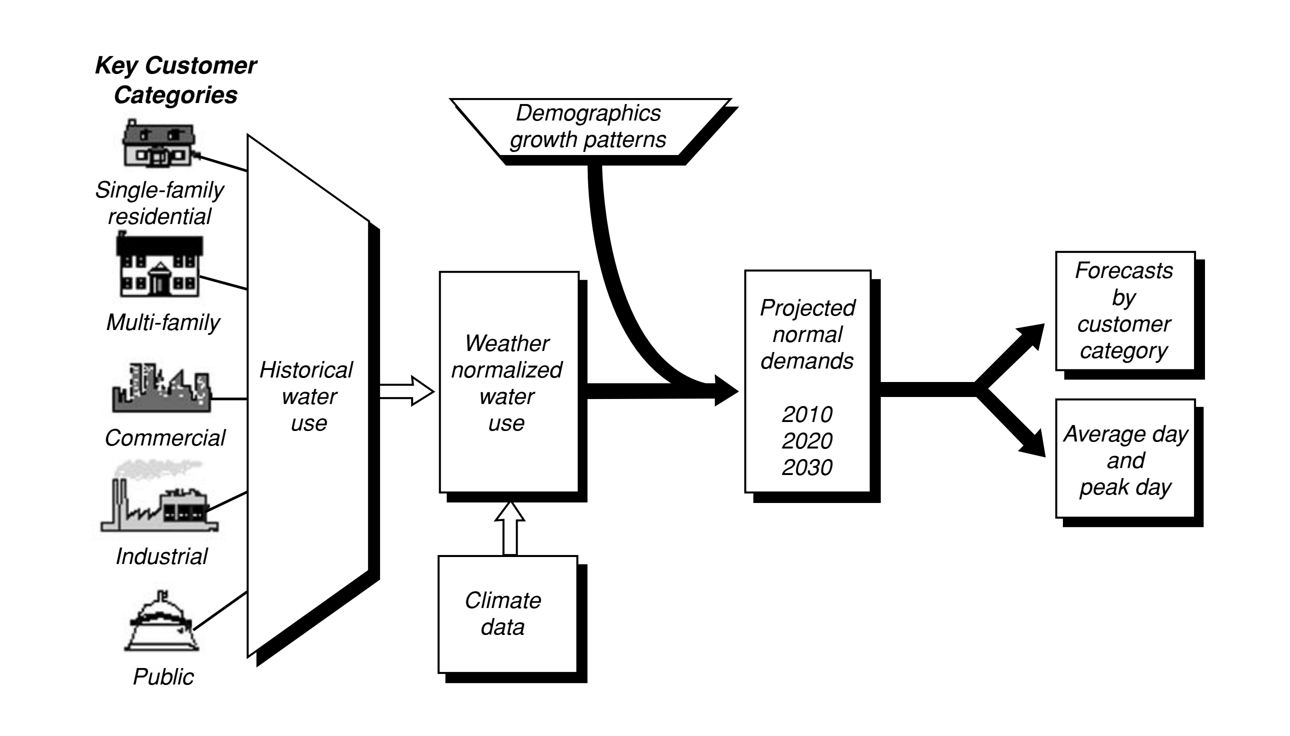


Figure II. Overview of the water-use projection process

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.

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 Ml/d compared with 67.5 Ml/d. The difference in peak day use is even greater. Hence, method 2 is preferable where the data required to complete calculations are available.

C. 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 V);

(c) Estimate possible opportunities for capital project deferral or downsizing, using the "with conservation" forecast (see chapter VI).

IV. DEVELOPING WATER-USE EFFICIENCY GOALS

A. Establishment of goals

Chapters II and III have defined water supply to utilities and demand characteristics, which should enable planners to answer the following questions that are aimed at establishing water-use efficiency goals.

1. Supply

- If you have a water supply shortage, 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 publication).
- 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, 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 only or throughout the year?

2. Demand

- What level of water-use reduction is needed? Typically, a reduction of 1 to 10 per cent could be considered small, while 10 to 20 per cent could be considered as medium, and 20 per cent 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 will be most affected?
- What categories of use are growing the fastest?

B. Types of goals

Goals are essential to planning water-use efficiency programmes. They provide benchmarks against which progress in reducing consumption can be measured. A water utility or local government that understands local issues should set goals, not 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:

(a) Set overall programme goals before preparing the plan in order to provide direction and focus;

(b) After evaluating the proposed measures in terms of water savings and cost-effectiveness, an overall programme of measures and overall water savings goals can be selected;

(c) After developing the plan, specific goals for each water-use efficiency measure can be set 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 the quantity of water saved;

(b) Benefits realized, such as a capital project deferred or avoided and water made available for environmental purposes.

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 to the 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) The number of installations, surveys or contacts completed;

(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. Most importantly, planners can use the results to modify goals or strategies where necessary. Water savings for some programmes (for example, 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 V). 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 etc.

C. 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.

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 III-V). Residential use could account for 60 to 70 per cent of total consumption as shown by figure III, which represents water usage in a city of approximately 100,000 persons in Australia. Figure III is a demonstration of the usefulness of displaying data in this manner, which facilitates focusing water-use efficiency efforts on the largest sectors.

2. Estimate end use

It is important to understand the end-use breakdown of demand in the residential category as this category normally represents the highest consumption in urbanized areas. Figures IV and V provide a typical breakdown of residential indoor and outdoor water uses. Figure IV represents a typical water-use pattern for a family residing in a separate house, while figure V shows a typical water-use pattern in a family residing in a separate house, but 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.

3. Focus efficiency efforts

The efficiency effort needs to be focused in those areas where significant improvements have to 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 should be targeted. Alternatively, planners may target end uses that are more easily reduced (for example, by the installation of new water efficient technology).

4. Describe current demand management programme

In assessing ways of reducing water demand, recent, current and planned water efficiency programmes should be documented. First, actions taken by a utility to conserve water (such as distribution system losses reduction), should be

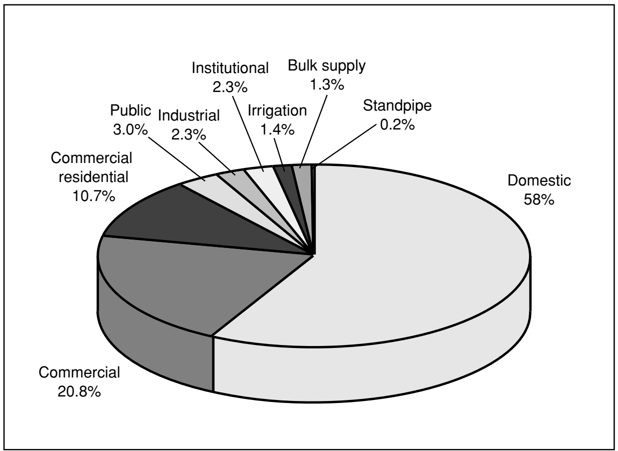


Figure III. Annual water use by consumer category in Coffs Habour, Australia

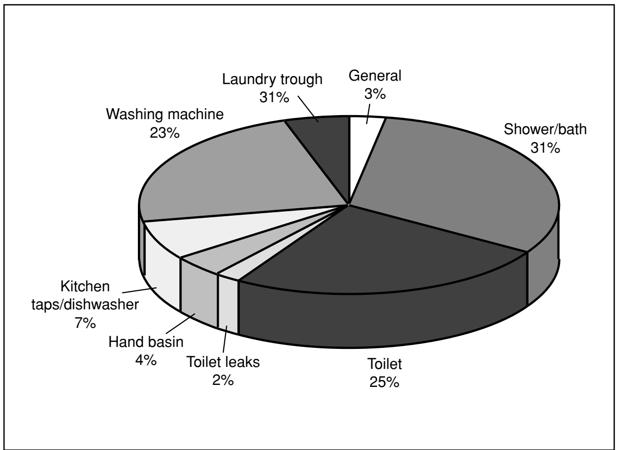


Figure IV. An example of residential indoor water use in Australia

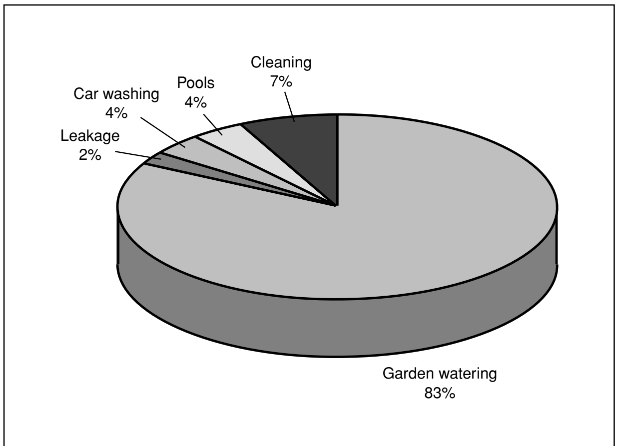


Figure V. An example of residential outdoor water use in Australia

described, including estimated costs and effectiveness. Second, customer efficiency programmes should be described, and should include the following key features:

- Programme title;
- Date(s) conducted;
- Targeted participants;
- Targeted end uses;
- Programme description;
- Implementation schedule;
- Actual numbers of distributed devices, audits, rebates etc.;
- Programme cost(s);
- Results of participants' surveys;
- Evaluation of the amount of water saved;
- Savings due to water-use reduction (in local currency per million litres).

D. Identification of 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 local currency/ 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 management plan (IWRMP), which is beyond the scope of this Guide. Planners will find more IWRMP information in the AWWA's *Water Resources Planning Manual*, M50, which was published in May 2002. (See chapter VI for additional information on how to evaluate the cost effectiveness of efficiency options.)

E. Involvement of the public in setting goals

Without public support, efficiency programmes 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) Participation 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) Participation in water efficiency programmes offered by local water utilities;

(d) Helping to educate others;

(e) Acceptance of the proposed measures by certain types of customers;

(f) Advising on the best way to target programmes.

1. Developing a public participation work plan

The AWWARF has developed a helpful handbook entitled *Public Involvement Strategies . . . Making it Work*, which describes 11 steps to go in designing an effective programme. Most of the steps are related to the research needed to form the foundations of an effective plan. The 11 steps are listed below, the first eight of which are related to developing the work plan:

1. Framing the problem. Focus on issues and boundaries, and describe the project needs.

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 project milestones. Develop a schedule that shows where the public will be able to provide input into decisions.

4. Identify potentially affected 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 the greatest conflict.

6. Determine the appropriate level of public involvement. Establish what level of involvement is needed in order to address stakeholder concerns.

7. Select processes and techniques. By completing the first six steps, the agency can save time and money by selecting the most suitable public participation process from many available techniques.

8. Develop a public involvement work plan. The agency should detail a schedule, budget and staffing requirements for carrying out the processes and techniques selected.

9. Implement and monitor the work plan. Periodic monitoring is necessary to ensure that:

   (a) The timeframe of the problem has not changed;

   (b) The issues and stakeholders remain valid; and

   (c) The techniques being used are effective.

10. Issue a policy statement. To finalize the process, utilities should issue a statement, based on the steps described above. This will help to focus the cost-effectiveness analysis described in chapter VI.

11. Manage change. The process must be flexible enough to adapt to changes in schedule, political climate, staff or critical issues.

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 include: citizens; elected officials; utility managers; policy makers; community leaders; environmental 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; and the mass media. This list can be used to identify stakeholders and specific group representatives to be invited to participate.

3. Consensus-building process

(a) Techniques for consensus building

A wide variety of consensus-building techniques exists. When the first seven steps listed in subsection 1 above have been conducted and the stakeholders identified, the specific techniques can be selected. Available techniques include:

(a) Public meetings 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, which allow a broad range of stakeholder input on a regular basis throughout the duration of a project;

(c) Workshops, 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 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, which comprise experts 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, aids in conflict resolution without making a ruling or binding parties to any particular course of action;

(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.

(b) Tools for consensus building

In addition to the procedural models listed above, a wide variety of tools can be used in conjunction with, and as support for, the selected model. These tools include:

(a) Participant's 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.

(c) 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. Remain focused on the key issues that require consensus and 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 (for example, 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. In some cases, water efficiency plans have been more successful in getting plans implemented because those plans used public input in determining the appropriate balance between water resource development, demand management and the environment.

V. DETERMINING THE FEASIBILITY OF WATER-USE EFFICIENCY MEASURES

The key to determining the success of a water efficiency programme is 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. Section A covers efficiency measures that utilities can take such as leak reduction, metering and water pricing. Section B considers the potential range of efficiency measures that can be taken by customers. To streamline the evaluation, the chapter proposes a method to screen measures down to a more manageable list for cost-effectiveness evaluation.

A. 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.

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. The amount of water lost can vary greatly from less than 10 per cent in new, well-managed systems to more than 50 per cent in older systems suffering from poor maintenance. Trends are also an important indicator, as rising water losses should trigger investigation and active leakage control programmes.

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. Traditional performance indicators, such as the commonly used term "unaccounted-for water" (UAW), often give conflicting perceptions of the true success in controlling water losses. With this problem in mind, the International Water Association (IWA) has developed and published a well-defined water audit methodology and an array of rational performance indicators. In 2000, the IWA published its work in the *Manual of Best Practice: Performance Indicators for Water Supply Services*, which is available at <http://www.iawhq.org.uk>.

As 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.

(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. They 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 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 7 shows how real losses are defined and determined. The terms in table 7 are defined in table 8, with the key parameter being real losses. The methodology for computing the real losses is explained in the above-mentioned IWA *Manual of Best Practice*.

(b) Technical performance indicators for real water losses

The IWA methodology focuses on one key technical indicator of real losses (TIRL), 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

Table 7. 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	
			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: Adapted from G. Kunkel, 2003, "Committee Report: Applying Worldwide Best Management Practices in Water Loss Control", *Journal of the American Water Works Association*, August 2003.

[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 "unaccounted-for water" is often used in place of "non-revenue water". Therefore, it is defined as shown for non-revenue water in table 7.

TIRL = Current annual volume of real losses/Nc

TIRL 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 average real losses (UARL). UARL can be calculated based on the equation

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

where Lm equals length of mains in metres, Lp equals total length of service connections from the edge of the street to customer meters in metres, P equals average pressure in metres and A, B and C are 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 references together with example calculations.

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

ILI = TIRL/UARL

This ratio has been observed to be between 1.0 and 10.0. 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. If ILI is higher than 2.5 to 3.5, the required reduction in leakage needed to achieve this level of ILI should be calculated and set as the target.

2. Metering with rates 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

Table 8. 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 others.
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 residential, 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: G. Kunkel, 2003, "Committee Report: Applying Worldwide Best Management Practices in Water Loss Control", *Journal of the American Water Works Association*, August 2003.

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.

When existing unmetered connections are retrofitted with water meters and customers can be billed at a volumetric rate (i.e., a rate 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 per cent of the water may be used by only 25 per cent of the population and that the installation of water meters can reduce consumption by up to 20 per cent. Metering an unmetered community can take a number of years.

(a) Non-promotional efficiency water pricing programmes

Using this measure, a water utility would modify its existing water (efficiency) rate 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 rate structure design include (a) basing the rates on the costs to serve, (b) providing adequate and stable revenues, (c) providing fairness or equitability among customer classes and volume users, and (d) ease of implementation and administration. In developing countries, the collection rate of water bills must be factored into the rate-setting process in order to prevent revenue shortfalls.

Efficiency rates 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 rate for water as the number of units used increases. Efficiency rates are often not based on historical costs to serve each customer group and are therefore considered by some customers to be unfair. It is, therefore, essential that efficiency rates be developed through a public process that assures acceptance of the purpose and design of the rate structure. It is important that regardless of the efficiency rate 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 rates include:

- A combination of low rates for baseline minimum water quantity (the same fixed charge in every billing cycle for the baseline volume) and high volumeric charges for the amount that the customer uses above the baseline volume;
- Inclining tier rates with volume amounts (or blocks) where higher unit charges are triggered at higher levels of use to encourage efficiency;
- Seasonal rates or excess-use surcharges;
- 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 rate structure (a fixed fee regardless of water use);
- A uniform rate structure (the same unit charge for water regardless of how much is used).

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

It is difficult to predict changes in water use due to changes in price. Definitions and methods for assessing the response to rate 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 rate 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 rate 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 *Principals of Water Rates, Fees and Charges* by the AWWA and *Designing, Evaluating, and Implementing Conservation Rate Structures* by T. W. Chestnutt.

(b) Multi-tiered rates

(i) Rate structure

Multi-tiered rates involve water-use charges at two or more levels. Multi-tiered rates are common for single-family residential customers, although, technically, can be used for all customer groups. Many utilities impose multi-tiered rates only for residential customers who use consistent amounts of water over time (for example, where annual water use per account remains the same from year to year). Using a rate structure with a fixed (flat) charge and two or more volumetric blocks allows adjusting two- or three-tiered rates 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 rates are changed the water utility should still collect the same total amount of money per year.

(ii) Two-tiered structure

In a two-tier rate structure that aims at efficiency, the first tier (for residential customers) is usually set to include a major portion (say, 80-90 per cent) of non-discretionary interior use. The higher rate 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 per cent rate 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 rate difference is that the higher the second tier rate, the lower the first tier rate must be, if revenue neutrality is to be achieved and maintained. When the first tier is set at a very affordable rate and the second tier is a rate applied to, say, 80 per cent or more of the total volume billed (expected revenue), there is no effective efficiency incentive.

(iii) Structures of three tiers or more

A rate 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 (for example, the top 10 or 20 per cent) 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 rate structure argue that this structure promotes economic efficiency by charging rates that more nearly reflect the costs of peaking to those who cause the need for peak capacity.

The third and fourth tiers are generally set at 15-20 per cent 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 (for example, 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.

(c) Seasonal rates

A seasonal rate is commonly applied during the dry season to encourage efficient irrigation practices and relieve peak water demands. Seasonal rates can use either of the structures discussed above. The distinguishing feature is that the rate 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 rates are used during the entire year but with elevated tiered rates or surcharges in the dry season.

In still other instances, a three-tier structure is used with the same rates during the entire year. The logic of this alternative is that the rates are set such that the higher tiers are not effectively applied during the off-peak water demand months. Another variation of the seasonal rates is to apply the peak rates 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 rate structures argue that they discourage wasteful water use and promote efficiency.

(d) Billing cycle

For water supply rates to form an effective deterrent to wasteful water use, it is not enough for the rate 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:

Box 4. Funding a water conservation programme with a water bill surcharge: Albuquerque, New Mexico, United States

The City of Albuquerque has an overall budget of US$ 2.4 million for water conservation generated by a water rate surcharge with over 50 per cent of the revenue generated being given back to the customers in the form of incentives. Rebates include residential and commercial landscape rebates that are based on the area retrofitted. For approved low water use landscaping projects, the rebate rate is US$ 0.25 per square foot (approximately US$ 0.75 per m^3) that is replaced. The rebate maximum is US$ 500 for residential customers and US$ 750 for commercial customers. Other conservation programmes funded by the surcharge include public education through workshops and demonstration gardens.

(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 rates. 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.

(e) Integration of efficiency and rates

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, customers are unlikely to engage and persevere in water-saving habits such as shorter showers, fewer number of toilet flushes, larger laundry loads, etc. 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 rate structure, there is little latitude for setting a high second-tier rate without driving down the first-tier rate or changing the balance between fixed and volumetric derived revenue. Consequently, in using a two-tier rate structure, outside water use cannot be effectively addressed with rates, 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 rate structure of three or more tiers, the high end users can be targeted with penalty water rates for assumed wasteful water use. This can affect the top 5-10 per cent of customers with the highest water usage rates. However, the majority of customers receive bills for unchanged or lower amounts.

(f) Recommended approach

Although water prices do not appear to be effective as the prime motivator for efficiency, 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 rate 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 rate 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 rate 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.

B. Water efficiency measures for customers

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) residential; (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 distribution method and possibly an incentive, such as a rebate, 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.

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, which is available at <http://www.iccsafe.org/dyn/prod/320BNL03.html>.

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 rates 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 table 9. These provisions of the United States Energy Policy Act are available at <http://www.eere.energy.gov/buildings/appliance_standards/>.

Table 9. Summary of the United States Energy Policy Act, 1992: plumbing efficiency standards

Fixture	Maximum flow rate or flush volume
Faucets	8.3 litres per minute
Showerheads	9.5 litres per minute
Toilets	6.0 litres per flush[a]
Urinals	3.8 litres per flush

[a] Blow-out toilets limited to 13.2 litres per flush; this standard for commercial toilets took effect on 1 January 1997.

(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* published by the California Urban Water Conservation Council in 2002, which contains a list of best management practices; and (c) *BMP Cost and Savings Study* by T. W. Chestnutt, published in 2002.

Table 10 provides a summary of devices. Demand reductions and costs shown need to be checked against local water-use patterns and costs;

Table 10. List of water efficient devices by category

Device	Flow rating [a]	Estimated cost for the United States (US$)			Device life (years)[a]	Demand reduction (litre/conn/d)[b]
		Supply	Install	Annual[a]		
Bathroom						
Low-flow showerhead	9.5 litres/min	10-70			5-10	30[c]
Flow control device	8.3 litres/min	2			10	10
Faucet aerator	8.3 litres/min	5-10			5	5
Toilets						
Squat-pour toilets	1 litre/flush	50	100		20-30	100[d]
Four-litre toilets	4 litres/flush	200-400	200-400		20-30	70[d]
Six-litre toilets	6 litres/flush	200-400	200-400		20-30	45[d]
Dual flush toilets	6/3 litres/flush	200-400	200-400		20-30	65[d]
Water dam devices	1 litre/flush	5			5	10
Composting toilets	0 litres/flush	2 000	500	200	20+	100
Kitchen						
Faucet aerator	8.3 litres/min	5-10			5	3
Faucet flow control	12 litres/min	5-15			10	3
Dishwashers	18 litres/wash	300-900	200		10-15	25
Laundry						
Faucet aerators	8.3 litres/min	5-10			5	2
Efficient washing machines	22 litres/kg of dry washing	750-1 200	100		15-20	50
General household						
On-demand or point-of-use hot water systems	20-24 litres/min[i] 18-24 litres/min[j]	1 200-1 800 850-1 050	200-400		20+	15
Household pressure reducing device	413 kPa	50	200		20+	10
greywater systems		>3 000	>400		15-25	80
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		1 000[f]	4 000		20+	40
Trigger shut-off valves on hoses		10-15			5	5
General commercial (other than above measures)						
Waterless urinals	0 litres	700	300	150-200[e]	20+	70[g, h]
Infrared sensor flush controllers urinal	3.8 litres	750	100-400		20+	70[g, h]
Dual flush toilets	6/3 litres	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 15 litre/min 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.
[i] Internal systems.
[j] External systems.

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 etc.

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 matching

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 water-use analysis indicates minimal irrigation.

(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, for example, 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).

4. Suggested menu of water efficiency measures

A list of more than 110 specific measures is provided in annex II. The list can be used as a starting point, and planners can add or delete measures using the resources detailed above.

5. Example of a screening process

The measures listed in annex II to this chapter can be rated on a scale of 1 to 5 as shown in table 11. 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 17 or more points in the total rating in order to pass the screen.

Table 11. Example of the matrix for initial screening of water-use efficiency measures

Device	Distribution method	Possible incentive	Screening criteria[a] Technology/ market maturity	Service area match	Customer acceptance/ equity	Better measure available[b]	Total pass[c]
Residential interior							
Residential 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: Montgomery Watson Harza, 2000, "Clarence Valley/Coffs Harbour Water Efficiency Strategic Plan", prepared for the Lower Clarence Valley and Coffs Harbour City Councils, New South Wales, Australia, August 2000.

[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.

Note: Table should be continued to include all the measures listed in the annex II.

VI. EVALUATING THE 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 annex III and the software package on the attached diskette. The software package contains a Microsoft Excel Workbook, which is programmed to perform a simplified benefit-cost analysis. A blank cost effectiveness evaluation spreadsheet and a completed example of a water-use efficiency measure are provided as appendices to annex III. After reading this chapter, it is suggested that planners explore the preparation of cost-effectiveness evaluations using the accompanying software package.

A. 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 V), the next critical step is to assess the benefits and costs to the utility from each measure as well as from the measures after they have been incorporated into an efficiency programme. 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 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.

B. 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.

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) 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 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) 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 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) Verification that customers have an interest in voluntary programmes or can have mandated participation in programmes being proposed

This should be done, for example, when a customer survey has been performed, it should be reviewed as a culturally acceptable practice, or laws can be established to require and enforce the efficiency measure. One mistake can be copying a practice from another community and assuming that it will be equally or more successful without consideration of local demographics, community patterns of water use, or local laws and regulations that may need to be added or changed.

(d) Establishment of a baseline water demand and a tracking mechanism for water efficiency activities 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 installations or events, and dates are unavailable. This lack of information leads to a lack of documented water savings and credibility of programme successes, and ultimately may lead to a lack of 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) of the programme and the staff (or hired contractors) or, alternatively, under-funded programmes that do not adjust the scope may be a key reason for any lack of success. Details (such as staff hours and costs of materials) concerning each measure will enable planners to determine whether measures will be highly successful (short implementation time and low investment costs) in achieving anticipated water savings, or whether they will be underperforming or time-intensive and thus require modification (for example, more staff support or funding) or discontinuation.

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 annex III.

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 VI illustrates the basic methodology for benefit-cost analysis.

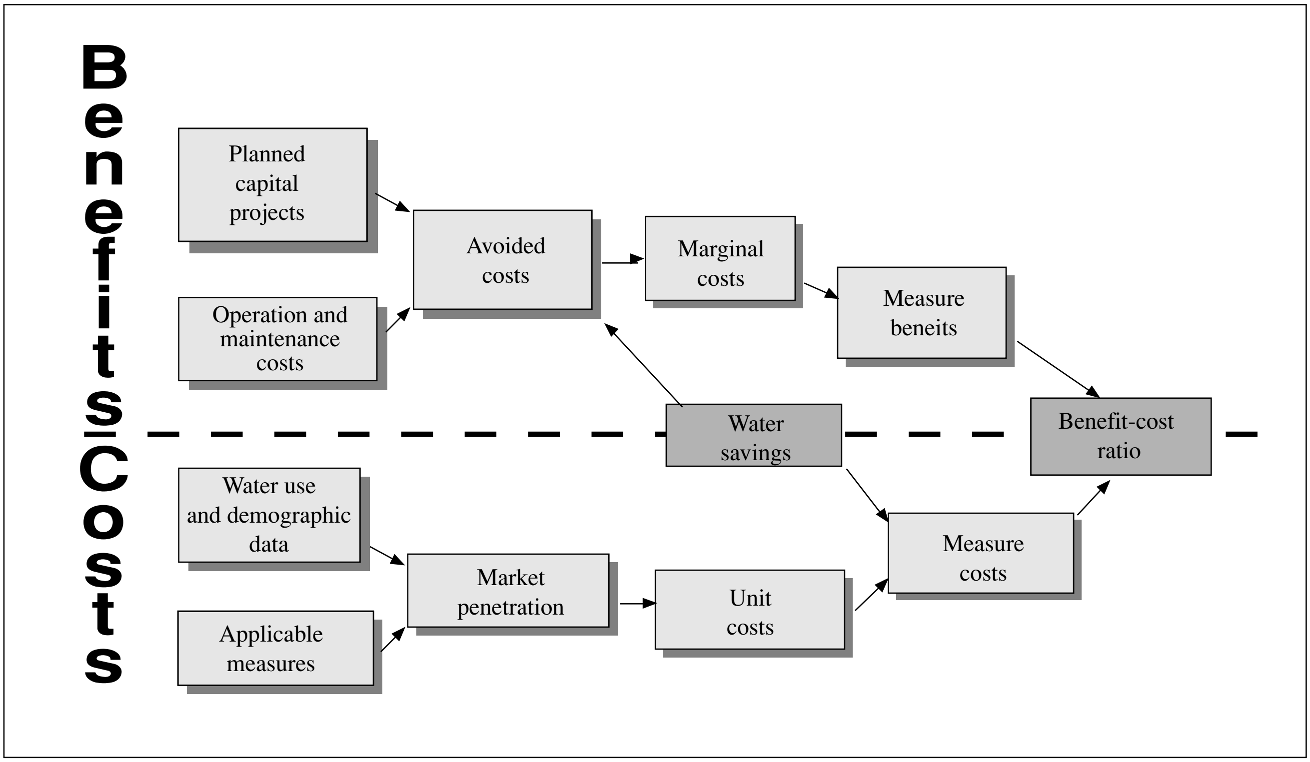
Figure VI can be explained by the following steps (which are further defined with formulae for actual calculations in annex III):

Box 5. 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) x 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-residential efficiency measures. Therefore, it would not be good practice to compare that utility's efforts in residential water efficiency measures to the service area of the utility making the evaluation, if the customers of the latter utility are residential users.



Source: W.O. Maddaus and others, *AWWA Journal*, November 1996.

Figure VI. Benefit-cost analysis methodology

(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 III);

(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 residential 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 III);

(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 V);

(d) For each measure, estimate the number of events (for example, 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 V);

(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;

– Determine the avoided costs (deferred or downsized expenditures) associated with the planned water supply or wastewater treatment projects;

– 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; for example, 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 (that is, total cost savings);

(l) Compute the current value of timeframe of benefits and costs for each measure;

(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 well designed.

C. 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 from pumping (production, treatment, and distribution);
- Lower chemical use;
- Reduced or deferred costs of water treatment plant capital expansion;
- Reduced water storage costs;
- Reduced wastewater processing costs.

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 1,000 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 (that is, 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.

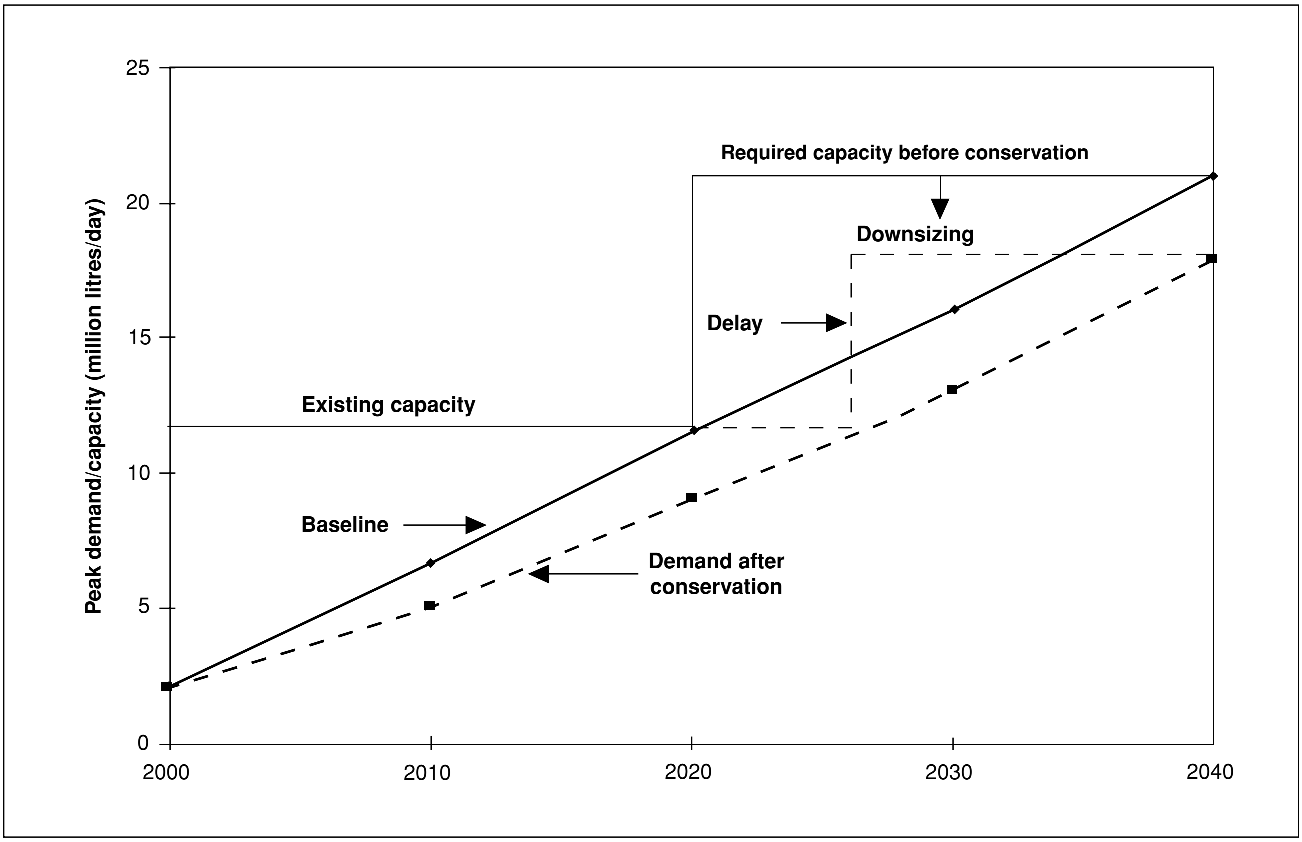
Water treatment and distribution facilities such as water treatment plants, transmission pipelines, pumping stations and distribution storage tanks are designed to meet peak day demands. Demands increase on peak days due to hot, dry weather conditions. Reductions in peak day demands can be accomplished 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 VII illustrates how water efficiency can affect the timing of capital facilities. In this case, a facility needed in 2020 could be delayed by about seven years. In the example shown, demand reduction would reduce peak-day demands by about 20 per cent. 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 2027 instead of 2020.

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



Source: R. Beatty, S. Chapman and W. O. Maddaus, proceedings of the AWWA Water Sources Conference, 2002.

Figure VII. Delaying and/or downsizing a capital facility due to water demand reduction from efficiency measures

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 to rate adjustments over time are needed to cover projections in reduced revenues.

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 (for example, plumbing fixture replacements, irrigation system improvements etc.).

Also of importance to the benefit-cost analysis are other non-economic impacts (for example, water quality improvements due to less run-off from irrigated landscapes that carry pesticides and fertilizers through storm water systems that discharge these contaminates directly into streams and rivers).

D. Estimated customer benefits

Customer benefits and costs should also be considered; this aspect is discussed further in annex III. 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.

E. 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. 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 (1,000 m^3) saved. More information on creating tracking and monitoring programme implementation is provided in chapter VIII.

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.

F. Example of evaluating programme cost effectiveness

Tables 12 to 15 provide an example of a benefit-cost analysis for a residential water survey programme for residential single-family homes. This is a shortened version of the example provided with the software provided on the diskette for use together with annex III. 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 1,000 homes are surveyed annually. Programme participants average 10 per cent in water savings. The programme runs for 10 years. The savings from the measure are effective 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 12; water utility costs, table 13; water utility benefits, table 14; and benefit-cost ratio, table 15.

This example is a cost-effectiveness test and evaluates whether an investment in an efficiency measure for one year is cost-effective or not.

Table 12. Residential water survey programme: water utility savings

	Measure: residential water survey		Value
1.	Total average single family-residential 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		1 000
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 x Line 6b)		30 000
8.	Total savings at end of life of the measure (5 years), litres per day (Line 7 x 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 /years (Line 8 ÷ by Line 6c)		30 000
11.	Lifetime savings* (25 years), million litres		54.54

$$\text{*Lifetime savings (Ml)} = \frac{\text{Participant savings per day x 365 x number of participants per year}}{\text{1 million}} \times \frac{1-(1-1/\text{life of measure})^{25}}{1-(1-1/\text{life of measure})}$$

where:

25 years = length of planning period chosen for analysis
Participant savings = litres per day
Life of a measure = years

Table 13. Residential water survey programme: water utility costs

Measure: residential water survey				Value
1.	Administration costs	a.	Staff hours	150
		b.	Hourly cost, US$/hour	50
		c.	Annual cost, US$/year (Line 1a x Line 1b)	7 500
2.	Field labour costs	a.	Staff hours	500
		b.	Hourly cost, US$/hour	30
		c.	Annual cost, US$/year (Line 2a x Line 2b)	15 000
3.	Materials costs	a.	Unit cost per participant, US$	20
		b.	Number of participants/year	1 000
		c.	Annual cost, US$/year (Line 3a x Line 3b)	20 000
4.	Total service area population			100 000
5.	Targeted population	Percentage		10
6.	Targeted population	Number of customers contacted (assume 10 per cent positive participation response)		10 000
4.	Publicity costs	a.	Marketing cost, US$/year	3 000
		b.	Advertising costs, US$/year	3 000
		c.	Annual cost, US$/year (Line 4a + Line 4b)	6 000
5.	Evaluation and follow-up costs	a.	Labour and consultant, US$/year	5 000
		b.	Annual cost, US$/year (Line 5a)	5 000
6.	Total costs (Line 1c + Line 2c + Line 3c + Line 4c + Line 5b)			53 500
7.	Programme cost sharing (For example, partnerships with wastewater, storm water or neighbouring water utilities)	Cost share from other organizations, US$ (assume 25 per cent)		13 375
8.	Net agency annual cost/year (Line 6 – Line 7)	US$		40 125

Table 14. Residential water survey programme: water utility benefits

	Measure: residential water survey		**Value**
1.	Next source of water		River
2.	Average annual (discounted) avoided supply acquisition cost, US$/million litres		0
3.	Average annual (discounted) avoided water treatment and distribution costs, US$/million litres		1 000
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(i) – Line 5a(ii)]	50 000
		(iv) Average annual treated water use, million litres	1 095
		(v) Unit cost of chemicals, US$/million litres [Line 5a(iii) ÷ by Line 5a(iv)]	45.7
5b.	Energy costs	(i) Total annual energy costs, US$/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$/year [Line 5b(i) – Line 5b(ii) – Line 5b(iii)]	80 000
		(v) Average annual treated water use, million litres	1 095
		(vi) Unit Cost of Energy, US$/million litres [Line 5b(iv) ÷ by Line 5b(v)]	73.1
6.	Avoided unit variable treatment and distribution costs, US$/million litres [Line 5a(v) + Line 5b(vi)]		118.8
7.	Total average annual unit supply and treatment benefits, US$/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 15. Residential water survey programme: benefit-cost ratio

	Measure: residential water survey			**Value**
1.	Present value of costs	a.	Total participants per year	1 000
		b.	Total annual costs, US$/year (table 13)	53 500
		c.	Cost share from others, US$/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 14)	1 618.80
		b.	Lifetime water savings, million litres (table 12)	54.54
		c.	Total water utility benefits, US$/year (Line 2a x Line 2b)	88 290
Benefit-cost ratio Line 2c ÷ by Line 1d				**2.2**
			Benefit-cost ratio is greater than 1.0. Programme design for this measure is cost effective	

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VII. 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 (for example, by reducing non-revenue water losses); (b) using capital facility budgets; (c) innovative water pricing schemes; (d) private financing; and (e) outside sources from other government agencies, national banks or international banks.

A. 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 VI 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 preferable 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.

B. Water tariff pricing 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 V). 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;

(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.

C. Private funding

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.

- In 2002, a developer in northern California (Shapell Homes) agreed to pay the local water utility (East Bay Municipal Utility District) US$ 8.5 million to develop 1,400 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 dual-flush toilets and efficient washing machines, would be included. 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. Projects considered included the most advanced technologies, called evapotranspiration[1] landscape irrigation controllers, apartment sub-meters on individual units and additional fixture rebates.

D. Outside sources of funding

Funding from other government or international funding agencies may be available. In the United States, funds from some citizens voter-approved water bond finances may be used for certain water efficiency projects. For example:

- Between 1984 and 2001, California passed five water bond laws that included funding for efficiency programmes. Although primarily for large capital projects, the bonds have provided between US$ 10 million and US$ 20 million per year for water efficiency projects. In the past, typical water efficiency projects often involved concrete lining of irrigation canals or replacing leaking water mains.

- In 1998, 2000 and 2002, California voters passed additional water bonds that set up funding for specified water efficiency projects. Approximately US$ 10 million has been made available per year. Administered by the California Department of Water Resources, water utilities must submit proposals to receive funding.[2] In 2002, 210 agencies submitted proposals and 29 were funded. 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. 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 eater efficiency projects where it can be shown that water efficiency is cost-effective.

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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 per cent 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.

2 For details, see <http://www.water.ca.gov>.

Other sources of funding could include the Asian Development Bank and the World Bank as well as international assistance agencies of the developed countries. Previously, these agencies did not fund water efficiency programmes with the exception of infrastructure rehabilitation projects, which targeted 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.

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VIII. PROGRAMME IMPLEMENTATION AND OVERCOMING BARRIERS TO WATER-USE EFFICIENCY

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.

A. Implementation

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.

2. 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. 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;
- Evaluate the cost-effectiveness of each measure;
- Update the efficiency plan every two to three 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;
- Liaising and coordinating with programmes run by neighbouring water supply utilities.

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) Publi 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;

(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 as rebates can all convince customers that they should participate.

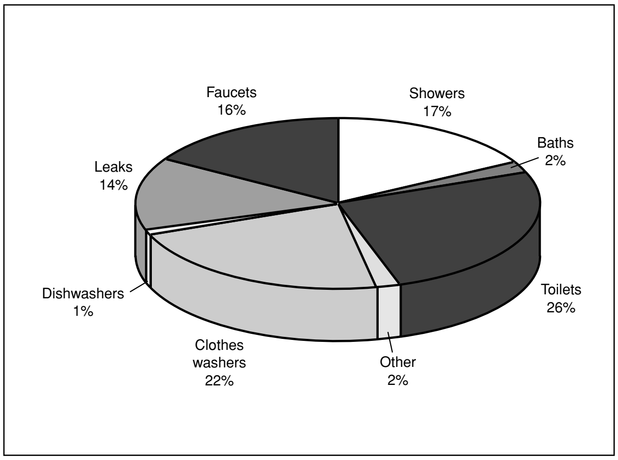
B. Overcoming constraints

1. Lack of data

The following best available data are needed to enable efficiency plans to be prepared:

- Demographic data and projections;
- Monthly water production data;
- The number of water accounts by customer class;
- Monthly water sales (usage) data by customer class.

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. Figure VIII shows how water is generally used in single-family homes in 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 IV). Data of this type are not yet widely available in the countries of Asia; however, when they do become available they could be used in the absence of local data to estimate how effective various efficiency measures will be in reducing water use in existing homes.



Source: AWWARF Residential End Use Study, 1992.

Figure VIII. Average indoor end uses of water in single-family homes in the United States

2. Knowledge of efficiency measures

Water efficiency planners are often hampered by a general lack of knowledge about water-saving devices and measures. 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.

3. Availability of long-range capital facility plans

Deferring or downsizing 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$ 500,000 and US$ 1 million for a capacity of 3,875 m^3 per day.

4. Provision of necessary training, guidebooks and software

Newly qualified professionals who are hired to administer efficiency programmes often lack the experience to carry out their work effectively. Asian countries could follow the lead of the local section of the AWWA, which has organized a training and certification programme in California. Three levels of training could be offered. For each level, a two-day course could be taught to a group of about 25 students who, at the end of the course, could take a test to be certified at that level. Later, after a specified amount of work experience, trainees could undergo the course and test for the next level. The training programme in California is patterned after training programmes for certifying operators of water treatment plants.

In some countries, professionals have access to guidebooks and computer software to evaluate and plan new water efficiency programmes. However, guidebooks written specifically for Asia are lacking. This guidebook and its accompanying least-cost planning software used together with the ESCAP Water Resources Series publication (No. 81; 2001) entitled *Water Conservation: A Guide to Promoting Public Awareness*, will greatly assist planners in evaluating the cost-effectiveness of potential programmes.

C. 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 IV. 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 (for example, 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).

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. Various comparative statistical tests can be used on a sampling of pre-programme customers and post-programme participants. The literature provides ample examples of how to perform such an analysis. The main recommendation is to save water meter readings for several years, as this will enable such analyses to be made.

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 20 to 40 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 per cent, 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.

D. 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.

Annex IV 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) the California Urban Water Conservation Council, which is dedicated to furthering water efficiency in the State of California (see <www.cuwcc.org> and <www.h2ouse.org>); (b) the California Department of Water Resources (see <www.owue.water.ca.gov>); (c) the Arizona Municipal Water User Association (see <www.amwua.org>); (d) the American Water Works Association Waterwiser, which sells useful publications and runs the Waterwiser organization. (see <www.waterwiser.org>); (e) the United Kingdom Demand Management Centre (see <www.environment-agency.gov.uk/savewater>); and other water utilities such as Singapore, which provides a good example from Asia (see <www.pub.gov.sg/efficiency>).

Annex I

GLOSSARY OF KEY TERMS

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 ration, with benefits divided by costs; typically used as an evaluation tool for different water efficiency measures and programmes.

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.

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, consumptive use requirement.

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.

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.

Evapotranspiration – 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, etc.

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.

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.

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.

Marginal cost pricing – a rate design method where prices reflect the costs associated with producing the next increment of supply.

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/off-peak rates – rates charged in accordance with the most and least popular hours of water use during the day.

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.

Reclaimed water – wastewater that is treated and reused to supplement water supplies.

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.

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.

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.

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.

Tiered pricing – increasing block-rate pricing.

Uniform rate – a pricing structure in which the price per unit of water is constant, regardless of the amount use.

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 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, etc.

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 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.

Annex II

LIST OF POTENTIAL WATER EFFICIENCY MEASURES

Device	Alternative distribution methods	Possible incentives	Description of measure
All customers			
Education			
Publications (e.g., newspapers), television and radio	Water utility to supply	Encourage efficiency	Water utility sets up a public education to encourage water efficiency and provide information on demand management techniques. The education programme would work in accordance with other efficiency measures, thereby increasing the implementation rate and savings of the other measures. The water utility would provide information to produce articles and segments in the newspapers as well as via television, billboards, and radio, on methods and the importance of saving water.
Presentations: tables, booth	Water utility to supply	Encourage efficiency	Water utility provides presentations to interested community groups and in public places such as shopping malls.
Community events	Water utility to supply	Encourage efficiency	Water utility encourages and organizes community events such as participating with teachers to develop school plays on water efficiency that are then presented to the public.
Demonstration gardens	Water utility to supply; encourage community groups/schools to participate	Encourage efficiency	Water utility donates a portion of land to create a demonstration garden displaying living examples of low water-using gardens and landscaping. Water utility caretakers would be available to answer any questions, and would provide signs and brochures to educate visitors.
In-school training	Water utility to supply teaching materials; perform presentations	Encourage efficiency	Water utility provides school efficiency programmes with workbooks and presentations, teaching materials and other tools for teaching students the importance of conserving water. The water utility would sponsor water efficiency poster contests and activities for schoolchildren.

Device	Alternative distribution methods	Possible incentives	Description of measure
Residential interior uses			
Residential water audits	Water utility audit	Free; optional retrofit kit	This measure targets existing residents in order to reduce indoor and outdoor water use. The top 20 per cent of single-family and multi-family home water users (on a m^3 per account per day basis) are offered a free audit that includes indoor water efficiency measures and development of an irrigation schedule, where applicable. Indoor water savings are realized from low-flow showerheads, toilet water-displacement devices and leak repairs. The audit needs to be repeated every five years to maintain savings.
Install retrofit kit	Water utility installation	Free	Water utility provides a free retrofit kit to existing single-family residences. The kit could contain a low-flow showerhead, shower flow restrictor; toilet leak-detection dye tablets, a displacement device, a faucet aerator, faucet washers to fix leaky faucets; and a pamphlet on conserving water and reading meters to detect leaks. Water utility employees may help install the devices upon request.
Retrofit-on-resale	Water utility regulation	Enforcement	Water utility works with the real estate industry to add bathroom retrofit (toilets and showers) into the home transfer process. New homeowners would not be able to get water service until a retrofit certificate can be presented, signed by a licensed plumber or water utility inspector.
Shower regulation	Water utility (or local government) regulation	Enforcement	Water utility (local government) will pass a regulation that requires no more than 9 litres per minute low-flow showerheads in all new construction projects.
New fixed head	Customer purchase	Free, coupon or rebate	Water utility provides a coupon or rebate for customer installation of a new 9-litre per minute showerhead to encourage water savings in residences and businesses.
Toilets			
Toilet regulation	Water utility or government regulation	Enforcement	Water utility or government passes a regulation requiring 6-litre flush toilets to be fitted during all new construction and retrofitting.
Replace toilet with 6-litre flush	Customer purchase	Free, coupon or rebate	Water utility offers a coupon or rebate to replace existing toilets with 6-litre flush toilets.
Replace toilet with 6/3-litre dual flush	Customer purchase	Free, coupon or rebate	Water utility offers a coupon or rebate to replace existing toilets with 6/3-litre dual flush toilets.

Device	Alternative distribution methods	Possible incentives	Description of measure
Displacement device(bag or dam)	Water utility to mail, or provide with bill or audit	Free	Water utility mails, or provides during bill payment or an audit, a plastic bag device that the customer may fill with water and attach to the inside of the toilet tank to displace tank water and thereby reduce the amount of water during each flush.
Leak detection-dye tablets plus brochure on how to read meters to check for leaks	Water utility to mail, or provide with bill or survey	Free	Water utility mails, or provides during bill payment or audit, leak detection dye tablets to customers, to be placed in toilet tanks to determine whether a leak is present.
Replace toilet flapper	Water utility to mail, or provide with bill or audit	Free	Water utility offers to replace the flapper valve on leaking toilets or toilets that have been in use for periods surpassing the life of the original flapper valve.
Composting toilets	Water utility promotes	Credit on bill, coupon	Water utility offers a coupon or credit on the water bill to install a composting toilet in an existing house.
Faucets			
Faucet regulation	Water utility will pass a regulation	Enforcement	Water utility passes a regulation requiring low-flow faucets of no more than 9 litres per minute to be installed in all new construction.
Conduct plumbing repair workshops	Water utility to supply brochure and conduct workshops	Free	Water utility provides a brochure and workshops for training homeowners on repairing leaking household faucets. Training would be conducted periodically depending on the demand.
Fix leaky faucets	Water utility to supply kit and provide plumber	Free	Water utility provides a leaky faucet repair kit containing new washers, directions, and tools to repair the leaky faucets. The water utility can be informed of leaks either through audits or by having customers call in a leaky-faucet hotline. It can then offer to provide a plumber to repair leaks.
Dishwashing			
Labelling	In-store advisory	Education or potential regulation.	Water utility encourages dishwasher distributors to use brightly-coloured labels to distinguish those machines that save money. The water utility could then mount a campaign encouraging customers to buy water-saving dishwashers by comparing water bill savings with either hand-washing or non-conserving machines. Another method would be for the water utility to propose a regulation requiring that such labelling be included on machines sold in the area.

Device	Alternative distribution methods	Possible incentives	Description of measure
Settings	Advertising	Education; save water/energy/ money	Water utility educates its customers through bill collection brochures, displays at points of purchase and through the media and school education programmes, on using dishwashing machine controls to save water and energy.
Clothes washing machines			
Washing machine regulation	Water utility to pass a regulation	Enforcement	Water utility passes a regulation that permits only water-efficient washing machines can be sold in the water utility area.
Labelling	In-store advisory, advertising	Education; save water/money	Water utility encourages dishwasher distributors to use brightly-coloured labels to distinguish those machines that save money. The water utility could then mount a campaign encouraging customers to buy water-saving dishwashers by comparing water bill savings with either hand-washing or non-conserving machines. Another method would be for the water utility to propose a regulation requiring that such labelling be included on machines sold in the area.
Settings	Advertising, education	Education; save water/money	Water utility educates its customers through bill collection brochures, displays at points of purchase and through the media and school education programmes, on using dishwashing machine controls to save water and energy.
Promote efficient washing machines	Education to promote	Rebate, or coupon	Water utility educates its customers through bill collection brochures, displays at points of purchase and through the media and school education programmes, on the latest water conserving technology. In cooperation with local energy companies, the water utility could offer rebates on purchases of water efficient machines. Rebates would be scaled to water efficiency ratings.
Water heating			
Place water heater in center of demands	Building code changes; education, customer purchase	Enforcement for new rebates for existing	For new residences being constructed with a water heater, the water utility could encourage building code changes to place the hot water heater near the centre of the house. The water utility could also offer rebates for retrofits of existing homes. It could then encourage the public to look for such features when purchasing a house. Hot water would have less piping to flow through before reaching the faucet, thus ensuring that less water is run while waiting for it to become hot.

Device	Alternative distribution methods	Possible incentives	Description of measure
Install on-demand point-of-use water heating systems.	Building code changes; education; customer purchases	Enforcement for new rebates for existing	Water utility encourages building code changes to require point-of-use, hot-water heating systems and hot-water pipe installation in new residences. The water utility could also offer rebates for retrofits of existing homes. It would then encourage the public to look for this feature when purchasing a house.
Insulate pipes	Education via media, displays; building code change	Enforcement for new. rebates for existing	Water utility encourages building code changes to require placement installation of hot-water pipe insulation on new residences. The water utility could offer rebates or coupons for retrofits in existing homes.
Residential exterior uses			
Trigger shut-off valves	Water utility give-away; manufacturer to include with hose purchase	Rebate, free	Water utility encourages manufacturers to include trigger shut-off valves with hoses, and then encourage customers to purchase these hoses either by offering a rebate on such purchases or a separate valve that customers could fit on their current hose.
Outdoor faucet timers	Water utility to give away or provide rebate	Rebate, free	Water utility makes faucet timers widely available in the water utility area. It can use giveaways at community events, in-store promotions including rebates, coupons in water bills etc. Timers are assumed to have a three-year lifespan, so the programme would continue indefinitely.
Cleaning – use a bucket	Education	Potential for lower water bills	Water utility educates its customers to clean their cars, homes, and walkways with a bucket of water rather than a continuously running hose. Educational tools would consist of media announcements and school education.
Cleaning: use broom	Education	Potential for lower water bills	Water utility educates its customers to use a broom sweep their walkways, patios, and driveways rather than using a continuously running hose. Educational tools would consist of media announcements and school education.
Plant labels	Water utility promotion	Education	Water utility works with nurseries to tag plants with low water requirements. Plant labels would be a bright colour (such as orange) and depict the flower.

Device	Alternative distribution methods	Possible incentives	Description of measure
Landscape use efficiency	Education	Potential for lower water bills	Water utility provides information for planting water-efficient landscaping, including (a) avoiding the use of strip turf sections (less than 2 metres wide) that are difficult to water efficiently and (b) preferential use of native plants that do not require supplemental watering. Information brochures would be provided with the water bill or mailed. Informational displays at the water utility offices and nurseries could also be set up. The water utility could sponsor a xeriscape garden for homeowner education.
Landscape regulations for multifamily	Water utility or government regulation	Necessary to obtain building permit	This measure requires the use of low-water requirement or native plants for landscaping purposes, and irrigated with efficient systems. Proof of compliance would be necessary for obtaining a water connection permit on all new multi-family projects.
Display (model) home landscape code	Water utility regulation	Enforcement	Water utility passes a regulation that specifies that at least half of the display (model) homes would be landscaped according to xeriscape principles. Information on xeriscapes would be given to new homebuyers.
Rain shut-off device	Water utility education, regulations	Enforcement	Water utility could require the installation of these devices on automatic irrigation systems in new construction. The water utility would inspect new accounts and fine those that do not have a rain shut-off device installed.
Water-waste policy	Water utility regulations	Enforcement	Water utility passes a regulation or enforces an existing regulation against wasteful water use. The water utility would provide wastewater patrols, and those customers found wasting water would be given a warning. Repeat offenders would be required to pay higher penalties.
Mandatory irrigation days	Water utility regulations	Enforcement	Water utility continues to enforce an odd/even watering programme (based on street address numbers) in the dry season to reduce peak water use.
Mandatory irrigation times	Water utility regulations	Enforcement	Water utility creates a regulation allowing irrigation only at specified times to reduce peak usage and the amount of water lost to evaporation. The water utility would need to exercise caution to ensure that water pressure does not fall below minimum standards during permitted irrigation times.

Device	Alternative distribution methods	Possible incentives	Description of measure
Residential supply			
Cisterns/rain water tanks	Educational, brochure with bill; customer purchase	Potential for lower water bills; rebates	Water utility encourages customers to collect rainwater for non-consumptive use such as outdoor irrigation.
New home points programme	Building design regulations	Minimum number of points before water connection permit is given	Water utility will not provide a water connection permit, without the permitted party having installed demand management plumbing and landscaping fixtures. Each efficiency device would be worth a specific number of points, set by the water utility. A regulation would be implemented requiring each new residence to have efficiency devices that meet a minimum number of points.
Award programme for efficient designs	Water utility promotion	Education	Water utility gives an annual award to the homebuilder with the most water-efficient design. The award will be prestigious and highly publicized. The water utility will publish guidelines on water-efficient design criteria.
Home leak detection audit and repair for low-income elderly and handicapped etc.	Water utility provide	Free	Water utility audits residences of low-income, elderly and handicapped persons solely to determine whether and where leaks are occurring on the premises. The water utility then provides a plumber free of charge to repair leaks.
Pressure reduction in new homes	Water utility, regulation	Enforcement	Water utility requires pressure regulators on all new homes
Pressure reduction in existing homes	Water utility, installation programme	Water utility installs free for customer	Water utility offers a programme of free installation of pressure regulators in all existing homes
Multi-family sub-metering	Water utility regulation	Enforcement	Water utility rescinds regulations that prohibit sub-metering of multi-family buildings. Sub-metering encouraged through water audits and direct mail promotions to building owners.
Reuse greywater	Customer purchase and install; regulations	Rebates; enforcement	Water utility offers rebates to customers who install systems approved by the local Health Department. The systems would have to meet certain published standards and would be inspected after installation.
Plumb new homes for greywater use	Water utility regulation	Enforcement	Water utility would require that all new single-family homes be plumbed to allow greywater to be readily intercepted for treatment and reuse. Toilet drains would go directly to the sewer.

Device	Alternative distribution methods	Possible incentives	Description of measure
Commercial and government interior			
Laundries			
Laundromat water audit	Water utility audit	Potential for lower water bills	Water utility sends water auditors to the top 20 per cent of high water-using commercial laundries to examine washing procedures and fixtures, and offer recommendations to customers on saving water and, therefore, money.
Water-efficient machines	Customer purchase	Rebate, discount on water bill	Water utility offers a rebate or coupon for the purchase of water-efficient laundry machines. Horizontal axis machines would be emphasized. The rebate would be based on water efficiency. The rebate notice or coupon could be provided to customers with water bills.
Hotels/resorts/clubs			
Bathroom audit • Showers • Toilets • Faucets • Urinals	Water utility audit, plumber	Free; discount on water bill; optional low flow fixtures rebate and leak repair	Water utility provides a free audit of bathrooms of the top 20 per cent of high water-using hotels. The auditor would examine the bathrooms for low-flow showers, toilets, faucets and urinal fixtures, and for any leaks. The auditor would then report the results together with recommendations for low-water-using fixtures. As an optional incentive, the water utility could provide low-flow fixture rebates.
Pool audit; (cover, filter backwash)	Water utility audit; customer purchase	Free audit; rebate or coupon	Water utility provides a water audit of a hotel's pool cleaning and upkeep practices, checking for use of a cover, whether a filter backwash system is used, and for leaks. As in the irrigation audit, the auditor would report the results together with recommendations for efficiency. This measure could be combined with other audits.
Laundry audit	Water utility audit	Free; discount on water bill	Water utility provides a water audit of a hotel's laundry washing procedure. As in the irrigation audit, the auditor would report the results together with recommendations for efficiency. This measure could be combined with other audits.
Restaurant audit	Water utility audit	Free; discount on water bill	Water utility provides a water audit of a hotel's restaurants. The auditor would examine food preparation, cleaning practices, and check for leaks. The auditor would report the results together with recommendations for efficiency. This measure could be combined with other audits.

Device	Alternative distribution methods	Possible incentives	Description of measure
Cooling tower audit	Water utility audit	Free; discount on water bill	Water utility provides a water audit of hotel cooling towers to determine the type of fixtures and practices used to operate and maintain the air-conditioning system. The auditor would report the results together with recommendations for efficiency. This measure could be combined with other audits.
Cooling tower meters	Water utility requirement or rebate	Enforcement or rebate	Offer a rebate to buildings that install sub-meters to measure the make-up and bleed-off water of the facility cooling towers. Educational brochures and a phone contact of a knowledgeable person able to provide efficiency information can be made available.
Self-closing faucets	Education; customer purchase	Rebate, coupon	Water utility encourages hotels to purchase automatic or manual self-closing valves for their common restrooms through educational brochures presented with water bills, rebates and coupons. The shut-off valve can either be automatic and use a sensor, or be manually turned on and shut off by a timer.
Infrared sensor urinals	Water utility promotion	Rebate	Water utility provides a rebate to any commercial building owner installing infrared sensor type urinals in new construction or in renovated buildings.
Air cool instead of water cool	Water utility audit education; customer purchase	Rebate, coupon	Water utility educates the customer during an audit of water bill savings the customer could receive from retrofitting equipment. It could sponsor a rebate programme for those facilities that purchase water-conserving equipment or reuse cooling equipment.
Replace toilets with 6-litre or 6/3-litre dual flush	Educating customer purchase	Coupons, credit on bill	Water utility provides each account with an incentive package for replacing existing toilets with 6-litre or 6/3-litre dual flush toilets
Water-wise programme	Water utility promotion	Free; discount on water bill	Water utility provides hotels/resorts with information about a water-wise programme that encourages self-auditing of water use and analysis of the water-use follow-up procedure. Hotels/ resorts that agree to participate in the programme would also agree to install cost-effective water-conserving equipment.

Device	Alternative distribution methods	Possible incentives	Description of measure
Serve water only when asked	Education, table brochures	Free	Water utility provides table placards for placement on all restaurant tables that encourage customers to conserve water and inform them that water will be served only upon request. The water utility would work with restaurants to encourage this change in policy.
Dishwashing practice audit	Water utility audit, education	Free	Water utility provides an audit of the dishwashing procedure at the top 20 per cent of high water-use restaurants. The auditor would provide results and recommendations to the restaurant management. This measure may be combined with other audits.
Low flow spray rinse valve	Water utility audit promotion	Water utility installs	A water utility representative would offer to install a low-flow spray rinse valve at restaurants with dishwashers. These valves, which are used to rinse dishes before putting them in the dishwasher, cut water use in half.
Self-closing faucets	Education; customer purchase	Rebate, coupon	Water utility encourages restaurants to purchase automatic or manual self-closing valves for customer restrooms, through educational brochures presented with water bills, rebates and coupons. The shut-off valve can either be automatic and use a sensor, or be manually turned on and shut off by a timer.
Toilet audit and replace with 6-litre or 6/3-litre dual flush	Water utility audit, education	Free displacement device or toilet rebate	Water utility conducts an audit determining the flush volume of existing toilets and whether the toilets have leaks. An auditor could install a free displacement device in applicable toilets. As an optional incentive, the water utility could provide a rebate for toilet replacement.
Infrared sensor urinals	Water utility promotion	Rebate	Water utility provides a rebate to any commercial building owner who installs infrared sensor-type urinals in new or renovated buildings.
Waterless urinals	Water utility promotion	Rebate	Water utility provides a rebate to any commercial building owner who installs waterless urinals in new or renovated buildings.
Employee education	Education: seminar, workshop	Free	Water utility conducts a workshop for restaurant managers to explain the latest water-conserving restaurant plumbing fixtures and describe water savings that could be achieved through implementation.

Device	Alternative distribution methods	Possible incentives	Description of measure
Change water-cooled ice makers to air-cooled models	Water utility audit, education; customer purchase	Free audit; rebate, coupon, water bill discount	Water utility conducts an audit and provides information encouraging restaurants to change from water-cooled icemaker compressors to air-cooled icemakers. The water utility may offer a rebate or coupon to encourage applicable restaurants to upgrade their icemakers to water-efficient models.
Schools			
Drinking fountains	Automatic shut-off valve; audit, customer purchase	Regulation/ building code. Potential to save water/ money	Water utility creates a regulation requiring new drinking fountains to shut off automatically when not in use. Any versions that stay on continuously would be phased out.
Employee education	Water utility personnel, teaching materials	Free	Water utility implements a school education programme consisting of teaching employees to conserve water on site, and the importance of efficiency. The programme would target cafeteria and landscape management personnel in particular. (A separate education measure for students is described under education). This measure could be combined with others.
Water-wise school	Water utility promotion	Education	Water utility provides materials, training and technical assistance to implement the water-wise school programme in area schools. The programme would involve students in analysing school water use and school retrofit projects.
Self-closing faucets	Education; customer purchase	Rebate, coupon	Water utility encourages schools to purchase automatic or manual self-closing valves for student restrooms by using educational brochures presented with water bills, rebates and coupons. The shut-off valve can either be automatic and use a sensor, or manually turned on and shut off by a timer.
Toilet/urinal audit, replace with 6-litre or 6/3-litre dual flush	Water utility audit	Free audit, devices, rebates	Water utility audits the toilets and urinals of the top 20 per cent of high water-use schools and provides recommendations and rebates for the installation of low-flow/low-flush toilets/urinals, and the repair of leaks.
Offices (including government buildings)			
Toilet/urinal audit, replace with 6-litre or 6/3-litre dual flush units	Water utility audit	Free audit, devices, rebates	Water utility audits the toilets and urinals of the top 20 per cent of high water-use buildings and provide recommendations and possibly rebates for the installation of low-flow/low-flush toilets/ urinals, and repairs of leaks.

Device	Alternative distribution methods	Possible incentives	Description of measure
Self-closing faucets	Education; customer purchase	Rebate, coupon	Water utility encourages building managers to purchase automatic or manual self-closing valves for employee restrooms through educational brochures presented with water bills, rebates and coupons. The shut-off valve can either be automatic and use a sensor, or be manually turned on and shut off by a timer.
Cooling tower audit	Water utility audit	Free; save water/money	Water utility provides a water audit of the office cooling towers to determine the type of fixtures and practices being used to operate and maintain the air-conditioning system. An auditor would provide the results and recommendations for efficiency. This measure could be combined with other audits.
Cooling tower meters	Water utility requirement or rebate	Enforcement or rebate	Offer a rebate to buildings that install sub-meters to measure the make-up and bleed-off water of the facility cooling towers. Provide educational brochures and a phone contact for a knowledgeable person to provide efficiency information.
Manual flush urinals	Water utility promotion	Rebate	Water utility provides a rebate to any commercial building owner who installs manual flush urinals in new or renovated buildings.
Infrared sensor urinals	Water utility promotion	Rebate	Water utility provides a rebate to any commercial building owner who installs infrared sensor type urinals in new or renovated buildings.
Waterless urinals	Water utility promotion	Rebate	Water utility provides a rebate to any commercial building owner who installs waterless urinals in new or renovated buildings.
Public building retrofit	Water utility regulation	Enforcement	Water utility passes a regulation requiring all water utility-owned and leased buildings to be retrofitted with a specified time (five years). Retrofitting would include toilets, showers, faucets, urinals as well as other fixtures to be determined. Retrofitting could be encouraged for other buildings in their territory.
Hospitals			
Water audit	Water utility audit, education	Free; rebates; free devices	Water utility conducts an audit of hospitals to determine if the water-using fixtures (e.g., ice-making machines) and processes (e.g., using reclaimed water for cooling purposes) could be upgraded or retrofitted to conserve water. An auditor would provide the results, rebate forms for appropriate water-saving fixtures and recommendations for efficiency.

Device	Alternative distribution methods	Possible incentives	Description of measure
Cooling tower audit	Water utility audit, education	Free	Water utility provides a water audit of the top 20 per cent of high water-using hospitals' cooling towers to determine the type of fixtures and practices being used to operate and maintain the air-conditioning system. An auditor would provide the results of the audit and recommendations for efficiency.
Employee education	Water utility seminar	Free; save water/money	Water utility conducts a free seminar for hospital staff on methods of reducing hospital water consumption.
X-ray (photos) Temperature control valve – less flow when X-rays are not being developed. Recycle rinse bath effluent for developer/ fixer solution	Water utility audit, education; bill insert; customer purchase	Save water/ money; free audit; rebate	Water utility conducts an audit of X-ray and other photographic machines at the top 20 percent of high water-using hospitals to determine the water flow meets the specifications for the machines, that less water flows when X-rays are not being developed, and whether developer bath effluent or filter solution is, or could be, recycled. An auditor would provide the results and recommendations for efficiency. The water utility could offer rebates for water-efficient equipment upgrades. This measure could be combined with other audits.
Retrofit for 6-litre or 6/3-litre dual flush; low flow shower retrofit	Water utility audit; customer purchase; education	Free; save water/money; credit on water bill	Water utility conducts an audit of hospitals to determine the flush volume of existing toilets, whether the toilets have leaks, and the shower flow rates. An auditor would install a free displacement device in applicable toilets and provide audit results and recommendations to the hospital management. As an added incentive, the water utility could offer rebates for replacement of high-volume fixtures.
Prohibit once through cooling	Water utility or local government regulation	Enforcement	New hospitals would be prohibited from installing once-through cooling for refrigerators, ice makers, cooling systems, fountains etc.
Air cool, not water cool ice making	Water utility audit, education; customer purchase	Rebates; enforcement	During an audit of water bill savings, the water utility educates customers on the benefits from retrofitting equipment. It could sponsor a rebate programme for those facilities that purchase water conserving cooling equipment.

Device	Alternative distribution methods	Possible incentives	Description of measure
Car washes			
Recycle water	Education; water utility audit	Save water/ money	Water utility conducts an audit of the top 20 per cent of car washes to determine if any water-using processes could benefit from reusing the wash water. An auditor would provide the results of the audit and provide specific recommendations for recycling water.
Recycling systems	Water utility regulation	Enforcement	Water utility passes a regulation requiring all new drive-through car washes to recycle water, before a building permit is issued.
Water audit	Water utility audit	Free	Water utility sends auditors to the top 20 per cent of high water-using car washes to examine the washing procedures and fixtures, and offer recommendations to the customers on how to save water and money.
Commercial and government exterior			
Landscaping			
Landscape regulations	Water utility regulation	Enforcement	Water utility drafts and encourages adoption of a water utility regulation to require landscaping of new non-residential properties that uses only native or water-conserving species, plus efficient irrigation systems. The water utility would provide personnel to educate those affected by the regulation and ensure effective implementation once the regulation has been adopted.
Irrigation meters	Water utility regulation	Enforcement	Water utility requires all significant landscaped areas to have separate meters. This will facilitate preparation of landscape water budgets and water audits.
Train landscape managers	Water utility audit, workshop	Free	Water utility provides a free workshop to train landscape managers on the amount of water necessary for irrigation, the importance and potential savings from water efficiency, and the use of native or low water-using plants. The water utility, accompanied by the landscape managers, would provide audits of the landscapes as a training device.
Train landscape maintenance workers	Water utility audit, workshop	Free	Water utility provides a free workshop to train landscape maintenance workers on setting irrigation time clocks; finding and repairing simple leaks; and proper turf care (fertilizing, mowing, thatch removal etc.). The water utility, accompanied by the maintenance workers, would inspect public landscapes as a training device.

Device	Alternative distribution methods	Possible incentives	Description of measure
Automatic irrigation systems	Education, displays, media	Rebate	Water utility may create a rebate programme encouraging all new construction with landscaping to install automatic irrigation systems.
Efficient irrigation system design standards	Local government regulation	Enforcement	Require installation of irrigation systems that are efficient and installed by trained/certified contractors.
Reclaimed water use	Regulations, education, create market	Enforcement	Water utility produces and sells filtered secondary treated wastewater to interested large-landscape water managers for irrigation of sites such as golf courses. The water utility would seek to create such a market while meeting all health regulations.
Pool/fountain recycle	Local government regulation	Enforcement	Local governments prohibit new swimming pools and fountains constructed without provisions for recycling water. Once-through water systems would be prohibited.
Demonstration gardens	Water utility to provide	Free	Water utility donates a portion of land for a demonstration garden displaying living examples of low water-using gardens and landscaping. Water utility caretakers would be available to answer any questions, and to provide signs and brochures to educate visitors. The water utility could work with a school or other community group such as Scouts to implement this measure.
Irrigation audit	Water utility audit, regulations, education, media	Enforcement; save water/ money	Water utility provides outdoor audit of top 20 per cent of high water-using public landscape facilities. An auditor would determine how irrigation practices are implemented, present the results and provide recommendations for conserving water including: irrigating during appropriate times; not irrigating upon pavement; and the use of evapo-transpiration programmes, if available. The water utility would encourage irrigation efficiency methods through the media.
Landscape water budgets	Water utility to provide	Free	Water utility provides each large irrigation customer with a monthly irrigation water budget. The budget would account for landscape type, landscape area and irrigation method, and would reflect the normal monthly climate. The water utility would put the water budget information on the water bill for the customer.
Mandatory irrigation days	Water utility regulations	Water utility regulations	Water utility continues to enforce the odd/even watering programme in the dry season to reduce peak water use.

Device	Alternative distribution methods	Possible incentives	Description of measure
Mandatory irrigation times	Water utility regulations	Water utility regulations	The water utility creates a regulation allowing irrigation only at specified times of the day, to reduce peak usage and the amount of water lost to evaporation.
Swimming pool leak detection and repair	Water utility audit	Decrease water/ money loss	Water utility conducts a leak detection audit for all public swimming pools and offers recommendations on how to save water and, therefore, money. The water utility would detect leaks and repair them.
Swimming pool covers	Water utility regulations	Water utility regulations	Water utility requires public swimming pools to use a pool cover during periods of pool closure to reduce evaporation.
Water utility departments would be sent a monthly water statement and given a goal of reducing water usage by 10 to 20 per cent	Water utility policy	Departments save money/ water	Water utility sends a monthly statement to all water utility departments and assigns a goal of reducing water usage by 10 to 20 per cent to each department. This would provide an incentive for each department to use water efficiently.
Water efficiency training for water utility employees	Water utility provide	Departments save money/ water	Water utility conducts training for water utility staff regarding water efficiency and water-efficient measures that can be practiced in the workplace and at home.
Non-residential supply			
Capacity buy-back programme	Water utility promotion	Rebate	Water utility sets up a low-interest loan or grant programme to buy back capacity from large users who install water-efficient equipment. Customers would propose a project (possibly as the result of a water audit); the water utility would estimate the water savings and calculate a rebate based on the avoided costs for new capacity. Customers would receive an immediate payment upon signing a contract to install the equipment.
Require efficient process equipment for selected businesses (restaurants, hotels/motels, offices)	Local government regulation	Enforcement	Water utility requires new facilities to install water-efficient equipment in new facilities, such as those listed. Equipment would be selected from a list such as air-cooled ice makers and refrigerators, recycling fountains, low water-use sanitary fixtures, efficient washing machines and dishwashers etc.

Source: Montgomery Watson Harza, 2000, “Clarence Valley/Coffs Harbour Water Efficiency Strategic Plan”, prepared for Lower Clarence Valley and Coffs Harbour City Councils, New South Wales, Australia, August 2000.

Annex III

GUIDE TO MAKING BENEFIT-COST CALCULATIONS

Introduction

The guidelines given in this annex 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 VI. 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 Microsoft Excel Spreadsheet Tool provided on diskette with this manual to perform many of the simplified benefit-cost calculations for one efficiency measure at a time. The guidance provided in this annex 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. A printout of each worksheet of the spreadsheet software is provided in appendix B to this annex.

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 or and pays the costs, and (b) be consistent in the perspectives to have an accurate analysis.

In addition, benefits and costs may be determined separately for customers and the water utility, and then combined for the community as a whole under social benefits. The Microsoft Excel spreadsheet software tool is limited to the utility and customer accounting perspectives. For simplicity, only utility and environmental benefits (step 3) and customer benefits (step 4) are accounted for in the spreadsheet tool. An expanded cost estimate for more benefits (such as a broader sustainability viewpoint of benefits) may be included within the model input under environmental benefits (step 3), if desired.

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 (for example, 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, (litres per day), W equals average water use without the efficiency measure in place (litres per day), 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 per cent. 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 per cent is the goal for implementation of the measure (for example, 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 per cent 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 per cent, and if mandatory national plumbing efficiency standards are in place and well enforced, then the overall percentage reduction will be:

$$E = 0.094 \times 1.0 = 0.094 \text{ (or } 9.4\%)$$

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 1,000 million litres per year, then the reduction in water use from the installation of water-efficient showerheads is:

$$EWS = 0.094 \times 1.0 \times 1{,}000 \text{ Ml/year} = 94 \text{ Ml/year}$$

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 (for example, 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 accounted for in the cost savings shown below.

(a) Energy cost savings

To estimate the variable cost of energy, use the formula:

$$\text{Unit cost of energy} = \frac{\text{(Annual energy bill)} - \text{(12 x monthly fixed charges)} - \text{(Energy costs not related to water production)}}{\text{Total number of units of water used annually, million litres per year}}$$

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 (for example, 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:

$$\text{Unit cost of chemicals} = \frac{\text{(Annual chemicals bill)} - \text{(12 x monthly fixed charges)} - \text{(chemicals costs not related to water production)}}{\text{Total units of water used annually, million litres per year}}$$

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: Cost savings = (Cost at original size) – (Cost at reduced size)

(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 net 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:

In-house costs = Administrative costs + field labour costs + measure unit cost x number of units + publicity costs + evaluation and follow-up costs; and

Contractor costs = Administrative costs + number of events (or sites) x unit cost per event (including programme unit costs} + (if applicable), contractor costs for publicity or evaluation or follow-up.

(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 to 15 per cent of the total programme costs.

(b) Field labour costs

Field labour costs (that is, field labour hours x 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 programmes, 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 programmes. 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 (for example, 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 (for example, 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 per cent 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*, published in 1998 by the California Urban Water Conservation Council. The report can be ordered via their web site at <www.cuwcc.org>.

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:

$$\text{Benefit-cost ratio} = \frac{\text{Sum of } \dfrac{\text{benefits (US\$) in year } (t)}{(1+i)^t}}{\text{Sum of } \dfrac{\text{costs (US\$) in year } (t)}{(1+i)^t}}$$

where i equals selected interest rate, as a decimal (5 per cent = 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:

$$\begin{array}{l}\text{Cost of water saved =}\\ \text{(US\$/million litres)}\end{array} \quad \frac{\text{Present value of total efficiency programme costs over planning period (US\$)}}{\text{Total volume of water saved over the planning period (million litres)}}$$

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 step (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 (for example, 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.

Appendix A

INTRODUCTION TO THE SOFTWARE PACKAGE: SPREADSHEET TOOL FOR COST-EFFECTIVENESS EVALUATION OF A WATER EFFICIENCY MEASURE FOR RESIDENTIAL WATER EFFICIENCY PROGRAMME

Prior to using this spreadsheet tool, read the instructions below together with annex III, “Guide to making benefit-cost calculations”, which is provided on the diskette with this software package.

A. Model approach

This spreadsheet tool provides a simple model for evaluating the cost effectiveness of a single water conservation measure. This cost-effectiveness analysis is from a water utility’s perspective and is simplified to evaluate only one efficiency measure and a one-year investment in that measure. The benefits (water savings) over the life of the measure are evaluated against the one-year cost of implementing this measure. If the benefit-cost ratio is greater than 1.0 (that is, the benefits are greater than the costs), then the measure can be considered cost effective and a good investment for the utility.

Even if the measure is not cost effective, the agency may still wish to pursue it for other reasons. For example, measures with water savings that are difficult to quantify (for example, public information or school education programmes, which typically have low benefit-cost ratios) but are critical to the success of other efficiency measures should be included in the package of measures chosen for implementation. A completed example of a water efficiency measure demonstrating a residential water survey programme is also provided on the diskette. This software example matches the example provided in tables 12-15 in chapter VI.

It should be noted that this software does not cover a more comprehensive approach that would comprise multiple years of costs to implement the measure and estimate the sum of the savings for the life of each measure.

B. Model organization

The model is organized into five data entry steps and one analysis review step. Each step is defined as one worksheet (see tabs at the bottom of the computer screen) within the Excel Workbook. The steps are described below.

1. Step 0: Define target for measure

Prior to identifying any costs or other related data, the goal of the measure must be defined and quantified. The goal may be a certain number of residential customers, industrial customers, commercial enterprises, institutions (for example, government facilities or schools), or the water utility itself (leakage reduction, number of kilometres of replacement piping, or leak repairs).

2. Step 1: Annual costs

Enter information to calculate the expected annual costs to the utility to implement a Water Efficiency Measure.

3. Step 2: Customer water savings (benefits)

Enter information to calculate the expected lifetime water savings from implementation of the water efficiency measure.

4. Step 3: Utility benefits

Enter information to calculate the benefits to the water utility from the water savings estimated in Step 2. Note that water utility benefits equal water utility cost savings (from producing less water or processing less wastewater, if applicable).

5. Step 4: Other benefits and costs

Enter information to calculate benefits and costs that may accrue to parties other than the water utility from the implementation of the water efficiency measure. Note that other benefits equal other (wastewater) utility benefits plus customer benefits. Worksheet also includes customer or other social/environmental costs.

6. Step 5: Discounting information

Discount and cost escalation rates are defined and then entered for the present value analysis.

7. Step 6: Review results

Evaluate the model results. These results are based on the information provided in the first five steps above. Note that society benefits equal water utility benefits + other utility benefits + customer benefits + environmental benefits.

C. Data requirements

This model requires a variety of data, including:

(a) Implementation costs, including costs of staffing, materials, outside contractors and marketing;

(b) Estimates of water savings from an efficiency measure, including initial savings for the first year after the measure is introduced and accumulated water savings for the rest of a measure's life;

(c) Utility water production costs, including costs of a source of supply, capacity expansion, energy and chemicals;

(d) Environmental benefits of the water saved. In many instances, users will not have this information. In such cases, the model can be used to conduct a "what-if" analysis to determine the effect of environmental benefits on the cost effectiveness of residential water surveys;

(e) Discount rates, both for the water utility and for society in general.

Much of the data required, particularly on labour rates and the cost of products needed to implement this model, are available from local companies. Some basic examples of the period required for conducting a water survey are provided. Where appropriate, and if possible, this model attempts to make reasonable estimates of water savings and programme costs for most each water efficiency measure. The measures that can be evaluated using this software are only those for which water savings are quantified.

D. Cell colour keys

Green Cells are cells that require data from the user, while White Cells are cells that contain the formulae used by the model. If the formulae in White Cells are overwritten, the model will cease to work properly. Enter data in Green Cells only.

E. Measurement units

Model data represent specific quantities denoted in metric units. These units must be used or the model will provide incorrect results.

F. Saving model scenarios

Model scenarios can be saved by renaming the spreadsheet and saving as a new file on your computer. Each spreadsheet will then represent a scenario that contains of all the values entered for the model variables plus the benefit-cost results for those values. By varying values in each scenario, it is possible to evaluate the sensitivity of this spreadsheet model's results to changes in key variables.

G. Model limitations

This model provides a simple representation of benefits and costs for a user-specified water efficiency measure. It is unlikely that the model will suit all situations that a user wishes to evaluate. Users are free to adapt the model to their particular circumstances. Doing so, however, may affect the underlying formulae and visual basic procedures used by the model. Users should be familiar with programming Microsoft Excel if they intend to make changes to the formulae embedded in the spreadsheet model.

Appendix B

EXAMPLE SPREADSHEET TOOL FOR COST-EFFECTIVENESS EVALUATION OF A WATER EFFICIENCY MEASURE: RESIDENTIAL WATER SURVEY PROGRAMME

Name of measure: Residential Water Survey – completed example
Computer file name: AppendixB_Example_24Dec03.XLS

This is a completed example for evaluating the cost effectiveness of a water efficiency measure (residential water survey). This software example matches the example provided in tables 12-15 in chapter VI of "Guide to Preparing Urban Water-Use Efficiency Plans".

Model organization
The model is organized into five data entry steps and one analysis review step. Each step is defined as one worksheet (see tab at the bottom of the computer screen) within this Excel Workbook. The steps are described as:

Step 0: Define target for measure
Prior to identifying any costs or other related data, the objective of the measure must be defined and quantified. The target may be a certain number of residential customers, industrial customers, commercial enterprises, institutions (such as government facilities and schools), or the utility itself (leakage reduction, kilometres of pipe to be replaced or leak repairs).

Step 1: Annual costs
Enter information to calculate the expected annual costs to implement a water efficiency measure.

Step 2: Customer water savings
Enter information to calculate the expected lifetime water savings from implementation of a water efficiency measure.

Step 3: Utility benefits
Enter information to calculate the benefits to your utility from the water savings estimated in Step 2.

Step 4: Other benefits and costs
Enter information to calculate benefits and costs that may accrue to parties other than your utility from implementation of a water efficiency measure.

Step 5: Discounting information
Discount and cost escalation rates are defined and then entered for the present value analysis.

Step 6: Review results
Evaluate the model results. These results are based on the information you provided in the first five steps.

Cell colour keys
Green Cells are cells that require data from the user. White Cells are cells that contain formulae used by the model. If the formulae in White Cells are overwritten, the model will cease to work properly. Only enter data in Green Cells.

Saving model scenarios
Users may save model scenarios by renaming the spreadsheet and saving as a new file on the computer. Each spreadsheet will then represent a scenario that contains of all the values the user has entered for the model variables plus the benefit-cost results for those values. The user can then evaluate the sensitivity of this spreadsheet model's results to changes in key variables.

Model limitations

This model provides a simple representation of programme benefits and costs for a Residential Water Survey Programme. It is unlikely that the model will suit all situations that a user wishes to evaluate. Users are free to adapt the model to their particular circumstances. Doing so, however, may affect the underlying formulae and visual basic procedures used by the model. Users should be familiar with programming Microsoft Excel if they intend to make changes to the model.

Source: ESCAP, Water Resources Series No. 83, *Guide to Preparing Urban Water-Use Efficiency Plans*, Software Version 1, December 2003.

STEP 0: Define target for measure

Instructions: Fill in all green cells.

Target Measure Type

1.	Define target of measure	Residential	Residential customers, commerical, industrial, institutional, utility
2.	Total population, area of coverage or actions needed (for example, number of accounts)	10,000	Describe the total available opportunity – population for outreach, kilometres of pipe to survey for leakage programme, leaks to repair etc.
3.	Total number of connections in customer type (or actions)	100,000	For utility measures, use total number of actions, for example, number of pipe leaks repaired
4.	Percentage of targeted customers (or actions)	10%	For example, target 10 per cent of residential customers
5.	Total number of targeted customers (or actions) for programme (Line 3 x [Line 4/100])	10,000	
6.	Estimated number of planned actions per year	1,000	Enter the estimated number measures to be completed for each year; for example, residential surveys, showerheads replaced etc., should be a percentage of the total number of actions [Line 5]
	ANNUAL TARGET (from Line 6)	1,000	per year

GO TO STEP 1

STEP 1: Annual costs

Instructions: Fill in all green cells.
Define local currency for this spreadsheet tool by filling in this cell: US$

Administration costs

1.	Staff hours to administer this measure's programme		150.00	hours/year
2.	Staff hourly rate, including overhead	US$	50.00	/hour
3.	Administration costs (Line 1 x Line 2)	US$	7,500.00	/year

Field labour costs
(**Note**: An example for "Category 1" may be single-family housing and "Category 2" may be multi-family housing which require different amounts of labour and materials for same water efficiency measure)

Note: Category 2 does not need to be completed, if not applicable

			Category 1 Measures			Category 2 Measures	
4.	Field labour hours		500.00	hours/year		–	hours/year
5.	Field labour hourly rate, including overhead	US$	30.00	/hour	US$	–	/hour
6.	Field labour cost (Line 4 x Line 5)	US$	15,000.00	/year	US$	–	/year
	Materials costs		**Measures**			**Measures**	
7.	Unit cost of materials (for example, retrofit kits, lawn kits, nozzles)	US$	20.00	/unit	US$	–	/unit
8.	Number of specific measure (e.g., surveys)		1,000.00	/year		–	/year
9.	Total materials cost (Line 7 x Line 8)	US$	20,000.00	/year	US$	–	/year

Publicity costs

10.	Marketing collateral cost (for example, brochure design, printing, web site services)	US$	3,000.00	/year
11.	Advertising costs (newspapers, radio, TV, web sites)	US$	3,000.00	/year
12.	Total publicity costs (Line 10 + Line 11)	US$	6,000.00	/year

Evaluation and follow-up costs

13.	Labour and consultancy costs	US$	5,000.00	/year
14.	**Total costs** (Line 3 + Line 6 + Line 9 + Line 12 + Line 13)	US$	53,500.00	/year

Programme cost sharing

15.	Cost share from others (for example, other organizations, labour/materials contributions)	US$	13,375.00	/year
16.	**Net utility cost** (Line 14 – Line 15)	US$	40,125.00	/year

GO TO STEP 2

STEP 2: Customer water savings

Instructions: Fill in all green cells.

		Category 1 Measures		Category 2 Measures	
1.	Reduction in average use [litres per day (l/d) per residential unit]	30.00	l/d	30.00	l/d
2.	Savings decay	20.00	%/year	20.00	%/year
3.	Number of measures (e.g., surveys) (from Step 1, Line 8)	1,000.00		–	
4.	**Lifetime savings**	**54.54**	**million litres**	**–**	**million litres**

GO TO STEP 3

STEP 3: Utility benefits

Instructions: Fill in all green cells.

Avoided supply acquisition costs (include future avoided capital costs as appropriate)

1.	Next unit of source of water supply (List name)		River	
2.	Avoidable supply acquisition cost	US$	0	/million litres

Avoided treatment and distribution capacity costs

3.	Avoided capacity expansion costs (Cost per million litres of water saved by conservation)	US$	1,000	/million litres

Avoided wastewater capacity costs (*if service provided by utility*)

4.	Avoided capacity expansion costs (Cost per million litres of water saved by conservation)	US$	500	/million litres

Avoided treatment and distribution variable costs *(include wastewater services if provided by utility)*

Avoided chemical costs

5.	Total annual chemical costs	US$	60,000.00	/year
6.	Annual fixed costs for chemicals	US$	5,000.00	/year
7.	Annual chemical costs not related to water production	US$	5,000.00	/year
8.	Avoidable chemical costs (Line 5 – Line 6 – Line 7)	US$	50,000.00	/year
9.	Average annual treated water use		1,095	million litres
10.	Unit cost of chemicals (Line 8 ÷ Line 9)	US$	45.66	/million litres

Avoided energy costs

11.	Annual energy costs	US$	230,000.00	/year
12.	Annual fixed costs	US$	70,000.00	/year
13.	Annual energy costs not related to water production (for example, lighting, heating/cooling)	US$	80,000.00	/year
14.	Avoidable energy costs (Line 11 – Line 12 – Line 13)	US$	80,000.00	/year
15.	Average annual water use (from Line 9 above)		1,095.00	million litres
16.	Unit cost of energy (Line 14 ÷ Line 15)	US$	73.06	/million litres
17.	Avoided treatment and distribution variable costs (Line 10 + Line 16)	US$	118.72	/million litres
18.	Total supply and wastewater benefits (Line 2 + Line 3 + Line 4 + Line 17)	US$	1,618.72	/million litres

Environmental benefits

19.	Environmental benefit per million litres saved (for example, value of instream flow, improved water quality, avoided environmental mitigation for supply development or wastewater disposal)	US$	0	/million litres

Note: This is where the planner may incorporate sustainable benefits (from triple bottom line accounting), if desired. It is assumed that water efficiency is a completely sustainable measure and does not have negative benefits (or environmental or social costs).

GO TO STEP 4

STEP 4: Other benefits and costs

Note: This step may be expanded to include sustainable triple bottom line accounting, if desired.

Instructions: Fill in all green cells.

OTHER BENEFITS

Avoided customer energy costs

	Item		Category 1 Measures		Category 2 Measures	
1.	Hot water use as a percentage of total water used by appliance		50	%	0	%
2.	Percentage of hot water heated with natural gas (can get estimate from local energy utility)		80	%	0	%
3.	Marginal cost per MJ	US$ 0.01 /MJ (MJ = Mega Joules, thermal units of natural gas)				
4.	Marginal cost per KWh	US$ 0.04 /KWh (KWh = kilowatt hour)				
5.	Lifetime customer energy benefit (cost savings)	US$	27.81	/measure	US$ –	/measure
			modify calculations in boxes to right ->			

Avoided wastewater utility variable costs (IMPORTANT: do not include those listed in Step 3: Utility benefits)

6. Avoided energy and chemical costs US$ ________ /million litres of conserved water

Avoided wastewater utility capacity costs (IMPORTANT: do not include those listed in Step 3: Utility benefits)

7. Avoided wastewater capacity expansion US$ ________ /million litres of conserved water

OTHER COSTS

Customer participation costs

	Item		Category 1 Measures			Category 2 Measures	
8.	Average customer or other social expenditures per measure (e.g., purchase equipment, appliances, new landscape plants, etc.)	US$	25	/measure		0	/measure
9.	Number of measures (from Step 1, Line 8)		1,000.00	/year		–	/year
10.	Total customer costs (Line 8 x Line 9)	US$	25,000.00	/year	US$	–	/year

GO TO STEP 5

Note: For each efficiency measure, the amount of energy saved will be different. The lifetime energy savings from installing a more water efficient appliance (such as water efficient showerhead or clothes washer) should be the difference between energy use with existing inefficient water appliance and the new efficient appliance. The use by customer should be the same amount (for example: minutes for a shower or number of clothes washer laundry loads per customer remain the same).

	Natural gas MJ	Electricity KWh
Energy savings per measure	2,841.68	635.10
	e = 79% efficiency	*e* = 98% efficiency

Note: For calculation above of the lifetime energy savings, the following formula may be used (and must be modified for different measures that install different water savings):

$$LES = UL*DWS * ER * 365 * (T_o - T_i) * (1/e)$$

where

- LES = lifetime energy savings for a water consuming appliance (device) (total MJ or KWh per measure over device or appliance lifetime)
- UL = total useful life of the measure (years) = 1/water savings decay (see Step 2)
- DWS = daily water savings of the appliance (litre per measure per day) (this example uses 9.8 litres per showerhead times 3 persons per household)
- ER = energy required to raise 1 litre of water 1°C (MJ or KWh - °C)
  $ER_{NG} = 4.184 \times 10^{-3}$ MJ per litre -°C
  $ER_e = 1.16 \times 10^{-3}$ KWh per litre - °C
- T_o = temperature at appliance (or device) outlet (°C)
- T_i = incoming service line (colder) temperature at appliance (or device) inlet (°C)
- *e* = water-heating efficiency as a decimal (0.79 or 0.98)

Source: W. Maddaus, *Water Conservation Handbook*, American Water Works Association, 1987.

Note: Customer benefits may be expanded to include other social costs, if desired.

STEP 5: Discounting information

Discount rates (required)

1.	Utility discount rate	–	%
2.	Society discount rate	1.0	%

Annual escalation rates (optional to add a percentage of increase in costs per year)

3.	Avoided cost of water and wastewater	–	%/year
4.	Environmental benefits	5.0	%/year
5.	Energy cost	1.0	%/year

GO TO STEP 6

STEP 6: Review results

Programme present value costs	Currency	Utility perspective		Customer (society) perspective	
1. Total measures		1,000		1,000	
2. Total measures water savings		54.5	million litres	54.5	million litres
3. Utility programme costs	US$	53,500		53,500	
4. Customer (society) programme costs	US$	NA		25,000	
5. Cost share	US$	13,375		NA	
6. Net programme cost	US$	40,125		78,500	
Programme present value benefits					
7. Utility supply and wastewater benefits	US$	88,290		84,998	
8. Environmental benefits	US$	0		0	
9. Customer (society) programme benefits	US$	NA		26,676	
10. Other utility benefits	US$	NA		0	
11. Total benefits	US$	88,290		111,674	
12. Net present value (Line 11 – Line 6)	US$	**48,165**		**33,174**	
13. Benefit-cost ratio (Line 11 ÷ Line 6)		**2.20**		**1.42**	
14. Simple unit supply cost (Line 6 ÷ Line 2)		$736	/million litres	$1,439	/million litres
15. Discounted unit supply cost (Line 6 ÷ discounted water savings)		$736	/million litres	$1,495	/million litres

Note: This benefit-cost ratio represents only one year worth of investment compared to the avoided costs (benefits) of water savings over the life of the measure. That is, for a residential water survey measure, the intial cost to perform the survey results in five years' total water savings.

This Residential Water Survey Programme as designed is cost effective to implement from the utility's perspective

This Residential Water Survey Programme as designed is cost effective to implement from society's perspective

TO REVIEW DETAILS, GO TO "ACTUAL BENEFITS AND COSTS WORKSHEET"

Residential Water Surveys efficiency measure – detailed benefit-cost calculations

Note: Results are provided at the bottom of Step 6

Utility perspective **Local currency** **US$**

	Water savings			Undiscounted utility benefits			Discounted utility benefits			
	Category 1	**Category 2**	**Total**	**Supply and wastewater**	**Environmental**	**Total**	**Supply and wastewater**	**Environmental**	**Total**	**Discounted water savings**
Year	Ml	Ml	Ml	US$	US$	US$	US$	US$	US$	Ml
0	11.0	–	11.0	17,725	–	17,725	17,725	–	17,725	11.0
1	8.8	–	8.8	14,180	–	14,180	14,180	–	14,180	8.8
2	7.0	–	7.0	11,344	–	11,344	11,344	–	11,344	7.0
3	5.6	–	5.6	9,075	–	9,075	9,075	–	9,075	5.6
4	4.5	–	4.5	7,260	–	7,260	7,260	–	7,260	4.5
5	3.6	–	3.6	5,808	–	5,808	5,808	–	5,808	3.6
6	2.9	–	2.9	4,647	–	4,647	4,647	–	4,647	2.9
7	2.3	–	2.3	3,717	–	3,717	3,717	–	3,717	2.3
8	1.8	–	1.8	2,974	–	2,974	2,974	–	2,974	1.8
9	1.5	–	1.5	2,379	–	2,379	2,379	–	2,379	1.5
10	1.2	–	1.2	1,903	–	1,903	1,903	–	1,903	1.2
11	0.9	–	0.9	1,523	–	1,523	1,523	–	1,523	0.9
12	0.8	–	0.8	1,218	–	1,218	1,218	–	1,218	0.8
13	0.6	–	0.6	974	–	974	974	–	974	0.6
14	0.5	–	0.5	780	–	780	780	–	780	0.5
15	0.4	–	0.4	624	–	624	624	–	624	0.4
16	0.3	–	0.3	499	–	499	499	–	499	0.3
17	0.2	–	0.2	399	–	399	399	–	399	0.2
18	0.2	–	0.2	319	–	319	319	–	319	0.2
19	0.2	–	0.2	255	–	255	255	–	255	0.2
20	0.1	–	0.1	204	–	204	204	–	204	0.1
21	0.1	–	0.1	163	–	163	163	–	163	0.1
22	0.1	–	0.1	131	–	131	131	–	131	0.1
23	0.1	–	0.1	105	–	105	105	–	105	0.1
24	0.1	–	0.1	84	–	84	84	–	84	0.1
Total:	**54.5**	**–**	**54.5**	**88,290**	**–**	**88,290**	**88,290**	**–**	**88,290**	**54.5**

Customer (society) perspective

	Water savings			Undiscounted programme benefits				Discounted programme benefits				
	Category 1	Category 2	Total	Supply and wastewater	Environmental	Customer energy benefits	Wastewater utility benefits	Supply and wastewater	Environmental	Customer energy benefits	Wastewater utility benefits	Discounted water savings
Year	Ml	Ml	Ml	US$	US$	US$	US$	US$	US$	US$	US$	Ml
0	11.0	–	11.0	17,725	–	5,563	–	17,725	–	5,563	–	11.0
1	8.8	–	8.8	14,180	–	4,450	–	14,040	–	4,406	–	8.7
2	7.0	–	7.0	11,344	–	3,560	–	11,120	–	3,490	–	6.9
3	5.6	–	5.6	9,075	–	2,848	–	8,808	–	2,764	–	5.4
4	4.5	–	4.5	7,260	–	2,279	–	6,977	–	2,190	–	4.3
5	3.6	–	3.6	5,808	–	1,823	–	5,526	–	1,734	–	3.4
6	2.9	–	2.9	4,647	–	1,458	–	4,377	–	1,374	–	2.7
7	2.3	–	2.3	3,717	–	1,167	–	3,467	–	1,088	–	2.1
8	1.8	–	1.8	2,974	–	933	–	2,746	–	862	–	1.7
9	1.5	–	1.5	2,379	–	747	–	2,175	–	683	–	1.3
10	1.2	–	1.2	1,903	–	597	–	1,723	–	541	–	1.1
11	0.9	–	0.9	1,523	–	478	–	1,365	–	428	–	0.8
12	0.8	–	0.8	1,218	–	382	–	1,081	–	339	–	0.7
13	0.6	–	0.6	974	–	306	–	856	–	269	–	0.5
14	0.5	–	0.5	780	–	245	–	678	–	213	–	0.4
15	0.4	–	0.4	624	–	196	–	537	–	169	–	0.3
16	0.3	–	0.3	499	–	157	–	425	–	134	–	0.3
17	0.2	–	0.2	399	–	125	–	337	–	106	–	0.2
18	0.2	–	0.2	319	–	100	–	267	–	84	–	0.2
19	0.2	–	0.2	255	–	80	–	211	–	66	–	0.1
20	0.1	–	0.1	204	–	64	–	167	–	53	–	0.1
21	0.1	–	0.1	163	–	51	–	133	–	42	–	0.1
22	0.1	–	0.1	131	–	41	–	105	–	33	–	0.1
23	0.1	–	0.1	105	–	33	–	83	–	26	–	0.1
24	0.1	–	0.1	84	–	26	–	66	–	21	–	0.0
Total:	**54.5**	**–**	**54.5**	**88,290**	**–**	**27,709**	**–**	**84,998**	**–**	**26,676**	**–**	**52.5**

Note: Ml = million litres.

Appendix C

SPREADSHEET TOOL FOR COST-EFFECTIVENESS EVALUATION OF A WATER EFFICIENCY MEASURE: FILL IN UTILITY NAME

Name of measure: **To be determined by user**
Computer file name: **FILL IN and SAVE FILE WITH THIS NAME AND DATE**

This is a blank spreadsheet. This spreadsheet tool provides a simple model for evaluating the cost effectiveness of a single water efficiency measure. This model evaluates only costs for one year implementation of the measure and then resulting water savings for the reasonable "useful life" of the measure.

Model organization
The model is organized into five data entry steps and one analysis review step. Each step is defined as one worksheet (see tab at the bottom of the computer screen) within this Excel Workbook. The steps are described as:

Step 0: Define target for measure
Prior to identifying any costs or other related data, the objective of the measure must be defined and quantified. The target may be a certain number of residential customers, industrial customers, commercial enterprises, institutions (such as government facilities and schools), or the utility itself (leakage reduction, kilometres of pipe to be replaced or leak repairs).

Step 1: Annual costs
Enter information to calculate the expected annual costs to implement a water efficiency measure.

Step 2: Customer water savings
Enter information to calculate the expected lifetime water savings from implementation of a water efficiency measure.

Step 3: Utility benefits
Enter information to calculate the benefits to your utility from the water savings estimated in Step 2.

Step 4: Other benefits and costs
Enter information to calculate benefits and costs that may accrue to parties other than your utility from implementation of a water efficiency measure.

Step 5: Discounting information
Discount and cost escalation rates are defined and then entered for the present value analysis.

Step 6: Review results
Evaluate the model results. These results are based on the information you provided in the first five steps.

Cell colour keys
Green Cells are cells that require data from the user. White Cells are cells that contain formulae used by the model. If the formulae in White Cells are overwritten, the model will cease to work properly. Only enter data in Green Cells.

Saving model scenarios
Users may save model scenarios by renaming the spreadsheet and saving as a new file on the computer. Each spreadsheet will then represent a scenario that contains of all the values the user has entered for the model variables plus the benefit-cost results for those values. The user can then evaluate the sensitivity of this spreadsheet model's results to changes in key variables.

Model limitations

This model provides a simple representation of programme benefits and costs for a generic programme. It is unlikely that the model will suit all situations that a user wishes to evaluate. Users are free to adapt the model to their particular circumstances. Doing so, however, may affect the underlying formulae and visual basic procedures used by the model. Users should be familiar with programming Microsoft Excel if they intend to make changes to the model.

Source: ESCAP, Water Resources Series No. 83, *Guide to Preparing Urban Water-Use Efficiency Plans*, Software Version 1, December 2003.

STEP 0: Define target for measure

Instructions: Fill in all green cells.

Target measure type

1.	Define target of measure	____________	Residential customers, commerical, industrial, institutional, utility
2.	Total population, area of coverage or actions needed (for example, number of accounts)	____________	Describe the total available opportunity – population for outreach, kilometres of pipe to survey for leakage programme, leaks to repair etc.
3.	Total number of connections in customer type (or actions)	____________	For utility measures, use total number of actions, for example, number of pipe leaks repaired
4.	Percentage of targeted customers (or actions)	____________	% For example, target 10 per cent of residential customers
5.	Total number of targeted customers (or actions) for programme (Line 3 x [Line 4/100])	____________	
6.	Estimated number of planned actions per year	____________	Enter the estimated number measures to be completed for each year; for example, residential surveys, showerheads replaced, etc., should be a percentage of the total number of actions [Line 5]

ANNUAL TARGET (from Line 6) ____________0 per year

GO TO STEP 1

STEP 1: Annual costs

Instructions: Fill in all green cells.
Define local currency for this spreadsheet tool by filling in this cell: US$

Administration costs

1. Staff hours to administer this measure's programme			hours/year
2. Staff hourly rate, including overhead	US$		/hour
3. Administration costs (Line 1 x Line 2)	US$	–	/year

Field labour costs
(Note: An example for "Category 1" may be single-family housing and "Category 2" may be multi-family housing which require different amounts of labour and materials for same water efficiency measure)

Note: Category 2 does not need to be completed, if not applicable

	Category 1 Measures		Category 2 Measures	
4. Field labour hours	–	hours/year	–	hours/year
5. Field labour hourly rate, including overhead	US$ –	/hour	US$ –	/hour
6. Field labour cost (Line 4 x Line 5)	US$ –	/year	US$ –	/year

Materials costs

	Measures		Measures	
7. Unit cost of materials (for example, retrofit kits, lawn kits, nozzles)	US$ –	/unit	US$ –	/unit
8. Number of specific measure (for example, surveys)	–	/year	–	/year
9. Total materials cost (Line 7 x Line 8)	US$ –	/year	US$ –	/year

Publicity costs

10. Marketing collateral cost (for example, brochure design, printing, web site services)	US$	–	/year
11. Advertising costs (Newspapers, radio, TV, web sites)	US$	–	/year
12. Total publicity costs (Line 10 + Line 11)	US$	–	/year

Evaluation and follow-up costs

13. Labour and consultancy costs	US$	–	/year
14. **Total costs** (Line 3 + Line 6 + Line 9 + Line 12 + Line 13)	US$	–	/year

Programme cost sharing

15. Cost share from others (for example, other organizations, labour/materials contributions)	US$	–	/year
16. **Net agency cost** (Line 14 – Line 15)	US$	–	/year

GO TO STEP 2

STEP 2: Customer water savings

Instructions: Fill in all green cells.

	Category 1 Measures		Category 2 Measures	
1. Reduction in average use [litres per day (l/d) per residential unit]	______	l/d	______	l/d
2. Savings decay	______	%/year	______	%/year
3. Number of measures (e.g., surveys) (from Step 1, Line 8)	______		______	
4. Lifetime savings	–	**million litres**	–	**million litres**

GO TO STEP 3

STEP 3: Utility benefits

Instructions: Fill in all green cells.

Avoided supply acquisition costs (include future avoided capital costs as appropriate)

1.	Next unit of source of water supply (List name)		River	
2.	Avoidable supply acquisition cost	US$	0	/million litres

Avoided treatment and distribution capacity costs

3.	Avoided capacity expansion costs (Cost per million litres of water saved by conservation)	US$	0	/million litres

Avoided wastewater capacity costs (*if service provided by utility*)

4.	Avoided capacity expansion costs (Cost per million litres of water saved by conservation)	US$	0	/million litres

Avoided treatment and distribution variable costs *(include wastewater services if provided by utility)*

Avoided chemical costs

5.	Total annual chemical costs	US$	–	/year
6.	Annual fixed costs for chemicals	US$	–	/year
7.	Annual chemical costs not related to water production	US$	–	/year
8.	Avoidable chemical costs (Line 5 – Line 6 – Line 7)	US$	–	/year
9.	Average annual treated water use		0	million litres
10.	Unit cost of chemicals (Line 8 ÷ Line 9)	US$	–	/million litres

Avoided energy costs

11.	Annual energy costs	US$	–	/year
12.	Annual fixed costs	US$	–	/year
13.	Annual energy costs not related to water production (for example, lighting, heating/cooling)	US$	–	/year
14.	Avoidable energy costs (Line 11 – Line 12 – Line 13)	US$	–	/year
15.	Average annual water use (from Line 9 above)		–	million litres
16.	Unit cost of energy (Line 14 ÷ Line 15)	US$	–	/million litres
17.	Avoided treatment and distribution variable costs (Line 10 + Line 16)	US$	–	/million litres
18.	Total supply and wastewater benefits (Line 2 + Line 3 + Line 4 + Line 17)	US$	–	/million litres

Environmental benefits

19.	Environmental benefit per million litres saved (for example, value of instream flow, improved water quality, avoided environmental mitigation for supply development or wastewater disposal)	US$	0	/million litres

Note: This is where the planner may incorporate sustainable benefits (from triple bottom line accounting), if desired. It is assumed that water efficiency is a completely sustainable measure and does not have negative benefits (or environmental or social costs).

GO TO STEP 4

STEP 4: Other benefits and costs

Note: This step may be expanded to include sustainable triple bottom line accounting, if desired.

Instructions: Fill in all green cells.

OTHER BENEFITS

Avoided customer energy costs

		Category 1 Measures		Category 2 Measures	
1.	Hot water use as a percentage of total metered water use	0	%	0	%
2.	Percentage of hot water heated with natural gas (can get estimate from local energy utility)	0	%	0	%

3. Marginal cost per MJ US$ 0 /MJ (MJ = Mega Joules, thermal units of natural gas)

4. Marginal cost per KWh US$ 0 /KWh (KWh = kilowatt hour)

5. Lifetime customer energy benefit (cost savings) US$ – /measure US$ – /measure

modify calculations in boxes to right ->

Avoided wastewater utility variable costs (IMPORTANT: do not include those listed in Step 3: Utility benefits)

6. Avoided energy and chemical costs US$ 0 /million litres of conserved water

Avoided wastewater utility capacity costs (IMPORTANT: do not include those listed in Step 3: Utility benefits)

7. Avoided wastewater capacity expansion US$ 0 /million litres of conserved water

OTHER COSTS

Customer participation costs

			Category 1 Measures			Category 2 Measures	
8.	Average customer or other social expenditures per measure (e.g., purchase equipment, appliances, new landscape plants, etc.)	US$	0	/measure		0	/measure
9.	Number of measures (from Step 1, Line 8)		–	/year		–	/year
10.	Total customer costs (Line 8 x Line 9)	US$	–	/year	US$	–	/year

GO TO STEP 5

Note: For each efficiency measure, the amount of energy saved will be different. The lifetime energy savings from installing a more water efficient appliance (such as water efficient showerhead or clothes washer) should be the difference between energy use with existing inefficient water appliance and the new efficient appliance. The use by customer should be the same amount (for example: minutes for a shower or number of clothes washer laundry loads per customer remain the same). User will need to modify the following formulas per LES (see box below):

	Natural gas MJ	Electricity KWh
Energy savings per measure	2,841.68	635.10
	e = 79% efficiency	*e* = 98% efficiency

Note: For calculation above of the lifetime energy savings, the following formula may be used (and must be modified for different measures that install different water savings):

$$LES = UL * DWS * ER * 365 * (T_o - T_i) * (1/e)$$

where

- LES = lifetime energy savings for a water consuming appliance (device) (total MJ or KWh per measure over device or appliance lifetime)
- UL = total useful life of the measure (years) = 1/water savings decay (see Step 2)
- DWS = daily water savings of the appliance (litre per measure per day)
- ER = energy required to raise 1 litre of water 1°C (MJ or KWh - °C)
  $ER_{NG} = 4.184 \times 10^{-3}$ MJ per litre - °C
  $ER_e = 1.16 \times 10^{-3}$ KWh per litre - °C
- T_o = temperature at appliance (or device) outlet (°C)
- T_i = incoming service line (colder) temperature at appliance (or device) inlet (°C)
- *e* = water-heating efficiency as a decimal (0.79 or 0.98)

Source: W. Maddaus, *Water Conservation Handbook*, American Water Works Association, 1987.

Note: Customer benefits may be expanded to include other social costs, if desired.

STEP 5: Discounting information

Discount rates (required)

1. Utility discount rate – %
2. Society discount rate – %

Annual escalation rates (optional to add a percentage of increase in costs per year)

3. Avoided cost of water and wastewater – %/year
4. Environmental benefits – %/year
5. Energy cost – %/year

GO TO STEP 6

STEP 6: Review results

Programme present value costs	Currency	Utility perspective		Customer (society) perspective	
1. Total measures		–		–	
2. Total measures water savings		–	million litres	–	million litres
3. Utility programme costs	US$	0		0	
4. Customer (society) programme costs	US$	NA		0	
5. Cost share	US$	0		NA	
6. Net programme cost	US$	0		0	
Programme present value benefits					
7. Utility supply and wastewater benefits	US$	0		0	
8. Environmental benefits	US$	0		0	
9. Customer (society) programme benefits	US$	NA		0	
10. Other utility benefits	US$	NA		0	
11. Total benefits	US$	0		0	
12. Net present value (Line 11 – Line 6)	US$	**0**		**0**	
13. Benefit-cost ratio (Line 11 ÷ Line 6)		**#DIV/0!**		**#DIV/0!**	
14. Simple unit supply cost (Line 6 ÷ Line 2)		#DIV/0!	/million litres	#DIV/0!	/million litres
15. Discounted unit supply cost (Line 6 ÷ discounted water savings)		#DIV/0!	/million litres	#DIV/0!	/million litres

Note: This benefit-cost ratio represents only one year worth of investment compared to the avoided costs (benefits) of water savings over the life of the measure. For example, a residential water survey measure, the intial cost to perform the survey results in five years' total water savings.

This Water Efficiency Measure's Programme as designed is cost effective to implement from the utility's perspective

This Water Efficiency Measure's Programme as designed is cost effective to implement from society's perspective

TO REVIEW DETAILS, GO TO "ACTUAL BENEFITS AND COSTS WORKSHEET"

<u>Fill In Name of</u> efficiency measure – detailed benefit-cost calculations

Note: Results are provided at the bottom of Step 6

<u>Utility perspective</u> **Local currency** **US$**

	Water savings			Undiscounted utility benefits			Discounted utility benefits			
	Category 1	**Category 2**	**Total**	**Supply and wastewater**	**Environmental**	**Total**	**Supply and wastewater**	**Environmental**	**Total**	**Discounted water savings**
Year	Ml	Ml	Ml	US$	US$	US$	US$	US$	US$	Ml
0	–	–	–	–	–	–	–	–	–	–
1	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–	–
5	–	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–	–
12	–	–	–	–	–	–	–	–	–	–
13	–	–	–	–	–	–	–	–	–	–
14	–	–	–	–	–	–	–	–	–	–
15	–	–	–	–	–	–	–	–	–	–
16	–	–	–	–	–	–	–	–	–	–
17	–	–	–	–	–	–	–	–	–	–
18	–	–	–	–	–	–	–	–	–	–
19	–	–	–	–	–	–	–	–	–	–
20	–	–	–	–	–	–	–	–	–	–
21	–	–	–	–	–	–	–	–	–	–
22	–	–	–	–	–	–	–	–	–	–
23	–	–	–	–	–	–	–	–	–	–
24	–	–	–	–	–	–	–	–	–	–
Total:	–	–	–	–	–	–	–	–	–	–

Customer (society) perspective

	Water savings			Undiscounted programme benefits				Discounted programme benefits				
	Category 1	**Category 2**	**Total**	**Supply and wastewater**	**Environmental**	**Customer energy benefits**	**Wastewater utility benefits**	**Supply and wastewater**	**Environmental**	**Customer energy benefits**	**Wastewater utility benefits**	**Discounted water savings**
Year	Ml	Ml	Ml	US$	US$	US$	US$	US$	US$	US$	US$	Ml
0	–	–	–	–	–	–	–	–	–	–	–	–
1	–	–	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–	–	–	–
5	–	–	–	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–	–	–	–
12	–	–	–	–	–	–	–	–	–	–	–	–
13	–	–	–	–	–	–	–	–	–	–	–	–
14	–	–	–	–	–	–	–	–	–	–	–	–
15	–	–	–	–	–	–	–	–	–	–	–	–
16	–	–	–	–	–	–	–	–	–	–	–	–
17	–	–	–	–	–	–	–	–	–	–	–	–
18	–	–	–	–	–	–	–	–	–	–	–	–
19	–	–	–	–	–	–	–	–	–	–	–	–
20	–	–	–	–	–	–	–	–	–	–	–	–
21	–	–	–	–	–	–	–	–	–	–	–	–
22	–	–	–	–	–	–	–	–	–	–	–	–
23	–	–	–	–	–	–	–	–	–	–	–	–
24	–	–	–	–	–	–	–	–	–	–	–	–
Total:	–	–	–	–	–	–	–	–	–	–	–	–

Note: Ml = million litres.

Annex IV

INTERNET RESOURCES FOR WATER EFFICIENCY PLANNING

Websites of various organizations contain general information on water efficiency methods and techniques. Websites of utilities provide examples of specific programmes offered and a way of contacting utility conservation staff. Questions about the effectiveness of particular water efficiency measures can be posted to the AWWA Waterwiser web site, listed below.

Note: The web sites listed below are current as of 2003 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

International Water Association
<http://www.iawq.org.uk/template.cfm?name=home>
Malaysian Water Association
<http://www3.jaring.my/mwa/>
Water for People
<http://www.water4people.org/>
METRON – Metropolitan Areas and Sustainable Use of Water, European Union
<http://www.aegean.gr/enpl/newpage119.htm>
Environment Agency, United Kingdom
<http://www.environment-agency.gov.uk/subjects/waterres/286587/?version=1>
Water UK
<http://www.water.org.uk/index.php>
Environmental Canada, Canada
<http://www.ec.gc.ca/water/en/manage/effic/e_weff.htm>
Water Institute of South Africa
<http://www.wisa.org.za/Home.htm>
Wai Care Auckland, New Zealand
<http://www.waicare.org.nz/main.jsp>
Department of Land and Water Conservation, New South Wales, Australia
<http://www.dlwc.nsw.gov.au/care/water/index.html>

Water utilities

Singapore Public Utilities Board, Singapore
<http://www.pub.gov.sg/conservation.htm>
Environment, Transport and Works Bureau, Hong Kong, China
<http://www.etwb.gov.hk/boards_and_committees/ace/99ace/paper0499/index.aspx?langno=1 &nodeid=373>
Wastewater Management Authority, Thailand
<http://www.wma.or.th/webdoc/english.html>
Sydney Water Corporation, Australia
<http://www.sydneywater.com.au/>
Thames Water Waterwise, United Kingdom
<http://www.thameswateruk.co.uk/waterwise/>
Yorkshire Water, United Kingdom
<http://www.yorkshirewater.com/index.html>
North West Water, United Kingdom
<http://www.nww.co.uk/index.asp?section=yourhome&subsection=Water%5FSaving%5FIdeas>

City of Ottawa, Ontario, Canada
<http://city.ottawa.on.ca/city_services/water/27_5_2_en.shtml>
Engineering Services, City of Vancouver, British Columbia, Canada
<http://www.city.vancouver.bc.ca/engsvcs/watersewers/water/conservation/index.htm>

United States organizations

Waterwiser, American Water Works Association
<http://www.waterwiser.org/>
California Urban Water Conservation Council, California
<http://www.cuwcc.org/home.html>
Water Saver Home Website
<http://www.h2ouse.org>
California Department of Water Resources, Office of Water Efficiency, California
<http://www.owue.water.ca.gov/index.cfm>
Environmental Protection Agency
<http://www.epa.gov/owm/water-efficiency/index.htm>
American National Standards Institute (standards)
<http://www.ansi.org/>
Bureau of Reclamation, United States Department of the Interior
<http://www.usbr.gov/waterconservation/>
Water Education Foundation
<http://www.water-ed.org>

United States water utilities

Tampa Bay Water, Florida, United States
<http://www.tampabaywater.org/Conservation/Conservation/conserv-intro.htm>
City of Tampa Bay, Florida
<http://www.tampagov.net/dept_water/conservation_education/>
WaterSmart, Cobb County, Georgia
<http://www.cobbwater.org/conservation/watersmart.asp>
Denver Water, Colorado
<http://www.denverwater.org/conservation/conservframe.html>
San Diego County Water Authority, California
<http://www.sdcwa.org/manage/conservation.phtml>
East Bay Municipal District (EBMUD), California
<http://www.ebmud.com/conserving_&_recycling/>
Los Angeles Department of Water and Power, California
<http://www.ladwp.com/ladwp/areaHomeIndex.jsp?contentId=LADWP_WATER_SCID>
New York City Environment Agency, New York
<http://www.ci.nyc.ny.us/html/dep/html/dodont.html>
City of Albuquerque, New Mexico
<http://www.cabq.gov/waterconservation/index.html>
City of Phoenix, Arizona
<http://www.ci.phoenix.az.us/WATER/wtridx.html>
Washington Suburban Sanitary Commission, Maryland
<http://www.wssc.dst.md.us/info/tips.html>

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United Nations publication, Sales No. E.84.II.F.7. Price $US 12.50.

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