

WATERWISE

**EVIDENCE BASE FOR LARGE-SCALE WATER
EFFICIENCY:**

INTERIM REPORT – MARCH 2008



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**WRc Ref: UC7702.01
MARCH 2008**

EVIDENCE BASE FOR LARGE-SCALE WATER EFFICIENCY: OPTIMISING WATER EFFICIENCY COSTS AND BENEFITS

WRc Report No.: UC7702.01
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1. INTRODUCTION

There is increasing pressure on water resources in the UK. In the last 15 years there have been several periods of drought which have resulted in water restrictions or increased measures to reduce demand in an effort to avoid restrictions. A twin-track approach to water resource planning means that both new resource development and demand reduction approaches must be considered when balancing supply and demand.

The UKWIR study 'A framework for valuing the options for managing water demand'¹ gives sound best practice guidance for planning and implementing a water efficiency programme. However, the water industry and its regulators agree that more robust economic evidence is needed to support the development of water demand management measures as options in their own right. This is especially important when the demand management measures are compared with new resource development options in the water resource planning process.

The Evidence Base project will produce a set of scenarios for large scale water efficiency programmes based upon the best available knowledge currently in existence. There has been a step-change in the number of large-scale water efficiency projects in recent years, and the Evidence Base will analyse around 20 of these. The scenarios developed from them will contain robust, best available cost and benefit information which can be used to inform water company investment in water efficiency with particular relation to the Periodic Review and Water Resource Management Plans. The scenarios will look at different approaches to delivering water efficiency and will present various logistical options and their influence on the costs and benefits, for example the methods used to identify households for retrofit and the staff used to carry out the work.

The project is being led by Waterwise and overseen by a Steering Group (see 1.4).

The final report of the Evidence Base project will be in October 2008, supported by a further interim report in June 2008. This timetable was agreed by the Evidence Base Steering Group to enable the use of best available evidence in both the PR09 and WRMP processes.

1.1 Project objectives

The objectives for the Evidence Base project are:

- To extract information on costs and benefits from UK and international water efficiency pilots and programmes, including the UKWIR database.
- To filter these projects in terms of local conditions and practicality of replication and transferability and statistical robustness.
- To develop a table of water efficiency options and to produce optimised possible cost benefit figures for different classifications of water efficiency project.
- To describe the range of water efficiency devices and approaches available for projects.
- To develop a set of different water efficiency scenarios and to produce cost benefit analyses for these scenarios.

¹ A Framework for valuing the options for managing water demand. UKWIR, 2007.

- As far as possible to translate cost-benefit figures into alternative accepted accounting figures, such as AISC (Average Incremental Social Cost), LRMC (Long Run Marginal Cost).
- Map the project outputs and timescales onto the PR09 timescales.

1.2 This Report

This report analyses evidence from 7 water efficiency trial reports. The report summarises the methodology used (Section 2) and presents data from the 7 trial areas (Section 3). The report then presents an example Long Run Marginal Cost (LRMC) calculation to illustrate how the data will be used in subsequent reports.

1.3 Future work

The final Evidence Base report will be in October 2008. This will be supported by a further interim report in June 2008.

The reports are timed to enable their use by water companies and regulators in PR09 and in the Water Resource Management Plan process. This (March) interim Evidence Base project report is work in progress. As new water company water efficiency trials deliver they will be analysed, disaggregated and added to the Evidence Base. See Appendix D for details of the projects due to be analysed for the June and October reports.

Illustrative examples (also termed scenarios) will be developed by Waterwise and WRc and included in the June report. These examples will show how the evidence derived by this project can be used to determine the best, most effective water efficiency scheme in terms of planning, implementation, optimising cost benefit and maximising yield. They will also inform a gap analysis and recommendations for potential future water efficiency projects by water companies.

In the near future a dissemination meeting will be held to engage those who will use the evidence and the process outlined within this report. This will ensure that the end users of the project fully understand the methodology adopted and how the information can best be used.

The end result of the Evidence Base project will be a consistent source of information across the industry to enable water efficiency schemes to be designed in the most effective way. This will enable an iteration of the water efficiency schemes proposed within water companies' Water Resource Management Plans, and can be used to inform water company investment and determinations in the forthcoming Periodic Review.

1.4 Steering Group

This work is being led by Waterwise for Workstream 2 of the Water Saving Group. WRc are the consultants developing the Evidence Base for large scale water efficiency schemes. A Steering Group of key stakeholders has overseen the project as it has progressed and will continue to review the project as it delivers. The methodology outlined in this interim report has been approved by the Steering Group.

The Steering Group is chaired by Jean Spencer, Regulation Director at Anglian Water and includes representation at a senior level from the following organisations;

- Communities and Local Government (CLG)
- Consumer Council for Water
- Defra
- Environment Agency
- Ofwat
- UKWIR
- Water UK Regulation Group
- Water UK Water Efficiency Network
- Waterwise

2. METHODOLOGY

2.1 Summary

The methodology described below aims to use existing evidence and best practice cost benefit procedures to allow the costs and benefits of demand management interventions to be estimated. The methodology relies on 3 main pieces of best practice:

- UKWIR WR25A “Sustainability of water efficiency measures”, from which we have used the confidence grading system for water efficiency evidence.
- UKWIR WR25B “A Framework for valuing the options for managing water demand”, from which we have used the cost benefit analysis procedure and spreadsheet tool.
- “Economics of Balancing Supply and Demand” (EBSA), which is ultimately used to develop the optimum mix of resource and demand interventions to balance supply and demand. The outputs generated from the WR25B spreadsheet tool are designed to be used in the EBSA process.

The calculation of AISC in this project will be consistent with the WR25B approach, the EBSA and the Water Resource Planning Guidelines.

The inclusion of environmental and social (external) impacts will be considered, as will the carbon impact (for example measures that save hot water use). However, unless evidence of these impacts can be derived from the projects, the quantification of these externalities is beyond the scope of this study.

Evidence will be obtained from water efficiency projects carried out by water companies, and collected and assessed by Waterwise. The overall process will be to:

- Collect the evidence
- Extract the costs and water savings from individual water efficiency measures from the evidence
- Allocate confidence grades to these individual measures (in line with WR25A)
- Construct scenarios as example projects to demonstrate the application of the cost and benefit data
- Analyse the costs and benefits of these scenarios using the spreadsheet tool (from WR25B)
- Produce outputs that can be used in the EBSA process

This will provide a set of useable evidence, a methodology and output format which is flexible enough to allow companies to apply their own scenarios, using standard tools to provide outputs for the EBSA which are consistent with Ofwat’s guidance on cost benefit analysis.

The text below sets out the basic methodology. Ideally, there would be hard evidence for each of the input variables into the process. However, we know that this cannot be the case and so therefore each input variable will be assigned a confidence (reliability) grade: the Steering Group has agreed that the best available evidence is sufficient in this exercise, including for PR09. Some of the inputs will be derived from expert judgement, until there is sufficient evidence to replace the assumptions made. Where this is the case the methodology explains the process used for applying expert judgement, which will ensure a consistent approach.

The method of calculating and presenting the costs and benefits will be transparent, clear and robust, so that it can be applied to other measures in the future.

The presentation of the results will be in the form of tables which project forward in time the costs, impacts and water savings, along with an AIC (Average Incremental Cost), or AISC (Average Incremental Social Cost) value. In the June report these will include a sensitivity analysis to identify which variables have the biggest impact on AISC.

2.2 Demand management measures and sub measures

There are a range of devices and interventions which can be classed as water efficiency measures (WEM): for example cistern displacement devices, tap inserts, water efficiency promotion and water efficient showerheads. There are constant technological developments of devices to improve performance, desirability and cost. Some measures have sub measures: for example, there are several different WEM associated with WCs.

Below is an all-encompassing list of WEM currently available on the market. Any of these devices or a combination could be incorporated into a large scale water efficiency programme;

- WCs
 - Cistern displacement devices
 - Retrofit dual flush
 - Retrofit low flush
 - Replacement dual flush
 - Replacement low flush

- Taps
 - Tap inserts
 - Low flow - restricted
 - NB. Alternative options associated with taps include push taps and infrared taps but these measures are considered to be unlikely in a domestic setting*

- Showers
 - Low flow shower heads
 - Low flow – restricted

- Reuse
 - Rainwater recycling
 - Grey water recycling
 - Water butts

- External Use
 - Hosepipe flow restrictors
 - Spray guns
 - Drip irrigation

- Water Audit
 - Audit of water consumption
 - Action to reduce water consumption

- Metering
 - Metering

- Metering with sophisticated tariffs
- Water Efficient White Goods
 - Washing machines
 - Dishwashers
- Publicity
 - Water efficiency publicity and promotion
- Other

The above is a comprehensive list of single water efficiency measures. In reality it is likely that multiple demand management measures (a “basket of measures”) would be included in a water efficiency programme.

2.3 Disaggregating the evidence

2.3.1 Measures and scenarios

To quantify the costs and water savings associated with each individual measure and to allow the construction of scenarios, Table 1A and B need to be populated. Information is required about the individual measures, the context of the trial, and the implementation and scaling of the project.

Table 1 A and B Information required from evidence to enable the disaggregation of individual water efficiency measures

A measures	Most likely	Worst case	Best case	B scenarios	Most likely	Worst case	Best case
Costs • Capex • Opex • externals				Costs • Capex • Opex • externals			
Yield				Target Population			
Half life				Uptake rates			

Where possible, the information will be obtained directly from evidence extracted from the projects and trials reported and supplied to Waterwise. If the evidence is derived from a project which contains only one WEM then the data can be extracted into Table 1 A and B. However, many of the projects are multi-WEM (or ‘baskets’ of measures) and in these cases we will need the evidence derived from micro-component data to disaggregate the costs and yields. There is a wealth of knowledge of individual micro-component use in the home, and this can be used to ensure robust assumptions are made. The Market Transformation Programme (MTP) gives good evidence of the frequency of use and replacement of water-related products. In addition to the MTP research a confidence grade can be allocated to the evidence which has been estimated based on UKWIR WR25A methodology as shown in Appendix A. As well as measured water volumes from externally logged data point of use measurements of single devices will be incorporated into the Evidence Base.

The outcomes of the application of disaggregation, reliability and accuracy will be used to populate Table 2.

Table 2 Outcomes of disaggregation of evidence and application of accuracy and reliability bands

Measured	Basket of measures	
	Yield	Confidence grade
WCs		A
Taps		B
Showers		B
Advice		?
Total		A1

Table 2 is an example of the disaggregation that must be undertaken. In this example a basket of water efficiency devices were installed into a measured property. As a result, the water saving scores an A for reliability as it is an actual measured value. The composite devices for this yield have not been individually measured and so require some estimation in order to disaggregate the individual information from the sum of total water savings.

Devices associated with WCs, such as cistern displacement devices, are considered to be reliable in delivering consistent water savings - e.g. 1 litre every flush. WCs would therefore be assigned a high reliability score. There is uncertainty regarding the frequency of use, but there is good evidence from MTP and other research to help to reliably estimate this.

Water savings from taps and showers are more uncertain as they rely on more varied volume, duration and frequency of use than WCs. The water saving can be quantified in theory, but depends on a more varied volume, frequency and duration of use and higher uncertainty than WCs, and thus scores a B for reliability.

The water savings in an unmeasured property will be more uncertain than in a measured property because they are based on estimates and assumptions rather than any measurements from meter readings.

The evidence for single measures will be built up from multiple measured projects with a range of different costs and water savings and will help inform the estimates of best case, worst case and most likely scenarios. This is described in more detail in Section 3.

From the above methodology, Tables 1 A and B can be populated, and this data will then be used to populate the spreadsheet tool and calculate the AISCs for each WEM. This process is illustrated in the worked example in Appendix B. Scenarios will be developed by Waterwise and the WRc project team and entered into the spreadsheet tool.

2.4 Introduction to the spreadsheet tool – used to calculate AISC

For each step in the spreadsheet tool where data is entered, uncertainty is accounted for by having a range of values: a best estimate (most likely), best case (an optimistic result) and worst case (a pessimistic result). For example, for costs, the best case will be the lowest cost and the worst case will be the highest cost; the best estimate is the most likely cost.

The spreadsheet tool is a 6 stage process as described below:

2.4.1 Step1: Target Households

Step 1 requires the input of the projected household numbers (target households) for up to 4 subgroups of households in each zone. These can be used to represent the data for the scenarios. These sub-groups can vary from each other either in the water savings made or costs incurred. For example, the target population may be split between metered and unmetered households or between urban and rural households. Each sub-group can be treated individually with regard to scheme uptake, costs and water savings. However, each household sub-group must be mutually exclusive in order for the Total Households' yields and AISCs calculated in the spreadsheet tool to be meaningful.

2.4.2 Step 2: Scheme Implementation Type:

Any scheme being assessed can be implemented on a 'One-off' or 'Periodic' Implementation. A One-off implementation assumes that the scheme is implemented in Year 1 and takes 'X' years to complete, with no re-implementation. Periodic implementation allows the planner to implement the scheme as many times as is required throughout the 25 year planning period, in order to maintain savings. Periodic implementation can also be used to allow uptake to be delayed until scheme set up is completed, if scheme set up is deemed to take more than 2 years.

Scheme Life/ Projecting Water Savings forward in time

If there is evidence of the change in water savings over time, then this can be used in the spreadsheet tool. However, for most of the projects there will be limited time series data - typically only 1 or 2 years. Therefore the spreadsheet tool uses a method of projecting water savings forward in time which allows for decay in savings which may be due to behaviour, customer intervention (removing the device), and device under performance. This method is described below.

Projecting water savings forward in time

A water saving measure (device, appliance, number of devices or other intervention) is/are installed in multiple households. The measure results in a volume of water saved. We assume that the volume saved in year 1 is known. The savings are a sum of multiple households (not a single household). After this time we cannot know what the water savings will be: they may continue at the same level, or they may decrease. The reason for the decrease may be that a proportion of households each year remove the water saving measure, or that a proportion of the measures deteriorate such that their water saving is reduced. The reduction in water saving may start immediately; therefore the volume should take into account any fall off in water savings during the first year.

The water saving measure is assigned a 'half-life' after which the water saving is halved: i.e. the half-life is the length of time in which half of the measures will be replaced or abandoned. When the measure is replaced, abandoned or deteriorates, no future water savings are gained.

Using this approach water saving projections are made for the "Best Estimate" (most likely), "Best Case" and "Worst Case".

The half-life needs to be estimated for each of these cases. Time series evidence can be used, if available, to estimate the half-life. However in most cases this will not exist. Therefore we have developed a “rule of thumb” to apply to ensure consistency. This is:

- The "Best estimate" or "Most likely" value is given by a half-life equal to half the asset life
- The "Best case" is given by a half-life equal to 2 times the asset life
- The "Worst case" is given by a half-life equal to one quarter of the asset life

For example:

A water saving measure may have an asset life of 10 years, after which time it is expected that the water saving from this particular water efficiency intervention will become zero. The starting water saving is 400 (units not important in this example).

Using the process set out above, the result is illustrated in Figure 1, where the half life for “most likely” is 5 years, so the savings are halved (equal to 200 units) *at the end* of year 5.

This element feeds into the uptake rate calculations and determines how quickly the number of households which take up the scheme are returned to the ‘not taken up’ population.

International evidence on longevity of savings will be considered in the Evidence Base project for the June and October reports.

Uptake Rate

The uptake rate is the percentage of the target population that participates in the scheme. Uptake rates used in the scenarios will reflect the range of uptake rates from the evidence base (projects/studies from WR25B database). In most cases the uptake rate of a scheme is fundamental to the water savings which may be made and, given the unpredictability associated with human behaviour, the uncertainties around this element are in many cases the most significant.

In developing scenarios the assumptions need to be clearly stated: for example, “measured households are usually assumed to achieve a higher uptake rate for water efficiency schemes than unmeasured due to the financial incentive to save water” or “uptake rate is assumed to be closely related to what the scheme offers in terms of subsidies for water-saving devices and their installation, and the extent to which the scheme is promoted”.

The possibility of disaggregating uptake rates for each water efficiency trial within the Evidence Base will be explored for inclusion within the June report. This would be useful for the design of future water efficiency schemes because it would aid the consideration of different methods encouraging uptake - enabling the most effective scheme to be planned so that the optimum uptake rates are achieved.

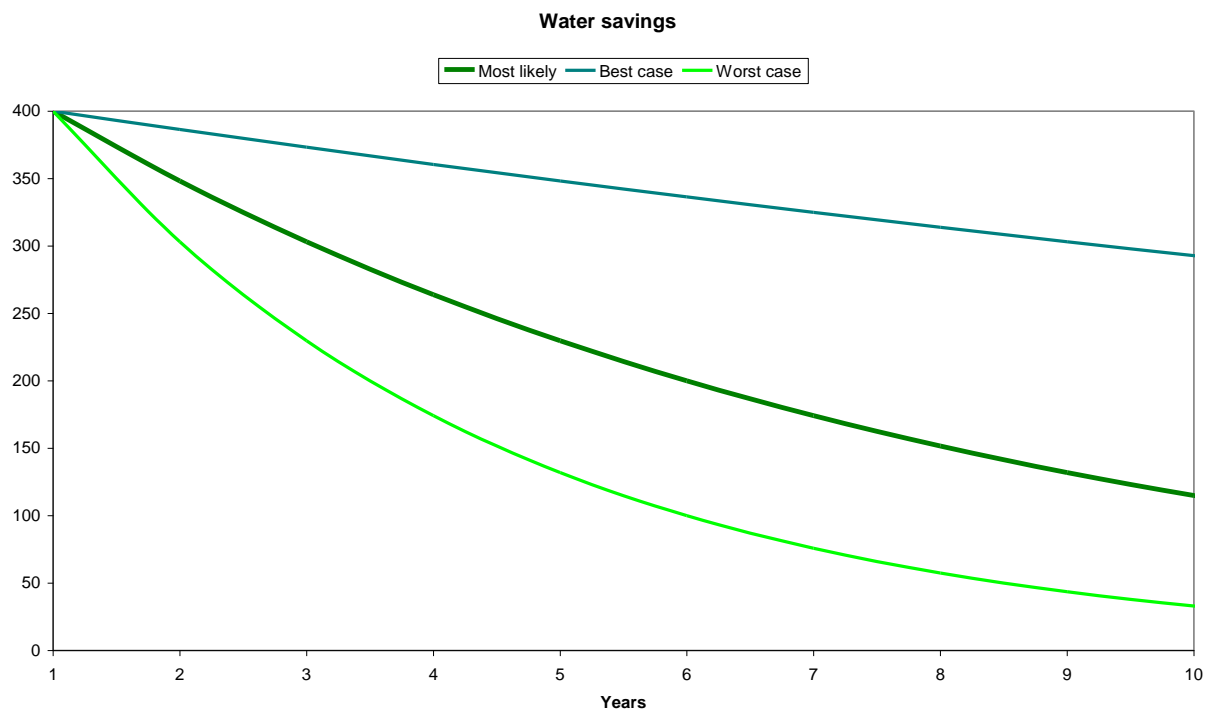


Figure 1 Water saving and half life of a water saving device

2.4.3 Step 3: Costs

The Evidence Base will be used to estimate the range of costs (best estimate, best case and worst case) for each scenario. Each measure will have an associated unit cost, as shown in Table 1. Thus, by knowing what basket of measures constitutes each scenario and how many of each measure will be needed, it is possible to calculate the cost of the measures/devices. This cost can be adjusted for economies of scale or for any subsidy, if necessary.

The cost of fitting will depend on whether the scheme includes free professional installation, subsidised professional installation, or if the customer is expected to fit the device themselves. If the company employs a plumber to install the device(s) then the cost of installation is equivalent to the cost of employing a plumber to carry out the fitting. The cost of the installation will then be based on the average hourly rates and the average time it takes to fit the device.

Customer recruitment costs apply to the entire target population (regardless of whether they participated in the scheme or not).

2.4.4 Step 4: Water Savings

Step 4 requires the input of the worst case, best estimate (most likely) and best case water savings (yield) per household per day for each target population. Each scenario will have a basket of measures. Each measure will have an associated saving. Therefore, the water saving associated with the scenario can be estimated.

2.4.5 Step 5: Social and Environmental Costs

If data is available, social and environmental costs should be considered in order to include externalities such as the benefit of the water remaining in the environment, and the impact of schemes on householders. The environmental savings/costs and the social costs/benefits may be entered as the best case, best estimate and worst case savings per megalitre and/or per installation. The net savings/costs are entered with savings applied as a negative value.

The June report will list the relevant factors to be considered in an assessment of social and environmental costs.

2.4.6 Step 6: Results

The results worksheet displays the AISCs and yield and cost profiles over the 25 year assessment period for each of the target household groups, as well as the total households. The spreadsheet tool allows planners to see instantly how cost-effective spend in different areas is by looking at the change in the AISC.

3. EXISTING EVIDENCE

There are numerous sources of evidence available in the form of trials and projects which some water companies have undertaken in recent years. This evidence will be collected and assessed by Waterwise to determine its suitability for inclusion in the Evidence Base analysis, in terms of quality of data.

Ideally, the information contained within the Evidence Base will be able to populate Table 3.

Table 3 Data required from water efficiency projects

Water efficiency measure	Yield	Confidence grade
a	a	a
b	b	b
c	c	c
total	X	X

However, most water efficiency trials to date have used baskets of measures rather than one single device: for example, water audits combined with retrofit installations for cisterns and showers. A basket of measures is likely to have a total cost that is not equal to the sum of the individual measures.

The individual costs must therefore be disaggregated with care from the total costs given in the project reports. In addition, the water savings will also be a sum of the devices installed and these too must be disaggregated from the individual components. A worked example of the disaggregation methodology is given in Appendix B.

Table 4 shows the water efficiency trials which were available for analysis during this phase of the work.

Note: A great many of the projects analysed in this March Interim Report were carried out by Essex and Suffolk Water, which has been a leading force in the design, development and implementation of large-scale water efficiency projects for a number of years. Because some of the projects relied in part on assumptions rather than measured savings, they have been awarded, according to the Evidence Base methodology, a lower confidence grade. However, Waterwise would like to underline the importance of these and other Essex and Suffolk projects not only in their own right, in terms of results for analysis for this project, but also in the key role they have played in the iterative process of the design of an effective water efficiency scheme, across the industry. Four further Essex and Suffolk projects will be analysed in the June report – these include measured savings.

Table 4 Existing water efficiency evidence used for disaggregation

	Water Company	Title of Trial	Status
1	Essex & Suffolk	(2007) Retrofitting variable flush toilets	Follow-up from EA collaborative study – not viable for analysis separately
2	Essex & Suffolk	(1998) A Household water audits in Moulsham (2002) B Water audit follow up audit Moulsham	disaggregation complete
3	Essex & Suffolk	(2006) Sustainable water audits research (Chelmsford)	disaggregation complete
4	Essex & Suffolk	(2004) Home surveys in Brentwood	disaggregation complete
5	Essex & Suffolk	(2002) Home surveys in Witham	Theoretical water savings to be assessed in June report
6	Essex & Suffolk	(2006) Thurrock Homes survey	Work in progress – to be analysed in June report
7	Essex & Suffolk	(2007) Toolkit (1000 homes visit and fix)	disaggregation complete
8	Essex & Suffolk	(2007) 6-700 homes visit and fix - Ecobeta - Chelmsford	Report to be analysed in June report
9	South West Water	(2007) Water Efficiency Trial	disaggregation complete
10	Thames Water	(2008) Liquid Assets (PHASE 1) (draft report only)	disaggregation complete
11	Environment Agency	(2004) Retrofitting of variable flush devices	disaggregation complete
12	Southern Water	(2007) Single measure retrofit - toilets	Work in progress – to be analysed in June report
13	Tynemarch	Paper study follow up from trial	Not analysed

Of the seven completed projects, some have two phases or follow-up audits, and this has resulted in nine disaggregations in total for inclusion in this report. There are an additional ten projects which will be included in the June report, and a further three projects which are due to deliver in time for the October report. A full list of projects (current and future) is contained in Appendix D. Other projects can be added if they come to light, and the methodology is designed to incorporate future projects beyond the end-date of the Evidence Base project (6 of these are outlined in Appendix D, but we expect there to be others which are already being considered by water companies.)

The information about water savings per device obtained from the disaggregation will then be used to develop scenarios and populate the spreadsheet tool to calculate an AISC. An example of a scenario of a water efficiency scheme and a full breakdown of the AISC calculation is contained in Appendix E.

For the June report, a range of suitable scenarios will be developed between WRc and Waterwise, based on a more complete dataset.

A summary of the disaggregation of the seven projects follows. For an example of the disaggregation methodology refer to Appendix B.

3.1.1 Essex and Suffolk Water: Household water audits in Moulsham

Between May and October 1997, Essex & Suffolk Water (ESW) developed an initiative which was piloted in the district metered area (DMA) of Moulsham in Chelmsford. In total, 1,419 audits were carried out, of which 1,375 audits were within the pilot DMA. The response rate for the pilot was 76% of all domestic properties. A control zone in a similar, neighbouring DMA was established for comparative evaluation purposes.

In terms of the measures, the pilot delivered 5,449 individual measures, broken down as follows:

- 1,097 cistern devices were installed
- 781 showerheads were replaced
- 284 plumbing losses were reported (207 repaired)
- 220 waterbutts with 220 rainsavers were installed
- 1,406 loft pipe and tank surveys were carried out
- Every household audited received a water efficiency pack and advice
- Additionally, the pilot detected and reported 22 external leaks.

The water savings achieved from this trial were estimated and not directly measured. In assessing water savings, three methods were considered: a direct estimate on the basis of measures installed; the comparative changes of water input into the pilot and control zones; and individual case studies carried out by ESW. The best estimate of the savings recorded is 55,000 l/d, representing 10% of estimated average daily delivered water per property within the pilot zone.

The results of the disaggregation are as follows:

Essex & Suffolk Household Water Audits in Moulsham 1997-98

Phase 1

A	B	C	D	E	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Conf. Grade
1	Cistern displacement devices	32.50	76.80%	24.96	XX
2	Shower heads	8.95	4.51%	0.40	XX
4	Plumbing losses	5.57	100.00%	5.57	XX
5	External leakage	12.00	100.00%	12.00	XX
6	Water butts	2.71	15.49%	0.42	XX

Total water saving estimated using report assumptions	43.35
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* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:

- 1 This table uses estimated savings based on the assumptions set out in the Essex & Suffolk report. There were no measurements of water savings carried out during the study.

3.1.2 Essex and Suffolk Water: Sustainable Water Audits in Chelmsford

In 2005 Essex & Suffolk Water (ESW) wanted to research its water efficiency strategy by comparing the benefits of the various audits in relation to changing customers' behaviour patterns with regards to water usage. The research consisted of comparing the effectiveness of six audits, and 20 customers were required to participate per audit. The disaggregation analysed results from a retrofit audit and the full audit as these had actual devices fitted. The other audits were questionnaire-based and were associated with changing behaviour rather than a volumetric saving.

Loggers were fitted to a sample of the properties and measured the savings obtained from the 'Retrofit' audit and the 'Full' audit. The results of the disaggregation are as follows;

Essex & Suffolk Sustainable water audits
Retrofit Audit

A	B	C	D	E	F	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Adjusted for measured savings (l/prop/day)	Conf. Grade
1	Ecoflush	23.04	10.53%	2.43	22.15	BX
2	Variflush	23.04	26.32%	6.06	22.15	BX
3	Dudley Turbo 88	23.04	52.63%	12.13	22.15	BX
4	Save-a-flush	11.52	5.26%	0.61	11.07	BX

Total water saving calculated from microcomponent data	21.22
Total water saving (measured) as recorded from report	20.4

* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:

- 1 Post installation this device will save 2 litre every flush.
- 2 Post installation this device will save 2 litre every flush.
- 3 Post installation this device will save 2 litre every flush.
- 4 Post installation this device will save 1 litre every flush.

Essex & Suffolk Sustainable water audits

Full Audit

A	B	C	D	E	F	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Adjusted for measured savings (l/prop/day)	Conf. Grade
1	Save-a-flush	11.52	100.00%	11.52	6.66	BX
2	Water-butts	2.74	36.84%	1.01	1.58	BX
3	Hose gun	2.08	63.16%	1.31	1.20	BX
Total water saving calculated from microcomponent data					13.84	
Total water saving (measured) as recorded from report					8	

* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:

- 1 Post installation this device will save 1 litre every flush.
- 2 Assume 1000 litres saved per year, averaged across year.
- 3 Assume hose gun saves 5 % of outside tap use.

3.1.3 Essex and Suffolk Water: Home Surveys in Brentwood and Romford

Between January 2004 and September 2004 83,573 domestic customers in the Brentwood and Romford areas of Essex and Suffolk were invited to take part in the Water21 Home Water Conservation Scheme via a direct mail marketing campaign designed to improve customer and public relations. The main aim of the scheme was to encourage water efficiency by educating ESW's domestic customers in techniques to use water wisely and provide an awareness of the limited water resource situation in the ESW area. This was achieved by a combination of direct mail, the positive promotion of practical household solutions that can reduce consumption and personal home visits. Phase 1 was conducted in Brentwood and Phase 2 in Romford.

Of the 84,973 invited to participate in the scheme, 33,381 Water Conservation Packs were delivered to customers. Subsequently, 21,271 Audit Forms were completed and returned between January 2004 and September 2004. As a direct result of these surveys, 86,497 measures / components were installed or used at customers' properties which amounted to water savings of 240,190 litres per day. This is a total saving of 11.29 litres per audited property per day. These water savings are estimated and not measured.

Customers responded positively to the explanation for the need for water conservation and appeared genuinely supportive of the efforts and activities of ESW in this area. This project is believed to have made a positive contribution to the public's perception of ESW and to water conservation.

The results for the disaggregations based on assumptions for the two phases are as follows:

Essex & Suffolk Home surveys in Brentwood

Phase 1

A	B	C	D	E	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Conf. Grade
1	Save-a-flush	9.44	74.03%	6.99	XX
2	Tap washers	9.90	0.40%	0.04	XX
3	Teeth cleaning	26.73	5.00%	1.34	XX
4	Trigger hoses	1.58	79.73%	1.26	XX
5	Showers	19.11	5.00%	0.96	XX

Total water saving estimated using report assumptions	10.58
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* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:

- 1 This table uses estimated savings based on the assumptions set out in the Essex & Suffolk report. There were no measurements of water savings carried out during the study.

Essex & Suffolk Home Surveys in Romford

Phase 2

A	B	C	D	E	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Conf. Grade
1	Save-a-flush	10.80	76.71%	8.28	XX
2	Tap washers	13.08	0.26%	0.03	XX
3	Teeth cleaning	29.75	5.00%	1.49	XX
4	Trigger hoses	1.58	75.92%	1.20	XX
5	Showers	22.36	5.00%	1.12	XX

Total water saving estimated using report assumptions	12.12
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* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:

- 1 This table uses estimated savings based on the assumptions set out in the Essex & Suffolk report. There were no measurements of water savings carried out during the study.

3.1.4 Essex and Suffolk Water: Water Saving Toolkit

As part of the Essex & Suffolk Water (ESW) long term water efficiency programme the Water Saving Toolkit project was commissioned, to take place in Chelmsford, Essex. The project involved the mailing out of an application pack to over 5,000 domestic customers. The application pack presented details of 19 water saving products and services for the customers to choose from, in exchange for details about their home and water use characteristics.

The key objective was to reduce water consumption through customer engagement. Critical to this was the collection of data to enable a robust evaluation of the project and cost benefit analysis.

A database was constructed to store the large volumes of data generated by the project. Extracts of the customer database, customer contact details and customer survey forms were all stored in the project database. Additionally, the database was used for scheduling of appointments to deliver and fit the selected products and services, recording which items they received, the collation of meter read data and producing daily work schedules for the site technicians visiting the customers' homes. Of 5,378 customers contacted, 1,073 households

completed the audit and were fitted with water saving products and services between November 2006 and March 2007.

Meter-reading data were collected from those properties that had an externally accessible water meter, and 187 flow loggers were installed to collect detailed water use information. Calculations were also undertaken to estimate the theoretical water saving achieved as a result of installing the products during the Water Saving Toolkit project.

The project resulted in each participating property saving on average 13.85 l/prop/day. This equates to a total saving of 0.015 MI/day for the project study area.

The disaggregation of this project was split into two sections:

- Plumbed savings - to include actual devices requiring a plumber to install.
- Non-plumbed savings - to include audits, advice and devices to encourage behavioural change.

The results from the disaggregation are as follows:

Essex & Suffolk Tool kits		Plumbing fittings				
A	B	C	D	E	F	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Adjusted for measured savings (l/prop/day)	Conf. Grade
1	Aerated shower	6.25	24.32%	1.52	6.51	B2
2	Variflush	23.04	19.82%	4.57	23.98	B2
3	Dudley Turbo 88	23.04	23.42%	5.40	23.98	B2
4	Tap inserts	11.37	32.43%	3.69	11.83	B2
Total water saving calculated from microcomponent data					15.17	
Total water saving (measured) as recorded from report					15.79	

* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:	
1	If an aerated shower head is fitted, this will result in the delivery of 10/12 of the initial flow rate e.g. a reduction of 2/12 of the original flow
2	Post installation this device will save 2 litres every flush regardless of the cistern size
3	Post installation this device will save 2 litres every flush regardless of the cistern size
4	If tap inserts are fitted the flow delivered will be 1.7/2.3 of initial flow rate for 50% of tap uses. (the remaining 50% are volume related e.g. filling up a sink and so would not result in a water efficient saving as the usage is not dependent on flow rate)

Essex & Suffolk Tool kits		Non-plumbing fittings				
A	B	C	D	E	F	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Adjusted for measured savings (l/prop/day)	Conf. Grade
1	Digital shower alarms	6.99	37.70%	2.64	7.22	B2
2	Egg shower timer	1.29	9.84%	0.13	1.33	B2
3	Childrens pack	0.00	18.03%	0.00	0.00	B2
4	Save a flush	11.52	34.43%	3.97	11.90	B2
Total water saving calculated from microcomponent data					6.73	
Total water saving (measured) as recorded from report					6.95	

* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:	
1	A digital shower time reduces the time in the shower by 1.75 mins for an 8 min shower
2	Using an egg shower timer equates to a shower duration approximately 0.95 of normal
3	This measure has no measurable impact on immediate water savings
4	Post installation this device will save 1 litres every flush regardless of the cistern size

3.1.5 South West Water – Water Efficiency Trial

South West Water conducted a water efficiency trial which involved measuring the effectiveness and costs of fitting a range of self-selected water efficiency devices to measured customers' houses. The devices were chosen from a range which were made available to the customer by the company.

The trial was designed to measure the effect of a group of customer-selected water efficiency devices rather than to measure the effectiveness of any individual device. There were some customers who selected just one device from the basket of measures, but the number is too small to enable the drawing of statistically valid conclusions.

The project aimed to recruit 500 customers to have devices fitted, with a further 100 customers to act as a control group. A total of 2056 water efficiency devices were installed into a total of 349 metered homes. As mentioned, most customers opted for a multi-measure retrofit and few customers chose an individual device.

There was an initial water reduction across the whole sample of approximately 5% after the devices were fitted which reduced to 4% between six and seven months after the trial.

In the analysis of the data, SWW were available to identify a range of properties which only had a single measure installed. From these properties we were able to extract the following information on the impact of individual WEM;

SWW Water Efficiency trial

A	B	C		
	WEM	Measured saving per day	Number of properties in sample	Conf. Grade
1	Dudley turbo	24.39	22	A2
2	CDDs	0.01	29	A2
3	Mixture	11.70	56	A2
	WCs Weighted average	11.14		A2

A	B	C		
	WEM	Measured saving per day	Number of properties in sample	Conf. Grade
1	Mira shower	10.79	1	A2
2	Challis shower	-9.12	3	A2
3	Mixture	2.63	4	A2
	Showers Weighted average	-0.76		A2

A	B	C		
	WEM	Measured saving per day	Number of properties in sample	Conf. Grade
1	Challis tap inserts	-3.24	2	A2
2	Magic tap inserts	54.08	6	A2
3	Miracle tap inserts	34.21	9	A2
4	Mixture	24.89	25	A2
	Tap inserts Weighted average	29.72		A2

A	B	C		
	WEM	Measured saving per day	Number of properties in sample	Conf. Grade
1	Leak alarm	-94.13	2	A2
2	Spray gun	-388.60	2	A2
3	Mixture	-53.06	8	A2
	Other weighted average	-115.83		A2

Closer analysis of the individual water efficiency measures yielded some interesting results. Admittedly, the sample size of houses with individual devices installed is very small (<10), but the trends could represent what may happen if the devices were to be implemented within a larger size water efficiency programme.

Noticeably there was a significant increase in consumption after the installation of a spray gun. The trial period of monitoring was during the late winter and spring months therefore not a typical peak period when garden watering would be expected to increase. The sharp increase in demand could be attributed to the fact that a spray gun is a new “fancy” gadget and so customers are keener to use it, and it makes garden watering easier. In addition, consumption increased with the installation of a new Challis shower head. The theory behind offering shower heads is to encourage the customers to have showers instead of baths. However, if the showering experience has improved due to an increased flow from a new showerhead then the customer may shower for a longer duration than usual.

As mentioned, the sample size is too small to draw statistically robust conclusions from. It does signify that it is less reliable to achieve water saving from devices which consume water controlled by behaviour. Consumption associated with a volumetric water e.g. retrofit toilets is more reliable.

3.1.6 Thames Water – Liquid Assets (Phase 1)

In November 2006, Thames Water (TW) appointed Mouchel Parkman (MP) to carry out a Water Efficiency Audit Project (Audit Project) on domestic properties in Bromley and Swindon.

The objectives of the Audit Project were:

- To gain a better understanding of household water use and to quantify a reduction in Per Capita Consumption (PCC) in the households audited
- To carry out 1,000 water efficiency audits; 500 in Bromley and 500 in Swindon
- To quantitatively assess different water efficiency technologies

- To assess the costs and benefits of water efficiency (WE), to inform the Water Resources Management Plan (WRMP)
- To compare theoretical water savings from water efficient technologies against actual measured savings

A total of 10,454 metered domestic customers within Bromley and Swindon were sent an invitation letter offering them the chance to take part in the Audit Project, where a TW approved plumber would install free of charge water efficient devices (dual flush retrofit device, save-a-flush, tap aerators, reduced flow showerhead, shower timers).

Of the 10,454 households invited to participate in the Audit Project, a total of 1,307 households responded positively, making the initial uptake rate 12.5%. At the completion of the project a total of 962 audits were achieved (420 from Bromley and 542 from Swindon) reducing the uptake rate to 9.2%.

Using household data, product data and assumptions, theoretical savings were calculated for each device and for each household. The actual savings were based on meter reads. A total of five meter reads were taken throughout the project, one in the month prior to the audit, one during the audit and three post-audit. Together with the measurements taken during the audit, these meter readings were used to analyse what water savings the households made as a result of having water efficiency devices installed.

The final report for this project is in the process of being drafted and so individual measured water savings were not verified. The MP report used theoretical savings but these should be verified in the future against measured savings. However, the overall water savings in the two areas were measured (at a DMA level) and so the disaggregation carried out and presented below has been tested against this measured saving.

The disaggregation used a series of assumptions to calculate the water savings for this trial. The results are as follows:

Thames Water Liquid Assets Draft Report

A	B	C	D	E	F	
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Adjusted for measured savings (l/prop/day)	Conf. Grade
1	Aerated showerhead	6.25	34.74%	2.17	5.95	B2
2	Tap aerator	11.37	38.96%	4.43	10.82	B2
3	Sand shower timer	1.88	74.50%	1.40	1.79	X2
4	Save-a-flush	11.52	44.58%	5.14	10.97	B2
5	Ecobeta Dual Flush	11.52	41.57%	4.79	10.97	B2
6	Miracle tap aerator	11.37	30.72%	3.49	10.82	B2

Total water saving calculated from microcomponent data	21.42
Total water saving (measured) as recorded from report	20.39

* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions to derive estimated volume saved:	
1	If an aerated shower head is fitted, this will result in the delivery of 10/12 of the initial flow rate e.g. a reduction of 2/12 of the original flow
2	If tap inserts are fitted the flow delivered will be 1.7/2.3 of initial flow rate for 50% of tap uses. (The remaining 50% are volume related e.g. filling up a sink and so would not result in a water efficient saving as the usage is not dependent on flow rate)
3	Using a shower timer equates to a shower duration approximately 0.95 of normal
4	Post-installation this device will save 1 litre every flush regardless of the cistern size
5	Assume that this device will save 2 litres for a small flush at 1:1 ratio small:large flush
6	Assume same as normal tap aerator (number 2)

3.1.7 Environment Agency and Water Companies collaborative research – Retrofitting Variable Flush Devices

Toilet flushing represents the largest single use of water in households, accounting for approximately 30% of domestic water use. While the Water Supply Regulations 1999 reduced the maximum toilet cistern size to 6 litres, a large proportion of the existing housing stock has toilets with a flush of 7.5 litres or more.

Retrofit devices convert existing single flush siphon cisterns into variable flush models – offering the potential to reduce existing flush volumes without the expense of a complete toilet replacement.

In 2003 and 2004, a collaborative water efficient toilet retrofit trial was undertaken by 9 water companies; the Environment Agency then independently analysed the results (and published the report). The aim of the trial was to build on previous research and to explore further whether retrofit devices are suitable for demand management programmes.

The devices were installed into 136 measured properties across the different water company areas. In the weeks after the devices were installed water demand fell by an average of 8.5% per property. It was thought that savings could be increased in two ways; by targeting specific groups of customers; and to make sure the customer knows how to use the device correctly.

Specific and detailed information about costs was not included in this report. Some assessment was made of the cost benefit to the customer in terms of revenues saved by reducing consumption, but no details of project and trial costs were documented. As a result the costs for this trial will be based on assumptions from other water company trials conducted.

The disaggregation for this project is more straightforward than in previous projects as this is a single measure retrofit. In addition the water savings are measured and not based on assumptions, and as a result the trial scores a maximum of A1 for the confidence and accuracy grades. The results are as follows:

Environment Agency retrofit variflush project

A	B	C	
	WEM	Measured saving per day	Conf. Grade
1	Variflush	24.00	A1
2	Ecoflush	16.90	A1
3	Both	9.80	A1

The reduced saving when both devices were fitted could potentially be as a result of misuse. The devices operate in slightly different ways and if one home has each device fitted then there could be confusion as to how to operate the particular device thus reducing the water saving achieved.

3.2 Costs

The cost of implementing a water efficiency trial varies greatly between water company evidence. The costs must be disaggregated in a similar manner to water saving in order to achieve a best industry estimate. The implications of scaling costs up from small trials to large schemes must be robust and transparent. Fixed costs, e.g. unit costs of devices, are relatively easy to scale up. Overhead costs, e.g. project management and project implementation costs are more difficult to scale up into large water efficiency schemes.

In addition it is important to learn from previous trials conducted to ensure that the best practise for designing and implementing a water efficiency programme is understood and followed. Within the ten years of evidence used within this analysis, it is possible to use the experience to design the most efficient water efficient trial.

For the scenario example in Appendix E, the costs were taken from the Essex and Suffolk Toolkit water efficiency trial. This is the most recent trial to have been delivered and is a good example of a well executed efficiency trial. In addition, the costs were well documented and thus workable to disaggregate and use for the AISC calculation.

3.3 Summary

Table 5 is a summary of the disaggregation process showing the water saving for each water efficiency measure. The mean, maximum and minimum are translated into best estimate, best case and worse case respectively for water savings to populate the spreadsheet tool for the AISC calculation. In the June report, a sensitivity analysis and a gap analysis will be carried out on the results.

Table 5 Summary of water savings per device from the disaggregation process

Water efficiency measure - volume saving when installed (l/prop/day)	Source of Evidence													
	measured / estimated water saving single / multi measure	Environment Agency retrofit variflush project	Essex & Suffolk Sustainable water audits - Retrofit Audit	Essex & Suffolk Sustainable water audits - Full Audit	Essex & Suffolk Sustainable water Audits in Moulsham	Essex & Suffolk Household Water Brentwood Phase 1 1997-98	Essex & Suffolk Home surveys in Brentwood Phase 1	Essex & Suffolk Home surveys in Brentwood Phase 2	Essex & Suffolk Tool kits	Thames Water Liquid Assets Draft Report	SWW Water Efficiency Draft	Mean	Maximum	Minimum
Variflush	24.0	22.1					24.0					23.4	24.0	22.1
Ecoflush	16.9	22.1										19.5	22.1	16.9
Ecobeta									11.0			11.0	11.0	11.0
Dudley Turbo 88		22.1					24.0			24.4		23.5	24.4	22.1
Save-a-flush		11.1	6.7		9.4	10.8	12.0	11.0				10.2	12.0	6.7
Water-butts			1.6	2.7								2.1	2.7	1.6
Hose gun			1.2									1.2	1.2	1.2
Cistern displacement devices				32.5						0.0		16.3	32.5	0.0
Aerated shower heads ¹				9.0	19.1	22.4	6.5	6.0				12.6	22.4	6.0
Plumbing losses				5.6								5.6	5.6	5.6
External leakage				12.0								12.0	12.0	12.0
Tap washers					9.9	13.1						11.5	13.1	9.9
Teeth cleaning					26.7	29.7						28.2	29.7	26.7
Trigger hoses					1.6	1.6						1.6	1.6	1.6
Mira Showers										10.8		10.8	10.8	10.8
Tap inserts ²							11.8	10.8		29.7		17.5	29.7	10.8
Digital shower alarms							7.3					7.3	7.3	7.3
Egg shower timer							1.3	1.8				1.6	1.8	1.3

^a A gap analysis will be conducted on the evidence collated to date. Future water efficiency projects undertaken could provide evidence for the gaps identified

^b The sample size and the confidence grades for the disaggregation evidence will be added to this table for the June Reprpt. This will enable outliers and the robustness of the evidence to be assessed

¹ There are a range of values for aerated shower heads. These will be split down into different types and different manufacturers for future reporting

² There are a range of values for aerated taps. These will also be split down into different types and manufacturers for future reporting

3.4 AISC calculation for Scenario 1

A full worked example of an AISC for a given scenario using the spreadsheet tool is given in Appendix E. For the given scenario (detailed in Appendix E) of retrofitting 10,000 homes with retrofit dual flush toilets and aerated shower heads the AISC results are detailed in

Table 6a. The scenario was developed for a best case, best estimate (most likely) and worst case likelihood. **Error! Reference source not found.**

Table 6a AISC for water efficiency scenario (detailed in Appendix E)

AISC (p/m ³)		
Best estimate	Best case	Worst case
124.4	23.1	545.0

This AISC did not including the opex saving. The inclusion of the opex saving is a subject of debate with regards to water efficiency schemes. Table 5b shows the AISC calculation with the inclusion of the opex saving at 5p/m³.

Table 6b AISC for water efficiency scenario (detailed in Appendix E)

AISC (p/m ³)		
Best estimate	Best case	Worst case
124.9	23.6	545.5

The figures quoted above and throughout this document have quoted costs in terms of AISC – average incremental social cost. An explanation of this equation and composite parameters is given in Appendix C. The use of an AISC requires the inclusion of costs for social and environmental benefits and costs within the calculation.

None of the reports within the Evidence Base to date contain any information on environmental or social (E&S) costs and benefits. As a result, there is not sufficient information or evidence available to include any E&S impacts within the cost assessment: the costs should therefore be quoted as AIC (Actual Incremental Costs) or LRMC (Long Run Marginal Costs).

There is a need to make an assessment of the social and environmental costs of all new water resource options and so the next phase of the Evidence Base project (including for the June and October reports) will include liaising with the water companies, represented by Water UK at the Steering Group Meetings, to ask if E&S costs and benefits were included in the draft Water Resource Management Plans. If this information is available, access to it will be sought, and the E&S costs will be audited and included within the June report.

If the quantification of E&S impacts is limited or incomplete, a possible recommendation would be for a small sub project to be undertaken to develop robust default E&S impacts for a range of measures. This would then be included in the final Evidence Base report in October.

APPENDIX A ROBUSTNESS OF DATA

A1.1 Robustness of data

It is important that the cost-benefit analysis is informed by the robustness of the data used for the calculation and the accuracy of results obtained. There are three indicators of robustness which can be used for this:

1. **Statistical confidence:** a 90% confidence interval around the water savings reported, as assessed by individual project managers using the WR25⁽²⁾ methodology.
2. **Subjective categories:** a simple scoring system based on 11 categories, derived from use of the best practice checklist given in WR25⁽²⁾. Guidance on scoring is also given in the online evidence database (www.wrcplc.co.uk/WR25B).

	Robustness score (1 = low, 5 = high)					
	N/A	1	2	3	4	5
Project management						
Approach						
Monitoring period						
Sample composition						
Sample size						
Control group						
Data collection						
Data analysis						
Data audit						
Statistical inference						
Transferability						

3. **Method of quantifying the savings:** an indication of which measurements and methods were used in quantifying the water savings from the project. More than one method may be ticked, as a project may have involved a combination of measures and approaches.

- Judgment
- Questionnaire based
- Individual property meter(s)
- Small area or DMA meter
- Time series comparison (week on week)
- Time series comparison (month on month)
- Time series comparison (year on year)
- Comparison with control
- Individual appliance meter(s)
- Benchmark data used

A1.2 Accuracy bands

From the robustness data described in section 2.4.2 above, accuracy and reliability bands can be developed in a similar vein to those employed by Ofwat for regulatory reporting.

² WR25 Quantification of the savings, costs and benefits of water efficiency. 03/WR/25/1. UKWIR 2003.

The bandings apply at the individual project level and are designed to give an instant indicator of project robustness. The bandings rely on the data entered by individual project managers and should not be seen as an independent assessment, nor as a definitive judgment on the project – they are simply *indicators* of robustness.

The **accuracy bands** are based on the 90% confidence intervals around the water savings for each project and are as follows:

Band 1	Confidence limits (upper and lower) for at least one year are given and all limits are less than or equal to 25% of the water savings.
Band 2	Confidence limits (upper and lower) for at least one year are given and at least one limit (upper or lower) exceeds 25% of the water savings.
Band X	No confidence limits are given, or only one sided limits are given (either upper limits only or lower limits only)

A1.3 Reliability bands

The reliability bands are based on:

- the 11 categories of the subjective robustness categories
- the methods of quantifying the water savings.

The reliability band, therefore, reflects both the robustness of the project and the likelihood that the project has delivered robust water savings data. A total score (labelled a Z-score) can be calculated for each project, using the following four-step process;

Step 1: Add together all the subjective robustness scores for the 11 categories (maximum is $11 \times 5 = 55$).

Step 2: Assign points based on the methods of quantifying the water savings as follows:

Method	Points	Comment
Judgement	0	Not based on project data and unlikely to be as accurate as questionnaires or measurements
Questionnaire based	5	Data from customer questionnaires unlikely to be as accurate as measurements
Individual property meter(s)	15	Measurement likely to be accurate
Small area or DMA meter	10	Measurement likely to be obscured by leakage and other demand components
Time series comparison (week on week)	0	This aspect is covered in the subjective robustness categories
Time series comparison (month on month)	0	This aspect is covered in the subjective robustness categories
Time series comparison (year on year)	0	This aspect is covered in the subjective robustness categories
Comparison with control	0	This aspect is covered in the subjective robustness categories
Individual appliance meter(s)	15	Measurement likely to be accurate
Benchmark data used	0	Not based on project data and unlikely to be as accurate as questionnaires or measurements

Step 3: Add together the points from Step 1 (subjective robustness categories) and Step 2 (methods of quantifying the water savings) to obtain the total Z-score.

Step 4: Assign reliability band according to the following:

Band A	Z-score greater than 55 and data were provided for both the subjective robustness categories and the methods of quantifying the savings
Band B	Z-score not exceeding 55 and data were provided for both the subjective robustness categories and the methods of quantifying the savings
Band X	Data were not provided for either the subjective robustness categories or the methods of quantifying the savings

The accuracy and reliability bands are designed to give an indication of the robustness of the outcomes of the cost benefit analysis. The bands can be applied across a whole project or for an individual measure.

APPENDIX B WORKED EXAMPLE: THAMES WATER

This worked example is to illustrate one potential method of disaggregating individual water efficient measure savings from a project which has implemented a basket of measures. The example is based on a recent Thames Water project (Liquid Assets Phase 1) and uses initial findings which may change before the project is completed. The method is still being developed, and will include a full list of assumptions.

Thames Water undertook a water efficiency trial in two areas; Swindon and Bromley. The trial included water audits and the installation of water efficiency devices. The trial offered a range of different water efficiency measures (WEM) to householders, and the water savings recorded in the report are total savings from all of the devices installed, not measured on an individual WEM basis. As a result the water savings per device must be disaggregated from the total water saving using the methodology described in Section 2.4.

The cost benefit analysis will use all available information from the report. The information obtained is contained in table B1. The information in table B1 is the basis from which the disaggregation of the individual water savings will be calculated. In addition to this, the project resulted in accurate information about uptake rates per device.

Table B1 Information extracted from Thames Water's preliminary draft water efficiency trial report

Information From TW Report	
Number of properties	498
Total litres saved per day	10,154
Volume saved (l/prop/day)	20.4

The estimates of water savings per device and associated assumptions are listed in table B2, and the methodology behind this is explained in the subsequent text.

Table B2 shows how the total water savings recorded in the Thames Water trial have been disaggregated to give water savings at a micro component level. The evidence used for the disaggregation is based on assumptions (as listed below the table) which are derived from both identiflow microcomponent analysis and from the Market Transformation Programme (MTP).

The estimates of water use per household (highlighted in blue) have been built up using a set of assumptions and best knowledge regarding ownership, frequency and duration of use. This data has been taken from CP187 which is the WRc Microcomponent data set. Using the assumptions listed above and the CP187 data we have estimated the volume saved for each measure if it is installed in an average home (column C). This totals 21.4 l/property/day for a sample of properties. The actual measured water saving per property for the Thames trial was 20.39 l/property/day and so the theoretical saving has been adjusted to fit this volume but follows the ratio of water saved per device (column F). This then produced a profile of water savings per measure which correlates to the actual saving recorded during the trial and is based on current best evidence and knowledge.

Table B2 Estimates of water savings per measure (from Identiflow and MTP)

A	B	C	D	E	F
	WEM	Estimated Vol saved (l/prop/day)	Up take rate	Estimated Vol saved (l/prop/day)*	Adjusted for measured savings (l/prop/day)
1	Aerated showerhead	6.25	34.74%	2.17	5.95
2	Tap aerator	11.37	38.96%	4.43	10.82
3	Sand shower timer	1.88	74.50%	1.40	1.79
4	Save-a-flush	11.52	44.58%	5.14	10.97
5	Ecobeta Dual Flush	11.52	41.57%	4.79	10.97
6	Miracle tap aerator	11.37	30.72%	3.49	10.82

Total water saving calculated from microcomponent data	21.42
Total water saving (measured) as recorded from report	20.39

* The estimated volume saved (column E) has been adjusted by uptake rates

Assumptions:

1. If an aerated shower head is fitted, this will result in the delivery of 10/12 of the initial flow rate e.g. a reduction of 2/12 of the original flow
2. If tap inserts are fitted the flow delivered will be 1.7/2.3 of initial flow rate for 50% of tap uses. (The remaining 50% are volume related e.g. filling up a sink and so would not result in a water efficient saving as the usage is not dependent on flow rate)
3. Using a shower timer equates to a shower duration approximately 0.95 of normal
4. Post installation this device will save 1 litre every flush regardless of the cistern size
5. This device will save 2 litres for a small flush at 1:1 ratio small:large flush
6. As for normal tap aerator (ie as per assumption 2)

Table B3 shows the cost, adjusted yield per device and associated confidence grade given for the disaggregated water saving. The confidence grades are based on the methodology as described in Appendix A of the interim report (23rd Jan 2008).

Most devices have scored a B as they are assumed values and not measured at a microcomponent level. However, the assumed values are based on best evidence and knowledge available and so score reasonably well. The two devices which score an X are based on customer behaviour and this is highly uncertain. The figure of 2 for all devices shows that the confidence limit for at least one year exceeds 25% of the water savings for the upper and lower confidence limits.

Table B3 Confidence levels for disaggregation of water efficient measures

Water Efficiency Measure	Item cost (£)	Installation cost (£)	Yield (l/prop/day)	Confidence grade
Aerated showerhead	<i>Commercially sensitive</i>	27.54	5.95	B2
Tap aerator	<i>Commercially sensitive</i>	27.54	10.82	B2
Sand shower timer	<i>Commercially sensitive</i>	27.54	1.79	X2
Digital shower timer	<i>Commercially sensitive</i>	27.54	1.79	X2
Save-a-flush	<i>Commercially sensitive</i>	27.54	10.97	B2
Ecobeta Dual Flush	<i>Commercially sensitive</i>	27.54	10.97	B2
Miracle tap aerator	<i>Commercially sensitive</i>	27.54	10.82	B2

This data is now ready to populate the spreadsheet and thus calculate the AISC for this trial. This can then be used to construct scenario runs and populate Tables B4 a and b. The best, worst and most likely scenarios will be completed once more trials have been analysed. This will allow good and bad lessons learnt from all water efficient trials analysed in this project to be incorporated in the scenario runs.

Table B4 a and b Information required from evidence to enable the disaggregation of individual water efficiency measures

A measures	Most likely	Worst case	Best case
Costs • Capex • Opex • externals			
Yield			
Half life			

B scenarios	Most likely	Worst case	Best case
Costs • Capex • Opex • externals			
Population			
Uptake rates			

APPENDIX C AISC CALCULATION

The AISC calculation is as presented in WR25B:

$$AISC = \frac{C + O + E - OS}{W}$$

- C = net present value (NPV) of the capital expenditure (Capex) (£)
- O = NPV of the operating cost (Opex)
- E = NPV of the social and environmental cost/benefit of the scheme
- OS = NPV value of the opex saving i.e. the money saved by not producing the water saved by the scheme. Including OS reflects the advice given in the Environment Agency Water Resource Planning Guidelines.
- W = NPV of the total water saved in megalitres (Ml)

The net present value (NPV) of each element is defined as the sum of the annual costs/savings over 60 years (regardless of scheme life), with future costs/ savings discounted at a rate input by the user.

APPENDIX D LIST OF WATER EFFICIENCY PROJECTS

CURRENT PROJECTS:

No	Water Company	Title of project
1	Essex & Suffolk Tynemarch	(2007) Retrofitting variable flush toilets Paper study follow up from trial
2	Essex & Suffolk	(1998) A Household water audits in Moulsham (2002) B Water audit follow up audit Moulsham
3	Essex & Suffolk	(2006) Sustainable water audits research (Chelmsford)
4	Essex & Suffolk	(2004) Home surveys in Brentwood
5	Essex & Suffolk	(2002) Home surveys in Witham FOR ANALYSIS IN JUNE REPORT
6	Essex & Suffolk	(2006) Thurrock Homes survey FOR ANALYSIS IN JUNE REPORT
7	Essex & Suffolk	(2007) Toolkit (1000 homes visit and fix)
8	Essex & Suffolk	(2007) 6-700 homes visit and fix - Ecobeta – Chelmsford FOR ANALYSIS IN JUNE REPORT
9	South West Water	(2007) Water Efficiency Trial
10	Thames Water	(2008) Liquid Assets (PHASE 1) (draft report only)
11	Environment Agency	(2004) Retrofitting of variable flush devices
12	Southern Water	(2007) Single measure retrofit (toilets) FOR ANALYSIS IN JUNE REPORT

FUTURE PROJECTS – FOR ANALYSIS IN JUNE REPORT:

13	Sutton & E Surrey	(and Waterwise) Visit and fix - multimeasure retrofit – 500 homes
14	United Utilities	Visit and fix - showers and Ecobetas – 500 homes
15	Severn Trent	Visit and fix - multimeasure retrofit – 1200 homes
16	South East	Visit and fix - multimeasure WEM installation - 250 new homes
17	Essex & Suffolk	Ecobeta - single measure visit and fix – 1500 homes
18	Thames Water	Self-audit – 2,000 homes

FUTURE PROJECTS – FOR ANALYSIS IN OCTOBER REPORT (AND BEYOND OCTOBER):

19	Anglian Water	Visit and fix - multimeasure retrofit - 1000 homes
20	Wessex Water	Visit and fix - housing association - multimeasure retrofit - 400 homes
21	Yorkshire Water	Visit and fix - multimeasure retrofit - 500 homes
22	Folkestone & Dover	Visit and fix – 500 homes WILL REPORT BEYOND OCTOBER
23	Severn Trent	Employee trial 200 homes - self fit WILL REPORT BEYOND OCTOBER
24	Southern Water	60,000 homes - Ofwat funded WILL REPORT BEYOND OCTOBER
25	Thames Water	Liquid Assets (Phase 2) Visit and fix - 1000 homes WILL REPORT BEYOND OCTOBER
26	South East	Visit and fix - multimeasure retrofit - 500 homes WILL REPORT BEYOND OCTOBER
27	Folkestone & Dover	Tariff Trials WILL REPORT BEYOND OCTOBER

APPENDIX E AISC WORKED EXAMPLE FOR SCENARIO 1

A water efficiency programme scenario has been developed and the data from the disaggregation will be used to populate the spreadsheet to calculate the AISC. The scenario modelled included:

- Target to achieve 10,000 home participation.
- To achieve the desired number of homes, assume 10% uptake rate and therefore target 100,000 homes.
- Retrofit Dudley Turbo dual flush toilets and aerated shower heads.
- Asset life of 10 years.
- Half life (as defined in section 2.4.2) of; best estimate = 5 years, best case = 20 years, worst case 2.5 years.
- Discount rate 4.5%.
- Discount period – 25 years.
- Costs – taken from Essex & Suffolk Toolkit water efficiency trial.

Step 1: Target Households

Populate the spreadsheet with data in order to achieve the desired customer participation

Target Households (000s)			Year											
			1	2	3	4	5	6	7	8	9	10	11	12
Pop 1														
1	Best Estimate Predicted Households	000s	100	100	100	100	100	100	100	100	100	100	100	100
	Uncertainty in Household Numbers - Maximum	000s	110	110	110	110	110	110	110	110	110	110	110	110
	Uncertainty in Household Numbers - Minimum	000s	90	90	90	90	90	90	90	90	90	90	90	90
Pop 2 e.g. unmeasured														
2	Best Estimate Predicted Households	000s	0	0	0	0	0	0	0	0	0	0	0	0
	Uncertainty in Household Numbers - Maximum	000s	0	0	0	0	0	0	0	0	0	0	0	0
	Uncertainty in Household Numbers - Minimum	000s	0	0	0	0	0	0	0	0	0	0	0	0

Step 2: Uptake rates and uncertainties

This includes an estimation of what type of scheme it will be – a one off or a periodic over a set amount of years. Input assumption of half life and the best, most likely and worst case assumptions.

Estimating Expected Uptake Rate & Uncertainties

• Check the relevant box below to identify the scheme as a 'One-off' scheme, i.e. the scheme is implemented just once or a 'Periodic' scheme which assumes the scheme is implemented more than once over the 25 year period.

Implement as a 'One Off' Scheme

Implement as a 'Periodic' Scheme

Half Life of Scheme Savings

Best Estimate: Best Case: Worst Case: Years

NB: Inputs must be Integers

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One Off Implementation

• Enter the 'Best Estimate' (most likely), Best and Worst Case **Total** expected uptakes for each household group. Enter the number of years over which these uptake rates are estimated to be achieved.

NB: a 15% uptake implemented over 3 years is treated as a 5% uptake rate for 3 years.

Uptake Rate (%)	Best Estimate	Best Case	Worst Case	Period Scheme Implemented	Guidance
1 Pop 1	5.0%	10.0%	2.5%	2 Years	NB: Input must be an Integer up to a maximum of 10 years
2 Pop 2 e.g. unmeasured					
3 Population 3					
4 Population 4					
Total	5.0%	11.0%	2.3%		

Step 3: Costs

Input costs derived from best available information from previous studies. Assumptions regarding efficiencies of scale, scaling up costs from small trials to large schemes and project management costs must all be referenced.

	Best Estimate	Best Case	Worst Case
Capital Costs			
1 Set Up Costs	£ 50,000.00	£ 40,000.00	£ 60,000.00
Number of Years CAPEX covers	2 Years		
	NB: Input must be an Integer		

	Best Estimate	Best Case	Worst Case
Opex Cost per household where scheme taken up			
1 Equipment Costs	£25.50	£20.00	£30.00
Installation Costs	£62.00	£22.00	£147.00
Administration Costs			
Recruitment Costs			
Opex Cost per household Installed	£87.50	£42.00	£177.00
Opex Cost per household where scheme NOT taken up			
Recruitment Costs	£0.00	£0.00	£0.00
Opex Cost per household Not Installed	£0.00	£0.00	£0.00

Step 4: Water Savings

Data inputted derived from the disaggregation process. All assumptions should be referenced and documented. The water saving will have best case, best estimate and worst case limits. Opex cost can be accounted for during this stage of the AISC calculation.

Estimating Water Savings & Uncertainties

- Identify the 'Best Estimate' (most likely), Best and Worst Case Water Savings associated with the scheme on a litres per household per day basis. It should be noted that water savings per household should be highest in the 'Best Case' situation.

Water Savings	Best Estimate	Best Case	Worst Case	
1 Pop 1	36.10	46.80	28.10	l/Household/day
1 Pop 2 e.g. unmeasured	36.10	46.80	28.10	l/Household/day
Population 3				l/Household/day
Population 4				l/Household/day

Guida

- Enter the costs associated with production of water in pence per cubic metre in this demand zone - monetary savings will be made by implementing this scheme by not having to abstract/treat the water saved.

OPEX cost of water p/m³

Guida

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Step 5: Environmental and Social costs

An AISC calculation must evaluate costs and benefits of environmental and social impacts. This has not been possible at this stage of the project due to a lack of data. Refer to Section 3 for further information and a strategy to overcome the data gaps for future assessment.

Estimating Social & Environmental Costs & Uncertainties

- Identify the 'Best Estimate' (most likely), Best and Worst Case **Net** Social and Environmental Costs and Savings associated with the **water saved** on £/Ml basis. It should be noted that Social and Environmental Costs should be lowest in the 'Best Case' situation. **Note that savings should be entered as a negative number.**

Costs & Savings associated with the water saved	Best Estimate	Best Case	Worst Case	
Net Environmental Costs per Megalitre of water saved	<input type="text"/>	<input type="text"/>	<input type="text"/>	£/Ml
Net Social Costs per Megalitre of Water Saved	<input type="text"/>	<input type="text"/>	<input type="text"/>	£/Ml

- Identify the 'Best Estimate' (most likely), Best and Worst Case **Net** Social and Environmental Costs and Savings associated with the **installation of the scheme** on £/installation basis. It should be noted that Social and Environmental Costs should be lowest in the 'Best Case' situation. **Note that savings should be entered as a negative number.**

Costs & Savings associated with Installation	Best Estimate	Best Case	Worst Case	
Net Environmental Costs per Installation	<input type="text"/>	<input type="text"/>	<input type="text"/>	£/Installation
Net Social Costs per Installation	<input type="text"/>	<input type="text"/>	<input type="text"/>	£/Installation

Step 6: AISC RESULTS

AIC results in p/m³ for best case, best estimate and worst case limits for the scenario.

Scheme Results Summary - 'One Off' Implementation Method

- Enter the discount Rate at which costs and savings are to be discounted into the future

Annual Discount Rate %

Guidance

Average Incremental Social Cost (p/m³)

Best Estimate

AISCs		
Pop 1	124.9	p/m ³
Pop 2 e.g. unmeasured	#DIV/0!	p/m ³
Population 3	#DIV/0!	p/m ³
Population 4	#DIV/0!	p/m ³
Total Population	124.87	p/m³

Best Case

AISCs		
Pop 1	23.6	p/m ³
Pop 2 e.g. unmeasured	#DIV/0!	p/m ³
Population 3	#DIV/0!	p/m ³
Population 4	#DIV/0!	p/m ³
Total Population	23.64	p/m³

Worst Case

AISCs		
Pop 1	545.5	p/m ³
Pop 2 e.g. unmeasured	#DIV/0!	p/m ³
Population 3	#DIV/0!	p/m ³
Population 4	#DIV/0!	p/m ³
Total Population	545.47	p/m³

Net Present Values (Assessed over 60 a year period)

WAFU NPV	382.01	MI
CAPEX NPV	0.049	EM
OPEX NPV	0.428	EM
Opex Savings NPV	0.0000	EM
Social & Env Costs NPV	0.000	EM

WAFU NPV	2077.92	MI
CAPEX NPV	0.039	EM
OPEX NPV	0.452	EM
Opex Savings NPV	0.0000	EM
Social & Env Costs NPV	0.000	EM

WAFU NPV	82.20	
CAPEX NPV	0.059	
OPEX NPV	0.390	
Opex Savings NPV	0.0000	
Social & Env Costs NPV	0.000	

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