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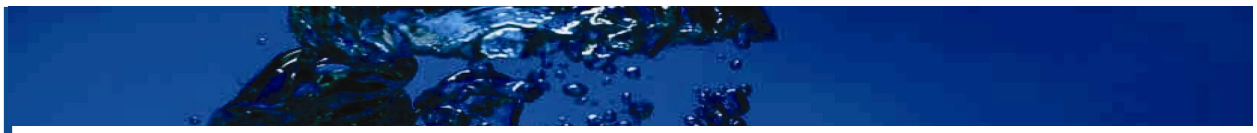

Water efficiency audit programmes:

A best practice guide

Final report
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Waterwise is an independent, not-for-profit, nongovernmental organisation that promotes water efficiency in the UK. Our aims are to decrease water consumption in the UK by 2010, and to build an evidence base to support large-scale water efficiency initiatives. We are the leading authority on water efficiency in the UK. In England, we sit on the Environment Minister's Water Saving Group, and in Scotland, we convene the Saving Water in Scotland network.

To achieve our aims we work with water companies, governments, manufacturers, retailers, nongovernmental organisations, regulators, academics, retailers, consumers, the media, and other stakeholders.

We conduct our own research and occasionally undertake work as consultants. In addition to research, we are also involved in policymaking, advising, public relations, and other activities.

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Disclaimer

Effort has been made to ensure the accuracy of the content of this report, as well as the reliability of the analysis presented. Waterwise accepts no liability for any actions taken based on the contents of this report.

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1. Introduction

Water companies have been initiating and managing water efficiency research projects over the last ten years. These have ranged from small studies on new products or components of domestic demand, to larger pilot projects aimed at studying the effects on demand of a package of water saving devices.

Three UKWIR projects WR25, WR25a, and WR25b (see appendix 2) have addressed these water company projects, providing advice to companies that are planning new projects. All existing and recently completed projects are in a database compiled by WRc. Indeed the first of the reports to come out of the database, covering the period 2000 to 2003, addressed vital issues such as study design, statistical analysis, and reporting.

This short guide summarises current best practice for creating and managing new water efficiency projects related to domestic demand in households. This guide is based on discussions that occurred during a workshop held by water companies on 12th December 2006, which was hosted by Thames Water. Waterwise is grateful to the water companies for allowing material derived from the workshop to form the basis of this guide. Their cooperation reflects the increasing interest and activity in this area of work by many of the UK water companies.

This guide covers many aspects of water efficiency audit programmes, from planning the project to handling the data and recruiting customers. It also contains a brief section on water efficient products and another on the role of contractors.

2. Planning the project

Arguably the most important aspect of the study, planning takes a lot of time and effort to carry out effectively. The following stages are recommended:

1) Define your objectives;
2) Estimate the costs;
3) Confirm you have sufficient budget available, allowing some contingency; and,
4) Create a detailed project plan that includes a realistic timetable.

Objectives are important in that they should precisely define the output requirements, i.e. what results are expected from the study. Objectives should also define the scope of the study, and indicate whether results could be applied to a greater population within the company or even more widely. A key objective that affects many subsequent decisions is whether the project is intended to be scaled up to provide representative results of the company's area, or whether the project targets a specific aspect of water efficiency.

The project plan should include realistic timescales, allowing for possible tendering and procurement processes. It should allow sufficient time to create documents for customer contact that may have to be cleared within the company. Time should also be set aside for the mailing and return of these documents. Generally, the planning stage takes much longer than anticipated, as does the set-up period for contractors.

Projects tend to fall into the following categories:

- Large-scale projects: ranging from self-audits in which water efficient fitting are installed by the householder, to visit-and-fix projects in which installation of fittings is done by the water company;
- Component studies: these examine one particular component of domestic demand, e.g. showers;
- Other studies: such as community projects or those that focus on metering, leakage, new homes, tariffs, etc; and,
- Public awareness campaigns: these may include the distribution of self-audit leaflets, media campaigns, etc.

Regardless of which type of study is being proposed, the first step is to assess your company's internal capabilities. If contractors are to be used, a clearly defined demarcation is necessary between the work of the contractors and that to be handled internally.

3. Data requirements

Water efficiency projects generate many data, and the collection, handling, and analysis of these data are of paramount importance to the project. There are many aspects of data, ranging from the theoretical statistical requirements to the practical data collection.

A good starting point may be to get a statistician in to provide initial guidance. A summary of the statistics of sample selection is given in appendix 1.

This section will briefly examine,

1) sample size and selection;
2) the collection of initial data;
3) supplementary data collection;
4) measurement and monitoring; and,
5) the final analysis of savings.

3.1 Sample size and selection

As detailed in the UKWIR WR25 project (appendix 2), selecting sample size is very important and will define the degree of confidence in the results. The larger the sample size the more

accurate the results will reflect the behaviour of the population. In general, the confidence interval is inversely proportional to the square root of the sample size. As a rule, to get within +/- 5 percent the confidence interval requires a sample size of around 400 to 500 households.

Appendix 1 discusses this subject in further detail, as does section 3.2.

3.2 Collection of initial data

In order to obtain a more representative sample it is sometimes better to carry out the process in two stages:

1) Send initial invitations to a greater number of households than is actually required. The number chosen depends on the type of survey planned. As a general rule, apply the following multipliers to obtain the number of households to initially contact: for self-audit the multiplier should be three, but for visit-and-fix the multiplier should be ten. That is, if the desired sample size is 400, in the case of self-audit the number of homes for initial contact should be 1,200, and in the case of visit-and-fix the number of homes contacted should be 4,000. Households can be chosen by selecting all or a random selection of properties from the company billing system in the selected areas.
2) Once replies to the invitation are received, a final sample can be chosen. To maximise water savings, all interested customers should be able to take part as refusal may adversely affect their willingness to participate in future water efficiency initiatives.

You can expect a 10 to 30 percent acceptance for visit-and-fix surveys and up to 70 percent acceptance of a self-audit pack. The acceptance rate will depend on the type of recipients and on what is offered as incentive.

While replies to the invitations are coming in, you can start to collect limited information about the households to help you select your final sample. Questions can relate to,

1) number of occupants in the house;
2) occupants by age group;
3) council tax band;
4) type of property, i.e. house/flat; and,
5) whether the property has a garden.

Final sample selection can then be made by comparing these criteria with similar criteria in the main population.

3.3 Supplementary data collection

As part of the process of writing to or visiting the household, you may wish to collect supplementary data about the household, such as appliance types and occupany numbers. But

before embarking on this process you should think carefully about what data you need and what are you going to do with the data received.

Questions can relate to,

1) people living in the house, including if they are in full/part time employment or unemployed/retired;
2) water using fixtures in the house, such as baths, showers, toilets, etc;
3) water using appliances, such as washing machines and dishwashers;
4) type of hot water systems;
5) water using devices in the garden;
6) number of vehicles at property; and,
7) if vehicles are washed at home.

In order to create an incentive for customers to return questionnaires, devices such as a prize draw for a water efficient white good could be used, or the offer of a free gift, such as a tea towel with water efficiency messages.

3.4 Measurement and monitoring

Surveys can be undertaken on metered or non-metered properties:

1) If metered properties are used, accurate meter readings can be obtained. Surveys using visit-and-fix have generally adopted this approach.
2) If non-metered properties are used or if mixtures of both types of properties are used, estimates of savings can be made from the number of devices fitted. The self-audit surveys tend to favour this approach.

For small samples, using metered property data loggers can enhance the data collection process. These can monitor readings over shorter periods (down even to every few minutes) and are the most accurate way to assess changes in water use. They may allow estimates to be made of the components of use within the household, thus identifying which devices save most water. For larger projects, a sub sample can be selected for data loggers.

Generally, large-scale studies have to rely on meter readings. The frequency of such readings is open to debate, but it is suggested that readings be taken monthly at minimum. It is also necessary to read meters at least two months prior to the start of the survey and then for three to six months following the fitting of the devices in order to establish before and after effects.

The choice of scale and frequency of the collection of data does depend on project objectives. Issues such as whether overall savings or more detailed sector savings are required should be considered before final decisions are made.

To adjust the data for natural patterns (e.g. seasonal effects), random effects, and non-random effects (e.g. change of household characteristics) a control sample should also be monitored. This control sample can be comprised of households in or around the areas chosen for the main sample, but the households should not be contacted in any way – only their meters read. Identifying suitable control groups can be difficult.

If a survey is undertaken on houses where no meters are fitted, theoretical saving can be calculated. This would involve estimating the savings from each water saving device fitted. The number and frequency of use of such fitted devices can be obtained from questionnaires if a self-audit approach is used.

3.5 Analysing the savings

Refer to section 8.

4. Water efficient products

Water efficient products are constantly changing, with some products well established and others just emerging. Some products are only suitable for the visit-and-fix approach because they require the assistance of a plumber; others can be sent to households with instructions for self-fitting.

For large-scale visit-and-fix projects, a package of water efficiency devices can be offered to each household. Some will be acceptable and practical to install in that particular household, whereas others will not. This will be decided on the visit to the household by the contract surveyor who will,

1) assess the suitability of each device for the household;
2) discuss the device with the householder;
3) fit the appropriate device(s); and,
4) leave full instructions and a telephone contact number.

The package of measures should involve several aspects of saving water in the household. For a comprehensive approach, areas of saving should include toilets, showers, taps, washing machines, outdoor water use and, possibly, leakage. These are the main areas where water is used and in some cases where that usage is increasing year on year. However, the disadvantage of this approach is that it may not be possible to disaggregate the savings and cost benefits accruing from each item.

For self-audit, the water company should choose a package that is easily fitted and where proven savings can be made.

As part of project planning, there needs to be an awareness of the long delivery times of some products, particularly if they need to be imported or branded for the water company. In addition, many products ordered in bulk will be delivered on pallets requiring a forklift for unloading. If the water company's stores are not near to the project location, there may be additional costs involved in the movement of materials or rental of local offices/stores.

A discussion follows on products associated with each area of savings.

4.1 Toilets

The approach taken will depend on whether the cistern is siphon or valve operated. For siphons, an initial check of cistern volumes should be made by the surveyor who may then need to carry out adjustments to ensure that volume is not greater than allowed by the Water Fittings Regulations or byelaws for Scotland. There should be a maximum water level line on the inside of the cistern to help the surveyor, but this is frequently not the case.

Each toilet should be assessed for suitability to have a cistern displacement or retrofit device fitted. Generally, the age of the toilet dictates the maximum allowable stored volume of the cistern:

- Before 1989: 9+ litres;
- 1989 to 1993: 7.5-9.5 litres dual flush;
- 1993 to 2000: 7.5 litres; and,
- After 2001: 6 litres.

There are three ways in which toilet flush volumes may be, depending on the age and suitability of the existing cistern:

1) Fit a retrofit device to convert the existing cistern to dual flush;
2) Fit a complete replacement cistern to convert to dual flush; or,
3) Fit a cistern displacement device.

To assess which of these options is most suitable the Water Fittings Regulations should be consulted, with particular reference to the type of toilet being converted. Generally, options 1) or 2) are felt to be more permanent and satisfactory than option 3).

Older cisterns, e.g. high-level cisterns, can be reduced the most, but expense and health and safety restrictions mean that these are less favourable for plumbers to change. Similarly, close-coupled WC's and slim line models impose restrictions.

For valve operated cisterns, a check should be made for leaks using either a dye or dry paper test.

4.2 Showers

An initial check of each shower should take place and the flow rate determined by using an appropriate test bag, of which there is a selection available.

Showers come in several different types, from instantaneous electric showers with average flow rates of around 4 to 6 litres per minute to pumped showers fed off hot water tanks that can deliver up to 30 litres per minute. Combi boilers and non-vented systems are becoming popular and these can deliver high flow rates to showers.

About 45 percent of households in the UK have an instantaneous electric shower and because the volume of water that needs heating limits flow rates, these devices cannot be improved for water efficiency. The UK and Ireland are unique as far as electric showers are concerned. Most countries do not have electric showers or low pressure systems making international comparisons of data very difficult.

All other showers can have their flow rate reduced by using a flow restricting device or by using a low flow showerhead – these restrict the flow by altering the spray pattern or by introducing air into the showerhead. An aerated showerhead seems to provide the best solution as it appears to deliver a higher flow than it actually delivers and so provides the user with the experience of a power shower, but with significantly less water. However, aerated showerheads will not necessarily work on gravity fed systems and need a pressure of at least one bar to function correctly.

4.3 Shower timers

As well as flow rates, two other parameters need considering:

1) durations of showers; and,
2) frequency of showering.

To help people limit showering durations, a shower timer can be used. These come in two types, either a sand timer set for a fixed duration or a digital alarm that the user can pre-set.

As for limiting the frequency of showering it is not felt as appropriate (unless switching from baths to showers) as this may be seen to be dictating lifestyles.

4.4 Washing machines

Washing machines have become much more water efficient over the past twenty years. AEG provided figures of average water usage of their machines, which twenty years ago were about 150 litres per use – whereas today these machines average about 50 litres per use, with the

most efficient machines using about 35 litres. See the Waterwise website (www.waterwise.org.uk) for a list comparing water use in all current washing machine models.

While washing machines have become more efficient, frequency of use has gone up dramatically, particularly over the past five to ten years (according to figures from water company surveys). It is therefore felt appropriate that the surveyor should offer an advice leaflet on washing machines and how to use them efficiently, with some sort of incentive for houses that are thinking of changing their machine. This could be in the form of a voucher to the customer that could be used when they are ready to purchase a machine. Vouchers can be partly funded by the manufacturer and partly by the water company.

4.5 Taps

An initial check of each tap should take place and dripping taps should have their washers replaced by the surveyor. Two options then exist to reduce the flow rate of taps:

1) Install a tap insert device into the tap – these do not fit all taps but are very effective in reducing flows without reducing the feel-good factor. Two types exist, aerated or spray; both are effective.
2) Fit a flow restrictor before the tap – this can only be fitted where relatively high pressure exists in the house.

The surveyor should assess which device, if either, is most appropriate and then fit it.

4.6 Leakage

Visual checks should be carried out both inside and outside the property, including examining storage cistern and toilet overflows and any leakage from toilet cistern drop valves and flappers. In addition, supply pipe leakage should be checked for visual leaks and, if the property is metered, the meter can be checked for movement when no water is being used in the house.

If appropriate, a leakage alarm should also be offered to the customer. This device attaches around the incoming water supply pipe and can be set to detect continuous water flows over 1- to 4-hour periods. These rely on having the incoming water main accessible.

4.7 Garden

For houses with gardens, water saving devices can be offered together with literature advising customers of how to be water efficient in the garden. Examples of good devices to offer customers include water butts and trigger hose guns (if no hosepipe ban exists in the customers' area).

4.8 Awareness raising

Conducting an audit provides a good opportunity for the delivery and explanation of water efficiency messages. Information can be provided to enable the consumer to make informed decisions about their water use, e.g. showering versus bathing. Consumption information can allow customers to benchmark their water use against other similar households. For metered customers potential financial savings can be explained and for all customers the energy and carbon impacts from reduced hot water use can be made known. Audits also provide an opportunity to engage children, and linking a domestic audit programme to a schools programme can help reinforce messages.

4.9 General

A list of products that can be used in audit programmes is being compiled on the Waterwise website at www.waterwise.org.uk. The list will be maintained and updated as new products become available.

4.10 Restrictions regarding products

Care needs to be taken that customers' expectations are managed, as various products are restricted in their use. In addition to the pressure and flow related restrictions described above, particularly in relation to showers and taps, there are other reasons that mean that a plumber will not wish to fit certain products. For taps and WC's, there can be a risk of cracking the basin or cistern, particularly if the sanitary ware is old. There may be circumstances where the theoretical potential for water saving is high, but the risk of unplanned remedial work is too great. Similarly, for health and safety reasons, it may not be possible to fit cistern displacement devices in high-level WC cisterns, but again these are the WC's with the highest flush volumes. In planning an audit project in an area where sanitary ware is likely to be old, consideration should be given at the planning stage as to what actions should be taken.

5. Customer issues

The success of a survey or audit is dependent on how the water company deals with the customers involved in the survey. If customers are brought in and involved in the survey with easy to read explanatory information or face-to-face visits, they will generally be much more cooperative and enthusiastic.

Publicity surrounding the survey or audit is also very important in explaining what benefits the water company and its customers will gain from the work. Most people are interested in information relating to domestic household water use and are very surprised by how much water is actually used. This lack of awareness extends to water resources availability in the UK.

A few customers are likely to be critical of the money collected from water bills being spent on the provision of devices that they did not want, and some may be confused by a commercial business trying to reduce sales of their product. Other customer issues relate to,

- mailings;
- feedback from customers;
- incentives to customers; and,
- guarantees on water saving devices.

Initial mailing involves writing an informative, carefully worded letter to groups of customers usually living in selected postcodes or DMAs (District Meter Areas). Follow up mailings relate to acceptance or non-acceptance of the house into the survey, and possibly inviting customers to share the results of the survey at its conclusion.

During the survey it is essential to collect information from customers. This information is of two types:

1) Information relating to the house, its occupants and their water using devices; and,
2) Feedback from the customers on how effective the water saving devices turned out to be.

Type 1 is discussed in sections 3.2 and 3.3.

Feedback from customers on the devices themselves (type 2) can be collected on forms or through telephone surveys, both/either following on after a suitable period post-installation. Such surveys can provide information about whether devices are still in use, how well they have performed, whether they have met customers' needs; and, the sustainability of the water savings.

The main problem here is getting customers to fill in and return forms. Some companies have found using customer incentives to be very beneficial for getting customer feedback. Incentives offered to customers range from free entry in a prize draw to small gifts or cash. The incentive can also be used to promote water efficiency messages. It is also good practice to provide feedback to the customers at the end of the project, to inform them of the water savings that have been achieved, and to demonstrate that as individuals they have made a difference. This can be useful in reinforcing the water efficiency messages given during the project, and to encourage further actions by the customers.

It is very important to decide who is responsible for the new devices from the outset of the project. Generally, the water company retains responsibility during the trial period with the customer being offered the option of retaining the devices (at their own risk) or reverting to their old devices at the end of the initial survey period (usually three to six months). Provision of a 24-hour emergency plumbing service may be required.

6. Contractors

Most water companies will want to engage contractors to carry out the main survey work that will also include the installation of devices.

6.1 Tendering process

Tendering will depend on the water company's procurement procedures. Generally, however, full details of the objectives and intended delivery methods need to be provided in order that clear and shared expectations exist between client and contractor, and to enable the contractor to accurately produce an overall cost of the project. Project management will be facilitated by the inclusion of detail at this stage. Topics to be considered for inclusion are,

- background to the project;
- objectives;
- timescales;
- audit process;
- mailing, customer details, property selection;
- data protection;
- office and storage requirements;
- availability of materials;
- database;
- ownership of data and intellectual property rights;
- training;
- staff clothing and identification;
- communications;
- code of conduct;
- progress meetings;
- guaranteed service agreements;
- customer concerns and complaints;
- quality assurance;
- data analysis and reporting;
- monitoring programme;
- follow up surveys;
- staffing;
- costing;
- criteria for tender assessment;
- reporting requirements; and,
- service level agreements.

6.2 Payment methods

Generally, payment methods will depend on how the contractor has been engaged. Many water companies have framework agreements with specific contractors for certain types of projects. Where this is the case, unit rates may already have been agreed and these will apply to an audit project. Where a specific tendering process has occurred the company will have had the choice of how to pay. The main issue with payment is which party bears the business risk. To the water company, a payment method closely linked to performance may be attractive, but care needs to be taken that this does not backfire by the contractor finding ways to increase their payments without delivering the full benefits of the audits. It also needs to be recognised that there are significant fixed costs associated with project management and initial set-up of the project. Payment for this element can be separated from the less certain plumbing and delivery costs.

6.3 Plumbers

Depending on the nature of the project, staffing requirements will vary. Where plumbing work is to be undertaken water companies will generally require the contractor's plumbers to be qualified in plumbing, to be registered under the National Water Hygiene Scheme, and to provide an out-of-hours service should remedial repairs be required.

6.4 Project management

Project management of water audit projects is the same as for other projects, but perhaps the main difference is that few contractors have any experience of previous water audit projects. This may affect their interpretation of project objectives or, if they have wrongly estimated how long various processes will take, they may look to recoup lost costs. However, first projects are likely to be seen as a loss leader that may positively affect the project.

The success of a project is dependent on contractor's performance. One company's experience has been that the take-up rate by customers for the same project has been variable depending on the marketing and staff management done by the contractor, rather than characteristics of the customers.

Clear objectives, targets, and milestones contribute to successful project management. Arrangements need to be made to ensure that data entry is quick, facilitating up-to-date information on progress.

6.5 Database

A well-designed database is essential for the efficient management of an audit programme. As well as controlling the customer elements (e.g. mailing, appointments, audit details), the database can be used for financial management, for ongoing estimation of water savings, and for weekly and final reporting. The project manager should be required to be able to analyse the database themselves in order to manage the project effectively and avoid unnecessary time delays in answering client queries. Careful checks need to be made to ensure that there are adequate data validation components, e.g. preventing ambiguous entry of dates (e.g. 1/4/07 versus 4/1/07) or the fitting of a water butt in a second floor flat. Fields should be well defined so that there can be no confusion caused by different users querying the database and producing different answers. Similarly, checks need to be made so that the final report returns the same numbers as the database.

It should be noted that the needs of the contractor may be somewhat different from those of the water company. For example, the main use of the database by the contractor is to view individual customers' records one at a time to make appointments or to enter data. For the water company there will be a requirement to select all or groups of customers in order to look at patterns.

7. Costs and benefits

The project should be designed in such a way as to enable a full cost-benefit analysis to be carried out when results become available. This will involve keeping detailed records of both internal and external costs as well as water savings from the project.

Examples of cost-benefit analyses are shown in the UKWIR 25 series of reports, which attempt to provide long run marginal costs for each project on the database. The main problem here is in scaling up the cost estimates of projects to represent a real situation rather than a one off project.

8. Other issues

There are many aspects not covered in this brief guide, including the timing of appointments, weekly reporting, assessing long-term sustainability, complaint handling, media and communications, economic analysis, evaluating success of components, assessing contractor performance, project review, and lessons learned. The UKWIR projects (WR25, WR25a and WR25b) address many of these aspects.

9. Results analysis

It is relatively easy to obtain quick savings figures from data, but it is strongly advised to make sure that data are complete and correct before commencing data analysis. This stage is termed quality control and can be a lengthy process. Part of this process involves looking for outliers and each one needs investigation to see if there are any particular circumstances that can explain the high or low level recorded, e.g. supply pipe leakage, holidays, etc. If in doubt, the house should be excluded from the sample, although this could seriously lower your sample size.

Data analysis then proceeds by comparing the results with the control sample and then by making any adjustments using questionnaire data. It is recommended that, after having heavily invested in the collection of data, adequate time is allowed by a skilled practitioner for this stage.

The calculated savings are dependent on the approach taken. Different results are likely to be obtained when comparing average consumption before and after, depending on time periods, e.g. a three month average before and after will likely be different from a two month average. The results are also dependent on the inclusion or exclusion of individual properties. Significant numbers of properties may end up being excluded because of logger failures or meter readings that indicate supply pipe leaks.

Further guidance is provided in the UKWIR projects WR25, WR25a, and WR25b reports on analysing water savings, sustainability of savings, and economic analysis.

In considering the cost effectiveness of a project, a decision needs to be made about whether the costs of monitoring should be included, and to what extent. For a research project, these costs can be significant compared with the costs of the actual audits themselves. For a rollout project, it can be argued that, based on a number of previous identical projects, the water savings can be taken as known and further measurement is not required. Alternatively, for a much larger scale project, monitoring can be completed on the same actual number of properties as for a moderately sized project (i.e. a smaller percentage of the total properties), with the same level of confidence. For comparisons between projects, it is useful if economies of scale can be taken into account by rebasing costs to a common number of properties. Such comparisons should also take into account differences in a whole range of potential explanatory factors such as demographics, and external influences such as the weather.

To help increase shared understanding, the project results should be entered into the WR25b database.

10. Report Writing

The project report should include sections on the following, as appropriate:

- Executive Summary
- Introduction
- Background
- Project Scope
  - The Area and its Composition / sample selection
  - Aims and Objectives
  - Project Management Team
  - Staff Training
  - Programme Schedule
- Programme Approach
  - Description of Audit Components
  - Delivery Technique
  - Promotion
  - Communications
  - Ensuring Uptake
  - Recording the Audit
- Database
  - Data Tables
  - Data Cleaning
  - Functionality

    - Validation
    - Errors
    - Training
    - Additional Properties
    - Database Issues
    - Results Quality Checks
- Project Results
    - Mailing
    - Customer Participation Trends including breakdowns such as metered/unmeasured
    - Process Timings
    - Water Savings
        - Savings by component/device
        - Savings by customer groups eg metered/unmeasured
        - Overall Savings
    - Customer Satisfaction
    - Additional Information/Advice
- Evaluation of Programme
    - Cost Benefits of Audit Components
    - Effect of Audit on Customer Behaviour and Perception
    - Project Successes
    - Project Limitations and Learning Points
- Conclusions
- Recommendations
- Appendices, e.g. letters, press releases, etc.

11. Conclusions

Water companies have already carried out many successful projects. This guide has summarised some of the main learning points that have been developed through these past projects, and had aimed to be an introductory guide on carrying out water efficiency audit programmes. The UKWIR 25 series of reports are recommended as further reading.

Appendix 1. Statistics of sample selection

All water efficiency pilot studies rely on sampling techniques. In essence, the study is set up to provide information about a population by using a sample to represent that population. The way in which the sample is selected, its size, and its constitution will have a significant effect on how it can be used to represent the population.

In the case of water company pilot studies, the population usually refers to its customer database, i.e. the houses and people in the area of supply of the water company. Sometimes it is enough to study only a part of the total population, e.g. metered customers or a specific water supply area within the water company. In such cases, an exact definition of the new population should be given at the outset of the project.

The problem then relates to estimating the value of a specified set of variables about the population by taking a sample from that population. Unfortunately, it is not possible to sample the whole of the population, which is the only way to be 100 percent accurate. The smaller the sample size the more cost effective the study; however, the less accurate are results. The art then is to balance cost and accuracy – and statistics can help in this process.

Statistical theory relies on assuming a normal distribution when dealing with sample data. Ninety-five percent of all the points in a normal distribution lie within two standard deviations of the mean. From this we can derive that there is a 95 percent probability that savings from a water company trial will apply to the whole population or, to put it another way, a saving in a water company trial is +/– 5 percent accurate.

Example *A water company trial yields a saving of twenty litres per person per day. Assuming the accuracy is +/– 5 percent, the yield will lie between 19 and 21 litres.*

This range is often referred to as a confidence interval.

In order to obtain the above calculation, several rules need to be applied:

1) The distribution should be normal;
2) samples should be selected at random; and,
3) the sample size should be sufficient to allow for assumptions.

In general, the confidence interval is inversely proportional to the square root of the sample size. So to get within a +/- 5 percent confidence interval requires a sample size of around 400 to 500 households.

The main complication comes with the way it is convenient for water companies to select samples in a pilot study. Although statistical theory relies on a random sample of houses, in practice it is more convenient to ‘cluster’ houses together for sample selection.

These clusters, which are usually in different areas within the water company, allow for easier access to houses when visits are required. It also allows for comparisons between areas. This process of clustering is known as stratification of a sample and can lead to greater sampling numbers being required in order to retain the same level of accuracy.

Appendix 2. UKWIR WR25 series of reports

Starting in 2000, work has been proceeding on a series of three projects designed to help water companies set up water efficiency research projects and to allow them to access previous projects undertaken by the Environment Agency and other water companies.

The reports are,

WR25	Best practice in water efficiency research
WR25a	Sustainability of water efficiency measures
WR25b	Framework for valuing the options for managing water demand

The WR25 project defined best practice in water efficiency research and provided water industry practitioners with robust guidance in planning and implementing water industry research. It includes guidance on project and risk management, project design, and statistical analysis.

The WR25a project collected data from numerous water efficiency research studies into an online database of information on the subject, including cost estimates of demand management in terms of long run marginal cost (LRMC). The LRMC values presented for a given activity varied widely, which reflected the inherent uncertainty in estimating these values.

The WR25b project was designed to develop a best practice framework for assessing the contribution of demand management to long term supply/demand balance planning. It also developed an online database of demand side measures, and developed a wider understanding for the improved use of economic analysis in considering the role of demand management in water resource planning and supply/demand balance.