Environment Agency

Towards water neutrality in the Thames Gateway

Modelling baseline, business-as-usual and pathway scenarios

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HM Government
Thames Gateway

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Steve Killeen

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Head of Science

Executive summary

Entec UK Ltd has been commissioned by the Environment Agency to explore the feasibility of moving towards ‘water neutrality’ in the Thames Gateway during the period to 2016, by modelling the demand for water in water resource zones within the Thames Gateway. The objectives include:

- establishing the current baseline for water demand;
- forecasting future water demand under a business-as-usual (BAU) scenario looking forward to 2016;
- designing and modelling the effects of several scenarios leading towards neutrality, taking into account costs (economic and carbon).

For the purposes of this study, water neutrality in Thames Gateway would be achieved if the total water used after new development was equal to or less than total water use in the Thames Gateway before the development.

Entec addressed these aims by estimating current (baseline) water demand and considering how demand might change under business-as-usual scenarios. The feasibility of achieving water neutrality was assessed through a series of scenarios measuring the impact of increased standards of water efficiency in new homes (through the Code for Sustainable Homes) and the retrofitting of water-efficient devices in existing housing. Water efficiency in non-households and the impact of compulsory metering and variable tariffs on household demand was also explored.

Carbon emissions associated with water supply and wastewater provision within the Thames Gateway, in the baseline year of 2005/06 and under the BAU and pathways scenarios to 2016, were quantified in terms of tonnes of CO_2e and in financial terms.

Baseline water demand

Total water demand in Thames Gateway in the baseline year of 2005-06 was assessed as 541 million litres per day (Ml/d).

Planned leakage repairs contributed 20 Ml/d to this estimate. Planned water company reductions in leakage to 2016 were excluded so that they would not constitute “easy wins” towards water neutrality. This resulted in an adjusted baseline of 521 Ml/d.

Approximately 90 per cent of the adjusted baseline demand within the Thames Gateway (461 Ml/d) was for public water supply purposes, with the remaining 60 Ml/d directly abstracted for non-public water supply purposes.

Unmeasured household consumption was the largest demand component within the adjusted baseline demand. This component made up 210 Ml/d or 40 per cent of the total. Non-household demand and adjusted leakage were the next largest components with 108 Ml/d (23 per cent) and 89 Ml/d (19 per cent) respectively, followed by non-public water supply abstractions at 60 Ml/d (11 per cent). Measured household demand accounted for 48 Ml/d (nine per cent).

Carbon emissions associated with the provision of water and the treatment of wastewater were estimated to be around 117,085 tonnes CO_2e per year.

Business-as-usual demand

The business-as-usual (BAU) scenarios forecast how demand for water would be likely to change over the period to 2016, without intervention to manage it. Two BAU scenarios were developed to reflect uncertainty over policy changes that might influence the uptake of water efficiency measures in new homes. These scenarios were an Upper Savings Scenario and a Lower Savings Scenario, reflecting more and less optimistic assumptions about the impact of changes in policy on water efficiency standards in new homes. Sensitivity analysis was also undertaken on the BAU forecasts by adjusting housing numbers by ±10 per cent.

Forecast demand grew from the adjusted baseline of 521 Ml/d to 563 Ml/d in the BAU Lower Savings Scenario. This increase of 42 Ml/d was the benchmark value used in the analyses of pathway scenarios. Sensitivity analysis of the BAU forecasts indicated an uncertainty range around this value of -6.6 Ml/d to +4.2 Ml/d.

The total estimated increase in demand from new households and new non-households was 44.5 Ml/d. These increases were offset by a decrease in demand from existing households of 2.3 Ml/d and a decrease of 0.2 Ml/d in demand from other minor water use components. The net result was a 42 Ml/d demand increase.

Carbon emissions increased by nine per cent above the baseline to about 128,000 tonnes CO_2e in 2016 under the BAU Lower Savings Scenario.

Pathways scenarios

Water neutrality could be achieved in a combination of ways, by:

- making new developments much more water-efficient;
- ‘offsetting’ new demand by retrofitting existing homes and other buildings with more efficient devices and appliances;
- expanding metering and introducing innovative tariffs for water use which would encourage households to use water more efficiently.

Seven pathway scenarios were developed using different combinations of these approaches. Five scenarios achieved water neutrality, one went beyond neutrality by 20 per cent and one only achieved a third of the savings needed to meet neutrality:

- Progressive Scenario – A step up from business-as-usual, reflecting the upper limit of what might be possible within current and future regulatory frameworks.
- Neutrality Scenario 1a – High retrofit. Emphasis on retrofitting in existing homes.
- Neutrality Scenario 1b – High retrofit with variable tariffs. Impact of variable tariffs used to dampen the need for high retrofit programmes.
- Neutrality Scenario 2a – Ambitious CSH. Ambitious aims for water efficiency in new homes through implementing higher levels of the Code for Sustainable Homes (CSH).
- Neutrality Scenario 2b – Ambitious CSH with variable tariffs. Variable tariffs used to dampen the effect of building to high CSH standards.
- Neutrality Scenario 3 – Composite scenario with variable tariffs. Assumes a less extreme approach to new and existing homes than the previous ‘a’ scenarios and explores the impact of constructing

new homes to a pcc standard that lies between CSH Level 3/4 (105 litres per head per day or l/h/d) and CSH Level 5/6 (80 l/h/d).

- Beyond Neutrality Scenario – Assumes maximum uptake of retrofit measures and a very ambitious programme for new homes, with all new homes assumed to reach Code Level 5/6 from 2013/14. Variable tariffs included.

Conclusions

Water neutrality is theoretically possible, and could be achieved in a number of ways. However, neutrality is an ambitious goal that will require much effort from all those involved.

Achieving water neutrality in Thames Gateway would cost between £127 million (Scenario 2b) and £181 million (Scenario 2a) (for households only). At the household level, the retrofit programme would cost between £135 and £154 per household (costs averaged across all existing homes). Cost per new household varies by much more, from £275 to £765 (costs averaged across all new households), depending on the neutrality scenario in question.

Compulsory metering is a fundamental requirement of achieving water neutrality. Variable tariffs are likely to provide metered households with additional incentives to reduce their demand for water through behavioural change. Variable tariffs are not a pre-requisite of neutrality but could significantly reduce the cost of achieving neutrality, by reducing the number of new homes that need to be built to the highest levels of the Code for Sustainable Homes.

Scenarios that assume more new households will be built to the highest standards of the Code for Sustainable Homes are more likely to achieve neutrality. In these scenarios, fewer existing households would need to be retrofitted to offset demand from new households. However, building high numbers of homes to the highest levels of the Code for Sustainable Homes would be expensive, because of the high cost of rainwater harvesting and/or grey water harvesting technologies.

Ambitious retrofit rates are required to achieve water neutrality. The retrofit rates assumed in the neutrality scenarios are achievable, but it may be more realistic to meet these rates by extending retrofitting beyond the Thames Gateway, but within the relevant water catchment/resource zones.

For areas outside of the Thames Gateway, if neutrality were to be pursued only through the household sector (and not include compulsory metering or the use of variable tariffs), between three and eight existing houses would have to be retrofitted to offset the demand from one new household.

The carbon analysis presented in this report shows marginal differences in emissions under the neutrality scenarios. Under these scenarios, emissions differ by less than 200 tonnes CO_2e per year, giving a difference in present value of approximately £1 million. This may reflect the limitations of the approach and data used in this study; a more detailed analysis using data specific to the Thames Gateway is recommended.

The results of this study should be interpreted with due consideration to the uncertainties within the data and the assumptions made. Further work is needed to quantify this uncertainty where possible.

Contents

1 Introduction

The Thames Gateway lies in an area of England where water resources are already stretched, particularly in dry years. Rainfall is relatively low compared to the rest of England, and many catchments are considered to be over-licensed or over-abstracted. At the outset of this project, approximately 165,000 new homes were planned for the Thames Gateway area between 2001 and 2016, representing the largest regeneration project in Europe. All things remaining equal, development of the Thames Gateway would likely lead to an increase in water use. However, a development of this scale and nature presents an excellent opportunity to implement sustainable planning and design principles to minimise the impact of the development on the water environment.

The concept of water neutrality is relatively new and at present there is no clear and commonly accepted definition, but for the purposes of this study, the following definition has been developed:

Water neutrality in the Thames Gateway would be achieved if the total water used after new development is equal to or less than total water use in the Thames Gateway before the development.

Entec UK Ltd was commissioned by the Environment Agency to explore whether water neutrality was feasible in the Thames Gateway, by modelling the demand for water in water resource zones within the Thames Gateway. The aims of the study were to:

- Establish the current baseline for water demand.
- Forecast future water demand under a business-as-usual (BAU) scenario looking forward to 2016.
- Design and model the effects of several scenarios leading towards neutrality, taking into account costs (economic and carbon). These scenarios included existing and possible future technical and policy measures such as water efficiency regulations for new homes; retrofitting options for existing buildings; water metering and variable tariffs. The influence of scale (such as household or community level) and development type (such as domestic or commercial property) were considered in terms of the measures available and the impact on costs.

This report outlines the analysis carried out and the results of the investigation, together with conclusions and recommendations.

In order to explore the feasibility of water neutrality, it is necessary to first determine the baseline water use and then forecast water use under business-as-usual scenarios. The baseline water use represents current levels of demand for water from existing housing, industry supplied by water companies, and other abstractors such as farmers.

The forecast water use in the BAU scenario is an estimate of how demand for water is likely to change without any interventions to manage this future demand above or beyond existing policy, behavioural or technological drivers. This forecast was made between 2005-06 and 2016 − the time when the Thames Gateway development is expected to be complete (Communities and Local Government, 2006a).

Two BAU forecasts were produced, reflecting uncertainty in the impact of existing and likely policy measures. The two scenarios were an Upper Savings Scenario where optimistic assumptions about level of uptake of water-efficient measures were adopted, and a Lower Savings Scenario (with less optimistic assumptions). The two scenarios formed opposite ends of a BAU range, with actual consumption expected to fall somewhere within the range.

Having established BAU demand forecasts, investigations were undertaken to assess the feasibility of different pathway scenarios that move towards water neutrality in the Thames Gateway. These scenarios explored how the growth in demand for water over the period could be reduced to as close to zero as possible.

Many measures could be implemented in the Thames Gateway to reduce water demand, each with different costs, practicality of implementation and carbon emissions. For the purposes of this study, these were simplified to represent three main outcomes:

Progressive	Representing the upper limit of what might be achieved by stepping up existing approaches to demand management.
Neutrality	Representing the options that could be implemented to achieve neutrality within the Thames Gateway.
Beyond Neutrality	Representing options reducing demand below the baseline level.

1.1 Structure of this report

Section 2 describes the types of water use considered in this study and presents some key types of data used in the analysis in later chapters.

Section 3 describes how ‘baseline water use’ (present water use) in the Thames Gateway was assessed, and presents the results of this analysis.

Section 4 outlines the analysis and estimation of demand under two business-as-usual scenarios spanning a range of optimistic and pessimistic assumptions about water use.

Section 5 considers the full range of measures that could be adopted as part of a water neutrality approach, based largely on the results of previous research. Assumptions on savings associated with the measures are discussed.

Section 6 presents the cost data used in the analysis. The section also highlights costs that have not been included in this study and the reasons for their exclusion.

Section 7 describes how the pathway scenarios were selected and the assumptions used to define the scenarios in terms of the number of households subject to different measures.

Section 8 presents the results of the scenario analysis in terms of costs and savings, broken down by the various measures considered.

Section 9 presents further analysis of the scenario results, including an assessment of average costs per household and number of existing retrofits required to offset each new household and non-household. Uncertainties in the results are also assessed here.

Section 10 provides a summary of the results and conclusions drawn from the study. Recommendations are also given.

Each of the sections includes an assessment of carbon emissions.

Appendices 1 to 8 include additional technical detail to support various sections and are referenced as appropriate. Appendix 9 is a glossary of terms.

2 Water use in the Thames Gateway

2.1 Introduction

This section describes the types of water use considered in this study and presents some of the key types of data used in the analysis in later chapters.

Water use in the Thames Gateway can be split into two broad categories: public water supply (PWS) and non-public water supply (non-PWS). The analysis presented in Section 3 shows that public water supplies account for about 90 per cent of the water used in the Thames Gateway. These two categories are described in the following sub-sections.

Section 2.4 describes the carbon assessment in this report in the context of the more comprehensive low carbon study being undertaken for Thames Gateway.

2.2 Public water supplies in the Thames Gateway

The Thames Gateway area is served by four water companies: Thames Water, Essex and Suffolk Water, Southern Water and Mid Kent Water. The water company supply areas are further sub-divided into areas known as water resource zones (WRZs). A WRZ is defined as the largest area over which all customers receive the same levels of service. It is the level at which all water companies discuss their water resource needs with the Environment Agency and the Water Services Regulation Authority (Ofwat).

Figure 2.1 illustrates the Thames Gateway area and location of water company WRZs. The Gateway area falls mainly within three WRZs:

- Essex Zone (Essex and Suffolk Water);
- London Zone (Thames Water);
- Medway Zone (Southern Water).

The Gateway area also falls within two other zones: Burham and North Downs, both part of Mid Kent Water.

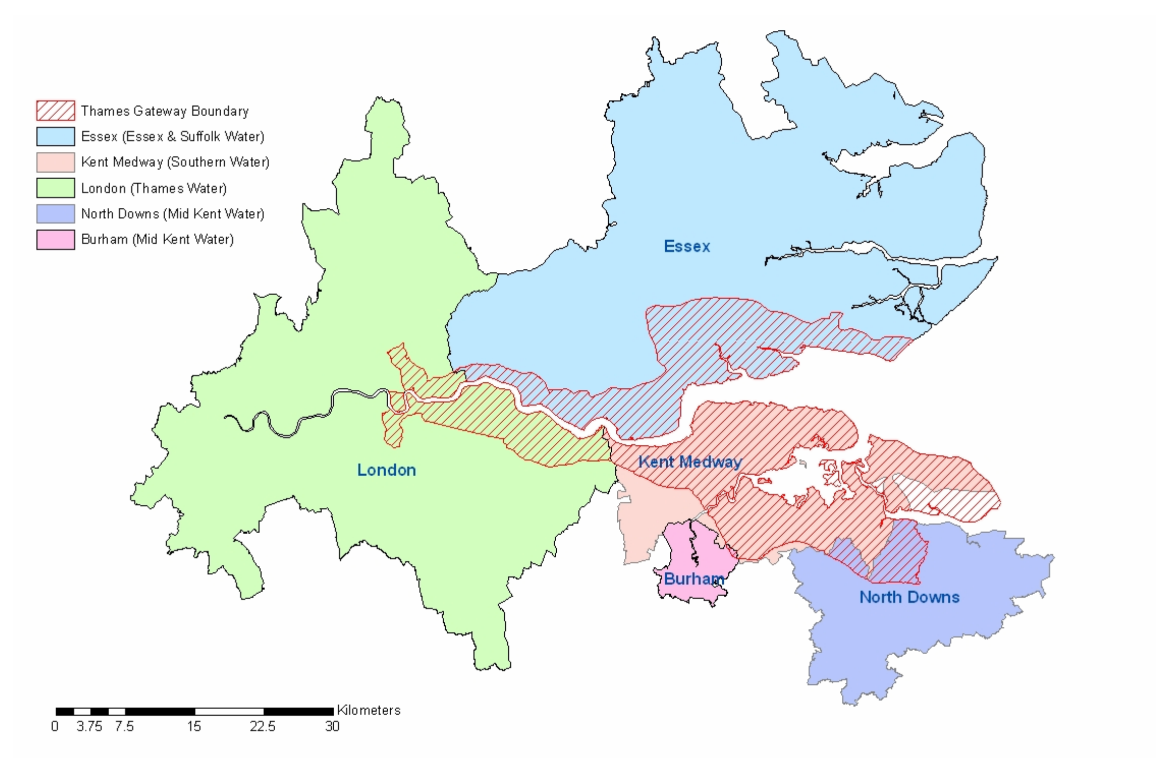

Figure 2.1: Water resource zones within the Thames Gateway

Water use is divided into a number of components that represent the main users of water, as follows:

- Unmeasured households – these are domestic households that are not billed on a metered basis. At present, water used by this group is generally the largest proportion of total water demand.
- Measured households – these are domestic households that are billed based on metered consumption. In this study, metered households includes households which opt to switch to a metered tariff, new households which are automatically metered and others, such as swimming pool owners and sprinkler users, who may be metered at the discretion of individual water companies.
- Measured non-households – non-households include all commercial, industrial and public sector buildings such as schools and hospitals. The majority of these premises are metered, therefore this category represents most of the non-household water use.
- Unmeasured non-households – a small proportion of non-households are not metered, usually because it is not cost-effective for the water company to do so.
- Leakage – leakage is classed as ‘water use’ in the way that water is accounted for by water companies, the Environment Agency and Ofwat. This component includes water lost from water company assets (such as distribution mains and service reservoirs) as well as ‘supply pipe losses’ from pipes connecting the water company network ‘in the road’ to the domestic plumbing system.

- Other minor components – a number of small components of demand have been included in this study. 'Water taken unbilled' includes water used for fire-fighting and some supplies to premises such as churches. Distribution system operational use (DSOU) is water used by the water company to maintain the supply system, either during normal operations or as part of mains rehabilitation works.

Other measures used in this study:

- Household numbers – water companies estimate household numbers and population forecasts based on data from local and regional government. The water company data used in this study includes an allowance for housing and population growth due to the Thames Gateway.
- Household consumption – this is commonly measured on the basis of per capita consumption (pcc), which is an estimate of how much each person in a household uses.
- Occupancy – occupancy rates in households have been used to estimate total population by multiplying this value by household numbers. The occupancy rate (referred to simply as 'occupancy') is also an important measure in determining household consumption. Per capita consumption tends to be inversely proportional to occupancy.
- Meter penetration – this is a measure of the proportion of households in a WRZ that are billed on a metered basis.

The following parameters were taken from water company PR04 submissions:

- WRZ pcc (2005/06) for measured and unmeasured households (for use with PR04 forecast metering penetration, 2005/06);
- WRZ occupancy rate (2005/06) for measured and unmeasured households (for use with PR04 forecast metering penetration, 2005/06);
- household meter penetration forecasts;
- non-household demand forecasts;
- total leakage (2005/06);
- water taken unbilled (2005/06);
- distribution system operational use (DSOU) (2005/06).

2.3 Non-public water supplies in the Thames Gateway

A large number of independent abstractions take place in the Thames Gateway area for non-household consumption. Such abstractions include water used for agriculture (for example, spray irrigation) and industry. These abstractions have been quantified and included in the total Thames Gateway baseline demand using the annual average actual abstraction data from 2000 to 2005 and licence values for independently supplied non-household demand within the Thames Gateway.

Some large non-PWS licensed abstractions in the Thames Gateway area are not taken into account in this study because they abstract from tidal reaches of river. Examples of this include power stations, the largest of which is licensed to abstract over 6,000 million litres per day (Ml/d) for cooling purposes. This study is concerned only with non-PWS licensed abstractions for freshwater, and not for tidal water.

2.4 Scope of the carbon assessment

The production, treatment and distribution of water and collection and treatment of wastewater require energy. Electricity generation through the burning of fossil fuels results in the emission of greenhouse gases. The additional water use and wastewater treatment from development in the Thames Gateway will likely result in an increase in greenhouse gas emissions (assuming that the additional energy will not be sourced from renewable energy sources that do not emit greenhouse gases).

A study being prepared for Government by consultants Arup and Turner and Townsend is assessing the potential for the Thames Gateway development to be low carbon. The study attempts to estimate emissions associated with water and wastewater provision to the Thames Gateway to 2050. This report does not assess the carbon emissions of water use in detail and the reader should refer to the low carbon study for detailed carbon assessments within the Thames Gateway.

This report primarily explores the potential for achieving water neutrality in the Thames Gateway. Water efficiency measures proposed in the later phases of this report will have the effect of reducing water use and some degree of wastewater treatment and will therefore have an impact upon carbon emissions. The actual impact on carbon emissions is likely to be highly variable. Although the volume of wastewater will be reduced, its concentration may increase. The carbon effect of treating more concentrated effluent will vary according to the individual treatment plant. In addition, some of the measures proposed may have their own energy requirements (for example, rainwater harvesting usually requires pumping) and will have embedded energy costs from their manufacture, transport and fitting which may or may not be greater than the embedded/construction energy of ‘standard’ infrastructure.

To assess the potential carbon impact of the measures proposed in this report requires the establishment of a baseline carbon emission, both in 2005/06 and in forecasts of demand under the BAU scenarios. This will allow comparison of carbon emissions from the proposed demand management scenarios with those of the BAU forecasts.

3 Baseline water use

3.1 Introduction

Baseline water use is the water used in the baseline year, in the Thames Gateway[1]. This section of the report describes how baseline water and associated carbon use has been estimated and presents the results of this analysis.

Most of the analysis focuses on estimating baseline water use from public water supplies (PWS - water supplied by the water companies). The analysis of baseline water use is described in Section 3.2, with the results presented in Section 3.3. The analysis of baseline carbon use associated with water use and disposal is presented in Section 3.4, with results presented in Section 3.5.

3.2 Analysis of baseline water use

This study relied extensively on water company data to estimate water use in the Thames Gateway area. All companies produced water resource plans (WRPs) as part of the periodic review process in 2004. Data taken from these plans is referred to as 'PR04' (Periodic Review for 2004) data. Water companies plan their water supply-demand balance over years that cover the April to March period (in line with the financial year), and report their performance annually over this period.

The baseline year was set as 2005/06, the most recent 'complete' year in the water companies water resource plans. The study used PR04 dry year annual average per capita consumption (pcc) forecast data for this year, with the exception of Thames Water. Thames Water updated its water resource plan in 2006 and this more recent data was used for this study. References to PR04 data within this document hereafter refer to 2006 data for Thames Water. Analysis was undertaken to establish that this was the most appropriate source of data for estimating demand. This analysis is presented in Appendix 1.

3.2.1 Proportioning of water use components

Figure 2.1 illustrated the geographical interaction of WRZs and the Thames Gateway region. Water companies produce a range of data on water use at a WRZ level; for our purposes, it was necessary to translate these data to the Thames Gateway region. The study used GIS tools to proportion certain elements of the data from the WRZs to the Thames Gateway, using Address Point data supplied by the Royal Mail.

Address Point data provided the location of individual households within the WRZs covered by the Thames Gateway area. This data was believed to include most flats and apartments. A comparison of existing households estimated by water companies revealed a difference of around one per cent, considered acceptable for this study. GIS software was then used to determine the proportion of households within each WRZ that were inside or outside the Thames Gateway area.

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[1] The baseline year is taken to be the year from April 2005 to March 2006, for the reasons given in Section 3.2.

3.2.2 Existing households

The total number of existing households within the Thames Gateway was calculated based on water company PR04 data, using Address Point data and GIS software. The proportion of measured and unmeasured existing households was estimated using metering penetration levels as forecast by the water companies in their final PR04 water resource plans. The number of measured and unmeasured houses and metering penetration levels for the base year are provided in Table 3.1.

Table 3.1: Households within the Thames Gateway (2005/06)

Water resource zone	Existing total households (000s)	Existing measured households (000s)	Existing unmeasured households (000s)	Metering penetration %
London	220.4	38.0	182.4	17
Kent Medway	180.0	39.7	140.2	22
Essex	209.0	72.8	136.2	35
North Downs	3.3	1.2	2.1	37
Burham	0.75	0.24	0.51	32
Total	613.4	152.0	461.4	25

Total domestic consumption was calculated by applying the WRZ measured and unmeasured pcc and occupancy rates (shown in Table 3.2) to the estimated number of measured and unmeasured existing homes in the Thames Gateway.

Table 3.2: Measured and unmeasured pcc and occupancy information

Water resource zone	Unmeasured household occupancy (persons per household)	Measured household occupancy (persons per household)	Unmeasured household pcc (litres per person per day)	Measured household pcc (litres per person per day)
Burham	2.44	2.03	173.7	154.3
North Downs	3.00	2.81	174.6	153.4
Kent Medway	2.66	1.84	173.7	170.8
London	2.52	2.13	169.6	164.1
Essex	2.81	1.95	172.1	151.8

3.2.3 Leakage

Approaches to leakage analysis

Water companies forecast how they will manage leakage over time, in line with regulatory requirements to reach and maintain an economic level of leakage (ELL). Thames Water's leakage forecasts for the London WRZ include leakage reductions to meet their ELL target in this zone. All other water companies in the Gateway operate approximately at or below the ELL.

To reflect the exemplar nature of the Thames Gateway development, the forecast reduction in leakage in the Thames Gateway part of London WRZ to meet ELL was excluded. This meant that only leakage reductions that went beyond the levels in water company forecasts at the end of the study period (2015/16 forecast leakage value) would be counted as a measure to achieve water neutrality in Thames Gateway.

The baseline section presents a forecast baseline water use, including leakage values in the water company's 2005/06 forecasts, and an adjusted forecast baseline water use with leakage reduced to the 2015/16 forecast level. Therefore, any forecast leakage reductions already planned by water companies within the study period would not be counted towards reaching water neutrality. This approach was agreed for two reasons:

- Firstly, the numbers in question were relatively arbitrary. This study used forecast estimates of water put into supply from water companies, which did not necessarily reflect the actual situation. To count the forecast leakage reductions planned by one water company would overlook the fact that other water companies were maintaining leakage at or below their respective ELL rates.
- Secondly, there was the issue of transferability of the study's findings to other parts of the country. Thames Gateway has higher-than-typical leakage levels relative to the ELL (due in part to the difficulties of leakage management in London and Thames Water not operating at or below the ELL in London WRZ), so easy wins against a water neutrality target would be possible through leakage reduction. This would not necessarily be the case in other parts of the country.

The adjusted baseline water use was used as the first year in the BAU scenario.

Leakage estimation methods

Leakage in the four Kent and Essex zones (all zones except for London) were calculated using WRZ leakage totals for 2005/06 in the PR04 forecasts. The forecasts were proportioned using the property numbers approach described in Section 3.3.

Thames Water has provided leakage data for 2005/06 specifically for the area of the London WRZ within the Thames Gateway, and these data were used as a leakage estimate in the London WRZ portion of the Thames Gateway. This approach was adopted for the London WRZ because of the significant variation in leakage levels in different areas of the zone.

3.2.4 Minor components

Proportioning factors were also used to estimate the proportion of water taken unbilled and distribution system operational use (DSOU). These were both minor components of demand, representing approximately 1.4 per cent of total water company demand.

3.2.5 Non-household demand

Non-household PWS demand includes demand from all buildings other than homes, such as schools, hospitals, offices and commercial premises. Current non-household demand within the Thames Gateway was based on the 2005/06 PR04 forecast.

However, total non-household demand often comprises a small number of customers who consume very large volumes of water, along with many customers consuming much smaller volumes of water. This means that proportioning total non-household demand purely on a geographical or customer-number basis may be inaccurate. In order to improve understanding of non-household demand within/outside the Gateway area, additional information was collated, where available, from each water company:

- The 10 largest non-household customers within the Thames Gateway area for Essex and Kent Medway WRZs.
- Non-household demand estimates for 2005/06 specifically for the area of Thames Water's London zone within the Thames Gateway.

For Essex and Kent Medway WRZs, total consumption of the 10 largest users within the Thames Gateway was removed from the PR04 non-household consumption forecast. The remainder was proportioned to the Gateway area using geographical area proportioning factors and consumption from the 10 largest users added back in[2]. This approach was deemed to provide a good estimate of non-household demand in the Thames Gateway part of these WRZs, as the large users in these areas represented a significant proportion of total non-household demand.

Thames Water provided a non-household demand specifically for the area of the London WRZ within the Thames Gateway for the 2005/06 report year. This was useful given the high numbers of non-households in this WRZ, and provided a much more accurate estimate of non-household demand in this area.

The two Mid Kent Water zones, Burham and North Downs, had no additional information beyond the PR04 2005/06 forecast as these zones cover only a small proportion of the Gateway area. Further information would therefore be unlikely to have a significant impact on the total demand.

3.2.6 Non-PWS demand

Water company demand represents the majority of water taken (abstracted) from the environment. Water not abstracted for public water supplies (PWS) has also been considered in this study. This 'non-PWS' demand is based on actual abstractions from the environment, using data supplied for the period 2000 - 2005 by the Environment Agency.

3.3 Baseline water use results

3.3.1 Baseline water use using 2005/06 leakage estimates

Baseline demand results based on forecast (actual) leakage estimates for 2005/06 are summarised in Table 3.3 and shown in Figure 3.1.

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[2] Identification of large non-household customers could have been based on an alternative measure, such as the largest customers that represent a certain percentage of total non-household demand (for example, 60 or 70 per cent). However, the 'top 10' approach was simpler for the water companies to implement and would be likely to give similar results to any other method.

Table 3.3: Baseline water use in Thames Gateway using 2005/06 leakage values

Zone	PWS (Ml/d)	PWS (%)	Non-PWS (Ml/d)	Non-PWS (%)	Total (Ml/d)	Total (%)
Burham	0.4	0.1	0.0	0.0	0.40	0.1
North Downs	2.6	0.5	0.0	0.0	2.6	0.5
Kent Medway	122.2	22.6	43.5	8.0	165.8	30.7
London	206.0	38.1	13.6	2.5	219.6	40.6
Essex	149.3	27.7	2.8	0.5	152.2	28.2
Total	**481.3**	**88.9**	**60.0**	**11.1**	**541.3**	**100.0**

Table 3.3 shows that the total forecast demand for water is approximately 541 million litres per day (Ml/day), based on forecast leakage estimates for 2005/06. Figure 3.1 shows that demand for public water supplies predominate in all three main WRZs in the Thames Gateway; however, non-PWS demand makes up over 25 per cent of total demand in Kent Medway – significantly more than in London or Essex WRZs.

Figure 3.2 contains a range of information, including summary statistics for Thames Gateway and the WRZs. For example, the total baseline population in Thames Gateway is estimated to be just over 1.5 million, and there are an estimated 613,000 households in the study area. Average per capita consumption (pcc) is similar in all WRZs, but varies from a low of 167 litres per head per day (l/h/d) in the Essex WRZ, to a maximum of 173 l/h/d in the Kent Medway WRZ. The percentage of household properties that are metered also varies considerably between WRZs from a low of 17 per cent in London WRZ to a maximum of 37 per cent in North Downs. This information is relevant to the baseline situation, regardless of whether actual or adjusted leakage is considered (although the values of total demand in Figure 3.2 will vary depending on the approach to leakage).

For reference, further information on historic pcc and the percentage of properties metered are provided in Appendix 2.

3.3.2 Baseline water use using 2015/16 leakage estimates

Baseline demand results based on adjusted leakage estimates for 2015/16 are presented in Table 3.4. These adjusted baseline values are used as the basis for analysis from this point on.

Table 3.4: Adjusted baseline water use in Thames Gateway using 2015/16 leakage values

Zone	PWS (Ml/d)	PWS (%)	Non-PWS (Ml/d)	Non-PWS (%)	Total (Ml/d)	Total (%)
Burham	0.4	0.1	0.0	0.0	0.4	0.1
North Downs	2.6	0.5	0.0	0.0	2.6	0.5
Kent Medway	122.4	23.5	43.5	8.3	165.9	31.8
London	186.9	35.9	13.6	2.6	200.5	38.5
Essex	149.0	28.6	2.8	0.5	151.8	29.1
Total	**461.2**	**88.5**	**60.0**	**11.5**	**521.3**	**100.0**

Table 3.4 shows that total adjusted baseline demand in the Thames Gateway is estimated to be around 521 Ml/d, which is 20 Ml/d lower than the forecast demand (Table 3.3). Of the 521 Ml/d, only 60 Ml/d (11.5 per cent) is for non-PWS purposes. The majority of water abstracted is thus for PWS purposes. In terms of geographical spread, over 99 per cent of water use (both PWS and non-PWS) is in the London, Kent Medway and Essex WRZs. Less than one per cent of demand is in the Burham and North Downs WRZs of Mid Kent Water.

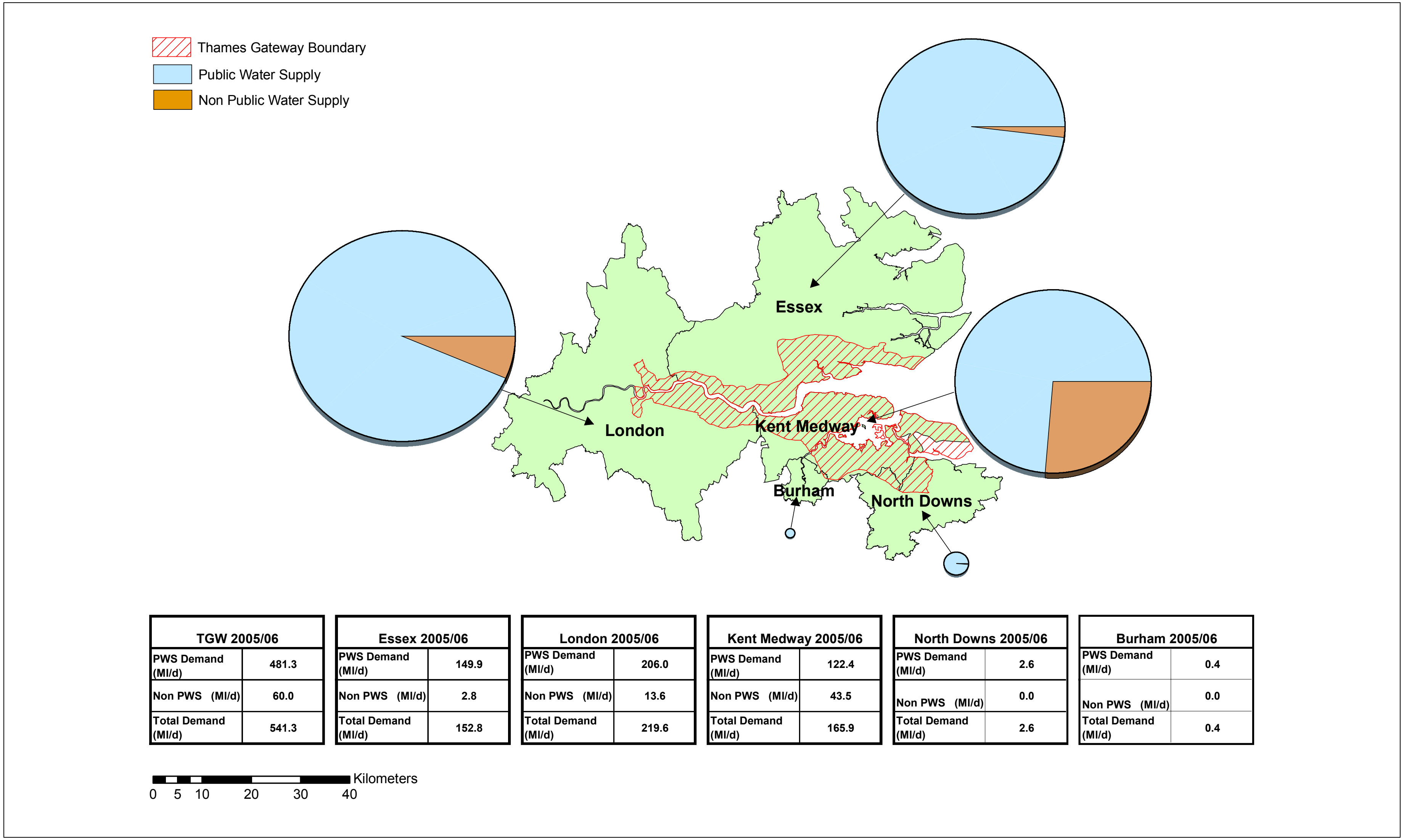
A further breakdown of the PWS component of total adjusted baseline is presented in Figure 3.3. Table 3.5 shows data from both the PWS and non PWS. The data in Table 3.5 show that of the total water demand in the Gateway, approximately 50 per cent is from household PWS customers (nine per cent from measured customers and 40 per cent from unmeasured ones). Non-household water use accounts for approximately 20 per cent of total water use and leakage accounts for around 17 per cent of total water use. Eleven per cent of demand is for non-PWS. Under the adjusted baseline, leakage in the Kent Medway and Essex WRZs accounts for approximately four per cent of total demand each. Leakage in Thames Water's London WRZ accounts for about nine per cent of total demand in the Gateway.

Table 3.6 shows the components of PWS demand by WRZ in the Thames Gateway area in 2005/06, and as a percentage of total PWS demand (excluding non-PWS demand). The majority of PWS demand is for households, with the bulk of this being for unmeasured households.

Over 40 per cent of PWS demand in the Thames Gateway is in the London WRZ. This reflects both the concentration of household and non-household properties in this WRZ and the higher level of leakage in Thames Water's supply area. The Essex and Kent Medway WRZs account for around a third and a quarter of PWS demand respectively. Mid Kent Water's two WRZs account for less than one per cent of PWS demand in the Thames Gateway.

Well over half (60 per cent) of the PWS demand is from households, with nearly a quarter (23 per cent) from non-households. Adjusted leakage values make up nearly 20 per cent, with the remainder (1.4 per cent) from the minor components.

Figure 3.3 presents a graphical illustration of these data. Figure 3.4 shows the location of non-PWS abstractions in the Thames Gateway area and indicates the relative sizes of average abstractions at these sources over the period 2000 to 2005 (used as a proxy for 2005/06 demand). The majority of abstractions are less than 1.5 Ml/d. However, a small number of licences account for around 80 per cent of the non-PWS. Abstraction under only six of the licences exceeded 2.0 Ml/d over that period, and together these account for around 48 Ml/d.



TGW 2005/06	
PWS Demand (Ml/d)	481.3
Non PWS (Ml/d)	60.0
Total Demand (Ml/d)	541.3

Essex 2005/06	
PWS Demand (Ml/d)	149.9
Non PWS (Ml/d)	2.8
Total Demand (Ml/d)	152.8

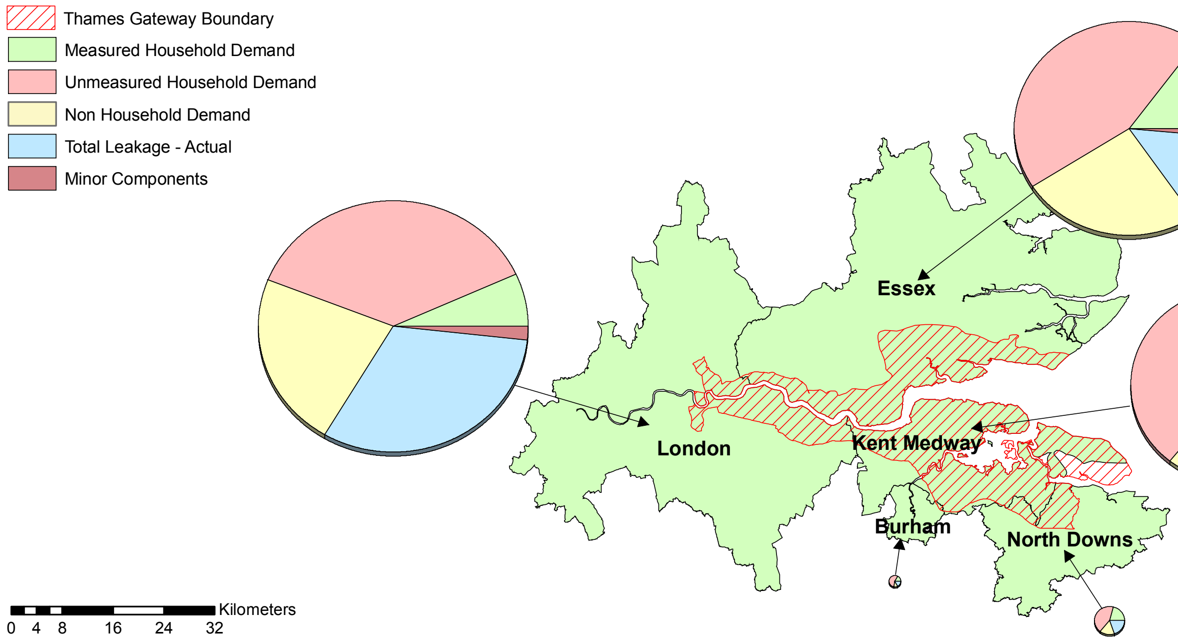
London 2005/06	
PWS Demand (Ml/d)	206.0
Non PWS (Ml/d)	13.6
Total Demand (Ml/d)	219.6

Kent Medway 2005/06	
PWS Demand (Ml/d)	122.4
Non PWS (Ml/d)	43.5
Total Demand (Ml/d)	165.9

North Downs 2005/06	
PWS Demand (Ml/d)	2.6
Non PWS (Ml/d)	0.0
Total Demand (Ml/d)	2.6

Burham 2005/06	
PWS Demand (Ml/d)	0.4
Non PWS (Ml/d)	0.0
Total Demand (Ml/d)	0.4

Figure 3.1: Baseline actual demand by WRZ split into PWS and non-PWS components



	TGW 2005/06 Actual	Essex 2005/06 Actual	London 2005/06 Actual	Kent Medway 2005/06 Actual	North Downs 2005/06 Actual	Burham 2005/06 Actual
Population Total	1,523,379	524,439	540,833	446,672	9,702	1,732
Household Total	613,398	208,998	220,384	179,951	3,314	751
Total PWS Demand (Ml/d)	481.3	149.9	206.0	122.4	2.57	0.40
Average PCC (l/h/d)	169.3	166.6	168.8	173.3	167.01	168.30
Household Metering %	25%	35%	17%	22%	37%	32%
Non PWS (Ml/d)	60.0	2.8	13.6	43.5	0.03	0.00
Total Demand (Ml/d)	541.3	152.8	219.6	165.9	2.60	0.40

Figure 3.2: Baseline actual demand by WRZ (pie charts exclude non-public water supply)

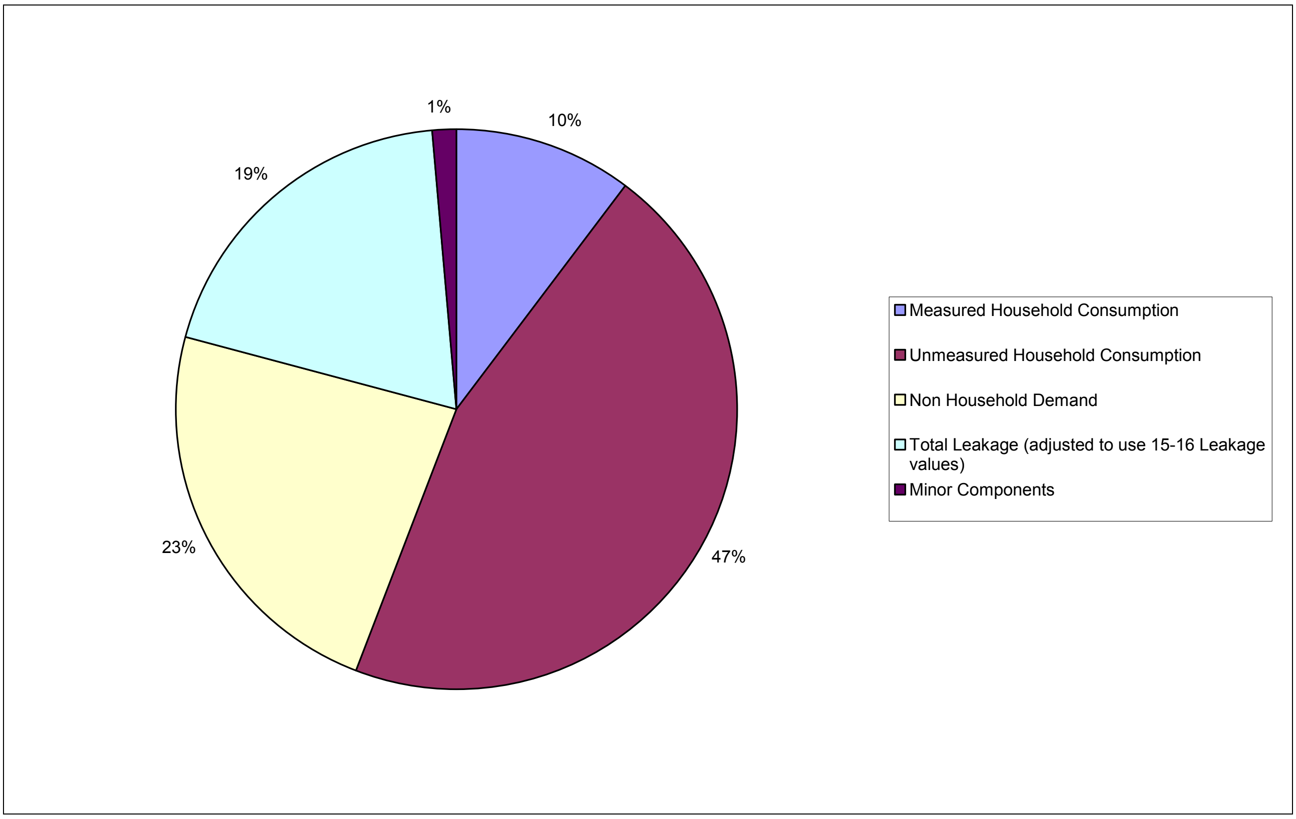


Figure 3.3: Baseline PWS demand for Thames Gateway area split by demand components (leakage adjusted to 2015/2016)

Table 3.5: Thames Gateway adjusted baseline demand (2005/06) expressed in Ml/d and as a percentage of total demand

Water resource zone	Measured household consumption Ml/d	Unmeasured household consumption Ml/d	Non-household demand Ml/d	Total leakage Ml/d	Minor components Ml/d	PWS total demand Ml/d	Non-PWS 00-05 average Ml/d	Total baseline demand Ml/d
Burham	0.07	0.22	0.04	0.07	0.00	0.40	0.00	0.4
North Downs	0.53	1.09	0.42	0.49	0.02	2.55	0.00	2.6
Kent Medway	12.49	64.90	23.06	20.91	1.04	122.39	43.50	165.9
London	13.32	77.96	44.81	47.47	3.38	186.94	13.60	200.5
Essex	21.51	65.88	39.24	20.25	2.09	149.0	2.80	151.8
Thames Gateway	**47.93**	**210.04**	**107.56**	**89.18**	**6.53**	**461.24**	**60.01**	**521.25**

	Measured household consumption (%)	Unmeasured household consumption (%)	Non-household demand (%)	Total leakage (%)	Minor components (%)	PWS total demand (%)	Non-PWS 00-05 average (%)	Total baseline demand (%)
Burham	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
North Downs	0.1	0.2	0.1	0.1	0.0	0.5	0.0	0.5
Kent Medway	2.4	12.5	4.4	4.0	0.2	23.5	8.3	31.8
London	2.6	15.0	8.6	9.1	0.6	35.9	2.6	38.5
Essex	4.1	12.6	7.5	3.9	0.4	28.6	0.5	29.1
Thames Gateway	**9.2**	**40.3**	**20.6**	**17.1**	**1.2**	**88.5**	**11.5**	**100.0**

Table 3.6: PWS components of Thames Gateway adjusted baseline demand (2005/06) expressed in Ml/d and as a percentage of PWS demand

Water resource zone	Measured household consumption Ml/d	Unmeasured household consumption Ml/d	Non-household demand Ml/d	Total leakage Ml/d	Minor components Ml/d	PWS total demand Ml/d
Burham	0.07	0.22	0.04	0.07	0.00	0.40
North Downs	0.53	1.09	0.42	0.49	0.02	2.56
Kent Medway	12.49	64.90	23.06	20.91	1.04	122.39
London	13.32	77.96	44.81	47.47	3.38	186.94
Essex	21.51	65.88	39.24	20.25	2.09	148.96
Thames Gateway	**47.93**	**210.04**	**107.56**	**89.18**	**6.53**	**461.24**
	Measured household consumption (%)	**Unmeasured household consumption (%)**	**Non-household demand (%)**	**Total leakage (%)**	**Minor components (%)**	**PWS total demand (%)**
Burham	0.0	0.0	0.0	0.0	0.0	0.1
North Downs	0.1	0.2	0.1	0.1	0.0	0.6
Kent Medway	2.7	14.1	5.0	4.5	0.2	26.5
London	2.9	16.9	9.7	10.3	0.7	40.5
Essex	4.7	14.3	8.5	4.4	0.5	32.3
Thames Gateway	**10.4**	**45.5**	**23.3**	**19.3**	**1.4**	**100.0**

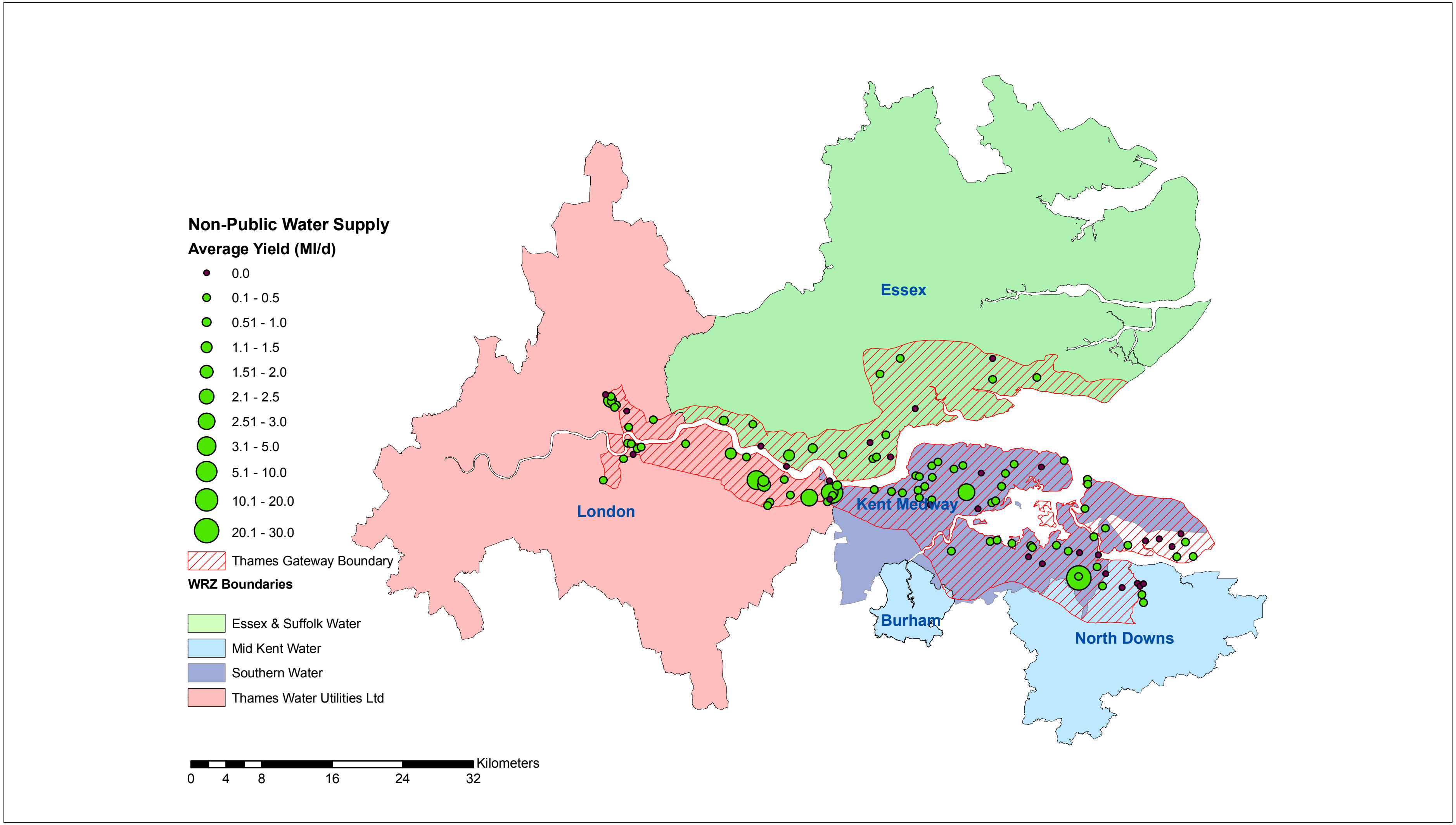


Figure 3.4: Non-PWS abstractions in the Thames Gateway

3.4 Baseline carbon assessment

Limited data is available on carbon emissions for water companies. Water UK has published carbon dioxide equivalents (CO_2e) emissions for water and wastewater provision (Water UK, 2006).

The national average figures are:

- tonnes of CO_2e to supply one million litres of water: 0.289 tonnes CO_2e;
- tonnes of CO_2e to treat one million litres of sewage: 0.406 tonnes CO_2e.

These figures may be skewed by the increased pumping requirements of Dwr Cymru Welsh Water and Scottish Water, due to the topographic nature of their supply areas. It was intended to use data specific to the supply of water and wastewater services in the Thames Gateway area, and ideally at the WRZ level. However, information on carbon emissions published by water companies in the Thames Gateway area was limited and consistent sets of data to compare companies were not available.

Since information for each company was not readily available, national average figures were used; it is therefore possible that carbon emissions were over-estimated by this study. As this is not a detailed study of carbon emissions and is aimed at assessing the relative emissions under different demand management scenarios, the actual emissions factors are to some extent less relevant than they would be for a study quantifying carbon emissions in detail. What is important is to establish a current baseline carbon emission assessment and a consistent forecast from which comparisons under different demand management scenarios can be made.

It was assumed that there would be no further energy requirements to supply or treat PWS within the home under the baseline and business-as-usual scenarios. Demand management measures (such as rainwater harvesting and grey water recycling) would have a separate energy requirement for pumping and treatment, of which the latter could be significant for grey water systems. This was addressed within the water neutrality pathway scenarios. The energy required to heat water in the home was not considered. It was expected that a reduction in domestic water use would lead to some reduction in household energy use.

Emissions associated with non-PWS were more uncertain. Emissions would be dependent on the methods and volumes of abstraction and the levels of treatment required by each abstractor. For example, a large abstraction from a deep borehole would likely require more pumping (and thus more electricity) than a surface water abstraction of small volume. There was also uncertainty over wastewater treatment requirements. Some non-PWS abstractions are consumptive (such as spray irrigators) and therefore no wastewater treatment is required. Other non-PWS return wastewater to sewer, and this would be taken into account indirectly by applying the national average energy requirements to treat one million litres of sewage. Some large industrial non-PWS abstractors might have their own wastewater treatment facilities. Due to these uncertainties, no account of carbon emissions from non-PWS water supply was undertaken.

3.5 Baseline carbon results

Using the national average greenhouse gas emissions for water and wastewater services, the following carbon emissions were calculated for the Thames Gateway:

Emissions from clean water provision	48,687 tonnes $C0_2$e/year
Emissions from wastewater provision	68,398 tonnes $C0_2$e/year
Total emissions	117,085 tonnes $C0_2$e/year

3.6 Key points

3.6.1 Assumptions

This section considered baseline water use in Thames Gateway. Water company data on PWS for 2005/06 was used to estimate this baseline water use alongside abstraction data from the Environment Agency for non-PWS demand.

Water companies analyse PWS data on the basis of water resource zones (WRZs). Most data from WRZs were proportioned to the Thames Gateway area using Address Point data and GIS analysis. The exceptions to this were non-household data, which took account of the location of the largest users in the area.

Two approaches to leakage were taken in this study. One version of baseline demand included water company estimates of current levels of leakage. However, leakage was excluded from the ‘adjusted’ baseline demand and all subsequent analysis of demand in this study. This approach was adopted because leakage in Thames Gateway is higher than it should be and the inclusion of leakage reductions in later analyses would skew the analysis of water neutrality.

3.6.2 Results

Actual demand for water in Thames Gateway is 541 million litres of water per day (Ml/d) in the baseline year (2005/06). Adjusted baseline demand (taking account of planned leakage reductions) is 521 Ml/d.

Nearly ninety per cent of the water used is for public water supplies (PWS). The remainder is made up of direct abstractions, mainly for agricultural or industrial use.

There are about 613,000 existing households in Thames Gateway, with a total population of just over 1.5 million people. Twenty five per cent of households pay for their water supply based on metered usage (they are metered households). The remainder are unmetered.

Households use 57 per cent of PWS; 23 per cent is used in non-households, and leakage represents 19 per cent of PWS.

Average per capita consumption in Thames Gateway is 169 litres per person per day.

Carbon emissions from the supply of this water and the treatment of related wastewater are estimated to be just over 117,000 tonnes $C0_2$e per year.

4 Business-as-usual scenarios

4.1 Introduction

Business-as-usual (BAU) scenarios were used to estimate how demand for water was likely to change without any interventions to manage this future demand above or beyond existing policy, behavioural or technological drivers. This forecast was made between 2005-06 and 2016, the time when the Thames Gateway development would be expected to be complete (Communities and Local Government, 2006a).

Two BAU forecasts were produced, reflecting uncertainty in the impact of existing and likely policy measures. The two scenarios were an Upper Savings Scenario with optimistic assumptions about the uptake of water efficiency measures and a Lower Savings Scenario (with less optimistic assumptions). In line with the precautionary principle, the latter scenario is referred to in the results, unless stated otherwise.

The business-as-usual scenarios only considered changes in demand from public water supplies. Non-public water supply abstractions were assumed to remain constant throughout the planning period. This assumption was based on trends in the annual abstraction data which, despite fluctuations in the annual abstracted totals, did not show a significant increase or decrease in the average trend over the analysed period of 2000 to 2005.

Section 4.2 considers water use in existing properties, including existing households and non-households. Section 4.3 considers water use in new properties to be constructed during the study period. Again, this analysis is divided into new households and new non-households, and includes a section on how the Olympic Games will affect demand for water in the Thames Gateway. Section 4.4 considers leakage and the other minor components of PWS demand.

4.2 Water use in existing properties

4.2.1 Forecast water use in existing households

To forecast water use for existing households, the following information was used:

- Number of existing properties for each WRZ in the Thames Gateway at the base year (taken from the baseline demand estimation).
- Unmeasured and measured per capita consumption (pcc) figures as forecast in PR04 from 2005/06 to 2015/16.
- Unmeasured and measured occupancy rates as forecast in PR04 from 2005/06 to 2015/16. The weighted average rates for total households as forecast by the water companies (2.42) was slightly higher than the average rate specifically for the Thames Gateway region provided by CLG (2.23), based on 2003 household projections. The implications of using the water company occupancy forecast instead of the CLG forecast are discussed in Section 9.5.2.

- The annual forecast rate of existing households switching from an unmeasured to a measured supply by WRZ from 2005/06 to 2015/16 (as illustrated in Table 4.1).

This approach assumed that all existing homes used the estimated WRZ average measured and unmeasured pcc and occupancy rates. This was a simplification, because the average measured household pcc forecast reflected a number of types of metered household customers[3]. However:

- It was not possible to account for the consumption rates of different metered groups using readily available data (which was the only viable approach within the project timescales).
- The effect of this was considered to be small and likely to have a negligible impact on demand.

Table 4.1: Percentage of households metered within the Gateway (from WRP data)

Zone	2005/06	2009/10	2015/16
Burham	32%	34%	40%
North Downs	37%	46%	60%
Kent Medway	22%	30%	40%
London	17%	21%	39%
Essex	35%	42%	49%
Total Thames Gateway	**21%**	**25%**	**41%**

4.2.2 Forecast water use for existing non-households

The forecast water use from existing non-households was based on PR04 demand forecast data proportioned to the Thames Gateway. Existing non-household demand was calculated for each year of the planning period with the same method used in the baseline demand, taking account of the large users identified at that stage of the analysis. Future demand from these large users was assumed to be static over the planning period, based on anecdotal evidence from the two water companies concerned regarding recent trends in non-household water use. This was thought to be the most accurate way of addressing this element of non-household demand, as detailed information required to predict changes in the consumption of individual non-household properties was not readily available.

4.3 Forecast water use in new properties

Water company plans include forecasts of water use from new housing growth. We removed new housing growth from the water companies' PR04 forecasts and replaced it with forecasts of water use based on the latest Thames Gateway housing trajectories from Communities and Local Government (CLG).

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[3] That is, households opting for a meter, new properties that are automatically metered and properties that may be selectively metered by water companies (for example, based on swimming pools or sprinklers).

4.3.1 Forecast water use in new households

New homes projections

New homes projections were provided by CLG as estimated annual growth by local authority. The projections were based on the Regional Spatial Strategies and the best available information at the time (Summer 2007) . These data represent approximately 165,500 new houses in the Thames Gateway area.

This total relates to the construction of new homes over a 15-year period from 2001 to 2016. Of this total, it was estimated that almost 32,500 had been built by 2006 (based on CLG figures), leaving a further 133,000 to be completed in the Thames Gateway by 2016. Past completions were therefore assumed to be included in the existing households which made up the 2005/06 baseline demand.

To allow for uncertainty in the number of household completions by 2016, a sensitivity analysis of ±10 per cent was applied to the CLG figures. New housing was allocated to WRZs based on the location of local authorities within the zones. The distribution of new homes was assumed to be spread evenly across the local authorities.

The growth rates by region and allocation of these to WRZs is presented in Table 4.2. Figure 4.1 and Figure 4.2 present the housing numbers graphically.

Table 4.2: Estimated household growth within the Thames Gateway by sub-region

County	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
London	7,374	10,617	12,069	11,598	10,948	7,944	7,475	6,730	6,411	5,505	**86,673**
Kent	3,378	3,235	3,460	2,263	2,417	2,023	1,998	1,773	1,723	1,730	**24,000**
Essex	2,029	2,475	2,906	2,700	2,540	1,955	1,955	1,955	1,955	1,955	**22,425**
TG Total	**12,781**	**16,327**	**18,435**	**16,561**	**15,905**	**11,922**	**11,428**	**10,458**	**10,089**	**9,190**	**133,098**

Table 4.3: Household growth within the Thames Gateway by water resource zone

WRZ	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Kent Medway	2,189	2,411	1,957	1,555	1,717	1,264	1,239	1,014	964	973	**15.285**
London	7,383	10,142	12,489	11,111	10,365	7,600	7,390	6,914	6.609	5,741	**85.744**
Essex	3,035	3,591	3,848	3,815	3,721	3,001	2,742	2,473	2.459	2,419	**31.104**
North Downs	174	183	141	81	103	57	57	57	57	57	**965**
Burham	0	0	0	0	0	0	0	0	0	0	**0**
Thames Gateway	**12,781**	**16,327**	**18,435**	**16,561**	**15,905**	**11,922**	**11,428**	**10,458**	**10.089**	**9,190**	**133.098**

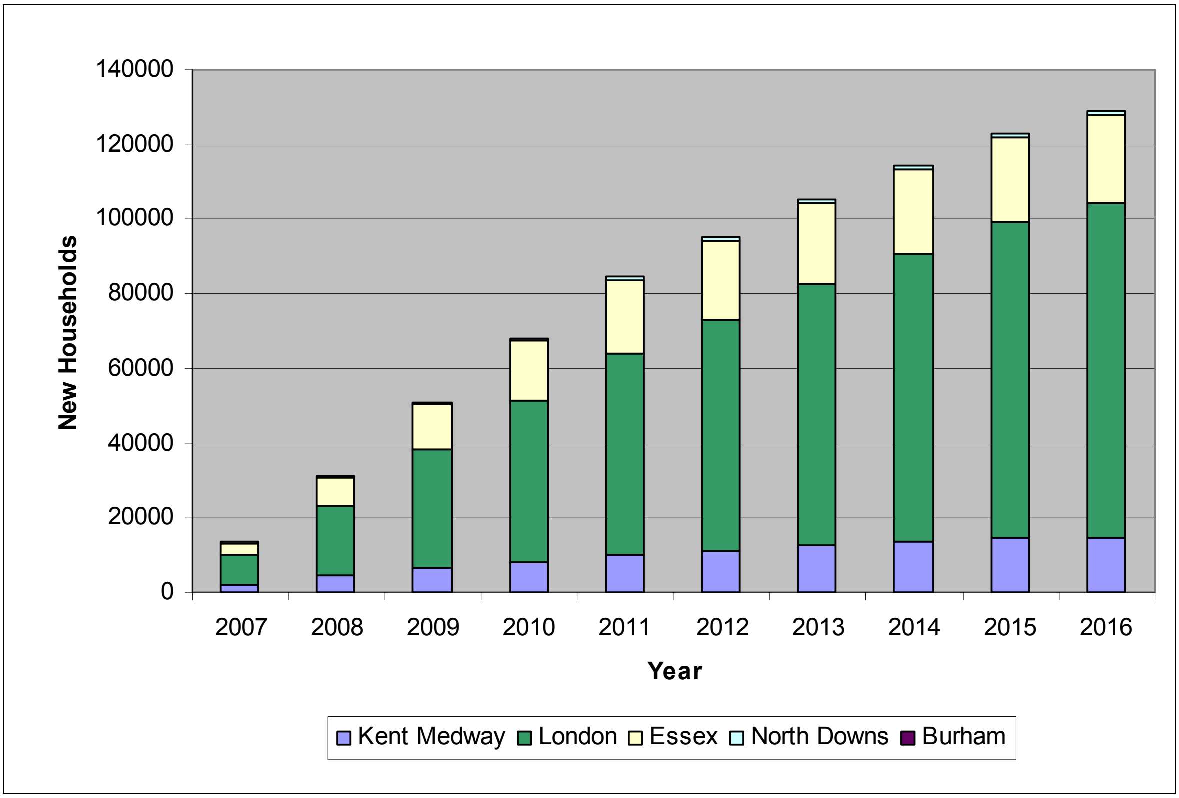

Figure 4.1: Cumulative housing growth by water resource zone

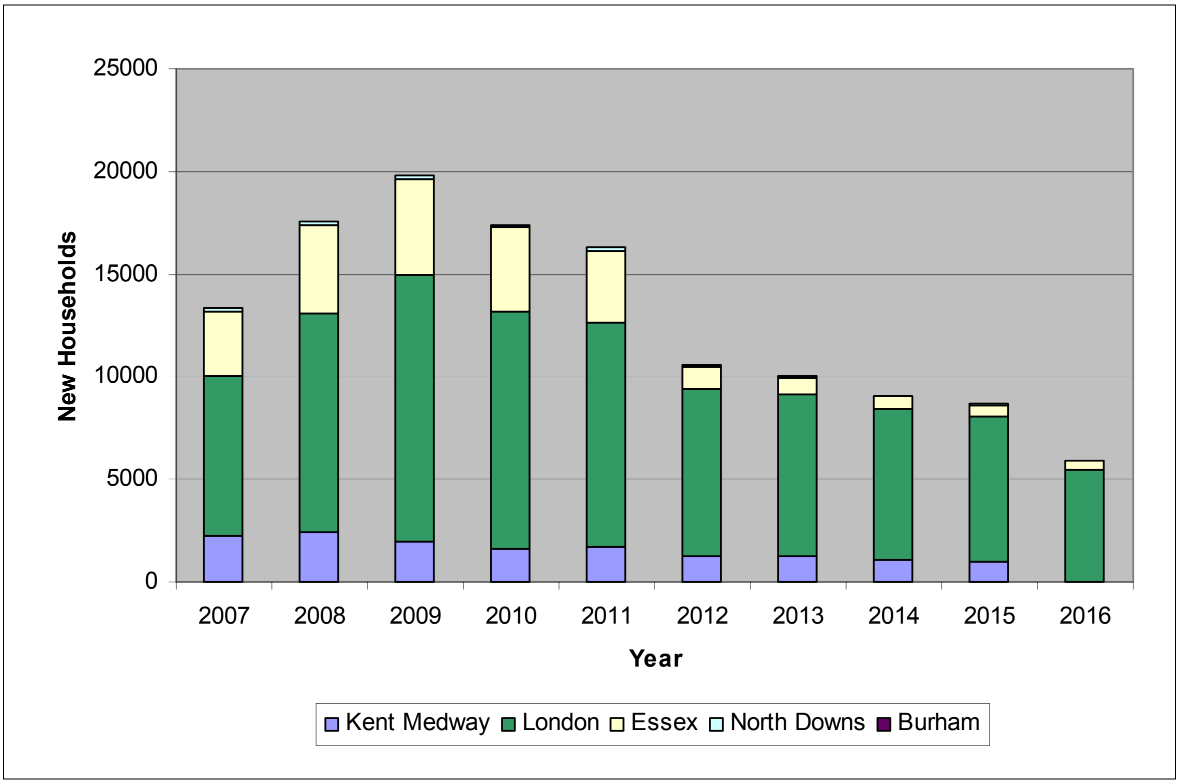

Figure 4.2: Annual housing growth by water resource zone

Water usage assumptions for new households

There is uncertainty over water use in new households (forecast of pcc), and at how present policy being developed and/or implemented (for example the Code for Sustainable Homes) may affect how the BAU scenario may develop. For these reasons, this study devised two BAU scenarios, representing an upper and lower estimate of water use in new households. The differences as they apply to new homes are summarised below, with background and justification to the data set out at the end of this section:

i. Upper savings BAU scenario

- Thirty per cent of new homes assumed to be publicly funded (social) housing (Housing Corporation properties and those built on English Partnerships land). It was assumed that all of these would be built to CSH Level 3 from 2008/9.
- Five per cent of new homes assumed to be privately funded, taking up measures that would achieve (an average of) CSH Level 3 from 2008/9.
- Sixty-five per cent (the remainder) of new homes assumed to be privately funded, achieving an assumed regulatory standard consumption rate of 120 l/h/d (internal use) from 2009/10[4]. Water Company measured pcc figures as estimated in PR04 were applied before this time.

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[4] This assumed regulatory standard was agreed before the announcement of 125 l/h/d (internal and external water use) as the actual regulatory standard (Communities and Local Government, 2007b).

ii. Lower savings BAU scenario

- Fifteen per cent of new homes assumed to be publicly funded (social) housing which would achieve CSH Level 3 from 2008/9.
- Two per cent of new homes assumed to be privately funded, taking up measures that would achieve (an average of) CSH Level 3 from 2008/9.
- Eighty-three per cent (the remainder) of new homes assumed to be privately funded, achieving the forecast metered household pcc in water companies PR04 plans. This was considered to be a conservative estimate of what might be achieved and was above the assumed regulatory standard of 125 l/h/d (or 120 l/h/d internal use only).

All new homes built with government funding (for example, through the Housing Corporation) by registered social landlords, as well as those developed by English Partnerships or with direct funding from the Government's housing growth programmes should comply with Level 3 of the CSH from April 2007, with further, similar commitments or encouragement by 2008 from the Ministry of Defence and the Department of Health. However, homes designed in 2007 will not be built for about a year, when the home moves from the design board to finished and inhabited new home. This delay of one year is accounted for in the modelling.

Only limited data was forthcoming on the percentage of houses in Thames Gateway that would be publicly funded or built on land owned by English Partnerships. For the purposes of modelling, a range was therefore assumed to capture this uncertainty with 30 per cent and 15 per cent of new households assumed to be publicly funded in the Upper and Lower Savings Scenarios respectively.

The pcc volumes in the CSH currently do not include any allowance for external use and an additional volume was therefore added to CSH pcc to account for this. This volume was based on the results of the WRc study into micro-components of demand, which showed that outdoor water use averaged around 42 litres/household/day (WRc, 2005). Data from the same study showed ownership of outdoor taps to be around 65 per cent. To convert to a pcc, the outdoor use was multiplied by the percentage ownership of outdoor taps and divided by household occupancy. The exact volume allowed for external use in this study changed with occupancy over time, but was in the range of 11-12 litres/head/day.

The percentage of new private households achieving an average of CSH Level 3 was estimated based on current uptake rates of EcoHome standards. The uptake rates did not reflect possible future changes in policy, such as making it mandatory for all new homes to be rated against the Code (Communities and Local Government, 2007c). While such a move would be expected to increase the uptake rate, there was not enough evidence to quantify this increase. The figures were therefore considered to be rough and fairly conservative estimates.

The new households per capita consumption rate of 120 l/h/d (internal use) used in the Upper Savings Scenario represented an assumed regulatory building performance standard pcc (Communities and Local Government, 2007b). The new regulatory standard is actually 125 l/h/d, but this includes a nominal external usage of four per cent or 4-5 l/h/d. If this external use is stripped out, the internal use is 120 l/h/d which is in line with CSH Levels 1 and 2 (for water use). The same allowance for external use described in relation to the CSH (above) was applied to new households built to the new regulatory standard. At 11-12 l/h/d, this was higher than the 4-5 l/h/d outlined in the new regulations, reflecting the drier than average conditions in the South East compared to the rest of the country.

The Lower Savings Scenario included a new household pcc rate equal to the forecast metered pcc from water company plans – which were forecast before the new regulatory standard was introduced. The new household pcc varied by WRZ, but equated to approximately 137 l/h/d as an average across the Thames Gateway. This was approximately 5-6 l/h/d more than that estimated in the previous scenario and 12 l/h/d more than the new regulatory minimum. This higher forecast was used as a precautionary approach to estimating future water savings in this study.

Occupancy rates for all new households were taken from PR04 forecasts as provided for new homes in WRP Supplementary Table 2.

4.3.2 Forecast water use for new non-households

It was not clear from an analysis of water company data whether the WRZ level non-household forecasts included in the PR04 plans included some, all or none of the expected growth in non-household demand resulting from the Thames Gateway development. As a result, the apportionment of WRZ-level trends to the Thames Gateway might not reflect growth levels within the Thames Gateway growth area. Economic growth plans for the area indicated that 180,000 new jobs would be created. In order to provide a more robust estimate of water use from new non-households, this study estimated water use resulting from these new jobs as an addition to the non-household demand forecasts in water company plans. This was done using the following assumptions:

- All of the new jobs would be office-based, with no new demand for water for industrial processes.
- In the Upper Savings Scenario, daily water consumption by office workers in the office (in addition to household consumption) was estimated to be 16 l/h/d (CIRIA, 2006).
- In the Lower Savings Scenario, daily water consumption by office workers in the office (in addition to household consumption) was estimated to be 20 l/h/d (Defra, 2007 personal communication).
- New jobs would be created linearly from 2005/06 to 2015/16.

As with new households, the approach was to assume an upper and lower water use value for the 180,000 new jobs in the BAU Lower and Upper Savings Scenarios. Recent data from a CIRIA report states that average water use in offices is around 16 l/h/d (CIRIA, 2006). In the consultation on water efficiency in new buildings, the proposed regulatory minimum[5] was higher than this value, at 20 l/h/d (Communities and Local Government, 2006b). For the purpose of this study, the CIRIA figure was applied to the Upper Savings Scenario and the proposed regulatory minimum to the Lower Savings Scenario.

Demand from the 10 largest non-household consumers in each WRZ in the Thames Gateway (included in the companies' public water supply allowance) was assumed to remain constant throughout the planning period.

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[5] This proposal was not taken forward when the Government published their response to the consultation (Communities and Local Government, 2007b)

4.3.3 Olympic Games and the Thames Gateway

The Olympic Games will take place in London in 2012 and the Olympic Park lies within the Thames Gateway. The area will be subject to large scale regeneration over the period to 2012. An allowance of 3.0 Ml/d increase in demand during 2012 was included in the BAU analysis, to take account of the additional demand from the Olympic Games. The basis for this allowance is described fully in Appendix 3.

4.4 Leakage and other components

4.4.1 Analysis of leakage

The approach to leakage analysis and estimation is described in Section 3.2. Leakage in BAU scenarios was fixed at the forecast values for 2015/2016 throughout the period.

4.4.2 Analysis of minor components

Forecasts for the following components were taken from PR04 submissions and proportioned to the Thames Gateway:

- Water taken unbilled – including water used for fire-fighting and some supplies to premises such as churches.
- Distribution system operational use (DSOU) – water used by the water company to maintain the supply system, either during normal operations or as part of mains rehabilitation works.

4.5 BAU carbon assessment

To calculate the BAU carbon emissions, the same factors were applied as outlined in Section 3.4. For the purposes of this study, it was assumed that the CO_2e emissions to treat each megalitre of water and wastewater would remain at the baseline level.

This assumption may have significant simplifications. The energy consumption associated with the provision of water and wastewater services will fluctuate with demand in response to growth and annual changes in customer demand (for example, in response to weather), although the effect of this should be overcome by using the dry year demand forecast data. In addition, energy requirements could change with large scale upgrade/replacement or deterioration of assets, or with changes in water quality requirements, or innovations made to water treatment processes and technologies. For example, the energy requirements to treat water could increase as a water treatment works ages and parts become worn or could decrease with replacement of an ageing asset.

Carbon emissions change with time due to the combination of sources supplying the national grid. For example, electricity conversion factors (converting kilo watt hours to kilograms of CO_2) have decreased from 0.77 kg CO_2 kWh in 1990 to 0.54 kg CO_2 kWh in 2003, reflecting changes in energy sources and their emissions (Defra, 2005). The combination of sources supplying the national grid could be expected to change in the future with further uptake of renewable resources, but will also depend on issues such as government policy on nuclear power generation. In the absence of any information, it was assumed that the Water UK emissions factors remain unchanged.

The development within the Thames Gateway may increase stormwater run-off that is directed to sewage treatment works. This could increase the energy requirements of wastewater treatment services. This is not taken into account in the BAU assessment, as this study is concerned with the relative impact of different demand management scenarios on carbon emissions.

4.6 Business-as-usual results

4.6.1 Business-as-usual water use

Table 4.4 presents the range of demand forecast under the BAU demand scenarios. Demand is forecast to increase by approximately 35 Ml/d under the Upper Savings Scenario (-10 per cent housing), and 46 Ml/d under the Lower Savings Scenario (+10 per cent housing). The BAU Lower Savings Scenario (as highlighted in Table 4.4) is used as the benchmark for assessing the performance of the pathway scenario later in this study. Demand increases by 42 Ml/d in this version of business-as-usual. This is the reduction in demand that would be required to achieve water neutrality.

The results presented in Table 4.4 suggest that the range of uncertainty around this value is -6.6 Ml/d and +4.2 Ml/d.

Table 4.4: Forecast demand under the BAU scenarios in Ml/d

Zone	2005/06	2009/10	2012-13	2015-16	Increase
Upper Savings (-10 per cent housing)	521.2	539.7	552.6	556.7	35.5
Upper Savings	521.2	541.7	555.8	560.7	39.5
Lower Savings	521.2	542.2	557.0	563.3	42.1
Lower Savings (+10 per cent housing)	521.2	544.3	560.3	567.5	46.3

Figure 4.3 is a graphical representation of the data in Table 4.4. The Olympic Games is assessed as increasing annual average demand by 3 Ml/d in 2012. Although the Olympic Games are likely to cause large short-term peaks in demand, the annual average impact of the games is not forecast to be significant, equivalent to approximately 0.5 per cent of demand in the Thames Gateway.

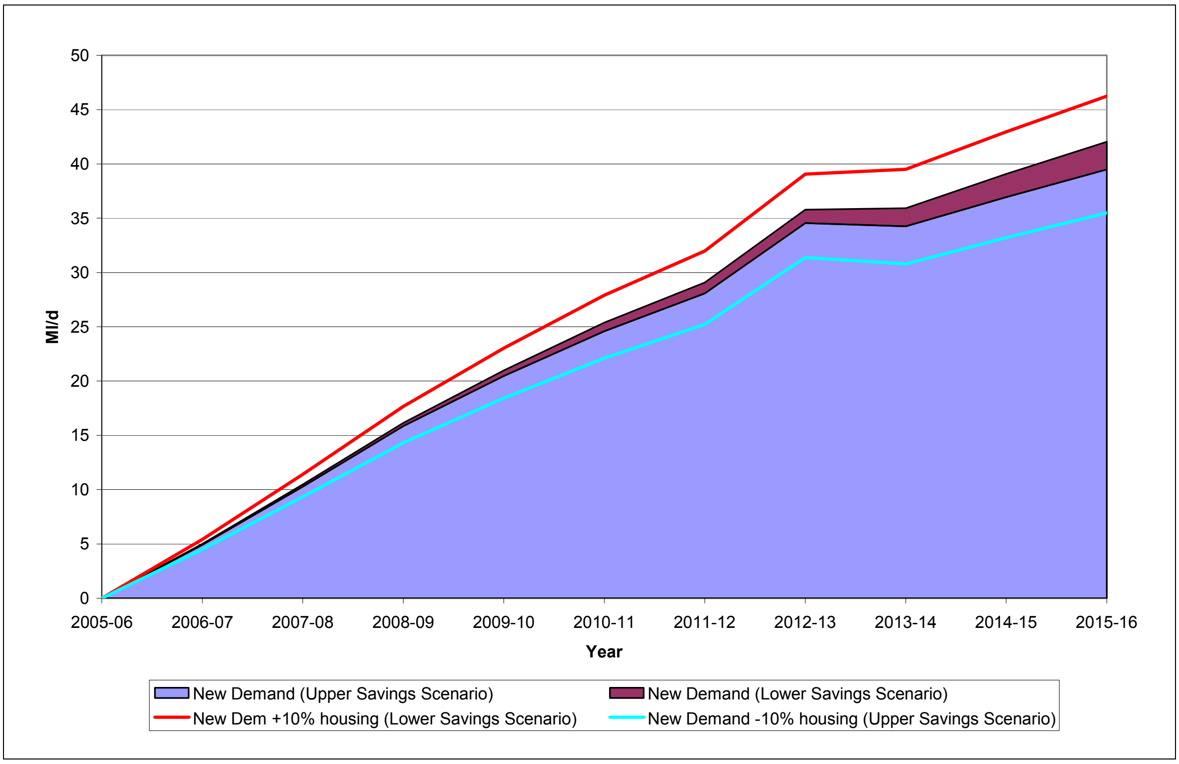

Figure 4.3: Business-as-usual demand

Figure 4.4 illustrates total demand and its components under the BAU Lower Savings Scenario, placing the estimated growth in demand in Thames Gateway under this scenario in the context of existing demand. Growth is almost entirely due to new households, accounting for 41.9 Ml/d of the increase in demand. However, there is also a small increase in non-household demand of 2.6 Ml/d.

The net increase in non-household demand is due to the additional demand of 3.6 Ml/d considered in this report from this sector, over a forecast decrease in demand of 1 Ml/d (across Thames Gateway), based on water company forecasts.

The total estimated increase in demand from new households and non-households is therefore 44.5 Ml/d. These increases are offset by a decrease in demand from existing households of 2.3 Ml/d[6] and a decrease of 0.2 Ml/d in demand from the minor components. The net result is the 42.1 Ml/d demand increase presented in Table 4.4.

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[6] The reasons for this change in existing household demand are discussed at the end of this section.

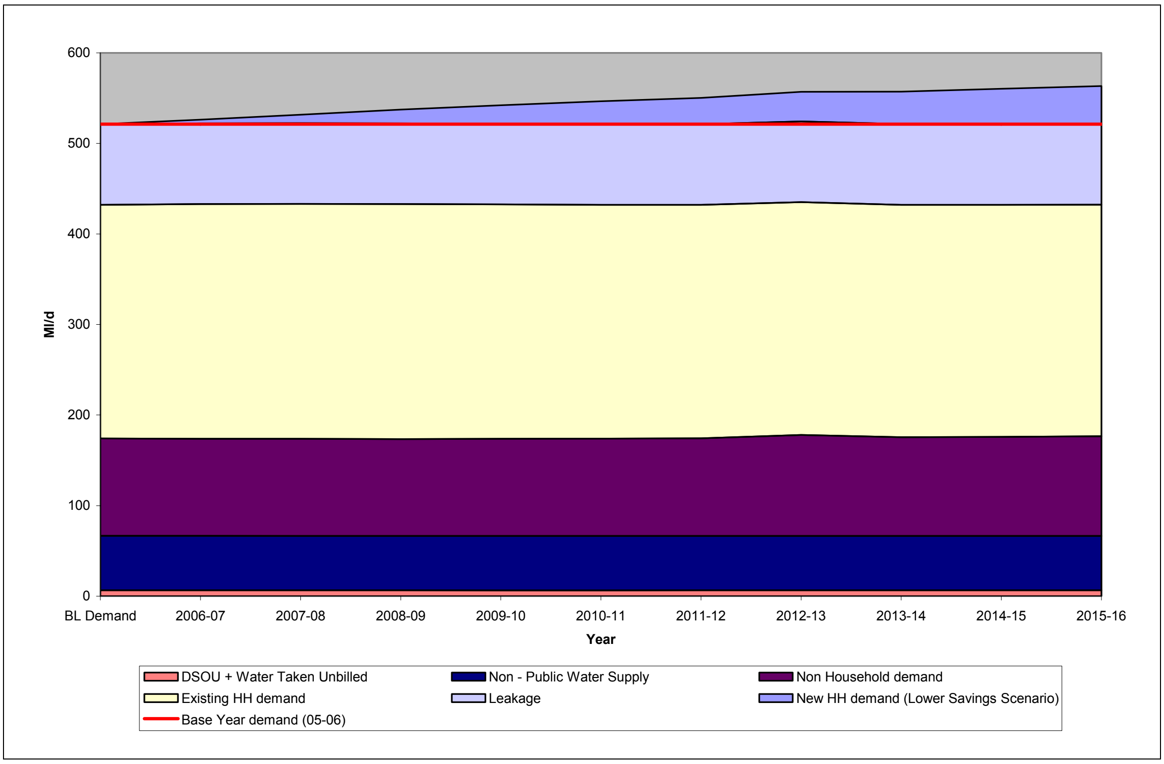


Figure 4.4: Thames Gateway demand forecast by component (BAU Lower Savings Scenario)

The percentages of PWS and non-PWS demand remain unchanged from 2005-06, with around 90 per cent PWS and 10 per cent non-PWS. However, there is some movement in the components of PWS demand. Table 4.5 shows the 2016 component breakdown of PWS demand for the BAU Lower Savings Scenario and should be compared to Table 3.5 in the previous section. In Table 4.6 the same data is compared, this time in percentage terms. A full breakdown of demand under both the Upper and Lower Savings Scenarios are presented in Appendix 4 for the baseline year, 2012 and 2016.

Table 4.5: Breakdown of PWS demand, Lower Savings Scenario 2016 (adjusted leakage)

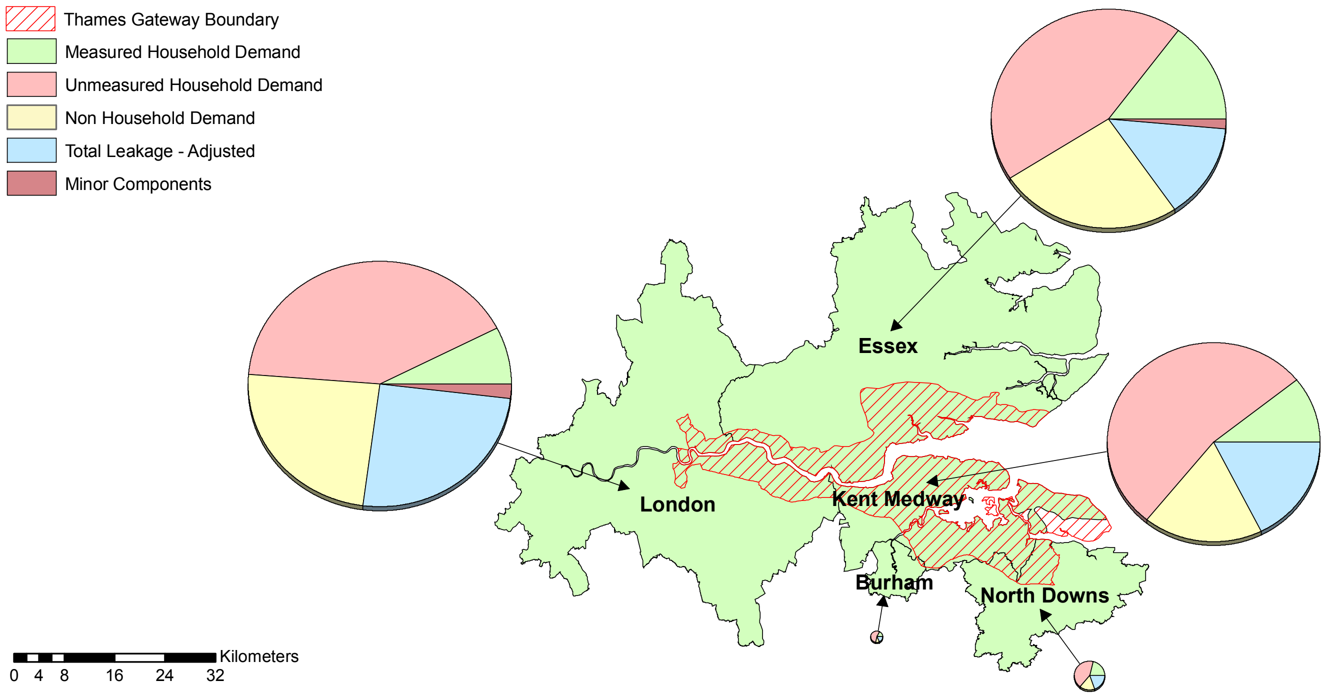
	Measured household consumption (Ml/d)	Unmeasured household consumption (Ml/d)	Non-household demand (Ml/d)	Total leakage (Ml/d)	Minor components (Ml/d)	PWS total demand (Ml/d)
Burham	0.1	0.2	0.0	0.1	0.0	0.4
North Downs	1.2	0.7	0.4	0.5	0.0	2.9
Kent Medway	27.2	55.5	23.6	20.9	1.0	128.3
London	56.2	58.3	48.7	47.5	3.3	213.9
Essex	51.9	46.2	37.5	20.2	2.1	157.8
Thames Gateway	**136.8**	**160.8**	**110.2**	**89.2**	**6.4**	**503.3**

Table 4.6: Comparison of PWS demand, baseline and 2016 (Lower Savings Scenario)

Baseline	**Measured household consumption (%)**	**Unmeasured household consumption (%)**	**Non-household demand (%)**	**Total leakage (%)**	**Minor components (%)**	**PWS total demand (%)**
Burham	0.0	0.0	0.0	0.0	0.0	0.1
North Downs	0.1	0.2	0.1	0.1	0.0	0.6
Kent Medway	2.7	14.1	5.0	4.5	0.2	26.5
London	2.9	16.9	9.7	10.3	0.7	40.5
Essex	4.7	14.3	8.5	4.4	0.5	32.3
Thames Gateway	**10.4**	**45.5**	**23.3**	**19.3**	**1.4**	**100.0**
2016 adjusted	**Measured household consumption (%)**	**Unmeasured household consumption (%)**	**Non-household demand (%)**	**Total leakage (%)**	**Minor components (%)**	**PWS total demand (%)**
Burham	0.0	0.0	0.0	0.0	0.0	0.1
North Downs	0.3	0.1	0.1	0.1	0.0	0.6
Kent Medway	5.4	11.0	4.7	4.2	0.2	25.5
London	11.2	11.6	9.7	9.4	0.7	42.5
Essex	10.3	9.2	7.4	4.0	0.4	31.4
Thames Gateway	**27.2**	**31.9**	**21.9**	**17.7**	**1.3**	**100.0**

In 2016, demand from households is still the single largest component of PWS demand, increasing from around 56 per cent in the baseline to around 59 per cent. Existing household demand actually falls slightly, by about 2 Ml/d, therefore the new household demand from the Thames Gateway accounts for a seven per cent rise in household demand. These adjusted figures exclude reductions in leakage. Within the household demand components a significant shift occurs. In the baseline the majority of households are unmeasured, but by 2016 the proportion of measured and unmeasured households are much closer together, accounting for 27 per cent and 32 per cent of the total water demand respectively. Demand from the other components remains relatively static.

Figure 4.5 to Figure 4.7 provide snapshots of how total demand is forecast to change in the Thames Gateway in 2012 and 2016, according to the Lower Savings BAU. These diagrams also show that there is a trend toward increased metering within the Thames Gateway over this time. By 2016, around 46 per cent of households are expected to be metered in the Thames Gateway. Over the same period, average per capita consumption is expected to fall from 169 l/h/d to 162 l/h/d. This is due to the combination of existing households switching from unmeasured to measured tariffs, and new households being constructed with an assumed lower pcc.



TGW 2005/06 Adjusted	
Population Total	1,523,379
Household Total	613,398
Total PWS Demand (Ml/d)	461.2
Average PCC (l/h/d)	169.3
Household Metering %	25%
Non PWS (Ml/d)	60.0
Total Demand (Ml/d)	521.2

Essex 2005/06 Adjusted	
Population Total	524,439
Household Total	208,998
Total PWS Demand (Ml/d)	149.0
Average PCC (l/h/d)	166.6
Household Metering %	35%
Non PWS (Ml/d)	2.8
Total Demand (Ml/d)	151.8

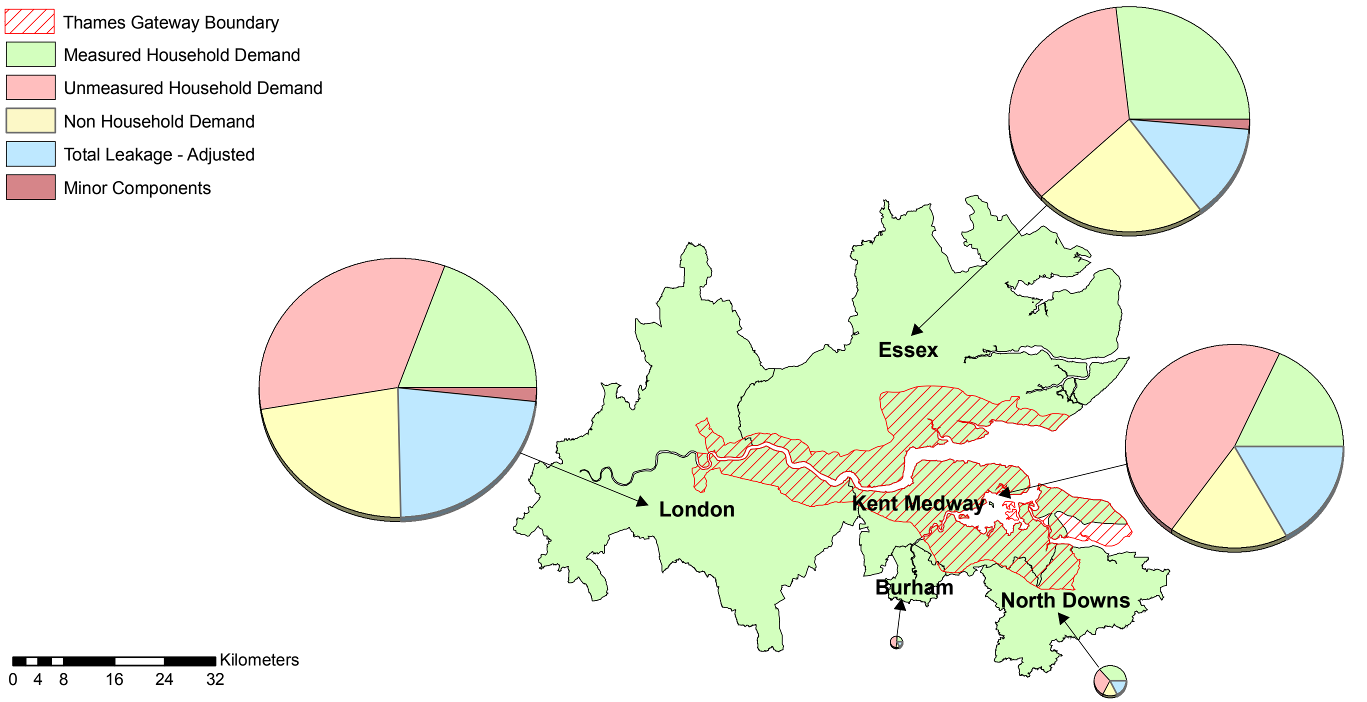
London 2005/06 Adjusted	
Population Total	540,833
Household Total	220,384
Total PWS Demand (Ml/d)	186.9
Average PCC (l/h/d)	168.8
Household Metering %	17%
Non PWS (Ml/d)	13.6
Total Demand (Ml/d)	200.5

Kent Medway 2005/06 Adjusted	
Population Total	446,672
Household Total	179,951
Total PWS Demand (Ml/d)	122.4
Average PCC (l/h/d)	173.3
Household Metering %	22%
Non PWS (Ml/d)	43.5
Total Demand (Ml/d)	165.9

North Downs 2005/06 Adjusted	
Population Total	9,702
Household Total	3,314
Total PWS Demand (Ml/d)	2.55
Average PCC (l/h/d)	167.01
Household Metering %	37%
Non PWS (Ml/d)	0.03
Total Demand (Ml/d)	2.58

Burham 2005/06 Adjusted	
Population Total	1,732
Household Total	751
Total PWS Demand (Ml/d)	0.40
Average PCC (l/h/d)	168.30
Household Metering %	32%
Non PWS (Ml/d)	0.00
Total Demand (Ml/d)	0.40

Figure 4.5: Baseline demand (2005/06)



TGW 2012 Adjusted	
Population Total	1,734,063
Household Total	705,330
Total PWS Demand (Ml/d)	490.3
Average PCC (l/h/d)	165.3
Household Metering %	36%
Non PWS (Ml/d)	60.0
Total Demand (Ml/d)	550.3

Essex 2012 Adjusted	
Population Total	568,534
Household Total	230,008
Total PWS Demand (Ml/d)	154.9
Average PCC (l/h/d)	167.5
Household Metering %	44%
Non PWS (Ml/d)	2.8
Total Demand (Ml/d)	157.7

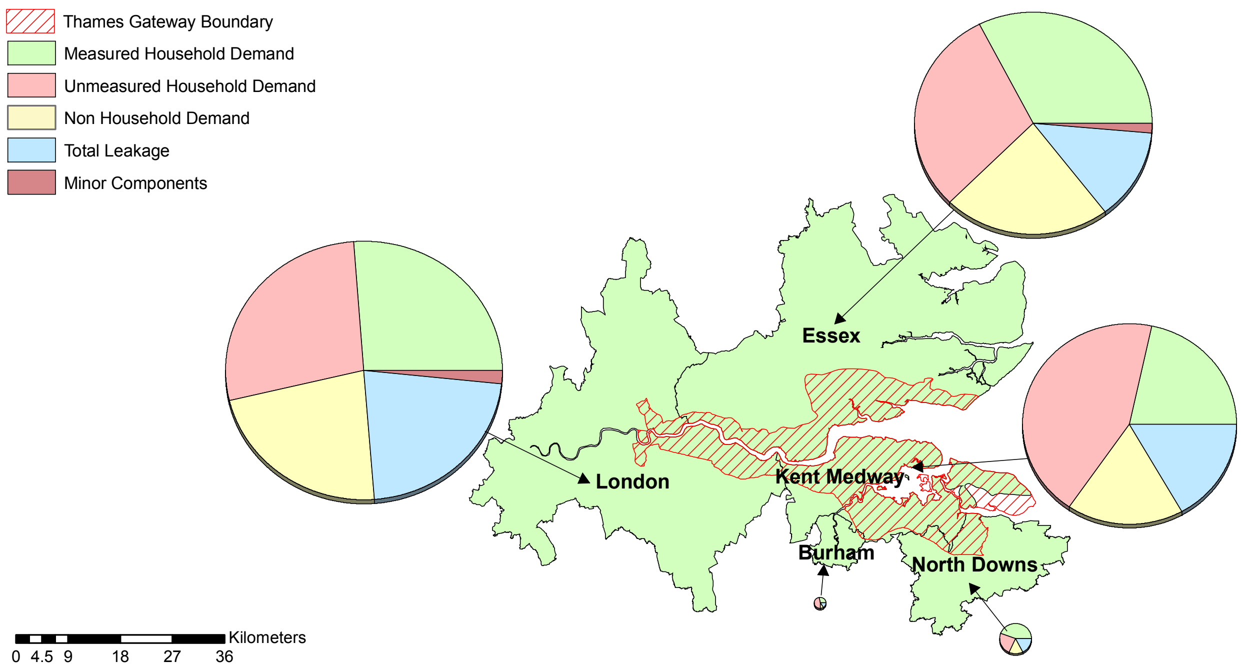
London 2012 Adjusted	
Population Total	681,551
Household Total	279,474
Total PWS Demand (Ml/d)	205.6
Average PCC (l/h/d)	158.4
Household Metering %	37%
Non PWS (Ml/d)	13.6
Total Demand (Ml/d)	219.2

Kent Medway 2012 Adjusted	
Population Total	470,929
Household Total	191,045
Total PWS Demand (Ml/d)	126.7
Average PCC (l/h/d)	172.7
Household Metering %	28%
Non PWS (Ml/d)	43.5
Total Demand (Ml/d)	170.2

North Downs 2012 Adjusted	
Population Total	11,317
Household Total	4,052
Total PWS Demand (Ml/d)	2.80
Average PCC (l/h/d)	165.13
Household Metering %	55%
Non PWS (Ml/d)	0.03
Total Demand (Ml/d)	2.8

Burham 2012	
Population Total	1,732
Household Total	751
Total PWS Demand (Ml/d)	0.40
Average PCC (l/h/d)	169.25
Household Metering %	32%
Non PWS (Ml/d)	0.00
Total Demand (Ml/d)	0.40

Figure 4.6: Business-as-usual demand 2012 – Lower Savings Scenario



TGW 2016 Adjusted	
Population Total	1,831,379
Household Total	746,972
Total PWS Demand (Ml/d)	503.3
Average PCC (l/h/d)	162.4
Household Metering %	46%
Non PWS (Ml/d)	60.0
Total Demand (Ml/d)	563.3

Essex 2016 Adjusted	
Population Total	593,068
Household Total	240,102
Total PWS Demand (Ml/d)	157.8
Average PCC (l/h/d)	165.3
Household Metering %	53%
Non PWS (Ml/d)	2.8
Total Demand (Ml/d)	160.7

London 2016 Adjusted	
Population Total	744,814
Household Total	306,604
Total PWS Demand (Ml/d)	213.9
Average PCC (l/h/d)	153.7
Household Metering %	49%
Non PWS (Ml/d)	13.6
Total Demand (Ml/d)	227.5

Kent Medway 2016 Adjusted	
Population Total	479,958
Household Total	195,236
Total PWS Demand (Ml/d)	128.3
Average PCC (l/h/d)	172.4
Household Metering %	33%
Non PWS (Ml/d)	43.5
Total Demand (Ml/d)	171.8

North Downs 2016 Adjusted	
Population Total	11,807
Household Total	4,279
Total PWS Demand (Ml/d)	2.87
Average PCC (l/h/d)	164.53
Household Metering %	66%
Non PWS (Ml/d)	0.03
Total Demand (Ml/d)	2.9

Burham 2016 Adjusted	
Population Total	1,732
Household Total	751
Total PWS Demand (Ml/d)	0.40
Average PCC (l/h/d)	170.00
Household Metering %	37%
Non PWS (Ml/d)	0.00
Total Demand (Ml/d)	0.40

Figure 4.7: Business-as-usual demand 2016 – Lower Savings Scenario

Trends within existing household demand

In Figure 4.4, demand in existing households is shown to reduce by approximately 2 Ml/d over the study period, from 258 Ml/d to 256 Ml/d. This is due to the interaction of a number of factors including changes in measured and unmeasured per capita consumption values, the rate of metering (changing from unmeasured to measured pcc) and changes in household occupancy.

Figure 4.8 shows the same data plotted for household demand in Essex and Suffolk Water's Essex WRZ. The data shows similar trends as the whole of the Thames Gateway, where total household demand increases, but existing household demand is almost static or falling slightly. In both the Gateway as a whole and the Essex WRZ, demand within the existing households changes markedly, with a significant decrease and increase in unmeasured and measured household demand respectively.

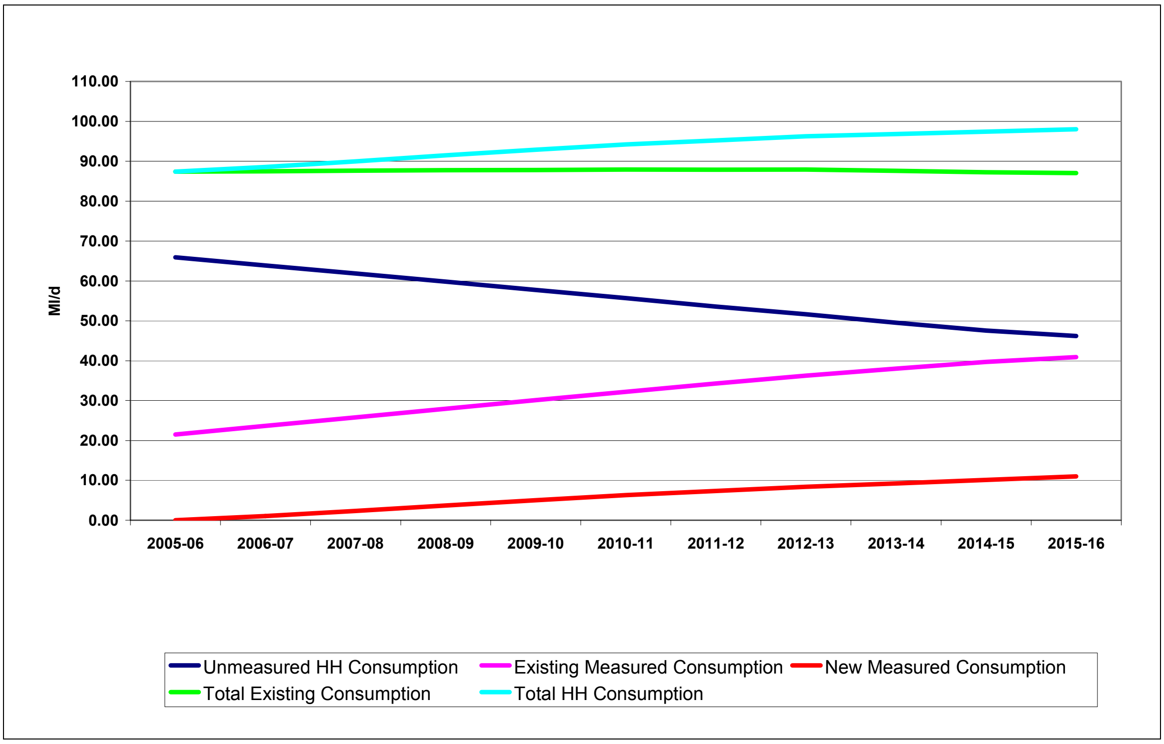


Figure 4.8: Breakdown of Essex WRZ household demand

Domestic demand is usually determined by three variables:

- per capita consumption
- occupancy rates
- population.

In this study, population estimates are based on occupancy rates multiplied by household forecasts; therefore, household numbers replace population as the third variable in this study.

Per capita consumption will vary according to occupancy, whilst occupancy will vary depending on the relative changes to population and household numbers. In addition, total demand will be influenced by the split between metered and unmeasured households in a WRZ. Whilst the interaction between these variables can be complex, a review of demand data for the part of the Essex WRZ in Thames Gateway highlights some clear trends which are reflected in the wider Gateway area. In summary:

- Unmeasured household consumption in existing homes in Essex falls from 63.9 Ml/d to 43.2 Ml/d. This is mainly due to a 33 per cent forecast reduction in the population living in unmeasured households. These existing unmeasured households are expected to change to a metered supply over the forecast period.
- Measured household consumption in existing homes is forecast to increase from 23.6 Ml/d to 40.9 Ml/d. This is mainly due to an 80 per cent forecast increase in the existing measured population. This increase in measured population is due to a 60 per cent increase in existing homes that receive a metered supply and an increase in measured household occupancy rate.
- Seventy-four per cent of the population lives in unmeasured households in the baseline year (2005/06). This drops to 51 per cent at the end of the forecast period. There is obviously an associated increase in metered population in existing households. The net effect of this forecast change is that total demand remains relatively stable, decreasing only slightly from 87.5 Ml/d to 87.0 Ml/d over the forecast period.

Data presented by water companies in their WRP tables show that occupancy rates in existing unmeasured households are forecast to fall. This may be because of the division of existing households into smaller households, including the new households planned in Thames Gateway, and/or migration out of the area. This trend would need to over-ride the more general national trend of increasing unmeasured occupancy rates, as an increasingly small cohort of high occupancy households resist switching to a metered supply for financial reasons.

Occupancy rates in existing measured households are expected to rise. This is in line with the more general national trend that larger and larger households (with higher occupancy rates) will opt to switch to a metered supply (or be persuaded to do so) for smaller financial benefits than the smaller ‘pioneer’ optants who expect to make the most financial gains. Occupancy rates will also increase in metered household whenever a strategy to meter on change of occupancy is implemented.

The expected decrease in total demand from a higher metered population is likely to be offset by the increase in pcc in both unmeasured and measured households.

The discussion above shows that occupancy and per capita consumption are important variables in deriving forecasts of water use. To simplify the approach used in this study occupancy rates were taken from water company WRP data. The scope of this study did not include an assessment of the impact of variations in occupancy on demand.

4.6.2 BAU carbon results

Figure 4.9 shows the BAU carbon results. There is little significant difference between the two scenarios. For the BAU Lower Savings Scenario, a total of around 127,760 tonnes CO_2e per year are generated by 2016, an increase of approximately nine per cent from the baseline. For the BAU Upper Savings Scenario, the equivalent figure is 127,110 tonnes CO_2e oer year or an increase of about 8.5 per cent from the baseline. The relatively small difference between the demand scenarios results in similar emissions under the two BAU scenarios.

Due to the limitations of the data available, there is no real value in examining the geographical distribution of the carbon emissions. The method applied means that there is a linear relationship between water demand and carbon emissions. The carbon emissions associated with water supply and wastewater treatment will therefore mirror the pattern of demand data, discussed in Section 4.6.1. However, in reality, carbon emissions associated with the delivery and treatment of water is dependent on the local topography (in terms of the need for pumping) and on the characteristics of the sewage treatment works and the nature of the effluent being treated.

Acknowledging the limitations in the derivation of carbon emissions, it is possible to provide a general assessment of the relative impact of demand management measures proposed in the following sections against these BAU scenarios.

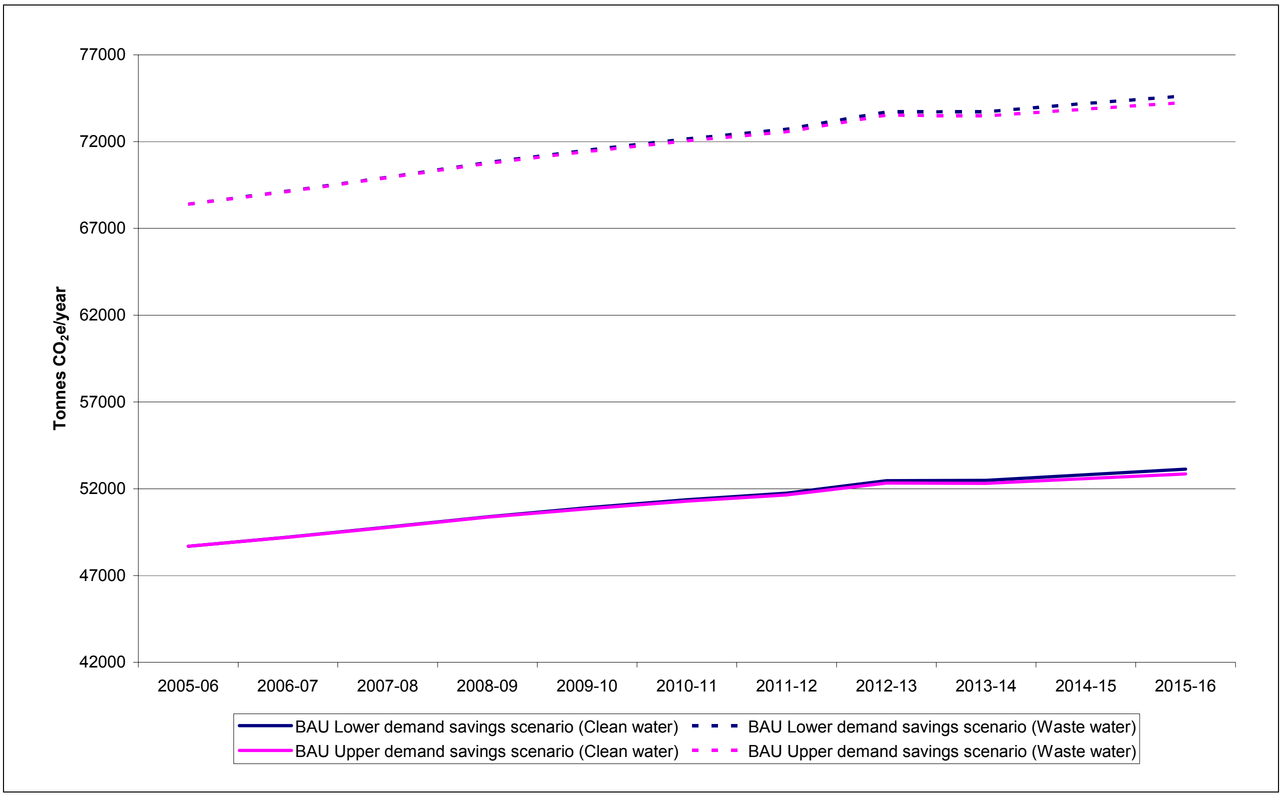


Figure 4.9: Water and wastewater carbon emissions under the BAU scenario

4.7 Key points

4.7.1 Assumptions

BAU forecasts are predictions of how demand for water is likely to change over the period to 2016, without further intervention to manage it. A number of uncertainties could affect the BAU forecast; therefore, this section considered upper and lower estimate of likely outcomes, and took account of the uncertainty in housing numbers.

BAU demand forecasts were based on water company estimates of how key parameters such as consumption rates, occupancy and metering of existing households will change in the future.

The forecast in the development of new housing, as part of the regeneration of Thames Gateway, was based on household completion rates from CLG. Just over 133,000 homes are forecast to be completed between 2006/07 and 2015/16. It is assumed that

32,500 households have been completed already, and form part of the baseline demand, making 165,500 total new households in Thames Gateway.

The upper and lower BAU forecasts explored different assumptions on the effect of new homes on demand. Assumptions related to the percentage of new homes that would be publicly funded (and therefore required to comply with CSH standards), the percentage of privately developed homes that would take up certain code standards, and the consumption levels that the remaining privately funded homes would achieve.

BAU water use in existing non-households was calculated in the same way as for the baseline, taking account of the location of the largest water users.

An estimate of water use in new non-households was based on the forecast that Thames Gateway would result in the creation of 180,000 new jobs, all assumed to be office-based. This forecast was in addition to the non-household demand forecast in water company plans.

Non-PWS abstractions were assumed to remain constant.

4.7.2 Results

Forecast demand grows from the adjusted baseline of 521 Ml/d to 563 Ml/d in the BAU Lower Savings Scenario. This increase of 42 Ml/d is the benchmark value used in later analyses of pathway scenarios. However, the sensitivity analysis of the BAU forecasts indicates an uncertainty range around this value of -6.6 Ml/d to +4.2 Ml/d.

The total estimated increase in demand from new households and new non-households is 44.5 Ml/d. These increases are offset by a decrease in demand from existing households of 2.3 Ml/d and a decrease of 0.2 Ml/d in demand from the minor components. The net result is the 42.0 Ml/d demand increase described above.

The BAU forecast includes demand from new non-households generally, and takes account of the Olympic Games in 2012.

Household demand increases from 56 per cent of PWS demand in the baseline year to 59 per cent of PWS demand in 2016. Forty-five per cent of households are forecast to be metered in 2016, compared to 25 per cent in the baseline year.

Carbon emissions increase by nine per cent above the baseline, to about 128,000 tonnes CO_2e in 2016 under the BAU Lower Savings Scenario.

5 Water efficiency measures

5.1 Introduction

This section considers a range of measures to manage demand and achieve water neutrality in Thames Gateway, and presents a list of preferred options used in the analysis of pathway scenarios (Section 7). Key assumptions are presented in this section on the costs and water savings associated with the measures.

The following sections consider the costs and benefits of measures for: existing and new households; variable tariffs and compulsory metering; and existing and new non-households.

A summary of the potential costs and benefits of leakage reductions below the economic level of leakage is also considered.

5.2 Identification and selection of measures

This section considers which measures are appropriate for use in managing the demand for water, and in which setting. The definition of pathway scenarios is based on consideration of all known, feasible demand management technologies. The identification of measures was undertaken by Nick Grant of Elemental Solutions, on behalf of Entec. A list of the measures identified is presented in Table 5.1. Sections 5.3 to 5.5 consider which of these measures will be considered further in existing households, existing non-households, new households/developments and new non-households.

Table 5.1: Suitability of measures identified

Measure (T) = Technical measure (B) = Behavioural measure	House-hold	Non-house-hold	Retrofit	New build	Possible scale of implementation (individual property unless indicated)
Toilets					
Hippo **(T)**	■	■	■		
Save-a-flush **(T)**	■	■	■		
Dual-flush retrofit devices **(T)**	■	■	■		
Variable-flush retrofit devices **(T)**	■	■	■		
Low-flush cistern (4.5 l/flush or 6/3 l dual flush) **(T)**	■	■	■	■	
Ultra-low flush (4/3 l dual flush) **(T)**	■	■	■	■	
Propelair toilets **(T)**	■	■	■	■	
Vacuum toilets **(T)**	■	■		■	
Composting toilets **(T)**	■	■		■	
Waterless urinals **(T)**		■	■	■	
Urinal flow controllers (**T**)		■	■	■	
Showers/baths					
Low-flow showerheads **(T)**	■	■	■	■	
Electric showers **(T)**	■	■	■	■	
Lower volume baths **(T)**	■	■	■	■	
Taps/flow regulators/plumbing					
Flow regulation **(T)**	■	■	■	■	
Pressure control **(T)**	■	■	■	■	
Spray taps **(T)**	■	■	■	■	
Tap magic **(T)**	■	■	■	■	
Leak alarms **(T)**	■	■	■	■	

Measure **(T) = Technical measure** **(B) = Behavioural measure**	**House-hold**	**Non-house-hold**	**Retrofit**	**New build**	**Possible scale of implementation (individual property unless indicated)**
Domestic appliances					
Point-of-use water heaters (**T**)	■	■	■	■	
Water-efficient white goods **(T)**	■		■	■	
Garden					
Water butt **(B)**	■		■	■	
Harvesting/reuse technologies					
Rainwater harvesting **(T)**	■	■	■	■	Can be implemented at individual property or different scales within the community
Grey water reuse **(T)**	■		■	■	Can be implemented at individual property or different scales within the community
Water audits					
Domestic audits **(T/B)**	■		■		
Commercial audits **(T/B)**		■	■		
Water efficiency promotion and publicity **(B)**	■	■	■	■	
Leakage reduction					
Find and fix leakage on supply pipes **(T)**	■	■	■		
Metering					
Compulsory metering **(B)**	■		■		
Variable tariffs **(B)**	■		■	■	Would be applied across the supply area to all metered household customers

5.3 Assessment of potential measures in existing households

The discussion below shows that some of the measures are suitable for use in existing households, whilst others are better suited to new developments. The selection of options builds on previous work wherever possible, so that the findings from this study can be put in context of similar research.

The recently published Environment Agency study, *Water efficiency in the South East of England – Retrofitting existing homes* (Environment Agency, 2007a), was used as the basis for evaluating demand reductions from retrofitting water-saving devices in existing homes in this study. The project built on an earlier investigation to assess the viability of different retrofit options in the South East, which considered a wide range of demand management options, including many of those identified in Table 5.1. The results of this screening process from the Environment Agency study for existing households is summarised in Table 5.2. This screening process does not apply to new households, and it should not be taken out of the context of this study. Retrofit evidence within the UK is relatively immature and a range of trials are currently underway which will generate more reliable data on costs, benefits and practicalities.

Table 5.2: Summary results of long list screening for existing households

Measure	Considered Further?	Comments
Cistern displacement devices	No	Excluded due to an assumed existing high ownership and limited potential for further savings.
Rainwater harvesting	No	Excluded due to large uncertainties surrounding potential savings.
Water butts	No	Excluded due to an assumed existing high ownership and limited potential for further savings, plus variability of rainfall.
Grey water recycling	No	Excluded due to large uncertainties surrounding potential savings.
Water audits	No	Excluded due to lack of data on the durability of savings associated with this option.
Water efficiency promotion/publicity	No	Excluded due to lack of robust data for this option.
Variable flush retrofit devices	Yes	Selected because of availability of more robust data, feasible implementation and the potential for significant savings.
Low-flush replacement toilets	Yes	Selected because of availability of more robust data, feasible implementation and the potential for significant savings.
Low-flow showers	Yes	Selected because of data availability and feasible implementation.
Pressure control	No	Excluded due to lack of robust data on this option.
Metering	Yes	Selected because of the potential for significant savings, feasible implementation and ‘in combination’ benefits.
Sophisticated tariffs	Yes	Considered further in this study although there is a lack of quality data for this option.
Taps	Yes	Excluded as a stand-alone option, but selected as part of a ‘low use fittings’ suite due to data availability and feasible implementation.
Point-of-use water heaters	No	Excluded due to lack of quality data for this option.
Flow regulation	No	Excluded due to lack of quality data for this option.
Water-efficient garden irrigation	No	Excluded due to lack of quality data for this option.

5.4 Measures considered further for existing households

5.4.1 Summary of measures and implementation strategy

Based on this review, a range of preferred approaches to retrofitting were identified in the Environment Agency (2007a) study. These were:

- variable flush retrofit devices;
- ultra-low flush toilet replacement scheme;
- low-flow showers;

- compulsory metering;
- range of low water-use fittings.

Potential implementation strategies were assessed in terms of the costs of the retrofit programme and the possible water savings. From this, two preferred implementation strategies were explored in the Environment Agency (2007a) study, based on a combination of retrofit measures. These were:

- metering combined with variable flush retrofit devices and low-flush replacement WCs;
- metering combined with low-use fittings.

The Environment Agency (2007a) study concluded that implementation strategies combined with compulsory metering resulted in greater savings than implementation without metering, or metering only on change of occupancy. This study therefore set out to assess the potential savings from a retrofit strategy based on compulsory metering, plus the installation of either variable flush retrofits or ultra low-flush toilets with low-flow showerheads and low-flow taps. These measures are described in the following sub-sections.

5.4.2 Assumptions

In the BAU forecasts, no existing household properties were assumed to be retrofitted with water-efficient fixtures and fittings beyond any allowances included in water company demand forecasts[7]. For the scenario modelling, different rates of uptake of retrofitting were used as a means of reducing demand (details and justification are provided for each scenario, as described in Section 7).

It was assumed that meter installation would be carried out by the water companies (or their contractors) and the retrofit or installation of fittings would be undertaken by professional plumbers. Further assumptions on the delivery methods associated with the retrofit of measures to existing households are described in the following sections.

The principal assumptions about the retrofit measures considered in this study are based on those set out in the Environment Agency Retrofit Study (Environment Agency, 2007a). These are described in the following sections and summarised in Table 5.3.

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[7] Water companies do consider the effects of new technologies on the demand for water as part of their water resource planning. They assess how market forces and policy drivers may affect the uptake of efficient white goods and fittings over time, as householders renew and refurbish their property. This means that the implementation of demand management measures as presented in this report may bring forward reductions in demand that water companies forecast to happen in any case at some later date in the future.

Table 5.3: Data used for demand management measures in existing homes

Appliance	Average saving (l/HH/d[1])	Average saving (l/h/d[2])	Description	Assumptions	Cost (£)
Variable flush retrofit device	24.65	10.27	Variable flush device retrofitted to existing WCs	Savings based on results from two studies: *Retrofitting variable flush mechanisms to existing toilets* (Environment Agency, 2005a) and *The water efficiency of retrofit dual flush toilets* (Southern Water, 2000a) Can only be fitted in approximately 70 per cent of WCs.	8
Ultra-low flush WC replacement	53.1	22.13	Replacement WC	Average use currently approx 50 litres per person per day for WC flushing (*Conserving water in buildings 9: Water-efficient WCs and retrofits*, Environment Agency leaflet). If assume 4.5 litres per flush (WRAS approved Tribune CC Suite low-flush WC) at 1.5 toilets per household (*Customer survey: Report on appliance ownership and attitudes to water efficiency*, Southern Water, 2004) and only one is low-flush at an average flush rate of 4.1 flushes/person/day (*Retrofit options for water efficiency in existing buildings* (Environment Agency, 2005a) at an average household size of 2.38 (South East average, Census, 2001), then average saving is 53.1 litres per household per day. Average life of toilet = 16.5 years = six per cent of toilets changed each year	140
Low-flow showerhead	12.9	5.38	Showerhead replacement	Water usage of average shower = 10.8 l/min Water usage with LF showerhead = 9.0 l/min Average length of shower = five minutes. Number of showers taken = 1.43 per day. Forty-three per cent of showers estimated to be suitable.	15
Low-flow taps	2.7	1.13	Tapmagic inserts	Average water usage without restrictor = 6.5 l/min (not operated at full flow) Water usage with flow restrictor = 5 l/min Number of uses per day = 16.9 Average length of use = 6.5 seconds	5
Installation				Installation of variable flush, showerhead and tap retrofit devices only	72

Notes: [1] l/HH/d – litres/household/day

[2] l/h/d – litres/head/day

When assessing the water savings from these retrofit schemes, it is standard practice to consider the period (in years) over which the measure will deliver the savings. This period will vary depending on a number of factors such as the durability of the fitting, the normal rate of replacement (how often households replace bathrooms) and the ease with which the fitting can be replaced or removed. This 'scheme life' is an important variable in the assessment of the 'average incremental social costs' (AISCs) that are commonly used in water resource planning. Scheme life is independent of the length of the study period in this investigation, and also separate to the period over which AISCs are calculated (60 years).

5.4.3 Compulsory metering

Compulsory metering is included in all of the pathway scenarios based on the conclusions from the Environment Agency (2007a) study and given that water neutrality is an ambitious objective. This is a change from the assumptions in the BAU forecasts and is included because of the significant water savings that are possible and because government policy on metering in water-stressed areas is moving in this direction, as indicated by the recent Defra response on a consultation on the subject (Defra, 2007a). Compulsory metering means that all unmetered household properties will be obliged to change to a metered supply, where feasible. Metering within the context of this study refers to the installation of a standard meter and not a "smart meter", the latter of which is capable of measuring usage at specific time periods. Some variations on the scenarios considered also assess the benefits of using variable tariff structures, such as rising-block tariffs.

At present, a water company must apply for 'water scarcity' status in order to meter its household customers in this way. To date only one water company, Folkestone and Dover, has gone through this process. The Environment Agency recently consulted on the definition of water stress, indicating that all of the Thames Gateway would be in an area classified as 'seriously water-stressed' (Environment Agency, 2007c). Following consultation, Defra announced that from October 2007 water companies in areas of serious water stress will be required to include an assessment of the costs and benefits of compulsory water metering in their 25-year forward plans (WRMPs) (Defra 2007a). The new requirement is for compulsory metering to be assessed alongside existing supply and demand options for ensuring long-term security of supply.

The reductions in water use that result from switching from an unmeasured to a metered supply are difficult to define accurately, as unmeasured consumption has to be estimated. In addition, most meter 'optants' derive an automatic financial benefit from metering, as they are usually high rateable value properties with only one or two occupants. This means that direct comparison of actual metered and unmetered consumption (for example, from Ofwat data) is unlikely to provide a reliable indication of the effect of metering on demand.

Folkestone and Dover Water indicated that they expected to achieve savings of between 10 and 12 per cent as a result of compulsory metering, when putting their case to Defra to be granted 'water scarcity' status (Folkestone and Dover Water Services, 2005). This estimate was based on evidence from previous studies such as the National Metering Trials.

Based on the available evidence and discussions with steering group members, in this study compulsory metering was assumed to result in a 10 per cent reduction in annual average demand. This assumption was made for modelling purposes, and was relatively conservative (bearing in mind the higher than average baseline pcc values in the area). This was to minimise the risk of double-counting savings (from variable tariffs, for example). The value of 10 per cent was based on available evidence, such as the recent UKWIR report (UKWIR 2006), which indicates that savings in the range of 10-15 per cent are possible when an unmetered customer switches to a metered tariff. This study assumed that savings due to metering would be maintained at a constant rate, since no evidence was made available that indicated metering savings deteriorate over time.

It was also necessary to make some assumptions over the uptake of domestic metering, as any government policy change or decision would be unlikely to occur before the next periodic review in 2009, and even if a decision was made, compulsory metering would require several years to implement over large regions of the country (such as the South East). The available evidence on possible rates of compulsory metering was restricted to studies undertaken by Folkestone and Dover Water as part of their application for water scarcity status (Folkestone and Dover Water Services, 2005). This small company assumed that they would be able to meter 90 per cent of domestic properties by 2016, at a rate of 10 per cent of unmetered households per year from a baseline of 41 per cent in 2004-05 (F&DWS, 2005). The company hoped to bill the remaining 10 per cent of households (where metering might not be feasible for practical and other reasons) on an assessed charge.

This rate was considered high, when applied to a large region such as the South East, as there would likely be constraints on meter supplies and workforce availability at this scale. Therefore, for the purposes of this study we assumed an annual rate of meter penetration five per cent higher than the water companies allowed for in their water resource plans. This was close to the rate that some companies indicated for metering on change of occupancy, and so could be considered conservative in terms of compulsory metering. Metering at this rate would result in 70 per cent of domestic properties in the Thames Gateway being metered by 2016.

Compulsory metering is not relevant to new households, since most newly built properties are metered. Exceptions include some new build apartment properties that are bulk metered rather than being individually metered.

Metering costs were based on the following:

- Thirty-five per cent of households assumed to have a boundary box in place – standard meter (not smart meter) installation £71 (Environment Agency, 2007a).
- Sixty-five per cent of households assumed to have no boundary box – standard meter (not smart meter) installation £250 (Environment Agency, 2007a).
- Meters assumed to be replaced every ten years.
- Operating cost assumed of £10 per meter per year, based on industry average operating costs provided by Ofwat (Ofwat, pers comm).

5.4.4 Variable flush retrofits

The retrofit of variable flush mechanisms in toilets is achieved by replacing the internal parts of toilet cisterns with flush controls that allow the user to set an appropriate flush volume. This is an updated approach to what was often referred to as 'dual-flush retrofit' in the past. The variable flush retrofit device scheme aims to reduce the amount of water used for toilet flushing in households with the older nine and 7.5 litre siphonic cisterns, where whole toilet replacement is not planned. These devices modify the single flush cisterns without the need to replace the cistern or toilet itself. This approach has the benefit of little aesthetic impact on the existing toilet cistern. Once installed, the devices allow the option for two or more flush volumes to be chosen.

There have been a number of research studies and trials of this technology and this measure is perhaps the best understood of all retrofit options. Research indicates that 70 per cent of toilets in existing households would be suitable for the fitting of a variable flush device (Environment Agency, 2005a). This reflects the large number of toilets in the existing housing stock with cistern volumes of 7.5 litres or greater. However, the suitability of individual toilets for retrofit will depend on the set-up of the toilet cistern (some may have their fill limit already set below the nominal size of the cistern).

In order to ensure high uptake, it was assumed that installation would be free to the householder. The scheme life was assumed to be 10 years, reflecting an average period before the retrofitted toilet would be replaced.

The main uncertainties associated with this option are in the uptake rates and savings generated by the scheme. Uptake rates will be affected by policy and the investment made in up-front social marketing campaigns, as well as the degree of subsidy made to householders. The savings generated will also depend on the effectiveness and acceptability of the devices, but crucially upon behavioural change.

5.4.5 Ultra-low flush toilets

The term “ultra-low flush” is not a formal one and is used here to describe toilets with flush volumes that are generally considered to be a practical limit for gravity flushed toilets connected to normal drains (four to 4.5 litres per flush). Lower flush volumes than this can be achieved (see sub-ultra low flush toilets below). For the purpose of this study, a flush volume of 4.5 litres was assumed. The installation of ultra-low flush toilets requires the replacement of the whole toilet, including the cistern and pan, and so is a much more significant exercise in terms of disruption to the householder. There are obvious issues around the acceptability of such a programme and this is reflected in the uptake rates for this aspect of the retrofit programme.

The modelled schemes were voluntary, based on providing replacement toilets free to householders. The £140 cost was based on the cost of the Water Regulations Advisory Scheme (WRAS) approved Tribune CC Suite, which has a full flush volume of 4.5 litres and a reduced flush volume of three litres. The costs associated with the scheme did not include the cost of fitting the toilet, which the customer would be expected to cover. The average interval after which toilets are replaced is estimated at 16.5 years. Therefore, it was assumed that the scheme life of this measure would be 16.5 years.

The key uncertainties associated with this option surround the uptake rates (which depend on policy measures, not considered in this study) and savings generated by the scheme, although the uncertainties associated with savings are likely to be less than for variable flush retrofit, as ULF toilets will have to have been approved for use by the Water Regulations Advisory Service (WRAS) or similar.

5.4.6 Low-flow showerheads

The retrofit of low-flow showerheads is considered to be a relatively straightforward exercise. The installation of a low-flow showerhead is a simple DIY job that only requires the replacement of the actual shower head at the end of the shower hose.

The scheme considered here consisted of the fitting of low-flow showerheads to suitable showers to reduce the volume of flow per minute. Analysis of this measure was based on provision of a free showerhead to the householder, including delivery and installation. An additional incentive beyond lower water bills was that 22 per cent of domestic energy is used for heating water; thus, lower hot water use for showering would also reduce energy bills. The scheme life was assumed to be eight years.

The main uncertainties associated with this option are in the achievable savings, uptake rates and cost of showerheads. Significant uncertainty is also associated with sustainability of the savings - the low-flow showerhead could easily be replaced by the user with a device able to deliver higher flow rates. Careful design and selection of the low-flow showerheads would be important to prevent this from happening. For example, aerated showerheads perform well, but regularly scale-up in hard water areas (such as Thames Gateway). Clear guidance would need to be provided during installation to promote proper maintenance of the showerhead, to prolong effective performance and maintain savings.

Care would also need to be taken to identify the shower units where such an installation would actually result in a reduced flow. Showerhead replacement is only possible on certain types of showers. Electric showers, power showers and low-pressure gravity-fed showers may be unsuitable for the installation of a low-flow showerhead, restricting the potential uptake of the scheme. A degree of uncertainty also exists in each of the shower-specific inputs for calculating the average water saving. These include the average duration of a shower, number of showers taken per day and the water usage of the showerhead that is replaced. Whereas individually these inputs have little impact on the final results, together their impact on the savings and costs of the scheme can be significant. In this study an average saving was assumed, to simplify the scenario modelling. In terms of the uncertainty in savings from low-flow showerheads, a previous study included an uncertainty of +/-10 per cent to the average household savings of the scheme (Environment Agency, 2007a).

5.4.7 Low-flow taps

The fitting of low-flow inserts is a fairly simple plumbing job, depending on the configuration of the existing system. This measure would involve the installation of retrofits to existing taps to reduce flow rates. Implementation would take the form of a house call by an installer who would assess the existing fittings and offer the installation of appropriate inserts or retrofits where possible. Costs and uptake rates were modelled on the basis of a fully subsidised scheme with no cost to the customer.

A large uncertainty is associated with this scheme due to the uncertainties in initial usage rates, variation in usage rates and flow rates at different taps and the long-term durability of savings (given that inserts are easily removable). As with low-flow showerheads, some uncertainty exists in the savings that might be achieved through the retrofitting of low-flow taps. In this study an average value for savings was assumed, to simplify the scenario modelling. To indicate the level of uncertainty with savings from low-flow taps, a previous study included an uncertainty of +/-10 per cent to the average household savings from low-flow taps as part of a wider “low-use fittings” retrofit package (Environment Agency, 2007a).

5.4.8 Delivery of retrofit measures

The pathway scenarios described in the following sections assume significant levels of uptake of retrofits in existing households to achieve neutrality. In order to achieve extensive uptake, it will likely be necessary to implement an effective campaign to promote the retrofit schemes and develop policy measures to encourage take-up by households. Ideally, campaigns and policy measures will result in attitudinal changes to water use, similar to those observed for waste recycling. These messages may have to be reinforced with similar methods over time, to ensure the savings initially achieved are maintained.

This study did not assess any potential policy measures that may be needed to achieve water neutrality. However, the study did assess costs, although the cost estimates only considered the direct costs associated with retrofitting. Assessing the costs of policies and campaigns to deliver water neutrality was beyond the scope of the study.

It was assumed that retrofit measures would be rolled out in combination, ensuring the cost-effective use of installation time and maximising the number of possible installations. This was taken into account in the analysis.

It is likely that higher uptake rates would be achieved in metered households than unmetered ones, where there is a clearer financial gain in minimising water use. However, the magnitude of the difference is difficult to predict. In addition, this difference might be masked under the significant uptake rates required to achieve neutrality. Therefore, this study assumed that uptake rates for metered and unmetered households would be the same in the three scenarios achieving neutrality or beyond. Different uptake rates were assumed in the fourth scenario considered in the study (the Progressive Scenario).

5.5 Measures not considered further for existing households

The use of outputs and results from the Environment Agency (2007a) study meant that a number of measures identified in Table 5.1 were excluded from the assessment of potential savings from **retrofit approaches** in existing households. These were:

- cistern displacement devices;
- sub-ultra low-flush toilets;
- dry toilets;
- flow control measures;
- garden measures (including water butts);
- harvesting and reuse technologies;
- water audits;
- water efficiency promotion and publicity.

The reasons for excluding these measures are outlined in the following sections. The discussion presented in this section refers only to retrofit options and not new build, where there is likely to be greater opportunity for including the most effective measures. These exclusions are consistent with the Environment Agency (2007a) study, and should not be taken out of context.

5.5.1 Cistern displacement devices

Cistern displacement devices can be placed into toilet cisterns to displace water, reducing the capacity of the cistern and thus the flush volume of the toilet. Examples include the “Hippo”, saving up to three litres per flush, and the “Save-a-flush”, saving around one litre per flush. These devices have been distributed by water companies to customers in large numbers since the mid to late 1990s. For example, in the June Return 2005 Thames Water reported having distributed 630,000 cistern displacement devices over the previous five years to 2005.

Although large numbers of these devices have been distributed, there is little evidence on the number that have been installed and the length of time that they remain installed. For the purpose of this study, this measure was excluded on the assumption that the majority of customers who would be likely to install a device had done so to date. In addition, the inclusion of variable flush retrofits in this study meant that the reduction of toilet flush volume would be addressed by an alternative measure.

5.5.2 Sub-ultra low-flush toilets

This term is not a formal one and is used here to mean flush volumes lower than the four litres full flush that is generally considered to be a practical limit for gravity-flushed toilets connected to normal drains. It was assumed that an additional source of energy would be required to achieve drain carry or alternatively, a flush booster used to collect a number of toilet flushes for discharge together. Propelair[8] and other prototype and/or specialist products could reduce flush volumes to 1.5 litres or less; however, the technology was considered unlikely to be commercially available at the time of this study or achieve the necessary market testing to be implemented on a wide scale.

Vacuum toilets use just over one litre per flush, but are not generally considered to be appropriate for houses because of the capital cost. Examples are limited, but evidence from Denmark’s Environmental Protection Agency suggests that costs would be between 70 and 150 per cent higher than conventional toilet systems (Danish EPA, 2007). Flats offer economies of scale, but if one toilet fails it can depressurise the whole system. Therefore, sub-ultra low-flush toilets were excluded from this analysis.

5.5.3 Dry (composting) toilets

Dry or composting toilets do not require a water supply to convey waste away from the toilet. Instead, waste is collected in a chamber below the toilet and then subject to passive anaerobic treatment to kill pathogens before removal. Despite a number of technologies being available, none were considered appropriate for widespread use in an urban setting given problems of user acceptability and the lack of a large scale co-ordinated system for collection and disposal of dry waste.

5.5.4 Flow control measures

Demand can be reduced by controlling the rate of flow to appliances and fittings. This can be done in the domestic plumbing system in the pipework immediately upstream of taps or showers, using flow regulators, or by reducing pipe pressures in the house. This can be achieved most simply by adjusting the stop-cock.

Estimates of savings from this kind of measure are not reliable. This measure is most likely to be implemented as part of a wider ‘professional water audit’ package, and so was not considered separately here.

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[8] http://www.propelair.com/

5.5.5 Garden measures

Water butts are simple rainwater harvesting systems that collect non-potable water for external use. Evidence is variable on the effectiveness of water butts in reducing demand. For example, when South West Water questioned a sample of customers about their water use 15 months after being provided with a subsidised water butt, 50 per cent said that they no longer used any mains water in the garden (Environment Agency, 2005b). Conversely, the Southern Water study at Chesswood School included the installation of two water butts, but was not expected to show quantifiable reductions in demand (Southern Water, 2000b). In this case, the school would be closed for a large part of the summer when the growing season was at its peak, and therefore when water butts would offer the most potential for reducing demand.

The key constraint on water butt effectiveness is the relatively small stored volume of water, which is typically consumed rapidly once rainfall ceases prior to a prolonged dry period. Therefore the annual variation in rainfall patterns will significantly affect their effectiveness.

Water butts reduce peak demand, but their effect is likely to be limited. The effectiveness of a large scale scheme would also be limited by high existing levels of ownership, driven in part by the discounted sale of water butts by water companies in the area. Water butts were therefore excluded as a measure for existing households, on this basis; however, they offer useful benefits in new households, and so are considered further in Section 5.6.

5.5.6 Harvesting and reuse measures

Rainwater harvesting is becoming more of a mainstream option in new build schools, community centres and other similar buildings. It is less well advanced in domestic new builds, largely because the payback periods are long and there are maintenance issues. For retrofit systems, the installation costs are much greater, reducing the overall benefits.

Grey water recycling remains a relatively esoteric demand management option, even in new builds. There are many issues associated with retrofitting grey water systems – the main ones are high costs and high maintenance requirements. An Environment Agency (2005c) report on domestic grey water recycling concluded that if grey water systems are to appeal to the general public, reliable systems that operate more or less on a ‘fit and forget’ basis are required to reduce the need for ongoing maintenance. Technology has improved since this report was published, although it is still questionable whether current designs can be considered a reliable, cost-effective and publicly acceptable solution.

It is generally assumed that collecting rain from the roof saves energy and resources compared with centralised mains and distribution over long distances. In reality this is unlikely to be the case, although optimised header tank systems can be more effective, as they do not usually pump mains water when there is no rain. Direct pumped systems typically use 1-2 kW.h/m^3 when delivering rainwater and 1.35-2.35 kW.h/ m^3 when pumping mains water, compared to the value of 0.59 kWh/ m^3 used for potable water energy consumption in this study. Rainwater harvesting systems can therefore increase the energy requirements for water supply compared to mains-sourced water (Nick Grant, personal communication).

Rainwater harvesting retrofits for existing household properties were excluded as a retrofit option. However, given that this measure is more attractive in new build schemes, it is considered further in Section 5.6. Grey water recycling was excluded as an option for both existing and new households in all but the most ambitious of scenarios.

5.5.7 Household water audits

Household water audits were excluded on the basis of insufficiently reliable savings. Several water companies have undertaken studies of the savings from household water audits (either professional or domestic self-audits). These studies do not provide convincing evidence of reliable savings on a long-term basis. In the case of self audits, customers may react positively after receiving water efficiency advice in a self-audit pack and change their water use behaviour accordingly. However, there is little evidence on the extent to which these responses are maintained over a period of weeks, months or years after the audit.

For example, Essex and Suffolk Water undertook a study of self audits in Romford and Brentwood in 2004 in which the company contacted 88,500 customers to offer them a self-audit pack including cistern devices, a trigger gun for hoses and other devices such as shower timers. The company received over 33,000 requests for a pack and 21,271 completed audits were returned from customers. Essex and Suffolk estimated the savings at around 11 litres/property/day (Essex and Suffolk Water, 2004). However, there is little or no information on the longevity of such savings.

Although the longevity of savings could be viewed as an issue for a number of measures, it can perhaps be considered more relevant to measures more reliant on behavioural changes (such as self audits) rather than technological solutions (such as retrofitting variable flush devices).

5.5.8 Water efficiency promotion and publicity

Water efficiency promotion and publicity was excluded from the original Entec study due to a lack of evidence that the measure can generate reliable savings. The lack of studies meant that levels of uncertainty surrounding these were unacceptably high. However, it was recognised that promotion and publicity campaigns would be a necessary part of the retrofit measures considered and would bring additional costs. Whilst water efficiency promotion might provide encouragement to households, it is unclear as to how often the message would need to be repeated to sustain savings.

5.6 Measures for new households at the development level

5.6.1 Summary of household measures

The measures considered in new households were based on assumptions in the Environment Agency report, *Assessing the cost of compliance for the Code for Sustainable Homes*, (Environment Agency, 2007b). The report, authored by WRc, identified the micro-component use of fittings and appliances in new homes that would be required to meet a range of consumption rates. This (Entec) study considered a range of measures in new homes, some of which were excluded from existing homes, based on the costs and practicality of installing these systems in new and existing homes.

Section 5.4.2 presents details of the data and assumptions used, but in simple terms, the assessment was based on use of the following measures in new homes:

- dual flush or low-flush toilets;
- low-flow showerheads or electric showers;

- low-flow/spray taps;
- small volume baths;
- water-efficient washing machines and dishwashers;
- water butts;
- rainwater harvesting systems.

Some of the technologies that would be unattractive at the domestic scale could make sense at a small municipal scale, such as a housing development. The following sections consider the issues associated with development-scale measures.

5.6.2 Rainwater harvesting

There are frequent references to the economies of scale obtainable from rainwater harvesting at the development or community level, compared to individual property. Economies of scale could be introduced to the installation, performance and maintenance of the systems when installing at the community/development level. In addition, it is possible that maintenance of a development-scale system by a suitable contractor could well result in a more reliable system than at the household level. However, the available drainage area for large-scale systems will not vary significantly from household-level installations; therefore, the volume of rainwater generated is still likely to be a constraining factor.

A key issue for the Thames Gateway is the availability and seasonal variability of rainfall in one of the driest areas of the country. Rainfall data provided by the Environment Agency for the long, dry period from September 2004 showed that rainfall was low, averaging 374 mm for each of the two years. Whilst this is clearly exceptional, it is useful to understand how rainwater systems might perform during drought periods. Under generous assumed roof areas (up to 100 m^2/property), the average daily household yield would be around 70 l/day compared to a demand for non-potable water of over 220 l/day. This is illustrated in Table 5.4.

Table 5.4: Comparison of rainwater harvested and demand during drought periods

Roof area m^2	Occupancy (persons per house)	Non-potable water use per day[9] (litres/ property day)	Rain water used (litres/year)	Rain available (litres/day)	Percentage of non-potable demand met (%)
50	4	226	13,000	36	16
100	4	226	25,000	69	31
50	2.4	140	13,000	36	26

Annual average rainfall in Thames Gateway is 585 mm per year. Using the same calculations, this gives a daily average household yield of 108 l/day – approximately 50 per cent of non-potable household demand. This value was used in later analysis of rainwater harvesting.

Even allowing for rainwater collection over greater areas at the development scale, it is unlikely that rainwater harvesting would provide sufficient volumes to meet all non-potable demand during drought periods in this particular area. However, this analysis showed that under average conditions, rainwater harvesting could provide 50 per cent of non-potable

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[9] Ecohomes frequency assumptions with 6.5 litre WC, 50 litre washing machine and 10 litres per day outdoor use (N Grant, personal communication)

household demand over a year, and under drought conditions rainwater harvesting could provide around 30 per cent of average annual non-potable demand.

Therefore, whilst it would be unreasonable to dismiss development scale rainwater systems on this very stringent test, it presents some interesting findings. It is clear that demand for water during prolonged dry periods and peak periods would have to be met from elsewhere. Given the statutory duty of water companies to maintain supplies, this kind of demand would likely fall upon public water supplies, and water companies might argue the need to invest in resources to ensure demand was met at such times.

Additional benefits from development-scale rainwater harvesting systems include the attenuation of surface water run-off and sustainable drainage systems (SuDS). Assessment of these benefits is beyond the scope of this study.

5.6.3 Grey water and black water recycling

It may be possible to achieve economies of scale by collecting grey water or black water at the community level and recycling it for toilet flushing. The main advantage that these systems have over rainwater harvesting is that they generate a relatively steady stream of recycled water, and do not rely on seasonally varying rainfall. In fact, the Draft London Water Strategy (GLA, 2007) considered the benefits of using rainwater and grey water together for this reason. However, information in the public domain suggests that the two greatest barriers to communal uptake of such technology are likely to be public concern about the risk to health and system maintenance requirements (Market Transformation Programme, 2006).

The issue of public acceptability is linked to the relative novelty of the technology in the UK. However, rainwater and grey water are routinely used in other cities like Tokyo (GLA, 2007). The following sub-sections consider the types of technology that would be necessary to develop grey water or blackwater systems in the UK.

Living machines™

Living machines have a 'green' image but are in effect traditional aeration treatment plants in greenhouses[10]. UK examples include systems at BedZed, the National Botanic Garden Wales, Findhorn Foundation and the Earth Centre. Grant and Morgan (1999) analysed the performance and energy requirements of Living Machines™ and found that the technology was unlikely to be sufficiently reliable to provide black water recycling for demand management purposes. The energy requirements for operating the system and maintaining sufficient temperature to sustain the plants meant that the system would have a high carbon footprint relative to other options (if operated off grid electricity).

Membrane bioreactors

Membrane bioreactors (MBRs) are a rapidly developing technology that can produce a high quality effluent suitable for non-potable reuse including WCs, washing machines and irrigation. These systems are best suited to treating combined grey and black water rather

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[10] Brix, H, 1999. How 'green' are aquaculture, constructed wetlands and conventional treatment systems? *Water Science and Technology*, 40, 3. Grant, N, Morgan, C. 1999. Ecological wastewater management: Challenging assumptions and developing contextual design solutions. *CIBSE National Conference Proceedings*, October 1999.

than grey water alone; the economics start to improve with systems treating about 300 m^3/day (2,000 people). Capital costs for a project of this size would be about £1 million.

Adding reverse osmosis (RO) followed by re-hardening to an MBR would allow the production of potable water, thus achieving water neutrality on site. A small volume of rainwater would make up for any losses.

Whilst possible with current technology, such a solution would be unlikely to be acceptable and would be high risk and uneconomic for a single development because of the need for sustained monitoring and backup. A slightly less controversial variant would be aquifer recharge, possibly with local abstraction. This would provide some extra treatment, dilution and re-mineralisation.

As sludge would need to be disposed of or treated, another option would be sewer mining with an MBR, with waste returned to the same sewer. A better option would perhaps be to add ultra filtration[11] to the outlet of a local sewage treatment works. The energy requirement would be pumping plus one Bar membrane pressure drop.

These technologies make most sense for large industrial demands, especially where low hardness would be beneficial.

Rotating biological contactors

Rotating biological contactors, ‘Biodiscs’ or RBCs are a wastewater treatment technology that has been used for grey water recycling, as well as normal wastewater treatment. RBCs tend to be reliable and have low energy consumption compared with many other treatment systems. RBC effluent could be further treated to a standard suitable for WC flushing and even washing machines.

Sand filters and reed beds

Fixed film processes such as intermittent sand filters or vertical flow reed beds work by gravity and so have low energy consumption. On a site without the required metre or so of fall, pumping would require minimal energy. The main energy input would be pumping the treated effluent back to the buildings.

Sand filters are capable of achieving high effluent quality suitable for WC flushing and subsurface irrigation. Disinfection might allow use in washing machines and garden, but would typically require the use of chlorine or ultraviolet. This could lead to operational and maintenance issues and increased life cycle impacts.

Required area would be around 2 m^2 per 100 litres of effluent or 2-3 m^2 per population equivalent, but filters could be buried or designed into the soft and hard landscape or planted as with reed beds.

5.6.4 Summary and implications for further analysis

This section has outlined some of the key issues associated with development-scale harvesting and recycling measures. Development-scale measures offer certain advantages over household installations, mainly in economies of scale for infrastructure costs and maintenance. These advantages are particularly relevant to grey water or blackwater recycling, such that these technologies would only be considered at a development scale.

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[11] Ultra filtration is defined as a filter membrane of approximately 0.02 microns in diameter.

Given the state of these technologies as well as public perception issues, rainwater harvesting would be the most likely development-scale measure to be implemented in Thames Gateway in the near future. However, grey water and blackwater recycling could be part of a water neutral solution in the later stages of the Gateway development, once the technology had advanced and been proven further. Public perception is likely to be a key issue for these recycling options, with grey water systems more likely to be accepted given the lower risks associated with pathogens and odour.

The analysis of pathway scenarios in Section 7 takes account of the findings presented here, by adjusting the costs of harvesting/recycling technologies to reflect the assumed cost savings of implementing them at the development scale.

5.7 Measures for new households at the household level

The pathway scenarios considered in this study investigated the effects of applying lower consumption rates to larger proportions of new households than considered in the BAU analysis. For ease of understanding, these lower consumption rates were assumed to relate to current CSH levels. The underlying assumptions behind increasing numbers of new households meeting lower consumption levels included the gradual move to greater water efficiency through tightening (new) building regulations, and through year-on-year increases in the take-up of the CSH.

Analysis of the micro-components of demand in new households was central to considering how the CSH could contribute to water neutrality. Micro-component analysis was based on consideration of the following:

- ownership rate of appliances (percentage of population who own toilets, showers and so on);
- frequency of use of fittings and appliances (in terms of uses per day);
- volume of water consumed per use (toilet flush, bath volume and so on).

These three variables were multiplied to obtain a total use rate per fitting/appliance per day and this product summed to obtain a per capita consumption rate. Ownership and frequency of use rates were taken from the Technical Guidance for the CSH (Communities and Local Government, 2007a), whilst volumetric information was from the Environment Agency report on the cost of compliance for the CSH (Environment Agency, 2007b).

The following text is a précis of the introductory section from the aforementioned report and summarises the approach used to select product usage information.

In essence, the method aimed to establish the range of water consumption by the most water-efficient products currently available or under development and the costs associated with each type of appliance. The appliances considered should perform satisfactorily so householders would not replace them with products of better performance, but which might use more water. Product water use information was sourced from:

- Market Transformation Programme (MTP) information sources;
- Water Technology List (Enhanced Capital Allowance Scheme);
- WRc's Identiflow micro-component studies (WRc, 2005).

In addition, only products complying with Water Supply (Water Fittings) Regulations 1999 (HMSO, 1999), for example, being Water Regulations Advisory Scheme (WRAS) approved and listed in the water fittings and materials directory (WRAS, 2006, www.wras.co.uk) were considered. The products selected were also, where possible, included in the Water Technology List (WTL) (www.eca-water.gov.uk).

In selecting products for the cost scenarios relating to CSH levels, products that would not affect customer behaviour or perception were considered first. For example, a lower flush toilet would use less water but there would be no change in performance observed by the user. Similarly, lower flow rate taps with an appropriate flow pattern should provide the same amount of washing capability.

Only when these were all incorporated were products that might require a change in behaviour or have an impact on the customer included in the analysis. For example, the inclusion of electric showers was avoided until such a point where the Code level could not be met without changing from a mixer shower or gravity shower to electric. The use of grey water recycling, as the most complicated and technologically demanding option, was avoided in all scenarios in favour of rainwater harvesting. With increasing water efficiency the volume of available grey water would decrease, whereas rainwater yield would remain unaffected by any such measures.

Product cost information was sourced from:

- manufacturer and supplier literature and websites;
- water efficiency and green building product websites;
- the Home Builders Federation.

Product installation would be carried out for new homes at the time of building construction. The costs of installation (other than for rainwater harvesting or grey water systems) would not be likely to be different to those of the base scenario and were therefore not included. Currently, developers do not commonly install grey water recycling or rainwater harvesting systems; however, the cost of construction into a new build would not be as significant as a retrofit.

As with the BAU scenarios, consumption rates considered in the pathway scenarios took account of likely external water use (not included in the standard CSH figures). The allowance was based on around 11.5 l/h/d additional demand.

A full breakdown of pcc into micro-components of demand is provided in Tables 5.5 to 5.7. These tables present total indoor use for comparison with CSH standards, as well as total household use which includes an allowance for external use (not part of the CSH performance level). The assumptions used to calculate the data are set out in Appendix 8.

Code level 5/6 (with a pcc of 80 l/h/d) can only be achieved through the use of rainwater harvesting technology. A report by the Environment Agency (2007b) assumed that rainwater would be able to replace mains water for toilet flushing altogether; however, the analysis presented here assumed rainwater would replace 50 per cent of the water used for toilet flushing. Grey water recycling was not considered feasible in the 2007 study, but would deliver a similar result.

Table 5.5: Micro-components of demand, equivalent to CSH Level 1/2 (120 l/h/d)

Micro-component	Frequency of use (use/day)	Volume per use (litres)	Total (litres/head/day)
WC	4.8	4.0	19.2*
Basin	7.9	2.0	15.9
Shower	0.6	40.0	24.0
Bath	0.4	64.0	25.6**
Kitchen sink	7.9	2.0	15.9
Washing machine	0.34	45.0	15.3
Dishwasher	0.3	12.0	3.6
TOTAL INDOOR USE			119.4
Outdoor	1.0	11.5	11.5
TOTAL USE			130.9

*Based on a 6/3-litre dual-flush toilet.

**Assumes a 160-litre bath typically filled to 40 per cent of its capacity.

Table 5.6: Micro-components of demand, equivalent to CSH Level 3/4 (105 l/h/d)

Micro-component	Frequency of use (use/day)	Volume per use (litres)	Total (litres/head/day)
WC	4.8	3.5	16.8
Basin	7.9	1.1	9.0
Shower	0.6	30.0	24.0
Bath	0.4	64.0	25.6**
Kitchen sink	7.9	2.0	15.9
Washing machine	0.34	45.0	15.3
Dishwasher	0.3	12.0	3.6
TOTAL INDOOR USE			104.2
Outdoor	1.0	11.5	11.5
TOTAL USE			115.7

*Based on a 4.5/3-litre dual-flush toilet.

**Assumes a 160-litre bath typically filled to 40 per cent of its capacity.

Table 5.7: Micro-components of demand equivalent to CSH Level 5/6 (80 l/h/d)

Micro-component	Frequency of use (use/day)	Volume per use (litres)	Total (litres/head/day)
WC	4.8	3.5	8.4^
Basin	7.9	1.1	9.0
Shower	0.6	30.0	24.0
Bath	0.4	56.0	22.4**
Kitchen sink	7.9	1.1	9.0
Washing machine	0.34	45.0	7.7^
Dishwasher	0.3	12.0	3.6
TOTAL INDOOR USE			78.0
Outdoor	1.0	11.5	11.5
TOTAL USE			89.5

*Based on a 4.5/3-litre dual flush toilet.
**Assumes a 140-litre bath typically filled to 40 per cent of its capacity.
^ Fifty per cent of water replaced by recycled water.

5.8 Variable tariffs

Variable tariffs offer potential savings by increasing the economic incentive to manage and reduce demand. In the context of this study, 'variable tariffs' refer to rising-block tariffs that include higher unit rates for each unit of water above a certain threshold. At present, variable tariff models of this type are not used in the UK for household customers. It is appreciated that this kind of approach would present challenges (for example, in terms of setting appropriate thresholds), but rising-block tariffs offer the advantage that advanced metering is not required.

Variable tariffs should offer useful reductions over and above the effect of metering alone (using only standard tariffs) at relatively low costs. Variable tariffs were applied within this study to both existing metered households and new metered households from 2010-11 onwards. This is the first year of the next Asset Management Plan (AMP) period, thought to be the earliest point at which variable tariffs could be implemented. The assumptions used in estimating potential water use savings from variable tariffs are outlined below.

Based on the assumption that metering alone (switching from an unmeasured bill to a standard domestic measured tariff) would result in a 10 per cent reduction in demand, variable tariffs were assumed to provide an additional five per cent reduction in annual average demand. This assumption was for modelling purposes only. It was based on limited evidence not directly relevant to the Gateway or the scenarios being considered and so some working assumptions about how water using behaviour might change in the study area were also made. Rising water bills, a higher risk of drought (compared to the national average) and changing attitudes to water efficiency could all increase pricing. Because significant numbers of homes would be built or retrofitted to higher water efficiency standards, the opportunities for further efficiency reductions might be reduced. Consequently, there is considerable uncertainty associated with these savings.

Most of the UK evidence for the effects of metering on demand implicitly considers the combined effects of metering and variable tariffs, and most of these are dated. The only two studies assessing the impact of seasonal tariffs in the UK were from national metering trials in the late 1980s, where seasonal metered tariffs were introduced in homes previously billed by rateable value. They showed a reduction of 12 and 17 per cent in the average demand, and much higher reductions in the summer (UKWIR, 2006). However, this reduction was compared to unmeasured water use and therefore represented savings due to metering and variable tariffs.

There is also limited international evidence on the effects of variable tariffs (regardless of the type of tariff in question), and the few international studies that exist may be considered only partially relevant to the UK situation (for example, external water use in the US is significantly higher than in the UK).

This study assumed the use of rising-block tariffs, where customers pay a higher unit rate for water used above certain thresholds. Rising-block tariffs could be implemented with standard water meters that would be read manually once or twice a year.

5.9 Measures for existing non-households

Non-households include the following types of customers:

- offices (large public sector buildings to small businesses);
- retail premises from high street shops to large shopping centres;
- commercial and industrial premises of all types, including those using very little water (such as storage units) to those using large amounts (such as food and drink manufacture);
- service sector customers, including hotels, restaurants, golf clubs, health clubs and holiday parks;
- public sector buildings including primary and secondary schools, colleges, hospitals, prisons and leisure centres, as well as general municipal use (such as parks and gardens).

This is not an exhaustive list, but demonstrates the wide range of water users in the non-household sector. Many of the uses of water here are specific and in general, it is not possible to approach non-household use in the same way as household water use, where most households use water for the same purposes. This means that it is relatively difficult to build up a ‘bottom-up’ picture of water use in non-households without a detailed understanding of individual users. Whilst this is less complicated for certain classes of users (such as schools), it is much harder for others (such as commercial and industrial customers).

It is also difficult to access reliable and consistent data for non-household customers, and estimating usage (for example, by considering pupil numbers in schools) is likely to introduce even more uncertainty into the analysis. Therefore, this study adopted a ‘top-down’ approach to assessing potential savings, based on the non-household consumption data provided by water companies in their WRP tables.

This approach, by definition, was relatively simplistic, but a detailed consideration of water use by individual non-households, or even groups of non-household customers was beyond the scope of this research. However, the study made use of data where this was available and for this reason, office use was considered separately.

5.9.1 Evidence base for existing non-households

Bottom-up estimates of water savings for existing non-households were not possible within the scope of this project; therefore, the contribution that non-households might make to water neutrality was based on simpler top-down estimates. By taking this approach, the study used straightforward percentage reductions applied to total non-household demand. These percentage reductions were also based on relatively high-level information

The potential for reduction in offices was based on evidence presented in the Construction Industry Research and Information Association (CIRIA) report C567, *Water key performance indicators and benchmarks for offices and hotels* (CIRIA, 2006), which showed that office workers typically use 20 l/h/d whilst at work and that reduction to 12 l/h/d is achievable. Based on these values, a 40 per cent reduction in office water use was assumed.

The potential for reduction in other existing non-households (everything except offices) was based on a high level assessment by Envirowise (www.envirowise.gov.uk), which showed that businesses could expect to make a saving of between 20 and 50 per cent by using simple and inexpensive measures, and that savings at the lower end of this range would likely be no-cost or low-cost. Envirowise suggested that demand management from toilets, taps and showers would provide a combined water use reduction of 40 per cent. This supported the 40 per cent savings value this study assumed for offices.

Evidence from published Envirowise data on demand management measures (both savings and costs) is presented below. The published information focuses on office water use, although the measures detailed below could be used in other non-household properties. The costs and savings quoted by Envirowise support our assumptions on the scale of achievable non-household savings and the indicative costing presented in this study.

Figure 5.1 shows a component breakdown of water use within a typical office. The greatest use of water is for toilet flushing, at 43 per cent of the total. When combined with urinals' use of 20 per cent, just under two-thirds (63 per cent) of water use in offices is for toilets. Almost one-third of water use (27 per cent) is for washing purposes including personal hygiene and non-catering domestic use. Canteen use accounts for nine per cent, whilst cleaning uses less than one per cent of the total.

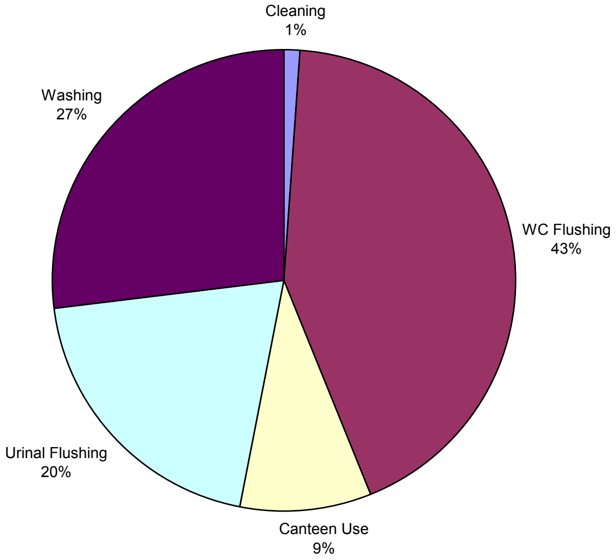

Figure 5.1: Breakdown of office water use into demand components (from the Environment Agency, cited in Envirowise, 2005)

Figure 5.1 shows that toilets and urinals together are likely to offer the greatest potential for savings within offices. By implication, they are also likely to offer significant opportunities for savings in other non-households.

For toilet flushing, water savings could be achieved at little or no cost. For a toilet cistern of nine-litre flush volume, savings of 1.5 to two litres per flush (around 20 per cent) could be achieved with cistern displacement devices (Envirowise, 2005). These devices absorb or fill with water and displace water in the cistern, reducing the volume of water used for each flush. These devices are not suitable for all toilets, especially newer toilets where cisterns are of smaller volume (7.5 litres, six litres or less).

An alternative to cistern displacement devices would be retrofitting dual-flush mechanisms, as detailed in Section 5.4.4. Again, these would be a relatively low-cost retrofitting measure, with the devices themselves costing around £8 per unit.

Significant non-household savings could be made with flush controllers on urinals. Theoretical calculations are widely published, with the following information from an Envirowise fact sheet on urinal water use (Envirowise, 2006). A typical urinal flush system based on 7.5 to nine-litre cistern flushing up to three times per hour would use approximately 197-315 m^3 per year (based on 100 male staff working 260 days per year). Measures to reduce urinal use include those with almost negligible cost, such as the installation of a timer and solenoid valve to stop flushing when urinals were not in use, to the use of passive infrared (PIR) sensors to detect when urinals were being used. PIR sensors would be relatively cheap to install, costing around £120 per unit. Timers and solenoid valves and PIR sensors could achieve savings of up to 75 per cent in water use.

Water use for urinal flushing could be reduced by around 90 per cent through the installation of waterless urinals (some water may be required for hygiene purposes). There are several different types of waterless urinals available, which use different mechanisms to ensure that urine is disposed of whilst managing odour. Costs quoted by Envirowise are £80-90 to retrofit existing urinals with waterless urinals.

Savings achieved through urinal controls could be significant at relatively low cost. However, the savings at any one site would be largely determined by the existing cistern operation (whether urinal flush controllers were already installed), the number workers/users of the facility and the frequency of use. In the case of waterless urinals, running costs could be significant with the requirement to maintain the urine capture and deodorising mechanism. These could cost between £20 and £45 per year, depending on frequency of use (Envirowise, 2006). For these mechanisms, there are also issues about the generation of waste associated with the disposal of the components (such as cartridges).

For washing, savings could be achieved through the installation of percussion taps (push taps that shut off after a fixed duration). These taps could save up to 50 per cent of water used by conventional taps at a cost of around £20 per tap (Envirowise, 2005). However, the savings achieved at any one site would depend on the current taps installed on site.

Greater savings could be achieved through the installation of spray taps. As with household options, this could be done through the installation of retrofit tap inserts or through the replacement of existing taps with spray tap units. These could achieve savings of 60-70 per cent over standard taps (Envirowise, 2005).

Other mechanisms for savings in non-households include the installation of flow control or pressure control valves. By reducing pressure within the water system, the volume of water used when a tap is opened would be reduced. Savings from such activities are difficult to quantify and would be site-specific in terms of applicability. The cost of installation of such devices would be minimal (tens of pounds).

For non-household sites with showers, similar savings to those outlined in Section 5.4.6 could be achieved through electric showers or low-flow showerheads.

Non-households also offer the opportunity for water savings in canteens and kitchens in activities such as the cooking and preparation of food, washing dishes and disposal of waste. For general water use (through taps), the flow reduction measures outlined above would be applicable to canteens. Where automatic dishwashing facilities were provided, it would be possible to make savings when appliances were due for renewal by selecting appliances with more efficient energy and water use ratings.

5.9.2 Assumptions used in analysis

The evidence shows that potential water savings in offices is greater than in other types of non-household properties. Office water savings are also better understood, as the potential for savings are linked to well-understood domestic products such as toilets, taps and showers. Therefore, the 40 per cent savings assumption made here had relatively low uncertainty.

To use this figure it was necessary to determine what proportion of total non-household demand was made up of office water use. Some water companies provide a breakdown of non-household demand by customer type in Supplementary Table 2 of the WRP tables. Only Southern Water's tables provided enough information to allow an estimate of the proportion of total non-household demand from offices, at about five per cent. This value was supported by information provided by Thames Water (personal communication). Therefore, a 40 per cent reduction in demand was applied to five per cent of non-household use to account for reductions in offices.

The top-down approach adopted in this study inevitably included a relatively high degree of uncertainty for the remaining non-household use, given the wide range of potential uses. The value used here could be critical to neutrality scenarios, as non-household demand constituted around 107 Ml/d, or 20 per cent of the total baseline demand in the Gateway. As a result, this study assumed a conservative potential savings rate for this portion of non-household demand. Instead of the 20-50 per cent suggested by Envirowise, this study assumed a 10 per cent reduction. This reflects the limited appreciation of what industrial processes are significant in the Gateway, their current state of water management and what further savings are possible.

Increasing this value (based on reliable evidence) could significantly alter the make-up of the neutrality scenarios considered later in the report, with implications for the feasibility and cost of achieving neutrality.

5.10 Measures for new non-households

For new non-households, measures were largely constrained to those outlined above for new households. Some additional measures such as urinal controls would be available to non-households. In addition, there would likely be economies of scale with some technologies (such as rainwater harvesting). Water efficiency measures for industrial premises associated with more modern processes were not considered.

5.10.1 Assumptions used in analysis

New non-household demand was combined with existing non-households into total non-household demand for modelling purposes. New non-household demand was thus subjected to the reduction assumptions used for existing non-households.

5.11 Leakage savings

The three water companies involved in this study (Thames, Southern and Essex and Suffolk Water) provided information on leakage forecasts, indicating leakage rates were predicted to fall by 20 Ml/d across the Gateway area over the study period. These planned reductions (mainly in Thames Water's London WRZ) were excluded from the BAU calculations for reasons outlined in Section 3.2.3. The BAU scenario therefore considered the demand resulting from the three water companies meeting their 'economic levels of leakage' (ELL). ELL is a theoretical leakage rate reached when the cost of reducing leaks further is greater than the cost of managing the supply-demand balance in a different way (such as through developing new resources).

Therefore, this report considered the potential contributions that additional leakage reduction beyond the ELL could make, based on the limited available information.

This study aimed to consider whether companies could contribute to neutrality by reducing leakage below the ELL, by considering leakage schemes included in the water resource plans (WRPs). However, it was not possible to do this due to the limited data available. Some data were available from Essex and Suffolk and Thames Water's WRPs, but these data were company-specific and not readily transferable.

Approximately 60 per cent of leakage in 2005/06 in the Thames Gateway was within the London WRZ. Thames Water believes that further reductions in leakage above those included in their WRP could only be achieved through additional mains replacement (Thames Water, personal communication).

To carry out a meaningful assessment of the savings achievable through mains replacement would require information on the condition of the distribution network, especially the areas in the worst condition, which was not available for this study. However, an indicative assessment of the costs of mains replacement is provided in Table 5.8. This assessment is based on average water industry costs for mains replacement of £300-£350 per metre (Thames Water, personal communication) and leakage data within the public domain. For this assessment the following assumptions were made, which resulted in considerable uncertainty in the estimated costs:

- Mains replacement was the only leakage reduction method considered; Thames Water indicated that this was the only method that would achieve further leakage reduction beyond the levels planned by the water companies in their 2004 water resource plans.
- Company-level total leakage in m^3/km/day was indicative of leakage levels within the Thames Gateway.
- Replacing mains would leave no residual leakage within the new network. In reality, the new network would leak to some degree and therefore more mains replacement would be required to achieve the 1 Ml/d reduction.
- Cost of replacement of one metre of mains was assumed to be £300.

Table 5.8: Indicative costs of leakage reduction through mains replacement

Company	Total leakage (m^3/km/day)*	Assumed length of mains replaced to reduce leakage by 1 Ml/d	Assumed cost per metre of mains replaced (calculated)	Cost to reduce leakage by 1 Ml/d (calculated)	Average incremental cost for 1 Ml/d reduction (pence/m^3) (calculated)
Thames Water	27.7	36 km	£300	£10.8 million	127
Essex and Suffolk water	7.9	127 km	£300	£38 million	472
Southern Water	6.9	144 km	£300	£43.5 million	543

* Taken from *Security of supply, leakage and water efficiency 2005-06* (Ofwat, 2006)

Leakage reduction costs through mains replacement could be in the order of £10 million to £44 million per megalitre of water saved. To achieve a further five per cent reduction in the 2016 leakage levels (reducing 89 Ml/d by 4.5 Ml/d) could cost between £49 million and £196 million.

In water resources planning terms, water companies are required to investigate the relative cost-effectiveness of leakage reductions (cost per cubic metre of water saved). Indicative average incremental costs for making a 1 Ml/d reduction through mains replacement are shown in Table 5.8, ranging from 127 to 543 pence/m^3. The cost per cubic metre will increase as the amount of leakage is reduced through mains replacement. This is because the areas in worst condition would be replaced first, as there would be more water saved in return for the investment.

A number of physical constraints should be considered when assessing the potential for leakage reductions through mains replacement over and above those within WRPs. Such constraints could include gaining access/permission for road closures or the availability of skilled labour.

5.12 Key points

5.12.1 Assumptions

A full range of measures were considered in this study. However, in order to be consistent with previous work, this study used assumptions from two recent studies:

- *Water efficiency in the South East of England – Retrofitting existing homes* (Environment Agency, 2007a).
- *Assessing the cost of compliance for the Code for Sustainable Homes* (Environment Agency, 2007b).

The measures identified as feasible in these projects were included in this study for existing and new households respectively. Reasons for excluding measures are presented but are not discussed in detail, as they reflect justifications used previously.

The effect of retrofitting measures in existing homes was assessed by subtracting the estimated savings from the BAU demand. Assumptions on the micro-components of demand made in the Environment Agency report (2007b) were largely retained when considering the basis of new household consumption in relation to CSH levels.

A number of assumptions were made about the measures used in the analysis that do not bear full repetition here. Key assumptions are presented in Tables 5.5 to 5.7.

Compulsory metering and the use of variable tariffs were considered important in working towards neutrality. This study assumed metering would generate a 10 per cent reduction in demand when existing unmeasured households switched to a metered supply. An additional saving of five per cent was applied to reflect the effect of tariffs on all metered properties (new and existing).

There was limited data on measures for non-households. For the purposes of this study, we assumed a 40 per cent reduction in office water use was possible, and that office water use represented five per cent of all non-household use. A conservative estimate of 10 per cent reduction was used for the remaining non-household demand.

6 Costing

6.1 Introduction

This section sets out the approach to the financial costing in this study. The overall approach to scenario costing is summarised first, with details on the source of costs for new homes, retrofitting existing homes and the costs for non-households and carbon. Costs were drawn from a number of sources including manufacturers' data and published reports. The section also highlights costs that were not included in this study and the reasons for their exclusion.

6.2 Scenario costs

Costs were assessed over a 60-year period and discounted to a present value (PV)[12] in millions of pounds using a 4.5 per cent discounting rate, as indicated in the latest Environment Agency *Water resources planning guidelines* (Environment Agency, 2007d). Where appropriate, capital costs for replacement of measures and operational costs were included. The potential (economic, social or environmental) benefits of reduced water consumption to either water companies, customers or society in general were not taken into account, because the distribution of costs (and benefits) were not assigned to any particular parties, such as a homeowner, business or water company.

Costs were also expressed as an average incremental cost (AIC) in pence per cubic metre. AICs are used in water resource planning by the water industry and regulators, as a method for comparing the costs and benefits of various schemes.

The AIC is calculated using the following formula:

$$\text{AIC (pence/m}^3\text{)} = \frac{C + O - OS}{W*10}$$

Where:

C = discounted present value of the cost of the water saving measure over time horizon of option (capital expenditure, Capex) (£)

O = discounted present value of the operating cost (Opex), that is, the cost of achieving or maintaining the water saving (£)

OS = discounted present value of the opex saving, that is, the money saved by not pumping and treating the water saved in the scenario (£)

W = discounted present value of the total water saved in megalitres (Ml)

The present value (PV) of each element is defined as the sum of the annual costs/savings over 60 years, with future costs/savings discounted at a rate of 4.5 per cent per year.

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[12] In water company planning terms, 'net present value' is sometime used interchangeably with 'present value'. In economic terms, the former relates to the difference between the discounted sum of all the benefits arising from a project and the discounted sum of all the costs arising from the project. In this study, benefits were not assessed, therefore costs are presented as 'present value' of costs.

Although the nature of these schemes means that water savings spanning 60 years are unlikely, these figures are in line with the Environment Agency's *Water resources planning guidelines*. The same source was used for the discount value, which is one per cent higher than the rate stated in the Green Book (HMT 2003). The value for the Opex saving was taken from the previous Entec study for the Environment Agency (Environment Agency 2007a) and used a standard 'current cost of water production' of 10 pence/m^3, representing water costs in the South East.

6.3 Costs for new homes

The costs of constructing new households to the different CSH levels were calculated based on the costs of fixtures and fittings required to deliver a pcc lower than that of a standard new home. The costs of installing water efficiency measures into new homes were based on the WRc report for the Environment Agency (Environment Agency, 2007b). Table 6.1 lists these assumptions.

Table 6.1: Cost assumptions for new homes

Water efficiency measure	Total cost per household	Cost above standard	Assumptions
6-litre flush toilet (standard)	£134	£0	Two in house (2 x £67)
6/4-litre dual flush toilet	£240	£106	Two in house (2 x £120)
3.75-litre toilet	£240	£106	Two in house (2 x £120)
Basin taps 5 l/min (standard)	£20	£0	Two sets in house (2 x £10)
Basin taps 3 l/min	£40	£20	Two sets in house (2 x £20)
Basin taps 1.7 l/min	£120	£100	Two sets in house (2 x £60)
Kitchen taps 6 l/min (standard)	£42	£0	
Kitchen taps 3 l/min	£60	£18	
Mixer shower 48.7 l/use (standard)	£184	£0	
Mixer shower with low-flow showerhead 31.3 l/use	£209	£25	£25 for the low-flow showerhead
Bath 80 litres (standard)	£118	£0	
Bath 60 litres	£198	£80	
Rainwater harvesting/grey water recycling (individual household)	£2,300	£2,300	50% of systems assumed to be for individual households
Rainwater harvesting/grey water recycling (communal system)	£680	£680	50% of systems assumed to be communal

Table 6.2 shows the cost per scenario over and above the costs for fittings in a new home. CSH Level 5/6 costs over £2,000 more than CSH Level 3/4, because of the requirement for water recycling technology. These costs only consider the installation of efficient fittings in new households and not costs associated with variable tariffs. These are included in later cost analyses presented in Sections 8 and 9.

Table 6.2: Cost to achieve each standard of the code above the cost of a standard home

CSH Standard	Cost per property over and above cost of fitting in standard new home
120 l/h/d (CSH Level 1/2)	£237
105 l/h/d (CSH Level 3/4)	£309
80 l/h/d (CSH Level 5/6) and 62 l/h/d	£2,866
95 l/h/d	£586

To calculate costs for each scenario, the cost of constructing a new household to each CSH level (over and above the cost of constructing a standard new house) was multiplied by the number of households for each year. Costs were then discounted using a 4.5 per cent discount rate.

Costs for new homes did not include any marketing costs. Only the costs of the fixtures and fittings themselves were included, as it was assumed the costs of installation would be borne by the developer and ultimately the house buyer (as would occur for a standard new home).

Although the savings were assumed to be maintained throughout the accounting period, no replacement costs were assumed for any of the fixtures/fittings. It was assumed that the householder would undertake any maintenance/replacement of fixtures and fittings. This is a simplification and illustrates the uncertainty in the assessment.

6.4 Costs for existing homes

Costs for the retrofitting of new homes with more efficient fixtures and fittings are shown in Table 6.3. These costs were taken from a previous Entec report for the Environment Agency (Environment Agency, 2007a).

Table 6.3: Costs of retrofitting measures

Appliance	Cost (£)
Variable flush retrofit device	8
Ultra-low flush WC replacement	140
Low-flow showerhead	15
Low-flow taps	5
Installation	72

These costs were applied as a one-off capital cost for each property in the year that it was assumed to be retrofitted.

Installation costs of £72 per property were applied to variable flush retrofit devices, low-flow showerheads and low-flow taps. The ultra-low flush WC replacement was assumed to be offered as a subsidy to homeowners who would otherwise be replacing their toilets. Consequently, there would be no installation cost for ultra-low flush WCs. Within the scenario modelling, the numbers of households retrofitted with each device was different due to the percentage of existing homes assumed to be fitted with a device and the percentage of homes suitable for retrofitting each device. As a result, some homes would have three devices retrofitted, some homes two devices, and some only one device. To avoid double counting of installation costs, the installation cost of £72 was applied for each visit to a property, regardless of the number of devices installed. This might be considered conservative, as the devices are designed to be self-fitting. However, the installation visit might be deemed necessary to allay fears of fitting devices inappropriately.

Based on the figures presented in Table 6.3, the cost per household for installation varies from £232 for a household retrofitted with an ultra-low flush WC, low-flow showerheads and taps, to £77 for a household retrofitted with just low-flow taps.

No allowance was made for the replacement of fixtures and fittings over the 60-year accounting period. In reality, items would need replacing as parts became worn or when the household replaced the bathroom. However, these costs were not included here as retrofitting was assumed to accelerate the implementation of measures that would otherwise occur with the natural rate of replacement of household fixtures and fittings, as householders upgrade their kitchens and bathrooms.

In the case of retrofitting existing households, demand savings were assumed to decline linearly to zero over the 15 years following the retrofit. This was different to the approach assumed for new households constructed to CSH standards, where savings were assumed to be maintained throughout the accounting period. This approach was adopted in modelling since water-efficient fixtures and fittings are designed into new build houses and are therefore more likely to be maintained.

No operating costs were included for the retrofit measures, because these items were assumed to be the customer's responsibility to maintain once installed.

6.5 Compulsory metering costs

Compulsory metering costs were only applied to existing households metered above the BAU assumptions of metering uptake rates. Costs were not included for the metering of new households, as this was not a cost associated with the scenarios (all new households would be metered as a matter of course). The costs that would be incurred through compulsory metering include the capital costs of the meter itself, the cost of installing the meter and the eventual cost of replacing it. Ongoing operating costs such as the costs of meter reading and water company administration associated with billing customers were included.

Capital costs for compulsory metering of existing households were taken from the previous Entec study for the Environment Agency (Environment Agency, 2007a), and were based on information from Welsh Water. The cost of installing a meter includes the excavation and installation of a boundary box as well as the meter itself. Some household properties will already have a boundary box installed as a result of previous construction activities by the water companies. To account for this, it was necessary to assume the percentage of households that did and did not have boundary boxes already installed. This assumption was also taken from the previous Entec study (Environment Agency, 2007a). These assumptions are set out in Table 6.4.

Table 6.4: Capital costs for compulsory metering

Boundary box assumption	Assumed percentage of existing households	Cost per meter installation	Cost per meter replacement after 10 years
Assumed to have a boundary box already installed	35%	£71	£71
Assumed NO boundary box installed	65%	£250	£71

Also shown in Table 6.4 is the assumed cost of replacing a meter. For the purposes of this study, it was assumed that a domestic water meter had a lifespan of 10 years. Again, this assumption was taken from the Entec study (Environment Agency, 2007a).

The cost information used in this study was not for a water company in the Thames Gateway area, but was readily available to this study and had previously been applied to a study in the South East of England. The cost of installing a meter varies between water companies and depends on a number of factors such as geographical location of the installation, the number of meters being installed and ground conditions. During the implementation of compulsory metering, it is likely that some efficiency savings could be made in meter installation costs, since it should be possible to organise meter installation at properties in one geographical location at a time. However, in the absence of supporting evidence, this was not included in this study.

In terms of operating costs, an allowance of £10 per meter per annum was included on the basis of advice from Ofwat (Ofwat, personal communication). The operating cost of compulsory meter reading will vary between water companies, reflecting the different billing systems and methods of meter reading. For the purpose of this study, the £10 per meter per annum figure provided by Ofwat was assumed to be representative of the average domestic meter operating costs per year.

The £10 cost was applied to each domestic property that had been compulsory metered in each scenario. The cost was assumed to be an annual cost incurred for each property over the 60-year period.

To summarise, for a domestic property without a boundary box that was assumed to be metered in 2012, the capital cost of meter and boundary box installation would be incurred in 2012 (£250). An annual operating cost of £10 would be incurred for each remaining year of the 60-year accounting period, whilst a capital cost of meter replacement (£71) would be incurred in 2022, 2032, 2042 and 2052.

6.6 Variable tariff costs

In the scenarios where variable tariffs were included, an additional operating cost of £5 per meter per year was assumed. It was assumed that this cost would be incurred for every domestic property with a meter, including both existing metered households and households constructed during the period under consideration. This was assumed to be an annual cost, incurred during each year of the accounting period from the time that variable tariffs were assumed to be implemented (2010-11).

Due to the lack of data on the cost of implementing variable tariffs, the cost was taken as half the operating cost of £10 per metered customer supplied by Ofwat. This could be an overestimate of costs as additional reading of the meter might not be required, but upgrades to billing systems would be. The cost of this could be more or less than the £5 per meter per year assumed in this study.

6.7 Non-household costs

Section 5.9 summarises the water efficiency measures that could be retrofitted to existing non-household properties and the costs for each measure. However, it is considerably difficult to apply this information to the Thames Gateway, because of the difficulty in determining the types of non-household properties within the Gateway. Non-household properties range from corner shops that may be integrated with a flat or domestic dwelling through retail units, schools, hospitals and offices to large-scale industrial sites. These properties will have widely different water fixtures and consumption figures, ranging from less than 500 litres per property per day up to almost 10 million litres per property per day (the largest single non-household use identified in the Thames Gateway within this study).

For this reason, it was not possible to determine the costs that would be incurred in retrofitting existing non-household properties, and no costs were included within the scenarios for non-household demand reduction. Instead, indicative costing was used based on a range of cost assumptions per retrofit, to illustrate the potential range of costs associated with non-household demand reductions.

The total number of existing non-households in the Thames Gateway in the base year was calculated in this study as 195,400 properties. Sensitivity analysis was undertaken by assuming different property costs for retrofitting (£0, £50, £100, £200, £500 and £1,000 per retrofit) based on the available evidence summarised in Section 5.9. There is considerable uncertainty associated with these costs. For some sites, the cost of retrofitting is likely to be greater than £1,000. However, a larger percentage of the properties are expected to consist of smaller commercial, industrial or retail units (where costs could be under £200 per property) and therefore would offset the costs of more expensive retrofits.

It was assumed that the 195,400 properties could be retrofitted over a nine-year period (at a rate of 21,712 properties per year). The costs of installing retrofit devices were assumed to be incorporated within the property costs, although no allowance was made for the promotional costs that would be required to facilitate access to properties.

The capital cost of installation was assumed to be a one-off cost, with no replacement costs included within the assessment. Operational costs for the retrofit devices were also excluded. Costs were calculated as a present value over a 60-year accounting period and discounted using a factor of 4.5 per cent. As with all cost assumptions, the potential economic benefits of increased water efficiency (in terms of reduced water bills) were not assessed in this report.

Costs for new non-households were also estimated. However, as before, there was considerable uncertainty with these costs and some assumptions were necessary. An estimated 180,000 new jobs are to be created in the Thames Gateway. As stated in Section 4.3.2, a simplifying assumption that these jobs will be office-based was made for the purposes of estimating demand. Some jobs might be created within existing office accommodation, and therefore taken into account in the existing non-household costs. For the purpose of this assessment, however, it was assumed that all the new jobs would be in purpose-built office accommodation.

It was assumed that 100 persons would occupy an office, and therefore a total of 1,800 new office buildings would be required to accommodate the new jobs. Costs were calculated using the method described above for existing non-households, and expressed as a range based on assumed costs of £0, £50, £100, £200, £500 and £1,000 per property. The costs of achieving reductions in new non-households would likely be less than those for retrofitting, since the costs incurred would be for purchasing new water-efficient fixtures and fittings over and above the purchase cost of standard fixtures and fittings that would be installed in new-build office.

6.8 BAU costs

Costs were calculated for the BAU scenario, and included those for households constructed to a standard of water efficiency greater than standard water company pcc (almost 23,300) households. There were no BAU costs for retrofitting existing properties, as no retrofits were assumed in the BAU scenario. BAU costs also excluded the cost of metering and variable tariffs. Metering was excluded on the basis that the programme of metering included in the BAU forecast was that already planned by water companies. Therefore, the metering programme included in the BAU forecast would not be additional to metering costs included in water company plans. No non-household costs were included in the BAU forecast, as no savings from non-households were included in the BAU scenario.

The present value cost for the BAU scenario was approximately £3.6 million.

6.9 Carbon costs

The cost of carbon was derived using the approach specified by Defra (Defra, 2007b). Defra guidance uses the shadow price of carbon, which can be used to calculate the damage costs of climate change caused by each additional tonne of greenhouse gas emitted. The guidance brings the value of carbon into line with the Stern Review's assessment of the social cost of carbon.

The guidance gives a cost per tonne for CO_2e emissions in 2007 prices (the value for 2007 being £25.40 per tonne). The cost per tonne changes over time due to inflation and the increasing cost of damage caused by climate change. The increasing cost of CO_2e emissions was calculated for each year using the method in the Defra guidance.

Costs for emissions under each scenario were calculated by taking the cost of carbon in each year and multiplying by the emissions (in tonnes) for that year. The costs were calculated over a 60-year accounting period, and discounted to a PVC using a discount rate of 4.5 per cent.

To ensure consistency with the approach to costing, the demand savings (and changes to emissions) associated with retrofitting in existing homes decreased to zero over the 15 years from 2016. In the case of the remaining demand savings from CSH levels, metering, variable tariffs and non-households, savings were assumed to remain at the 2016 level for the remainder of the 60-year accounting period. This was a simplification, where a detailed assessment was outside the scope of this study.

6.10 Key points

Costs were calculated as PVs and AICs. The potential benefits of reducing demand for water were not considered.

PV of costs was calculated over a 60-year period, and discounted using a 4.5 per cent discount rate, in line with the approach to water resource planning set out in the Environment Agency's *Water resources planning guidelines*.

Costs for new households were drawn from a previous study by WRc for the Environment Agency (Environment Agency, 2007b). The costs for achieving the CSH standards over and above the costs for fixtures in a standard new home are as follows:

- 120 l/h/d (CSH Level 1/2) - £237
- 105 l/h/d (CSH Level 3/4) - £309
- 80 l/h/d and 62 l/h/d (CSH Level 5/6) - £2,866
- 95 l/h/d - £586.

Costs for new households do not include operational or replacement costs. Savings are assumed to be maintained over the 60-year accounting period.

Costs for existing homes were based on those used in a previous report by Entec for the Environment Agency (Environment Agency, 2007a). Costs of the devices are as follows: variable flush retrofit (£8), low-flow showerhead (£15), low-flow tap (£5). Installation costs of £72 were applied to any property receiving a retrofit, regardless of whether one, two or three retrofit devices were being installed. The ultra low-flush toilets costs of £140 per toilet were assumed to be offered as a subsidy to homeowners who would otherwise be replacing their toilets, and therefore no installation costs were included for this measure.

Compulsory metering costs were applied to existing households metered above the BAU assumptions on metering uptake rates. Costs of £250 per meter installation (without existing boundary box) and £71 per meter installation (with existing boundary box) were used, based on water company data in a previous study by Entec for the Environment Agency (Environment Agency, 2007a). Meters are assumed to be replaced every 10 years, at a cost of £71 per meter.

Compulsory metering operating costs of £10 per meter per year were included, based on information provided by Ofwat (personal communication).

No capital costs were assumed for variable tariffs. The operational costs for variable tariffs were assumed to be half of the cost of compulsory metering operational costs (£5 per meter per year).

The cost of making demand reductions in existing non-households was excluded from the scenarios due to the uncertainties involved. Indicative costing was undertaken using the number of existing non-households in the Thames Gateway in the base year (approximately 195,000) and applying costs of £50, £100, £200, £500 and £1,000 per property.

The cost of making demand reductions in new non-households was also excluded from the scenarios due to the uncertainties involved. For the purposes of indicative costing, it was assumed that the planned 180,000 jobs would be provided in 1,800 new build offices containing 100 persons each. Indicative costing was undertaken based on an assumed cost per property of £50, £100, £200, £500 and £1,000.

Costs for the BAU scenario reflect the costs of building 23,300 properties to CSH levels. No costs were included in the BAU scenario for metering (as the BAU includes the planned water company metering programmes), retrofitting and non-household savings (as none are included in the BAU).

Carbon costing was undertaken using the latest Defra guidance on the shadow price of carbon of £25.40 per tonne CO_2e.

7 Pathway scenarios

7.1 Introduction

This section describes the range of approaches to scenario definition considered and explains why the chosen pathway scenarios were developed. Each of the scenarios are defined in terms of existing household numbers subject to specific retrofit measures and new households developed to different water use standards, including those set out in the Code for Sustainable Homes. This section also describes the way in which the effects of compulsory metering and variable tariffs are analysed, and considers how savings from non-households contribute towards neutrality.

7.2 Selection of pathway approach

7.2.1 Consideration of alternative approaches

A range of different approaches to scenario definition were considered at the start of this study. These included scenarios that:

- represented gradually increasing levels of demand management, from BAU to neutrality, or beyond;
- illustrated the feasibility and/or effectiveness of achieving neutrality at different spatial scales (household, development, Thames Gateway area);
- were based on technological fixes, behavioural change, or both combined.

Later approaches focused on the 'clustering' of measures, so that the long list of measures presented in Section 5 could be grouped sensibly, to reduce the potentially large combination of measures. This approach tied in with work undertaken in previous studies (Environment Agency, 2007a and 2007b), which focused on clusters of options targeted to existing housing stock and new builds respectively.

After some analysis, it was clear that scenarios that considered only technological fixes or behavioural change alone were not going to achieve neutrality. The retrofitting study (Environment Agency, 2007a) showed that metering (particularly compulsory metering) could make a significant difference to the effectiveness of retrofit activity. Metering and the use of variable tariffs are clearly aimed at changing behaviour by attaching a monetary value to each unit of water used, and giving a signal to how this value may change. The CSH and retrofit measures are based on technically achievable standards and to achieve these in practice users need to adapt their behaviour to some extent, which incentives (including price signals) will help to bring about. Therefore, all scenarios included a combination of technological fix and behavioural change.

The spatial approach to water neutrality (aiming to achieve neutrality at household, development or regional scales) was also considered, but rejected for the purposes of the modelling work. Achieving neutrality at the household level is unrealistic given the minimum requirements for potable water, and would result in unnecessary energy and chemical use. The project steering group also provided clear guidance that neutrality should be considered primarily at the Thames Gateway scale.

Therefore, the preferred approach to defining pathway scenarios was to consider increasing levels of demand management. Three main scenarios were selected:

- Progressive
- Neutrality
- Beyond Neutrality

Other scenarios that include contributions from other sectors (such as agriculture) could be developed, but were not pursued here.

7.2.2 Options for achieving neutrality

While achieving neutrality presents a significant challenge for this study, there is sufficient flexibility to enable neutrality to be achieved in more than one way. This study therefore considered three neutrality scenarios:

- The first neutrality scenario (Neutrality 1: Higher retrofit) placed a greater emphasis on demand management in existing households.
- The second neutrality scenario (Neutrality 2: Ambitious CSH) placed a greater emphasis on achieving low water use standards in new homes.
- The third neutrality scenario was a composite of a range of approaches.

Neutrality scenarios 1 and 2 were assessed with and without variable tariffs. The variable tariffs were used to dampen the effect of the extreme component of the scenario, to highlight the potential effect that tariffs can have on the extent of measures needed. The composite scenario included an alternative consumption standard of about 95 litres per person per day in new homes, instead of the equivalent CSH Level 5/6 (80 l/h/d). This consumption level could be achieved without the need for rainwater harvesting systems, so could be more cost-effective than achieving CSH Level 5/6.

Constraints on the CSH levels that could be used in the neutrality scenarios were discussed with the project steering group and representatives from the housebuilding sector. CSH ‘glide paths’ presented in this study take account of these discussions.

7.2.3 Summary of pathway scenarios

All of the scenarios assumed the implementation of compulsory metering programmes, but the effects of variable tariffs were considered separately. A 40 per cent reduction in demand in all offices plus a 10 per cent reduction in other non-household demand by 2016 was applied consistently for the scenarios (except the Progressive Scenario, where only the former was applied). For new homes, all pathway scenarios reflected business-as-usual up to and including 2007/08, as any new homes built now would be unlikely to achieve higher standards than business-as-usual, and houses currently ‘on the drawing board’ would be unlikely to meet higher standards until 2008/09.

The scenarios considered are summarised in Table 7.1.

Table 7.1: Summary of scenario analyses

Scenario name	Approach in existing houses	Approach in new houses	Effect of variable tariffs included?	Non-household assumptions
Progressive	Step up from BAU but limited retrofit and cautious approach to uptake of CSH, reflecting upper limit of what may be possible within current and potential future regulatory framework.		No	40 per cent savings from offices only
Neutrality 1a – Higher retrofitting	High level of retrofit uptake assumed.	More ambitious CSH glide path than Progressive Scenario.	No	40 per cent saving from offices and 10 per cent from other non-households
Neutrality 1b – Higher retrofitting with variable tariffs	Retrofit uptake levels reduced from 1a to reflect effect of variable tariffs.	Same as Scenario 1a	Yes	Same as Scenario 1a
Neutrality 2a – Ambitious CSH	Retrofit uptake assumptions reduced from 1a.	More ambitious CSH uptake than Scenario 1a. For example, uptake of CSH Level 5/6 at earlier stage.	No	Same as Scenario 1a
Neutrality 2b – Ambitious CSH with no Level 5/6 homes and variable tariffs	Retrofit uptake assumptions reduced from 2a in favour of variable tariffs effect.	Variable tariffs effect used to dampen CSH Level 5/6 implementation, so CSH Level 3/4 becomes most stringent level implemented.	Yes	Same as Scenario 1a
Neutrality 3 – Composite scenario	Retrofit uptake assumptions reduced from 2a because variable tariffs can provide a large saving at reduced cost. Introduction of 95 l/h/d scenario requires more retrofitting than 2b to achieve neutrality.	Replace 50 per cent of CSH Level 5/6 households from 2010/11 with pcc of 95 l/h/d.	Yes	Same as Scenario 1a
Beyond Neutrality	Maximum retrofit uptake assumptions (greater than 1a and all other scenarios).	The most ambitious CSH glide path with all new homes assumed CSH Level 5/6 (62 l/h/d) from 2013/14.	Yes	Same as Scenario 1a

7.3 Definition of Progressive Scenario

7.3.1 Description

The Progressive Scenario was designed to indicate the upper limit of what might be achieved by a step up in existing approaches to demand management. This included changes to levels of water efficiency in new build and existing households, and only to offices in the non-household sector. Where possible, the uptake rate of retrofitting measures was based on available evidence.

7.3.2 Existing household

The uptake rates of retrofit measures assumed for the Progressive Scenario are presented in Table 7.2. The retrofit uptake rates included in this scenario were slightly higher than those assumed for the recent Environment Agency study into retrofitting water efficiency across the South East (Environment Agency, 2007a), but this was considered feasible, based on feedback from the recent Ipsos MORI study related to the feasibility study into public attitudes to water use in the Thames Gateway (Ipsos MORI, 2007). In addition, the Thames Gateway is a smaller area than considered in previous research into the effects of retrofitting (on all of the South East), and so could potentially be targeted for promotion and marketing more effectively.

Table 7.2: Uptake of retrofit measures in existing households – Progressive Scenario

Measure	Uptake rate (%)		Feasible households (%)		Net uptake rate (%)		Total households
	Metered	Umetered	Metered	U/metered	Metered	U/metered	
Variable flush toilet retrofit	25	15	70	70	17.5	10.5	91,472
Ultra-low flush replacement	0	0	100	100	0	0	0
Low-flow showerhead replacement	25	15	43	43	10.75	6.45	56,190
Low-flow tap replacement	25	15	100	100	25	15	130,674

The uptake rates for retrofits in existing households considered in the scenarios took account of the number of households where installation was considered feasible. For example, if an uptake rate of 50 per cent was assumed, but only 60 per cent of households were considered feasible for installation, then the net uptake rate was 30 per cent[13]. Uptake rates for variable flush retrofit and ultra-low flush toilets were limited so that properties were not assumed to have both ULF and variable flush retrofits.

The Progressive Scenario included different uptake rates for measured and unmeasured properties, as measured properties have a financial incentive to save water. This difference was excluded from other scenarios, as much higher uptake levels would be required to achieve neutrality and so there was less scope to allow such a variation. In effect this means that, for those scenarios, greater effort would likely be required to ensure uptake rates in unmeasured households matched those in metered households.

7.3.3 New households

Table 7.3 (included at the end of this chapter) presents the implementation of the CSH assumed in the Progressive Scenario, highlighting the different implementation rates assumed for publicly funded and private developments. It was assumed that uptake of higher levels of the CSH would occur more quickly in publicly funded developments (involving English Partnerships and/or housing associations), but that suitably focused policy and market drivers would encourage adoption of similar standards in privately funded developments by the end of the study period (for example, by making rating of all new homes against the Code mandatory, Communities and Local Government, 2007c). This built on the assumptions in the BAU scenarios. Figure 7.1 shows how annual implementation of different CSH levels varies over time for all new households.

Public sector housing was assumed to be achieving the equivalent of the performance standard for water of CSH Level 1/2 from the start of the study period (2006/07), because those dwellings would likely be fitted with lower flow fittings that would lower running costs for the household. Public sector housing would move to Level 3/4 (as an assumed mandatory minimum) for 2008/09 as part of the business-as-usual scenario.

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[13] However, it would still be necessary to target all existing households as part of the retrofit programme, as it would not be possible to determine which were feasible for either variable flush retrofit or low-flow showerhead replacement, until the specific fittings were surveyed.

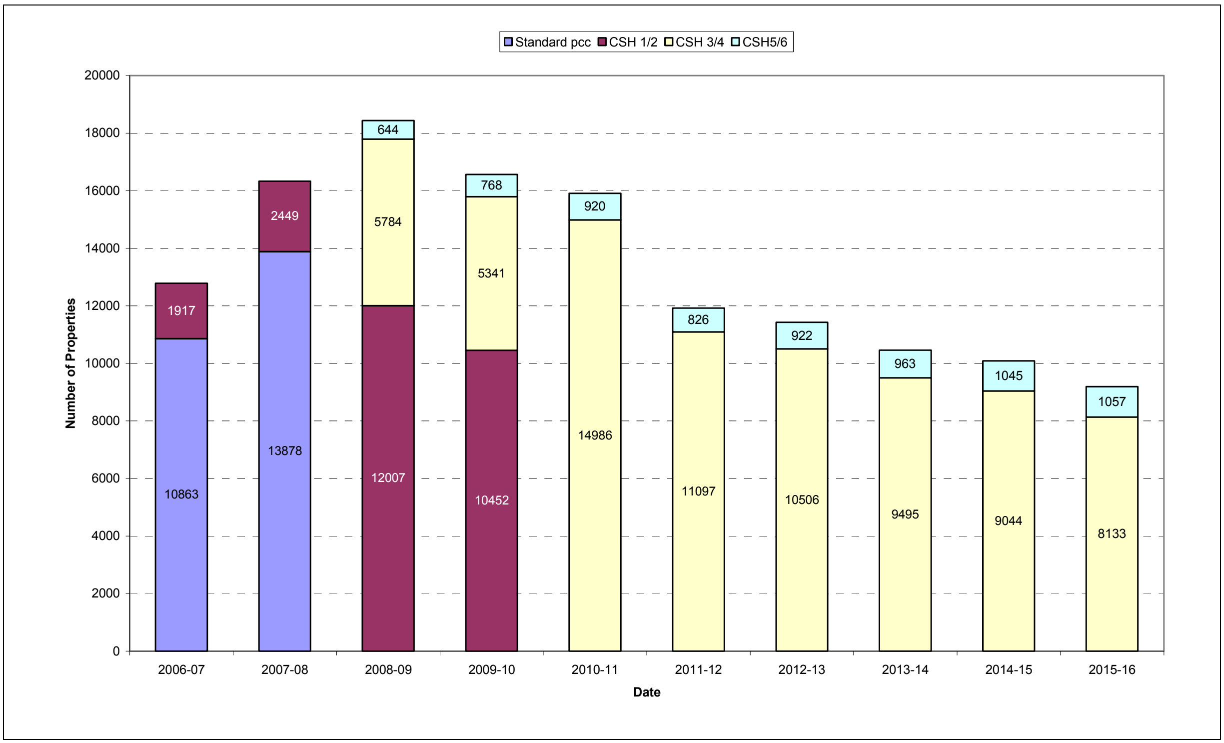

Figure 7.1: Annual new household completions by CSH consumption level – Progressive Scenario

The CSH data in Figure 7.1 and Table 7.3 indicates that for the Progressive Scenario:

- All public sector homes are assumed to be currently built to CSH Level 1/2, moving to Level 3/4 as a minimum from 2008/09.
- Approximately 11 per cent of new homes are assumed to achieve the water efficiency standards equivalent to CSH Level 5/6 in 2008/09 (which is ambitious), increasing to 20 per cent of new homes by 2015/16.
- No CSH standards (equivalents) are assumed for private sector developments until 2008/09, but the water efficiency equivalent of CSH Level 1/2 then becomes a minimum regulatory standard until 2010/11, when all developments are assumed to achieve the water efficiency equivalent of CSH Level 3/4 as a minimum.
- Just over 20 per cent of new privately developed homes are assumed to achieve the water efficiency equivalent of CSH Level 3/4 in 2008/09, with a further two per cent achieving Level 5/6 by taking up the standards on a non-mandatory basis. These proportions increase to 90 per cent and 10 per cent respectively by 2016.

In numerical terms this assumes that:

- All new homes will be built to the equivalent water efficiency standards of CSH Level 1/2 or better from 2008/09.
- A total of around 27,000 homes will be built to the equivalent water efficiency standards of CSH Level 1/2, between 2006/07 and 2009/10.
- Nearly 74,400 new homes will be built to the equivalent standards of CSH Level 3/4, peaking at a rate of almost 15,000 completions per year in 2010/11.

- Over 7,100 homes will be built to the equivalent water efficiency standards of CSH Level 5/6, at a rate of around 1,000 per year from 2008/09 onwards.

7.3.4 Existing and new non-households

It was assumed that a 40 per cent saving in all office buildings was technically possible, based on the CIRIA study (CIRIA, 2006). Office buildings were assumed to constitute five per cent of non-household demand in Thames Gateway, based on information provided by Southern Water. No further non-household savings were assumed.

7.4 Definition of Neutrality 1a: Higher retrofitting scenario with no variable tariffs

7.4.1 Existing households

Uptake rates of retrofit measures in the Neutrality 1a Scenario are given in Table 7.4.

Uptake rates were assumed to be the same for metered and unmetered properties for the reasons outlined in Section 7.3.2. Uptake rates were significantly higher than for the Progressive Scenario, with very high rates assumed for variable flush retrofit, showerheads and taps. These rates were considered ambitious and would require significant effort in marketing and promotion of retrofit campaigns, as well as strong incentives and possibly other policy measures to encourage high rates of installation.

Table 7.4: Comparison of retrofit uptake rates for Neutrality 1a Scenario

Measure	Uptake rate without variable tariffs (%)	Feasible households (%)	Net uptake rate (%)	Total households
Variable flush toilet retrofit	80	70	56	343,503
Ultra-low flush replacement (unmetered households)	18	100	18	69,595
Ultra-low flush replacement (metered households)	18	100	18	40,816
Low-flow showerhead replacement	90	43	38.7	237,385
Low-flow tap replacement	90	100	90	552,058

7.4.2 New households

Table 7.5 (included at the end of this chapter) presents the implementation of the new building regulations and CSH uptake (all related in terms of CSH levels) assumed in the Neutrality 1a Scenario, highlighting the different implementation rates assumed for publicly funded and private developments. Figure 7.2 illustrates how annual implementation of different CSH levels (equivalents) varies over time for all new households.

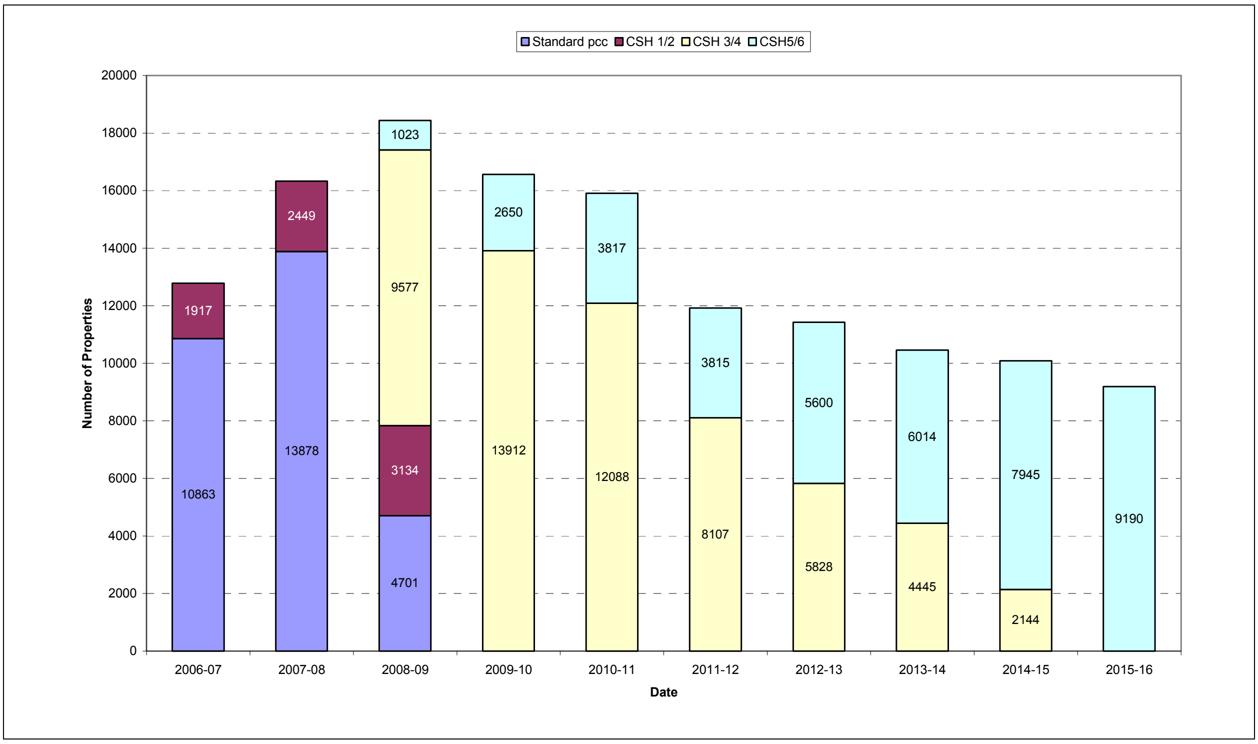

Figure 7.2: Annual new household completions by CSH consumption level – Neutrality 1a: High retrofit scenario

This scenario applied the business-as-usual assumptions up to 2007/08. However, from 2009/10 the scenario assumed that all new homes would be built at a minimum standard of CSH Level 3/4 only and there would be no further completions to Level 1/2. This would likely have implications for privately funded developments.

This scenario also assumed that a far greater number of new homes in both the public and private sector would be completed to Level 5/6 from 2009/10 onwards. Level 5/6 completions in publicly funded developments would increase from 20 per cent in 2008/09 to 100 per cent in 2011/12, whilst the equivalent percentages for private developments would be three per cent and 20 per cent for the same years.

In numerical terms this means that:

- There are only 7,500 new homes built to the water efficiency standard of CSH Level 1/2, all before 2008/09.
- There are just over 56,000 homes completed to CSH Level 3/4 – at least 20,000 fewer than in the Progressive Scenario.
- The peak rate of completions for Level 3/4 homes is assumed to be just under 14,000 in 2009/10.
- There are 40,000 new homes built to CSH Level 5/6, nearly five times more than assumed in the Progressive Scenario. The completion rate rises from just over 1,000 Level 5/6 homes in 2008/09 to over 9,000 in 2015/16.

7.4.3 Existing and new non-households

It was assumed that a 40 per cent saving in all existing office buildings was possible, based on the CIRIA study (CIRIA, 2006). An additional saving of 10 per cent of the demand from other non-households was included in all scenarios (see Section 5.9.2).

7.5 Definition of Neutrality 1b: High retrofit scenario with variable tariffs

The Neutrality 1a Scenario was adjusted to consider the effects of variable tariffs. The CSH glide-path assumptions from Scenario 1a were kept constant (as shown in Table 7.6 at the end of the chapter) and the retrofit uptake rates varied to deliver the same outcome in terms of overall neutrality. In this way, it was possible to consider how variable tariffs might improve the feasibility of achieving neutrality by reducing the extreme assumptions required – in this case around retrofit uptake rates – to achieve neutrality.

Table 7.7 presents the retrofit uptake rates required to achieve neutrality in this scenario. The inclusion of variable tariffs reduces the need to push for high retrofit uptake rates required to achieve neutrality in Scenario 1a. Retrofitting uptake can be reduced by almost half. For example, the number of ultra-low flush toilet retrofits drops from nearly 70,000 in Scenario 1a (Table 7.4), to less than 39,000 in Scenario 1b.

Whilst these rates are still relatively high (compared to the Progressive Scenario), they are less likely to require the levels of effort that would be necessary without variable tariffs. Variable tariffs themselves should provide an incentive to encourage retrofit uptake and secure savings in the long term.

Table 7.7: Comparison of retrofit uptake rates for Neutrality 1b Scenario

Measure	Uptake with variable tariffs (%)	Feasible households (%)	Net uptake rate (%)	Total households
Variable flush toilet retrofit	48	70	33.6	206,102
Ultra-low flush replacement (unmetered households)	5	100	5	38,664
Ultra-low flush replacement (metered households)	10	100	10	11,338
Low-flow showerhead replacement	45	43	19.4	118,693
Low-flow tap replacement	45	100	45	276,029

7.6 Definition of Neutrality 2a: Ambitious CSH scenario with no tariffs

7.6.1 Existing households

The uptake rates of retrofit measures in the Neutrality 2a Scenario are presented in Table 7.8. These were broadly similar to the uptake rates assumed in Scenario 1a, with only the variable flush retrofit uptake rate being lower, at 70 per cent compared to 80 per cent in Scenario 1a. Uptake rates were assumed to be the same for metered and unmetered properties for the reasons outlined in Section 7.3.2.

Table 7.8: Uptake of measures in existing households – Neutrality 2a Scenario

Measure	Uptake rate (%)	Feasible households (%)	Net uptake rate (%)	Total households
Variable flush toilet retrofit	70	70	49	300,565
Ultra-low flush replacement	17	100	17	104,278
Low-flow showerhead replacement	90	43	38.7	237,385
Low-flow tap replacement	90	100	90	552,058

7.6.2 New households

Table 7.9 (included at the end of this chapter) presents the implementation of the new building regulations and CSH uptake (all related in terms of CSH level) assumed in Scenario 2a, highlighting the different implementation rates assumed for publicly funded and private developments. Figure 7.3 illustrates how annual implementation of different CSH levels (equivalents) varies over time for all new households.

Assumptions on the CSH glide path for both publicly and privately funded developments was the same as for all other scenarios up to 2007/08; however, from 2008/09 this scenario assumed more ambitious CSH (equivalent) uptake rates than the previous scenarios. This meant that 60 per cent of all publicly funded developments were assumed to achieve water efficiency standards equivalent to CSH Level 5/6 from 2008/09, with all publicly funded developments achieving this level from 2010/11.

CSH Level 3/4 was assumed to be reached in 100 per cent of privately funded developments from 2008/9, and by 2011/12 the majority of these developments (65 per cent) were assumed to achieve CSH Level 5/6.

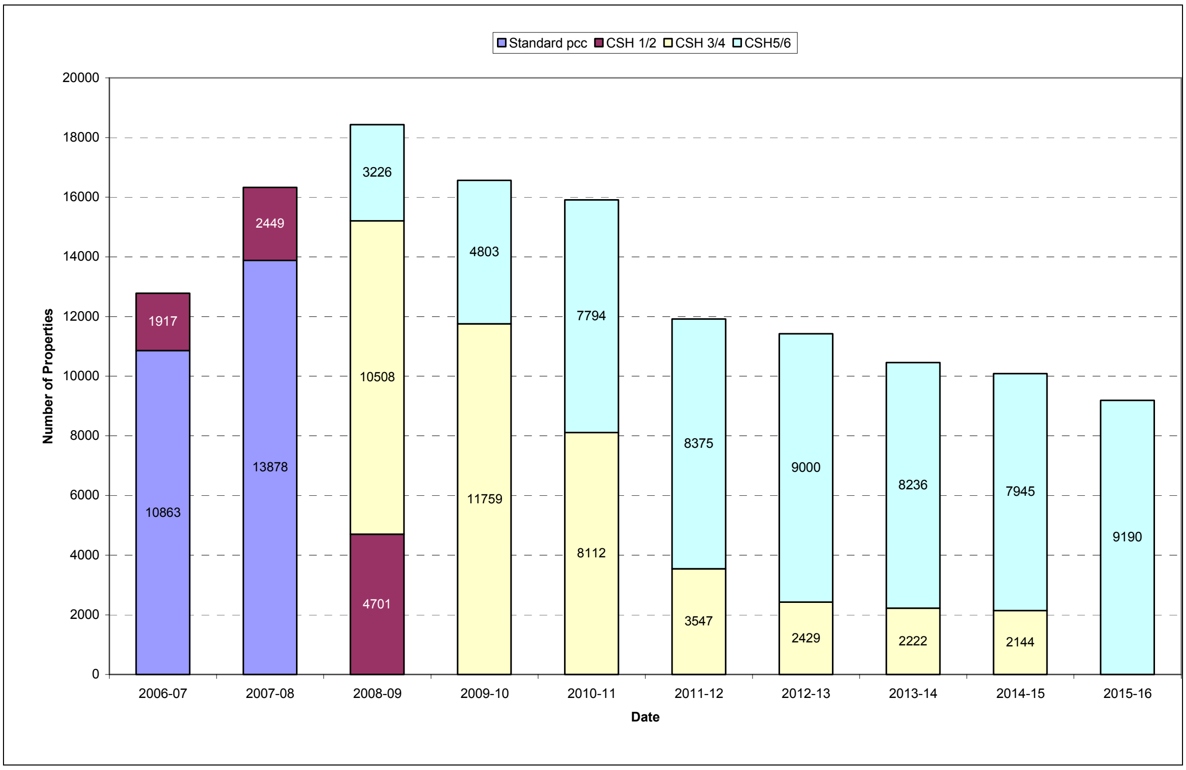

Figure 7.3: Annual new household completions by CSH consumption level – Neutrality 2a: Ambitious CSH scenario

In numerical terms, this scenario assumes:

- Just under 25,000 privately funded new homes are built to existing pcc levels before 2008/09.
- Only 9,000 new homes in total are built to the equivalent of CSH Level 1/2, up to and including 2008/09.
- Nearly 40,700 new homes achieve CSH Level 3/4, with 34,000 of these completed before 2011/12.
- Nearly 58,500 new homes are completed to CSH Level 5/6, at a rate of between 7,000 to 9,000 per year from 2010/11 onwards.

These CSH glide paths are highly ambitious. For context, current local planning guidance such as the London Plan Further Alterations document (GLA, 2006) quotes new homes achieving 40 m^3/bedspace/year (equating to approximately 110 l/h/d, equivalent to CSH Level 3/4), which would not encourage the high take-up of CSH Level 5/6 required to achieve neutrality under this scenario.

7.7 Definition of Neutrality 2b: Ambitious CSH scenario with variable tariffs

The Neutrality 2a Scenario was adjusted to consider the effects of variable tariffs. The existing household retrofit assumptions from Scenario 2a were kept constant (as shown in Table 7.10 at the end of the chapter) and the CSH glide-path rates were varied to deliver the same outcome in terms of overall neutrality. In this way, it was possible to consider how variable tariffs might improve the feasibility of achieving neutrality by reducing the extreme assumptions required – in this case around CSH glide-path rates – to achieve neutrality.

Figure 7.4 illustrates how variable tariffs could be used to remove the need for CSH Level 5/6 homes in new developments from this scenario. This approach is the most straightforward way in which to consider the potential effects of variable tariffs on this scenario, and demonstrates the significant benefits that a tariff-based approach may have. In addition, the introduction of variable tariffs means the retrofit uptake rates needed can be reduced to around 10 per cent of the levels presented in Table 7.7 for the Neutrality 1b Scenario.

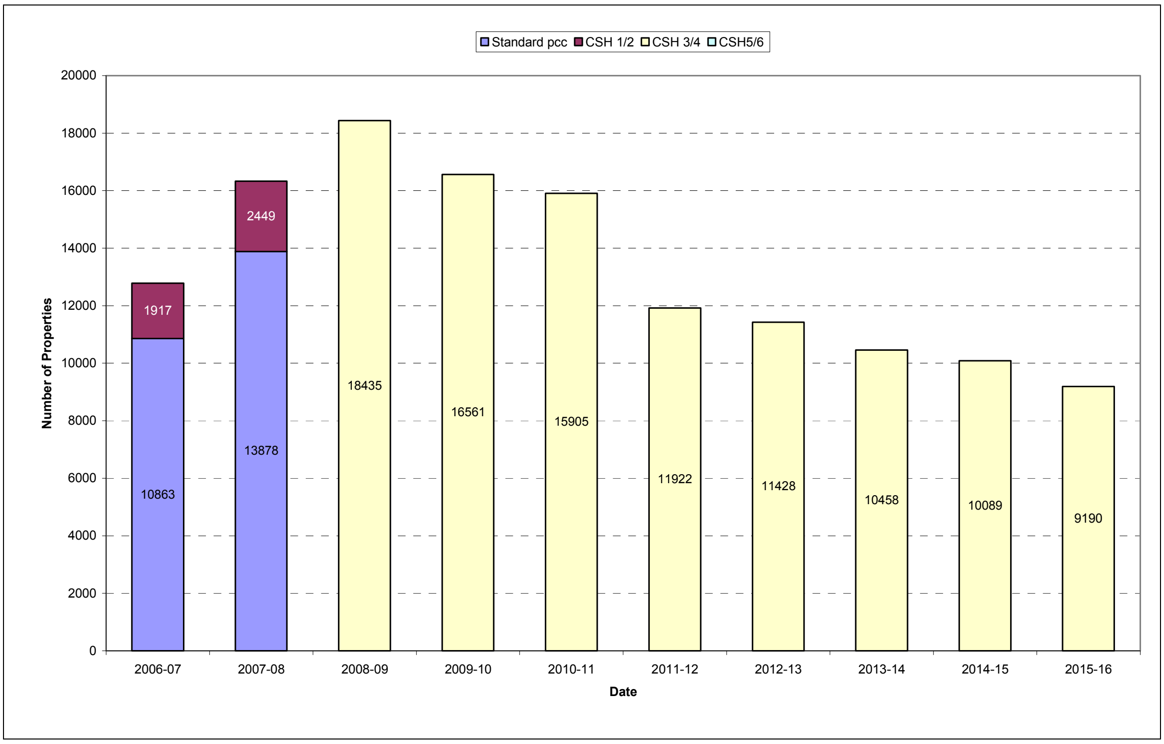

Figure 7.4: Annual new household completions by CSH consumption level – Neutrality 2b: Ambitious CSH scenario with variable tariffs

This scenario appears to be one of the most attractive of the scenarios presented so far, as it assumes relatively moderate levels of retrofit uptake and does not require the development of new homes to the highest CSH level.

7.7.1 Existing and new non-households

It was assumed that a 40 per cent saving in all existing office buildings was possible, based on the CIRIA study (CIRIA, 2006), in addition to 10 per cent of the demand from other non-household customers.

7.8 Definition of the Neutrality 3: Composite scenario with variable tariffs

7.8.1 Description

The Neutrality 3 Scenario with variable tariffs was developed to take a less extreme approach to both new and existing homes than the previous scenarios and to explore the impact of constructing new homes to a pcc standard between CSH Level 3/4 (105 l/h/d) and CSH Level 5/6 (80 l/h/d). The intermediate pcc could be achieved without the use of water recycling technology, thus enabling a lower pcc to be achieved than CSH Level 3/4 but without the high cost of implementing water recycling technology required to achieve CSH Level 5/6.

7.8.2 Existing households

The uptake rates of retrofit measures assumed in the Neutrality 3 Scenario are presented in Table 7.11.

Table 7.11: Uptake of measures in existing households – Neutrality 3 Scenario

Measure	Uptake rate (%)	Feasible households (%)	Net uptake rate (%)	Total households
Variable flush toilet retrofit	55	70	38.5	236,158
Ultra-low flush replacement	10	100	10	61,340
Low-flow showerhead replacement	50	43	21.5	131,811
Low-flow tap replacement	50	100	50	306,699

7.8.3 New households

The Neutrality 3 Scenario with variable tariffs considers reaching neutrality using an additional pcc level that falls between that of CSH Level 3/4 (105 l/h/d) and Level 5/6 (80 l/h/d). Table 7.12 shows that it is possible to achieve an internal pcc of around 95 l/h/d without rainwater harvesting or recycling, by using the same water-efficient fixtures and fittings as CSH Level 5/6 supplied through mains water, rather than with harvested/recycled water. Variable tariffs are considered within this scenario.

Table 7.12: Micro-components of demand (95 l/h/d)

Micro-component	Frequency of use (use/day)	Volume per use (litres)	Total (litres/head/day)
WC	4.8	3.5	16.8
Basin	7.9	1.1	9.0
Shower	0.6	30.0	24.0
Bath	0.4	56.0	22.4**
Kitchen sink	7.9	1.1	9.0
Washing machine	0.34	45.0	15.3
Dishwasher	0.3	12.0	3.6
TOTAL INDOOR USE			94.1
Outdoor	1.0	11.5	11.5
TOTAL USE			105.6

*Based on a 4.5/3-litre dual flush toilet.
**Assumes an 140-litre bath with a typical filling to 40 per cent of its capacity

Table 7.13 (included at the end of this chapter) presents the implementation of the new building regulations and CSH uptake (all related in terms of CSH level except for the 95 l/h/d pcc) assumed in Scenario 3, highlighting the different implementation rates assumed for publicly funded and private developments. Figure 7.5 shows how the annual implementation of different CSH levels varies over time for <u>all</u> new households.

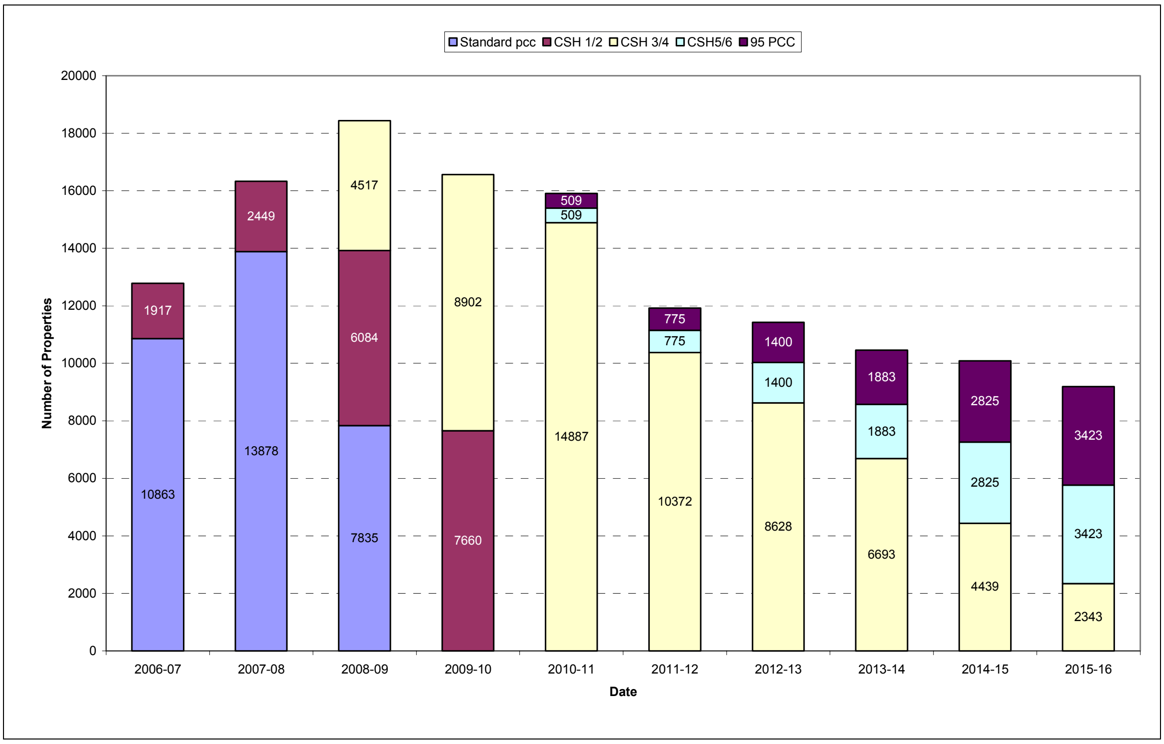

Figure 7.5: Annual new household completions by CSH consumption level – Neutrality 3: Composite scenario

In numerical terms, this scenario assumes:

- Just over 32,500 privately funded new homes are built to existing pcc levels before 2009/10.
- Nearly 18,110 new homes in total are built to the equivalent of CSH Level 1/2, up to and including 2009/10.
- Almost 60,800 new homes achieve CSH Level 3/4 from 2008/09 to the end of the period.
- Up to 10,815 new homes are constructed to the intermediate pcc standard of 95 l/h/d from 2010/11 onwards.
- Up to 10,815 new homes are completed to CSH Level 5/6, from 2010/11 onwards.

In this scenario, all new households are assumed to be built to a maximum of CSH Level 3/4 until 2009/10. From 2010/11 onwards, more households are assumed to be constructed to a higher standard of water efficiency than CSH Level 3/4. These have been evenly apportioned into homes equivalent to the intermediate pcc of 95 l/h/d and homes equivalent to CSH Level 5/6 pcc of 80 l/h/d. In 2010/11, just over 1,000 houses are constructed to a standard more efficient than CSH 3/4 (six per cent of households constructed that year). The percentage of homes built to this standard gradually increase until 2015-16, when 75 per cent of new homes achieve a pcc of 95 or 80 l/h/d.

7.8.4 Existing and new non-households

It was assumed that a 40 per cent saving in all existing office buildings was possible, based on the CIRIA study (CIRIA, 2006), in addition to 10 per cent of the demand from other non-household customers.

7.9 Definition of Beyond Neutrality Scenario

7.9.1 Description

This scenario considered what might be possible by assuming the most ambitious levels of water saving through retrofitting in existing homes and non-households and through implementing the CSH in new homes. It included the effect of variable tariffs and the same level of savings from non-households as the neutrality scenarios.

7.9.2 Existing household

The assumed uptake rates of retrofit measures in the Beyond Neutrality Scenario are presented in Table 7.14. The scenario does not include ultra-low flush toilets, but includes an assessment based on variable flush retrofits, because the cost of a variable flush-based programme would be less than a ULF one. It was also necessary to avoid double counting of the savings from toilet retrofitting.

Table 7.14: Uptake of measures in existing households – Beyond Neutrality b Scenario

Measure	Uptake rate (%)	Feasible households (%)	Net uptake rate (%)	Total households
Variable flush toilet retrofit	90	70	63	386,441
Ultra-low flush replacement	0	100	0	0
Low-flow showerhead replacement	90	43	38.7	237,385
Low-flow tap replacement	90	100	90	552,058

7.9.3 New households

Table 7.15 (included at the end of this chapter) shows the assumptions of the implementation of new building regulations and CSH uptake (all related in terms of CSH level) in the Beyond Neutrality Scenario, highlighting the different implementation rates assumed for publicly funded and private developments. Figure 7.6 illustrates how the annual implementation of different CSH level (equivalents) varies over time for all new households.

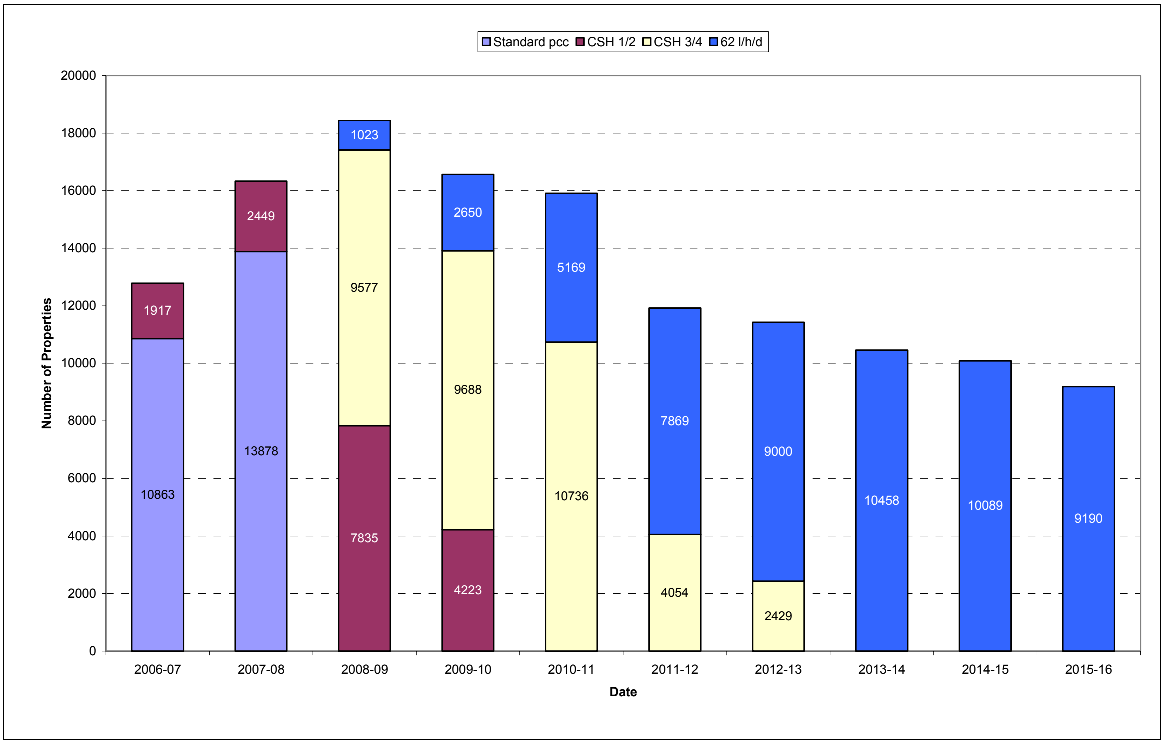

Figure 7.6: Annual new household completions by CSH consumption level – Beyond Neutrality Scenario

The Beyond Neutrality option has similar levels of uptake of CSH households to Scenario 2a. However, additional savings are made from assumptions over the amount of water that might be obtained from rainwater harvesting and grey water recycling. Under this scenario, it is assumed that all WC water and all washing machine water would be obtained from recycled water. All other assumptions about micro-component demand remain unchanged from the CSH Level 5/6 assessment, as detailed in Table 7.16.

Table 7.16: Micro-components of demand equivalent to CSH Level 5/6, with 100 per cent of toilet flushing and washing machine use replaced by rainwater/grey water (62 l/h/d)

Micro-component	Frequency of use (use/day)	Volume per use (litres)	Total (litres/head/day)
WC	4.8	3.5	0^
Basin	7.9	1.1	9.0
Shower	0.6	30.0	18.0
Bath	0.4	56.0	22.4**
Kitchen sink	7.9	1.1	9.0
Washing machine	0.34	45.0	0^
Dishwasher	0.3	12.0	3.6
TOTAL INDOOR USE			62.0
Outdoor	1.0	11.5	11.5
TOTAL USE			73.5

*Based on a 4.5/3-litre dual flush toilet.
**Assumes a 140-litre bath with a typical filling to 40 per cent of its capacity.
^ 100 per cent of water replaced by recycled water.

The modelling assumes that sufficient rainwater and grey water would be generated to meet this demand during a dry year. The analysis presented in Section 5.6.2 shows that even with optimistic assumptions about roof area, only around 50 per cent of non-potable household water could be supplied from rainwater in a year with average rainfall; therefore, the remaining recycled water must come from grey water.

In numerical terms, this scenario assumes:

- Almost 24,750 privately funded new homes are built to existing pcc levels before 2008/9.
- Over 16,420 new homes in total are built to the equivalent of CSH Level 1/2, up to and including 2009/10.
- Almost 36,500 new homes achieve CSH Level 3/4 from 2008/09 to 2012/13.
- Just under 55,500 new homes are completed to a pcc of 62 l/h/d (CSH Level 5/6), from 2010/11 onwards.

This scenario includes similar assumptions about CSH glide paths to the Neutrality 2a Scenario. The main difference is that the pcc of 62 l/h/d (CSH Level 5/6) is implemented in 100 per cent of privately funded new homes earlier, from 2013/14 instead of 2015/16, and has a greater reliance on rainwater and grey water recycling.

7.9.4 Existing and new non-households

It was assumed that a 40 per cent saving in all existing office buildings was possible, based on the CIRIA study (CIRIA, 2006), in addition to 10 per cent of the demand from other non-household customers.

7.10 Key points

7.10.1 Development of scenarios

This study selected pathways scenarios based on increasing levels of demand management, from the Progressive Scenario to the Beyond Neutrality Scenario.

Between these two scenarios, three principal approaches to achieving neutrality were chosen. The first focused on managing demand through high levels of savings in existing households. The second assumed that new homes would be developed to ambitious CSH standards. The effect of introducing variable tariffs to dampen the extreme component of these scenarios was considered. Finally, a third 'composite' scenario was considered which took a less extreme approach to both new and existing homes than the previous scenarios, and investigated how an intermediate consumption standard for new households could be used to achieve water neutrality.

7.10.2 Scenario statistics

New household totals

There are just over 133,000 new homes remaining to be constructed in Thames Gateway. The total number of new homes assumed to be built to 2005/06 water use standards[14] was relatively consistent across all scenarios, varying between just under 25,000 and 32,500. This consistency was a reflection of the relatively fixed number of homes already 'on the drawing board' that will be built before 2007/8.

The total number of new homes to be built to CSH Level 1/2 standards was equal to or less than that assumed in the business-as-usual scenario (just over 8,000) in Scenarios 1a, 1b, 2a and 2b. The highest number of CSH Level 1/2 homes was proposed in the Progressive Scenario, with nearly 27,000 in total, and 22,500 new privately developed homes. The Composite Neutrality and Beyond Neutrality Scenarios included about 18,000 and 16,500 CSH Level 1/2 homes respectively.

It was generally assumed that many more new homes would be built to CSH Level 3/4 standards. The largest number was estimated to be 104,000 in Scenario 2b, where the introduction of variable tariffs would allow nearly 60,000 homes built to CSH Level 5/6 standards in Scenario 2a to be built at this lower standard. The value for the remaining scenarios varied between 36,500 (Beyond Neutrality) and 74,500 (Progressive).

Construction of new homes to meet CSH Level 5/6 standards was greatest in Scenario 2a at over 58,500 properties, slightly higher than the 55,500 properties assumed in the Beyond Neutrality Scenario. Scenarios 1a and 1b assumed 40,000 CSH Level 5/6 properties compared with Scenario 3, where only 11,000 properties were assumed to be required to meet CSH Level 5/6 standards. This was the same number of properties that were assumed to deliver the intermediate consumption rate of 95 l/h/d in this scenario.

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[14] They are assumed to consume water at existing rates estimated by water companies.

CSH glide path comparisons

For all scenarios, CSH Level 1/2 in publicly funded housing and business-as-usual pcc in new privately funded development from 2005/06 to 2007/08 was assumed (except where stated).

For the Progressive Scenario:

- CSH Level 3/4 minimum in publicly funded housing from 2008/09, with a maximum of 20 per cent CSH Level 5/6 in 2015/16.
- Glide path for privately funded development about 75 per cent CSH Level 1/2 to 2009/10 before a CSH Level 3/4 minimum from 2010/11, with CSH Level 5/6 rising a maximum of 10 per cent in 2015/16.

For Scenarios 1a and 1b:

- CSH Level 3/4 minimum in publicly funded housing from 2008/09, moving towards a CSH Level 5/6 minimum from 2011/12.
- Twenty per cent of privately funded developments assumed to achieve CSH Level 1/2 in 2008/09, then CSH Level 3/4 minimum from 2009/10 (10 per cent Level 5/6), moving to a CSH Level 5/6 minimum in 2015/16.

For Scenario 2a:

- CSH Level 3/4 minimum in publicly funded housing from 2008/09, moving towards a CSH Level 5/6 minimum from 2011/12 (the same as for scenarios 1a and 1b).
- Thirty percent of privately funded developments assumed to achieve CSH Level 1/2 in 2008/09, then CSH Level 3/4 minimum from 2009/10 (20 per cent Level 5/6), moving towards a CSH Level 5/6 minimum in 2015/16.

For Scenario 2b:

- All new households to achieve CSH Level 3/4 minimum from 2008/09 (no CSH Level 5/6 at all).

For Scenario 3:

- CSH Level 1/2 extends to 25 per cent of publicly funded housing in 2009/10, with CSH Level 3/4 increasing to 75 per cent of new builds that year; CSH Level 3/4 becomes the minimum from 2010/11.
- Remaining new publicly funded houses are built to either the intermediate pcc standard of 95 l/h/d or CSH Level 5/6 (evenly split). These levels account for all completions in 2015/16.
- The business-as-usual pcc extends to 50 per cent of privately developed households in 2008/09, before CSH Level 1/2 becomes the minimum standard in 2009/10.
- CSH Level 3/4 becomes the minimum standard for private completions in 2010/11, accounting for 90 per cent of new homes in that year. This percentage reduces to 30 per cent in 2015/16.
- The remaining private developments completed from 2010/11 onwards are split evenly between the intermediate pcc standard and CSH Level 5/6.

For the Beyond Neutrality Scenario:

- CSH Level 3/4 minimum in publicly funded housing from 2008/09, moving towards a 62 l/h/d pcc (CSH Level 5/6) minimum from 2011/12 (the same as for scenarios 1a, 1b and 2a).
- CSH Level 1/2 is minimum standard in private developments from 2008/09, moving towards a CSH Level 3/4 minimum from 2010/11 and a 62 l/h/d pcc (CSH Level 5/6) minimum from 2013/14. This occurs two years earlier in this scenario.

A summary of the key CSH, retrofitting, variable tariff and metering assumptions for each scenario are included in Table 7.17 at the end of this section.

Table 7.3: Annual new household completions by CSH consumption level (%) – Progressive Scenario

Public Sector Housing	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
BAU pcc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	88.8	87.5	86.3	85.0	83.8	82.5	81.3	80.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	11.3	12.5	13.8	15.0	16.3	17.5	18.8	20.0
Private Housing											
BAU pcc	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	76.6	74.3	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	21.3	22.5	95.6	94.5	93.4	92.3	91.1	90.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	2.1	3.3	4.4	5.5	6.6	7.8	8.9	10.0

Table 7.5: Annual new household completions by CSH consumption level (%) – Neutrality 1a: Higher Retrofit Scenario

Public Sector Housing	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
BAU pcc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	80.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	20.0	50.0	75.0	100.0	100.0	100.0	100.0	100.0
Private Housing											
BAU pcc	100.0	100.0	100.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	47.0	90.0	85.0	80.0	60.0	50.0	25.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	3.0	10.0	15.0	20.0	40.0	50.0	75.0	100.0

Table 7.6: Annual new household completions by CSH consumption level (%) – Neutrality 1b: Higher Retrofit Scenario including Variable Tariffs

Public Sector Housing	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
BAU pcc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	80.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	20.0	50.0	75.0	100.0	100.0	100.0	100.0	100.0
Private Housing											
BAU pcc	100.0	100.0	100.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	47.0	90.0	85.0	80.0	60.0	50.0	25.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	3.0	10.0	15.0	20.0	40.0	50.0	75.0	100.0

Table 7.9: **Annual new household completions by CSH consumption level (%) – Neutrality 2a: Ambitious CSH Neutrality Scenario**

Public Sector Housing	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
BAU pcc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	40.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	60.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0
Private Housing											
BAU pcc	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	60.0	80.0	60.0	35.0	25.0	25.0	25.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	10.0	20.0	40.0	65.0	75.0	75.0	75.0	100.0

Table 7.10: Annual new household completions by CSH consumption level – Neutrality 2b: Ambitious CSH Neutrality Scenario including Variable Tariffs

Public Sector Housing	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
BAU pcc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Private Housing											
BAU pcc	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7.13: Annual new household completions by CSH consumption level (%) – Neutrality 3: Composite Scenario with Variable Tariffs

Public Sector Housing	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
BAU pcc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	50.0	75.0	80.0	70.0	50.0	30.0	10.0	0.0
Intermediate pcc 95 l/h/d	0.0	0.0	0.0	0.0	0.0	10.0	15.0	25.0	35.0	45.0	50.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	0.0	0.0	10.0	15.0	25.0	35.0	45.0	50.0
Private Housing											
BAU pcc	100.0	100.0	100.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	30.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	20.0	50.0	96.0	90.0	80.0	70.0	50.0	30.0
Intermediate pcc 95 l/h/d	0.0	0.0	0.0	0.0	0.0	2.0	5.0	10.0	15.0	25.0	35.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	0.0	0.0	2.0	5.0	10.0	15.0	25.0	35.0

Table 7.15: Annual new household completions by CSH consumption level – Beyond Neutrality

Public Sector Housing	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
BAU pcc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	80.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	20.0	50.0	75.0	100.0	100.0	100.0	100.0	100.0
Private Housing											
BAU pcc	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 1/2 (120 l/h/d)	0.0	0.0	0.0	50.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0
CSH Level 3/4 (105 l/h/d)	0.0	0.0	0.0	47.0	60.0	75.0	40.0	25.0	0.0	0.0	0.0
CSH Level 5/6 (80 l/h/d)	0.0	0.0	0.0	3.0	10.0	25.0	60.0	75.0	100.0	100.0	100.0

Table 7.17: Summary of scenario measures

		BAU Lower Savings	Progressive	Neutrality 1a	Neutrality 1b	Neutrality 2a	Neutrality 2b	Neutrality 3	Beyond Neutrality
New households constructed to standard water company pcc	Private	109,806	24,742	29,443	29,443	24,742	24,742	32,577	24,742
	Public	0	0	0	0	0	0	0	0
	Total	109,806	24,742	29,443	29,443	24,742	24,742	32,577	24,742
Total new households constructed to CSH Level 1/2	Private	1,187	22,459	3,134	3,134	4,701	0	11,739	12,058
	Public	7,131	4,366	4,366	4,366	4,366	4,366	6,370	4,366
	Total	8,318	26,825	7,500	7,500	9,067	4,366	18,109	16,424
Total new households constructed to CSH Level 3/4	Private	2,139	61,118	52,050	52,050	39,117	88,392	52,897	32,433
	Public	12833	13,268	4,051	4,051	1,603	15,598	7,885	4,051
	Total	14,974	74,386	56,101	56,101	40,720	103,990	60,782	36,484
Total new households constructed to CSH Level 5/6 (80 l/h/d)	Private	0	4,814	28,506	28,506	44,573	0	7,960	0
	Public	0	2,331	11,548	11,548	13,996	0	2,885	0
	Total	0	7,145	40,054	40,054	58,569	0	10,815	0
Total new households constructed to CSH Level 5/6 (62 l/h/d)	Private	0	0	0	0	0	0	0	43,900
	Public	0	0	0	0	0	0	0	11,548
	Total	0	0	0	0	0	0	0	55,448
Total new households constructed to 95 l/h/d	Private	0	0	0	0	0	0	7,960	0
	Public	0	0	0	0	0	0	2,885	0
	Total	0	0	0	0	0	0	10,815	0
Total new households	Total	133,098	133,098	133,098	133,098	133,098	133,098	133,098	133,098
Number of existing households retrofitted with variable flush	Total	0	91,472	343,503	206,102	300,565	218,983	236,158	386,441
Number of existing households retrofitted with ULF toilet	Total	0	0	110,412	50,002	104,278	61,340	61,340	0
Number of existing households retrofitted with low-flow showerhead	Total	0	56,190	237,385	118,693	237,385	131,881	131,881	237,385
Number of existing households retrofitted with low-flow taps	Total	0	130,674	552,058	276,029	552,058	306,699	306,699	552,058
Percentage of non-household demand assumed to be from offices (assumed reduction in office demand)		5% (0% reduction)	5% (40% reduction)	5% (40% reduct)	5% (40% reduct)	5% (40% reduct)	5% (40% reduct)	5% (40% reduction)	5% (40% reduction)
Remaining percentage of non-household demand (assumed reduction in remaining non-household demand)		95% (0% reduction)	95% (0% reduction)	95% (10% reduct)	95% (10% reduct)	95% (10% reduct)	95% (10% reduct)	95% (10% reduction)	95% (10% reduction)
Variable tariffs included?		No	No	No	Yes	No	Yes	Yes	Yes
Compulsory metering included?		No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

8 Results of pathway scenarios

8.1 Introduction

This section presents the results of the pathway scenario analysis, describing how the composition of measures in each scenario contributes to water neutrality and the costs associated with the scenario. Carbon cost analysis is shown at the end of the section.

8.2 Results summary

8.2.1 Water savings

Figure 8.1 shows how the five main scenarios[15] perform in achieving neutrality, compared to the forecast growth in demand under BAU Lower Savings Scenario. The variations on Neutrality Scenarios 1 and 2 (with variable tariffs included) are omitted for clarity in this graph, but are presented in the relevant sections below.

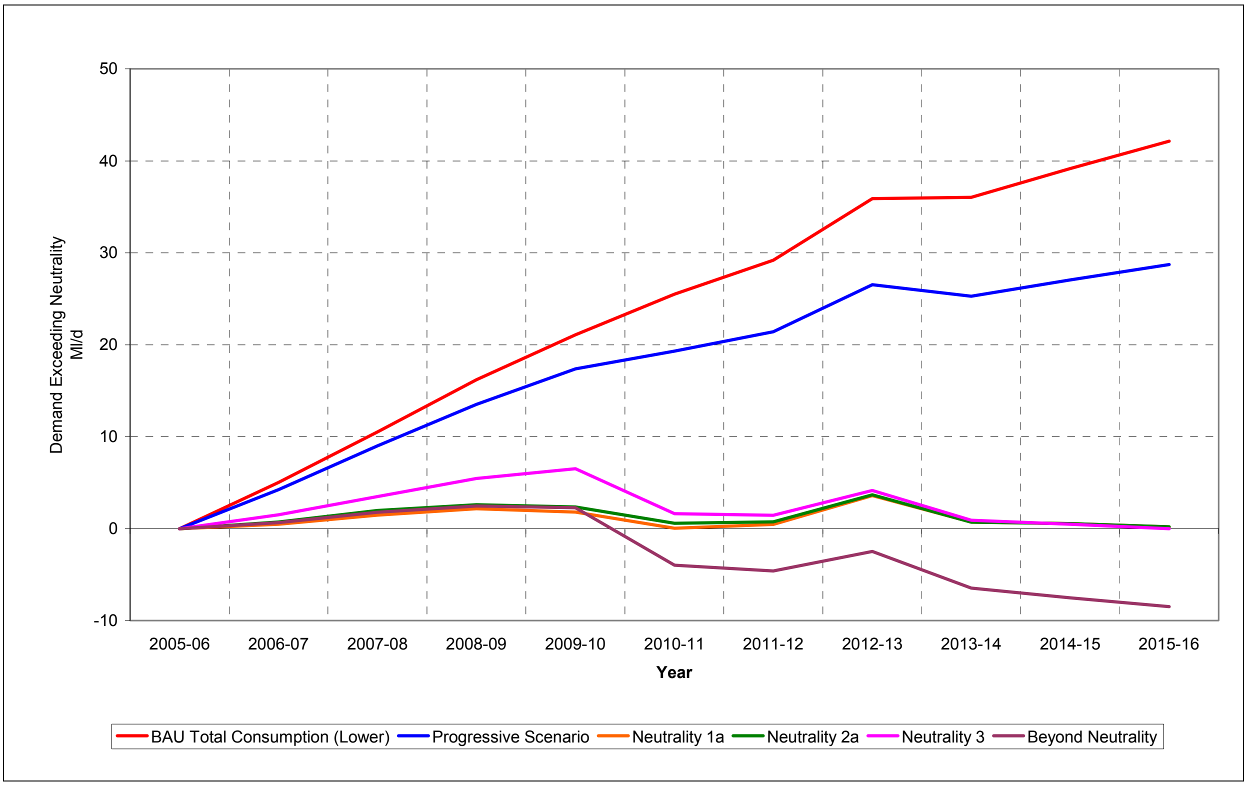

Figure 8.1: Performance of the five main scenarios in relation to water neutrality

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[15] i) Progressive; ii) Neutrality 1: High Retrofit; iii) Neutrality 2: Ambitious CSH; iv) Neutrality 3: Composite Scenario; and v) Beyond Neutrality.

In summary, Figure 8.1 shows that:

- The Progressive Scenario falls a long way short of achieving neutrality.
- The three main pathway scenarios all achieve water neutrality at the end of the study period, but not before (with the exception of Neutrality 1a and Neutrality 2a in 2010/11 and 2011/12).
- There is a clear 'Olympic effect' in 2012/13, which interrupts the gradual progress towards water neutrality in the three main pathway scenarios.
- Neutrality Scenarios 1a and 2a follow a very similar path, becoming close to achieving water neutrality in the early part of the study period than Neutrality Scenario 3, although this difference disappears later on.
- The Beyond Neutrality Scenario follows the same path as the three main scenarios to 2009/10, but the ambitious demand management assumptions in this scenario then drive down demand below neutrality from 2010/11 onwards.

These results are summarised in Table 8.1, which gives the 'neutrality deficit' for each scenario in 2009/10, 2012/13 and 2015/16 in millions of litres per day (Ml/d) and percentage terms. This value represents how far short of neutrality the scenario is estimated to be in the given year. For example, the assumptions in the Progressive Scenario result in demand reductions about 29 Ml/d short of neutrality in 2015/16, and this shortfall is over two-thirds (68 per cent) of the total difference between business-as-usual and neutrality (the Progressive Scenario only reaches 30 per cent of neutrality). These results are discussed further in the following sections.

Table 8.1: Summary performance of pathways scenarios

	2009/10		2012/13		2015/16	
Pathway scenario	**Neutrality deficit (Ml/d)**	**Neutrality deficit (%)**	**Neutrality deficit (Ml/d)**	**Neutrality deficit (%)**	**Neutrality deficit (Ml/d)**	**Neutrality deficit (%)**
Progressive	17.4	41.4	26.5	63.2	28.7	68.4
Neutrality 1a	1.8	4.3	3.6	8.6	0.2	0.5
Neutrality 1a	7.1	17.0	4.8	11.3	0.2	0.5
Neutrality 2a	2.4	5.6	3.7	8.8	0.2	0.5
Neutrality 2b	6.0	14.3	3.9	9.3	0.2	0.4
Neutrality 3	6.5	15.5	4.2	9.9	0.0	0.0
Beyond Neutrality	2.3	5.4	-2.5	-5.9	-8.5	-20.2

Figure 8.2 compares the percentage contribution from the different types of demand management measures employed in all seven scenarios (including the 'with tariffs' variations in Neutrality Scenarios 1b and 2b).

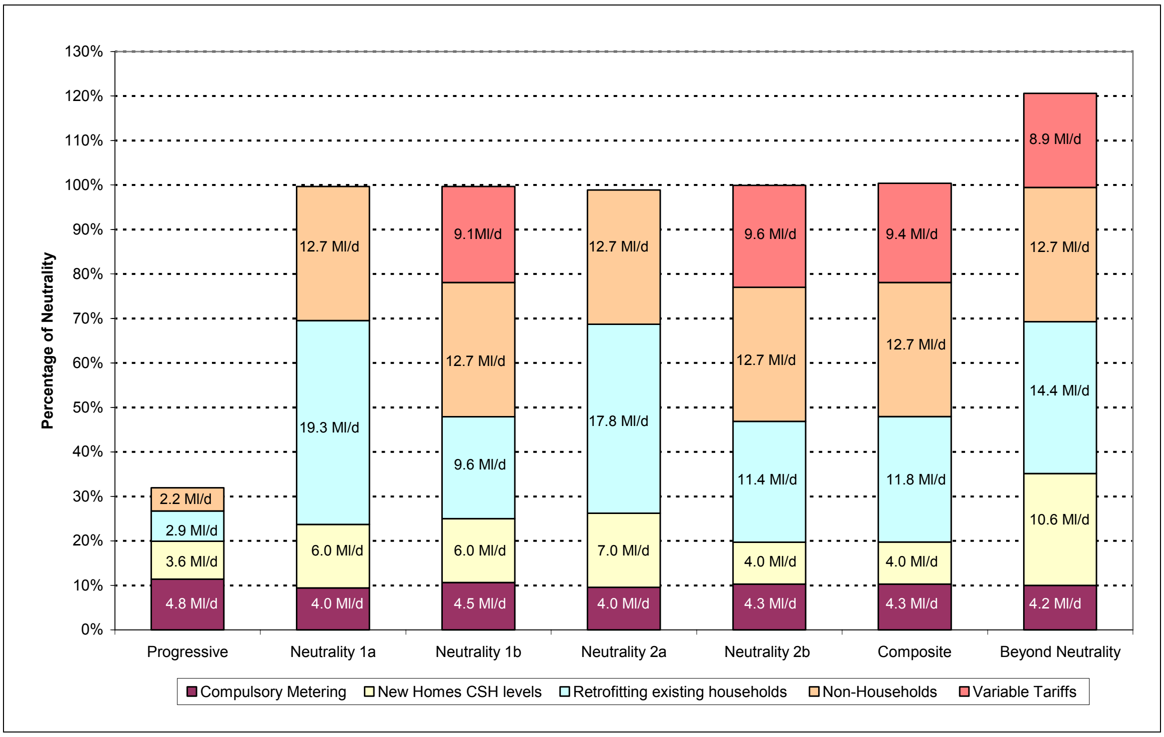

Figure 8.2: Contribution of measures to total water saved in each scenario

8.2.2 Scenario costs

Scenario costs were considered in two ways. Firstly, the ‘present value’ of costs of the measures was estimated, that is, the total cost of implementing the measure or CSH level in new homes, over a 60-year accounting period. This total cost was discounted to provide a cost/value in present terms.

Scenario costs were also assessed in terms of ‘average incremental cost’ (AIC), that is, the unit cost of water saved by each measure. AICs enabled a comparison of the cost-effectiveness of different measures. This cost was also discounted over the accounting period. Potential economic and other benefits of reducing demand were not assessed.

Present value analysis

Table 8.2 presents the present value of scenario costs, broken down by demand management measure and CSH level.

Table 8.2: Summary of present value of scenario costs

	Present value (£M)						
	Progressive	Neutrality 1a	Neutrality 1b	Neutrality 2a	Neutrality 2b	Neutrality 3	Beyond Neutrality
Existing H/Holds							
Variable flush retrofitting	2.9	10.8	6.7	9.1	7.1	7.7	12.4
ULF toilet retrofitting	0.0	12.2	5.4	11.6	6.8	6.8	0.0
Low-flow showerheads	1.9	8.1	4.1	8.1	4.5	4.5	8.1
Low-flow taps	3.9	17.1	8.6	17.0	9.5	9.6	17.1
Compulsory metering	36.9	36.9	36.9	36.9	36.9	36.9	36.9
Variable tariffs	0.0	0.0	29.1	0.0	29.1	29.1	29.1
Existing H/Hold Total	45.5	85.1	90.7	82.7	93.9	94.5	103.6
New H/Holds							
CSH Level 1/2	5.5	1.6	1.6	1.9	1.0	3.8	3.4
CSH Level 3/4	17.2	13.9	13.9	10.2	24.8	14.5	9.3
CSH Level 5/6 (80 and 62 l/h/d)	11.0	59.6	59.6	89.7	0.0	15.5	83.9
95l/h/d pcc	0.0	0.0	0.0	0.0	0.0	4.4	0.0
Variable tariffs	0.0	0.0	10.8	0.0	10.8	10.8	10.8
New H/Hold Total	33.8	75.1	85.9	101.9	36.6	48.9	107.4
BAU Costs	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Total Cost	75.8	156.6	173.0	181.0	126.7	139.8	207.4

These results are discussed more fully in the following sections, but in summary:

- Low-flow showerheads had the lowest PV of all of the retrofit measures, due to the relatively low uptake rates assumed for these devices compared to other retrofit options. This was a function of the smaller percentage (43 per cent) of properties deemed suitable for these devices.
- The higher PV of ULF and variable flush toilet retrofits (compared to low-flow showerheads) reflects the greater percentage of properties suitable for these retrofit measures.
- Low-flow taps had higher PV costs, despite their low unit costs. This was due to the relatively high uptake rates assumed, because more households would be suitable for installation of these devices than other retrofit devices. Since more of these devices would be installed, there would be a

greater number of properties where only this device was being retrofitted. The PV reflects the high cost of installation in these properties.

- The PV for compulsory metering remained the same in each of the pathway scenarios. This was because the same number of meters was assumed to be installed in each scenario, and assumed to make the same savings.
- The PV for variable tariffs was also the same in each of the scenarios where they were applied for the same reason – the same numbers of existing and new households subject to variable tariffs, with the effect of tariffs being the same. The PV of tariffs was higher in existing households because more of these would be subject to variable tariffs than new ones.

The PV of CSH levels increased progressively from Level 1/2 to Level 5/6 in most of the scenarios (except the Progressive Scenario). This is because:

- Relatively few CSH Level 1/2 households have low cost water fittings.
- There are generally more CSH Level 3/4 households with slightly higher cost water fittings.
- There are generally fewer CSH Level 5/6 households, but the large additional cost of water recycling systems has a significant effect on the PV of this code level. The exception is Neutrality Scenario 3, which has relatively few CSH Level 5/6 homes.

A business-as-usual PV was calculated and subtracted from the total scenario cost to give an additional PV for each of the scenarios. The lowest cost neutrality scenario was 2b (ambitious CSH with variable tariffs) with a PV of £126.7 million. Neutrality 3 (the composite scenario) was slightly more costly at £139.8 million. The highest cost scenario was 2a (ambitious with no variable tariffs) with a PV of £181 million.

Average incremental cost analysis

Table 8.3 summarises the ‘average incremental cost’ (AIC) of measures. AICs are unit costs for the water saved by each measure in pence per cubic metre (p/m^3), and allow a comparison of the relative costs of each of the measures, taking account of the reductions in demand that each measure achieves. AICs are expressed in pence per cubic metre throughout this report, as this is the standard format for comparing the relative costs of demand management and water resource development options within the water company WRPs. One cubic metre is equivalent to 1,000 litres.

Table 8.3: Summary of average incremental costs for scenarios

	Average incremental cost (p/m^3)						
	Progressive	Neutrality 1a	Neutrality 1b	Neutrality 2a	Neutrality 2b	Neutrality 3	Beyond Neutrality
Variable flush retrofitting	28.0	26.0	27.4	24.8	27.1	27.6	26.9
ULF toilet retrofitting	0.0	64.5	66.8	64.5	64.5	64.5	0.0
Low-flow showerheads	67.3	65.1	65.1	65.1	65.1	65.1	65.1
Low-flow taps	320.7	314.3	316.2	313.3	315.7	316.5	315.5
Compulsory metering	91.2	91.2	91.2	91.2	91.2	91.2	91.2
Variable tariffs	0.0	0.0	67.4	0.0	67.4	67.4	67.4
Code for Sustainable Homes	153.4	194.4	186.0	226.7	92.8	137.3	148.8

These results are discussed in more detail in the following sections, but in summary:

- Variable flush retrofit was the most cost-effective of the retrofit measures, offering significant savings compared to other measures at a similar total cost. The remaining retrofit measures generated smaller savings, but the installation costs were assumed to be the same whether all three retrofit measures, or only one or two measures, were installed at a property.
- The AIC for compulsory metering remained the same in each of the scenarios, because the same numbers of meters were assumed to be installed in each scenario, and assumed to generate the same savings.
- The AIC for variable tariffs was also the same in each of the scenarios where they were applied for the same reason.
- The AIC of the Code for Sustainable Homes varied according to the proportion of CSH levels assumed in each of the scenarios, and was heavily influenced by the numbers of CSH Level 5/6 households assumed. For example, the AIC for Neutrality 2b was particularly low, as there were no CSH Level 5/6 homes in this scenario, compared to Scenario 2a, which assumed nearly 59,000 households built to this standard.

When considering the relative costs of scenarios in terms of AIC, it is important to consider uncertainty, that is, what is and isn’t included within the costs. For example, no marketing or promotional costs were included with the retrofit options and the addition of these would increase the AIC. Equally, the benefits of reduced water demand to the water companies, the consumer or the UK in general were not considered.

It is also important to realise that low AIC costs do not necessarily equate to high achievability. For example, retrofitting low-flush devices may be substantially cheaper than compulsory metering. However, in terms of installation, it could be argued that since compulsory metering does not require entering customer properties (assuming an external meter), installation may be easier.

8.3 Progressive Scenario

8.3.1 Water saved

Figure 8.1 shows that the Progressive Scenario falls significantly short of achieving neutrality. In fact, it only reduces demand by 13.5 Ml/d by 2015/16, which is one-third of the total required to achieve neutrality, when compared to business-as-usual.

The Progressive Scenario was developed to reflect the upper limit of what might be achieved by existing approaches to demand management, and was therefore conservative relative to the other pathway scenarios in this study. However, the assumptions in this scenario go considerably beyond what has been achieved or even attempted in the UK to date, and therefore a significant shift in effort and approach would be required to move closer towards water neutrality.

Figure 8.2 shows the proportional contribution of each of measure to the total savings achieved. Compulsory metering is the single biggest contributor to demand reductions achieved under the Progressive Scenario, making up about one-third of the total savings. Improving the water efficiency of new homes (referred to through the CSH) is the next most significant sector for demand management at 27 per cent, followed by retrofitting existing homes at 20 per cent and non-household savings at 16 per cent.

8.3.2 Cost

Present value of costs

A breakdown of PV costs for the Progressive Scenario is presented in Table 8.2, which shows that the total PV of this scenario is estimated to be £75.8 million. This represents the cost of delivering the savings modelled in this scenario, based on the assumed contribution from the various measures, as described above. Note that there is no inclusion of non-household costs. The PV cost is additional to the costs required to deliver the business-as-usual scenario, estimated to be approximately £3.6 million. It excludes any implementation costs such as administrative and promotional costs, and is not net of any benefits (as these were not assessed).

Compulsory metering of existing households accounts for £36.9 million of present value costs, or about half of scenario costs. PV costs associated with constructing new households to the CSH levels is £33.8 million. The remaining costs (£8.7 million) come from retrofitting measures in existing households.

Average incremental costs

The data in Table 8.3 shows that the most cost-effective measure is the variable flush retrofit at 28 p/m^3. The higher savings from this measure offset the installation costs and unit costs of the device. The remaining retrofit measures deliver smaller savings, but the installation costs are assumed to be the same whether all three retrofit measures, or only one or two measures, are installed.

Compulsory metering is the second most cost-effective measure, at around 91 p/m^3. Although there is a higher capital cost for meters than for the retrofit devices, the benefits of metering are assumed to be constant throughout the 60-year accounting period. The savings from retrofit devices are assumed to diminish over time as they are replaced by other devices.

The CSH measures have an AIC of 153 p/m^3. For each scenario, AIC costs reflect the relative proportion of properties constructed to each CSH standard.

8.4 Neutrality 1a: High retrofit scenario with no variable tariffs

8.4.1 Water saved

Figure 8.1 shows that the Neutrality 1 Scenario achieves water neutrality at the end of the study period and remains well within 5 Ml/d of neutrality throughout the period. The largest departure from neutrality occurs in 2012/13, as a result of additional demand from the Olympic Games. The neutrality deficit increases from 0.5 Ml/d in 2011/12 to 3.6 Ml/d in 2012/13, resulting in an 8.6 per cent neutrality shortfall in the Olympics year.

Figure 8.2 shows the proportional contribution of each measure to the total savings achieved. Compulsory metering contributes 4 Ml/d or nine per cent of the total demand reduction in this scenario. The relative proportion of reduction achieved by compulsory metering is much smaller than in the Progressive Scenario, because other components are contributing much more. The more water-efficient new homes also contribute a relatively small proportion of the total (6 Ml/d or 14 per cent). The largest single demand reduction measure is the retrofitting of existing homes, contributing almost half of the total savings. This is logical, given the assumptions behind this scenario.

Non-households contribute 12.7 Ml/d or 30 per cent of total reductions in this scenario. This is higher than the Progressive Scenario, because it is assumed that 10 per cent savings can be achieved from non-households other than offices.

The effect of variable tariffs upon this scenario were considered in Neutrality 1b, by applying the assumed effect of variable tariffs to household demand and then adjusting the retrofit uptake rate downwards until neutrality was achieved. This resulted in a similar demand profile to that illustrated in Figure 8.1. However, the application of variable tariffs to this scenario generated notable changes in the distribution of savings from the different measures. There was a 9.1 Ml/d demand reduction from variable tariffs (based on a five per cent saving), equivalent to 22 per cent of the total savings.

This relatively large impact is because variable tariffs can be applied quickly to all existing metered properties and new households (which are metered as a matter of course), whereas meter savings only accrue from existing households that are compulsorily metered, and this is only assumed to occur at a relatively conservative rate of five per cent per year. The proportional contribution of the other components all remain similar, except for retrofitting, which reduces by half, from 46 per cent to 23 per cent. This reflects the changes made to this element, as described in Section 7.5.

8.4.2 Costs

Present value of costs

The estimated present value of costs for achieving Neutrality 1a Scenario is £156.6 million, shown in Table 8.2. This represents the cost of delivering the savings modelled in this scenario, based on the assumed contribution from the various measures. No non-household costs are included. The PV cost is additional to the costs required to deliver the business-as-usual scenario, estimated to be approximately £3.6 million, and excludes any implementation costs such as administrative and promotional costs or any consideration of benefits.

The £156.6 million is split between the retrofit element of this scenario, with a present value cost of £85.1 million, and the costs associated with new homes of £75.1 million.

The introduction of variable tariffs (Neutrality 1b) into this scenario increases the present value cost to £173 million. Variable tariffs enable the amount of retrofitting to be reduced. However, the reduction in retrofitting costs is more than offset by the increase in operational cost when variable tariffs are introduced, due to the operational costs of implementing variable tariffs in existing metered households. The actual savings that could be achieved from variable tariffs are uncertain, due to a lack of reliable data.

Average incremental costs

AICs of the demand management measures are presented in Table 8.3. The AIC for compulsory metering in Scenario 1a is the same as for all other scenarios, for the reasons stated in Section 8.2.2. In Scenario 1b, there is an additional AIC of 67.4 p/m^3 for variable tariffs that reflects the cost of administering this measure. This cost is around 24 p/m^3 lower than the AIC of compulsory metering. Although variable tariffs are modelled as resulting in a five per cent reduction, there is a significant operational cost of implementing variable tariffs across new and existing metered properties.

AICs of the retrofit options reflect the relative proportion of households assumed to have retrofit measures installed. As discussed in Section 8.3, where more households have either two or three device installed, the total installation cost is lower.

These costs only include costs directly associated with installation, so do not reflect the additional marketing and implementation efforts likely to be required to achieve the very high retrofit rates assumed in this scenario.

The AIC for CSH implementation in Scenario 1a is 194.4 p/m^3, compared to 153.4 p/m^3 in the Progressive Scenario. This difference is due to a greater proportion of houses being constructed to CSH Level 5/6 standard in Scenario 1a (approximately 40,000 households) compared to the Progressive Scenario (approximately 7,100 households). The greater cost of the CSH Level 5/6 compared to the other CSH levels and the larger number of properties constructed to this standard increase the AIC.

8.5 Neutrality 2a: Ambitious CSH scenario with no variable tariffs

8.5.1 Water saved

Figure 8.1 and Table 8.1 shows that the Neutrality 2a Scenario follows a very similar pattern of demand reduction to Neutrality 1a, with a 3.7 Ml/d (8.8 per cent) deficit in 2012/13, compared to 3.6 Ml/d (8.6 per cent) for Neutrality 1a.

The distribution of savings illustrated in Figure 8.2 is similar to that observed for the previous scenario, as the constraints defined for the CSH glide path by the project steering group (as described in Section 7.2.2) means it is not possible to vary CSH glide path by very much from Neutrality 1a. For example, it was only possible to bring forward the construction of all publicly funded homes to CSH Level 5/6 by one year in the Neutrality 2a Scenario compared to the Neutrality 1a Scenario.

8.5.2 Costs

Present value of costs

The present value cost for achieving Neutrality 2a is £181 million, shown in Table 8.2. This is greater than the present value cost of the retrofit-based scenario (Neutrality 1a), mainly because the cost of implementing the CSH is approximately £30 million (25 per cent) higher in this scenario. This increase is almost solely due to the extra 18,500 households assumed to be completed to CSH Level 5/6 in Neutrality 2a.

PVs of retrofit measures are similar for both scenarios (such as £10.8 million in Scenario 1a for variable flush retrofit compared to £9.1 million here).

Average incremental costs

These observations are also reflected in the AICs of measures in this scenario, as highlighted in Table 8.3. The costs for all measures except those associated with the CSH are very similar to those presented for the Neutrality 1a Scenario.

AICs associated with the Code for Sustainable Homes increase from 194.4 p/m^3 in Neutrality Scenario 1a to 226.7 p/m^3 in Neutrality Scenario 2a. This is due to the additional 18,500 new households assumed to achieve CSH Level 5/6 standards in Scenario 2a, each requiring rainwater harvesting or recycling systems[16] at an average of about £1,500 per property to achieve the 80 l/h/d target consumption rate.

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[16] Individual property rainwater systems are assumed to cost £2,300 per household and development scale systems are assumed to cost £680 per household. It is assumed that the rainwater harvesting systems installed in Thames Gateway are 50 per cent property level and 50 per cent development scale, resulting in an average cost per property to achieve CSH Level 5/6 of £1,490.

8.6 Neutrality Scenarios 1b and 2b

8.6.1 Water saved

Figure 8.1 omitted the water saving profiles of Neutrality Scenarios 1b and 2b for clarity. Figure 8.3 illustrates these data compared to Neutrality Scenarios 1a, 2a and 3. Note the different scale on the y-axis in this figure, which enables a clear view of how the scenario profiles compare. Line colours are the same as for Figure 8.1.

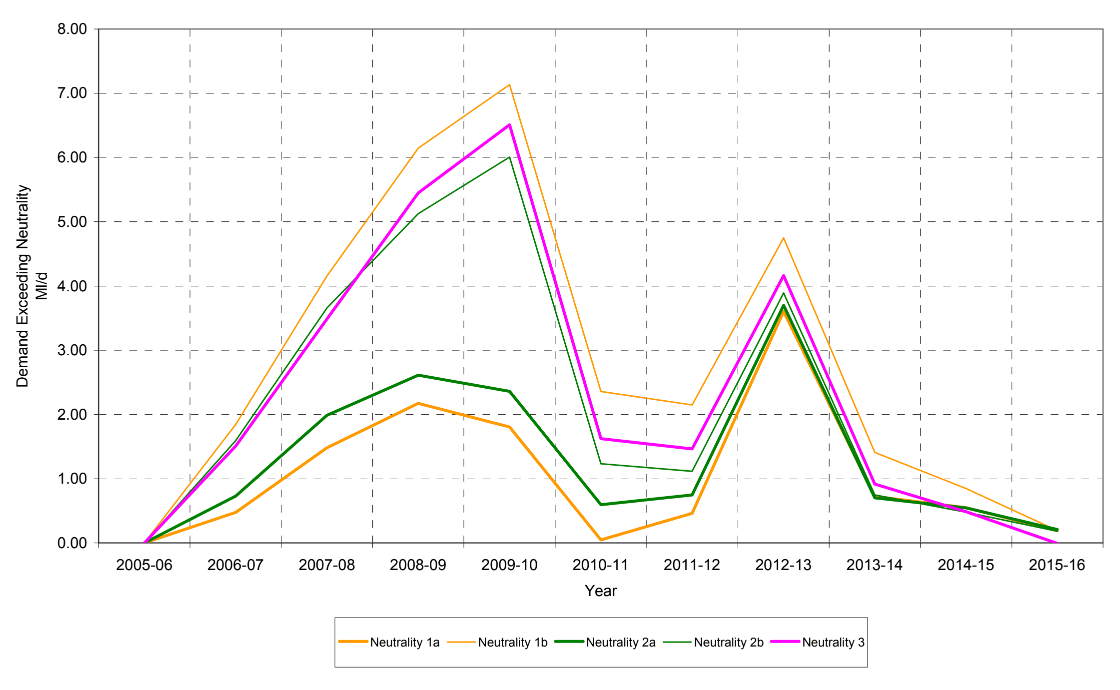

Figure 8.3: Performance of the neutrality scenarios with variable tariffs, compared to other neutrality scenarios

It is clear from Figure 8.3 that Neutrality Scenarios 1b and 2b follow a distinctly different path towards achieving water neutrality in 2015/16 than 1a and 2a respectively, matching the water saving profile of Neutrality Scenario 3 more closely. This path delivers lower levels of reduction in the early part of the study period, but achieves similar levels towards the end. For example, Table 8.1 indicates that Scenario 1b has a neutrality deficit of 7.1 Ml/d in 2009/10 compared to a value of 1.8 Ml/d for Scenario 1a in the same year. By 2012/13, this difference is much smaller, with Scenario 1b 4.8 Ml/d short of neutrality, compared to a value of 3.6 Ml/d for Scenario 1a.

8.6.2 Scenario costs

Present value of costs

Neutrality is modelled in Scenario 1b by adding the demand reduction assumed for variable tariffs, holding CSH assumptions steady and reducing retrofit rates in existing households. The result is that PV costs for retrofit measures in Scenario 1b are less than those for Scenario 1a by about 50 per cent. For example, the PV of variable flush retrofits is £10.8 million in Scenario 1a, compared to £6.7 million in Scenario 1b.

Neutrality is modelled in Scenario 2b by adding the reduction assumed for variable tariffs, reducing the retrofit assumptions for existing households slightly and assuming new households will only be developed to CSH Level 3/4 standard (no new households to CSH Level 5/6). This has a major impact on the present value cost, resulting in a total value of £126.7 million, a reduction of around £54.3 million against the PV cost of the Neutrality 2a Scenario. Present value costs for existing household retrofits in Scenario 2b are noticeably lower than for Scenario 2a. For example, PV costs for low-flow showerheads reduce from £8.1 million in Scenario 2a to £4.5 million in Scenario 2b, as just over 105,000 fewer low-flow showerheads are installed in Scenario 2b.

However, reductions in the rates of retrofits only reduce scenario costs by £18 million from Scenario 2a. The largest effect of introducing savings from variable tariffs has been to remove the need to implement CSH Level 5/6 altogether, resulting in PV cost savings of around £65 million.

Average incremental costs

The introduction of variable tariffs in Scenario 2b also reduces AIC costs for CSH measures significantly compared to Scenario 2a. The introduction of variable tariffs in Scenario 2b reduces the AIC of the Code for Sustainable Homes to 92.8 p/m^3, from 226.7 p/m^3.

8.7 Neutrality 3: Composite scenario with variable tariffs

8.7.1 Water saved

The Neutrality 3: Composite Scenario with variable tariffs, adopted a less extreme approach to both new and existing homes than the previous ‘a’ scenarios and explored the impact of constructing new homes to a per capita consumption (pcc) standard between CSH Level 3/4 (105 l/h/d) and CSH Level 5/6 (80 l/h/d). This intermediate pcc could be achieved without the use of water recycling technology, thus enabling a lower pcc to be achieved than CSH Level 3/4 but without the high cost of implementing water recycling technology required to achieve CSH Level 5/6.

Figures 8.1 and 8.2 show that it is possible to achieve water neutrality by assuming a more modest level of retrofitting in existing homes and water efficiency in new homes, if variable tariffs are also used. Figure 8.2 shows that the majority of the savings come from existing and new non-households and the retrofitting of existing households.

The proportion of savings attributed to implementation of the CSH is less significant in this scenario, because far fewer new households are assumed to be built to the highest CSH level (Level 5/6). For example, this scenario assumes fewer than 11,000 new households will be built to CSH Level 5/6 standards, whilst Scenario 2a assumes nearly 59,000 and Scenario 1a assumes over 40,000 new homes at this standard.

8.7.2 Costs

Present value of costs

The PV of total costs for this scenario is £139.8 million. The cost breakdown is shown in Table 8.2. The scenario has similar levels of retrofitting and therefore similar PV costs to Scenario 2b. The PV of building new households to CSH standards is low in this scenario at £48.9 million, compared to a maximum of £101.9 million in Scenario 2a. This difference is a result of the Composite Scenario assumption that neutrality is possible with only 11,000 new builds to CSH Level 5/6, and the same number of new households achieving the intermediate consumption target of 95 litres per person per day.

Average incremental costs

AICs for this scenario are shown in Table 8.3. AICs for all measures except CSH are comparable to those for previous scenarios. The AIC for the CSH is 137.3 p/m^3. This is more expensive than those for Scenario 2b, which does not include any homes of a CSH standard greater than Level 3/4, but less expensive than the Progressive Scenario, which has relatively conservative assumptions on new home completions.

8.8 Beyond Neutrality

8.8.1 Water saved

Figure 8.1 and Table 8.1 show how far beyond neutrality it is possible to go by assuming the highest levels of retrofit in existing homes and by applying ambitious glide paths to CSH uptake in new homes. This scenario includes a lower per capita consumption rate of 62 l/h/d for new households built to CSH Level 5/6, as all toilet flushing and washing machine use is assumed to be replaced with recycled water. This compares to a CSH Level 5/6 pcc of 89.5 l/h/d in the other pathway scenarios, based on the assumption that rainwater and/or recycled water would contribute to 50 per cent of domestic non-potable uses[17].

This scenario also includes the savings from variable tariffs as a matter of course. This scenario exceeds neutrality by nearly 9 Ml/d, or just over 20 per cent. As stated in Section 7.9, the retrofitting package in the Beyond Neutrality Scenario includes variable flush retrofitting. If ultra-low flush toilets were included in the retrofit package in 90 per cent of feasible households (instead of variable flush toilets), it might be possible to exceed neutrality by 28 Ml/d.

The contribution of the various measures to this saving is illustrated in Figure 8.2. The contribution of compulsory metering is relatively small, but the other measures all contribute significantly to the total demand reduction, as one would expect based on the assumptions in this scenario. Variable tariffs contribute more savings than

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[17] All these CSH consumption rates include an allowance for garden watering which takes the pcc rate used in this analysis above the actual CSH consumption rates, which exclude garden watering. The 62 l/h/d rate assumes garden watering is supplied wholly by rainwater and/or recycled water.

compulsory metering because variable tariffs are applied across the whole domestic metered customer base (including those households metered prior to 2005-06).

It might be possible to go even further beyond neutrality if the assumptions around CSH standards in new households were extended. In fact, the CSH assumptions in the Beyond Neutrality Scenario were similar to those adopted in Scenario 2a. However, the extent to which these assumptions could be extended was limited by the constraints put on CSH assumptions by the project steering group.

Other options to extend (or replace) reductions in the demand for water could include further reductions in water company leakage (beyond the ELL), reductions in household demand from water savings form other devices (such as efficient washing machines), or savings in other sectors such as farming, industrial processes and commercial activities (such as golf courses).

8.8.2 Costs

Present value of costs

The present value of total costs for this scenario is £207.4 million, shown in Table 8.2. This is the highest cost for any of the scenarios, as would be expected, given the assumptions involved; however, it is only 15 per cent more expensive than the cost for Neutrality Scenario 2a. This is because this scenario, like Scenario 2a, is close to the limits on CSH assumptions that were agreed with the project steering group.

Average incremental costs

Average incremental costs for this scenario are presented in Table 8.3. As before, the AICs for existing household retrofits, compulsory metering and variable tariffs are comparable to those for previous scenarios. However, the AIC for the CSH is much less than that for Scenario 2a, even though both scenarios make similar assumptions about the numbers of households to be developed to the three CSH standards. The AIC of CSH households is 148.8 p/m^3 for the Beyond Neutrality Scenario, compared to 226.7 p/m^3 for Scenario 2a. Rainwater harvesting and grey water recycling are assumed to replace all domestic non-potable consumption in the Beyond Neutrality Scenario, but only 50 per cent of non-potable consumption in Scenario 2a.

8.9 Indicative non-household costs

As discussed in Section 6.7, non-household costs were excluded from the scenario due to uncertainty in the non-household property types in the Thames Gateway. However, indicative costing was undertaken, the results of which are presented below.

The total number of non-household properties within the Thames Gateway in the 2005-06 is 195,400 properties. Presented in Table 8.4 is a high level assessment of the potential costs if every existing non-household property in the Thames Gateway were to be retrofitted. Due to the uncertainty over property types, these values are presented as a range determined by the cost assumptions per retrofit (£0 to £1,000). As with all the cost assumptions, the potential economic benefits of increased water efficiency (in terms of reduced water bills) were not assessed in this report.

Table 8.4: Indicative costing of retrofitting measures to existing non-households

Assumed cost per retrofit	PV (£ million)
£0	£0
£50	£7.9
£100	£15.8
£200	£31.6
£500	£78.9
£1,000	£157.8

The indicative costs range from a PV of £7.9 million based on £50 per non-household to £157.8 million based on £1,000 per property. There is considerable uncertainty associated with these costs. As discussed in Section 6.7, for some sites the cost of retrofitting is likely to be greater than £1,000. However, a larger percentage of the properties are expected to consist of smaller commercial, industrial or retail units (where costs are likely to be a maximum of £200) and therefore would offset the costs of more expensive retrofits. The costs can only be viewed as indicative and further work is required to understand the volume of savings that may be achieved from non-households in the Thames Gateway and the costs of making these savings.

Costs for retrofitting new non-households could be of a similar order of magnitude to the scenario costs presented in Section 8.2.2. However, as stated above there is likely to be a large proportion of non-households which could be fitted for less than £200. If this were the average cost of retrofitting properties, the cost for retrofitting non-households would be just under half that for the Progressive Scenario (see Table 8.2).

Table 8.5 provides indicative costing for the installation of fittings in new non-households. The assumptions behind this analysis are outlined in Section 6.7. Based on these assumptions, achieving a 40 per cent reduction in new non-households would cost between £0.07 million based on £50 per property, and £1.45 million based on £1,000 per property. Costs are much lower than existing non-households due to the far lower number of properties involved (it is assumed that 1,800 new office buildings would be required). Costs are likely to be lower per property than for retrofitting existing non-households, as the costs incurred would be for any premium to purchase efficient fittings over and above standard fittings. Based on £1,000 per property, the costs of achieving the 40 per cent reduction in new non-households is around two per cent of the cost of the Progressive Scenario, or less than one per cent of the cost of the Beyond Neutrality Scenario.

Table 8.5: Indicative costing of installing measures in new non-households

Assumed cost per retrofit	PV (£ million)
£0	£0
£50	£0.07
£100	£0.15
£200	£0.29
£500	£0.73
£1,000	£1.45

8.10 Carbon emissions under the pathway scenarios

The results of the carbon assessment are presented in Figure 8.4.

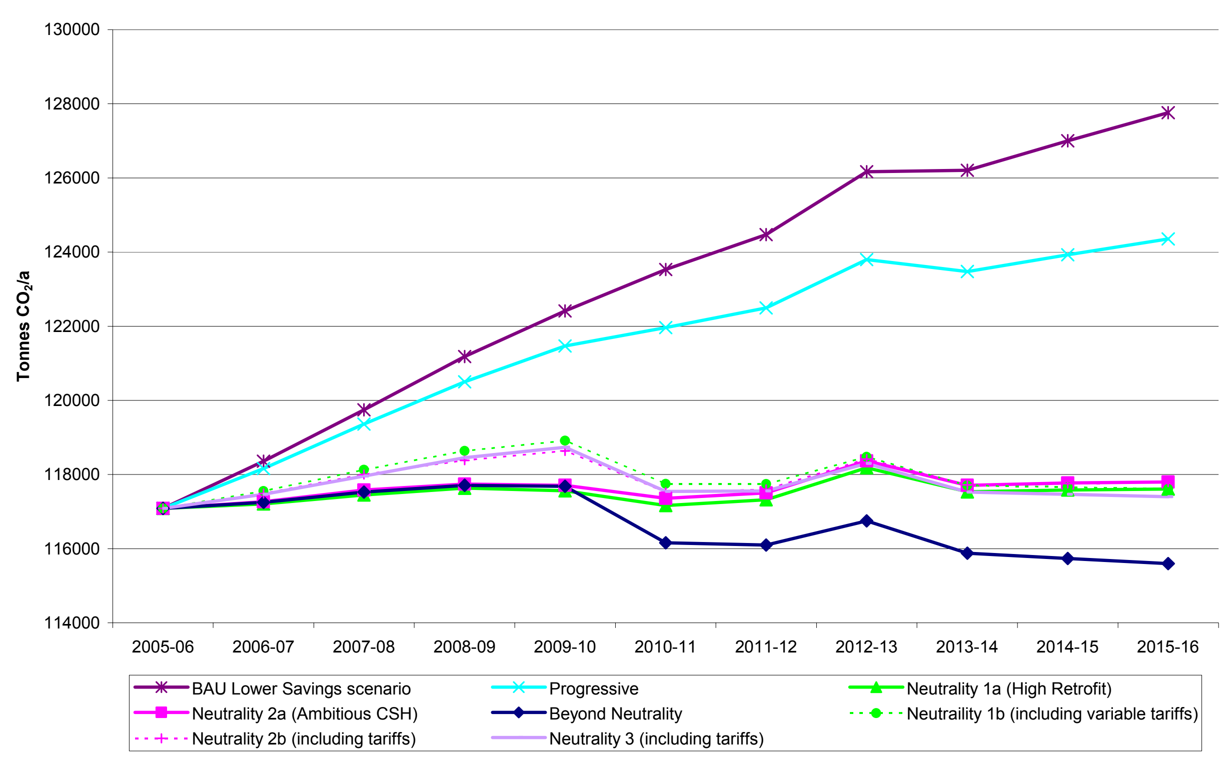

Figure 8.4: Comparison of carbon emission profiles under BAU Lower Savings Scenario to those under the pathway scenarios

These results are also presented in Table 8.6, where the reductions in carbon dioxide equivalent emissions for selected years are shown. The results show that under the Progressive Scenario, CO_2e emissions would be reduced by around 3,400 tonnes per annum by 2016. The greatest CO_2e savings would be achieved under the Beyond Neutrality Scenario, where emissions would be reduced by almost 12,164 tonnes per annum over the same period. These reductions are equivalent to approximately 2.7 per cent and 10 per cent of emissions under the BAU Lower Savings Scenario.

An allowance for the energy requirements associated with rainwater harvesting and recycling was made in the scenarios where homes were constructed to CSH Level 5/6 standard. Based on the assumption that 18 m^3/property/year could be sourced through rainwater and 2.2 kWh is required to pump each m^3, using the Defra conversion factor of 0.43 kg CO_2/kWh each household would produce 17 kg/CO_2 per year to operate the recycling/harvesting unit. For each property in the Thames Gateway assumed to be fitted with a water recycling unit, an allowance of 17 kg/CO_2 per year was made.

Table 8.6: Reductions in carbon dioxide emissions (tonnes CO_2e/year) under scenarios

Scenario	2006-07	2009-10	2012-13	2015-16
Progressive	198	945	2,375	3,407
Neutrality 1a	1,154	4,853	7,988	10,150
Neutrality 1b	807	3,500	7,696	10,150
Neutrality 2a	1,090	4,704	7,807	9,962
Neutrality 2b	870	3,778	7,757	9,969
Neutrality 3	972	3,876	7,767	9,998
Beyond Neutrality	1,108	4,734	9,421	12,164

Reductions in carbon dioxide emissions are driven by reductions in demand for potable water and wastewater treatment. The results show that there is little difference in emissions between the neutrality scenarios, where these differ by less than 200 tonnes CO_2e per year, giving a difference in PV of approximately £1 million. This may reflect the limitations of the approach and data available to this study and it is recommended that a more detailed analysis using data specific to the Thames Gateway be used.

The PV costs of carbon dioxide equivalent emissions under the scenarios are shown in Table 8.7. These were calculated using the approach set out in Section 6.9.

Table 8.7: PV cost of carbon dioxide emissions and reductions for each scenario

Scenario	PV of carbon emissions	PV of carbon reductions *
BAU (Lower Savings)	£101,421,430	-
Progressive	£98,670,659	£2,750,771
Neutrality 1a	£93,009,808	£8,411,622
Neutrality 1b	£93,103,696	£8,317,734
Neutrality 2a	£92,050,705	£9,370,724
Neutrality 2b	£93,015,679	£8,405,750
Neutrality 3	£92,921,814	£8,499,615
Beyond Neutrality	£91,096,135	£10,325,294

* This is the difference between the PV cost of the BAU and the scenario in question.

The data shows that the present value cost of carbon under the BAU Lower Savings Scenario is around £101.4 million. Under the Beyond Neutrality Scenario, the cost of carbon emissions falls to £91.1 million, a reduction of approximately £10.3 million. The smallest reduction in carbon costs (present value cost of £2.8 million) is seen under the Progressive Scenario. These reductions reflect the reduced demand for clean water and reduced volume of wastewater requiring disposal and treatment in the Thames Gateway. For the neutrality scenarios, there is little difference in the PV of the carbon emissions, with PVs differing by around £1 million between the scenarios (around one per cent of the PV of the baseline emissions).

The carbon assessment provided here is intended to be indicative, and is based on national average CO_2e emissions for water supply and wastewater equivalents. A more detailed study could take into account embedded carbon costs (for example, the carbon footprint in the manufacture of measures) and the carbon emissions associated with vehicle movements to install such measures. This study also excludes the potential carbon impact of measures within the home; for example, some measures may affect the volume of hot water used in the home and therefore the carbon emissions resulting from heating that water.

8.11 Key points

8.11.1 Water savings

The greatest savings are achieved in the Beyond Neutrality Scenario, where the volume of water saved is around 51 Ml/d, exceeding the neutrality target by 9 Ml/d. The Progressive Scenario falls short of achieving neutrality by 29 Ml/d. All other scenarios achieve water neutrality by 2015/16, although no scenario is able to maintain demand at the baseline level across the development period to 2016.

Neutrality is achieved in these scenarios by using assumptions based on ambitious uptake rates of retrofit measures and high numbers of new homes built with water efficiency to standards equivalent to the higher levels of the Code for Sustainable Homes, as well as compulsory metering. However, the use of variable tariff assumptions in these scenarios reduces the uptake/implementation rates required to reach neutrality. This was demonstrated most effectively in the Neutrality 2b Scenario, when the introduction of variable tariffs was used to remove the need to build to CSH Level 5/6 in new homes and reduced retrofit uptake rates by nearly half in existing homes.

The analysis shows that it is technically possible to model 'beyond neutrality'; however, this scenario has the most ambitious assumptions on retrofit uptake rates and the effectiveness of rainwater harvesting and grey water. It should thus be considered a theoretical maximum, representing what may be possible but relatively improbable. The level of water saving modelled in this scenario may be easier to achieve if other sectors not pursued in the scenarios, such as farming, were to play a role.

The Olympic Games have an effect on the savings that the scenarios can achieve in 2012/13. The two main neutrality scenarios that include tariffs (Scenarios 1b and 2b) achieve smaller reductions in demand in the early part of the study period, but they reach water neutrality by the end of the planning period.

Figure 8.2 shows how the various measures contribute to the total demand reductions in each of the pathway scenarios. Compulsory metering provides around 10 per cent of the savings in each scenario. Implementation of CSH levels above those in the BAU scenario saves between 4 Ml/d and 7 Ml/d in the neutrality scenarios[18].

Retrofitting measures in existing homes consistently brings larger demand reductions that the Code for Sustainable Homes, varying roughly between 10 Ml/d and 20 Ml/d, depending on whether variable tariffs are included. Variable tariffs generate reductions of about 9 Ml/d or approximately 20 per cent of the total savings. This is significantly greater than savings from metering, because variable tariffs can be applied to all metered customers.

Existing and new non-households also deliver significant savings, approaching 30 per cent of the total in each neutrality scenario. The assumptions used to estimate savings from existing and new non-households are based on limited data, but the potential savings estimated are considered reasonable.

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[18] Excluding Progressive and Beyond Neutrality Scenarios.

8.11.2 Scenario costs

Costs in terms of PV and AIC are summarised in Tables 8.2 and 8.3 respectively.

Present value of costs

The Progressive Scenario is the least expensive scenario, with a present value cost of £75.8 million. Beyond Neutrality is the most expensive scenario, with a present value cost of £207.4 million.

The least expensive of the neutrality scenarios is Scenario 2b, with a present value of £126.7 million. Significant cost reductions are possible in this scenario by introducing variable tariffs, thus enabling new households to be developed to a maximum standard of CSH Level 3/4 (no need for CSH Level 5/6 in new households).

Scenario 3 took various aspects from each of the other neutrality scenarios to produce a balance of measures, and was the second cheapest scenario at £139.8 million. This relatively low cost is a result of including only 11,000 new homes built to CSH Level 5/6, with another 11,000 built to achieve the intermediate consumption rate of 95 litres per head per day.

If variable tariffs are excluded from the modelling, the most cost-effective scenario to achieve water neutrality is Scenario 1a.

Average incremental costs

AICs presented in Table 8.3 show a similar range for the retrofit measures, because the volume of water saved is directly proportional to the number of retrofit measures installed (and therefore also directly proportional to the cost). This analysis excluded promotion and recruitment costs to achieve the high levels of uptake assumed and economic benefits, which were beyond the scope of this study.

The CSH AIC is determined by the number of properties constructed to each CSH level in each scenario. The number of properties constructed to each standard determines the total cost of implementing the CSH programme and also the resulting demand reduction achieved from the CSH component of that scenario. As a result, a scenario with a large number of CSH Level 5/6 properties is likely to have a high AIC. Although demand reductions will be greater in a CSH Level 5/6 house compared to, for example, a CSH Level 3/4 house, the reduction will be achieved at considerable extra cost.

This is shown in the results in Table 8.3, where Neutrality Scenario 2b has the lowest AIC for CSH, because there are no CSH Level 5/6 homes in this scenario. Relative to scenarios that contain CSH Level 5/6 homes, more water is saved for less money. Neutrality Scenario 2a has the most expensive AIC for CSH, because of the large number of houses constructed to CSH Level 5/6 in this scenario. Although these houses have the lowest demand per person, it is achieved at considerable cost relative to the other CSH levels and thus increases the AIC for the scenario.

8.11.3 Non-household costs

Indicative non-household costs are provided, although these were excluded from the pathway scenario costs due to the uncertainties involved in their derivation.

For retrofitting the 195,400 existing non-households in the Thames Gateway, indicative costs range from a PV of £7.9 million based on £50 per non-household to £157.8

million based on £1,000 per property. If the average cost of retrofitting existing non-households was £200 per property, the total cost of retrofitting all such properties would be £31.6 million, just under half the cost of the Progressive Scenario.

Based on the assumptions in this study, achieving a 40 per cent reduction in new non-households would cost between £0.07 million based on £50 per property and £1.45 million, based on £1,000 per property. For the latter, the cost of achieving the 40 per cent reduction in new non-households would be around two per cent of the cost of the Progressive Scenario, or less than one per cent of the cost of Beyond Neutrality.

8.11.4 Carbon

Under the Progressive Scenario, CO_2e emissions are reduced by around 3,400 tonnes per year by 2016, compared to emissions under the BAU Lower Savings Scenario. The greatest reductions are seen under the Beyond Neutrality Scenario, where emissions are reduced by 12,164 tonnes per year.

The reductions represent between 2.7 and 10 per cent of emissions under the BAU Lower Savings Scenario.

Under the neutrality scenarios, emissions differ by less than 200 tonnes CO_2e per year, giving a difference in PV of approximately £1 million. This may reflect the limitations of the approach and data available to this study, and it is recommended that more detailed analysis using data specific to the Thames Gateway be used.

The PV cost of emissions under the BAU Lower Savings Scenario is around £101.4 million, using the Defra 'shadow price of carbon' approach. The greatest reduction in the cost of carbon emissions is seen under the Beyond Neutrality Scenario, where the reductions in emissions have a PV of £10.3 million. The Progressive Scenario has the smallest reductions in the cost of emissions, with a PV of £2.8 million.

For the neutrality scenarios, there is little difference in the PV of the carbon emissions, with PVs differing by around £1 million between the scenarios (around one per cent of the PV of the baseline emissions).

9 Further interpretation of results

9.1 Introduction

This section offers additional analyses of the pathway scenario results, beyond the simple assessment of costs and savings presented in Section 8. In particular, this section considers:

- how scenario costs translate into costs per household;
- how many households and non-households need to be retrofitted in order to offset the demand from one new property;
- how leakage might contribute to neutrality;
- the uncertainties associated with the analyses in this report.

9.2 Scenario costs per household

9.2.1 Analytical methods

Table 9.1 presents the scenario cost information on a 'per household' basis. These costs were calculated as follows:

Cost per existing house – Present value of the costs of measures applied to existing properties within each scenario (including retrofit measures, compulsory metering and variable tariffs where applicable) divided by the total number of existing households calculated as being within the Thames Gateway at the start of the period under consideration (613,398).

Cost per new house – Present value of the cost of measures applied to new properties (including variable tariffs where applicable) within each scenario divided by the total number of new households to be built within the Thames Gateway during the time period under consideration (133,098).

Average cost per house – Present value of the scenario divided by the total number of household properties within the Thames Gateway at the end of the period under consideration (746,496).

Table 9.1: Summary of scenario cost data

Scenario	PV of total cost (£ million)	Cost per existing house (£)	Cost per new house (£)	Average cost per house in 2016 (£)
Progressive	75.8	74.2	254.1	106.3
Neutrality 1a	156.6	138.7	564.2	214.6
Neutrality 1b	173.0	147.9	645.1	236.6
Neutrality 2a	181.0	134.8	765.4	247.2
Neutrality 2b	126.7	153.0	274.9	174.7
Neutrality 3	139.8	154.1	367.2	192.1
Beyond Neutrality	207.4	169.0	806.7	282.7

These costs take account of the assumed numbers of households subject to retrofits, specific CSH levels, compulsory metering and variable tariffs in each of the seven pathway scenarios. The assumed household numbers vary between scenarios, so the costs also vary. The costs presented in Table 9.1 were discounted over the accounting period used in this study, and so are present values of the total cost for each scenario. This means that per household costs presented here are naturally different from those used as input data to the scenario analysis, as presented in Sections 6.2 and 6.3.

9.2.2 Results

In all three cost assessments, the Progressive and Beyond Neutrality Scenarios have the lowest and highest costs per house respectively. This is to be expected, given the assumptions within these scenarios.

The cost per existing household reflects levels of retrofitting and the inclusion of variable tariffs within the scenario. Of the neutrality scenarios, Scenario 2a has the lowest cost per existing house, due to the slightly lower number of retrofits compared to Scenario 1a. Although the inclusion of variable tariffs in Scenario 1b enables neutrality to be achieved with a smaller retrofitting programme compared to the other neutrality scenarios, the additional operating cost associated with the variable tariffs increases the cost per existing household compared to Scenario 1a.

The costs per new household reflect the level of uptake of the more efficient (and more costly) CSH levels, where greater levels of uptake result in higher costs per new house. Scenario 2a therefore has the highest cost per new house for a neutrality scenario, at around £765. The lowest cost per new house is £275 in Scenario 2b, which does not include CSH Level 5/6 in the scenario.

The trends in average cost per house mirror those of the total PV for each scenario, with Neutrality 2a and Neutrality 2b being the highest and lowest cost neutrality scenarios at £247 and £175 per house respectively.

The most cost-effective way of achieving neutrality without variable tariffs is via high levels of retrofit in existing homes (Neutrality 1a), with a total cost of £156.6 million, compared to £181 million for the Neutrality 2a Scenario. Retrofit in existing homes is more cost-effective than building new homes to CSH Level 5/6.

The introduction of variable tariffs reduces the total cost in Neutrality 2 Scenarios, where the PV cost falls by 30 per cent from £181 million to £126.7 million from Neutrality 2a to Neutrality 2b. The introduction of variable tariffs has been used to remove the need to develop new homes to CSH Level 5/6, with the requirement to include rainwater harvesting/recycling systems at an average cost of about £1,500 per property. In Scenario 1b, the introduction of variable tariffs reduces the amount of retrofitting necessary. However, the increased operational costs of variable tariffs result in the costs of this scenario being greater that Scenario 1a.

The inclusion of variable tariffs within the Neutrality 3 Scenario enables neutrality to be achieved at a relatively low cost, by introducing an intermediate consumption level of 95 litres per head per day for new homes. This avoids the need for rainwater harvesting/recycling systems to achieve CSH Level 5/6, and also reduces the number of CSH Level 5/6 standard homes required. As a result, the average cost of a new home is the second lowest of all neutrality scenarios at £367.

9.3 Retrofit and new property equivalence

9.3.1 Households

In order to make this study relevant to different areas and scales than that of the Thames Gateway, it is useful to understand how many homes need to be retrofitted to offset the new demand from a new home. Table 9.2 shows how many homes would need to be retrofitted, using which retrofit package, for a home built to each CSH level. These figures are based on the average savings per household per retrofit device given in Table 5.3. No contribution from non-households, compulsory metering or variable tariffs is included within the figures, and they are separate from the results of the pathway scenarios.

Table 9.2: Number of existing homes that need to be retrofitted to offset demand from a single new home of a specified CSH standard

New home standard	Retrofit combination including variable flush	Retrofit combination including ultra-low flush toilet
120 l/h/d (CSH Level 1/2)	7.6	4.5
105 l/h/d (CSH Level 3/4)	6.8	4.0
80 l/h/d (CSH Level 5/6)	5.4	3.1

These calculations are based on an assumed household occupancy of 2.4 persons per household. For a house constructed to CSH Level 5/6, demand is calculated as 89.5 (pcc for a CSH Level 5/6 house, including outdoor use) multiplied by the occupancy, giving a demand of 215.5 litres/property/day.

Using the assumptions previously stated in this report, the average savings from a retrofit combination of ultra-low flush toilet replacement, low-flow shower and low-flow taps is 68.7 litres/property/day. Therefore, 3.1 households would need to be retrofitted with these measures to offset the demand from one new household constructed to CSH Level 5/6 standard. This would increase to 5.4 households if a variable flush retrofit was included in the retrofit combination instead of the ULF toilet (this retrofit combination delivers an average saving of 39.8 litres per existing property).

The baseline and BAU analysis showed that there were approximately 613,000 households within the Thames Gateway in 2005-06. The analysis in Table 9.2 implies that if all 103,990 new houses constructed in the Thames Gateway from April 2008 were built to CSH Level 5/6, neutrality could only be achieved by retrofitting 322,369 or 53 per cent of existing homes within the Gateway with fittings, including an ultra-low flush toilet, to offset the demand from new homes.

9.3.2 Non-households

A similar high level assessment was undertaken for non-households, as shown in Table 9.3. This table shows the number of offices that would need to be retrofitted to offset the demand from one new office building. Demand from an office building will be determined by the per capita consumption per office worker and the number of workers within the office building. To undertake this assessment, it was necessary to make the following assumptions:

- Offices in this assessment were assumed to have 100 office workers.
- Office worker per capita consumption could be reduced by 40 per cent, from 20 litres/head/day to 12 litre/head/day, through the installation of retrofit measures (as indicated in CIRIA, 2006).

Table 9.3: Number of offices to be retrofitted to offset demand from one new office

Assumed new office per capita consumption for an office worker (litres/head/day)	Number of existing offices required to be retrofitted to 12/litres/head/day to offset demand from one new office
12	1.5
16	2.0
20	2.5

Table 9.3 shows that between 1.5 and 2.5 offices would be required to be retrofitted to offset the demand from one new office, depending on the level of efficiency of the new office. This highlights the value of policy measures to ensure that new office buildings (and other new non-households) are constructed to a high standard of water efficiency.

9.4 Leakage

Section 3.2.3 described the difficulties of defining useful leakage savings beyond the ELL to help achieve neutrality. In summary, there is little data available to assess what this kind of leakage saving could contribute to neutrality, and what data is available (as presented in Section 5.11) shows that further leakage reductions (using the method of mains replacement) beyond the ELL may be prohibitively expensive. This supports the view of the three main water companies in the Thames Gateway, who do not consider that meaningful savings beyond the ELL are likely to be feasible or cost-effective.

However, it is possible that the factors that determine the economics, regulations or policy around leakage management may change and make additional leakage reductions a more attractive or necessary measure in working towards neutrality. Should this be the case, it is likely, based on the evidence presented in this study, that additional leakage reductions would be relatively small, perhaps in the order of 3-5 Ml/d across the whole of the Thames Gateway. Therefore, additional leakage reductions could form part of a neutrality solution, but are only likely to be a minor part of any such scenario. Additionally, the cost analysis presented in Section 5.11 suggests that leakage repair is unlikely to be a low-cost alternative to the other measures analysed in this study, and in fact may be one of the costlier options.

9.5 Uncertainty

9.5.1 Discussion

This study is based on a range of information, from water company water resource plans to household forecast data and the estimated performance and costs of a range of water-saving measures. There is inevitable uncertainty associated with all of these data, which must be recognised when considering the results of this research. In addition, the scenario analysis relies on considerable assumptions regarding the effectiveness of future demand management measures, which are heavily dependent on the outcome of policy and regulations that are still being developed. Finally, many of the measures analysed in this study are dependent on behavioural change and specific responses from the public to messages about water use. These may be explicit messages in the form of marketing and promotion or implicit in assumptions about how water users respond to financial incentives to save water.

This study uses a scenario-based approach to consider what mix of drivers and what level of uptake of the CSH and retrofit devices could feasibly achieve water neutrality in the Thames Gateway. This approach was agreed at the outset of the study, as it provides clear indications of the feasibility and cost of achieving water neutrality. The alternative approach of probabilistic analysis would not have provided this clarity.

However, there is considerable uncertainty associated with the results of this study, and the results of the scenario analysis should not be ‘taken as read’. For example:

- The household occupancy forecasts were taken from water company WRP forecasts.
- The forecasts of changes in water consumption made by water companies may be inaccurate.
- The effect of compulsory metering on demand may be less (or more) than the 10 per cent assumed in this study.
- The water savings assumed for retrofit devices may be over-optimistic and may not be sustainable in the longer term (for example, if low-flow showerheads are replaced with higher flow ones).
- The assumed implementation rates for the Code for Sustainable Homes in different scenarios may not be achieved or be achievable (for example, due to a skills shortage) and actual pccs may be higher (or lower) in practice.
- There is a possibility of double counting some of the water savings in this study. The relationship between the savings that can be achieved from compulsory metering and the introduction of variable tariffs is not clearly understood and the combined savings may be less than the 10 per cent and five per cent assumed in this study.

Actual costs for retrofit and/or CSH implementation are likely to be greater than those assumed in the study, due to promotional, administrative and other related costs.

However, the benefits of demand management, for example a reduced or delayed need for new supply-side investments such as new reservoirs, and the potential for lower water bills for the individual consumer, were not assessed in this study. Water companies would need to assess the full costs and benefits of different supply and demand-side measures in their 25-year WRMPs.

Many of the assumptions used in this study are ambitious, and therefore the results are generally at the upper end of what is likely, taking into account the uncertainties described above. However, efforts were made throughout the study to err towards the conservative end when estimating savings from components such as metering, variable tariffs and non-household demand savings. Furthermore, the impacts of measures such as more water-efficient domestic white goods (dishwashers and washing machines) or reductions in gardening use, were not included.

9.5.2 Analysis

It was necessary to make a number of assumptions in the analysis of water demand and potential water efficiency savings in this study. The uncertainties associated with assumptions were often difficult to quantify without detailed further work which was outside the scope of this study. Therefore, the range of uncertainty within the component assumptions and overall scenario results were not quantified explicitly. Further work based on more robust research would be needed to quantify the uncertainty of some parameters.

This uncertainty led to a precautionary approach in the estimation of savings. The use of lower 'per property' savings meant that ambitious uptake rates of water efficiency measures were required to achieve neutrality. This was a lower risk approach, as higher actual demand reductions than estimated could reduce the extent of retrofitting or CSH uptake required.

One fundamental assumption in this study exemplifies this point. This study used water company household occupancy forecasts for reasons outlined in Section 4.2.1 and because this was a precautionary approach. The forecast weighted average water company occupancy rate for 2016 was 2.42 persons per household. Data provided by Communities and Local Government estimated household occupancy to be 2.23 persons for the same year. Use of the CLG estimate would result in a population of Thames Gateway in 2016 of almost 142,000 persons (or 8 per cent) lower than that based on water company occupancy forecasts. This lower population could reduce the BAU demand in 2016 by 15-20 Ml/d, reducing the demand management required to achieve neutrality by the same amount.

The impact of uncertainty in the case of metering and variable tariff savings is illustrated by the sensitivity analysis below. Table 9.5 shows the impact of changing the assumed savings from metering on the Progressive Scenario. All other assumptions remain consistent with those presented in Section 8.2. Table 9.5 shows that by halving the assumed savings (to five per cent) from those in the Progressive Scenario, demand in the Gateway would increase by 2.5 Ml/d. Conversely, if the assumed savings were doubled to 20 per cent, demand in the Gateway would reduce by 2.4 Ml/d. Table 9.5 shows that the uncertainty in the savings from metering could have a significant impact on the achievement of water neutrality in the Gateway.

Table 9.5: Impact of changing the assumed percentage savings from metering on the Progressive Scenario

Assumed saving from metering	Shortfall against achieving neutrality in the Thames Gateway in 2016 (Ml/d)	Change from Progressive Scenario as modelled (Ml/d)
5%	31.2	2.5
10%	28.7	0
12%	27.8	-0.9
15%	26.3	-1.5
20%	23.9	-2.4

This is further illustrated by the following sensitivity analysis, which demonstrates the impact of changing assumptions of savings from variable tariffs on both the demand in the Thames Gateway and the costs of achieving neutrality. This is shown in Table 9.6. The sensitivity analysis was undertaken on the Neutrality 2b Scenario. All other assumptions remain consistent with those presented in Section 8.2.7.

Table 9.6: Impact of changing the assumed percentage savings from variable tariffs, Neutrality 2b Scenario

Assumed saving from variable tariffs	Shortfall against achieving neutrality in the Thames Gateway in 2016 (Ml/d)	Change from Progressive Scenario as modelled (Ml/d)
3%	3.8	3.8
5%	0	0
7%	3.4	-3.4
10%	8.9	-8.9

The analysis indicates that if the savings from variable tariffs were two per cent less than those modelled, there would be a shortfall against neutrality of nearly 4 Ml/d, or roughly a 10 per cent shortfall in the reduction in demand required to achieve neutrality. Conversely, if the savings from variable tariffs were doubled (to 10 per cent), then neutrality would be exceeded by around 9 Ml/d or approximately 25 per cent of the reduction required to achieve neutrality. To save 9 Ml/d through retrofitting alone would require approximately 224,000 existing households to be retrofitted with a variable flush combination (including a low-flow showerhead and taps) at a PV of around £21 million.

This analysis shows that varying a key assumption such as the percentage saving from variable tariffs in this study could have a significant impact on the achievement of neutrality, and by implication the cost of achieving neutrality.

10 Summary and conclusions

10.1 Summary

10.1.1 Baseline demand

The adjusted baseline demand for the Thames Gateway in 2005/06 is estimated as 521 Ml/d[19]. In geographical terms:

- The London water resource zone accounts for the largest portion of baseline demand within the Thames Gateway area, with 200 Ml/d or 38 per cent of the total.
- The Kent Medway and Essex zones follow with 166 Ml/d (32 per cent) and 152 Ml/d (29 per cent) respectively.
- The two Mid Kent Water zones, North Downs and Burham, account for less than one per cent of the total demand, as only small proportions of these zones fall within the Thames Gateway.

Of the 521 Ml/d total demand:

- The majority (around 461 Ml/d or 88 per cent) is for public water supply, with the remaining 60 Ml/d (or 11 per cent) for non-public water supply.
- Unmeasured household consumption is the largest component in the total baseline adjusted demand, making up 210 Ml/d or 40 per cent of the total.
- Non-household demand and leakage are the next largest components with around 23 per cent and 19 per cent respectively, followed by non-public water supply abstractions at 11 per cent.
- Measured household demand accounts for only nine per cent of the total, as only a quarter of houses in the Thames Gateway area are on a metered supply in the baseline year.
- The remaining minor components of water demand account for about one per cent of total demand.

Carbon emissions associated with the provision of water and the treatment of wastewater are estimated to be around 117,085 tonnes CO_2e/year.

10.1.2 Business-as-usual demand

Two business-as-usual scenarios were developed to reflect uncertainty over the implementation of policy changes that might influence the uptake of water efficiency measures in new homes. These scenarios were:

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[19] Adjusted to remove leakage savings planned by water companies during the study period to 2015/16.

- An Upper Savings Scenario reflecting more optimistic assumptions about the impact of changes in policy on the uptake of water efficiency standards in new homes.
- A Lower Savings Scenario reflecting less optimistic assumptions about the impact of changes in policy on the uptake of water efficiency standards in new homes.

The analysis showed an additional demand of 39.5 to 42.0 Ml/d in the Thames Gateway area (7.6 to 8.1 per cent) from new household and non-household growth by 2016. This was based on 165,523 homes being built in the Thames Gateway between 2001 and 2016 and the creation of 180,000 new jobs. The BAU Lower Savings Scenario was adopted for further analysis, since this was a conservative approach and presented a more ambitious target for achieving water neutrality.

To account for the building of more or fewer houses than the anticipated 165,523, sensitivity analysis was performed on the housing numbers of +/-10 per cent. This increased the potential range of demand from new homes to 36 to 46 Ml/d (6.9 to 8.8 per cent).

There is some uncertainty over the amount of non-household growth in the Thames Gateway in the water company PR04 forecasts. An allowance of 3.6 Ml/d was added to the BAU to account for the anticipated 180,000 jobs in the Thames Gateway. Demand from the Olympic Games is expected to result in significant short-term peaks in demand within the Thames Gateway, but in terms of annual average demand, is expected to result in a 3 Ml/d increase in 2012.

Business-as-usual demand (based on the Lower Savings Scenario) increases by 42 Ml/d from 521 Ml/d to 563 Ml/d by 2016. The demand from existing households and non-households remains relatively constant over the study period, as a 2 Ml/d decrease in existing household demand is mostly offset by an equivalent increase in non-household demand. This decrease in existing household demand is due to increased metering penetration, the savings from which offset the forecast increase in average pcc. Other components of demand, including DSOU and non-PWS demand, are all forecast to remain static.

By 2016, unmeasured household consumption remains the largest component of total demand in the Thames Gateway as a whole. However, in the London and Essex zones high levels of housing growth and increased metering penetration result in total measured household demand being higher than unmeasured demand.

The London zone still accounts for the largest demand within the Thames Gateway with 42.5 per cent of the total in 2016. Essex is next with 31.4 per cent followed by Kent Medway with 25.5 per cent. The two Mid Kent Water zones still account for less than one per cent of the total.

Carbon equivalent emissions under the BAU Lower Savings Scenario increase by around nine per cent from the baseline figure, to 127,760 tonnes per year by 2016. For the BAU Upper Savings Scenario the equivalent figure is 127,110 tonnes per year, an increase of 8.5 per cent over the baseline emissions.

10.1.3 Pathway scenarios

Key assumptions and impacts

Seven pathway scenarios were developed, five of which achieve water neutrality:

- Progressive Scenario – A step up from business-as-usual, but limited retrofit and a cautious approach to uptake of CSH, reflecting upper limit of what may be possible within current and future regulatory frameworks. Compulsory metering but no variable tariffs. Non-household savings from existing and new offices only.

- Neutrality Scenario 1a – High retrofit assumptions with more ambitious CSH targets than Progressive Scenario. Compulsory metering but no variable tariffs. Non-household savings from new and existing offices and other existing non-households.

- Neutrality Scenario 1b – Retrofit assumptions reduced from Scenario 1a due to positive effect of variable tariffs (in addition to compulsory metering). CSH targets and non-household savings unchanged from Scenario 1a.

- Neutrality Scenario 2a – More ambitious CSH targets but less optimistic retrofit assumptions than Scenario 1a. Compulsory metering but no variable tariffs. Non-household assumptions unchanged.

- Neutrality Scenario 2b – Retrofit uptake assumptions reduced from 2a in favour of variable tariffs. Variable tariffs mean that CSH Level 5/6 implementation can be removed and CSH Level 3/4 becomes most stringent level implemented. Non-household assumptions unchanged.

- Neutrality Scenario 3 – Composite scenario. Retrofit uptake reduced from 2a because of variable tariffs. Introduction of 95 l/h/d scenario requires more retrofitting than 2b to achieve neutrality. Compulsory metering and variable tariffs. Non-household assumptions unchanged.

- Beyond Neutrality Scenario – Maximum retrofit uptake (greater than 1a and all other scenarios). The most ambitious CSH glide path, with all new homes assumed CSH Level 5/6 from 2013/14. Compulsory metering and variable tariffs. Non-household assumptions unchanged.

Assumptions in these scenarios are summarised as follows:

- All pathway scenarios include compulsory metering and this is estimated to make an important contribution towards achieving water neutrality[20]. Some scenarios assume very high levels of retrofit uptake, which will likely require strong incentives or a degree of compulsion. Compulsory metering may offer an incentive to existing households to install retrofit water efficiency devices since the householder would have a financial incentive to install devices. However, this incentive alone may be insufficient and all scenarios would likely require a considerable programme of marketing to encourage existing householders to retrofit devices to reduce demand from toilets, showers and taps.

- The demand reductions from rainwater harvesting and grey water reuse are considered in relatively simple terms. The five neutrality scenarios assume that rainwater or recycled water will contribute to 50 per cent of non-potable domestic consumption, regardless of whether this is from household or development-level systems. Costs are calculated assuming that half of the rainwater or recycled water is sourced from household-level systems and half from development-level systems.

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[20] Compulsory metering assumes that an additional five per cent of unmeasured households become metered every year above BAU, resulting in 70 per cent of existing households metered by 2015/16.

- The neutrality scenarios also assume ambitious schedules for improving standards in new homes, presented as Code for Sustainable Homes 'glide paths'. Assumptions around rapid and/or extensive implementation of CSH Level 5/6 are considered particularly ambitious. It may be possible to implement an alternative pcc target of 95 l/h/d using the same fixtures and fittings as CSH Level 5/6, but excluding water recycling, thus reducing the cost considerably. However, if this standard were to replace CSH Level 5/6, more homes would have to be constructed to the 95 l/h/d to achieve the same result. This would necessitate homes being constructed earlier in the period to enable enough homes to be constructed to this standard.
- The data available to this study limited any detailed assessment of the potential contribution to water neutrality from the non-household sector. It was assumed that 40 per cent savings could be achieved in existing and new offices, and that these made up five per cent of all non-households in Thames Gateway. It was also assumed that a 10 per cent reduction in demand from other existing non-households was possible. All new non-households were assumed to be offices for the purpose of this study. Assumptions regarding potential savings from non-households were relatively conservative in the context of widely quoted savings that could be achievable in this sector, and there may be greater potential for this sector to contribute to neutrality.

Headline findings

The key findings of the pathways scenario analysis are that:

- Water neutrality in the Thames Gateway is potentially achievable. Water neutrality is theoretically possible through different combinations of measures including compulsory domestic metering, variable tariffs, retrofitting of existing households, improving the water efficiency standards in new build domestic properties and increased water efficiency in existing and new non-households. However, it is an ambitious goal that will require significant effort from those involved.
- The analysis indicates that water neutrality in the Thames Gateway without the use of variable tariffs would cost between £157 million (Scenario 1a) and £181 million (Scenario 2a) for neutrality scenarios with an emphasis on retrofitting and new homes respectively. Costs were calculated for households only as costs for non-households were too uncertain to include.
- The cost of these scenarios would increase to £173 million in Scenario 1b and decrease significantly to £127 million in Scenario 2b with the introduction of variable tariffs applied across all measured household customers (both new and existing).
- Compulsory metering is a fundamental requirement to achieve water neutrality. Variable tariffs for metered properties have the potential to make a significant contribution to achieving water neutrality. Variable tariffs are not a pre-requisite, but they could significantly reduce the cost of achieving neutrality where an ambitious programme of CSH uptake is planned (as indicated in Scenarios 2a and b).
- The Progressive Scenario and Beyond Neutrality Scenario would cost approximately £76 million and £208 million respectively. The Progressive Scenario would fall short of achieving neutrality by 29 Ml/d (32 per cent

shortfall), whilst the Beyond Neutrality Scenario would exceed neutrality by 9 Ml/d (20 per cent beyond neutrality).

- Analysis of costs at the household level shows that the retrofit programme would cost between £135 and £154 per household to achieve neutrality. Cost per new household varies much more, from £275 to £765, depending on the neutrality scenario in question. The lowest costs for new households are achieved when assumptions on development to the highest CSH levels are minimised. All costs are present value figures and take account of compulsory metering and variable tariff costs where relevant.
- Planned leakage reductions are removed from the analysis of water neutrality. Leakage savings beyond ELL are also excluded. Brief analysis (based on limited data) indicates that the unit costs associated with further leakage reduction range from around 130 to 540 p/m^3. This is high compared to other measures considered in this study, although some of the measures analysed in the pathway scenarios fall in this range.
- The analysis in this report uses information and data from previous studies where possible. However, accurate information on the costs and savings of demand management measures is limited, and further primary research is beyond the scope of this study. As a result, a number of conservative assumptions on the cost-effectiveness of such measures were made.
- There are uncertainties associated with the data used to estimate baseline and business-as-usual demand and the longer term durability of savings from measures. The effectiveness of many of the measures considered in this study rely on behavioural change and/or changes in public perception (for example, to grey water reuse). There is inevitable uncertainty associated with this aspect of demand management.
- Although non-household costs were excluded from the BAU and pathway scenario costs due to uncertainty, indicative costing was undertaken based on assumed costs per property. For existing non-households, costs range from a PV of £7.9 million based on £50 per non-household to £158 million based on £1,000 per property. For new non-households, costs range from £0.07 million based on £50 per property to £1.45 million based on £1,000 per property.
- For areas outside of the Thames Gateway, the study estimates that if neutrality were to be pursued only through the household sector, then between three and eight existing houses would have to be retrofitted to offset the demand from one new household. This value varies depending on assumptions relating to water efficiency standards of new homes and the type and extent of retrofits in existing homes. Unless further water savings were achieved through the non-household sector or through the use of compulsory metering and/or variable tariffs, there would be insufficient building stock within the Thames Gateway area to achieve neutrality if homes were built to lower standards than CSH Level 5/6.
- The smallest reductions in CO_2e emissions occur in the Progressive Scenario, where emissions are reduced by 3,400 tonnes per year (2.7 per cent reduction) by 2016 compared to the BAU Lower Savings Scenario. The PV of these reductions is around £2.8 million. The greatest reductions in CO_2e emissions occur in the Beyond Neutrality Scenario, where emissions are reduced by 12,164 tonnes per year (10 per cent reduction) compared to the BAU Lower Savings Scenario. The PV of these reductions is around £10 million.

- Under the neutrality scenarios, there is little difference in the emissions of CO_2e (less than 200 tonnes CO_2e per year). The PV of the carbon emissions differ by around £1 million between the scenarios (around one per cent of the PV of the baseline emissions).

10.2 Conclusions and recommendations

Water neutrality in Thames Gateway region is feasible in broad terms.

Scenarios that assume more new households will be built to the highest standards of the Code for Sustainable Homes (CSH) are more likely to achieve neutrality. In these, fewer existing households will need to be retrofitted to offset the demand from new households, which in practical terms are likely to be harder to influence than new build homes. Neutrality Scenario 2a has the most ambitious assumptions on CSH standards, assuming that nearly 60,000 new households will be built to CSH Level 5/6. However, this scenario is expensive, at £181 million PV, with the high CSH standards driving this high cost (60,000 CSH Level 5/6 households contributing £89 million present value).

Variable tariffs are likely to provide metered households with additional incentives to reduce their demand for water through behavioural change. The study shows that variable tariffs can generate significant reductions in demand at relatively low cost. Variable tariffs can therefore reduce the overall cost of achieving neutrality by reducing the number of new homes that need to be built to high CSH standards.

Ambitious retrofit rates are also required to achieve water neutrality. The retrofit rates assumed in the neutrality scenarios are achievable, but it may be more realistic to achieve the number of retrofits required by extending this activity beyond Thames Gateway but within the relevant water catchments/resource zones. This breaks neutrality ‘rules’ in pure terms, but is unlikely to be an issue, as the Thames Gateway boundary is neither a practical constraint nor a border that will constrain the social marketing necessary to deliver the savings required in existing households.

The two most cost-effective neutrality scenarios analysed in this study (Scenarios 2b and 3) include variable tariffs and either no or relatively low numbers of CSH Level 5/6 homes (just under 11,000 in Scenario 3). Scenario 3 includes an intermediate consumption standard for new homes of 95 litres per person per day. This consumption level can be achieved without the need for expensive rainwater harvesting or grey water reuse systems.

Scenario 3 offers perhaps the most favourable scenario to achieving water neutrality. Of the scenarios modelled, it is the most feasible in terms of the speed and level of take-up of higher levels of the CSH. It is the second lowest cost scenario, with a present value cost of £140 million. Using this scenario as a guide, the most effective approach to achieving neutrality should:

- include compulsory metering of existing households at the highest practicable rate;
- include variable tariffs for all metered households;
- aim to build all new households to meet the CSH Level 3/4 water efficiency standards from 2010/11, but also encourage an increasingly significant number of new households to reach a water efficiency standard of 95 litres per person per day or better from 2010.
- aim for at least one retrofit measure in half of the existing households;

- promote demand management in existing non-households and ensure new non-households are developed to high water efficiency standards, including rainwater and recycling measures where appropriate.

Of the scenarios assessed in this study, Neutrality Scenario 3 is the closest to meeting these criteria.

The carbon analysis in this report shows marginal differences in emissions (and thus the PV of emissions) under the neutrality scenarios. Under the neutrality scenarios, emissions differ by less than 200 tonnes CO_2e per year, giving a difference in PV of approximately £1 million. This may reflect the limitations of the approach and data used in this study; it is recommended that more detailed analysis using data specific to the Thames Gateway be used.

This study has shown that achieving water neutrality in the Thames Gateway is possible in broad terms. However, it is beyond the scope of this study to consider the mechanisms for delivering water neutrality. This is the next step and requires urgent action, if the aim is to achieve neutrality within the timescales of the development.

However, there are constraints on what is possible in the short term due to:

- legislative and regulatory constraints on the water industry in terms of introducing compulsory metering;
- economic constraints on what water companies can do to deliver retrofit programmes (where it is not currently funded by Ofwat);
- the extent to which high CSH standards can be achieved in new households due to constraints on the availability of suitable technology, the capacity of the supply chain for rainwater harvesting and grey water reuse and demand from potential house buyers.

One option that could expedite progress would be for key groups to work together on a medium-scale pilot scheme over the next 18-24 months, incorporating the recommendations outlined above. This should aim for 500 to 1,000 new households to reach a range of CSH levels, with a suite of retrofits to between 2,500 and 5,000 existing households (for example). The pilot scheme should include compulsory metering and the use of variable tariffs. Finally, the scheme should seek to achieve savings in existing households and use the developing evidence base on water efficiency in new non-households to target this group of buildings.

If such a pilot scheme is developed, it is vital that it is used to better understand the cost-effectiveness of the demand management measures implemented. The study should focus in detail on developing a better understanding of the uncertainties associated with demand management, and whether these can be managed and reduced. Therefore, the pilot scheme should include an extensive programme of monitoring and analysis. This would benefit understanding of water neutrality concepts, as well as providing a significant contribution to the demand management evidence base.

The results of this study should be interpreted with consideration to the uncertainties within the data and the necessary assumptions made. The financial/time constraints (as well as other imperatives) associated with this study meant a scenario based approach to assessing the feasibility of water neutrality was considered most appropriate. Probabilistic modelling of demand management options could provide a more extensive consideration of the uncertainties associated with achieving water neutrality. This approach is used in water resource planning, and in other relevant disciplines (such as economics). Such a project could build on the outputs from this study.

Appendix 1: Selection of demand data

Selection of baseline demand data

Water use in the Thames Gateway can be split into two categories: public water supply (PWS) and non-PWS. The source data for the baseline demand for PWS and non-PWS is explained below.

PWS in the Thames Gateway

The Thames Gateway area is served by four water companies: Thames Water, Essex and Suffolk Water, Southern Water and Mid Kent Water. The water company supply areas are further sub-divided into areas known as water resources zones (WRZs). A WRZ is defined as the largest area over which all customers receive the same levels of service. It is the level at which all water companies discuss their water resource needs with the Environment Agency and Ofwat. The Thames Gateway is comprised of five such zones as shown in Table A1.1.

Table A1.1: Water resource zones in the Thames Gateway

Water resource zone	Water company
Burham	Mid Kent Water
North Downs	Mid Kent Water
Kent Medway	Southern Water
London	Thames Water
Essex	Essex and Suffolk Water

Demand data sources for this study

Water companies report their supply and demand data to the regulators in line with the financial year, running from April to March. The latest complete report year is 2005/06 (April 2005 to March 2006) and therefore this was selected to form the base year for this study. For the purpose of this study, two possible data sources were examined to obtain demand data for the 2005/06 report year.

One potential source of data was the water resource plan (WRP) 2004 data. All water companies submit WRPs to the Environment Agency on a five-year basis. The last WRP submission was April 2004. This was submitted at the same time as water companies submitted their strategic business plans to Ofwat as part of the Periodic Review of prices (the 2004 submission is therefore known as PR04). At PR04, the water companies set out how they plan to manage the supply and demand for water over a 25-year planning period. The information in the plan includes a forecast of water use over this period, and therefore could be used as the basis for estimating demand in the Thames Gateway in 2005/06.

The second potential source of data examined for this study was the water company annual returns, also submitted to the Environment Agency. The annual returns are submitted in June each year and detail actual demands over the preceding year (the annual review 2006 covered the period April 2005 to March 2006). The reviews allow the Environment Agency to monitor progress of the water companies against the plans they set out in their WRPs. The Environment Agency provided the annual return data for all four water companies for the six-year period 2000/01 to 2005/06.

There is a key difference between the two sets of data. PR04 data is a forecast of demand that will occur at some point in the future under specific dry year conditions, whilst annual return data reflects the demand that actually occurred during a report year. This is important, because there could be a significant difference between what the company forecasts at some point in the future and the demand from customers reported during that year. This could be due to legitimate uncertainties in demand forecasts, changes to accounting methods, responses of water customers to the weather experienced during a given year or failures in company performance.

The two sets of data were compared to establish which information would be more appropriate for the base year of this study. The results of this analysis are discussed below.

Comparison of PR04 and annual return data

At the initial project steering group meeting, two potential options were discussed as suitable baseline data. Two data sets were compared:

- the 2005-06 dry year forecast from PR04;
- the six-year average demand from 2000-01 to 2005-06 as reported in the annual return data.

The results of the analysis are shown in Table A1.2, which shows that there is little significant difference between the dry year annual average demand forecast for 2005-06 and the six-year average of demand. In all WRZs, the six-year average is lower than the dry year forecast. This would be expected, given that none of the six years were true “dry” years. Demand is less than three per cent lower than the dry year forecast for 2005-06, when perhaps a greater difference would be expected. This may be because there were at least two summers in the six years that were significantly drier than average (2003 and 2005), plus the impact of drought over the period late 2004 onwards. However, this is speculation and no analysis was undertaken for this study to determine this.

Table A1.2: Comparison of average of 2000-01 to 2005-06 annual return distribution input (DI) to PR04 forecast DI for water resource zones in the Thames Gateway

Water resource zone	2000-01 to 2005-06 six-year average DI (Ml/d)	2005-06 dry year forecast DI from PR04 (Ml/d)	Difference (Ml/d)	% Difference
Burham	12.21	12.50	-0.29	-2.3
North Downs	14.71	15.11	-0.40	-2.6
Kent Medway	120.60	124.07	-3.47	-2.8
London	2179.62	2230.68	-51.06	-2.3
Essex	401.08	403.70	-2.62	-0.6

On the basis of these data, it is clear that selection of either set of data to establish baseline demand in the Thames Gateway would arrive at a similar answer. When the components of demand are analysed in a similar way, there are greater variations between the dry year forecasts and the average of the reported values. Table A1.3 is a comparison of the six-year average of measured household pcc and the forecast figure from PR04. There is a significant difference in the data, with six-year average measured household pcc in Mid Kent Water's Burham and North Downs zones being around 10 per cent lower and higher than the PR04 forecast for those zones in 2005/06 respectively. This variation could reflect physical changes in demand, for example customer's response to different weather conditions, including responses to drought-related water restrictions, or it could reflect legitimate changes to the way that Mid Kent Water has accounted for their customer water use.

Table A1.3: Comparison of average of 2000-01 to 2005-06 annual return measured household pcc to PR04 forecast pcc data for WRZs in the Thames Gateway

Water resource zone	2000-01 to 2005-06 six-year average measured household pcc (l/h/d)	2005-06 dry year forecast measured household pcc from PR04 (l/h/d)	Difference	% Difference
Burham	169.83	154.34	15.49	10.0%
North Downs	137.34	153.39	-16.05	-10.5%
Kent Medway	164.26	170.77	-6.51	-3.8%
London	157.15	157.57	-0.41	-0.3%
Essex	149.30	151.78	-2.48	-1.6%

Given that Mid Kent Water's WRZs comprise less than one per cent of the demand in the Thames Gateway, these variations would not have a significant impact on demand calculations for the Gateway as a whole, but serve to highlight some of the issues that could arise by using the six-year average of reported data.

For the purpose of this study, it was decided to use the 2005/06 forecast from PR04 as the primary source for the baseline data. This was primarily because this was a consistent set of data, submitted by all water companies to the regulators, and was the data that they would be planning against. It was acknowledged that there could be differences in approach to demand forecasting between the companies in the PR04 data used by the companies within this study. Examination of these differences was outside the scope of the study. However, the annual reporting data could reflect external factors such as weather and demand restrictions, as well as differences in approach by any one company over the period 2001-2016. The latter appears not to have had a significant impact on distribution input, but could change the components of the water balance. For these reasons the PR04 data was selected for analysis.

Peak demands

The assessment in this study was based entirely on annual average demand, taken from the PR04 dry year annual average final planning tables for each WRZ in the Thames Gateway area.

Water companies plan to meet demands in each WRZ under dry year annual average conditions, or the conditions that the WRZ would experience under drought conditions. Some WRZs have relatively large volumes of raw water storage reservoirs that can be drawn on to meet demand and because of this, short-term peaks in demand can be met by treating more stored water. Conversely, in a WRZ where there is relatively little raw water storage there is a greater risk to supply during times of peak demand in a dry year. Such peaks in demand may be experienced when high levels of non-essential water use, such as garden watering or car washing, occur on hot summer days.

Of the five WRZs in the Thames Gateway, peak demand data is not submitted for two zones: Thames Water's London WRZ and Essex and Suffolk Water's Essex WRZ. These two zones comprise approximately 70 per cent of the water use in the Thames Gateway area. It is primarily for this reason that the feasibility of water neutrality under peak demand conditions was not assessed here.

Demand management measures could have different impacts on annual average and peak demand. Although no peak demand assessment was undertaken, a statement about implications for peak demand will be made in the Pathways Report when demand management scenarios are examined in detail.

Appendix 2: Historic pcc and metering data

Figure A2.1 below shows the percentage of properties metered in the WRZs that lie within the Thames Gateway over the period 2000-01 to 2005-06. For comparison purposes, the industry average is shown for the period 2001-02 to 2005-06.

The percentage of households metered within the WRZs that lie within the Gateway has increased over the period analysed. This would be expected, given that all new households built over this period were metered and because of the number of households switching from an unmeasured to a measured tariff. The percentage of metering in two WRZs, London (Thames Water) and Kent Medway (Southern Water) were around 10 per cent lower than the industry average in 2005-06.

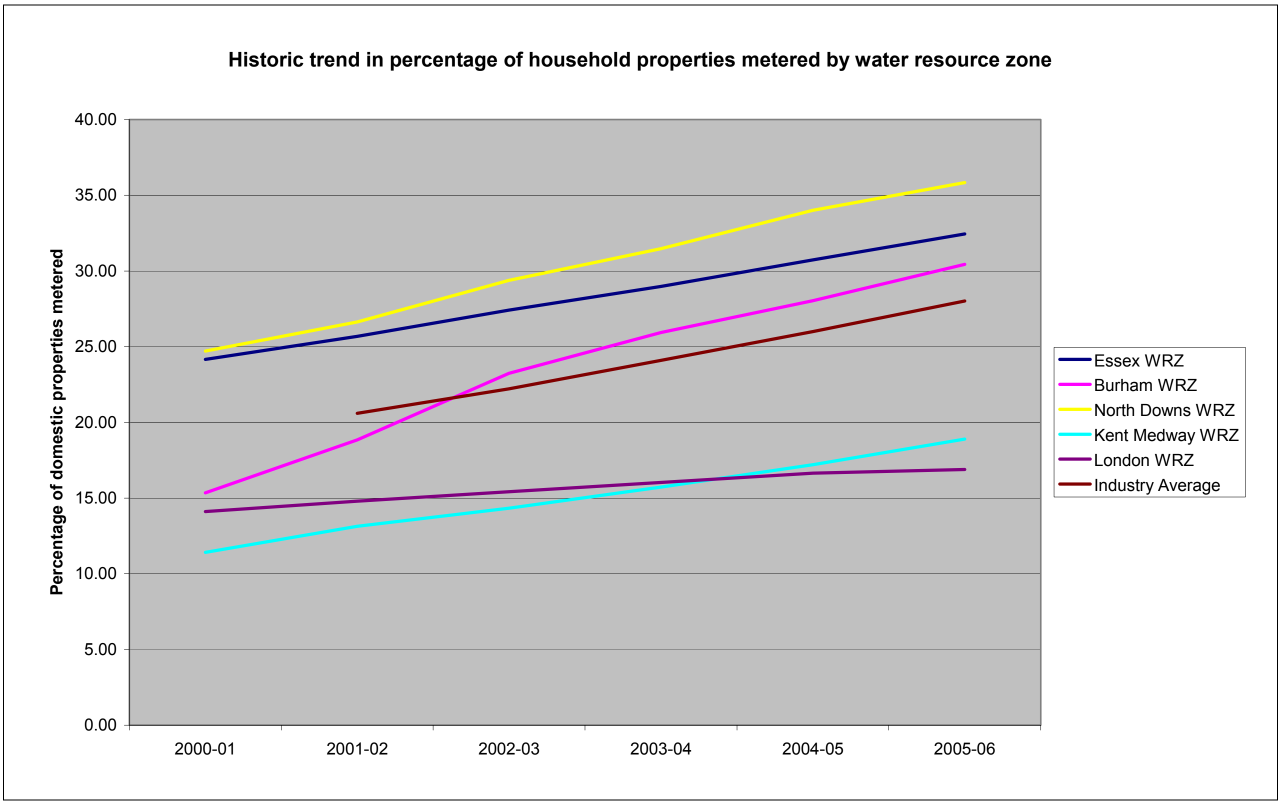

Figure A2.1: Historic trend in percentage of household properties metered (by water resource zone)

Figures A2.2 and A2.3 show the trends in unmeasured and measured pcc over the same period. These are not directly comparable with the forecasts for pcc included in the PR04 forecasts as the latter are dry year values, whilst those presented below are actual values. As a result, the values in Figures A2.2 and A2.3 can be influenced by customer behaviour, which in turn can respond to climatic conditions (for example, hot dry years can increase pcc by increasing non-essential water use). In addition to this, demand restrictions imposed by the water companies in response to the recent drought are likely to have reduced pcc in 2004-05 and 2005-06. Even if the companies in the

Gateway did not impose restrictions themselves, restrictions imposed by neighbouring companies could have influenced the pcc values.

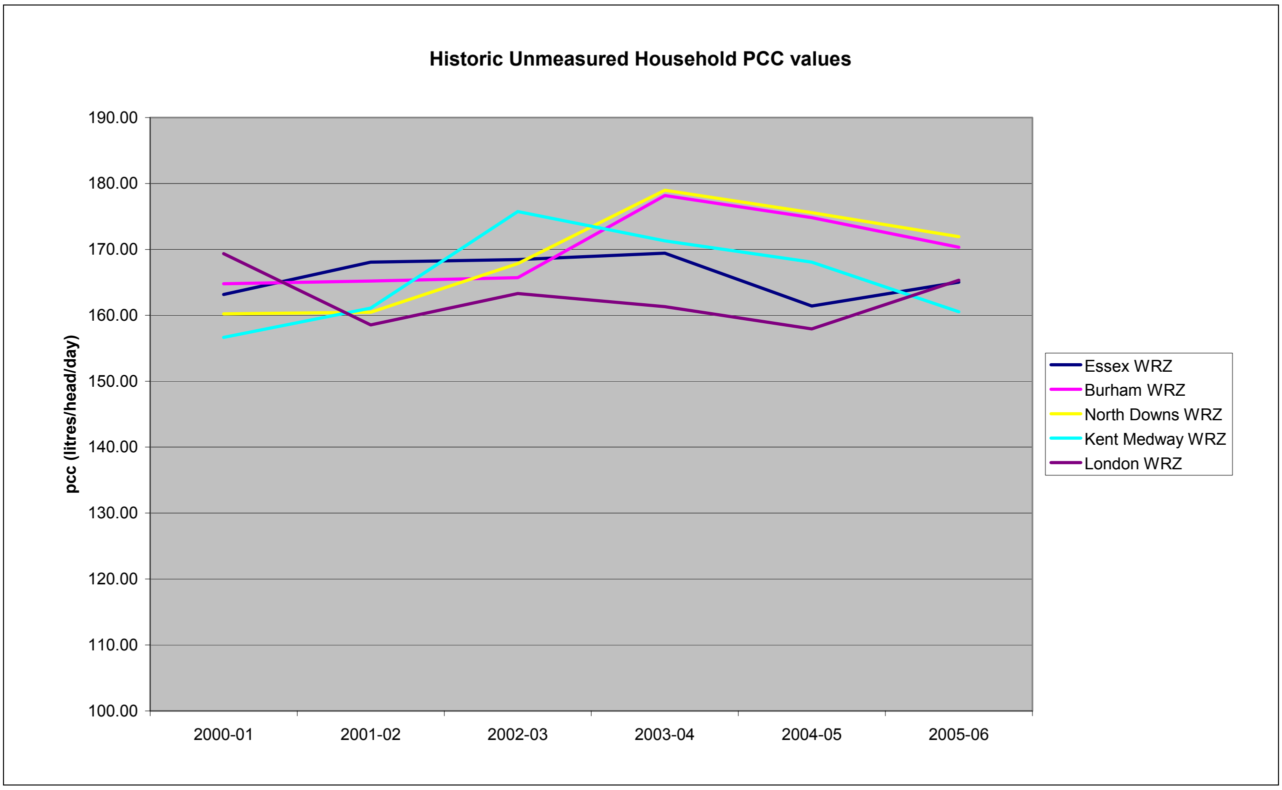

Figure A2.2: Historic unmeasured household pcc values by WRZ

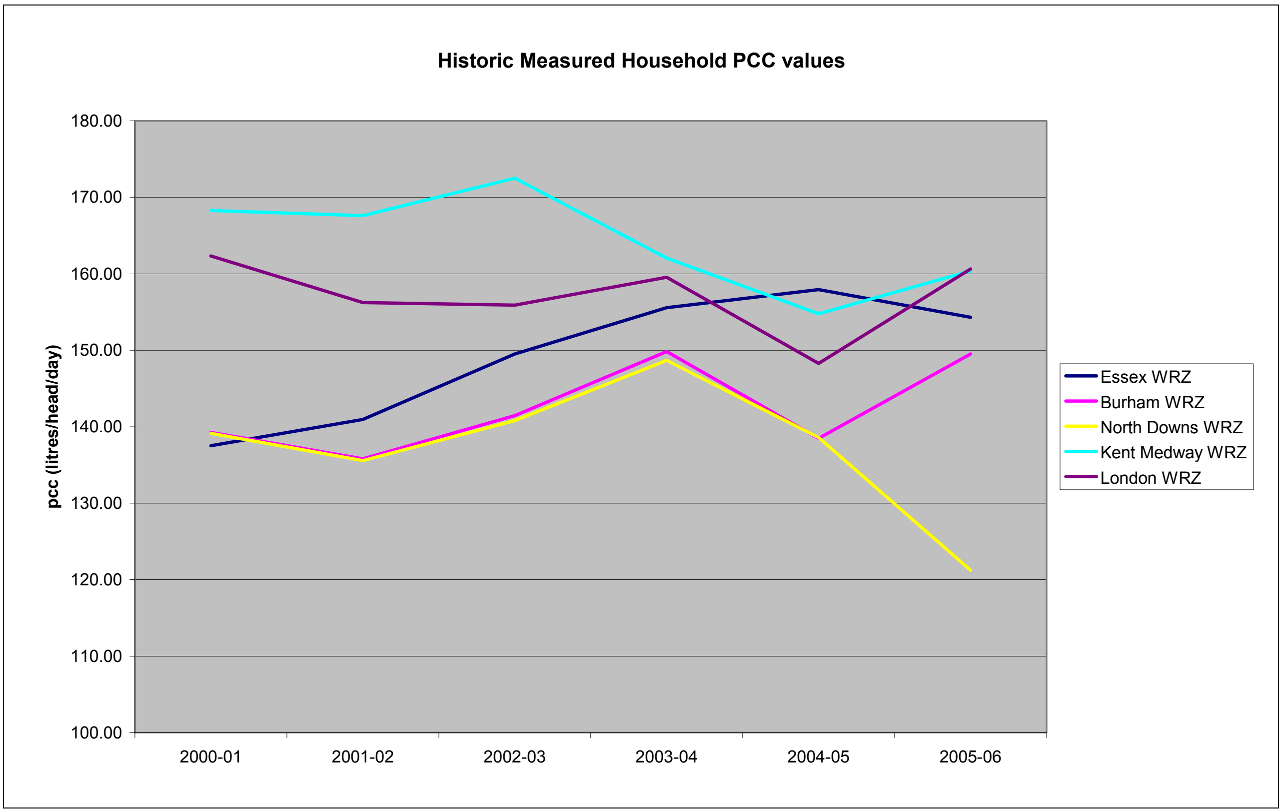

Figure A2.3: Historic measured household pcc values by WRZ

The data presented within these graphs are taken from the annual Ofwat *Security of supply, leakage and efficient use of water* reports 2001-2006. (Ofwat, 2001 to 2006)

Appendix 3: Assessment of demand from the Olympic Games

The Olympic Games will take place in London in 2012. The Olympic Park lies within the Thames Gateway and is subject to large scale regeneration over the period to 2012. In the context of the current report, it is difficult to reconcile the static growth forecast in non-households with such a massive investment programme. The purpose of this appendix is to discuss the issue in the context of demand anticipated from the Olympics and development.

In terms of water demand, the Olympics can be split into three periods. The first is the construction phase, which is likely to require water for construction purposes. Some of the buildings constructed are likely to require water as they become occupied in the run up to the Games. The second phase is the period of the Games themselves, which will take place in the summer of 2012. The third period is the legacy development, that is, the demand from the site in the years following the Olympic Games.

An estimate of demand expected from hosting the Games in 2012 is derived below. It was necessary to base the assessment on a number of assumptions and these are set out in the methodology below. No assessment of demand in the run up to the Games and in the post-Games period was made, for reasons discussed below.

Demand from the construction period and legacy development

The WRPs produced in 2004 were submitted prior to the announcement that the 2012 Olympic Games had been awarded to London. Thames Water's 2006 WRP (used in this study) retained the same non-household forecast used in the 2004 report. Consequently, no account of demand associated with the Olympic Games was included within the plans.

However, regardless of whether a positive decision on the Olympics was received, the Stratford area was planned for large-scale regeneration (Thames Water*, personal communication).* This was allowed for within Thames Water's WRP in the forecasts of household properties and should also have been taken into account in the non-household trends. Thames Water was approached as part of this study, but were unable to confirm the volumes allowed for this development. It was not possible to quantify the allowance that Thames Water made in its WRP, and some assumptions were therefore made here.

Working on the assumption that the area would have seen significant regeneration and that this was accounted for within the existing non-household forecast, this study can be considered to have captured the household demand within the forecast household numbers provided for the Thames Gateway area. Demand over and above this allowance could include water use associated with construction activities (for example, concrete batching and dust suppression). The Olympic Development Agency has set out plans to minimise water use from the Olympic Games (ODA, 2007a) and is suggesting using non-PWS sources for construction purposes. An example source is the dewatering of Stratford International railway station, where boreholes are used to ensure that the station is not flooded by groundwater. It is also possible that preparation of concrete (which can require large volumes of water) will take place outside of the Thames Gateway.

Demand during the staging of the Olympic Games

The nature of the Olympic Games is such that a large number of people (competitors, spectators, media and so on) are concentrated in the Olympic Park over a relatively short period of time while the games are staged. The ability to meet demands is therefore primarily focussed on meeting short-term peaks in demand. However, the scale of the Games is such that there will be an impact on annual average demand. An estimate of demand is provided below, with the underlying assumptions.

Number of attendees

The assessment is based on the capacity of venues, as a proxy for the number of visitors that can be expected. Although the Games are to take place in London, a number of events will be staged at locations outside the capital. Demand associated with these venues was excluded from the assessment.

Within London, the Games will be staged in a combination of existing and planned venues, of which some are located outside the Thames Gateway area (for example, beach volleyball will be taking place at Horseguards Parade). For this assessment, the planned developments within the Olympic Park and existing venues in the Gateway area such as Excel London, planned to stage the martial arts events, were included. The venues and their capacities are listed in Table A3.1.

For the purpose of this study, the capacity was rounded to 250,000. In addition to spectators, athletes and media will also attend the games. For press and media, it was assumed that the total number of press and media will be around seven per cent (17,500) of the spectator numbers. This is in line with numbers seen at the Sydney Games in 2000, which was attended by around 16,000 members of the media. At Athens in 2004, around 11,000 competitors took part in the Games (Olympic Movement, 2007). It was assumed that 12,000 athletes will attend the London Games.

Table A3.1: Olympic venues within the Thames Gateway, with planned capacity

Venue	Events	Capacity
Olympic Park Stadium	Athletics	80,000
Olympic Park Aquatics Centre	Swimming, Diving, Synchronised Swimming, Modern Pentathlon, Water Polo (finals)	20,000
Olympic Park Tennis Complex Tennis (Paralympic)		7,000
Olympic Park Velodrome	Cycling (track)	6,000
Olympic Park Sports Hall 1	Volleyball	15,000
Olympic Park Sports Hall 2	Basketball (prelims), Modern Pentathlon	10,000
Olympic Park Sports Hall 3	Handball (prelims)	5,000
Olympic Park Hockey Stadia	Hockey	20,000
University of East London	Water Polo (prelims)	5,000
Greenwich Sports Hall 1	Gymnastics (rhythmic), Badminton,	6,000
Greenwich Sports Hall 2	Table Tennis	6,000
Olympic Park BMX Track	Cycling (BMX)	6,000
Total capacity (new venues)		**186,000**
Excel London	Boxing, Judo/Taekwondo, Weightlifting, Wrestling	36,000
The Dome	Gymnastics, Basketball, Handball	20,000
Total capacity (existing venues)		**56,000**
Total capacity in the Gateway		**242,000**

Source: Olympic Delivery Authority website (ODA, 2007b)

Resident or transitory visitors

To estimate the demand from the Olympics, it was necessary to make some assumptions about the number of visitors staying in the Thames Gateway area and the number of day visitors. Other issues also needed to be considered. For example, of those visitors staying, some might be staying within the Thames Gateway, in other parts of London or outside London. In addition, some of the day visitors might live in the Thames Gateway area and therefore including an allowance for these attendees could lead to double counting of demand. There might also be an exodus of residents from the Gateway area at the time of the Games, due to the perceived overcrowding.

To simplify the assessment the following assumptions were made, based on best working estimates:

- Of the 250,000 spectators, 20 per cent are assumed to be staying overnight in the Gateway area for the duration of the Games.
- All of the 12,000 competitors are assumed to be resident within the Gateway area for the duration of the Games.
- Eighty per cent of the media are assumed to be resident within the Gateway area for the duration of the Games.

Demand

Demand allowances were made as follows:

- The 80 per cent of spectators and 20 per cent of media that are assumed NOT to be staying within the Gateway overnight are assigned a demand of 20 l/h/d. This covers demand that would be expected for a day visitor (toilet flushing, provision of food through catering facilities and so on).
- The 12,000 competitors and members of the media and spectators that are assumed to be resident are assigned a demand of 120l/h/d, that is, the CSH Level 3 pcc is assumed.
- An additional allowance is made for other demand within the Thames Gateway. This is an arbitrary allowance of 20 per cent above total demand estimated for the Olympic Games and accounts for visitors to the park itself (for example, to view the games on large screens and not taken into account within the stadia capacity) and for other demand such as cleaning and grounds maintenance.

The results are shown in Table A3.2 as the ‘central’ estimate. Sensitivity analysis was undertaken around the central values, as shown with the ‘low’ and ‘high’ scenarios.

Table A3.2: Range of demand estimates for hosting of the Olympic Games

		Low	Central	High
Day visitor demand	l/h/d	10	20	30
Resident visitor demand	l/h/d	105	120	150
Olympics daily demand	Ml/d	12.0	15.8	21.0
Paralympic daily demand	Ml/d	9.0	11.9	15.8
Annual average	Ml/d	1.7	2.3	3.0

	Low	Central	High
demand			

The table shows that demand planning for the Olympics should focus on meeting the short-term peaks in demand, which could be in the range of 12 to 21 Ml/d based on the assumptions in this assessment. In terms of annual average demand, the impact of hosting the Olympic Games is less significant. This assessment shows that the Olympics could be expected to add between 1.7 and 3.0 Ml/d to annual average demand in the Thames Gateway during 2012. To put this into context, it is less than one per cent of demand forecast in the Thames Gateway for that year.

An additional allowance was included in the assessment for the Olympic Games in 2012 of 3 Ml/d.

Appendix 4: Tabular results from the BAU scenarios

Table A4.1: Thames Gateway forecast baseline demand (2005/06)

Water Resource Zone	Measured Household Consumption Ml/d	Unmeasured Household Consumption Ml/d	Non-Household Demand Ml/d	Total Leakage Ml/d	Water Taken Unbilled Ml/d	DSOU Ml/d	PWS Total Demand Ml/d	Non- PWS 00-05 Avg Ml/d	Total Baseline Demand Ml/d
Burham	0.07	0.22	0.04	0.07	0.00	0.00	0.40	**0.00**	0.40
North Downs	0.53	1.09	0.42	0.51	0.01	0.00	2.57	**0.03**	2.6
Kent Medway	12.49	64.90	23.06	20.91	0.91	0.13	122.39	**43.52**	165.9
London	13.32	77.96	44.81	66.53	2.91	0.47	206.00	**13.61**	219.6
Essex	21.51	65.88	39.24	21.21	1.79	0.30	149.92	**2.85**	152.8
Thames Gateway	**47.93**	**210.04**	**107.56**	**109.22**	**5.62**	**0.90**	**481.28**	**60.00**	**541.3**

Table A4.2: Thames Gateway baseline demand (2005/06) (adjusted leakage)

Water Resource Zone	**Measured Household Consumption Ml/d**	**Unmeasured Household Consumption Ml/d**	**Non-Household Demand Ml/d**	**Total Leakage Ml/d**	**Water Taken Unbilled Ml/d**	**DSOU Ml/d**	**PWS Total Demand Ml/d**	**Non- PWS 00-05 Avg Ml/d**	**Total Baseline Demand Ml/d**
Burham	0.07	0.22	0.04	0.07	0.00	0.00	0.40	0.40	0.40
North Downs	0.53	1.09	0.42	0.49	0.01	0.00	2.55	2.58	2.58
Kent Medway	12.49	64.90	23.06	20.91	0.91	0.13	122.39	165.91	165.91
London	13.32	77.96	44.81	47.47	2.91	0.47	186.94	200.55	200.55
Essex	21.51	65.88	39.24	20.25	1.79	0.30	148.96	151.81	151.81
Thames Gateway	**47.93**	**210.04**	**107.56**	**89.18**	**5.62**	**0.90**	**461.24**	**521.25**	**521.25**

Table A4.3: Thames Gateway Upper Savings Scenario (2012 leakage adjusted)

Water Resource Zone	New Household demand Ml/d	Measured Household Consumption Ml/d	Unmeasured Household Consumption Ml/d	Non-Household Demand Ml/d	Total Leakage Ml/d	Water Taken Unbilled Ml/d	DSOU Ml/d	PWS Total Demand Ml/d	Non-PWS 00-05 Avg Ml/d	Total Demand Ml/d
Burham	0.0	0.1	0.2	0.0	0.1	0.0	0.0	0.4	0.0	0.4
North Downs	0.2	0.8	0.8	0.4	0.5	0.0	0.0	2.8	0.0	2.8
Kent Medway	3.5	18.4	58.9	23.3	20.9	0.9	0.1	126.1	43.5	169.5
London	17.8	22.1	68.5	46.6	47.5	2.8	0.5	205.8	13.6	219.4
Essex	6.9	34.3	53.6	37.2	20.2	1.8	0.3	154.3	2.9	156.8
Thames Gateway	**28.4**	**75.6**	**182.1**	**107.6**	**89.2**	**5.5**	**0.9**	**489.3**	**60.0**	**549.3**

Table A4.4: Thames Gateway Lower Savings Scenario (2012 leakage adjusted)

Water Resource Zone	New Household demand Ml/d	Measured Household Consumption Ml/d	Unmeasured Household Consumption Ml/d	Non-Household Demand Ml/d	Total Leakage Ml/d	Water Taken Unbilled Ml/d	DSOU Ml/d	PWS Total Demand Ml/d	Non-PWS 00-05 Avg Ml/d	Total Demand Ml/d
Burham	0.0	0.1	0.2	0.0	0.1	0.0	0.0	0.4	0.0	0.4
North Downs	0.3	0.8	0.8	0.4	0.5	0.0	0.0	2.8	0.0	2.8
Kent Medway	4.0	18.4	58.9	23.4	20.9	0.9	0.1	126.7	43.5	170.2
London	17.3	22.1	68.5	46.9	47.5	2.8	0.5	205.6	13.6	219.2
Essex	7.4	34.3	53.6	37.3	20.2	1.8	0.3	154.9	2.9	157.7
Thames Gateway	**29.0**	**75.6**	**182.1**	**108.1**	**89.2**	**5.5**	**0.9**	**490.3**	**60.0**	**550.3**

Table A4.5: Thames Gateway Upper Savings Scenario (2016 adjusted leakage)

Water Resource Zone	New Household demand Ml/d	Measured Household Consumption Ml/d	Unmeasured Household Consumption Ml/d	Non-Household Demand Ml/d	Total Leakage Ml/d	Water Taken Unbilled Ml/d	DSOU Ml/d	PWS Total Demand Ml/d	Non-PWS 00-05 Avg Ml/d	Total Demand Ml/d
Burham	0.0	0.1	0.2	0.0	0.1	0.0	0.0	0.4	0.0	0.4
North Downs	0.3	0.9	0.7	0.4	0.5	0.0	0.0	2.8	0.0	2.8
Kent Medway	4.6	21.7	55.5	23.4	20.9	0.9	0.1	127.2	43.5	170.7
London	25.3	31.2	58.3	48.2	47.5	2.8	0.5	213.8	13.6	227.4
Essex	9.8	40.9	46.2	37.4	20.2	1.8	0.3	156.5	2.9	159.4
Thames Gateway	**40.0**	**94.9**	**160.8**	**109.5**	**89.2**	**5.5**	**0.9**	**500.8**	**60.0**	**560.8**

Table A4.6: Thames Gateway Lower Savings Scenario (2016 adjusted leakage)

Water Resource Zone	New Household demand Ml/d	Measured Household Consumption Ml/d	Unmeasured Household Consumption Ml/d	Non-Household Demand Ml/d	Total Leakage Ml/d	Water Taken Unbilled Ml/d	DSOU Ml/d	PWS Total Demand Ml/d	Non-PWS 00-05 Avg Ml/d	Total Demand Ml/d
Burham	0.0	0.1	0.2	0.0	0.1	0.0	0.0	0.4	0.0	0.4
North Downs	0.3	0.9	0.7	0.4	0.5	0.0	0.0	2.9	0.0	2.9
Kent Medway	5.5	21.7	55.5	23.6	20.9	0.9	0.1	128.3	43.5	171.8
London	25.0	31.2	58.3	48.7	47.5	2.8	0.5	213.9	13.6	227.5
Essex	11.0	40.9	46.2	37.5	20.2	1.8	0.3	157.8	2.9	160.7
Thames Gateway	**41.9**	**94.9**	**160.8**	**110.2**	**89.2**	**5.5**	**0.9**	**503.3**	**60.0**	**563.3**

Appendix 5: BAU assessment of PWS non-household demand

Non-household demand is forecast to remain flat over the period to 2016. This is perhaps contrary to what might be expected, given the widely quoted figure of 180,000 new jobs planned within the Thames Gateway area and the developments associated with the Olympic Games.

The approach taken to assess non-household demand in this study was to apply the water company water resource zone trends in non-household demand to the Thames Gateway area. Water company non-household forecasts are based on econometric analysis of historical trends in water use by different sectors of the non-household customer base. The analysis relates water use to the different classes of non-household customers, and uses forecast trends in employment and sector output to forecast how water use within these sectors may change over time. There is therefore considerable uncertainty in non-household demand forecasts, since these depend on assumptions and estimates of economic performance in the future.

The uncertainty is increased by the approach adopted in this study, since the method assumes that forecast trends in non-household water use at the water resource zone level are applicable to sub-sections of water resource zones. Essex and Suffolk, Thames and Southern Water were approached to ascertain the allowances made for non-household growth within the Thames Gateway, given that all three show no significant growth in this demand component.

All three companies confirmed that allowances were included within their WRPs for development that was confirmed at the time their plans were put together. Plans for the development of the Thames Gateway were announced too late to be incorporated into the non-household assessments within the WRPs.

Based on the responses, it was not possible to quantify allowances specifically for the Thames Gateway. The responses of all three companies confirmed that the trend seen in this study is not dissimilar from the trends that they would expect based on the allowances in their WRPs. However, all three companies will be updating their demand forecasts for PR09 to include allowances for developments that have since been confirmed.

The additional non-household demand that could be expected from the 180,000 jobs planned in the Thames Gateway was assessed here. Based on information from the Thames Gateway Development Plan, the jobs were apportioned to the three main water resource zones in the Thames Gateway area: London, Essex and Kent Medway. The largest number of jobs fall within the London WRZ (about 116,000), with approximately 40,000 in the Kent Medway zone and the remainder (24,000) in the Essex WRZ.

For the purposes of this study, it was assumed that the additional jobs would be in the service sector. This was supported by the Development Plan data which showed that over a third of jobs for the Gateway are planned for the Canary Wharf and Isle of Dogs areas, which are largely associated with office-based employment. In the data available to this study, there was no temporal profiling of when the jobs would be created and a linear profile of job creation was therefore assumed.

In the analysis presented within this report, two BAU forecasts were produced for non-household demand. The Upper Savings Scenario uses an average water use value quoted in a CIRIA report of 16 litres/person/day (CIRIA, 2006). The Lower Savings

Scenario uses an assumed water consumption figure of 20 l/h/d per office worker provided by Defra (Defra, personal communication).

On the basis of these assessments, an increase of 0.2 Ml/d per year would occur, or a total of approximately 2.9 Ml/d and 3.6 Ml/d by 2016 in the Upper and Lower Savings Scenarios respectively. This is in addition to the Olympic demand assessed in Appendix 4. A breakdown of this additional demand by water resource zone is provided in Tables A5.1 and A5.2.

This assessment is intended to put non-household demand associated with the 180,000 jobs in the context of existing non-household demand. As such, it is a simplified assessment based solely on demand associated with these jobs and is intended to give an indication of demand that might be expected. The assessment has not directly sought to quantify demand from associated services such as schools, hospitals and GP surgeries. However, some of the demand from these services will be included through the jobs created in schools, hospitals and so on.

To put the assessment into context, non-household demand in the Thames Gateway is forecast to be 107 Ml/d by 2016. The Upper and Lower Savings Scenarios represent around three per cent of non-household demand or less than one per cent of demand in the Thames Gateway area. This is the equivalent of around 10 per cent of the demand from the ten largest non-household customers that Essex and Suffolk Water and Southern Water supply in the Thames Gateway. Significant changes to demand from these large users could offset the increase from the 180,000 jobs.

Table A5.1: Demand estimate for 180,000 office-based jobs, BAU Upper Savings Scenario. Figures are cumulative and in Ml/d

Water Resource Zone	2005-06	2006-7	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
London	0.0	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.5	1.7	1.9
Essex	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4
Kent Medway	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6
Thames Gateway Total	**0.0**	**0.3**	**0.6**	**0.9**	**1.2**	**1.4**	**1.7**	**2.0**	**2.3**	**2.6**	**2.9**

Table A5.2: Demand estimate for 180,000 office-based jobs, BAU Lower Savings Scenario. Figures are cumulative and in Ml/d

Water Resource Zone	2005-06	2006-7	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
London	0.0	0.2	0.5	0.7	0.9	1.2	1.4	1.6	1.9	2.1	2.3
Essex	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
Kent Medway	0.0	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.6	0.7	0.8
Thames Gateway Total	**0.0**	**0.4**	**0.7**	**1.1**	**1.4**	**1.8**	**2.2**	**2.5**	**2.9**	**3.2**	**3.6**

Appendix 6: Average per capita consumption

The average pcc for the Thames Gateway used in this study is approximately 169 litres/head/day (l/h/d). This was calculated by taking the total household consumption in the Thames Gateway area (measured and unmeasured) and dividing by the total household population (see Table A6.1). Total demand is 257.9 Ml/d and total population is 1,523,379, giving an average pcc of 169.3 l/h/d.

This is greater than the widely quoted average pcc, usually in the range of 150-160 litres/head/day. The primary reason for this is that the assessment presented in this report is based on dry year annual average data. It is based on the values used for planning purposes which include an allowance for customers using more water in dry conditions. If the same assessment is undertaken based on the average reported measured and unmeasured per capita consumption figures for the period 2001-02 to 2005-06 (Table A6.2), the result is a lower average per capita consumption for the Thames Gateway, of approximately 163 l/h/d.

Table A6.1: Calculation of household demand using 2005/06 dry year pcc data

Water resource zone	Measured households	Measured household occupancy (persons per household)	Measured household population (persons)	Measured household pcc (l/h/d)	Measured household demand (Ml/d)
Burham	239	2.03	484	154.34	0.1
North Downs	1,234	2.81	3,469	153.39	0.5
Kent Medway	39,705	1.84	73,152	170.77	12.5
London	38,028	2.13	81,148	164.09	13.3
Essex	72,822	1.95	141,740	151.78	21.5
Thames Gateway	**152,028**		**299,992**		**47.9**

Water resource zone	Unmeasured households	Unmeasured household occupancy (persons per household)	Unmeasured household population (persons)	Unmeasured household pcc (l/h/d)	Unmeasured household demand (Ml/d)
Burham	512	2.44	1,249	173.71	0.2
North Downs	2,080	3.00	6,233	174.59	1.1
Kent Medway	140,246	2.66	373,520	173.74	64.9
London	182,356	2.52	459,685	169.60	78.0
Essex	136,176	2.81	382,699	172.13	65.9
Thames Gateway	**461,370**		**1,223,387**		**210.0**

Table A6.2: Calculation of household demand using average reported 2001-02 to 2005-06 water resource zone pcc data

Water resource zone	Measured households	Measured household occupancy (persons per household)	Measured household population (persons)	Measured household pcc (l/h/d)	Measured household demand (Ml/d)
Burham	239	2	484	142.40	0.1
North Downs	1,234	3	3,469	137.34	0.5
Kent Medway	39,705	2	73,152	164.26	12.0
London	38,028	2	81,148	157.15	12.8
Essex	72,822	2	141,740	149.30	21.2
Thames Gateway	**152,028**		**299,992**		**46.5**

Water resource zone	Unmeasured households	Unmeasured household occupancy (persons per household)	Unmeasured household population (persons)	Unmeasured household pcc (l/h/d)	Unmeasured household demand (Ml/d)
Burham	512	2	1,249	169.83	0.2
North Downs	2,080	3	6,233	169.17	1.1
Kent Medway	140,246	3	373,520	165.57	61.8
London	182,356	3	459,685	162.63	74.8
Essex	136,176	3	382,699	165.92	63.5
Thames Gateway	**461,370**		**1,223,387**		**201.4**

The second reason that pcc figures are higher than the widely quoted average of 150-160 l/h/d is the geographical location of the Thames Gateway in the South East of England. It has been noted previously that water companies in the South and East of England tend to have higher pcc figures than the national average. This is supported by the data presented in Table A6.3 which shows that the average per capita consumption for all four water companies that supply the Thames Gateway is higher than the water industry average in 2005/06.

Table A6.3: Average per capita consumption 2005-06

Water company	Average pcc (l/h/d)
Mid Kent Water	165
Northumbrian – Essex and Suffolk	160
Thames Water	164
Southern Water	153
Industry average	**151**

Taken from *Security of supply, leakage and efficient use of water 2005-06*, Table 16

Appendix 7: Treatment of leakage in the assessment

Shortfall against leakage targets

The Ofwat report, *Security of supply, leakage and efficient use of water,* for 2005-06 shows that two water companies that supply the Thames Gateway area had a shortfall against leakage targets in the 2005/06 report year. Southern Water missed its leakage target by 1 Ml/d, although it is not stated where in Southern Water's supply area this shortfall occurred. On the basis that Southern Water has made commitments to Ofwat to recover the shortfall by the 2006/07 report year and because the shortfall is small, it was not included in the assessment.

Thames Water missed its leakage target in 2005/06 by 32 Ml/d. Using figures from the Ofwat report for 2005-06, Thames Water reported company-level leakage at 862 Ml/d compared to a target of 830 Ml/d. Thames Water confirmed that it was likely that the shortfall occurred in the London WRZ (and not in the Thames Valley WRZs).

For the purposes of this study, an assumption was made regarding the proportion of shortfall that occurred in the Thames Gateway area. Thames Water previously confirmed that trends in planned leakage reductions at the water resource zone level could be applied to the Thames Gateway area. On this basis, the shortfall against leakage targets was proportioned to the Thames Gateway area as follows. Base year leakage for the Thames Gateway area was assessed as 67 Ml/d, approximately nine per cent of leakage in the London WRZ for 2005/06 (755 Ml/d). Assuming that the shortfall against the target could be proportioned to the Gateway area in the same way, the shortfall in the Gateway was approximately 3 Ml/d (nine per cent of 32 Ml/d).

It is acknowledged that this approach overlooks local factors such as network condition. Network condition (and hence leakage) can vary geographically within a water resource zone. Advice from Thames Water concerning the business-as-usual forecasts was that the network in the Gateway area was sufficiently representative of the network across the London WRZ that the planned WRZ leakage reduction trends could be applied to the Thames Gateway area.

Thames Water's failure to achieve leakage targets in 2005/06 led Ofwat to initiate action against the company to ensure that leakage and security of supply performance could be recovered by 2009/10. Thames Water submitted an undertaking to Ofwat under Section 19 of the Water Industry Act 1991 agreeing to:

- complete an additional 368 km of mains renewal in London at the company's expense (the expenditure will never enter price limits);
- complete the 2005-10 Victorian mains renewal programme 12 months early;
- re-profile leakage targets reducing leakage by an extra 5 Ml/d by 2009-10;
- re-profile the security of supply index target securing the 2004 price review output of 100 per cent by 2009-10;
- submit a fully updated water resource plan by 1 December 2006.

The updated WRP is based on the 2005/06 report year and contains the leakage reduction profiles used in the BAU forecasts in this study. The shortfall against target for 2005/06 and re-profiled leakage targets are therefore included in this assessment.

This study aims to assess the potential for achieving water neutrality in the Thames Gateway. All water companies currently work towards achieving a least-cost balance between supply and demand for water, central to which is the concept of economic level of leakage (ELL). The ELL is the level of leakage at which it costs more to make further reductions in leakage than it costs to source the water elsewhere. One of the water companies in the Thames Gateway is operating significantly above its ELL (where leakage is higher than it should be). Ofwat sets leakage targets so that water companies meet their ELL. To offset the demand generated by new development within the Thames Gateway, it is therefore necessary to remove the leakage reductions planned by water companies to achieve their ELL, as this is the leakage level at which the water companies should already be operating at.

The concept is illustrated in Figure A7.1 below. The gap between the ELL and the leakage targets (labelled B in the diagram) is the element of demand that needs to be removed to assess the demand requirements from the Thames Gateway. If there was a shortfall against leakage targets (shown by "A" in the diagram), this would be an additional element of demand that would have to be removed from the assessment although, as acknowledged above, this was taken into account by using Thames Water's water resource plan for 2006.

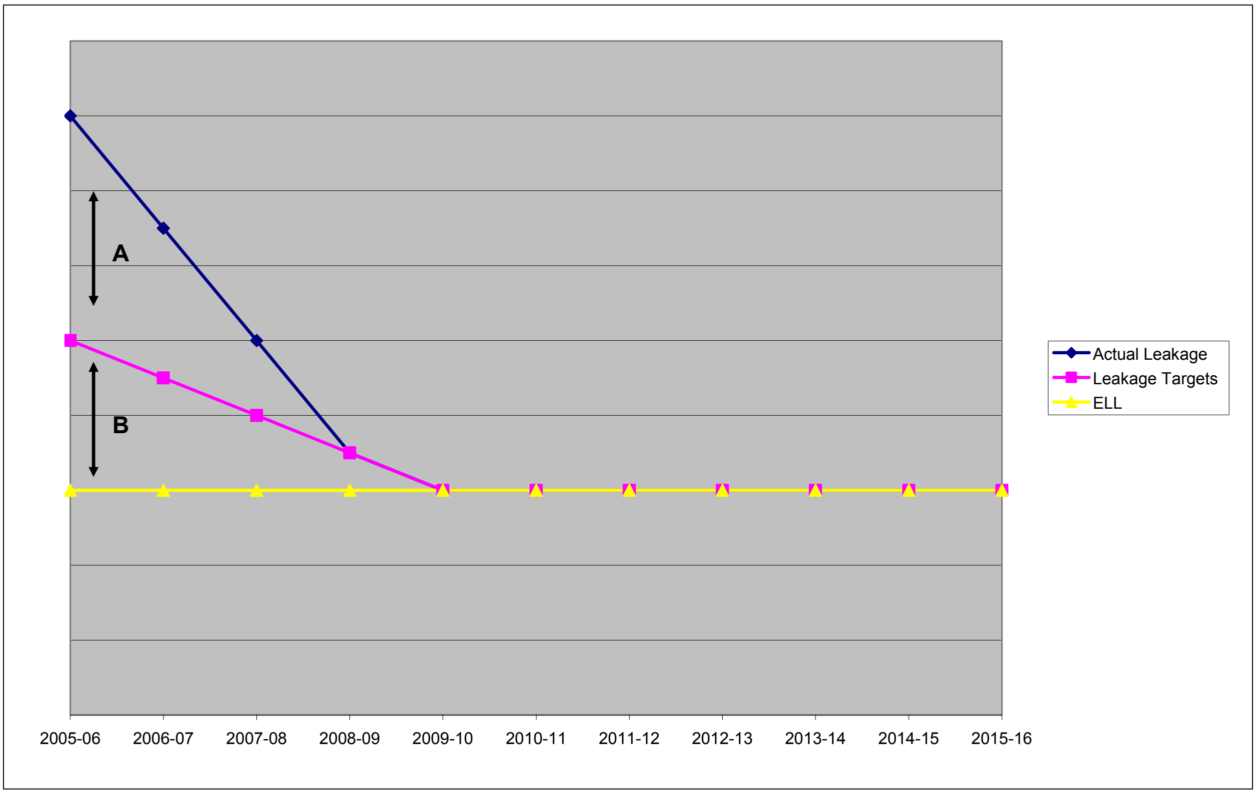

Figure A7.1: Relationship between actual leakage, leakage targets and ELL

In the Thames Gateway, it is only Thames Water that is currently operating above its ELL. The company has agreed targets with Ofwat to attain the ELL by 2009/10. The planned reductions over this period (about 162 Ml/d at the WRZ level) should not be counted towards the offsetting of demand in the Thames Gateway.

Appendix 8: CSH micro-components of demand derivation

The micro-components of pcc were derived using the frequency of use information presented in the Code for Sustainable Homes Technical Guidance (Communities and Local Government, 2007a). An example breakdown for micro-components of use is presented in Table A8.1 and is the equivalent of CSH Level 5/6 pcc. For the micro-components of demand where volume per use depends on duration of an activity (rather than a fixed volume per use), a use factor taken from the guidance was applied. An example of this is the use of a washbasin. The flow rate of taps in this study is assumed to be three litres per minute, with a frequency of 7.9 uses per day. However, the taps would not necessarily be used for one minute duration and this is taken into account within the pcc micro-components. For kitchen and basin taps, a factor of 0.67 is applied to account for the taps being on for an average of 41 seconds. The volume per use for kitchen and basin taps is therefore assumed to be:

0.67 x 3 = 2.01 litres per use

With an assumed frequency of 7.9 uses per day, the contribution of this micro-component to pcc is:

2.01 x 7.9 = 15.9 litres/head/day

Details on the derivation of use factors is presented in the Communities and Local Government report (2007a). In the case of micro-components that have an assumed fixed volume per use (WC, bath, washing machine, dishwasher), a use factor of one is applied. Note that in the table below, 50 per cent of water used for toilet flushing and washing machine use is assumed to be replaced by recycled/harvested water and not mains water.

Table A8.1: Micro-components of demand, equivalent to CSH Level 5/6 (80 l/h/d)

Micro-component	Frequency of use (use/day)	Flow rate (l/min)	Use factor	Volume per use (litres)	Total (litres/head/ day)
Dual-flush WC (full flush) *	4.8	N/a	0.33	2.25^	3.56
Dual-flush WC (part flush) *	4.8	N/a	0.67	1.5^	4.82
Basin	7.9	1.7	0.67	1.14	9.00
Shower	0.6	6.00	5.00	30.0	18.0
Bath	0.4	N/a	0.4	56.0**	22.4
Kitchen sink	7.9	1.7	0.67	1.14	9.00
Washing machine	0.34	N/a	1.00	45.0	7.65
Dishwasher	0.3	N/a	1.00	22.5	3.6
Total (indoor)					**78.0**
Outdoor use					11.5
Total					**89.5**

*Based on a 4.5/3-litre dual-flush toilet.
**Assumes a 140-litre bath with a typical filling to 40 per cent of its capacity.
^ Fifty per cent of water replaced by recycled water.

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List of abbreviations

AIC	Average incremental cost
BAU	Business-as-usual
CIRIA	Construction Industry Research and Information Association
CLG	Department of Communities and Local Government
CSH	Code for sustainable homes
Defra	Department for the Environment, Food and Rural Affairs
DSOU	Distribution system operational use
ELL	Economic level of leakage
Ofwat	Water Services Regulation Authority
PCC	Per capita consumption
PV	Present Value
PVC	Present Value Cost
PWS	Public Water Supply
SUDS	Sustainable drainage systems
WRAS	Water Regulation Advisory Service
WRP	Water resources plan
WRZ	Water resource zone

Glossary

Abstraction
The removal of water from any source, either permanently or temporarily.

Abstraction licence
The authorisation granted by the Environment Agency to allow the removal of water from a source.

Annual average
The total demand in a year, divided by the number of days in the year.

Average day demand in peak week
One seventh of total demand in the peak week in any 12 month accounting period (ADPW).

Average incremental social costs
The ratio of present social costs over present net value of additional water delivered or reduced demand.

Black water
Raw sewage.

Cistern
A fixed container for holding water to be used as toilet flush water.

Code for Sustainable Homes
A single national standard to be used in the design and construction of new homes in England, based on the BRE's EcoHomes© scheme. A set of sustainable design principles covering performance in nine key areas: energy and CO_2; water; materials; surface water run-off; waste; pollution; heath and wellbeing; management; ecology.

Demand management
The implementation of policies or measures which serve to control or influence the consumption or waste of water (this definition can be applied at any point along the chain of supply).

Distribution system operation use (DSOU)
Water used by a company to meet its statutory obligations particularly those relating to water quality. Examples include mains flushing and air scouring.

Economic level of leakage (ELL)
Level of leakage at which it would cost more to make further reductions than to produce the water from another source. Operating at ELL means that the total cost of supplying water is minimised and companies are operating efficiently.

Grey water
Wastewater from baths, showers and washbasins. This water can be collected in a household reuse system and treated to a standard suitable for WC flushing.

Meter optants
Properties in which a meter is voluntarily installed at the request of its occupants.

Meter programme
Properties which are to be metered according to company metering policy.

Micro-component analysis
The process of deriving estimates of future consumption based on expected changes in the individual components of customer use.

Net present value
The difference between the discounted sum of all of the benefits arising from a project and the discounted sum of all the costs arising from the project.

Non-households
Properties receiving potable supplies that are not occupied as domestic premises, for example, factories, offices and commercial premises.

Potable/mains water
Water company/utility/authority drinking water supply

Present value
The value of a future cost or benefit after adjusting for time preferences by discounting.

Water resource zone
The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall.

Thames Gateway
Area comprising 10,000 hectares of land along the riverside of eight London Boroughs: Barking and Dagenham, Bexley, Greenwich, Hackney, Havering, Lewisham, Newham and Tower Hamlets.

Total leakage
The sum of distribution losses and underground supply pipe losses.

Water Regulations Advisory Service
An advisory service for and on behalf of water suppliers and for any other person or body seeking guidance on the principles of water regulations.

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