Bristol Water Plc
Draft Water Resource Plan

DRAFT CONSULTATION DOCUMENT V1.1 **APRIL 2008**

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APPENDICES

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Section 1. Executive Summary

We have more than met customer expectations for all of the 160-plus years we have existed. This is our vision of how we will continue to provide a water supply of the same reliability, quality and value for money that our customers need and expect over the next 30 years.

During the next 30 years, though, the region and the company face challenges and pressures across a broad front of social and economic issues. These changes will reduce the amount of water available while at the same time, we predict there will be a rise in demand for water.

This document sets out what effects we believe the changes will have – and how we intend to cope with them on our customers' behalf.

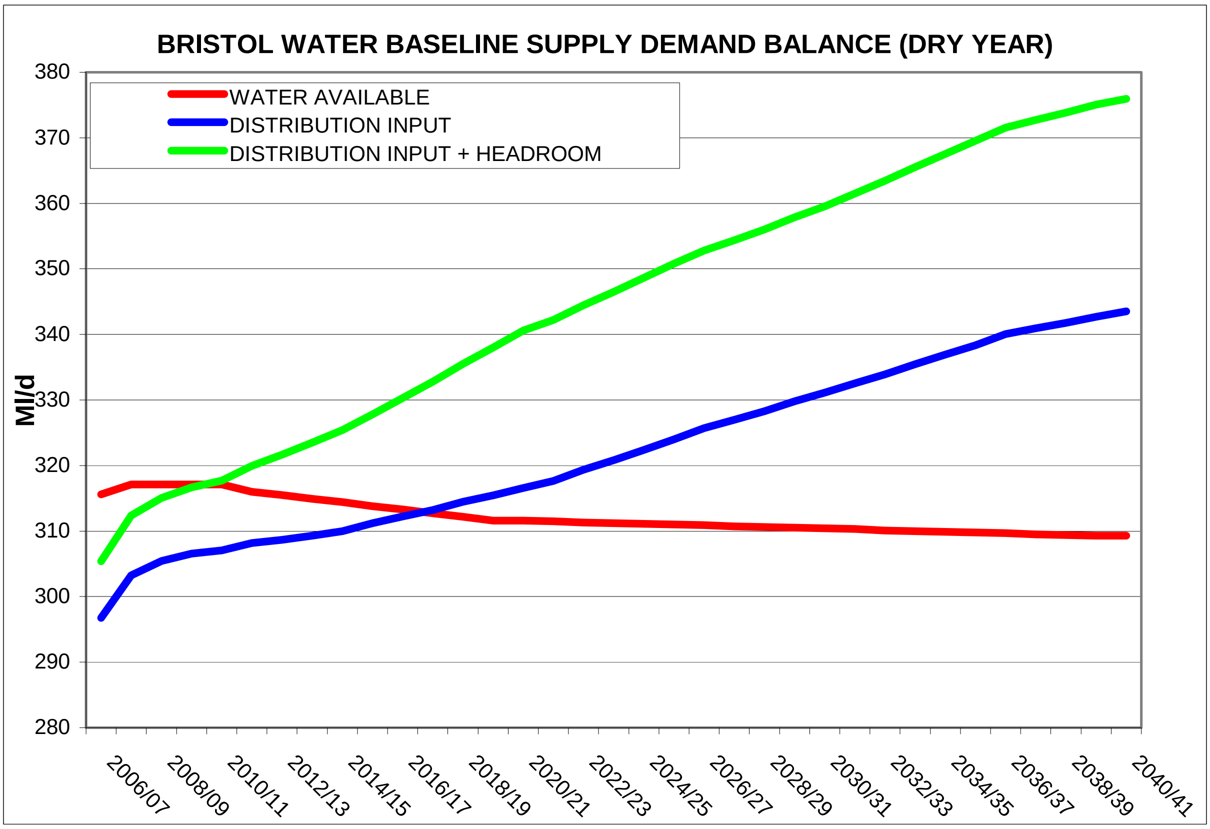
Today, we supply 1.1 million customers in the City of Bristol and surrounding areas. The water comes from a mixture of sources, half from the River Severn, a third from reservoirs in the Mendips and the remainder from small wells and springs.

At present, this is enough to supply an average daily demand for water of about 300 million litres. We have a small 'buffer' of water available to meet higher demands during dry weather and other eventualities.

This allows customers to benefit from a secure water supply without frequent hosepipe bans or other more damaging restrictions to water use. We want to maintain this level of service to customers in future. We will do this by ensuring that our future water resources and supply system is sufficiently robust to not require hosepipe bans more frequently than once in 15 years, on average.

Looking further ahead, though, future growth projections for population and housing will result in the demand for water rising by more than 10% by 2035 to over 330 million litres a day (Ml/d). This is significantly more than the currently available water resources can support.

The graph below illustrates the developing situation with respect to the demand for water and the declining availability of water.



This balance between supply and demand is presently 'favourable' and ensures our level of service can be maintained over the next few years. This means that we are able to meet our commitment of ensuring no restriction of water use more than once in 15 years on average, in the next few years. However, if we take no action, by 2013 there will probably be a net deficit of water available for public supply -- and if we do not restore the supply demand balance, we could not achieve the present level of service beyond 2015.

The causes of this unsustainable situation over the next 30 years are:

- Projected sustained growth in population of 15%.
- Forecast 25% growth in housing development.
- Falling household occupancy as a result of demographic changes.
- Continued rise in unmetered household consumption per capita.
- Problems associated with ageing mains infrastructure.
- Climate change reducing the water reliably available from sources by up to 10%.
- Higher probability of severe droughts, as shown by past climate records and future projections.
- Future water abstraction could be cut by environmental regulations to conserve habitats.
- New targets to reduce emissions of greenhouse gases.

A deteriorating level of service would eventually lead to an increased frequency of hosepipe bans and other more severe restrictions. Our draft plan contains a completely revised strategic approach to prevent this from happening.

Our past policies -- holding leakage at or below the economic level, providing free meter installations and pursuing a range of customer water efficiency activities -- have helped to mitigate demand for water over the past 10 years.

We support all Government-sponsored initiatives to improve building and fittings regulations so that demand for water is cut as more houses are built. However, we are concerned that change may not be happening fast enough.

As growth continues, the past level of activity by companies and Government may no longer be adequate to control demand. We have based our planning on the assumption that all new metered homes will have a minimum standard of efficiency better than 125 litres per capita per day and a significant proportion will have a standard of efficiency better than 105 litres per capita per day. Despite these assumptions, overall demand for water is still forecast to increase over the next 30 years.

We have analysed over 50 options designed to reduce demand for water, cut the losses of water from the distribution system and provide new sources of water. We plan significant increases of activity in the areas of both demand management and the enhancement or development of other water resources.

We have set out below the actions that we need to implement over the next 30 years. We believe that these are the options that have the best combination of social, environmental and cost benefits for the majority of our stakeholders. However, all of the options are still subject to further consultation and discussion with the public, non-governmental organisations and regulatory bodies.

These are our plans for ensuring a proper balance between supply and demand is maintained over the next 25 years:

- Carrying out extra free repairs to customers’ leaking supply pipes from 2010 -- saving water by cutting the length of time taken to stop leaks

- Establishing up to 60 new pressure reduction zones by 2015 -- cutting water losses from small leaks and bursts.

- Using new leakage metering technology from 2010 in a rolling programme to monitor poorly performing zones, together with additional deployment of leak noise detection equipment.

- Redeveloping seven smaller water sources in the Mendips in 2017 -- using new and efficient water treatment plant to ensure reliability, water quality and yield can be maintained at all times of year.

- Auditing of larger non-household customers to encourage demand reduction by efficient water use.

- Completing the metering of all non-measured non-household customers by 2020.

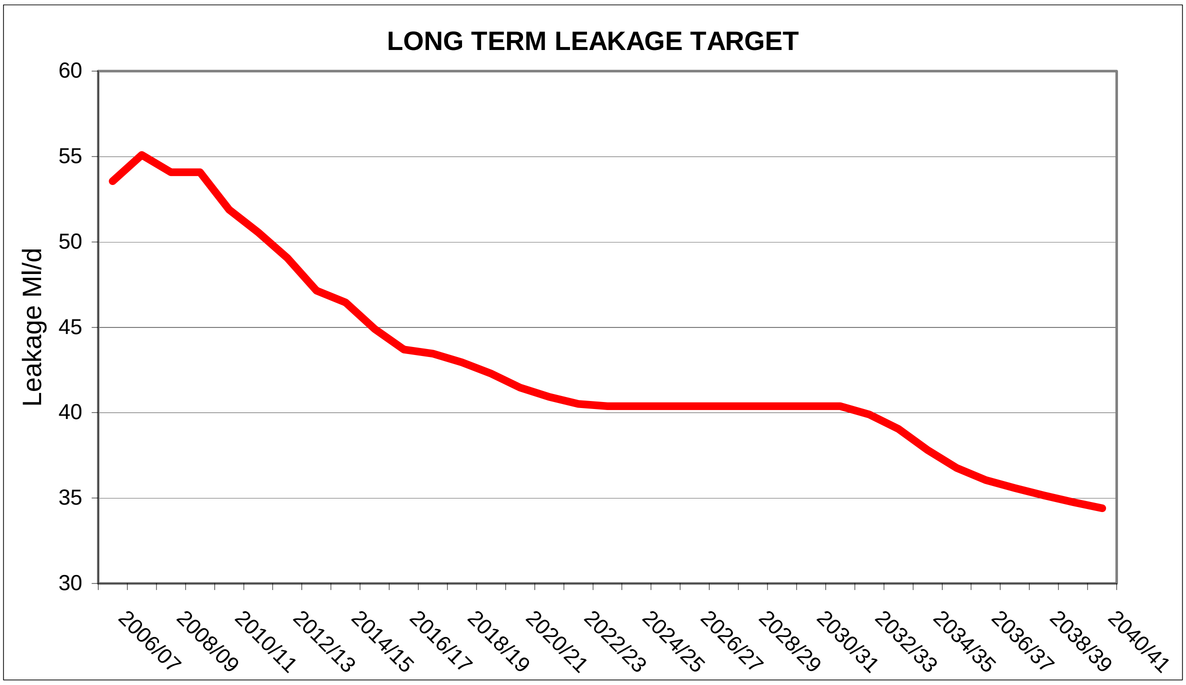
- Offering subsidised customer supply pipe replacements coupled with replacement of the company’s communication pipe after 2010 to reduce overall leakage.
- Metering household customers with large gardens on change of occupier up to 2020.

- Undertaking a step change in leakage management, investment and activity to bring leakage significantly below the present social and economic level to 40 Ml/d by 2020.

- Planning for an additional major water resource to be constructed by 2025, most probably as the second phase of the existing Cheddar Reservoir.

- Compulsory metering of all household customers from 2020 onwards, to achieve full metering penetration by 2035.

- Trialling different tariff types, including rising block tariffs.



Our forecasts for growth, driven by government policy, contain very optimistic assumptions of little or no further increases in per capita consumption. These are not reflected by past evidence or experience. The increase in demand for water together with the reduction in water availability means there is very little time to address the emerging deficit in water supply through accelerating metering schemes or other demand management measures.

After leakage control, metering and water efficiency schemes have yielded their maximum benefits, a major resources development scheme seems inevitable. Due to the substantial cost, we would delay implementation for as long as possible. However. Because of the time needed to realise large resource developments planning preparations will need to begin shortly.

A new reservoir would provide the most sustainable and resilient means of mitigating volatility of water supply and demand predicted as a result of climate change. In addition to water supply security, there are other benefits associated with extending Cheddar reservoir, including:

- Water stored close to demand centre reducing pumping and carbon footprint
- Improved opportunities for conservation
- Increased local biodiversity potential
- Locally available materials minimising disturbance during construction
- Social and recreational potential

We believe that our strategy should meet the expectations of as wide a range of stakeholders as possible. We have consulted extensively with our customers in order to understand their priorities and willingness to pay for the types of activity outlined above.

When published in April 2008, this document will be made available to a wide group of stakeholders and the general public as part of the statutory consultation process. Representations received from this part of the consultation will be taken into account in the final version of the plan.

Our work with customer focus groups to date shows:

- Customers do not wish to see the current level of service reduced and would be willing to support work that improves the security of supply.

- Customers accept that a totally secure and unrestricted water supply cannot be realised without unacceptable rises in water bills (or potential damage to the environment).
- Customers accept that the metering of supplies is the fairest way to pay for water.

- Customers consider that leakage is wasteful of both water and power and would be willing to support cuts in leakage below the current economic level.

- Customers understand that the rate of replacement of underground pipes and mains is not keeping up with the rate these assets are deteriorating.

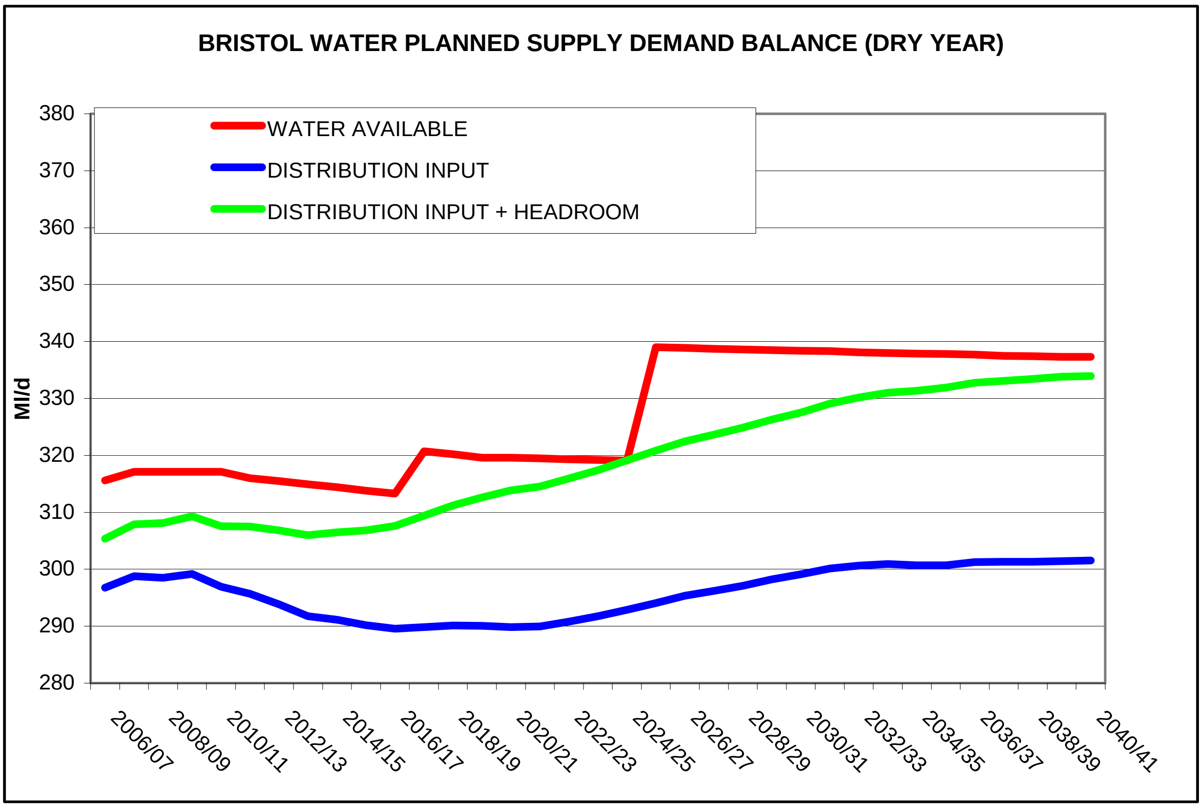
In considering all of the possible options in our draft Water Resources Plan, we have taken full account of the social and environmental impacts of the schemes over the long term. The extra issues captured as part of the assessment of options include the following:

- The financial costs of carbon emissions resulting from scheme construction.
- The social costs of benefits and disbenefits that arise from each scheme.
- The environmental costs of options including those impacting upon designated areas.
- The cost or savings of carbon emissions resulting from scheme operation.
- Customers willingness to pay to support issues such as leakage reduction.

The financial impacts of these social and environmental effects have been incorporated as monetary costs, together with the annualised capital and operating costs when analysing the financial impact of various options.

This creates a ‘level playing field’ on which to compare the most favourable options that also recognises the true value of landscape and the social environment as well as simple capital expenditure. Our approach ensures that a final planning solution is selected that best meets the expectations of the widest range of customers and stakeholders as well as delivering the best value final planning solution at lowest overall cost

The forecast effect on the supply demand balance of the activity we propose in our draft Water Resources Plan is clearly shown in the graph below.



Our preferred strategy is based upon the latest planning, information and assumptions that are currently available. However, the future is always uncertain. If actual events vary significantly from forecasts, we would have to modify our plan accordingly. Critical issues include:

- There is a probability that government will require a much higher regional growth strategy than the one we have used.
- There is a possibility that climate change impacts on water availability during dry conditions may already have occurred, or turn out to be much greater than forecast.
- There is a considerable risk that customer's use of water may vary significantly from the assumptions made.

In the main body of our plan, we consider how these risks would affect our preferred strategy, together with the challenges and extra costs that may result.

Section 2. Introduction

This document sets out how Bristol Water will manage water resources and the demand for water in its area of supply over the next 25 years while continuing to maintain or improve existing supply security. Our draft Water Resources Management Plan covers the period 2010 to 2035 and sets out in detail the issues impacting the availability of water and the demand for water in that period, together with actions to mitigate adverse impacts. The Company has regularly produced such plans, however, this will be the first time that our planning process is open to formal public consultation. The revised draft version of our plan now takes into account the new legislation and regulatory guidance as detailed below.

The Water Act 2003 has resulted in a number of significant changes to existing legislation and new statutory requirements on water companies to produce a Water Resources Management Plan for widespread public consultation. All companies must also explain how they have taken into account consultation representations made regarding their Water Resources Plans in the final version of their plan.

The legal requirements are defined in the Water Resource Management Plan Regulations 2007 (SI 2007/727), providing further detail on the process set out in Section 37 of the Water Industry Act 1991.These regulations define the statutory process for consultation, as set our below:

- To consult as widely as possible with the bodies suggested prior to developing the draft plan, particularly with the main statutory consultees.
- To produce a draft Water Resource Management Plan for submission to the Secretary of State, in accordance with the Water Resource Management Plan Directions.
- To consider all formal representations forwarded to us, or the Environment Agency from the Secretary of State after the consultation period.
- To demonstrate how representations have been considered, or taken into account within their plans.
- To comply with any direction from the Secretary of State to hold an enquiry and or requirement regarding the final plan.

The minimum content of the plan is set out in the Water Resources Management Plan Direction DEFRA 2007, together with the timetable for consultation. A company's Water Resource Plan must cover a 25 year planning period and provide detail regarding:

- Frequency of prohibitions or restrictions on its customers in relation to the use of water (these include hosepipe bans and other restrictions to the non-essential use of water etc. by the use of drought orders).
- The methods to be used to manage water resources to achieve compliance with obligations set out in section 37 of the Water Industry Act 1991.
- The emission of greenhouse gasses associated with any plans or schemes.

- How the impact of climate change on forecast of supply and demand has been taken into account.

- What assumptions have been made regarding future population, household numbers and the impact on the demand for water over the planning period.

- How the numbers of metered of household customers and metering is expected to increase over the planning period.

When developing our plan we have followed the guidance provided by the Environment Agency document, Water Resources Planning Guideline (April 2007). This document makes reference to other research papers and technical guidance that we have also used extensively. Such detailed technical guidance is referred to where appropriate in the text.

The plan is available for consultation in an electronic or paper form. A full set of appendices has been provided in the electronic version of the plan provided on CD. Only the most relevant material to the plan has been made available in the paper copy. This is due to the size of some of the supporting reports covering issues such as the Strategic Environmental Assessment and Social and Economic costs. These can be made available as a paper version upon request.

No material has been excluded form our plan on grounds of national security on the advice of the Secretary of State. We have included additional information regarding the impact of our plan on emissions of carbon dioxide, at the request of the Secretary of State.

Any person or organisation is entitled to make a formal representation in writing to the Secretary of State regarding the content of our draft Water Resources Management Plan. Those wishing to do so may send their representations by email or post to:

Water.resources@defra.gsi.gov.uk

Representations by post should be sent to:

Dawn Instone
Water Supply and Regulation Division
Department for Food and Rural Affairs
Area 2C Ergon House
Horseferry Road
London
SW1P 2AL

The consultation period for our draft Water Resources Management plan begins on the **28th of April 2008** and continues for 13 weeks until the week ending **25th July 2008**. During this period, the Secretary of State will review all representations and forward these to us regularly. We will publish our formal response to any representations we receive within 26 weeks of the start of the consultation period.

Section 3. Water Resources Plan

3.1 Overview and Methodology

The Company Water Resources Plan is based upon the operation of the Company area as a single resource zone. This means that all water resources within the company area are capable of being shared throughout the zone, with no part of the zone being solely dependent upon the yield of a single water source. This has been the approach adopted in the past and agreed as appropriate for the current draft plan with the Environment Agency.

The system is well integrated, with an inherent robustness that mitigates the effects of large peaks in demand and periods of dry weather. In addition, the system is also able to cope with operational problems such as temporary failure of sources or other components of the network. Since the 2004 Water Resources Plan, we have further developed our system, adding extra transfer capacity to cope with larger operational emergencies. Although these schemes have not provided any extra water resources, they have provided considerable extra flexibility in deployment of the water that is available.

Even though our supply system is robust at present, increasing economic prosperity drives rising stakeholder expectations. These expectations of an improving environment, secure water supply and improved levels of service have to be delivered in a future where there are significantly more uncertainties and challenges to address them in previous decades. These include:

- Forecast of large increases in population
- Forecasts of unprecedented housing development
- Affordability of water
- Targets for carbon emissions
- Increasing economic growth
- Impact of climate change
- Increased protection and remediation of environments

The drivers above all impact our system and will have the effect of simultaneously increasing the demand for water while reducing the water available for use in future.

Our Company Water Resources plan takes account of the impact of all of the issues over the period of the next 25 years (2010 to 2035). We have set out in our plan a clear analysis and description of how we will maintain the balance between the water available for social and economic use and the likely demand for that water. This has been done within the framework known as the ‘twin track’ approach. This means we have planned options to reduce customers’ demand for water and increase the overall efficiency of water use as well as considering the development of new sources of water.

Within the objective of balancing supply and demand, there may be many individual solutions or combinations of solutions available. In assessing the optimum approach to take over the next 25 years we have taken full account of the following sustainability objectives:

- Minimising the cost of the preferred solution (e.g. impact on water price)
- Improved social and environmental impacts (e.g. changes in abstraction, transport)
- Reduction of carbon emissions (e.g. reduced pumping, construction materials)
- Maximising the efficient use of water (e.g. leakage reduction, metering)
- Impact on level of service (e.g. hose pipe bans, drought orders)

By embedding these objectives in the planning process, we have produced a long-term and environmentally sustainable plan at an optimum cost, which will ensure an adequate level of supply security for future growth without environmental harm.

3.1.1 Company Area and Resource Zone

Bristol Water's area of supply covers 1000 sq miles and includes a current population of 1.09 million people. The area includes Bristol and many satellite towns and villages within a 20-mile radius of Bristol. The Company has existing water resources of three different types:

- A major abstraction from the Gloucester and Sharpness Canal supplied by the River Severn and other local rivers, the Cam and the Frome.

- A number of small groundwater sources such as springs, wells and boreholes.

- Surface water impounding reservoirs collecting water from the Mendip Hills catchment.

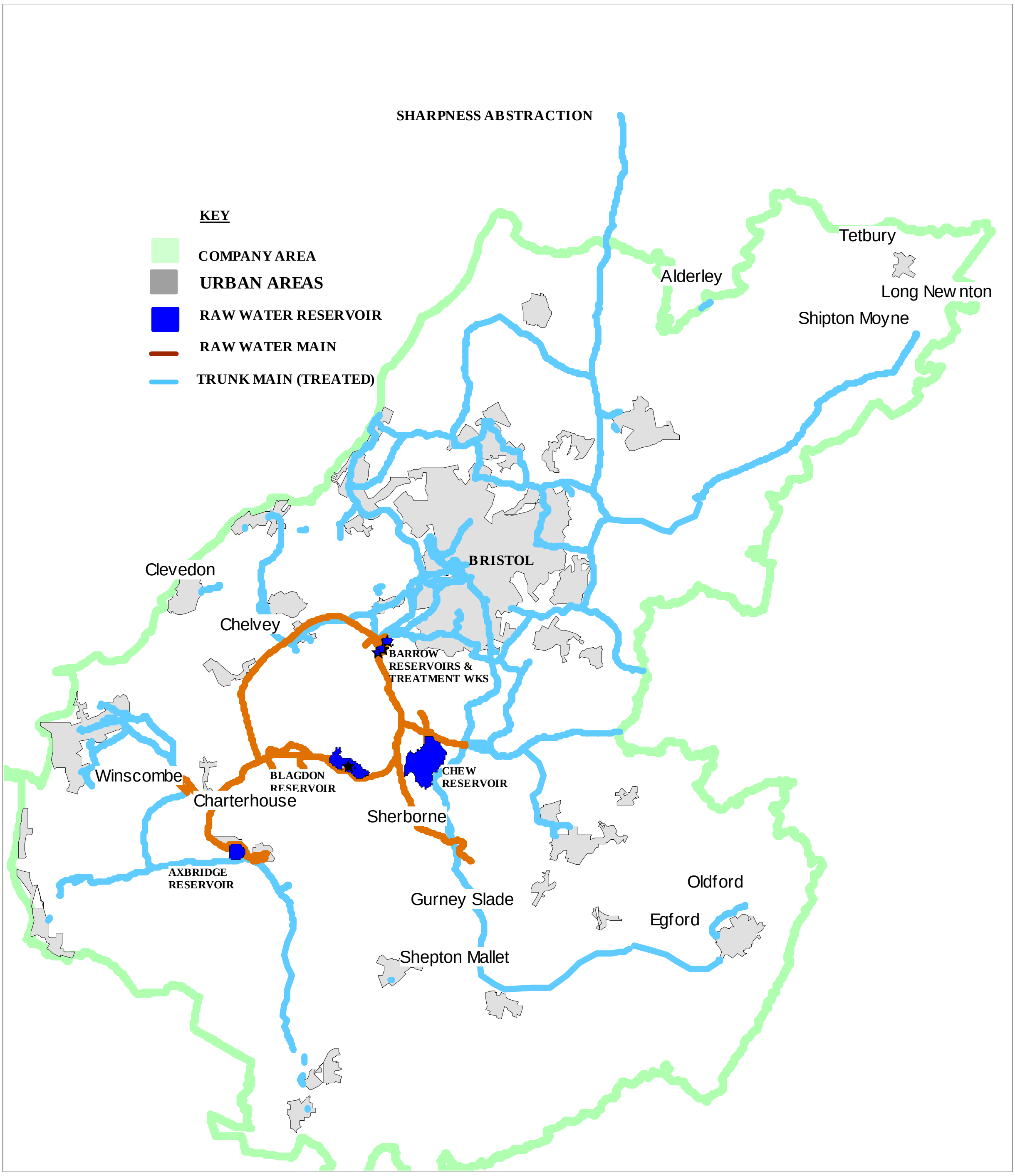
River water
Abstraction made from the River Severn is conveyed via the Gloucester and Sharpness canal to supply the largest northern treatment works and provides 50% of the water available. In dry periods, use of this particular source is increased to conserve water stored in reservoirs.

Groundwater
The groundwater source yields have been assessed using the UKWIR methodology as stand-alone sources. However, because the groundwater sources are used conjunctively, they have also been assessed in terms of their combined yield over the year. Groundwater sources account for only 15% of the water available and are operated at optimum output to meet the base load demand for water.

Surface water
The surface water reservoirs provide the flexibility to meet the peaks in demand that exceed the combined output of groundwater and river water sources. The yield from these reservoirs has been re-assessed using a hydrological rainfall run-off model for the Mendip catchments based on a long series climatic record from 1829 to present. This significantly extends the previous model and covers periods during which there were some severe and prolonged droughts in the late 1890s. The longer period of record has improved our understanding of issues such as the frequency of droughts that could trigger a hosepipe ban and the amount of water available from our reservoirs during dry periods.

The Bristol Water supply area is operated as a single resource zone, and all the Company's sources are operated conjunctively. This means that all water resources are shared and utilisation can be maximised when the water is most abundant at a particular source. This is the most efficient method of operating and maximises the total yield of the system. The transmission system is designed to facilitate conjunctive use by allowing water transfers between various sources and demand centres. In addition, there is substantial connectivity between the major surface water reservoirs, allowing further flexibility of operation.

A plan indicating the principal features of the Company area is provided below.




RAW WATER TRANSFER SYSTEM DETAIL
Map illustrates the primary impounding reservoirs and bulk transfer mains that permit transfers from the reservoirs to the treatment works
Transfers are expressed as typical maximum capacity and usual direction indicated by arrows
NAILSEA
LONG ASHTON
BRISTOL
BACKWELL
BARROW WTW
MAX TRANSFER 90 MLD
YATTON
MAX TRANSFER 45 Mld
CHEW MAGNA TRANSFER 0-30 Mld
CHEW MAGNA
BLAGDON TRANSFER 30 Mld VIA SAYS LANE
CHEW STOKE 70 Mld
STOWEY WTW
BLAGDON
CHEW
WINSCOMBE
LANGFORD
RICKFORD
BANWELL WTW
AXBRIDGE TRANSFER 45 Mld EX BANWELL
BLAGDON TRANSFER 30 Mlld VIA LoW
LINE OF WORKS TRANSFER 0-40 Mld
AXBRIDGE TRANSFER 10-60 MLD EX P.S.
AXBRIDGE
CHEDDAR
CHEDDAR SPRING SURFACE CATCHMENT
CHEDDAR WTW
COXES MILL CAVERN
CHEW HILL HEAD
CHEDDAR YEO
RIVER AXE SPRING SURFACE CATCHMENT
RIVER AXE
HENLEY GAUGE
WELLS

3.2 Company Policies

3.2.1 Relevant Policies

The company maintains regular contacts with both customers and regulators. These contacts over time have informed us regarding the general expectations of stakeholders. This in turn has resulted in general policies being established for activities that impact the area of water resources management. The key current baseline policies impacting water resources include the following:

Level of Service

This is the frequency customers can expect hosepipe bans or other water use restrictions, required as a consequence of unusually hot or dry periods. We have planned our strategy on the basis that hosepipe bans will not be required more than once in every fifteen years on average. We plan to remain at or close to our current stated level of service in future unless customers indicate otherwise.

Drought

The company has a set of procedures and policies in place detailed in the Drought Contingency Plan, to implement various levels of resource use and demand management if a dry period develops into a drought. The Drought Contingency Plan is a statutory document and publicly available.

Metering

There is evidence that metering helps to reduce the demand for water during climatically normal years, therefore the company considers metering to be a useful tool to reduce demand for water and would like to increase the number of household meters installed in future.

Leakage

The company has always managed its leakage at or below the current economic level and is committed to continue to do this over the long term.

Water efficiency

The company has a clearly stated water efficiency policy and seeks to maintain a high level of ongoing public awareness of water efficiency issues through a free leak repair service, regulation inspections, customer information and education programmes.

Environment

The company environment policy sets out our commitments to conserve and enhance the natural environment and a programme to minimise energy consumption, waste and other harmful emissions.

Competition

Our customers want a safe and reliable supply of water at an affordable price. Our customers may welcome any form of competition that can deliver these three objectives reliably and that we can support.

Value for Money

It is one of our goals to ensure that we find a level of operation where the majority of customers consider we are delivering the best balance between service and price.

Our commitment to these policies ensures that the ‘twin track’ approach of including both supply and demand reduction schemes is at the heart of the planning process. To build a wider context for the plan, all of these policies are taken into consideration when developing and selecting the preferred resources management strategy. However, the extent to which they drive finally selected options depends very much upon customers willingness to pay for improvements and the relative cost benefit of the competing options when implemented over the life of the plan.

This does not mean that the cheapest options in terms of prices are invariably selected. Where there are other social, environmental, or local policy agendas, these may significantly influence the selection of the final options. We expect that consultation with stakeholders will highlight areas of particular concern.

3.2.2 Level of Service (restrictions on customers’ use of water)

Bristol Water, as all other water companies, cannot guarantee to provide a secure and uninterrupted supply of water under all conceivable circumstances. To do so could cause some degree of environmental damage and may result in unacceptably high water bills for customers. To avoid this, we propose an implied contract to customers referred to as the ‘level of service’ that balances the availability of resources against the probability of supply restrictions.

The level of service defines the frequency at which demand restrictions are required, such as hosepipe bans. These restrictions would be used to conserve water during a drought and minimise the possibility of a supply failure that would lead to a grave emergency. The level of service target established in the 2004 Water Resources Plan implies demand restrictions are probable once in every 15 years. This target level of service quantifies the water available from our resources. It is also critical in establishing the timing of schemes to maintain the balance of supply and demand (to ensure the defined level of service can be maintained).

To give a fair indication to customers of the maximum degree of inconvenience they might expect, the company has simplified the level of service statement. We pledge to customers that hosepipe bans will not be required more frequently than once in fifteen years on average. Other types of planned restriction on water use during drought are as set out below.

Hosepipe ban and appeals for restraint	less than once in 15 years on average
Drought order to ban non-essential use	less than once in 33 years on average
Drought order to modify abstraction licences	less than once in 33 years on average
Partial supply or rota cuts	less than once in 100 years

Changes to level of service may be used as a tool for managing the balance of supply and demand, particularly where there may be benefits from short-term reductions or increases in the target level of service. Based upon the assumption that there is a finite volume of water available and demand for water increases, we could in future:

> Reduce the level of service thereby increasing the frequency of expected demand restrictions, but have very little security during dry conditions (i.e. the supply of water could fail more often if this approach was taken to its conclusion).

If additional resources are developed or demand could be reduced we would have the option to:

> Increase the level of service thereby reducing the likely frequency of demand restrictions and therefore have increased security during dry conditions (i.e. the supply of water could be maintained or extended for longer).

Unless the consultation process informs us otherwise, we would expect to maintain a target for the future level of service that is the same as currently provided.

3.3 Planning Scenarios considered

The ‘normal year’ is the baseline operating condition for the company that would be expected during years without unusual dry or hot periods. Predictions of the impact of dry conditions, climate change, future risks and uncertainty have been used to factor the various components in the baseline model to develop a forecast of demand for water, resources and leakage in a dry year. This dry year scenario forms the basis for the analysis of the future balance between supply and demand in the Water Resources Plan.

3.3.1 Normal year scenario

We have derived the normal planning scenario directly and without adjustment from the out-turn data recorded in the 2006/07 base year. We have made no adjustments to the 2006/07 audited submission to Ofwat relating to customer demand or water put into supply due to climatic reasons. A robust and audited MLE adjustment was carried out as part of the base year submission.

There was nothing climatically or operationally unusual about 2006/07 that indicated it was anything other than a ‘normal’ year. There were dry conditions in the south east of England but the Bristol Water area experienced no drought or other abnormal conditions.

The year was slightly warmer than usual on average, but the warm periods coincided with wet periods without abnormally increasing demand. There were no long periods of sustained high temperatures and no periods of extreme cold. There were no restrictions on customer demand in the company supply area during 2006/07. Customer information programmes relating to ‘using water wisely’ were maintained at the usual background level.

One small change was made regarding the estimation of supply pipe leakage following the Company Economic Level of Leakage submission. Industry research by consultants Tynemarch indicated that leakage from customers supply pipes was likely to be higher than we were reporting (as 8.9 Ml/d). Work is still continuing to verify this. We considered it appropriate to reflect these higher estimates in the longer-term forecasts. As a result we have increased the volume of water lost attributed to supply pipe leaks to 12.9 Ml/d in the baseline scenario. This has not changed the overall leakage figure. The other components of the water balance were adjusted slightly using the industry standard MLE approach.

3.3.2 Dry year scenario

During the last 15 years, the driest and warmest year experienced in the region was 1995/96. Although there have been hotter summers and drier years, none apart from 1995/96, has had the particular combination of sustained higher than average summer temperatures, with low rainfall over a long period.

We continue to use 1995/96 as the indicative dry year from which robust data was obtained to calculate the extra use of water that occurs due to a dry period. A baseline ‘normal’ year demand profile was constructed for previous years and the extra household demand recorded in 1995/96 over that baseline was attributed to climatic effects.

This data has been disaggregated to determine the impact of climate on metered and non-metered household demand, in terms of per-capita consumption (e.g. bathing) and per household consumption (e.g. garden watering). The approach followed is explained in more detail in Section 5.

This allows a component approach to estimate the likely increase in demand resulting from a dry period so that increasing populations and households drive the increase in discretionary use of water during dry periods.

3.3.3 Critical period scenario

If short-term high demand for water was close to, or exceeded the water available from our resources, we would need to consider how to address this particular issue. Because reservoirs are a significant component of our resource mix, we do not consider that such issues exist at present.

The analysis of climatic data from 1829 to 2002 indicates there were no drought or climatic events of such intensity that would have caused the resources system to fail within a single year. This leads us to conclude that our system is two-season critical at the current level of water demand and level of service. This is consistent with a system that has a significant component of resources stored in reservoirs

This means in practice that our resources system is vulnerable to the longer low intensity type of dry period, or dry winters rather than to short single season summer events. Because of this we have not analysed a critical period scenario.

3.4 Competition in water supply

The 2003 Water Act extended the opportunities for competition in the water industry. Two types of water supply licence can now be obtained.

A retail licence to supply water to customers using water provided by the company
A combined licence to introduce new water to supply customers using the company mains

We have no retail or combined water supply licencees operating in our company area.

3.5 Strategic Environmental Assessment

A water resources plan is a long-term strategy that sets out a number of actions that may affect future planning and development in the area as well as having the potential to generate environmental impacts (both positive and negative). By law, a plan of this type is subject to a Strategic Environmental Assessment of the likely effects.

We have carried out a Strategic Environmental Assessment (SEA) in parallel with the development of our draft Water Resources Plan to establish what the potential impacts of our proposed management strategy could be under the following sustainability issues:

- Economy and employment
- Health and wellbeing
- Community and quality of life
- Landscape and cultural heritage
- Energy and climate impact
- Managing waste and use of resources
- Protecting the water environment and encouraging efficient water use
- Maintaining or enhancing biodiversity

The Strategic Environmental Assessment has been conducted independently by external consultants ENTEC accordance with the SEA Directive requirements. This assessment is not a statutory plan, but is subject to consultation and comment from both the statutory consultees and wider stakeholders. We have used the findings of the SEA to inform the development of our draft Water Resources Plan.

The SEA is published as a separate document from the draft Water Resources Plan, but is included as part of the supporting information for our plan.

Section 4. Availability of Water

4.1 Yield Assessments

As stated previously, the Company obtains water from a variety of resources categories. At different times of the year, the proportion of water taken from each category will change reflecting the conjunctive use of resources over the year. The main categories and their average contribution to water pumped into supply are:

- from rivers, principally the River Severn (also Cam and Frome); typically 45%
- from small springs, but also some boreholes in Jurassic Limestone; typically 15%
- from shallow surface water reservoirs in the Mendips; typically 40%

The reliable yield that can be obtained from these sources during periods of dry weather has been calculated for previous Water Resource Plans. The yield assessment is based on source performance during noted dry periods such as 1975/76 (where reliable data is available). Other dry periods such as 1990/91 and 1995/96 have also been considered and the yield assessment, including any revisions, is summarised below.

4.1.1 Yield of River Severn abstraction (via Gloucester – Sharpness canal)

The licence for abstraction from the Sharpness canal is owned by British Waterways (18/54/20/138). The permitted unrestrained abstraction is for an annual average of 210 Ml/d with a maximum daily abstraction of 245 Ml/d. The company takes water from the Sharpness Canal, close to Sharpness docks.

The River Severn supplies many large towns in England and Wales with water. To achieve this, the river is usually supported during dry periods by regulated discharges from Clywedog reservoir in Wales and in some cases by support from the water pumped from boreholes (Shropshire Groundwater Scheme). This period of regulation occurs in most years from May to September. The river regulation discharges are tiered, and are determined by the flow conditions prevailing at Bewdley, the primary control point on the Severn at present. However, there are secondary flow conditions at Deerhurst governing the abstraction from Gloucester dock to the Sharpness canal that are not allowed for in the control rules for the River Severn. This means that under certain conditions, flows can be adequate at Bewdley but at a level at Dererhurst sufficient to trigger additional abstraction reductions. This issue may be significant if river flow downstream of Bewdley is impacted by climate change. This aspect is considered in more detail later in the report.

When the Severn is in a period of regulation, the maximum abstraction permitted in any 100-day period is an average of 210 Ml/d. At the next level of maximum regulation, the abstraction must not exceed 210 Ml/d on any single day (this occurs when discharges for river support are more than 500 Ml/d from Clywedog and the Shropshire groundwater sources).

Further restrictions occur when the maximum tidal level exceeds 9.0 m at Sharpness outer dock sill. When this occurs, the abstraction must not exceed 195 Ml/d. When River Severn flows at Deerhurst are below 2000 Ml/d, the abstraction reduction to 195 Ml/d may be required at a level of 8.5 m at Sharpness, increasing the number of days of possible abstraction reductions.

River Severn flows will be low from May to November in a dry year, therefore there are seven months of tides with an average of four days with a spring tide greater than 9m. The maximum allowable daily abstraction during each period is as indicated below:

For a dry year April to March the likely abstraction pattern is defined as:

80 days of river regulation conditions	210 Ml/d
62 days at maximum regulation (4 months less days of spring tides)	210 Ml/d
45 days drought order (1975/76)	199 Ml/d
28 days at reduced abstraction due to spring tides	195 Ml/d
150 days at up to 245 Ml/d but average cannot exceed 216 Ml/d	216 Ml/d
Sharpness Deployable Output annual average (dry year)	**210 Ml/d**

The Sharpness source also provides a major non-potable water supply for the Avonmouth chemical company, Terra Nitrogen. The contracted reservation agreement is for a volume of 16 Ml/d at present.

4.1.2 Groundwater yield

The groundwater yield assessment was carried out in 1998, and included the effect of dry periods such as1975/76 and 1995/96. Since this work was carried out, there has not been a significant dry period worse than 1975/76 or 1995/96. The dry weather yields estimated from the study are still considered valid (except in the case of Charterhouse Windsor and Yelling Mill springs). The estimated yields for operational groundwater sources including the reductions incorporated at the last WRP are provided in the table below.

Operational Sources

LICENCE REFERENCE	SOURCE NAME	SOURCE TYPE	DRY WEATHER YIELD CONJ. USE	ANNUAL LICENSED QUANTITY
18/84/23/S/013	Alderley	G	3.4	6.85
16/52/13/G/011	Banwell	G	5.90	13.29
16/52/15/S/013	Dundry	G	1.40	2.19
17/53/14/S/013	Sherborne	G	3.70	6.77
16/52/15/G/018	Chelvey	G	12.40	13.70
16/52/15/G/017	Clevedon	G	2.40	3.29
17/53/12/G/015	Egford	G	4.60	5.48
17/53/06/G/008	Long Newnton	G	7.60	18.60
17/53/11/G/094	Oldford	G	7.9	15.10
17/53/06/G/007	Shipton Moyne	G	10.1	18.0
17/53/06/G/006	Tetbury	G	1.6	3.29
16/52/12/G/046	Winscombe	G	2.3	2.60

Two sources have been subject to a yield re-assessment following the installation of membrane treatment plant. The quality of water at these two sources is highly variable and contains a particular combination of colloids and fine solids that cause the membranes to block unless operated at low filter loadings. The revised deployable output of these two sources is as detailed below

Sources with reduced Deployable Output

16/52/10/G/047	Shepton	G	1.20	2.74
16/52/12/G/042	Charterhouse	G	1.30	2.74

The revised yield has been assessed from analysis of the average daily output since 2003 during the few periods when the plant has been able to operate reliably. In the 2004 WRP we reported the yield of these two sources as 1.6 Ml/d for Windsor Hill and 1.7 Ml/d for Charterhouse. Our re-assessment has reduced the yield of these sources by 0.4 Ml/d each (0.8Ml/d loss of Deployable Output in total).

Two sources were abandoned in 2005 and their licences surrendered because they were considered too small and too poor in quality to be viable in future. These are detailed below.

Abandoned Sources

16/52/10/G/044	West Compton	G	0.00	1.23
16/52/12/G/052	Priddy	G	0.00	0.88

As these two sources were not in operation at the time of the 2004 Water Resources Plan, there has been no impact on groundwater sources yield as a result of the surrender of these licences.

There are a number of non-operational sources where the water is either polluted, or is of such poor quality that major plant investment would be required before the water could meet DWI standards for public supply. These sources are retained as it is considered they could be returned to service using emergency treatment plant during a drought period. These sources were also reported as not operational for the 2004 WRP and are listed in the table below.

Non Operational Sources

LICENCE REFERENCE	SOURCE NAME	SOURCE TYPE	DRY WEATHER YIELD CONJ. USE	LICENSED QUANTITY (Ml/d)
16/52/15/G/016	Barrow Gurney	G	0.00	2.74
16/52/12/G/050	Wells	G	0.00	1.23
17/53/12/G/097	Gurney Slade	G	0.00	4.93
16/52/12/G/047	Honeyhurst	G	0.00	4.11
16/52/12/S/130	Ellenge	G	0.00	1.37
16/52/14/G/014	Blagdon	G	0.00	1.18

The total estimated yield of all groundwater sources when operating at their maximum capacity for 365 days per year is 65 Ml/d, a reduction of 1Ml/d compared to the 2004 WRP.

Groundwater Deployable Output annual average (dry Year) 65 Ml/d

4.1.3 Surface water resources

The company has storage reservoirs supplied from river basins in the Mendip Hills. These reservoirs and their catchments have a large influence on the operation and security of the company's water supply. However, the water available from such sources is highly dependent on climatic conditions. These need to be carefully considered when assessing how much water can be taken from reservoirs during dry periods.

There are five major catchments that provide the inflow to the three reservoirs, Chew, Blagdon and Cheddar. The reservoirs are essential in providing the ability to meet peaks in demand and provide resilience during dry periods. The volume of water stored in the reservoirs forms a key component of the company Deployable Output (i.e. the water is not captured only for supply in an emergency and all reservoirs would be drawn down as part of normal operations). The components of the surface water system are detailed below.

Winford Brook and Chew Valley Reservoir

This is a pumped storage scheme, pumping water from Winford Brook that is stored in Chew Magna compensation reservoir to Chew Valley Lake. The modelled inflows have been used against an abstraction rule to derive the quantity that can be pumped to Chew Valley Lake, while maintaining adequate stored water for compensation requirements.

Chew Valley Reservoir and Line of Works

This is the largest reservoir and catchment in the system, and a significant volume flows into this reservoir from the Chew catchment independently of Line of Works. Line of Works takes the headwaters of the river Chew directly to the Barrow pump storage reservoirs, and collects some additional water from other streams and springs en-route. When water is not being taken in this way from Line of Works, the water would enter the river Chew and flow naturally into Chew Valley Lake. Compensation is provided for the River Chew downstream of the dam.

Blagdon Reservoir

This is the oldest and shallowest of the Mendip reservoirs. The catchment is relatively small, and is augmented to some degree by water transferred from the two small adjacent catchments at Rickford and Langford. Compensation is provided to the Congresbury Yeo downstream of the dam.

Cheddar Reservoir and Cheddar Spring

This is a large catchment that gives rise to a substantial spring that issues at Cox's Mill Cavern. Water is collected in a series of ponds at the spring rising, and gravitates to the reservoir by a series of pipes. Compensation for the Cheddar Yeo is provided at the ponds close to the spring rising. During wet periods, the spring discharge can be so high that it is not possible to capture all of the available water because of the lack of hydraulic capacity of the reservoir intake mains.

River Axe and Cheddar Reservoir

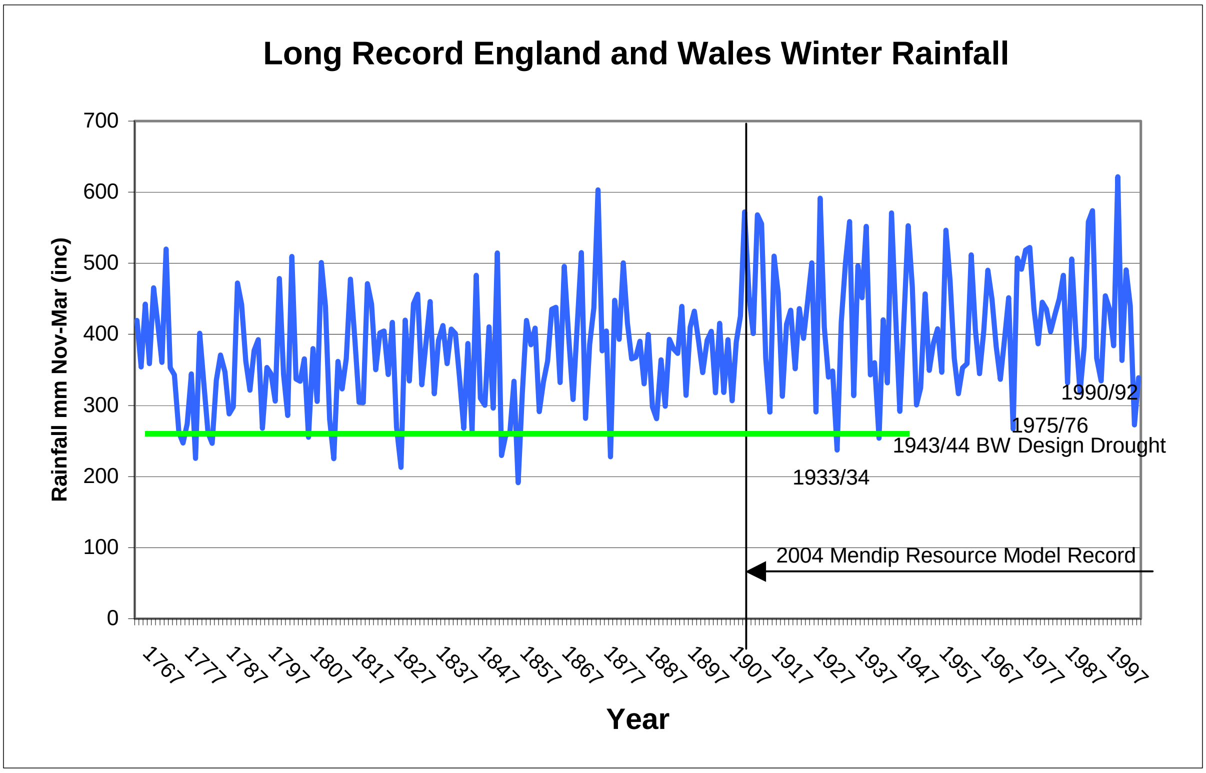
This is a pumped storage scheme taking water from the River Axe to Cheddar Reservoir. An abstraction rule further upstream at Wookey Hole is used to derive the available quantity that can be pumped to Cheddar Reservoir. Although the source is part of the company resources, the water is of extremely poor quality, having a high nutrient and ammonia load from agricultural pollution. Use of river Axe water is regarded as undesirable unless treated to remove nutrients. A new treatment works is now being constructed adjacent to the reservoir, but it is not known how effective this will be in resolving the quality issues of the river Axe water and its impact on Cheddar Reservoir in the long term.

4.1.4 Impact of longer climatic record

In 2004, we revised the yield of the Mendip resources based on new models for the individual catchments detailed above. These models were based upon a daily climatic record for our supply area back to 1910. At that time, the analysis provided a catchment level model that captured the observed variations of the system over nearly 100 years to an accuracy of 85 to 90%, and included several significant droughts.

In this country, most effective rainfall is expected in the winter and reservoirs are very effective at capturing this large volume of water if the rainfall materialises. A dry winter or series of dry winters has the potential to de-stabilise resource systems based upon reservoirs more than dry summers. Analysis of a longer climate record over the period to the beginning of the 19th Century reveals that periods of below average rainfall appear to have been much more frequent and more severe in the period before 1910.

Central England winter rainfall record showing drought periods more significant than Bristol Water current design drought (1943/44)



The plot displays the winter rainfall volume calculated from the central England long-term record. The reservoir resources system is particularly vulnerable to dry winters. In the case of the Mendip system, winters that deliver less than 300mm of rain over the winter period may require some form of demand management in the following summer to ensure water supply can be maintained without recourse to statutory measures such as drought orders.

The yield of the Mendip system is based on the modelled impact of the 1943/44 drought. This particular event was selected because within our climatic record to 1910, a similar or worse event would only be expected once in 50 years. In the 2004 model record period, only the 1933/34 drought is more severe, while other notable droughts typified by events such as 1975/76 and 1990/91 are much less severe but occur more often.

When considering the longer record the following points emerge:

- There is a greater frequency of periods where winter rainfall is as low or lower than our design drought of 1943/44 in the period before 1910 (indicated by winter rainfall events below the 1943/44 drought line).

- There are more sequential periods of low rainfall before 1910 (i.e. more two or three year droughts).

- The return periods of the reservoirs falling below the drought control curve and triggering a hosepipe ban remains approximately once in 15 years, but the drought events before 1900 tend to be more severe than post 1900.

- The 1933/34 drought remains the most intense event in the climatic record.

- There is an apparent trend of increasing winter rainfall over the longer record period.

Although the amount of rainfall is very significant in determining the yield of the reservoir system, it is not the only factor to be considering when assessing the performance within a single resource zone where sources are used conjunctively. Other issues are also significant including rainfall distribution over the critical period, temperature, evaporation and interaction with the other components of the resources system.

Because of the issues raised by the long-term climate record, a new HYSIM rainfall/runoff model was used to predict the inflow to the reservoirs over the longer record period. There has been a monitoring station at Barrow Gurney since 1829 and this data has been taken as the basis of the climatic record needed to generate the predictions of monthly catchment inflow. This data was input into a larger behavioural model including other resources, dry weather demand profiles and reservoir volumes so that the yield can be assessed in conjunction with the other components of the resources system:

4.1.5 Estimation of Mendip reservoir yield

Because of the interconnectivity of both the raw water system and the treated water transmission system, it is possible to regard the individual Mendip reservoirs as being a single grouped entity in order to simplify planning. The yield has been estimated by using a relatively simple behavioural model with the following components:

- A demand profile for the ‘dry’ year representative of the water put into supply
- Sharpness yield

- Updated groundwater yield using the 1976/77 conjunctive use monthly profile
- Mendip catchment inflows, simulated from 1829 to 1960 and recorded thereafter
- Winford Brook as available for pumping to Chew Valley Reservoir
- River Axe abstraction as available for pumping to Cheddar Reservoir

The model is based on a spreadsheet to compute gains and losses to the total stored water volume every month from 1830 to 2005. The yield of the system is defined by the maximum volume that can be supplied by the combined Mendip reservoirs to meet demand during the ‘dry’ 24 month period. Using this mass balance at the current level of service, the yield of the Mendip reservoirs at the ‘business as usual’ reservoir operating level is as reported below.

Total deployable surface water output = <u>94 Ml/d</u>

4.1.6 Reservoir volume

A bathymetric survey was undertaken in 2006 to confirm the theoretical maximum reservoir volumes. The results reported below did not indicate appreciable silt build up since the last survey in 1997.

	2006 survey	**1997 survey**
Chew Valley Lake	20530 Ml	20648 Ml
Blagdon Lake	8205 Ml	8083 Ml
Cheddar	5940 Ml	5957 Ml
Barrow Reservoirs	3655 Ml	3655 Ml
Total gross storage	**38330 Ml**	**38343 Ml**

The average depth of our reservoirs including Chew and Blagdon is less than 4m. This causes water management problems at very low reservoir levels, primarily due to water quality but also system hydraulics. The minimum ‘business as usual’ operating volume calculated for the 1999 and 2004 Water Resources Plans remains unchanged 9600 Ml. Of this volume, one third is reserved to allow for 31 days of emergency storage to allow inflow to reservoirs to re-establish in the period following a drought. The remainder would be spread over six shallow reservoirs, resulting in quite small residual volumes held in the individual reservoirs. These small volumes would either be unavailable due to the system hydraulics or difficult to acquire without the type of measures detailed as part of our Drought Contingency Plan.

The Company has not experienced a situation that could have caused a failure of the Mendip system in recent times. Therefore, the levels in reservoirs at which water would still usable on a ‘business as usual’ basis without remedial activity is a matter of past experience dating back to the 1976 drought. During the 1990 drought a significant amount of non-usual manual intervention was required to maintain output when the volume had not fallen below 15000 Ml in total. Since that time water quality standards have become much tighter.

The yield to be gained by reducing the operating volume approximates to 1.3 Ml/d/1000 Ml of decrease in operating volume over the 24 month critical period. It is doubtful whether significant extra yield could be achieved in practice due to the reasons outlined above, without new infrastructure and modifications to the draw off arrangements at dams and modifications to reservoir structures.

4.1.7 Yield Assessment and Level of Service

The Deployable Output is influenced by the yield of the Mendip reservoir system that in turn is related to the degree of supply security proposed in the level of service. The company level of service pledge is:

- **We will not plan to impose measures to reduce customers demand for water more frequency than once in fifteen years on average.**

This can be thought of as a probability of hosepipe ban once every fifteen years. A hosepipe ban may be imposed by the company without the use of statutory instruments and would be part of the first stage in managing a drought. However, further restrictions could be applied if the hosepipe ban was not effective in reducing demand. These include a range of statutory controls to reduce demand and increase the supply of water. These further measures are detailed in the Company Drought Contingency Plan and are not part of the Water Resources Plan. The frequency for application of further drought contingency measures is detailed below:

Hosepipe ban and appeals for restraint	less than once in 15 years on average
Drought order to ban non-essential use	less than once in 33 years on average
Drought order to modify abstraction licences	less than once in 33 years on average
Partial supply or rota cuts	less than once in 100 years

The current level of service has been derived by basing the yield of the Mendip reservoirs at the point that total storage would or could fall below the minimum operating volume in the second year of a drought (including a hosepipe ban during part of the second year).

From the historic data, the type of dry period that has most impact on our system usually occurs over two years. The system is therefore considered to be at greatest risk of failure in an 18 to 24 month dry period (i.e. is two season critical). Reservoirs are managed on an annual basis, using a control curve to ensure the profile of drawdown is not so great that there would be no prospect of re-filling the system over winter. If reservoir volume were to fall below this control curve in any single year, it is probable that demand restrictions such as a hosepipe ban would be needed.

The frequency of hosepipe bans in terms of their return period has been estimated by overlaying the behavioural model predictions for reservoir volumes from 1829 to date on the annual control curve for hosepipe bans developed from the 1 in 50 dry period. As there are approximately 6 to 7 occurrences every 100 years where the predicted reservoir volume from the model fall to, or below the control curve, the Level of Service is reported as one in fifteen for hosepipe bans (even though in many cases the hosepipe ban would have been in force for a very short period before the reservoir started to re-fill).

By changing the expectations surrounding security of supply during drought and the expected Level of Service, the system yield can be increased or reduced accordingly.

A greater Deployable Output could be obtained from the reservoir system if the reservoirs were routinely operated at a much lower level. This would result in a lower level of service and the risk of more frequent demand restrictions. This means in summary:

- System is made to yield more water
- Improved balance of supply over demand
- Less secure supply and greater risk of system failure
- Reduced Level of Service

By operating reservoirs at a higher level and retaining a greater volume of water in storage, the risk of demand restrictions may be reduced, the Level of Service would be increased, but less water is available from the system and engineering schemes to improve supply or reduce demand in the long term may need to be implemented sooner. In summary:

- System provides less water
- Reduced balance of supply over demand
- More secure supply and reducing risk of system failure
- Improved Level of Service

4.1.8 Comparison with past Deployable Output assessments

Since the last Periodic Review (PR04), there has been a reduction in the figure reported for deployable output in the base years. This has occurred for the following reasons:

- Two groundwater sources have been subject to a yield re-assessment following the installation of membrane treatment plant and subsequent reduction of capacity due to water quality issues. These sources are Charterhouse and Windsor Hill, referred to above. The revised yield has been assessed from analysis of the average daily output since 2003 during the few extended periods when the plant has been able to operate reliably. In the 2004 WRP we reported the yield of these two sources as 1.6 Ml/d for Windsor Hill and 1.7 Ml/d for Charterhouse. Our re-assessment has reduced the yield of these sources by 0.4 Ml/d each (0.8Ml/d loss of Deployable Output in total).

- There was a refinement to the Mendip surface water yield model in 2007, to take account of the analysis of the longer period climatic data from 1829. The water deployable has not been materially reduced at the policy level of service of once in 15 years for hosepipe bans.

- The dry weather yield of the River Severn sources has not been modified. We also investigated the effect of climate change on the river yield. From the analysis of data supplied by Severn Trent, the impact of climate change on river flows and Clywedog reservoir storage was not worse than already allowed for as a result of the 1976 drought.

The outputs from the three types of source are directly compared below for the base year for the WRP PR99, WRP PR04 and the Base Year PR09 (for the current draft plan). To align with the new reporting requirements, we have not deducted the either the process water losses or the volume of the raw water under the Terra Nitrogen reservation contract from the total of the deployable output. These volumes are now allowed for in the calculation of the value of water available for use, rather than calculation of the deployable output.

SYSTEM YIELDS AND DEPLOYABLE OUTPUT COMPARISON (Ml/d)

REVIEW PERIOD	**SBP PR99**	**2004/05 PR04**	**2006/07 PR09**	**2006/07 PR09**
Groundwater yield Mendip reservoir yield Sharpness yield	64 95 210	67 94 210	66 94 210	65 94 210
Reservation agreement Process water loss	- 23 -3	- 16 -6	- 16 -6	Not assessed as reduction of D.O.
DEPLOYABLE OUTPUT	**345**	**349**	**348**	**369**

4.2 Water Available

The volume of water deployable as calculated above is not all available to the Company for use by its own customers. The actual water available is reduced by impacts such as:

Sustainability- Long-term reductions in abstraction required for environmental reasons
Quality- Sources likely to be at risk of failing Drinking Water Standards
Outage- Pollution, treatment works maintenance or other plant failure
Process loss- Water treatment or raw water use or losses (e.g. aqueduct loss, filter washing)
Bulk supplies- Water contracts to supply industry or other water companies (on a secure basis)

4.2.1 Sustainability Reductions

The Company together with Wessex Water has volunteered to reduce abstraction from the Malmesbury sources north of Bath in order to improve low flows in the Malmesbury Avon. At present we operate a voluntary 10.1 Ml/d reduction in abstraction from the Shipton Moyne and Long Newnton sources since 1998. We have not been advised of a requirement for any additional reductions in abstraction for sustainability reasons at this time. We have also assumed that the current level of reduction will continue in future.

4.2.2 Water Quality

A number of shallow groundwater sources are at risk due to deteriorating water quality. At the time of the last WRP, some of these had been dealt with by taking them out of the list of deployable sources. Others had the problems addressed by the use of membrane treatment causing small reductions in yield, now factored in to the yield reduction since the 2004 plan.

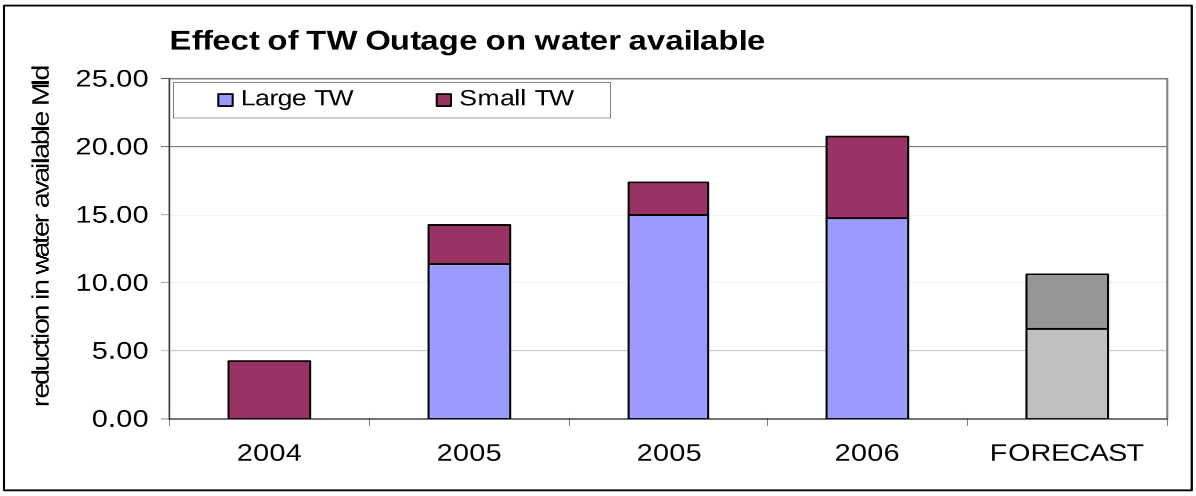
In the last two years, sources in the Nitrate Vulnerable Zone adjacent to Frome have shown a steady increase in the level of nitrate. One source at Egford had to be shut down over part of the winter to avoid supplying water failing the Drinking Water Standard.

This has been addressed in this plan as a loss of Deployable Output as repeat quality failures are likely to occur unless a specific cause can be identified, or the problem is addressed by additional treatment processes.

4.2.3 Outage

Monitoring of treatment works shut down for maintenance, failure and quality issues has now been in place for a number of years. This data provides a statistical view when averaged over time of the total loss of water available due to the accumulation of these small events.

As a result of the analysis, the observed outage was approximately 10 Ml/d and this has been carried forward as the long term forecast. The effects of commissioning and extended shutdowns were ignored. The plot below indicates the recorded outage reported each year as part of the Water Resources Plan monitoring provided for Ofwat and the Environment Agency.



In recent years, we have had a number of difficulties with the operation of our Severnside treatment works. These have caused periods when the works has been shut down. As can be seen, this has significantly increased the recorded outage in the past four years. This treatment works is now undergoing a refurbishment programme, intended to improve operating reliability and reduce outage.

The future assessment of outage for smaller works is based upon the average of the historic recorded values. Future outage for the larger treatment works has been assessed using recent experience of reduced output due to levels of nitrate above the drinking water standard in the water of the Sharpness canal. The grey bar in the graph represents our forecast for average outage over the period of the Water Resource Plan.

There is a theoretical risk of much more serious events occurring, such as the pollution of a large local source or failure of the Sharpness canal. Such extra-ordinary events would have a very large impact on deployable output, but are difficult to capture in terms of outage where there is no history of failure. These impacts have been quantified within the section detailing analysis of headroom.

4.2.4 Process Losses

This is the sum of both raw water lost or used as part of the transmission, storage and treatment process, together with the operational use or loss of water at treatment works. These include:

Raw Water Losses and operational use

Seepage, discharges and evaporative losses from pump storage reservoirs
Local transfer loses
Aqueduct losses and Draining down of mains and reservoirs for maintenance

Some of these items can be measured directly, but others such as raw water losses will be estimated from a balance of flows and subject to a large error. In most cases, the water 'lost' flows back to the source resulting in a negligible effect on yield

Treated Water Losses and Operational Use

Leaks from filter beds and onsite mains
Mains and filter conditioning
Filter washing
Re-commissioning and testing of treatment works before return to service
Draining down of mains and reservoirs for maintenance
Water sampling pump discharges

The analysis of operational water use is based on comparison of actual works inflow of raw water compared to outflow of treated water during the year. In situations where the water is known to flow back to the source, the volume would not be reported as a loss.

The planning forecast for raw and treated water losses/operational use as a potential effect on water available in the dry year is 6.3 Ml/d.

4.2.5 Potable and raw water transfers

Potable water transfers

There are minor un-contracted minor imports and exports of water that occur at the edge of the Company area and Wessex Waters area. These are charged for at the standard retail metered rates respectively for each company. The sum of these small imports and exports amounts to a net total import of approximately 0.8 Ml/d from Wessex Water. These transfers are made using the small diameter distribution mains at the extremity of each company's system, with very little scope for any increase in volume transfer. The volume imported is not expected to change significantly in future years.

The Company also has a large bulk supply contract providing for a transfer of treated water to Wessex Water, via Newton Meadows at Bath. This export of water is included at the full contract volume of 11.37 Ml/d over the planning period and is regarded by both Wessex Water and Bristol Water Plc as a secure supply available under all conditions except during periods when the Environment Agency have imposed drought restrictions on the River Severn. Under these conditions, the bulk transfer will be reduced by the same percentage as the overall percentage reduction in Sharpness abstraction. The companies are currently negotiating the terms of the contract covering the period from 2009 to 2019.

The Bristol Water network pressures would support a slightly higher volume of transfer up to 12.5 Ml/d from Bristol to Bath. However, the current infrastructure will not support a transfer from Bath to Bristol.

In the past, negotiations have taken place with Wessex Water and the Environment Agency regarding an increase to the volume of water available via the Newton Meadows link. Bristol Water has agreed in principle that the water could be made available. An offer to upgrade the infrastructure and provide an additional 3Ml/d of water at a discounted large user tariff was not taken up by Wessex Water.

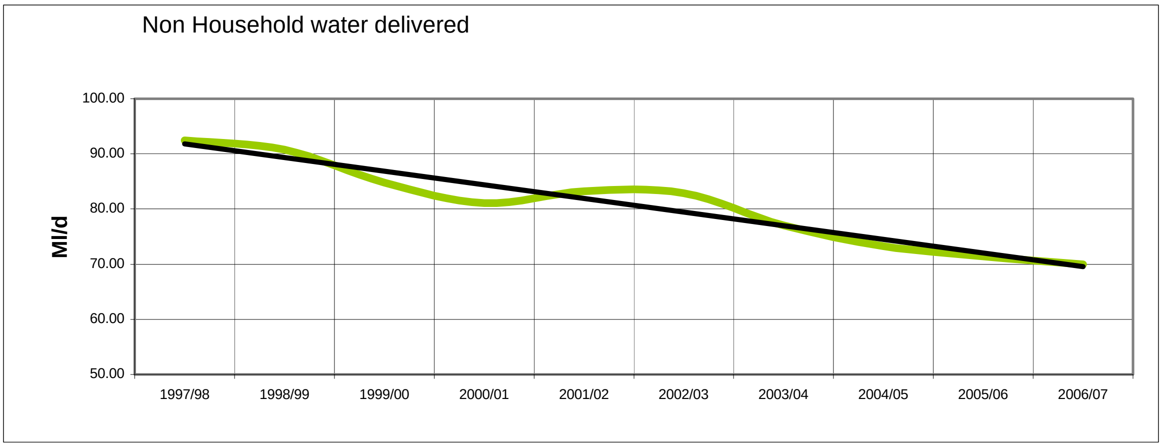
Raw water transfers

At present, the company has a significant reservation contract for a supply of untreated water to Terra Nitrogen at Avonmouth. The reservation volume is for 16 Ml/d, which Terra regard as secure and permanently available at that volume (even though the volume actually taken varies over the year). This agreement is still in operation, although we are awaiting a response from Terra Nitrogen regarding their intentions in respect of this contract.

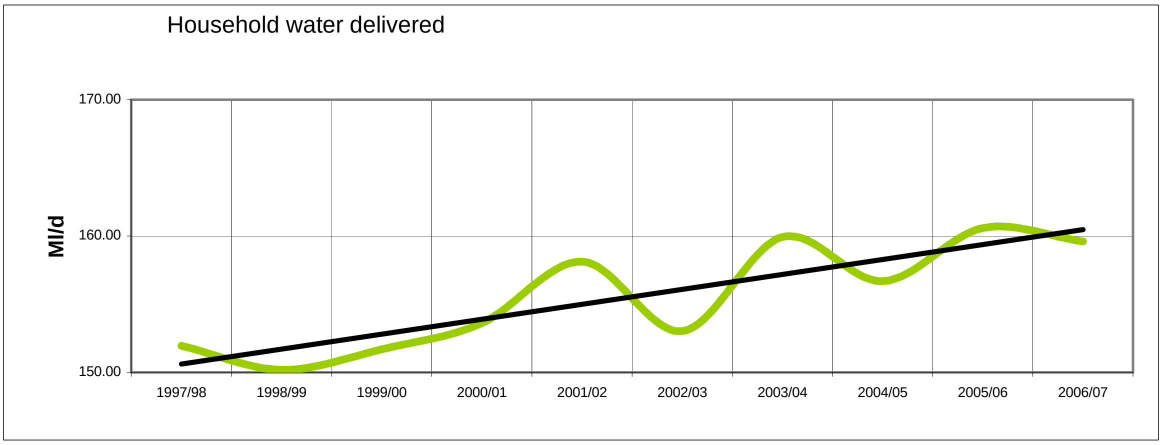
Section 5. Demand For Water

5.1 Historic water demand

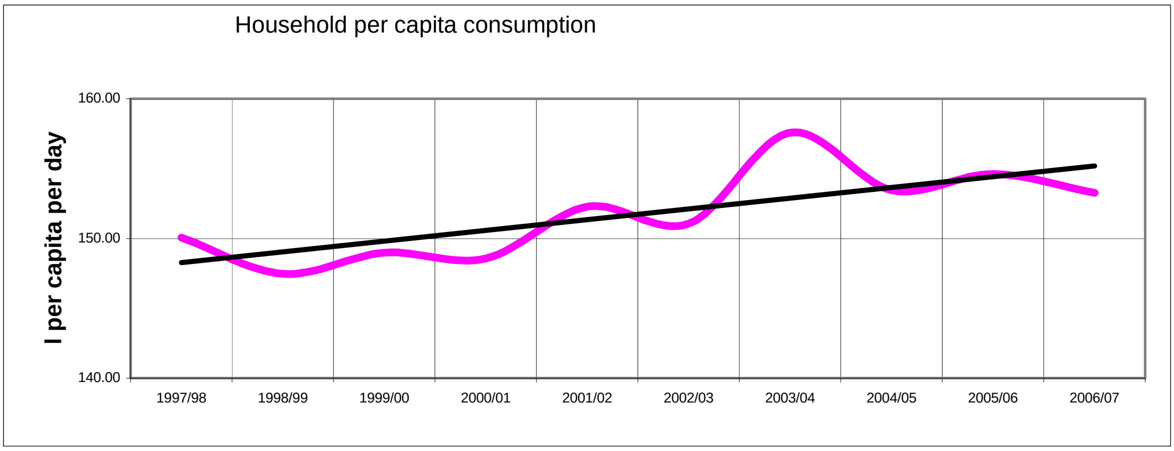
Over the last 10 years, the average daily volume of water put into the distribution system has fallen by approximately 20 Ml/d from 305 Ml/d to 285 Ml/d. Practically all of this reduction has been due to the decline in non-household consumption, mainly in the manufacturing sector. There has also been a reduction in mains leakage, which together with the decline in the non-household consumption has concealed a significant increase in household consumption.



Over this period the population of the supply area has increased by 4% and the number of connected household properties has increased by 8%. This growth has resulted in a 7% increase in water delivered to households from 150 Ml/d to 160 Ml/d.

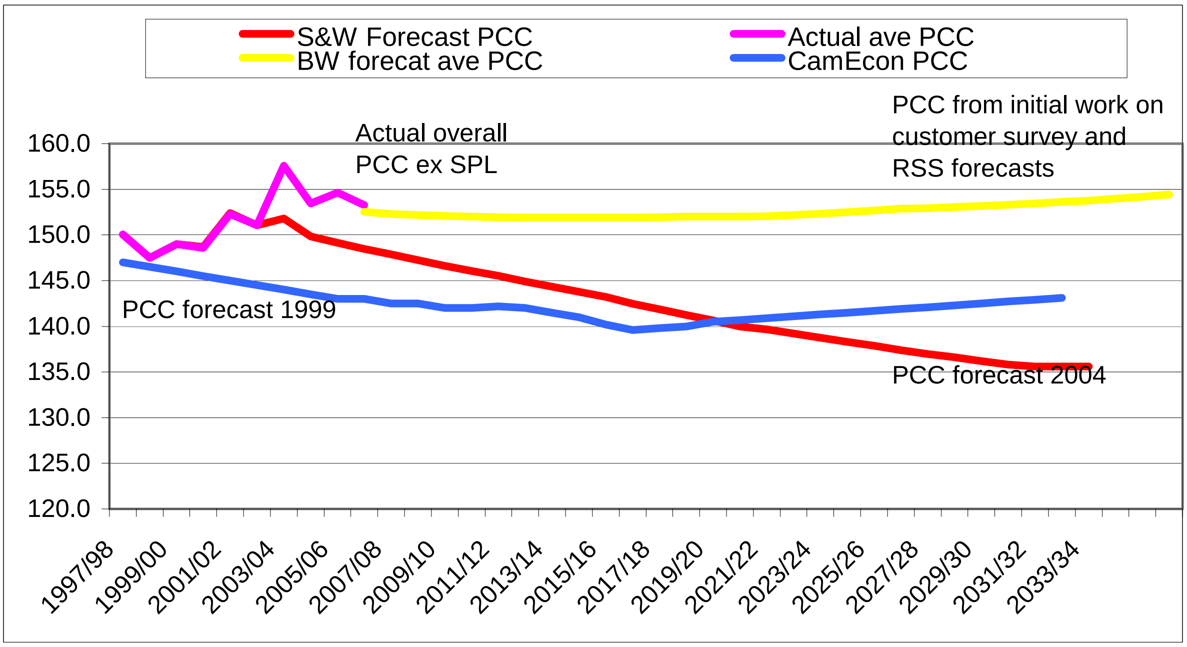


The higher growth rate of properties with respect to population has resulted in an overall declining occupancy trend, and a rising per capita consumption of water over the period. This has occurred despite the fact that the proportion of households with a metered supply has increased from 8% to 24%, driven by the free optant metering scheme. The per capita consumption of households with a metered supply has declined by 7% over the period, while the per capita consumption of unmetered customers has increased by 6%. Because the majority of household customers are unmetered, this, together with a falling occupancy, has been the driver for the increase in overall per capita consumption for the supply area.



These trends are of some significance, particularly with respect to past forecasts of consumption trends for household customers. In the past we have always used econometric consultants to develop these forecasts. They have considered such issues as ownership of water-using appliances, usage rates and efficiency of those appliances. Data for trends of the various components that make up household demand were collected from manufacturers, marketing agencies, government departments and agencies. In particular these forecasts gave some weight to the increasing efficiency of water-using devices, and increasing rates of replacement of older equipment.

The result of the econometric analysis was to forecast significant reductions in household consumption as indicated by the trends of per capita consumption in both 1999 and 2004. The forecast reductions in consumption have not been observed to date. Moreover, the observed per capita consumption has increased over a period in which approximately 50% of customers tell us they have replaced old style WC cisterns with new lower volume dual flush devices and have water-using devices, such as washing machines, of a higher than average efficiency.



It is possible that the water demand relating to the essential components may be static or reducing. However, the observed growth in household water demand points to consumption increasing in areas of personal wellbeing such as showering and bathing, or the discretionary use of water.

In the light of the past ten years of evidence, we consider that large reductions in per capita consumption driven by increases in the efficiency of domestic appliances are unlikely for the following reasons:

- Over half of existing customers have higher efficiency water-using devices
- Most current appliances are quite close to their maximum efficiency
- There is an increasing trend toward a leisure component of water use
- The trend for housing occupancy to fall will accelerate in future
- Limited impact of demand reduction tools

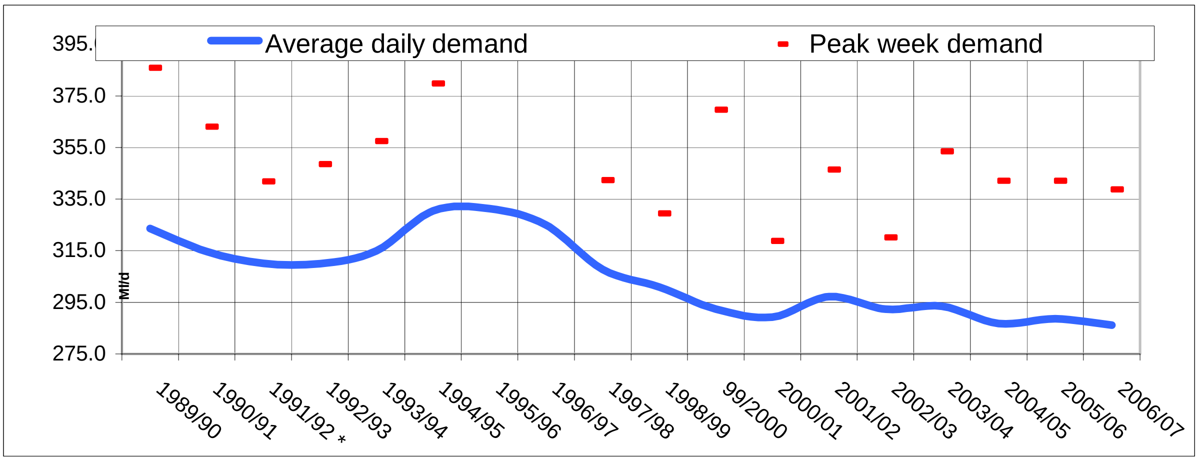
These factors all tend to drive upwards per capita consumption, with falling occupancy being a particularly strong driver for increasing per capita consumption.

For future planning scenarios, we have assumed the best outcomes from the aspirational demand management protocols outlined in the Code for Sustainable Homes and other policy documents referred to in the government Water Strategy. However, even if these protocols are rigidly and infallibly applied, we predict that the most optimistic baseline forecast is for a broadly static per capita consumption across the forecast period.

5.2 Demand for water in 2006/07

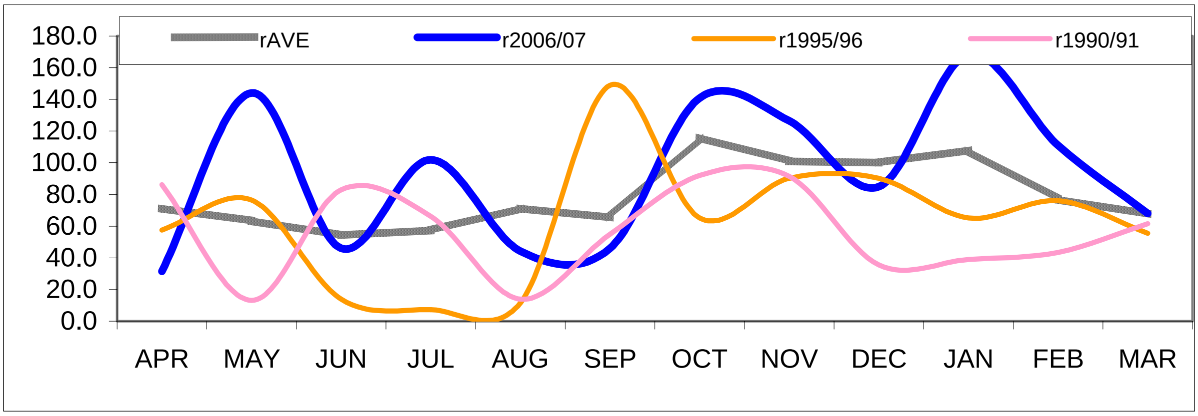
For the purposes of this plan, the actual demand for water and its components, the population and property count recorded in the financial year 2006/07 forms the baseline upon which future demand projections have been constructed. Demand for water does vary according to climatic variation in the company area, however the relationship is complex, not simply dependent on whether the year is drier or warmer than average. In order to significantly impact demand for water, sustained hot periods must coincide with sustained dry periods in a manner not observed since 1995. The volume of water put into the supply system since 1989 is shown below, together with the distribution input during the peak week for the indicated year.

Historic trend in demand for water



In 2006/07, the annual average demand was 286 Ml/d. (2 Ml/d lower than in 2005/06). However, this reflects a gradual trend observed over the last five years for the volume of water supplied to fall overall, due to declining commercial consumption, unconnected with climatic effects. The volume of water put into the distribution system is similar to recent past years, allowing for the general consumption trends. For this reason we see no requirement to adjust this year's baseline data to simulate an 'average' or 'normalise' the year with respect to demand for water due to climatic conditions.

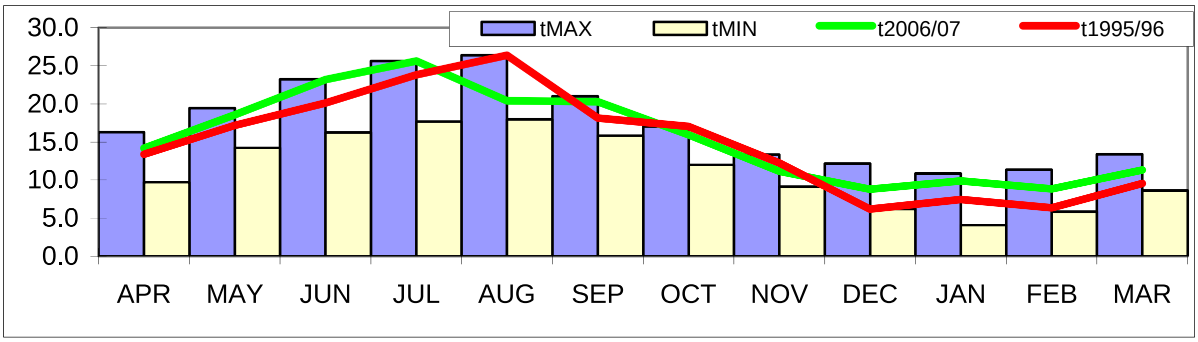
Average rainfall compared to 2006/07 and dry years



Precipitation over the year 2006/07 was 1113mm, above average for most months of the year and 166mm more than the average observed in the company area over the past 20 years. The summer period was sufficiently wet to not trigger significant discretionary water consumption in the form of garden watering, despite being warm. Substantial winter rainfall was received. Domestic plumbing leaks would not have been significant during the mild winter.

The monthly mean maximum temperatures recorded over the year 2006/07 were higher than some recent years but not excessively so. In addition, there was a notable lack of daily sequences of very hot weather seen in 2005/06 or 1995/96. The year of 1995/96 was the last recorded year where the climatic conditions significantly increased the demand for water. This was due to long periods of dry weather occurring at the same time as hot periods. Although 2006/07 was almost as warm as 1995, the warm periods also coincided with wet periods, and the distribution of rainfall over the year was much more even, resulting in a substantially lower demand for water than in 1995. In addition, there were no hosepipe bans or other restrictions on use in place that would have had any significant impact upon water demand.

Range of mean monthly maximum temperatures compared with 2006/07 and 1995/96

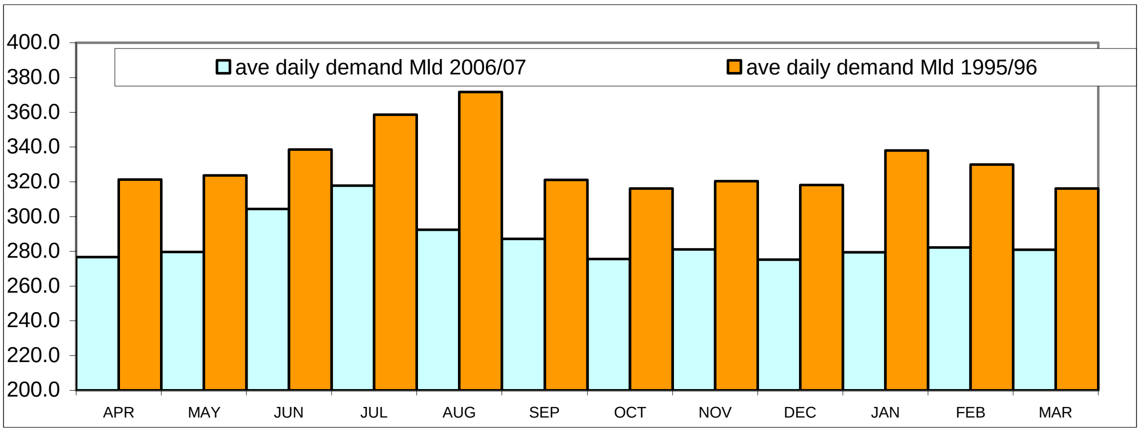


5.3 Demand during dry weather

Demand data from the year 1995/96 is used as a benchmark year to establish the impact of dry weather on demand. At that time, the difference between the peaks in the year's demand and the baseline demand in the cooler months of the year was used to estimate the portion of demand attributable to the 'dry' year. Since that time, the company has not experienced any year that has resulted in such a large increase in demand. Although the data for 1995/96 is over ten years old, it is still valid as there has not been any year with as substantial an impact upon demand and it remains the basis of our adjustment of a 'normal' year to a 'dry' year

The relative impact on demand of the climatic conditions in the two years is shown in the plot below. Although not strictly comparable due to the overall trend of falling demand since 1995, the point is illustrated particularly by the very high average daily demand of 370 Ml/d during August 1995.

Average daily demand in month for 2006/07 compared to 1995/96



Using the 1995/96 data, the extra demand due to dry weather was attributed to domestic consumption as a discretionary use component of water consumption, defined as:

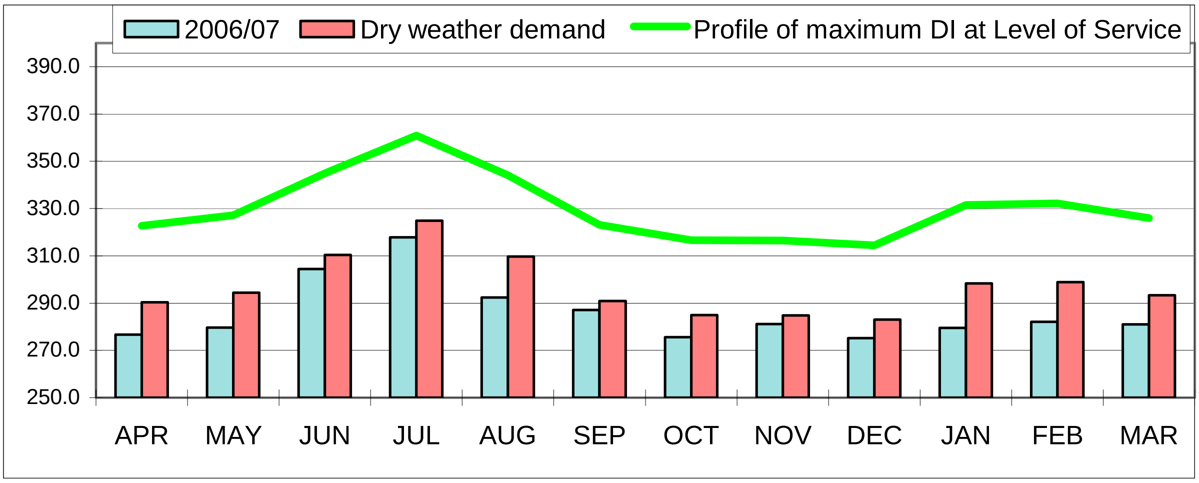
- 15l/prop/day Household use as mainly garden watering, car washing, clothes washing.
- 4l/capita/day Personal use for extra bathing, showering, cooking

We have no evidence to indicate that commercial and industrial consumption would increase significantly in response to seasonal variation in weather and do not factor this component of demand.

The dry weather demand component is multiplied by the number of properties and the population calculated for 2006/07 in order to generate the extra average daily demand as an annual average that would be due to dry weather.

The component of demand expected during a dry year derived using the method above is approximately 11 Ml/d, therefore when using 2006/07 as a the baseline for a 'normal' year, the average annual daily demand expected during the 'dry' year would be 297 Ml/d (286 Ml/d +11Ml/d). The comparison between the normal year, i.e. 2006/07 and the predicted impact of a dry year upon that baseline is indicated in the plot below.

'Normal' and 'dry weather' scenario water demand



Also shown in the plot is the profile of the maximum volume of water available as input to the distribution system at the current level of service. This profile is used for planning purposes to assess the maximum volume of water available from our resources. It is based upon a resource zone model incorporating all of the components of surface, reservoir and groundwater, together with exports and raw water transfers. The factors to generate the monthly profile of demand indicated is not based upon any single year, but has been synthesised from a number of dry years with significant demand impacts for which reliable date is available. These years were 1983/84, 1984/85, 1989/90, 1995/96.

5.4 Drivers of water demand

The following drivers will determine the baseline demand for water over the next 30 years:

- The current population and number of properties in the company area
- The regional policy impact on population growth
- The regional policy impact on household formation and house construction
- The occupancy rate that results from the effect of housing and population growth
- The projected ownership of water-consuming devices and their pattern of use
- The effect of a lack of mandatory design for domestic water efficiency
- The econometric projections for commercial and industrial growth
- The impact of Climate change on demand for water

Assuming that there are no mitigating interventions, the majority of these drivers will act to increase the demand for water over time. The use of aspirational targets and voluntary efficiency codes may help to reduce growth in water demand. However, the code for sustainable homes and other household efficiency objectives do not have the benefit of an approach based on the consumption of fittings and lacks effective legislative force at present. There is also no certainty that a 'water efficient' home would continue to operate at a high level of efficiency five or ten years following construction, as lifestyle choices will determine any appliance replacements.

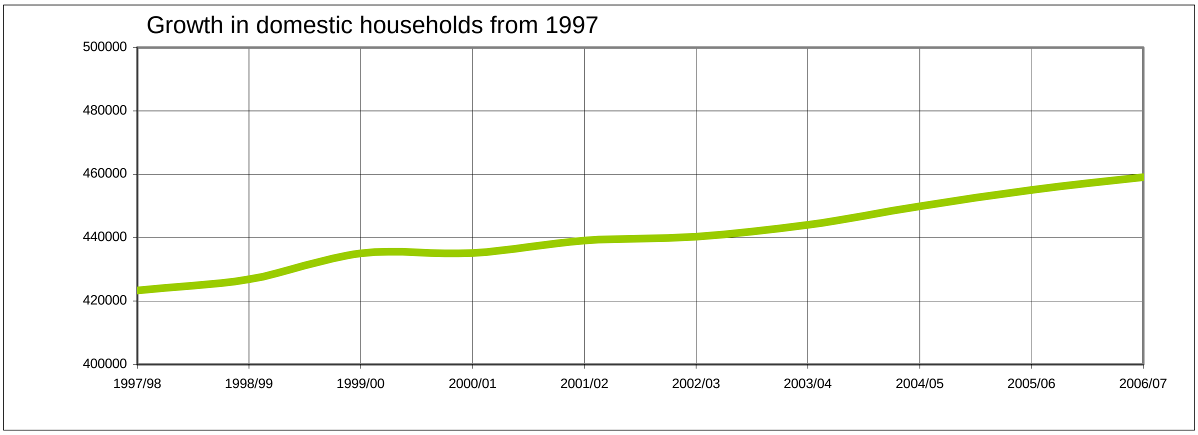
We are optimistic that government led water efficiency initiatives will ultimately reduce demand for water. However, we do not feel that we can plan purely on the basis of optimism. Forecasts will be re-appraised when there is clear evidence that the many proposed initiatives are clearly acting to drive down overall demand for water.

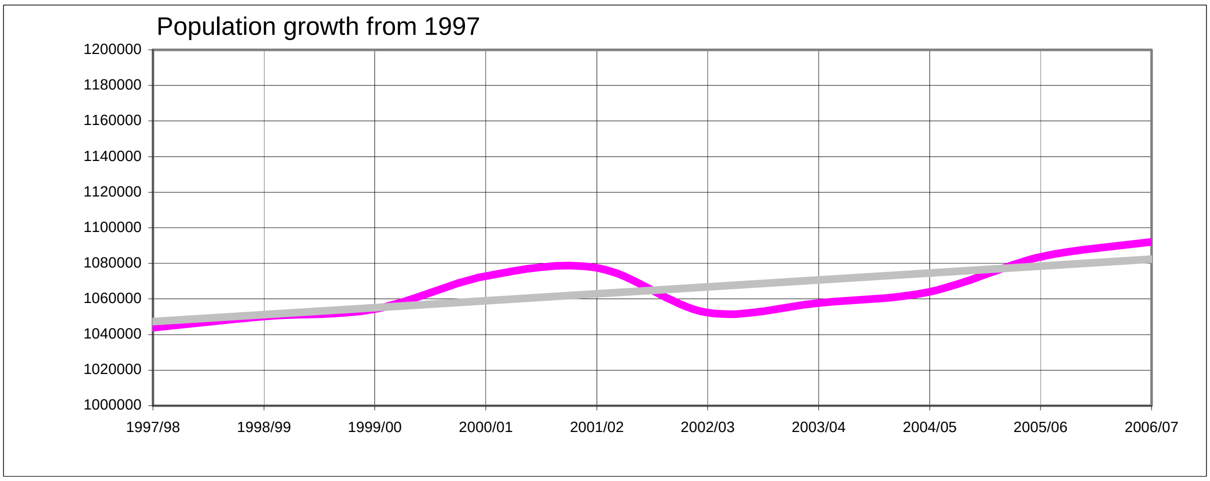
5.5 Base year population and properties

Both the population and number of properties continue to grow significantly in the Company area. The historic growth rate in domestic household properties has been approximately 1% p.a. and the growth in population has been approximately half of one per cent resulting in a steadily falling household occupancy rate.

5.5.1 Base year population

Marketing and demographic consultants CACI are used to produce annual estimates of populations and properties within the supply area and reconcile these with estimates from other sources. This activity is carried out as part the annual review prepared for Ofwat and is externally audited. The reported historic growth in household properties and population is shown below:





The apparent drop in population between 2001/02 and 2003/04 was due to the acknowledged data issues relating the 2001 census.

The CACI estimate of population is based upon the ONS 2001 Census data, updated by the latest ONS mid year estimate for population. This ONS mid year estimate is usually only available for a period of up to two years prior to any current reporting year, i.e. for the year 2006/07 report an ONS mid year estimate for census output areas was available for 2004.

CACI use the following databases to forecast the population at the mid point of the year 2006/07:

- 2001 Census of Population for a range of detailed information on population/property characteristics
- 2004 Mid Year Estimates for LA/UA districts (super output areas)
- Postal Address File counts of delivery point (properties)
- Various other input sources such as electoral roles, headships and household size projections

The method used to develop the forecast and ensure it is consistent with the LA/UA forecasts is relatively complex and is included in the appendices for this chapter.

For the purposes of the annual return to Ofwat, the company estimates the population for the extra few months to year-end 2006 by a simple linear regression to give the average population for winter. This will result in a slight difference between the CACI mid year population and the reported figure for 2006/07. The regression analysis indicated a population correction to winter 2006 of 4280 to give a total of 1092022. Following the annual Ofwat return, a later data set became available based upon the mid year 2005 ONS data set, and the 2007 postal address file geometry. As can be seen, the later CACI estimate is for practical purposes the same as the short-term regression forecast based on the 2004 ONS data. As a result, the base year population derived for the annual return has not been modified. The forecast is produced at the post-code level and is simple to aggregate to LA/UA level.

The supply area covers the following UA/LA in total:

- Bristol
- North Somerset
- South Gloucester

Parts of the following are also included within the company area:

- Bath and North East Somerset
- Gloucester
- Somerset
- Wiltshire

Base year population forecast reconciliation

	CACI PAF 06 estimate ONS 2004	CACI PAF 07 estimate ONS 2005	BW JR 07 Reported 2006/07	SWRA RSS S0 forecast 2006	ONS 2004 forecast 2006	ONS 2004 (Sept) forecast 2006
B&NES		78792	78737	78737	79846	80210
BRISTOL		402376	402095	405543	398700	404200
NSOMRST		198385	198246	197862	196600	200500
SGLOUC		250428	250253	248633	250200	255800
GLOUC		8790	8784	8784	8670	8658
SOMRST		151021	150915	150915	151235	151322
WILTS		2994	2992	2992	2260	2263
TOTAL	1087742	1092786	1092022	1093466	1087511	1102953

The table illustrates the various estimates of population from both trend and policy based sources, together with the CACI forecasts and the Bristol Water base year out-turn forecast. As can be seen, our base year estimate does not differ significantly from those provide from either policy or trend driven forecasts. The differences that do occur are due mainly to differing base year data used or forecast periods. These are not materially significant for water resource planning purposes when compared to other uncertainties.

There is considerable variation in the two forecasts provided in the same year from ONS. At the time the CACI forecast was completed the ONS re-forecast for 2006 from the mid year 2004 (Sept) estimate would not have been available.

For County or LA/UA areas that are not completely contained within the supply area, the population forecast for policy and trend based data has been factored pro rata by the ratio of the population from postcode areas within the Bristol Water area of supply compared to the County population. This proportion of the total population for each UA/LA area contained within the company supply area is indicated as a percentage in the table below.

Percentage of district population within Bristol WSZ

COUNTY / UA	PROPORTION OF POP IN BW AREA
B&NES	46%
GLOUC	1.5%
SOMRST	29%
WILTS	0.5%

5.5.2 Base year property types

The analysis and breakdown of the various property categories is carried out using the process developed to generate data for Table 7 of the annual Ofwat return (JR07). The company billing system (RAPID) is the source of the data, which is linked through Data Warehouse to other key company systems including GIS so that properties can be geo-located. The data is extracted on a monthly basis from the company billing system to provide the average property counts in the various categories over the year. The report specifically identifies all of the categories of non-household metered and un-metered customers together with household metered and un-metered categories.

The data has been corrected for metered households on a common single meter with a transfer of 3866 from non–household to metered household. In addition, a total of 7004 of the properties identified from the billing records are supplied from 509 communal meters. This data and methodology was been audited as part of the annual return to Ofwat

The property data from the annual return is indicated in the table below. Also shown are the estimates for the total household properties produced by CACI, two forecast from the CLG sources and one from the South West Regional Assembly, Scenario 1, Regional Spatial Strategy growth forecast. These latter forecasts are only available as total household counts. The CLG and RSS data is only provided at a LA/UA or County level. These total property counts have been factored to be company specific by the proportion of properties for the LA/UA or County falling within the company water supply zone to allow comparison.

Base year count of property type reconciliation of household property

PROPERTY TYPE	BW JR 07	CACI 2004	CLG 2003	CLG 2004	SWRA RSS S0
			(2006-0042)		
HH TOTAL PROPS	459044	462511	458340	459340	459044
HH TOTAL METRD	119097				
HH TOTAL UNMETRD	329373				
HH VOID	10574				
NON HH TOTAL PROPS	37382				
NON HH TOTAL METRD PROPS	30318				
NON HH TOTAL UNMETRD PROPS	7064				
NON HH VOID	2180				

The company has used the policy based forecasts for population and housing growth provided by the South West Regional Assembly when forecasting the future potable water customer base. The forecasts are only available at the LA/UA or county level. To establish the base year property count for each of the districts we have derived a reconciliation factor based on our JR07 out turn data for the numbers of properties in districts within the Bristol Water supply zone divided by the total number of properties in the district. This factor is then used to multiply future district forecast from the Draft RSS Scenario Zero to derive the population and property growth within the Company area.

The table below shows the reconciliation of the base year data and the factors derived for the total of household properties by administrative district.

Base year household property type by LA/UA/County reconciliation

LA/UA/COUNTY	BW JR 07 REPORTED	FACTOR	SWRA RSS S0 LA/UA TOT	BW AREA FACTORED
B&NES	**31338**	0.4206	74508	**31338**
BRISTOL	**169584**	0.9514	178255	**169584**
NSOMRST	**84795**	0.9573	88580	**84795**
SGLOUC	**104469**	0.9961	104880	**104469**
GLOUC	**3628**	0.0141	257045	**3628**
SOMRST	**63977**	0.2796	228822	**63977**
WILTS	**1253**	0.0045	277086	**1253**
TOTAL BW	**459044**			

5.5.3 Base year population categories

Base year data for population is the same as reported for JR07, the annual data return to Ofwat. The method used to assign the population to the various categories has been subject to annual audit and based on occupancy surveys as follows:

- Measured and indirectly measured households on a regular basis (2005/06 latest)
- Unmeasured mixed use non household on a regular basis (2006/07 latest)
- Measured non household sub-categories and indirectly measured households (i.e blocks of flats) on a regular basis (2005/06 latest)
- CACI estimate of population within communal establishments, (26,291 for 2004, included as past of the population assigned to measured non-household category).

The occupancy survey takes into account the various sub-categories of the household and non-household customer base. Sample surveys establish occupancy for each category type. The occupancy data is multiplied by the numbers of properties reported from the analysis of billing records for each sub-category to give the population totals for each category.

The sum of the populations for the four categories is subtracted from the total population forecast described above, to give the population associated with the non-measured household customers. The base year population by customer category is provided in the table below.

Base year population by category

TOTAL POPULATION	**1092022**
HH TOTAL POPULATION	1046168
HH METERED POPULATION	246653
HH UNMETERED POPULATION	799515
NON HH TOTAL POPULATION	45854
NON HH METERED POPULATION	42715
NON HH UNMETERED POPULATION	3139

For planning forecasts the results of the occupancy surveys have been aggregated to an average occupancy for the relevant customer categories are as below:

- Measured household 2.1 individuals per property
- Measured non household 2.2 individuals per property (inc. communal)
- Unmeasured non-household 1.1 individuals per property

5.6 Forecasting growth in the customer base

There is significant and substantial growth in both households and population planned for the Company area of supply. We have considered the latest forecasts developed from ONS trend based population data produced by the CLG department. We have also used the Policy based planning forecasts for the regional spatial strategy produced by the SWRA. In fact the SWRA has a number of scenarios, and we have considered two of these:

RSS Scenario zero
This is the growth rate of 23,000 new properties p.a. in the SWRA area as presented in the Draft RSS for examination in public.

Scenario 2
This is a high growth scenario with an additional growth of 5000 properties per annum targeted at existing urban centres across the region that would affect the West of England growth point including Bristol, Weston Super Mare and Bath.

These forecasts are based upon the growth in population derived from ONS population growth and migration and factored by local policy objectives for household formation rates.

The company has also reviewed the local development plans and discussed the issues of timing and size of growth with the significant Local Authorities within our area. We have checked the published development plans for housing from the Local Authorities where available with the policy and trend based forecasts for consistency.

The Local Authorities represented within the Company area are

- Bristol
- North Somerset
- South Gloucester
- Bath and North East Somerset
- Gloucester
- Somerset
- Wiltshire

Bristol, North Somerset and South Gloucester are all contained within the water supply zone. Approximately half of Bath and North East Somerset lies within the Company boundary. Only small parts of the County administrative districts lie within the water supply zone, the principal of which is Somerset, represented by Mendip DC.

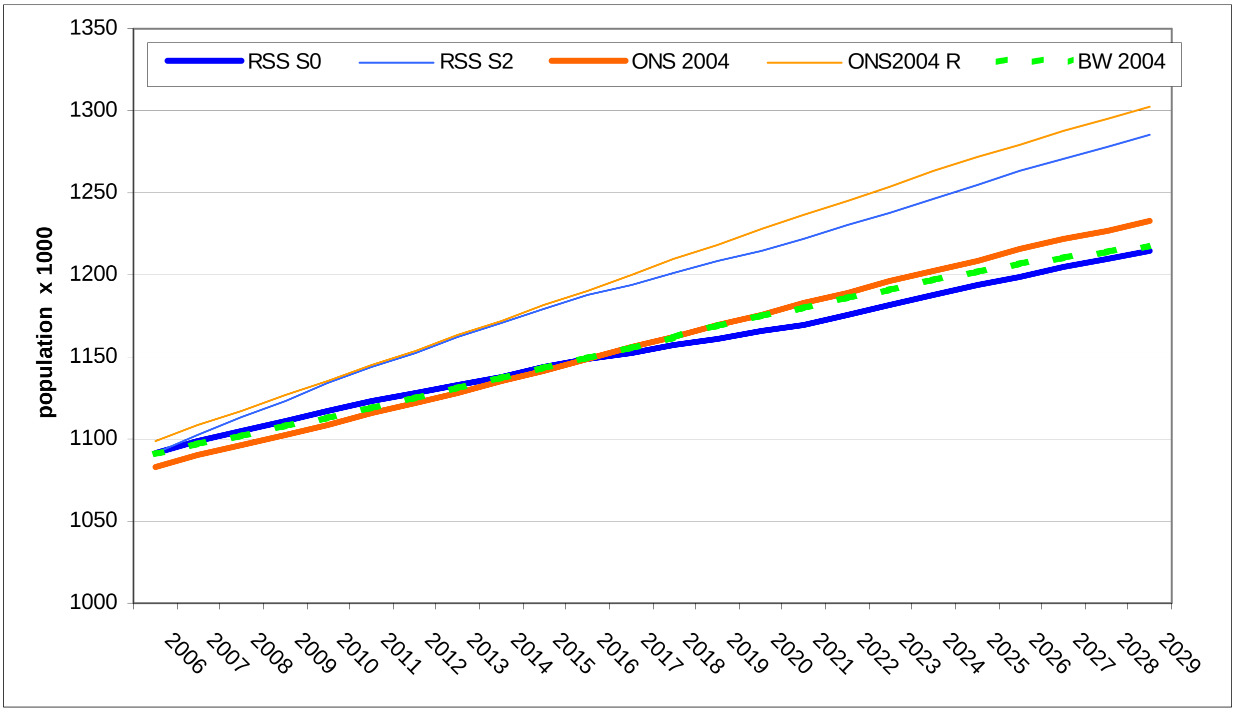
5.6.1 Population Growth

The population within the company water supply zone is forecast to grow significantly. However, many of the population forecasts are difficult to compare directly, as they have been carried out at different times and cover differing periods. The latest available forecasts have been obtained from government office web sites. In the case of the ONS forecasts, two were produced within the same year, the later one being significantly higher than the earlier one due to the inclusion of recent high rates of migration. The forecasts are not available for the full WRP period. Growth in population beyond the provided forecast period is continued to 2045 at the trend growth rate of the last 5 years of the available forecast data.

For comparison the forecast growth in population provided for the LA's we have reconciled to our water supply zone are:

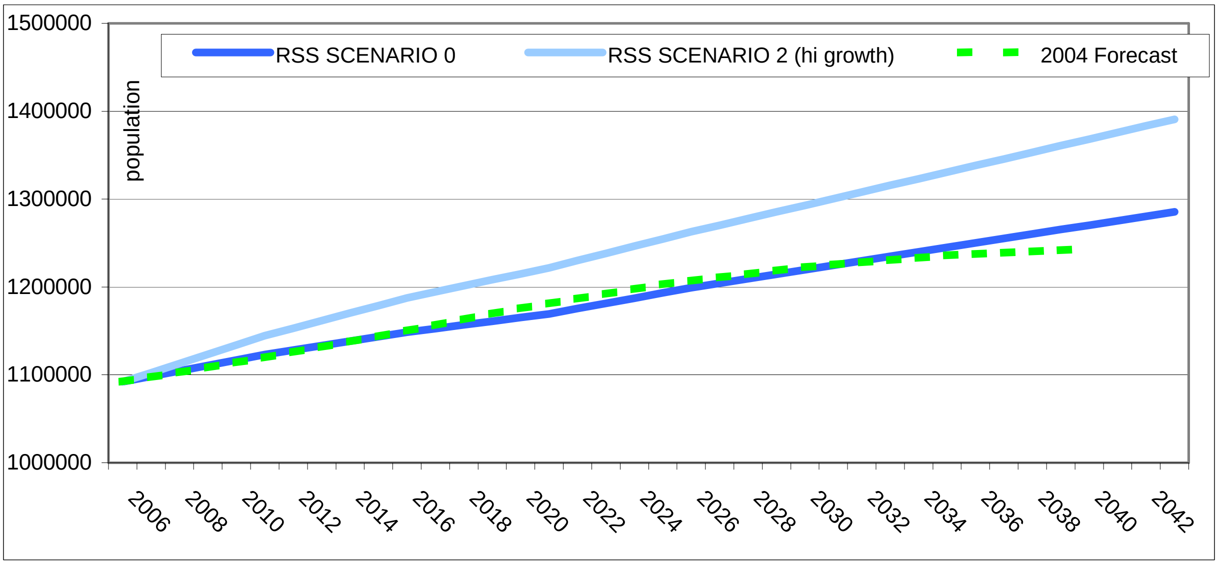
• Policy Based	SWRA scenario for draft RSS	to 2026
	SWRA scenario 2 high urban growth	to 2026
• Trend Based	ONS 2004 based early 2006	to 2029
	ONS 2004 based late 2006 re-forecast	to 2029
• Bristol Water	CACI 2004 PR04 forecast (for comparison)	to 2035

The forecast used for the PR09 population growth model is based upon the SWRA RSS S0 draft policy. The growth in population is forecast to be over 5000 p.a. in our area over the next 30 years. The various forecasts are displayed for comparison below.



As stated, the ONS trend based forecast 2004 R may be distorted by recent high rates if immigration, however the high growth policy based forecast from the SWRA may need to be considered as a potential sensitivity. However, the very high rate of house building that this rate of growth would imply has attracted a largely negative response from consultees and LAs across the region. The final outcome of the RSS examination in public together with the future policy growth rate is not expected until later in 2008.

The company planning forecast for population growth for the full period to 2040 is indicated below, together with the higher growth scenario and the past company population forecasts.



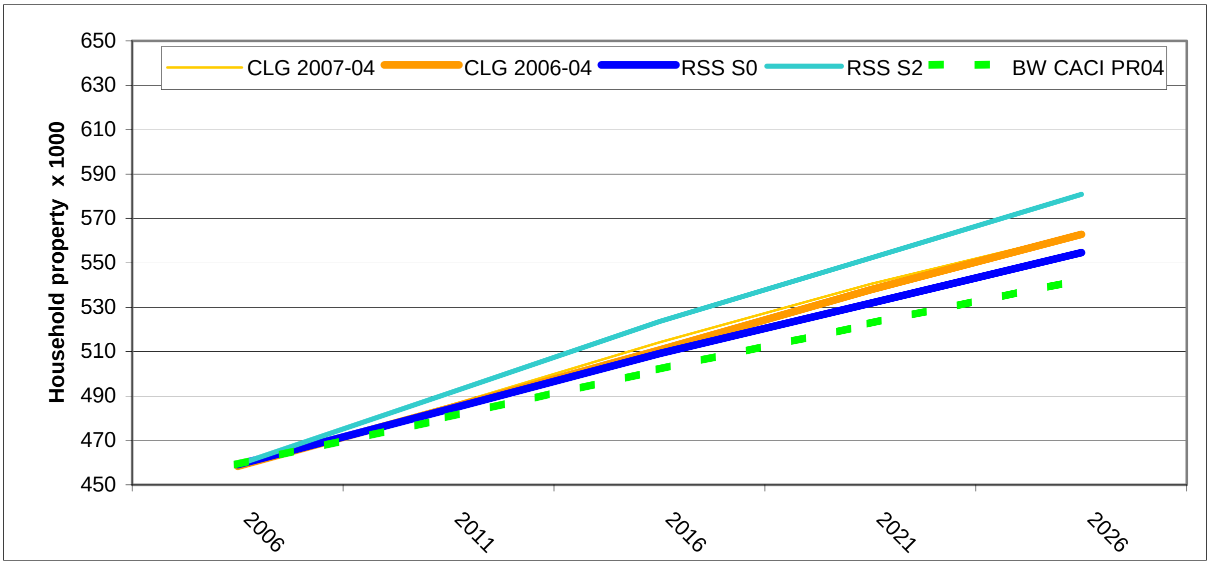
5.6.2 Household property growth

The latest available forecasts in the growth of household properties have been obtained from the policy based SWRA RSS web site and the trend based CLG forecasts which are based primarily on ONS population data and household formation rate trends. These forecasts were available only to 2026 in 5-year blocks (2029 for the latest CLG forecast). Beyond that period, the property growth rate in the last 5 years of the selected scenario was used as the trend growth rate in the period to 2040.

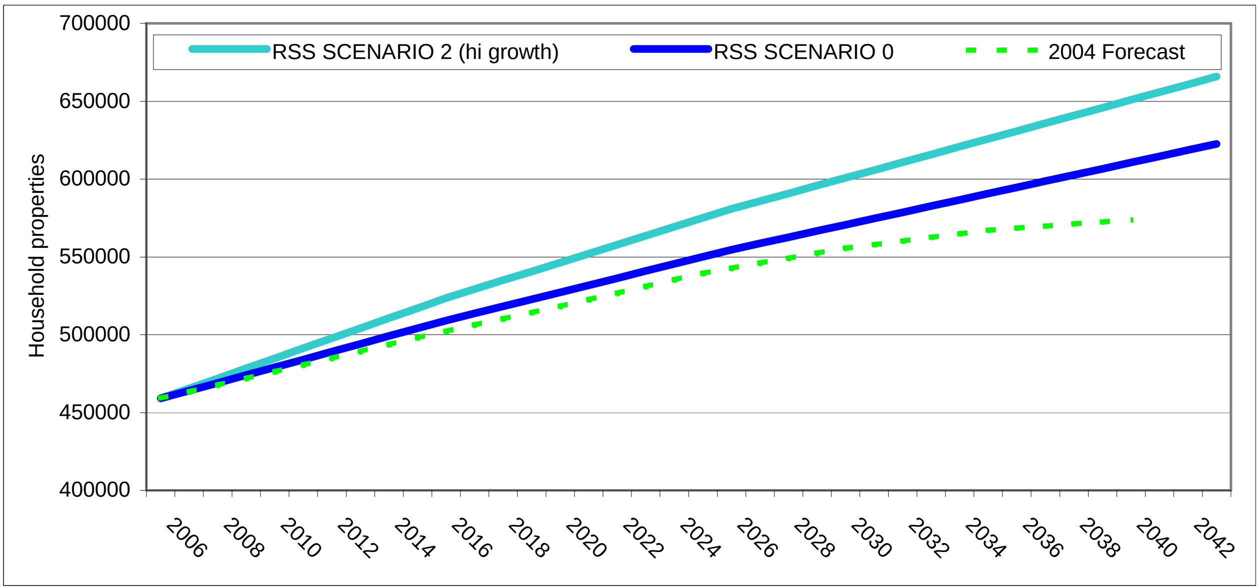
As with the ONS forecast, two household property forecasts were produced by the CLG, and both are shown for comparison, although there is little difference between the two. For comparison purposes we have reconciled the growth rates to the household property count in the company water supply area to these forecasts.

• Policy Based	SWRA scenario for draft RSS	to 2026
	SWRA scenario 2 high urban growth	to 2026
• Trend Based	CLG 2006 based early 2004	to 2026
	CLG 2007 based late 2004	to 2029
• Bristol Water	CACI 2004 PR04 forecast (for comparison)	to 2035

The forecast used for the PR09 property growth model is based upon the SWRA RSS S0 draft policy. This is forecast to result in 5000 new properties p.a. being constructed in the supply zone over the next 30 years, broadly in line with recent trend of 1% growth. All of the various housing growth forecasts are displayed for comparison below.



The company planning forecast for growth in numbers of household properties for the full period to 2040 is indicated below. This is the same as the SWRA policy based forecast for the draft RSS and is shown together with the higher growth RSS scenario and the past company forecast prepared at PR04.



Of the Local Authorities and Counties within the company area, the following have produced their own housing development forecasts up to 2026 that can be compared directly with the various forecasts for the Government agencies. Note that these forecasts are for complete LA areas and have not been adjusted for the company water supply zone

Comparative forecasts for total properties within LA by 2026

HH PROPERTY	SWRA RSS S0 Forecast total 2026	SWRA RSS S2 Forecast total 2026	CLG 2007 Sept Forecast total 2026
B&NES	**90000**	95000	90000
BRISTOL	**206000**	215000	207000
NSOMRST	**115000**	122000	108000
SGLOUC	**128000**	135000	126000
GLOUC	**306000**	315000	296000
SOMRST	**278000**	286000	298000
WILTS	**346000**	362000	236000

Comparative forecasts for increase in properties within LA by 2026

HH PROPERTY	LA STRUCTURE PLANS Published increase	SWRA RSS S0 Forecast increase 2026	SWRA RSS S2 Forecast increase 2026	CLG 2007 Sept Forecast increase 2026
B&NES	15500	**16000**	20000	16000
BRISTOL	28000	**28000**	37000	34000
NSOMRST	26000	**26000**	33000	23000
SGLOUC	23000	**23000**	30000	22000
GLOUC		**49000**	58000	47000
SOMRST	*44800	**49000**	58000	64000
WILTS		**69000**	85000	48000

* Forecast for 2011

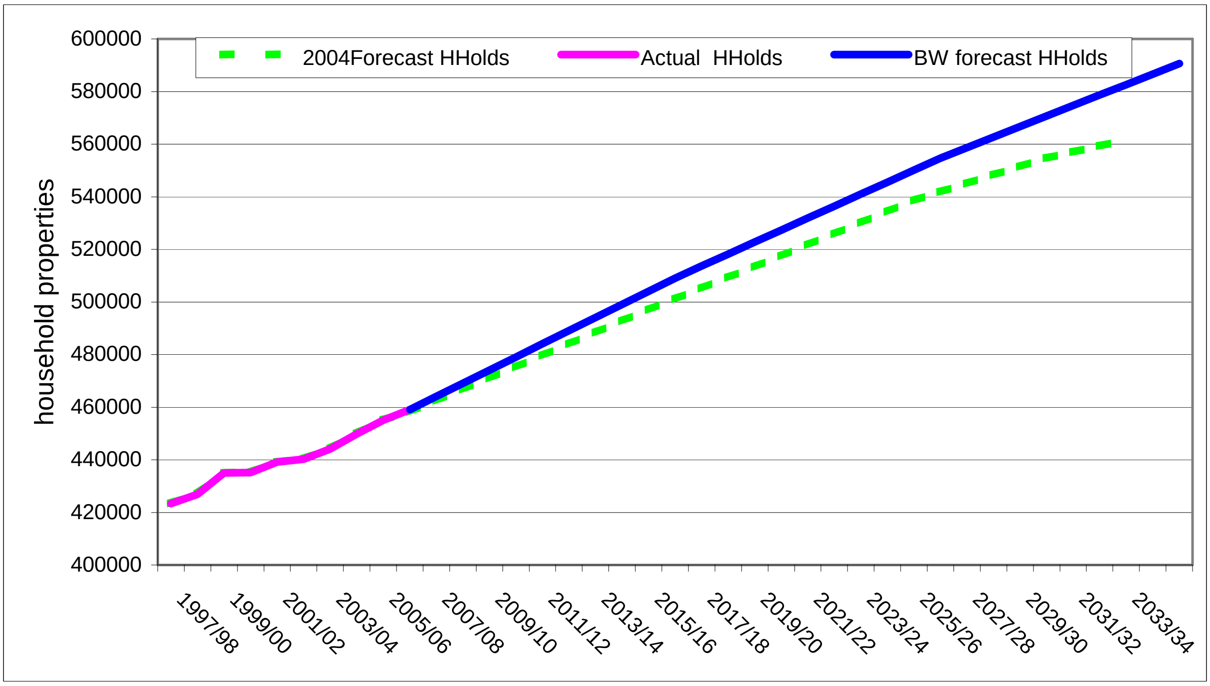
It is clear that the CLG have forecast housing growth that is similar to the SWRA RSS0 planning policy (although there is some variation). In the case of the counties of Gloucester, Somerset and Wiltshire a lack of updated forecasts meant that older data to the period 2011was used and these values may change in future.

The growth in household property numbers have been reconciled to the company water supply zone by using the proportion of domestic households of the LA within the company area to factor the growth in property numbers at each quinquennium for that LA. This forecast is provided in the table below. Also provided in the table are the forecasts of housing growth within recently published LA policy strategies. Our 2026 outturn forecasts compare very closely with the available LA forecasts, except in the case of Somerset for which recent district data was not available, and older comparative data was used.

Comparative forecast of increase in properties reconciled to Company water supply zone

HH PROPERTY	LA STRUCTURE PLANS Published increases To 2026	BW WSZ RSS S0 Forecast increase 2026	BW WSZ RSS S2 Forecast increase 2026	CLG 2007 Sept Forecast increase 2026
B&NES	7500	**7000**	9000	7000
BRISTOL	28000	**27000**	35000	34000
NSOMRST	26000	**25000**	32000	23000
SGLOUC	23000	**23000**	30000	22000
GLOUC	na	**1000**	1000	1000
SOMRST	*11000	**14000**	16000	18000
WILTS	na	**500**	500	200
	* Revised structure plans not available based on forecast for 2011	**98000**	**124000**	**105000**

Although the baseline predicted increase in housing growth from the SWRA RSS S0 is higher than forecasts made in the 2004 Water Resources Plan, the rate of growth is consistent with the actual observed increase in the numbers of households over the past 10 years, as shown below.



5.6.3 Baseline population and property forecast

For the draft Water Resources Plan, we have used the policy based forecast that equates to the RSS base scenario for the region (Scenario zero). At the time of the preparation of our plan we were advised by the Southwest Regional Assembly's RSS team that this was the most likely policy to be adopted. This also appeared to be the view of the LA's, as their planning forecasts match the base scenario growth rate very closely.

We are now aware that the following the public examination, recommendations were made that the SWRA should consider the higher policy growth rate (Scenario 2). We have not had a formal confirmation of this position, or the revised forecast numbers for population and properties. We will review the position with the SWRA before publication of our final plan.

5.7 Forecasting household demand for water

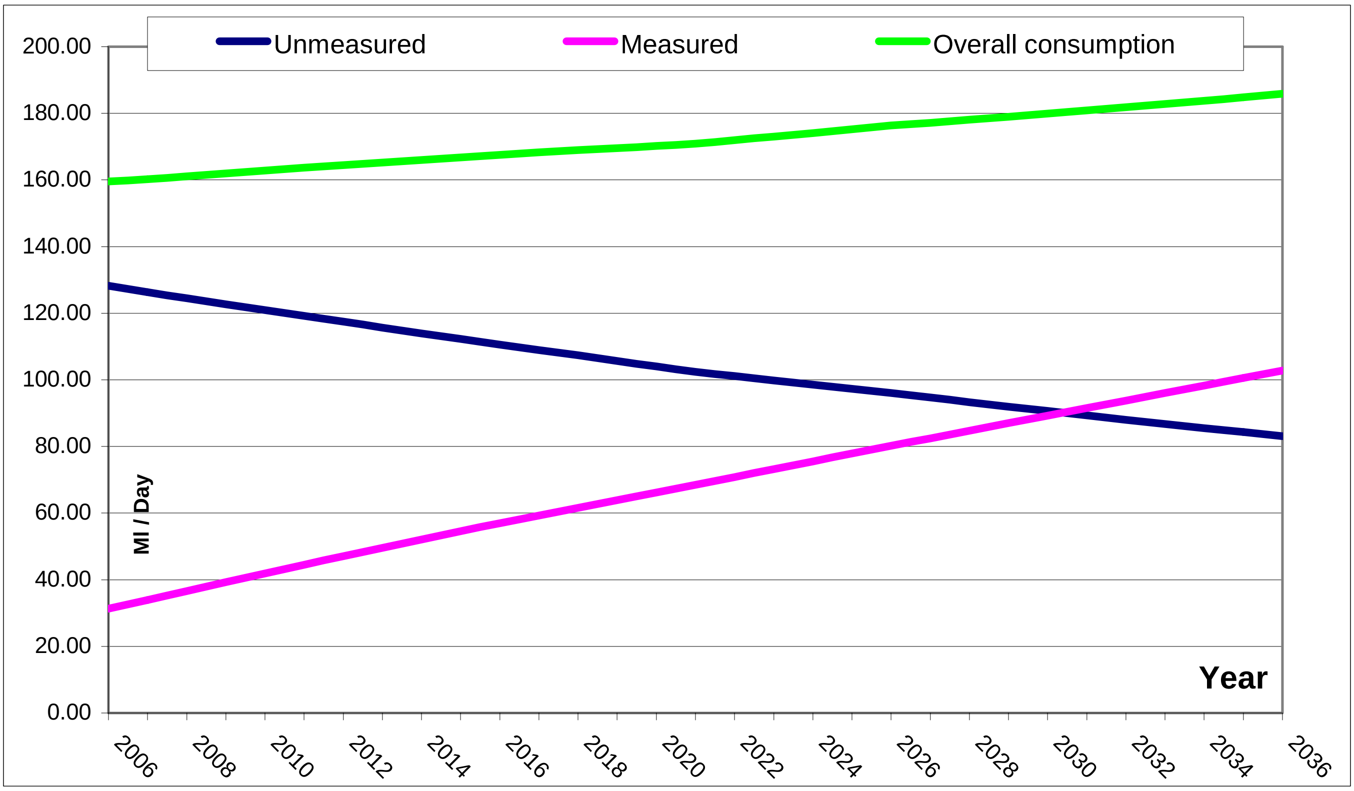
The numbers of properties and increase in population is a significant will result in an increased demand for water in future. Just as significant is the manner in which water is used within the home and the assumptions made regarding future trends in water use and appliance efficiency.

In our baseline forecast we have assumed that most replacement domestic water-using devices will increase in efficiency to their limiting values and most new homes will be built to have an efficiency standard equivalent to the Government sponsored Code 3 for sustainable homes. We also assume that there will be a certain amount of discretionary water use in new homes that will result in actual consumption being slightly higher than the 105 lcd specified in the Code. The impact of these improvements in efficiency will be reduced by a tendency for increased leisure use of water and trends towards retro-fitting larger baths and more powerful showers, as has been the case in recent years.

Although the number of properties supplied will increase by over 20% by 2026 and by 30% by 2035, household demand for water increases by less than 10% due to the efficiency assumptions made in the baseline forecast.

Approximately 5000 customers per annum will opt to switch from an un-metered supply to a metered supply over the plan period. This increase in metering is an additional factor in constraining household demand for water. By 2036, the volume of household consumption that is unmeasured falls from 75% to approximately 45%.

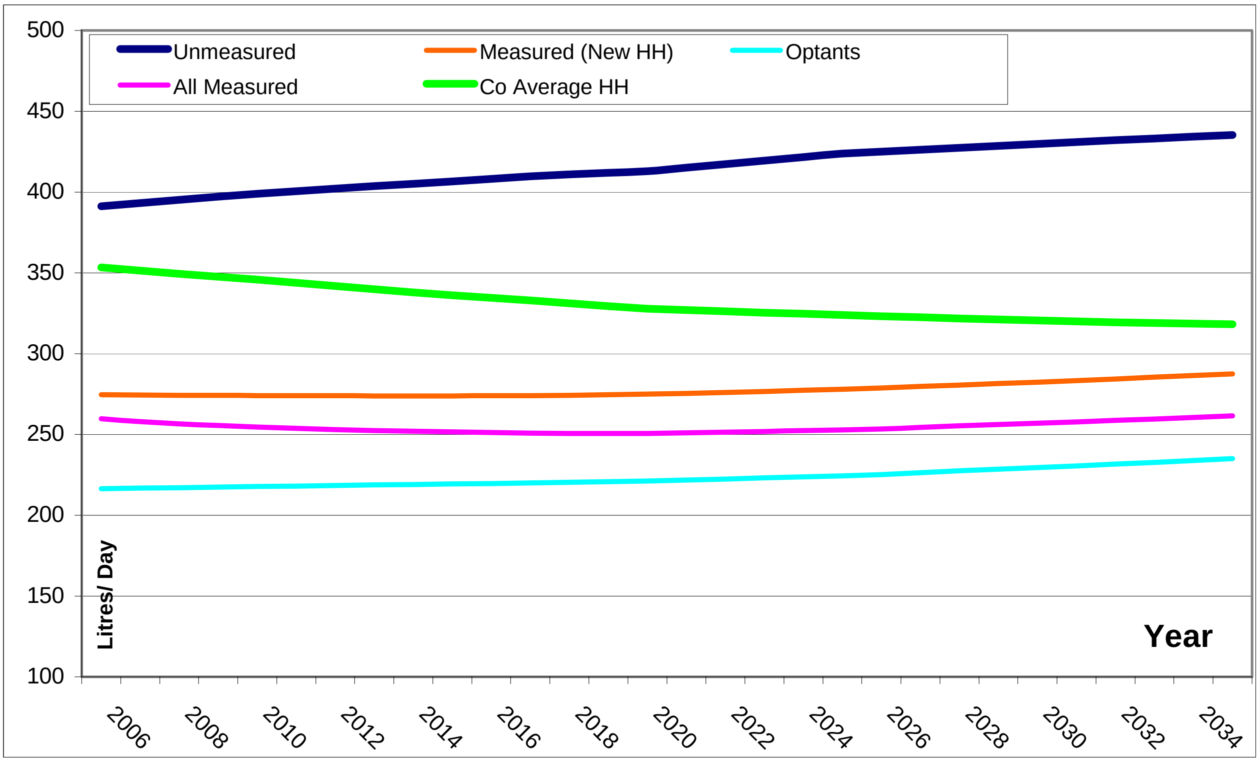
Overall impact of baseline demand assumptions on household consumption by category



The implication of the assumptions we have made in the component forecasts is that overall household consumption declines with time, but the remaining un-metered households consume more water as the more ‘water aware’ customers switches to metering.

There is also an assumption of a slight increase in household consumption of newly metered properties from initially low levels reflecting ‘sustainable’ homes or a cautious response to the cost of metered water. With time, the maximum efficiency of water-using devices will have been reached and increasing affluence and lifestyle choices are likely to have a greater impact on water consumption.

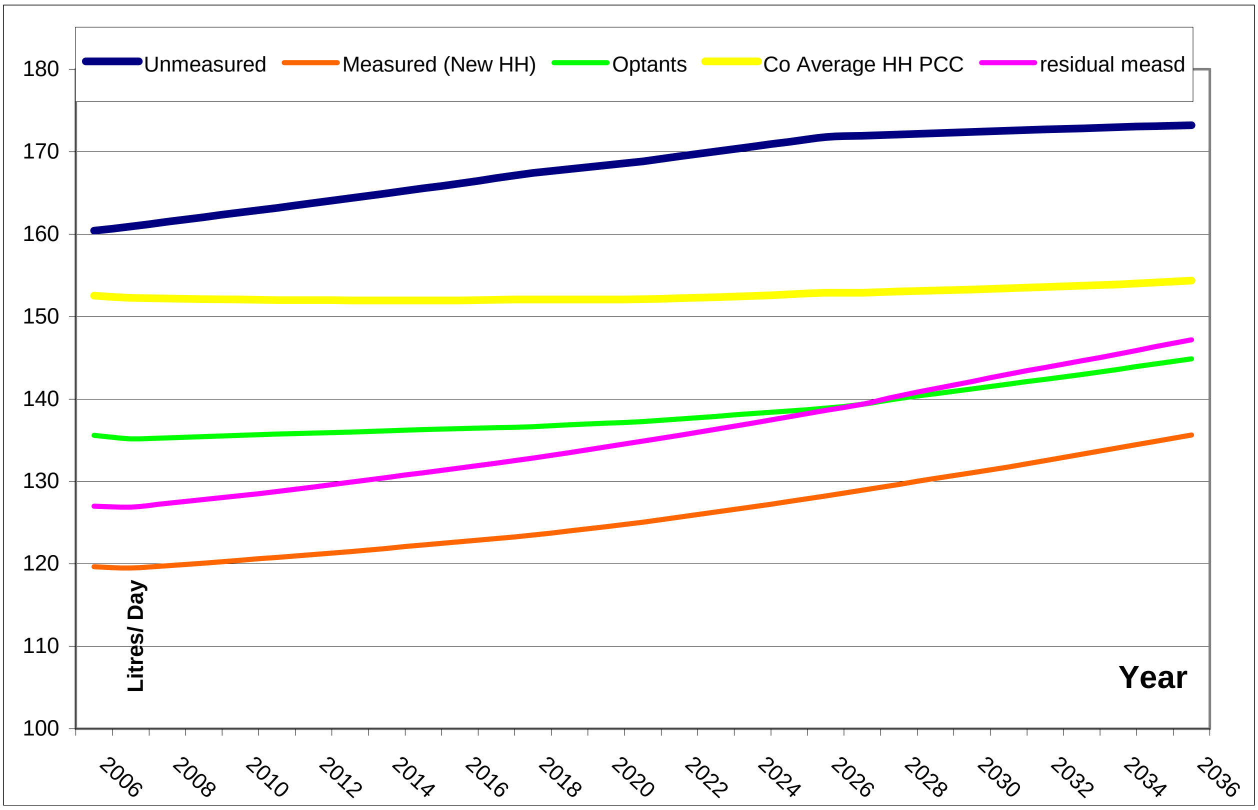
Baseline forecast of household consumption for customer categories



The results of the analysis in terms of daily Per-Capita Consumption (PCC) in litres per person per day indicate a broadly static PCC over the plan period for the company overall. However, for some groups of customers PCC will increase. In the case of un-metered households, this increase is driven by the residual of low efficiency households as the more efficient opt for a metered supply.

For metered customers, the increase in PCC is actually driven by the decline in occupancy. The fact that PCC is so sensitive to occupancy suggests that it is a poor indicator of overall water efficiency.

Baseline forecast of PCC for customer categories



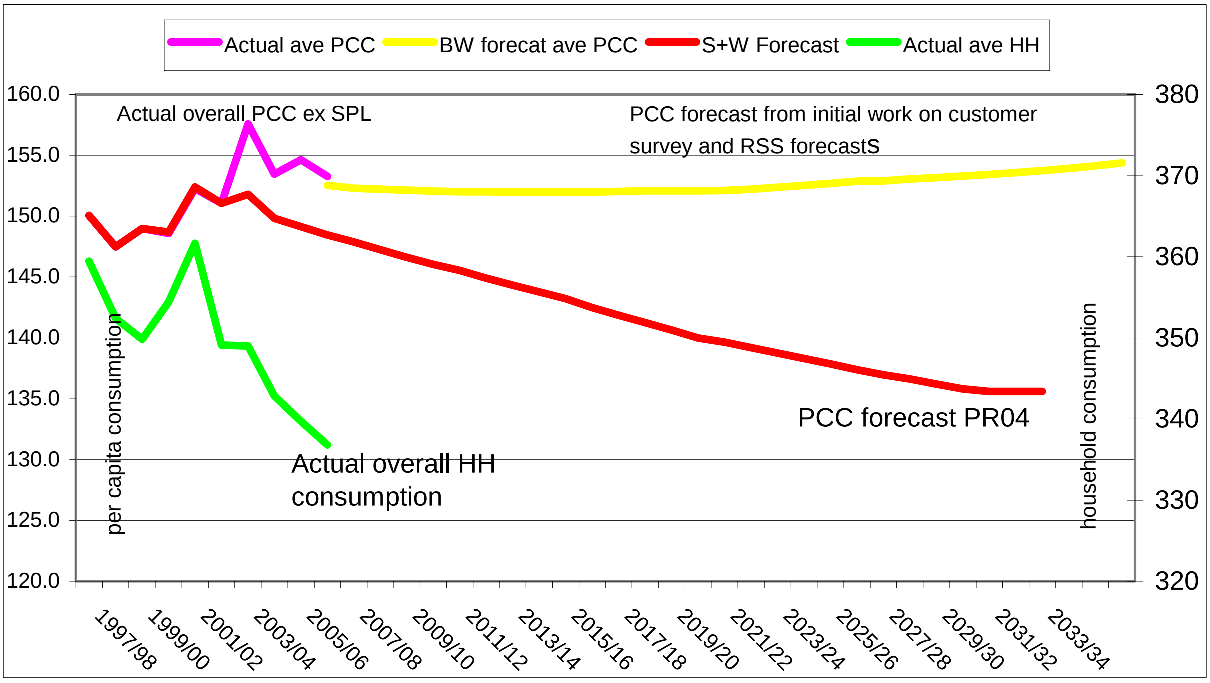
The past two econometric forecasts by leading consultants had predicted that PCC would fall rapidly in response to the availability of more efficient water-using appliances, the uptake of metering, the increase in prices and changing attitudes to water use. In fact, that has not happened.

Our customers tell us that in 2007 over 50% of households have low volume or dual flush WC cisterns, with over 40% claiming to have a water efficient washing machine or dishwasher. Despite these major improvements and the increases in metering that have taken place over the past 10 years, PCC has increased on average by nearly 5 litres per day.

To express it another way PCC is now 10 litres per person higher than the position would be, had the original econometric forecast in 1997 been correct, as indicated on the plot below. The other factors that may be more significant driving domestic consumption and in particular PCC are:

- Falling household occupancy
- Increasing discretionary use of water
- Personal bathing regarded as a leisure activity
- Low cost of water relative to other goods and services

Comparison of past PCC with forecast PCC and household consumption



It is encouraging that domestic consumption expressed as a volume per household is falling, indicating that metering and other efficiency actions are being taken up. However, these initiatives are being off-set by the falling occupancy leading to, at best, a stable PCC in future.

We would consider the baseline forecast for PCC to be quite optimistic in relation to past performance and depends upon all new homes being constructed to an unprecedented water efficiency standard and remaining at that level in the future. This may be achievable in theory but turn out to be difficult to sustain in practice.

Local Authorities have advised us that over half of the planned housing growth has already been given permission and construction may begin before there is any real legislative force to drive water efficiency in new build housing. Questions still remain regarding the following issues:

- The long-term effectiveness of the voluntary Code for Sustainable homes
- Code 3 whole building only applies to social housing
- Weak planning controls on developers
- The lack of a ‘fittings’ based approach to water efficiency in homes
- Poor product design and labelling
- The lack of progress or target date for updating Building Regulations
- Lack of impact of market transformation programme
- Lack of regulatory and statutory support for water efficiency

We support the contention that it is technically possible to force down water consumption. However, the practical effects of water efficiency measures based on a consensual rather than a legislative approach remains to be proven.

5.7.1 Forecasting the micro-components of household demand

The company uses a micro-component approach to disaggregate the total consumption figures recorded for metered and un-metered households customers. The base year data has been allocated to a range of domestic water consumption categories. These categories include the following:

WC	toilet flushing
INT TAP	kitchen and personal use
BATH	personal bathing
SHOWER	personal washing by power shower or normal shower
DISHWASHER	machine dishwashing only
WASHING MACHINE	machine clothes washing
DISCRETIONARY	external use gardening, car washing, by hose can or bucket

In the detailed analysis, these categories are sub-divided for further analysis, so that the take-up of devices such as power showers can be forecast separately from ordinary showers. There also is a distinction made between consumption that is a function of household owned devices such a washing machines and personal or population driven components such as showers. In addition, we have allowed for differing patterns of consumption for the differing groups of household customers in the baseline and forecast identified as:

UN-METERED	Considered to be the least efficient and least water aware
METER OPTANTS	Those with low use opting for meter to make financial gain
EXISTING METERED	The current household meter base, moderately efficient
NEW METERED	New housing with defined efficiency assumptions

An extra category of selectively metered customers is also considered when considering water efficiency options when developing the final planning solution.

In analysing the consumption of water, account is taken of the following:

- The ownership or take up of the various water using devices or categories
- The frequency of use of the devices or use categories
- The expected consumption of each device or use class

We have drawn on many sources to collate this information, including results of a survey of our customers wherever possible. The sources we have used are:

- Past econometric component analysis
- Mintel marketing database
- Waterwise reports and data
- WRc report Domestic Water Use Data for Demand Management P6832
- Other water company data (Southern and Anglian)
- Bristol Water customer survey

The components of water consumption of metered and un-metered household categories have been reconciled against the base year PCC, using the population and house numbers for that year. The apportionment of consumption to the various components has been based on the sources outlined above using the WRc research data and customer survey information.

Assumptions have also been made in respect of probable future trends for the efficiency of water using devices and changes in the pattern of use. For example, we expect the trend for water using devices to become more efficient to continue for the next ten years, but ultimately to reach limiting values. Other broad trends identified are:

- Ownership of devices such as washing machines and power showers increase in future
- Manual dishwashing decreases
- Small ‘discretionary’ use increase reflecting water used to support ‘leisure’ activity
- WC consumption falls due to dual flush and reducing size
- Bath size and shower increase to 2020
- Bathing and showering become more frequent
- Water used by domestic devices decreases to minimum by 2020 from better design
- Personal and discretionary consumption increases slightly over time

In the light of the past ten years of evidence, we consider that the large reductions in per capita consumption that we forecast in the past now look increasingly unlikely. These past forecasts were driven by assumed increases in the efficiency of domestic appliances. The changes to the drivers of consumption that we forecast have actually occurred, but per capita consumption has not, The changes to key drivers over the past ten years are:

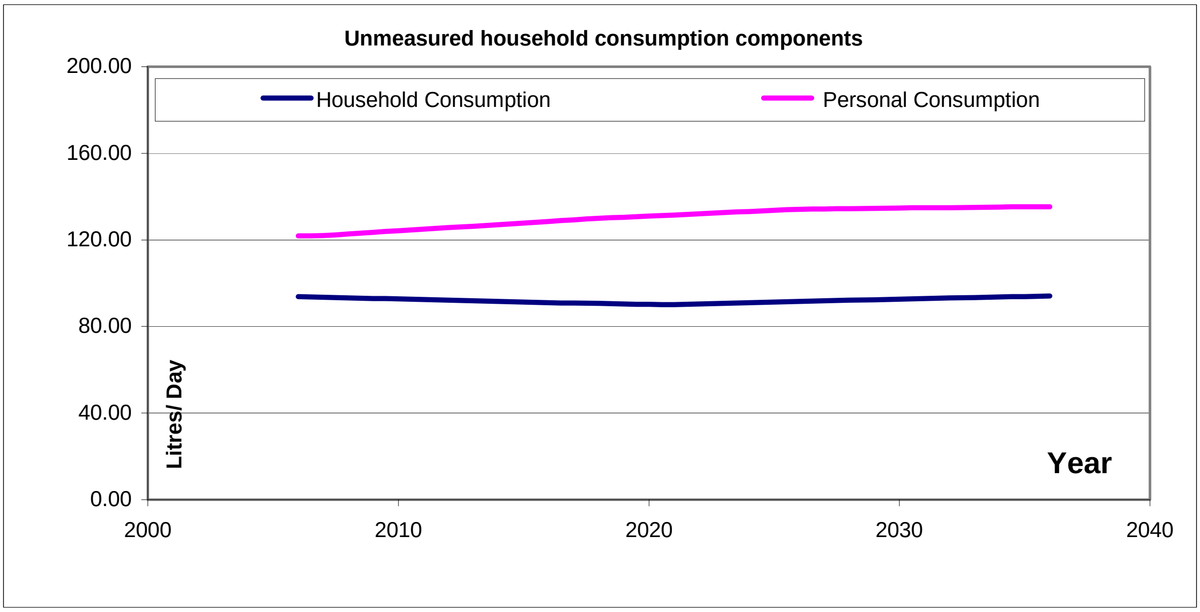
- Over half of existing customers have higher efficiency water-using devices
- Half of our customers have high efficiency or dual flush WC cisterns
- Appliances are now quite close to their maximum efficiency
- There is an increasing trend toward a leisure component of water use
- The trend for housing occupancy to fall
- Limited impact of demand reduction tools

During the period in which these changes have occurred, meter penetration has also increased to 30%, yet overall per capita water consumption has actually increased quite markedly from 150 l/hd/d to 155 l/hd/d

5.7.2 Un-metered households

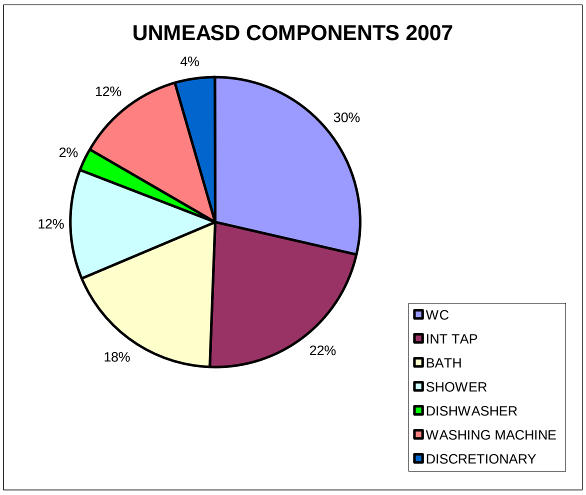
From the company analysis of water input to the distribution system and the company consumption monitor, un-metered households have the highest PCC of 160 lcd. In the forecast, we expect the un-metered customers to have low initial take-up of water efficient devices and a slower replacement rate compared to the metered customers. In addition, water consumption for personal use is higher and discretionary use of water is also higher.

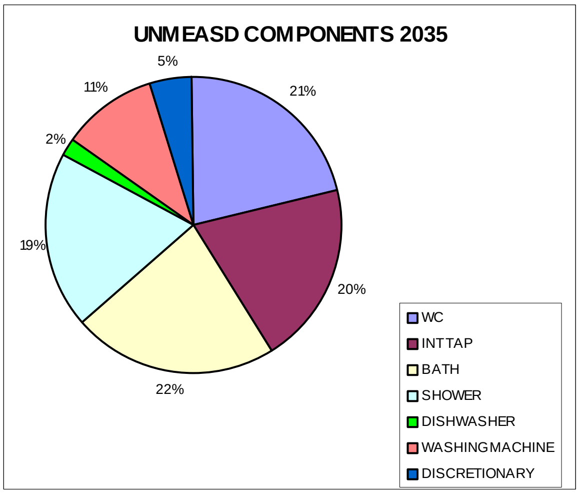
To calculate demand for water, the consumption components are split into those associated with communal in house activity such as use of washing machines or discretionary use and components associated with personal water consumption such as WC flushing and bathing, as illustrated below.



To aggregate demand to that expected for a typical household in future years, the personal elements of consumption have been multiplied by occupancy rate and added to the sum of the communal demand components for the forecast year.

The proportion of each of the components of the total household demand at average occupancy for the base year and at the end of the plan period are shown below:





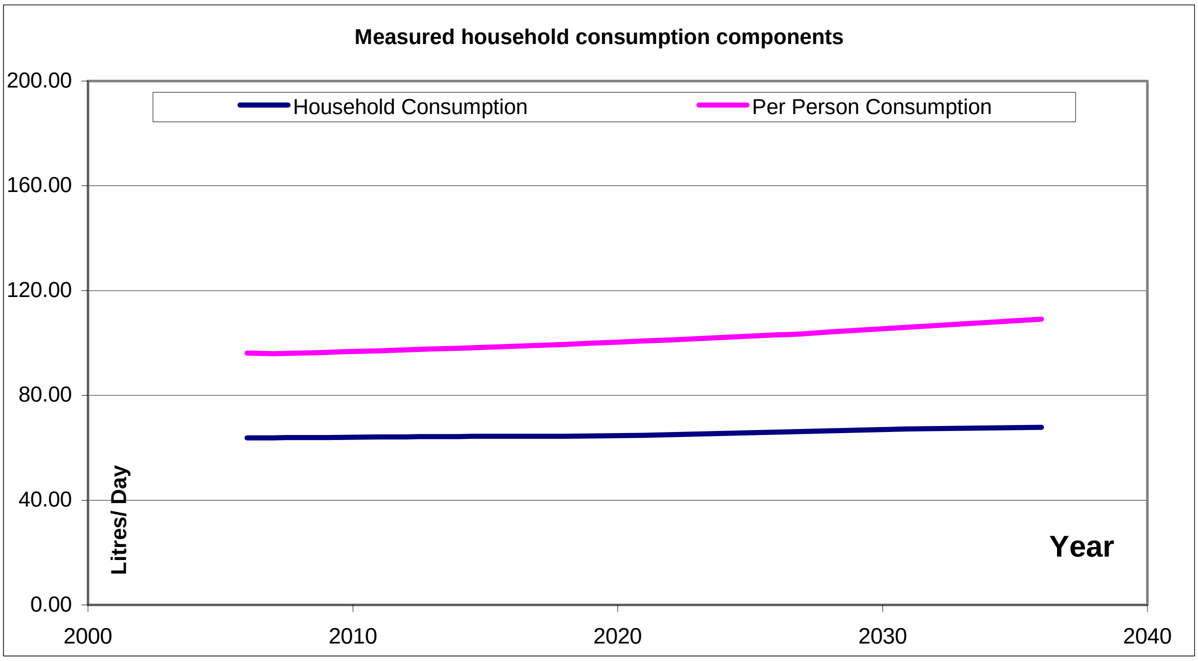
During the period of the plan, household consumption for this group of customers increases from 389 l/p/d to 439 l/p/d, while PCC also increases from 160 l/hd/d to 173 l/hd/d, a value held down by the predicted increase in household occupancy for this group. This change is driven by the forecast that more efficient and water aware customers leave the pool of un-metered customers to switch to a metered supply. This change will leave a rump of increasingly less efficient unmeasured customers with little or no incentives to change their behaviour

5.7.3 Metered households (existing mix of optants and new build)

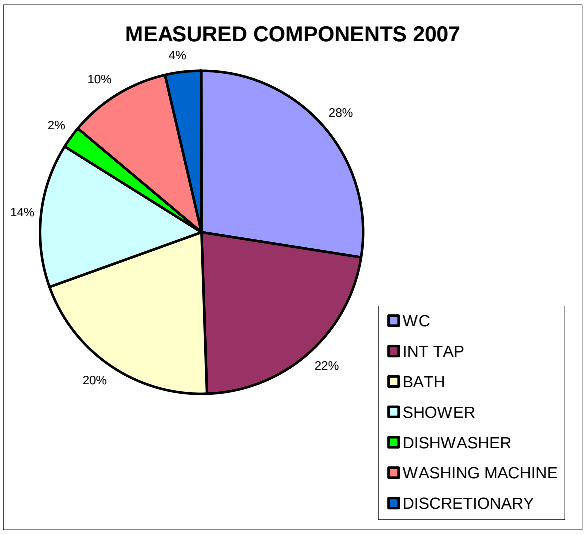
This group of customers includes new properties that are automatically metered together with a significant number of meter optants that would have slightly differing household characteristics. Of this mixture, approximately one third of households were originally meter optants. Meter optants are usually more water aware than the bulk of un-metered customers, but may have a higher PCC than a new property as they are typified by low occupancy households opting for metering as a lower cost option compared to charging based on rateable value.

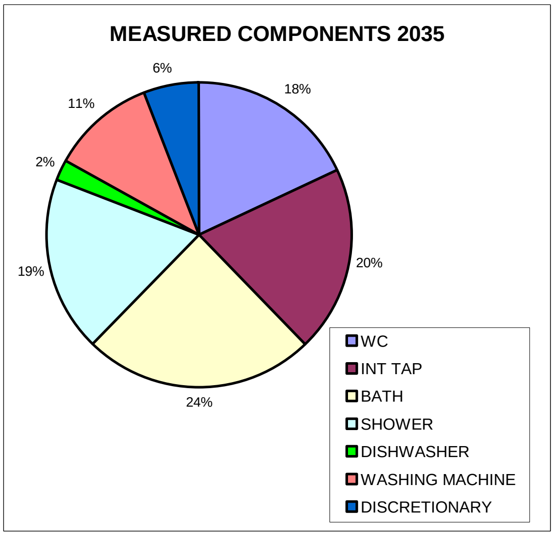
From the company analysis of water input to the distribution system and the company billing record for metered households, the PCC calculated from the meter reading was 127 l/hd/d (i.e. ignoring the effect of meter under-reading). In the forecast, we expect this group of metered customers to have higher initial take-up of water efficient devices customers and a slightly faster uptake in future of modern water using devices, including power showers.

We expect attitudes to water use in this group of customers to be different and more conservative than un-metered customers, with lower rates of discretionary use, lower rates of device use and lower rates of personal water use (i.e. use of showers rather than baths etc.).



The proportion of each of the components of the total demand for the base year and at the end of the plan period are shown below:





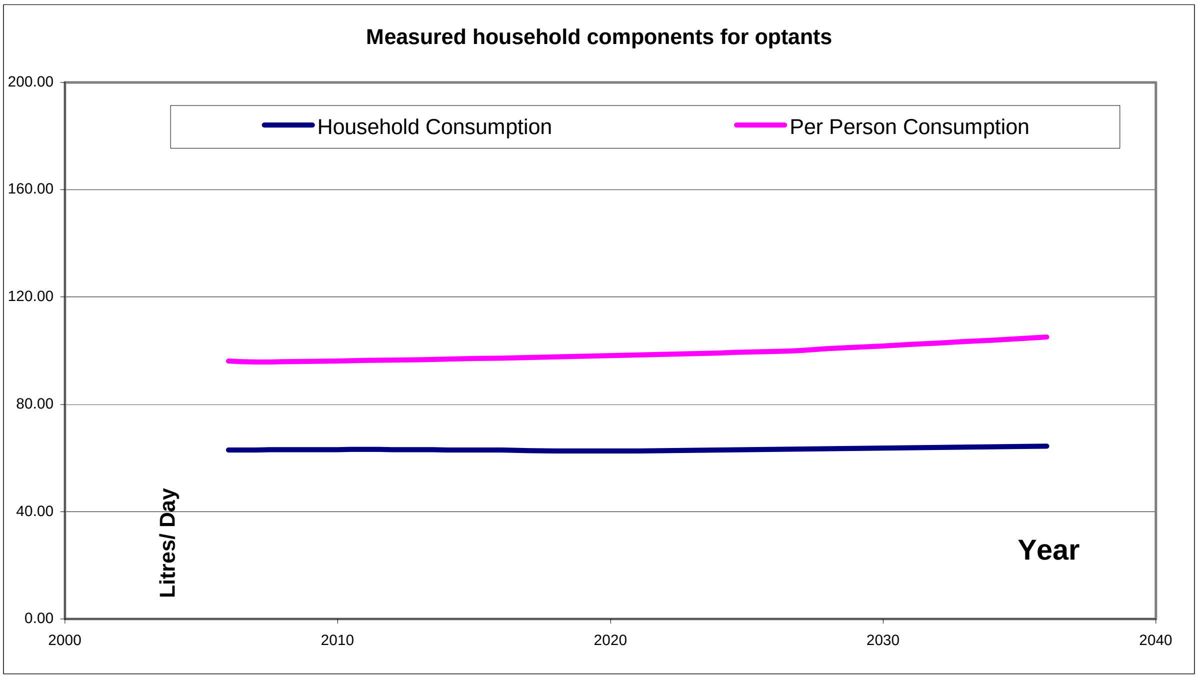
During the period of the plan, household consumption for this group of customers decreases from 266 l/p/d to 253 l/p/d, while PCC increases from 126 l/hd/d to 149 l/hd/d. The PCC increase is due to the steadily falling occupancy for this group, which is forecast to fall from 2.1 to 1.7 persons per household.

5.7.4 Meter optant households (current baseline metering policy)

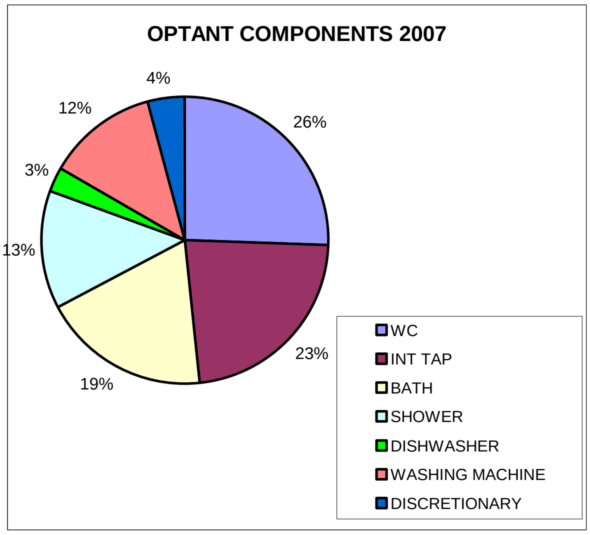
This group of customers includes households typified by low occupancy and high rateable value, often including a significant proportion of childless couples or those on fixed incomes. The reason for the switch from an un-measured supply to a measured supply is usually because of the likely financial savings. Meter optants are usually more water aware than the bulk of un-metered customers, but have a PCC somewhere between that of existing metered and un-metered households due to their low occupancy rate of 1.6 persons per property.

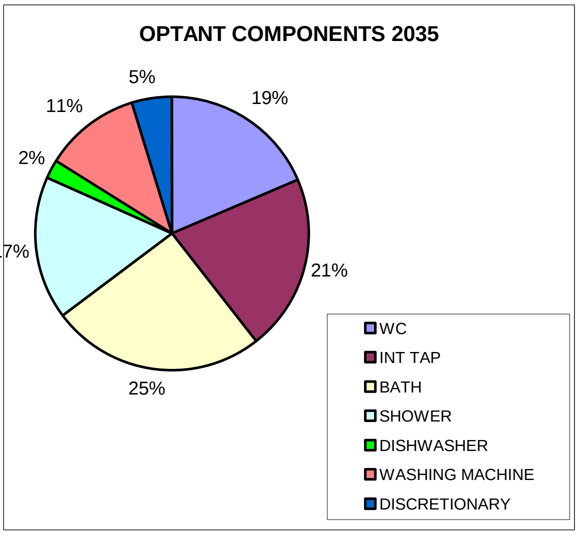
From the company analysis of the company billing record for optant metered households, the PCC calculated from the meter reading was 136 l/hd/d (ignoring the effect of meter under-reading). In the base year we assume this group of customers has a very similar component usage to the metered households. The model assumes lower rates of discretionary use, lower rates of device use and lower rates of personal water use (i.e. use of showers rather than baths etc.).

In the baseline forecast, the tendency to opt for a water meter is expected to continue into the future at approximately the same percentile rate of remaining un-measured household. We expect this group of households will make the same set of lifestyle choices, but be slightly more conservative in water consumption when compared to current metered households. However, as the numbers of very low occupancy households decrease due to the opting process, the occupancy rate of this group of customers increases slightly with time.



The proportion of each of the components of the total demand for the base year and at the end of the plan period are shown below:





During the period of the plan, household consumption for this group of customers increases from 216 l/p/d to 239 /lp/d, while PCC also increases from 136 l/hd/d to 144 l/hd/d The small PCC increase is due to the small increase in occupancy rates from 1.6 to 1.7 persons per household.

5.7.5 New build metered households

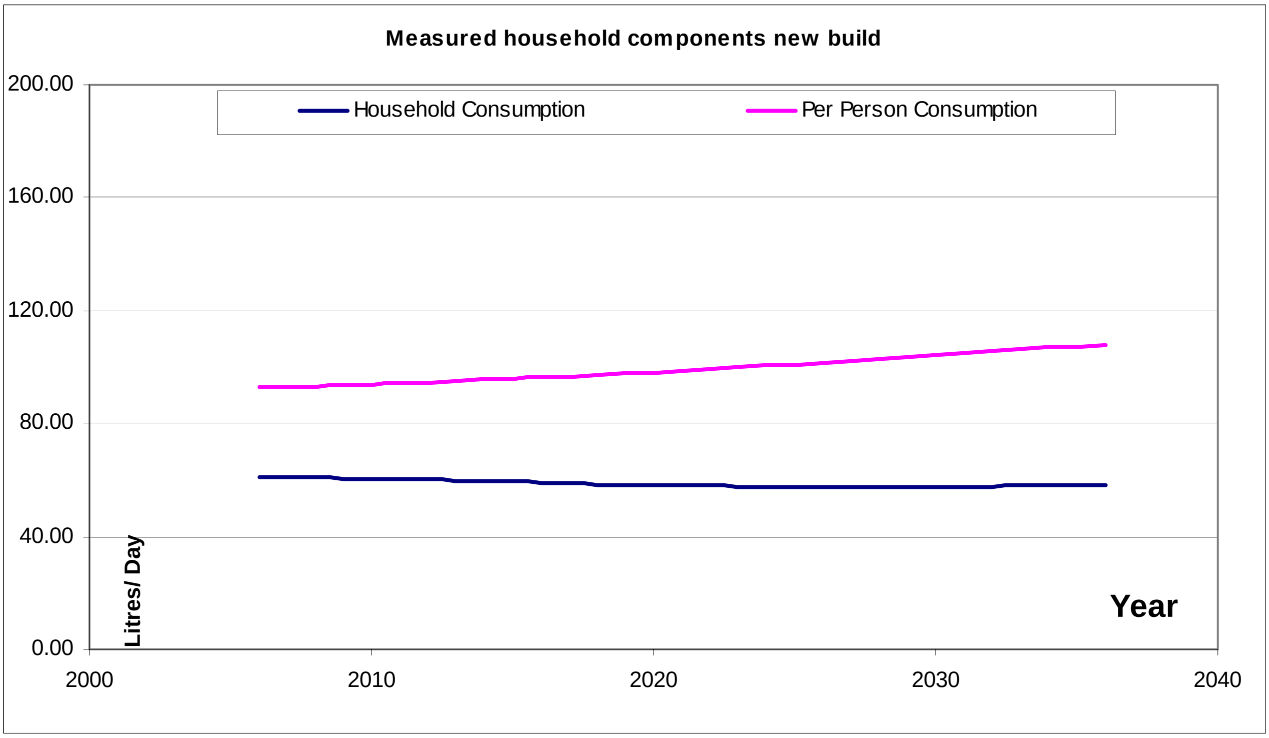
This group represents all new properties that are assumed to be constructed with the latest fittings and devices, following best practice and codes for sustainable buildings. It would be improbable that all houses built from 2008 would be constructed to level 3 of the Code for Sustainable homes. The Code has no legal or planning force at present and is not based on the performance of fittings within the dwelling. In addition, the daily PCC quoted in the code for sustainable homes does not include any allowance for discretionary use such as car washing, garden watering etc.

The Code for Sustainable Homes specifies three levels of water consumption:

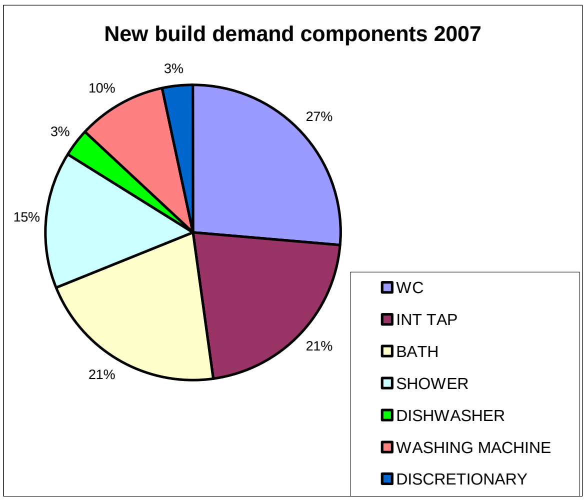
- Code 2 PCC 120 l/hd/d
- Code 3 PCC 105 l/hd/d
- Code 5 PCC 80 l/hd/d (requiring water recycling or rainwater harvesting)

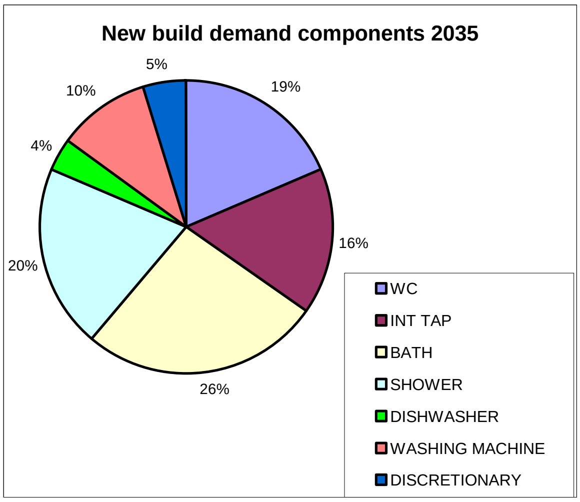
We expect that most new homes will be constructed to Code 2 standards and some will meet Code 3 (at least initially, even though this code applies only to social housing at present). We also expect that homes will be constructed with gardens and car spaces, requiring an allowance for discretionary water use similar to that for existing metered properties. This approach results in an initial forecast PCC for new homes of 119 l/hd/d (or an average of 113 l/hd/d excluding discretionary water use to reflect the realistic mix of homes at differing codes, with and without gardens). The forecast is based on assumptions such as ownership of low volume or dual flush WCs being 100%, maximum efficiency for washing machines and dishwashers and general positive attitudes to water efficiency prevailing to reduce the rate at which low consumption fittings are replaced with higher flow devices.

As with past consumer trends, increasing affluence and lifestyle choices are expected to result in a small but sustained increase in personal consumption as bathroom and kitchen fittings are replaced, offset by improvements in the efficiency.



The proportion of each of the components of the total demand for the base year and at the end of the plan period are shown below:





During the period of the plan, household consumption for this group of customers decreases from 275 l/p/d to 2/6/7 lpd, while PCC increases from 119 l/hd/d to 138 l/hd/d. The PCC increase is due mainly to the decrease in occupancy rates from 2.3 to 1.9 persons per household over the plan period.

5.7.6 Selectively metered households

This group of customers represents domestic households that are compulsorily metered as part of a policy decision to decrease water consumption for supply/demand balance reasons. Our policy in this area will be to initially meter houses with large gardens when there is an occupier change until 2020. After 2020, we expect that acceptance of metering will be general and we can continue with a programme of universal metering. In this way we can offset the higher cost of random installation of meters in the early years with a larger water saving. When metering is universal, the cost will decrease as the work can be more efficiently organised and economies of scale apply.

A selective metering policy will impact previously un-metered households. Therefore we expect this group of customers to have appliance ownership and usage similar to existing un-metered households. However, it is well documented that the change to a metered supply can reduce demand. The demand reduction with time is assumed to take place proportionally across the range of component consumption for the dry year as follows:

- Household device based consumption 10%
- Personal use consumption 5%

In the case of a universal metering programme, the sample of selectively metered properties will have the same characteristics as the un-metered households throughout the forecast period. The reduction approximates to a total consumption reduction of 7% when changing from an unmeasured supply to a measured supply.

5.8 Non-Household water demand

Non-household demand for water comprises the industrial and commercial sectors of the customer base. The bulk of the demand is for potable supplies of water. Included in this component is a very small element of domestic consumption in the instances where the commercial premises have an associated dwelling, as may be the case on some small farms. In these examples, the domestic component is not disaggregated as it so small and immaterial when compared to the overall quantity of non-household component.

In addition to the potable water supplied to non-households, the company has a significant reservation agreement to provide a non-potable water supply to a major customer in the Avonmouth industrial zone with up to 16 Ml/d (referred to in section 4 - water transfers)

5.8.1 Non-Household potable water demand

Approximately 95% of all non-household demand is metered, the remaining un-metered units are primarily small premises or farm troughs. As it is company policy to meter all supplies greater than 20mm, these supplies are all on small volume domestic size meters of less than 20mm.

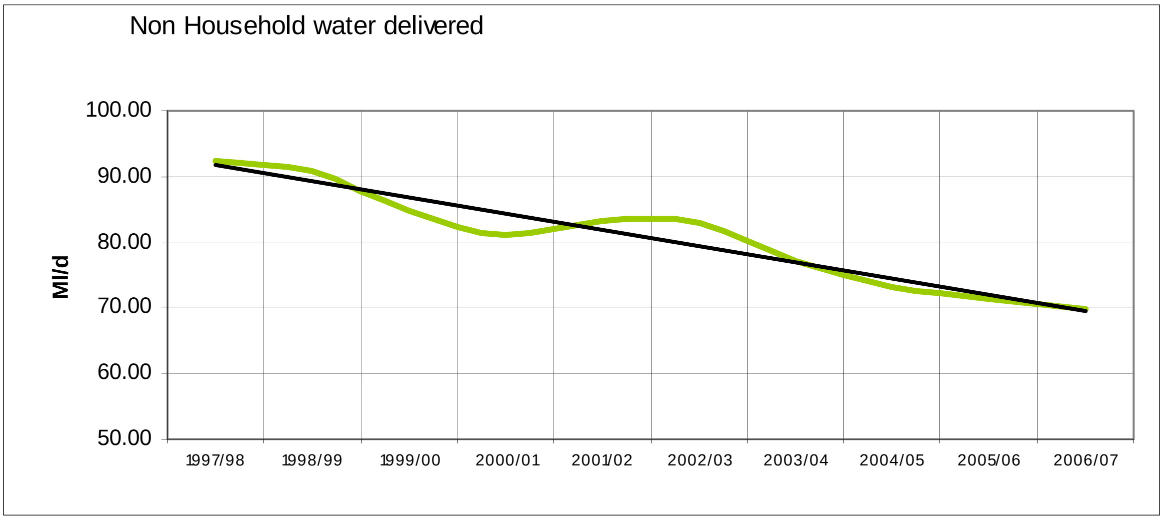
Metered non-household potable water consumption was reported as 63 Ml/d for the year 2006/07. Consumption data is extracted from the billing record for the non-household customers and provided by Bristol and Wessex Billing Services. Because the billing cycle for most of the non-household customers is six monthly, an accrual is made for water delivered, but not billed during the reporting year.

Consumption reported for the un-metered non-household customers was 4 Ml/d in 2006/07. This is estimated by assigning to the identified properties the average consumption for the equivalent SIC code for small meters. Selective metering of this group of customers will continue at a rate of between 300 to 400 p.a. so the volume attributed to this sector will fall until 2015 as part of the baseline plan. After that, the volume is forecast to remain constant at under 3Ml/d.

Due to the large numbers of smaller customers, the overall number of non-household customers has remained relatively constant over the past ten years, although the demand for water has decreased. Non-household demand now accounts for only 25% of the total amount of water put into the distribution system, compared to over 30% ten years ago. This has been largely due to de-industrialisation and the loss of small numbers of larger commercial and industrial customers.

We have also encouraged customers to take more interest in reviewing their water consumption and increasing their efficiency. An example of this is the provision of on-line metering data offered to large water users to allow a measure of self-audit of water use. Further competitive pressures are likely to be a factor for private industry in reducing water consumption in future as a means of cutting costs. Inefficiency of water use in the public sector still remains an issue, however, we expect the recent statutory duty on public bodies to ‘have regard to the efficient use of water’ to exert an effect in the longer term.

Decline in potable Non-Household water demand



5.8.2 Forecasting metered non-household water demand

We have used NERA econometric consultants to forecast the trends in industrial and commercial consumption, as we consider this will be determined by wider macro-economic operating across the region (output and employment being the main indicators).

There is a wide diversity of industry types represented in the company area, but relatively small numbers and associated consumption within each class. NERA precluded an analysis based on complete subdivision of all of the non-metered customers into all of the individual Standard Industrial Classification (SIC) types. To do this would have led to spurious forecasts where data for some classifications is sparse.

As a way of avoiding this, the non-household data has been grouped into the broader categories indicated in the table below.

NERA CODE	NERA NAME	SIC INCLUDED IN GROUP
1	Primary products and metals	A B C DH DI DJ
2	Food drink and tobacco	DA
3	Chemicals, oils and manufactures	DB – DG DK-DN
4	Public services	L M N
5	Other services (banking, hospitality etc.)	G H I J K O P Q
6	Other sectors (utility, building, gas etc.)	E F

The econometric model is based on the use of a verified data set for customers having consumption above 5Ml p.a. divided according to SIC. A regression model was constructed using the historic measured non-household data from 2003, past water prices, producer prices and employment for each of the NERA groups indicated.
The model parameters for each group of industries were:

- Index of economic activity for LA areas
- Marginal increase in water prices
- Time trend reflecting past activity (for customers >5 Ml/d)

A 5 Ml/d demand cut off was used to exclude very small customers. This allows the best estimate of relationship between consumption and explanatory variables without the ‘noise’ induced by the high variability of consumption associated with large numbers of small customers.

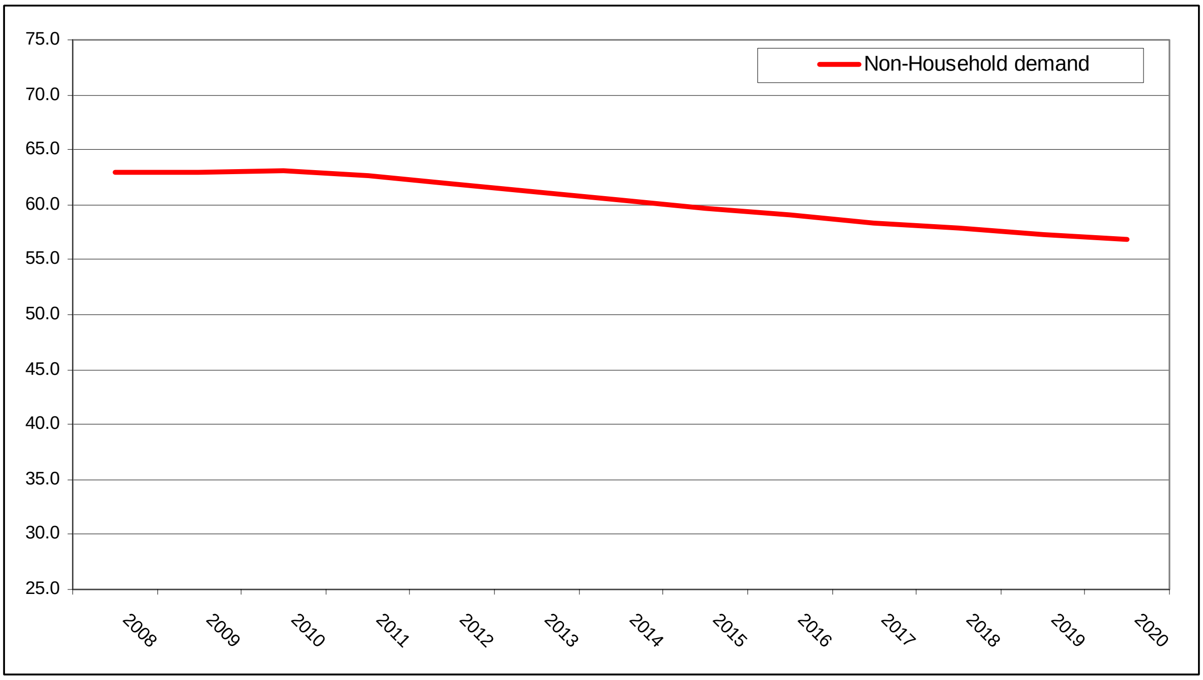
Experian Business Services provided a forecast of macroeconomic activity to 2020 for all LA areas within the company area. This forecast together with a forward estimate of marginal water charges was used to generate the coefficients of growth for the larger customers within each of the groups.

The model takes the coefficients obtained from the regression analysis of consumption and economic activity for large consumers to generate the forecast of consumption for the remaining smaller customers within the various groups.

The observed time trend for the larger non-household customers was strongly negative, a feature not seen in the non-household customers below 5 Ml p.a. However, the negative time trend is consistent with the observed loss of larger water users from de-industrialisation of the area. This negative time trend was used as part of the forecast for the large customers, but excluded from the model used to forecast demand for the small customers, to avoid distorting output for that sector.

There remains a considerable uncertainty over the forecast for non-household water demand based on long-term trends. A single large customer setting up or closing an operation could result in a rapid and substantial departure from the trend based econometric forecast presented.

The two forecasts were aggregated to give the predicted non-household consumption to 2020, shown below.

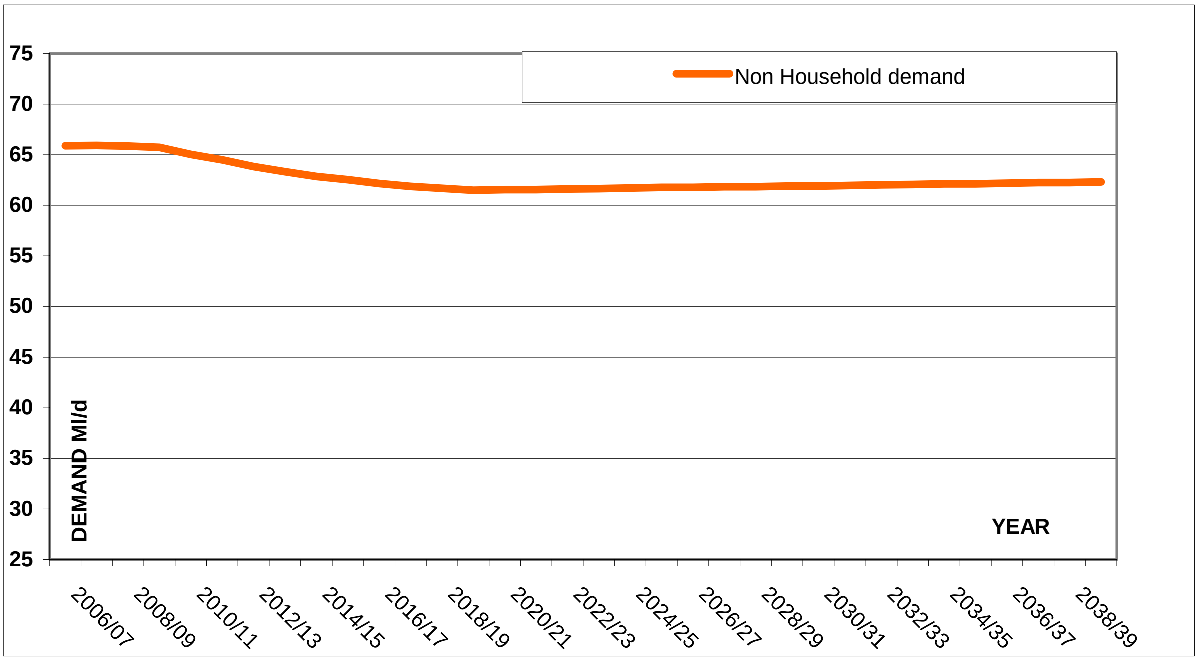


Because of the high rate of population and housing growth forecast in the strategic population policy for the supply area, we would not expect this negative trend to continue indefinitely for the following reasons:

- The loss of business and therefore employment opportunities must reach a limiting value, otherwise there may insufficient economic infrastructure to support the forecast growth in population and housing.

- The trend for improved water efficiency and more efficient water-using devices in shops, offices, public sector catering and other premises is also likely to reach a point of diminishing effectiveness in time, to be overtaken by employment growth effects.

For the period beyond 2020 to 2035, we have forecast a slight growth trend in non-household consumption of 0.4% p.a. based upon the rate of population increase in the region. The outturn plan forecast for the company area is indicated in the plot below.



The long-term baseline forecast of non-household potable water demand includes the following assumptions.

- Continued trend of 2 to 2.5% in long-term UK economic growth
- Continued long term decline of heavier and larger process industries
- Static consumption pattern for existing smaller customers across sectors
- No allowance for sudden loss or gain of very large customers
- Growth in public and service sector offset by improvements in water efficiency
- Growth beyond 2020 proportional to population growth

The full details of the NERA report on non-household demand for water are contained within appendix 5.

Section 6. Water Efficiency and Leakage Control

6.1 Water Efficiency and Metering

The company fulfils its statutory duties to promote the efficient use of water by the following activities:

- Free provision of meters to households wishing to change to a metered tariff
- Metering of all new household properties
- Selective metering of the non-household customers.
- A free service pipe repair policy 'Leakstop'
- Targeted and seasonal water efficiency activity aimed at promoting water awareness
- Water education activity aimed at children and schools
- Distribution of domestic water audit packs and advice
- Distribution of cistern displacement devices and advice
- Information on fittings and use of water butts, trigger sprays etc.
- Offering audits and online consumption monitoring for business customers

6.1.1 Water Efficiency

We have a current policy for water efficiency activity that we consider covers the majority of the items identified as appropriate for a company in our circumstances in the Ofwat Good Practice Guidelines for water efficiency initiatives. This includes items listed above as well as:

- Web site with advice on garden watering and household device consumption
- Web site with self audit advice and advice on advantages of metering
- Promotion/distribution of water efficiency calendar
- Use of newspapers and company newsletter to present conservation message
- Dedicated environmental and education centre
- School visits and educational programme
- Use of specific awareness campaigns (lagging of pipes in freezing weather)
- Provision of free leak-line number on web site and company vehicles
- Offer of onsite leakage and efficiency surveys to business customers

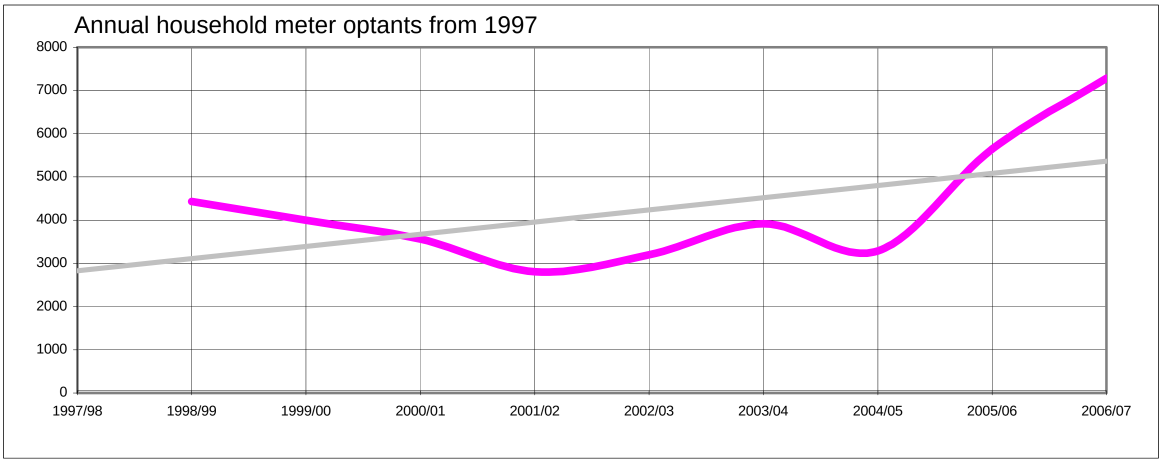
Our current Water Efficiency Policy included as part of the baseline supply demand forecast is contained within appendix 6.

Although there is a considerable level of activity being carried out, in practice it is difficult to measure precisely how effective these measures would be in reducing demand during a dry year. The evidence base is deficient in many of these areas. For this reason do not claim a significant impact on water efficiency arising from any of these activities in the baseline supply-demand forecast.

We consider that the water efficiency activities we carry out provide valuable information and sets an agenda for water awareness with our customers. However, the cost is relatively high, especially when balanced against the uncertain yield from the activities. Despite this, we have included efficiency schemes that could generate a measurable yield in our list of options to balance supply and demand in future. These are considered fully in the section on Options Appraisal.

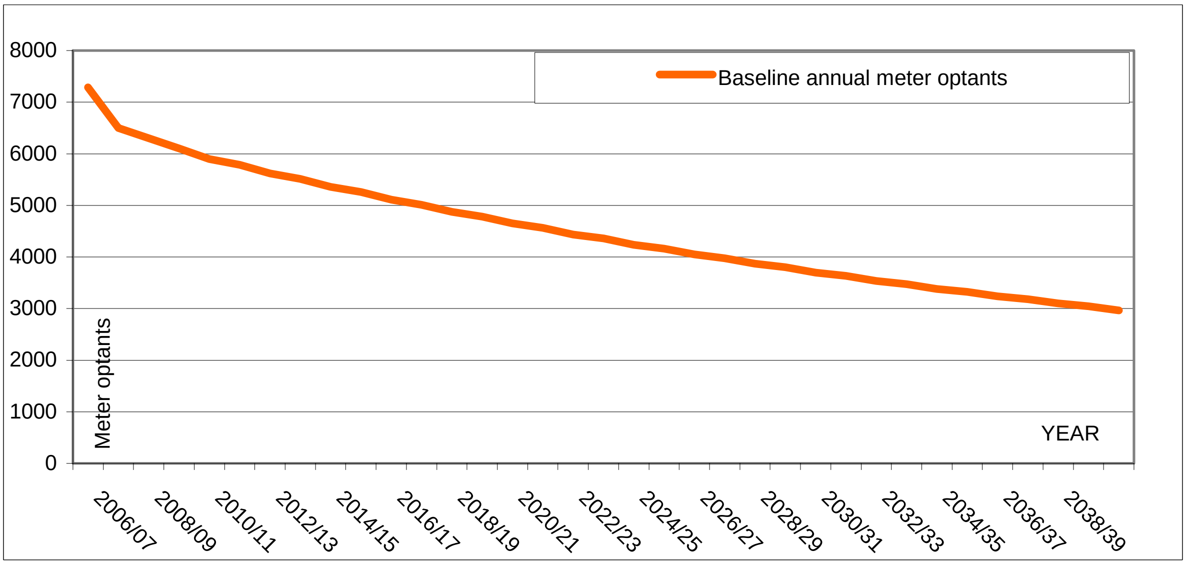
6.1.2 Metering

It has been the policy to meter all new build properties since 1991, and this will remain the case in future. Existing households that are un-metered are able take advantage of our free meter installation option. Over the past ten years, the proportion of metered households has increased from 12% to 26% of the total household customer base.



In the 2004 Water Resource Plan, econometric consultants Stone and Webster forecast that the number of households opting for meter installation would be between 4000 and 5000 p.a. In fact optant numbers have been almost double the original forecast in 2006/07.

For the baseline forecast for future years we have re-estimated the number of meter optants based upon the recent out-turns of an initial 1.8% of the un-metered household base, decaying to 1.6% of the remaining un-metered properties at the end of 30 years. This would result in between 6000 to 5000 meter optants p.a. over the plan period, increasing the metered proportion of the household customer base to 70% by 2040.



In addition to the current policy for domestic metering, we expect to continue the selective metering of un-metered non-household properties until 2015 as part of the baseline supply-demand balance.

We consider that paying for water on a volumetric basis is the fairest and most environmentally appropriate system of charging. Our supply area is not regarded as 'water stressed' as defined by the Environment Agency. This means compulsory metering of all domestic properties is not available as an option at present. We would prefer to meter all household customers on a compulsory basis, as this would be the most efficient metering policy (optant metering being the least efficient way to expand the metering programme). We would prefer to undertake a phased metering programme and move to the metering of all properties over an appropriate timescale.

We have considered a range of metering approaches as options to reduce demand in future. These are detailed in the section on maintaining the supply-demand balance.

6.2 Leakage Control

The company has consistently maintained leakage at or below the target economic level of leakage (ELL) of 54 Ml/d for the past ten years. In the base year, 2006/07, the total leakage reported was 53.6 Ml/d. This is broken down as:

1	35.2 Ml/d	Background leakage from small seepages and fittings
2	18.4 Ml/d*	Mains, fittings and service pipe bursts

* service pipes include both the section owned by the company and the part owned by the customer.

6.2.1 Leakage baseline activity

Bristol Water operates an active leakage control policy across the entire distribution network, including trunk mains and service reservoirs. The predominant leakage control method used in Bristol Water is based on continuously monitored district metered areas (DMA). For this method, flow is monitored at district meter level. If such a district meter shows an unusually high night flow then the area is temporarily divided into smaller districts and night flow at this level is monitored. This together with leakage detection techniques such as sounding or use of leak noise correlators help locate individual leaks and bursts.

Continuously monitored district and combined metering covers 98% of all properties. The remaining properties are covered by a policy of regular sounding. These are properties that do not fall under waste and combined, or district metering. These properties are sounded annually. Pressure reduction schemes using specialised pressure reducing valve installations cover 40% of all properties in the resource zone.

A standing test is performed on all service reservoirs as part of the routine structural inspection programme. This is based on a rolling cycle of 4 Additional tests are undertaken as required.

All Trunk Mains are inspected for leakage through an annual programme of route tracing with sounding on valves and fittings. For sixty trunk main systems a water balance is calculated through logging of all inlets and outlets. The balance is initially used to highlight any large meter errors or inaccuracies within the balance. The balance is resolved to within +/- 5%, after which the balance is deemed stable. Forty-four of the sixty trunk main systems are now within tolerance, with the other sixteen being dealt with at present for metering problems.

These leakage control methods locate both Company and customer leakage. Company leakage once located has a maximum repair time of 3 days, with mains bursts repaired within 2 days and communication pipe and other leaks within 3 days. Domestic homeowners receive a free leakage detection and repair service for the first repair under the Leak-stop programme (second repairs are subsidised). The average repair time for supply pipes in 2006/07 was 14 days.

A detailed description of the current methods of analysis and techniques is with the supporting information.

6.2.2 Economic level of leakage

Active leakage control predominantly impacts mains and service pipe failures, although system pressure reduction will help to reduce losses from the smaller seepages and fittings losses.

The economic level of leakage (ELL) is obtained by setting the amount of active leakage control (ALC) so that the costs of additional ALC are equal to the value of the water saved. The cost of leakage control mainly comprises the staff costs and travel costs associated with the leakage inspectors. This also includes the social cost of traffic disruption, accidents and carbon emissions associated with inspectors vans.

The value of the water lost through leakage is based upon the cost of power used to pump and treat the water, together with the cost of chemicals for treatment and the social costs of the carbon associated with pumping and treatment.

Our customer survey has revealed that customers are willing to pay more to reduce leakage. This additional social cost/value is taken into account below in the determination of the socially efficient level of leakage.

In June 2007, we re-submitted the calculation of ELL based on the forecasts of demand, water resource schemes and efficiency schemes developed for the 2004 Water Resource Plan. The 2007 ELL submission is provided in appendix 6, together with the methodology used to monitor and calculate leakage in the company water supply zone. We have updated that report with new data. The revised ELL position is reported below.

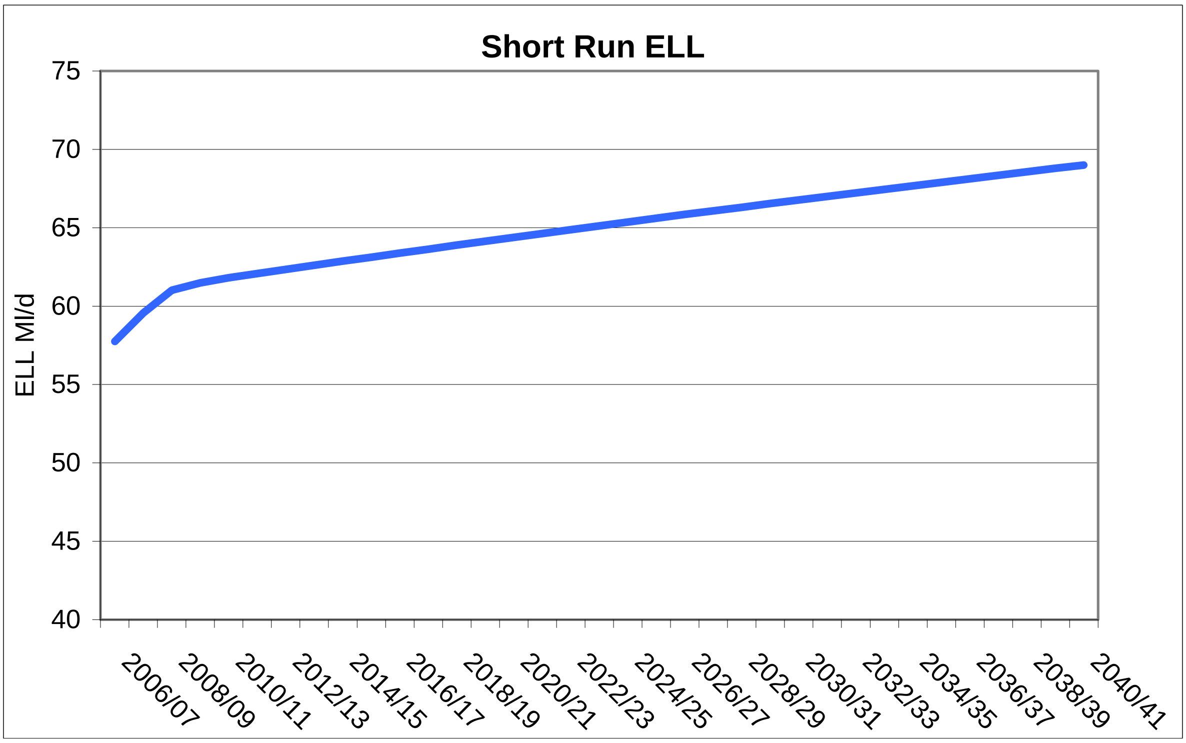
6.2.3 Current policy leakage target

Key differences between the revised ELL submission and that carried out for the 2004 Water Resource Plan include:

- A new ELL analysis tool "ELLen" with a more sophisticated leakage model
- Updated (2006/07) leakage data, schemes and operating costs
- Inclusion of planned infrastructure maintenance and the growth of the supply network
- Inclusion of the social costs of carbon for power use and active leakage activities

The short run ELL (referred to as variable operating cost ELL in the Tripartite Report) has been determined by comparing the cost and benefits of additional active leakage control against the marginal cost (including social costs of carbon) of the water lost. Our assessment is that the **short run ELL** for 2007/08 is 59.6 Ml/d and for 2009/10 61.5 Ml/d. This assessment is based on the current year forward wholesale market prices for power. If power costs increased by 20% the 2009/10 short run ELL would reduce 60.2 Ml/d. If the social costs of carbon were excluded the 2009/10 short run ELL would increase to 63.2 Ml/d.

The graph below illustrates the base supply/demand balance scenario before consideration of additional resource, demand, or leakage schemes. A key difference from WRP04 is that for this base scenario the leakage in each year is assumed to be at the short run ELL. The addition of new connections and the ageing (and associated degradation) of the network result in forecast short run ELL increasing over the period from 61 Ml/d to 68 Ml/d.



The assessment of ELL indicates that the leakage target for 2008/09 and 2009/10 should remain at 54 Ml/d (53.6 Ml/d rounded to the nearest whole Ml/d). On current information, achieving this level of leakage economically would require us to undertake a pressure reduction scheme identified for 2008/09 at an estimated cost of £261k.

Maintaining a target of 54 Ml/d beyond 2010 at current activity level will become increasingly difficult and expensive given the underlying increase in short run ELL. We have carried out a more detailed analysis of the issues including consideration of:

- The latest forecasts of population and housing growth
- Changes to yield from longer term climate record and climate change
- The impact of additional mains and service pipe replacement
- A wider range of metering and water efficiency options
- Changes to service level for hosepipe bans (based on customer willingness to pay)
- A more complete inclusion of environmental and social costs

6.2.4 Long term leakage target

A Water Resources Plan that allowed for a future increase in leakage is not acceptable under the current regulatory arrangements, even if this could be shown to be the ‘least cost’ solution.

To determine the long run ELL that does not allow leakage to rise in future, supply schemes, water efficiency and leakage schemes are all investigated as a basket of options. Different scheme combinations and timings were investigated until the least cost intervention programme that does not allow leakage to rise was obtained. The result is a programme measures to maintain the supply-demand balance over the period of the plan.

Key aspects of the least cost programme of measures include:

- Additional active leakage control
- Pressure reduction schemes
- Zonal monitoring schemes
- Supply pipe replacement
- Additional free supply pipe repairs
- Re-instatement or enhancement of existing water sources
- Additional metering options
- Water efficiency options
- Infrastructure replacement

Customers have indicated a clear ‘willingness to pay’ for reductions in leakage. This as been factored into the optimisation model used to select options for the company long-term management strategy.

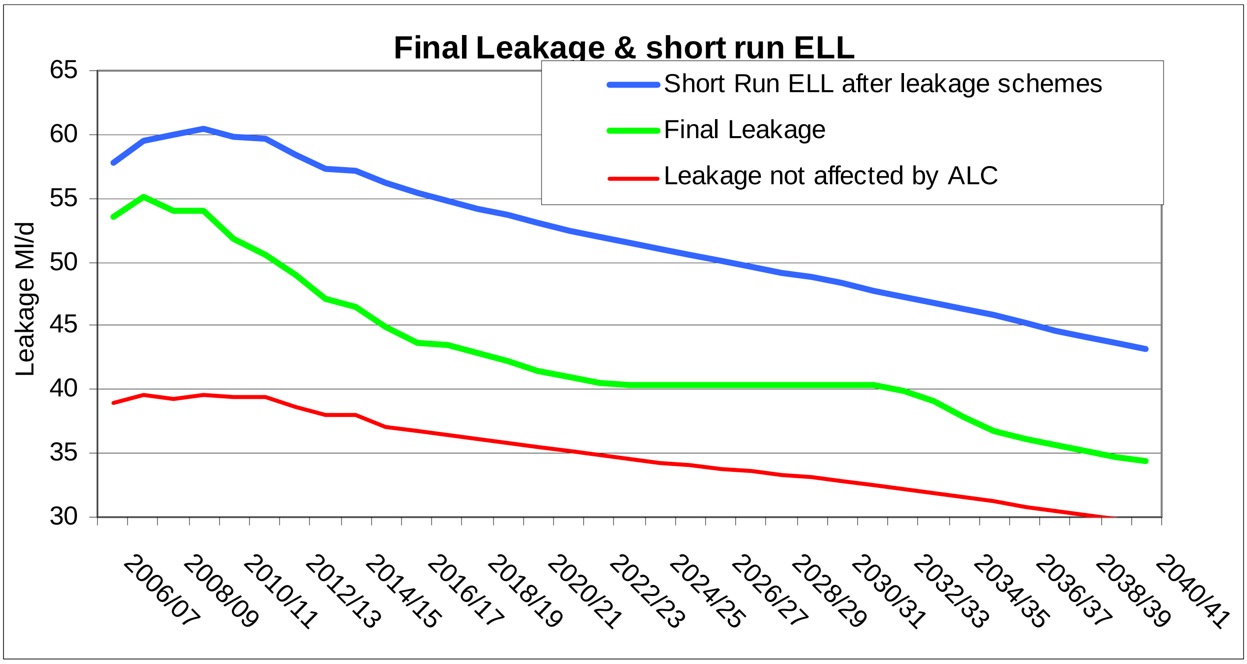
The graph below shows the short run ELL identified as a consequence of the least cost plan. The short run ELL is the level of leakage at which the marginal costs of additional ALC activity equal the marginal costs of water lost (including the cost of carbon). The short-run ELL declines over the period as a result of the additional investment in infrastructure replacement identified in the preferred plan.

The graph also shows the proposed target level of leakage. This proposed target reflects the additional benefits arising from:

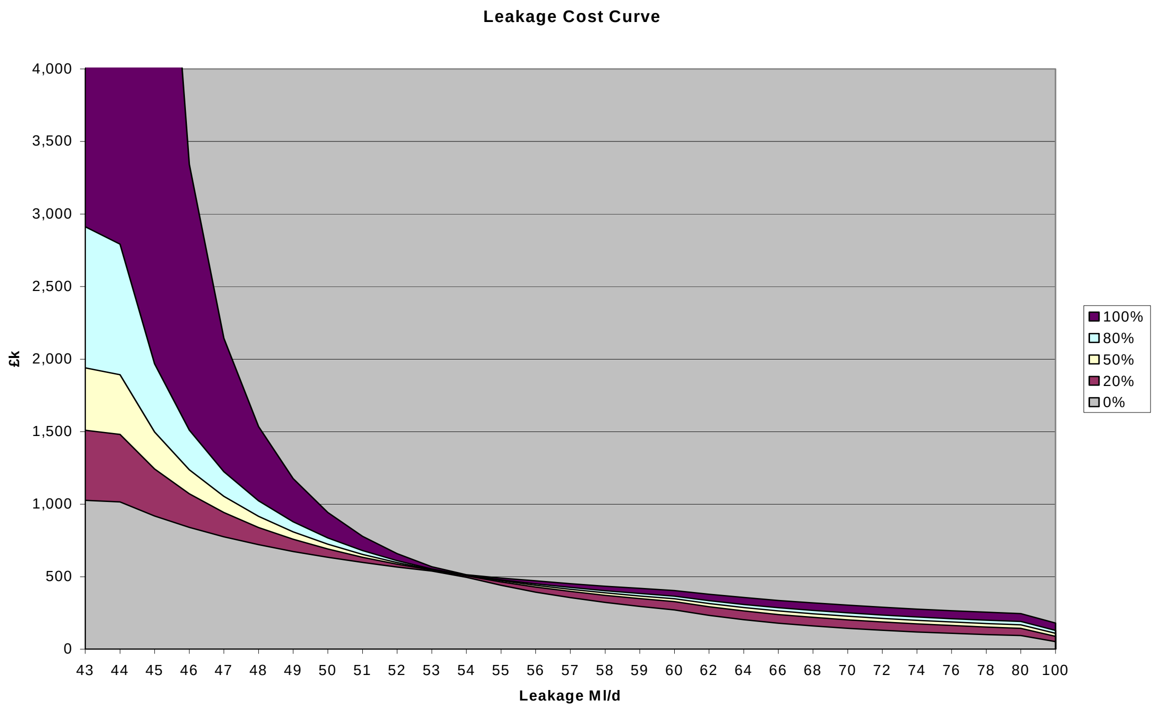
- Customers’ willingness to pay for lower leakage
- Customers’ willingness to pay for increased headroom
- The benefits of lower leakage in delaying resource schemes

The graph shows that total leakage is approaching minimum policy leakage by the end of the period. To achieve this, active leakage control costs will approach between two and three times current costs.

The detailed descriptions of options to reduce leakage are contained in the section on maintaining the supply-demand balance.



Given the significant proposed change in leakage activity, there is considerable uncertainty in respect that actual leakage savings that would be achieved for such a large increase in expenditure.



To allow for this uncertainty a probabilistic approach to the leakage cost curve was adopted. This approach used a monte-carlo approach to determine a range of cost curves based on an uncertainty in the current policy minimum of +/- 10%, and in the shape of the cost curve (index between –0.8 and -1.4 with a median of –1.0). The figure below shows the resultant leakage cost curves.

For the assessment of leakage, we have adopted the 80% confidence line. At this level of confidence there is a 20% probability that the proposed leakage control expenditure will not achieve the targeted improvements in leakage.

This is the same approach and consistent with the level of probability of delivering the target level of service set out in the section covering headroom.

Section 7. Climate Change

7.1 Treatment of Climate Change

The latest forecasts from the UK Climate Change Impacts Programme (UKCIP) show that the majority of the six global climate models used for the forecasts predict warmer and drier summers with warmer and wetter winters. There is a considerable range in the severity of effects between the six climate models used to develop the scenarios for the UK. This has resulted in a variation of the predicted impact for each climate model on the UK by 2025 and beyond.

The company has no catchments directly modelled in the UKWIR CL04 report. Instead we have used the spreadsheet model provided by UKWIR for estimation impact using the catchment base-flow index (this is the relationship between the groundwater and surface run-off components of catchment flow).

The spreadsheet model simplifies the six climate change scenarios for the UK. This is accomplished by taking the mean weighted statistical impact of all scenarios as the most likely outcome. The maximum range of impact is also considered by calculating the statistical 1 percentile and 99 percentile climate effect on river flow. Taken together, the climate change scenarios we have considered are:

- **'Dry'** equivalent to 1 percentile or a very warm and dry prediction for future climate
- **'Average'** equivalent to the mean prediction of all of the climate change scenarios
- '**Wet'** equivalent to a 99 percentile or cooler and wetter prediction for future climate

Using the 'average' statistical impact of the six UK climate scenarios for the catchments within our area, the following effects occur

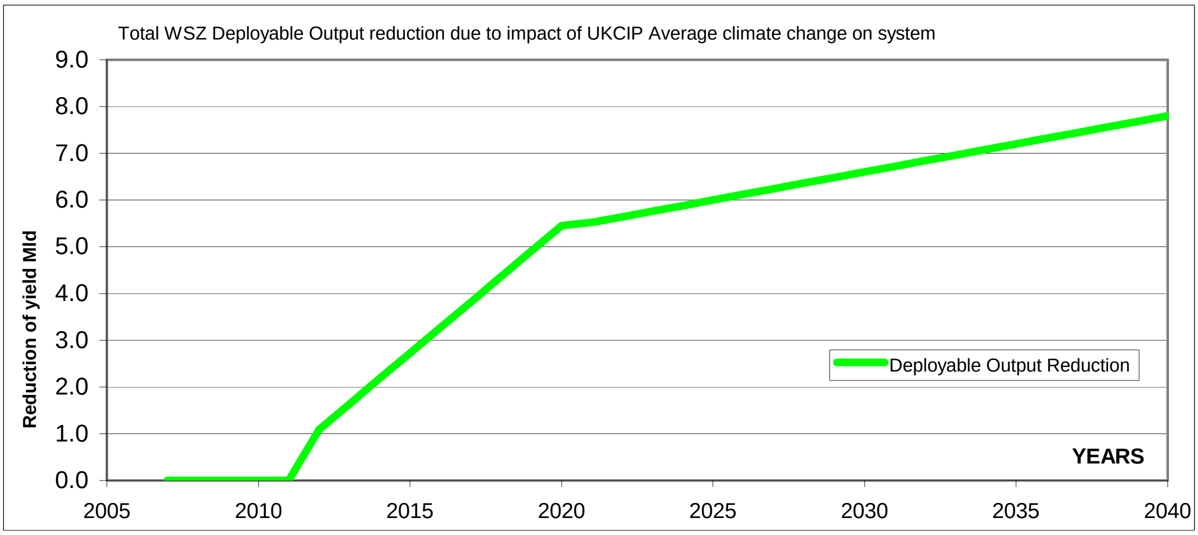
- Lower rainfall in summer months leading to reduced reservoir inflow
- Higher temperatures in summer reducing effectiveness of rainfall
- Higher rainfall in winter providing more rapid reservoir and groundwater recharge
- An overall reduction in the resource zone deployable output of 6 Ml/d by the 2020s (taken to be 2025).

The reduction in deployable output from the chosen scenario has been calculated for the complete water resource zone on the basis of the conjunctive use of all water resources. This has been done using the same water resource zone model used to determine the current level of service for hosepipe bans with the following assumptions:

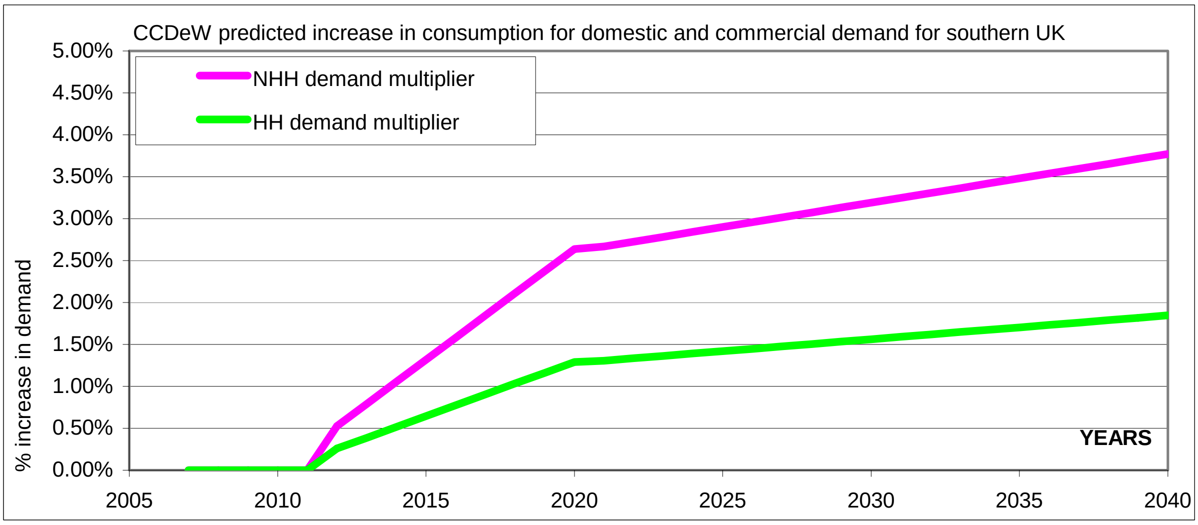
- Current level of service for customer restriction unchanged (once in fifteen years)
- Monthly inflow changes based on individual catchment base-flow index
- Groundwater impacts approximated from average of all base-flow index in WRZ
- Effect on River Severn yield (determined as negligible from Severn Trent model)

The UKWIR spreadsheet model is a prediction of possible effects in the 2020s. This is taken to mean 2025. The probable reduction in deployable output has been scaled from a 6 Ml/d impact at 2025 down to zero impact at 2011 and scaled up to 8 Ml/d by 2040 in the manner prescribed by the methodology.

The profile of the impact of climate change over time on resources deployable output is indicated in the plot below.



Climate change is also likely to have an impact on customer demand for water. The warmer drier summers and warmer winters will result in some increase in both household demand and non-household demand. To estimate these impacts, we have used research published in 2003 'Climate Change and the Demand for Water' (CCDeW) Downing *et al*. This research provides global factors for increased consumption by UK regions for the 2020s. We have taken this data and profiled it in the same manner as prescribed for the impact of climate change on water resources. The effects are relatively modest and are indicated in the plot below.



7.2 Impact on Water Resources

Bristol Water is dependent largely on surface water resources from rivers and reservoirs. Approximately 45% of the daily water put into supply comes from the River Severn and 40% from the Mendip reservoirs. For geological reasons, very little water can be obtained from groundwater sources in the company water supply zone. The Groundwater sources that are available predominantly consist of shallow wells and springs and account for less than 15% of the available water.

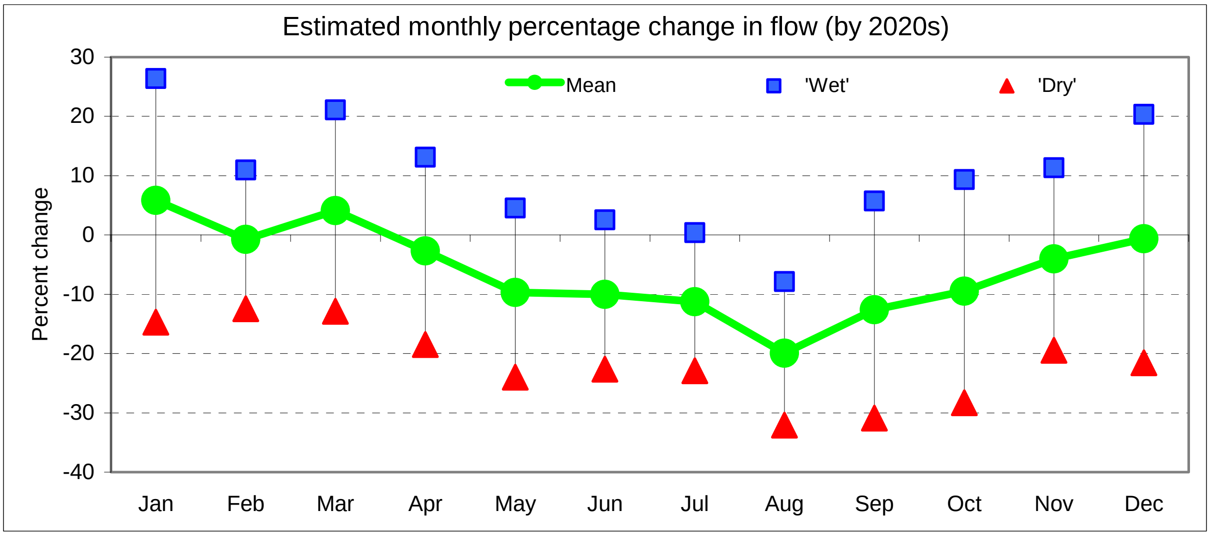
7.2.1 Reservoir inflows

All of the 5 main Mendip reservoir catchments will be impacted by climate change to a varying extent as determined by their relative base-flow index (BFI). The base-flow index has been provided by the Environment Agency for the following catchments in the resource zone.

- BFI 0.72 Chew reservoir
- BFI 0.72 Blagdon reservoir
- BFI 0.72 Chew Magna reservoir
- BFI 0.76 Cheddar reservoir
- BFI 0.69 River Axe

The data shows that the inflow and river flows in the area are moderately well supported from groundwater discharges, having a broadly similar characteristic. This indicates that although climate change impact will be different for the various sources, the difference will not be particularly marked.

Taking the example of Chew reservoir, the percentage reduction in inflow to the reservoir from the rivers on the catchment over the year is indicated on the plot below for each of the three climate change scenarios.



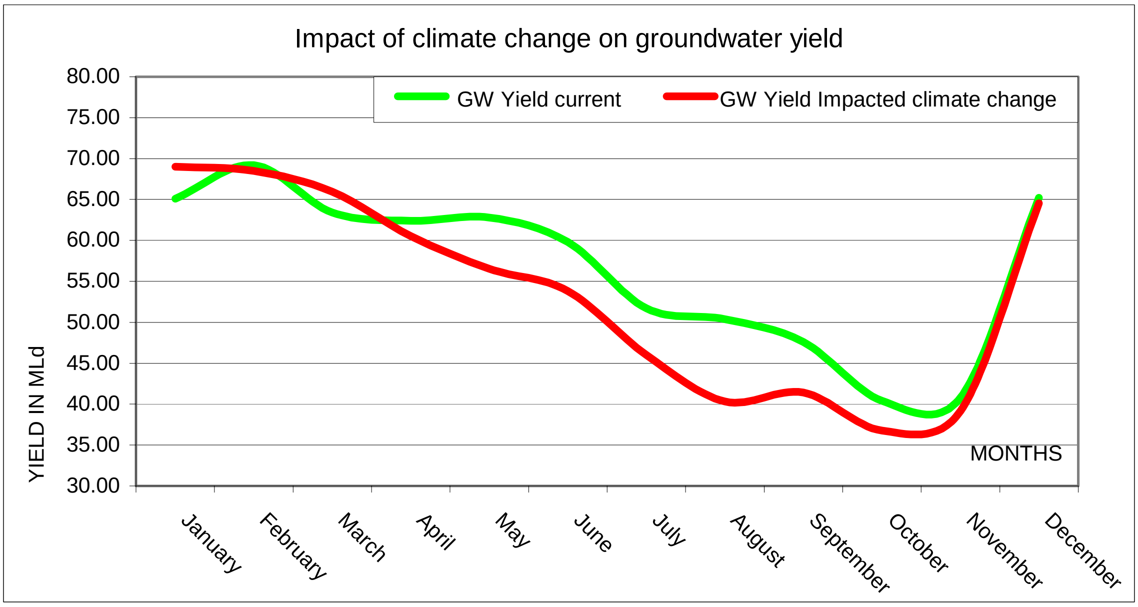
Note that the 'wet' scenario would result in an overall increase in the inflows to reservoirs and shallow ground waters by 2020 if it were to occur. The 'dry' scenario would result in a substantial decrease in inflow to reservoirs.

The ‘average’ (mean) climate change scenario impact in terms of reduction of inflow for each of the catchments has been used to modify the inflow sequences from 1829 to 2005 for each of the catchments in the resource zone model. The water resource zone model has taken the inflow sequences from the HYSIM rainfall run-off model originally created in 2003 and updated in 2007 to take account of the longer climate record available from 1829.

7.2.2 Groundwater Yields

The company groundwater supplies consist of small, shallow springs and boreholes, supplied mainly from recharge through conduit flow in Carboniferous limestone to small discontinuous aquifers such as the Dolomitic Conglomerate. Current ground water modelling techniques do not capture adequately the complexity of these small systems. These sources tend to behave as small surface water sources, declining rapidly in yield during dry periods. In addition, the majority of these groundwater sources occur within the Mendip catchment. Because of this, we have treated these small sources as subject to the same climate change influence as surface waters in the Mendip catchment.

We have used the average of all of the predicted inflow reductions for the Mendip catchments to give a monthly index of reduction of groundwater yield in the water resource zone model. The profile of percentage yield reduction is very similar to that shown in the plot above. The actual impact on total groundwater yield for the ‘average’ climate change scenario is compared to current yield and indicated in the table below:



This approach is considered acceptable because of the characteristic of the small sources described above. Less than 3% of the resource zone deployable output comes from sources in a ‘conventional’ aquifer. Developing a separate groundwater model for such small aquifer components would not materially improve the current analysis.

7.2.3 River Severn Yield

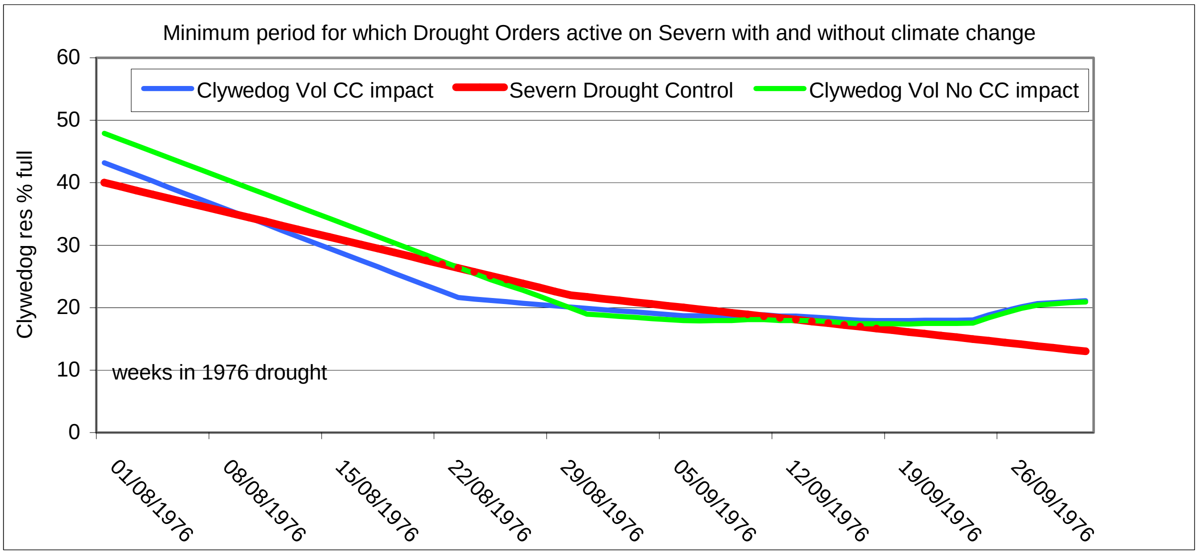
The catchment of the River Severn is outside the company water supply area. In addition, it is a complex system, subject to many abstractions and discharges. The River is also supported by discharges from Clywedog reservoir and groundwater in Shropshire. These are used to maintain statutory river flow conditions at strategic points along the river (Bewdley is one such control point). This system of river regulation is designed to support both environmental conditions and abstractions on the lower Severn. This includes British Waterway's abstraction from the Severn to the Gloucester and Sharpness canal that provides a maximum abstraction of 245 Ml/d to Bristol Water (average yield over the dry year is 210 Ml/d).

We would not expect the dry weather yield available from the Severn to decrease in response to climate change. To do so would imply some sort of failure or significant change to the system of river regulation in future. The Environment Agency has not advised us that they are considering any changes to the current regime of river flow support.

Periods of drought do have the potential to decrease the possible yield from the River Severn if they caused a longer or more rapid reduction in flow in the Lower Severn. Lack of rainfall could cause low volumes of storage at Clywedog reservoir to occur for longer periods which could trigger more frequent drought controls on water use from the River Severn.

During periods of drought, the Environment Agency may implement its Drought Plan for the River Severn if the volume of water stored in Clywedog falls below the prescribed level. If the situation does not improve, the Environment Agency could apply for a drought order. Under these circumstances, the company would attempt to reduce abstraction from the River Severn. The current yield assessment for the Severn already takes into account the effect on company abstraction of a notional 45 day period of drought restrictions that the 1975/76 drought would have required.

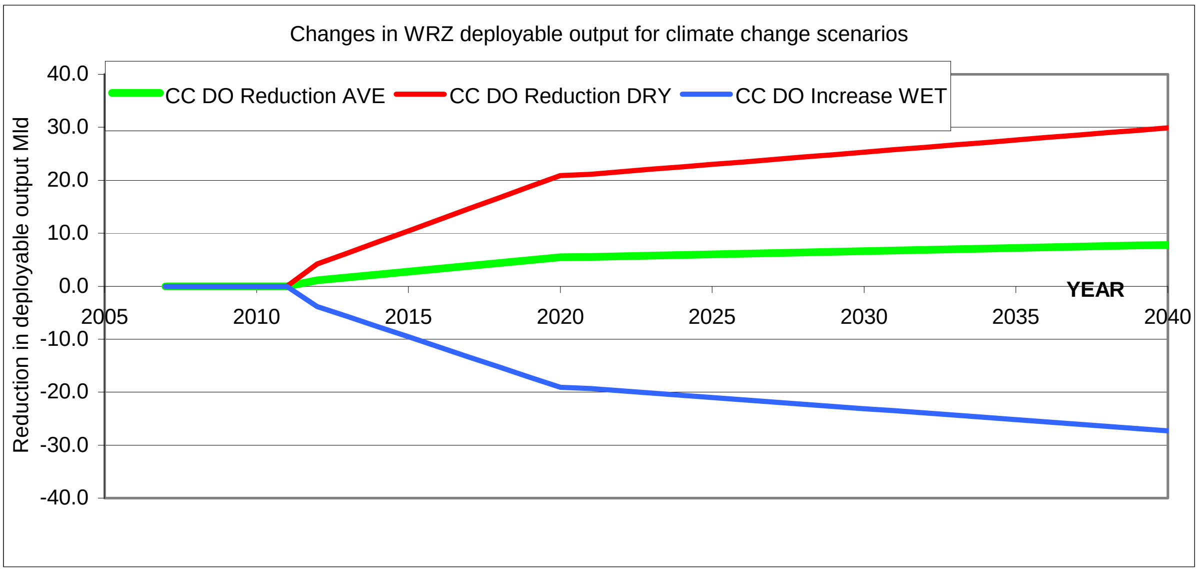
The company has used the output from the Severn-Trent water company's River Severn system model to indicate the current climate prediction of Clywedog storage during the 1976 drought together with the current drought control rule for Clywedog. The 1976 event is the worst dry period observed in the historical data captured by the Severn-Trent model that covers the period 1920 to 1996. The same model has been run again using the reduced inflow sequences equivalent to the 'average' climate change impact scenario for the Severn river basin. The plot below indicates that climate change would have the potential to increase the length of a drought equivalent to the 1976 event by about 30% by 2025.



However, the total length of the period during which abstraction would be reduced to 199 Ml/d does not appear to exceed the current 45 days of drought restrictions already allowed for in the company yield assessment. For this reason we have concluded that there would be no change to the yield available from the River Severn as a result of the 'average' climate change scenario. Our assessment of the River Severn yield remains at 210 Ml/d for the impact of climate change at the Environment Agencies 'average' scenario.

7.2.4 Other climate change scenarios

The 'average' of the UKCIP climate change scenarios is the prescribed planning target for determining impact on water supply. The 'average' scenario has a relatively modest impact on the supply demand balance even by 2040. In addition, the effect of the 'dry' and the 'wet' scenario on resources availability has also been considered. The comparison of impact of the three scenarios is indicated in the plot below:



Note that for the 'wet' scenario, there is actually an increase in deployable output forecast.

Although the ‘wet’ and ‘dry’ scenarios are not used directly to calculate the supply demand balance, they are considered as a future ‘risk’ element. The extent to which these very large reductions or increases in reservoir inflow impact the resources system is considered as a ‘risk variable’ within the section on headroom and not as part of the baseline system yields.

7.3 Impact on water demand

It is considered quite likely that if climate change results in more frequent warmer summers and warmer winters, there will be some increase in demand for water for the following reasons:

- Increases in personal water use and consumption
- Increase in garden watering and other discretionary
- Increase in commercial activity of service sector, food and leisure industries
- Increases in activity of extractive industries

To estimate these impacts, we have used research published in 2003 ‘Climate Change and the Demand for Water’ (CCDeW) Downing et al. The research contains considerable detail of all of the assumptions made regarding the likely impacts of higher temperatures on consumption. Global factors for increased demand by UK regions for the 2020s are provided for both household and non-household consumption. We have accepted that all of the assumptions within the CCDeW report are valid and have made no attempt to modify the figures as provided.

7.3.1 Household water demand

The regional estimate of the impact of climate change on household consumption by 2025 has been taken as the average of those predicted in the report for southern and southwest region in table 3.9 in the CCDeW report.

South	percentage increase in annual demand	1.45%
Southwest	percentage increase in annual demand	1.39%
Average percentage increase in annual household demand at 2025		**1.42%**

This increase in demand is only expected to reach the predicted level by 2025. For the purposes of estimating the supply demand balance, the factor has been interpolated between zero at 2011 to 1.42% at 2025 and upward to 2040 in the same manner as recommended for the climate change impact on resources.

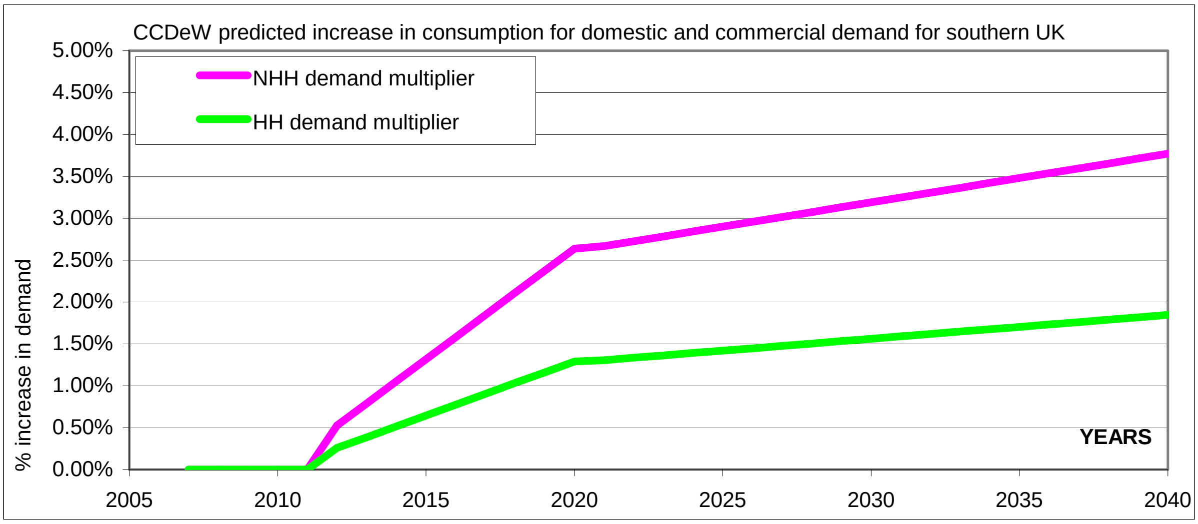
7.3.2 Non-household water demand

The regional estimate of the impact of climate change on non-household consumption by 2025 has been taken as the average of those predicted in the report for southern and southwest region for the ‘beta’ scenario in table 4.10 in the CCDeW report.

Average percentage increase in annual non-household demand at 2025 2.85%

This increase has been scaled over the period of the water resource plan in the same way as used to scale reductions in reservoir inflow (described in 7.2.1 above).

The plot below indicates the growth factors applied to the current forecasts in consumption. It is important to note that the baseline demand forecast for household and non-household water demand does not already include any allowance for climate change, to avoid 'double counting' the effect of climate change.



7.4 Impact on supply-demand balance

The impact of the 'average' scenario for climate change on the supply-demand balance is minimal before 2025. Even at 2030, the loss of resource yield is less than 2% of the forecast headroom adjusted demand for water.

Climate change impacts at the 'average' level do not have the effect of driving investment requirements, or other leakage and efficiency options within our preferred strategy. The main impact on the supply-demand balance is from the increased demand for water due to the forecast growth in housing and population taking place over the next 30 years. The strategy to maintain the supply-demand balance will need to begin in 2010, considerably before any significant effects of climate change are predicted.

The forecasts of impacts due to climate change are highly uncertain. To address this uncertainty, the risks of impacts being much greater or much less than the 'average' scenario have been addressed by using a probabilistic technique to determine a suitable planning 'factor of safety' described in the section on headroom.

Section 8. Headroom

8.1 Defining target headroom

Headroom is intended to be a planning margin or allowance of extra water between the forecast of demand during dry weather and water available to service that demand. The purpose of such an allowance is to take account of the uncertainties that may occur when developing long term and complex forecasts. It is important to have a reasonable margin, or headroom. A small allowance for headroom means there is a high risk borne by customers that the stated level of service may not be achieved. A large amount of headroom indicates there is a reduced risk of customer restrictions if unplanned or un-forecast events occur. The type of events considered are those that fall outside the scope of a 'business as usual' planning policy, including pollution events, or operational emergencies such as flooding.

Setting a target value for the amount of future headroom should be based upon the level of risk considered appropriate by customers. A headroom margin that allowed for a one hundred percent certainty that the level of service can be maintained at all times into the future may represent an unreasonably high level of security. It could also result in premature implementation of water resource management schemes.

Alternatively, if the headroom margin was so low as to only provide a twenty or even fifty percent certainty that level of service can be maintained, customers would consider that they are being exposed to too high a risk of inconvenience in future.

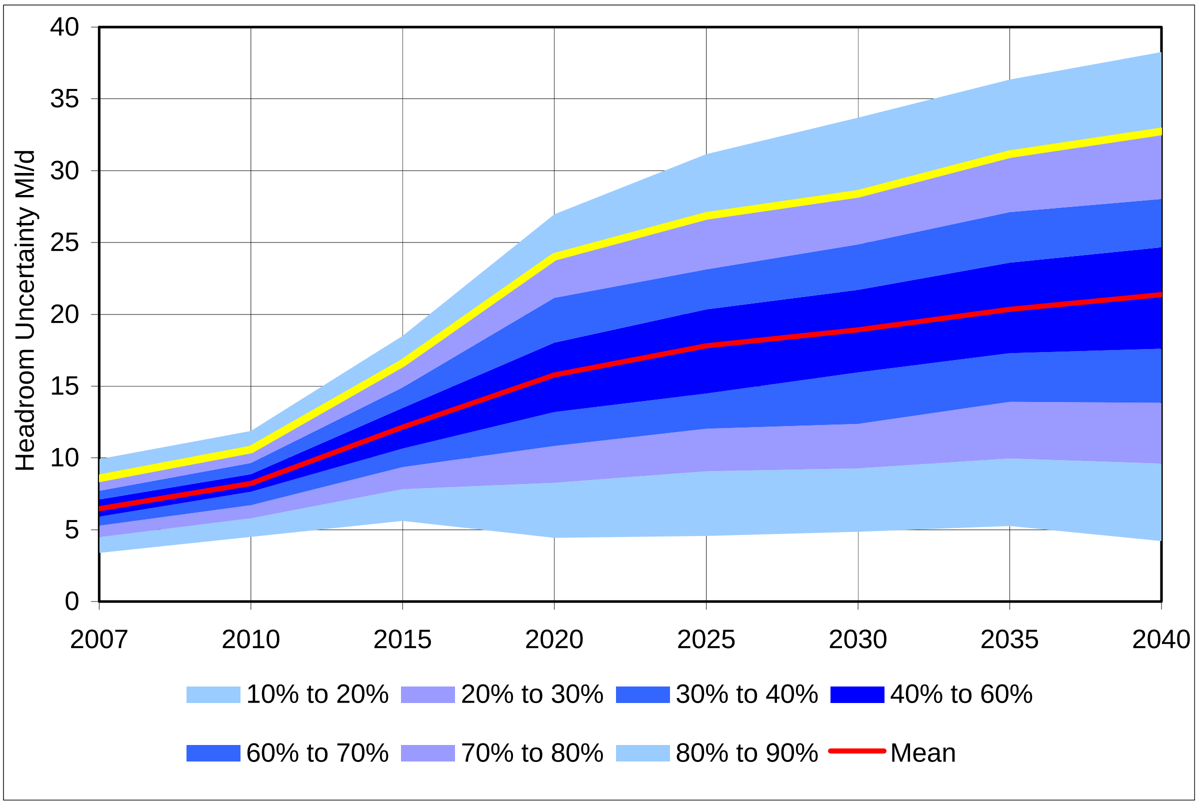
The available headroom estimated for the base year in 2006/07 was 18 Ml/d, the equivalent of only a 6% margin over the daily volume of water treated and put into supply. However, this is considered acceptable for current year operations it is regarded that operational certainties are higher in the current year than in the future. However, this small margin is expected to reduce even further in future as demand for water increases and the availability of water decreases due to climate change.

To ensure that the water resources management has sufficient flexibility in future we need to set an appropriate headroom target across the future planning period that takes into account both current and future uncertainties. As explained above, the size of this target headroom must ensure that the company's proposed level of service for customers has a reasonable certainty of delivery if events materialise outside the scope of a 'business as usual' planning scenario.

When estimating the size of the future headroom target, the sources of future uncertainty include:

- The possibility of unusual or uncommon system events or failures
- Possible derogation or pollution of sources (e.g. from nitrates)
- Allowances for errors in base data such as metered information
- Variation in outturn of yield from supply and demand schemes
- Variation in impact of climate change forecast
- Probable errors in forecasting future dry weather demand

To estimate the value of headroom required over the planning period, the 2003 UKWIR methodology 'An Improved Methodology for Assessing Headroom' has been used. This method assigns a range of probabilities to each of the areas of uncertainty. The outcome is a probability distribution of headroom uncertainty over the period of the water resources plan as set out in the plot below.



The key features of this plot of the company estimate of headroom uncertainty are:

In the early years of the planning forecast, most of the risks should be relatively well understood and long-term risks such as climate change impact are minimal. This gives a relatively narrow range of uncertainty between 4 and 10 Ml/d at the beginning of the plan.

In the later years of the plan, time dependent risks such as forecasting errors become more significant, and both the magnitude and range of impacts increase. Therefore, by 2035 a suitable headroom target could be between 5 and 35 Ml/d.

For the base year, the methodology indicates that a headroom of between 8 and 10 Ml/d above dry weather demand would be sufficient to ensure that the stated level of service could be met between 80% to 90% of the time. This is a very tight margin of only 3% above the dry weather distribution input.

The target headroom for the future needs to ensure the same or a similar probability that level of service can be met, at least for the first 10 to 15 years of the plan. This will ensure that there is sufficient time to implement schemes to restore the supply demand balance if there are significant departures from forecast assumptions. This is an important consideration as it may take some years for the yield of infrastructure schemes or resource schemes to be realised. During that period customers may be exposed to a reduced level of service.

We consider that in the base year, there should be close to 90% certainty that the declared level of service can be provided. This suggests a target headroom of at least 10 Ml/d at the start of the plan. From 2010 onward, we propose that an 80% certainty for level of service is appropriate.

The baseline level of service is for hosepipe bans and customer restrictions once every fifteen years. The baseline forecast of available headroom, together with our proposed target headroom to ensure at least an 80% probability of meeting the level of service is set out in the table below:

	2007	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Baseline available headroom forecast Ml/d	18	11	3					
Baseline actual supply demand deficit Ml/d				4	12	19	27	32
BW proposed target headroom Ml/d	**10**	**11**	**17**	**24**	**26**	**28**	**31**	**33**
Actual LoS certainty	**100%**	**100%**	**10%**	**Nil**	**Nil**			
Proposed LoS certainty	**90%**	**80%**	**80%**	**80%**	**80%**	**80%**	**80%**	**80%**

8.2 Risk and uncertainty components in headroom

In the Company area, the main uncertainty issues for water supply components identified are summarised below:

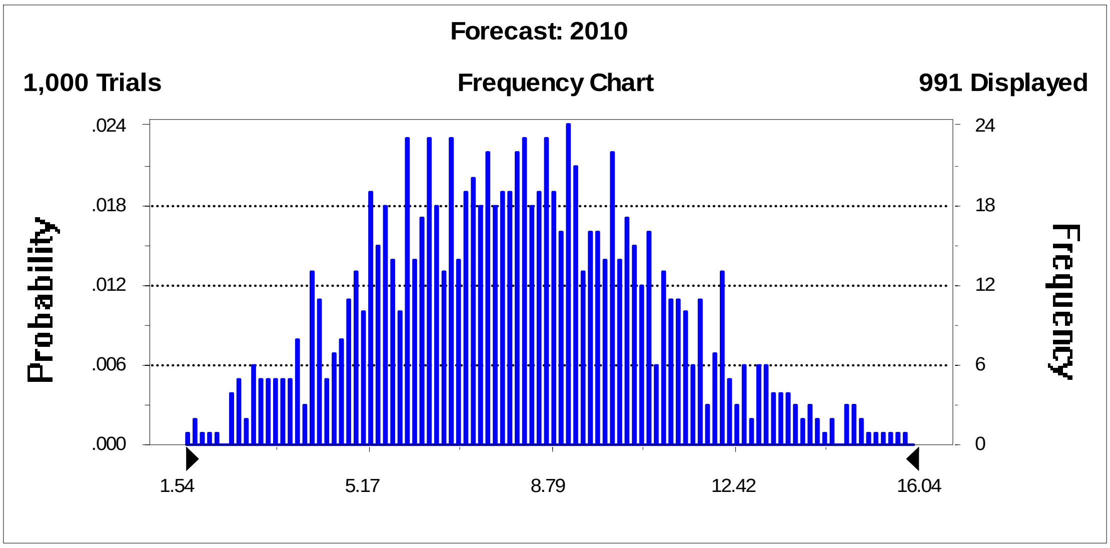
- Impact of additional abstraction restrictions from Severn above current 5%
- Failure or restrictions on BWW bulk transfer via Sharpness canal
- Water quality/derogation issues at sources requiring reduced abstraction
- Accuracy of surface water resources yield assessment based on hydrological models
- Ground water yield assessments reliability as based on old drought data from 1976
- Uncertainty on climate change impact on source yields
- Uncertainty over yields from new sources

The main uncertainty issues regarding the accuracy of the demand side components of the supply demand balance are:

- Limitations on metering accuracy on water into supply and validation meters
- Vulnerability of demand forecast to changes
- Uncertainty of impact of climate change on demand

The improved headroom model allows reasonable estimates of a range of alternative values about a central forecast to be taken into consideration. For example, due to the limitations of metering technology the accuracy might only be plus or minus 2% of the average value. The extent that forecasts based on metering data could be in error as a result can then be estimated on the basis of probability. This method is applied to all of the potential sources and ranges of uncertainties. These are then combined using the statistical technique known as Monte Carlo simulation. The output is a probabilistic distribution of the total impact of all uncertainty items.

The plot below illustrates the range and probable frequency of the impact of all uncertainty items allowed for in year 2010 in terms of a reduction of available water. The plot shows that worst impact might be a loss of 16 Ml/d, but the probability that this would occur would be very low and of the order of one in one-hundred. The same plot illustrates that there is a one in five probability that there could be a reduction in water available of 10Ml/d.



8.3 Uncertainty components – description

At present, the company has no time limited abstraction licences and no abstractions subject to future reductions. There are also no interdependences, correlations or mutual exclusions modelled between any of the headroom components detailed below.

S1 Surface Water Licence – abstraction reduction
This circumstance refers to a potential need for a further reduction in abstraction to maintain residual river flows in the Severn or conserve water stored in Clywedog reservoir. This allowance is over and above the 5% (11 Ml/d) already included in the yield assessment. These further reductions are indicated in the Environment Agency's draft River Severn Drought Contingency Plan. The company has indicated it would consider making such additional reductions if able to do so.

The basis for the estimation of quantity is for a period of 35 days requiring the extra reduction in abstraction in 2010, increasing to 120 days by 2040. This gives an annualised value between zero to 1Ml/d loss in water available increasing to 4Ml/d as a maximum in 2040. The driver for the time component of the increase is the uncertainty that the impact of climate change could have a more severe impact on the river Severn and water stored in Clywedog than allowed for in the 'average ' scenario.

S4 Bulk transfers – River Severn Sharpness canal
The yield from the River Severn is based upon a secure transfer of water via the three hundred year old Sharpness canal. This system incurred a major failure during June and July 1990 when a culvert beneath the canal collapsed. It is entirely possible that such an event could occur again, or other risks such as flooding or failure of the pumping taking water from the river Severn could occur.

Agreements are in place with British Waterways to provide a minimum transfer volume within the shortest practicable period of 100 Ml/d. Restoration of full capacity is subject to best endeavours. Other risks include the possibility of pollution incidents requiring the reduced output or temporary shutdown of plant (recently the occurrence of high concentrations of nitrate and methaldehyde have been issues).

The basis for the estimation of quantity is for a period of 10 days with abstraction limited to 100 Ml/d and a longer period of 60 days operating at 160 Ml/d. This gives an annualised value between 3 Ml/d to 10 Ml/d maximum loss in water available in 2040, if the event were to occur.

S5 Gradual pollution or derogation causing reductions in abstraction
Two issues are covered under this item; the recently observed increases in nitrate in the Egford wells at Frome and the likely derogation of yield at Oldford caused by the extension of Whatley Quarry into the recharge area of Oldford borehole.

The basis for the estimation of quantity is for loss of yield at Egford of 1.5 Ml/d out of the 5 Ml/d available representing reduced yields over winter for 120 days.

Pumping tests at Oldford now indicate that derogation is occurring, but the effects on the yield of the borehole are below 1 Ml during the critical period. In the early years, derogation will be small, but the full impact of the quarrying is not predictable, or whether the loss of yield would continue after the quarry permissions run out in 2030. A maximum impact of 11.5 Ml/d in 2025 is estimated, with a central estimate of 8 Ml/d.

S6.1 Accuracy of supply side data – Surface water yield
This component refers to the accuracy of yield estimate for surface water sources derived from the HYSIM rainfall run-off model. The model explains 85 to 90% of the variation in run-off, but is less good at estimating flow during dry years. The yield from the model was revised downwards for the 2004 Water Resource Plan.

The loss of yield has been estimated using an extreme value probability distribution predicting a mean reduction of 0.6Ml/d, a maximum potential yield increase of 2 Ml/d and a maximum potential yield decrease of 6 Ml/d across the period. This represents a modelling error of approximately 5%.

S6.2 Accuracy of supply side data – Ground water yield
This component refers to the accuracy of yield estimate for ground water sources derived from old data recorded at the last severe drought experienced in 1976. Since that time yields and flow pathways may have changed, but there has not been a sufficient intensity of drought to re-evaluate the yield

The loss of yield has been estimated based on a variation of –5% to +10% of the estimated dry weather yield of 55 Ml/d constant for the planning period.

S8 Uncertainty of climate change
This is to capture the uncertainty in the impact of climate change about the central forecast for the surface water and ground water yields and takes into account the UKCIP 'wet' and 'dry' scenarios. The effect of the 'average' scenario has already been taken into account directly in the baseline forecast for the supply-demand balance.

This component considers only the risks that impacts of climate changes could reduce yield or increase yield significantly in 2025 as reported in the section on climate change for the 'wet' and 'dry' scenario outturns. This has used a mean value of zero impact, a dry scenario impact of 29 Ml/d reduction in yield and a wet scenario yield increase of 27 Ml/d.

S9 Uncertainty over yield of new sources
This has not been considered as part of the baseline forecast.

In the final planning scenario where a yield has been assigned to a source development linked to reservoir construction, a variation of +3 to –5 Ml/d has been included as an uncertainty variation on yield from the point of construction.

D1 Accuracy of metering components
This component captures the effect of the limitations of accuracy of bulk supply meters. An individual meter is allowed a tolerance of 5% accuracy before replacement. The best meters generally have a tolerance of 1.5% to 2.5%. We have assumed a normal distribution for meter accuracy of ± 1.5%, resulting in a variation of approximately ± 4 Ml/d constant over the planning period, as we assume replacement of poorly performing meters in future.

D2 Demand forecast variation
The prediction of future household and non-household consumption is the forecast most susceptible to error, because of the number of sub components used including:

- Unreliability of government population and household forecasts
- Uncertainty of component demand in the forecasts of household consumption
- Uncertainty regarding economic activity and non-household demand

In the early years the uncertainty is limited to ±1% of consumption, increasing to ±5% in 2040.

D3 Uncertainty of impact of climate change on demand
The central forecast of climate change impact on demand has been taken account of in the baseline forecast (CCDeW report referred to in the section on climate change).

The prediction is for warmer summer and winters, therefore a distribution modified towards higher consumption of between approximately –1% reduction to +2% increase in total household and non-household consumption, with a best estimate of zero effect.

D4 Uncertainty of demand management
Resource development schemes usually result in a clearly defined yield. Demand reduction or water efficiency schemes do not have the same degree of certainty and this component recognises the issues associated with predicting the beneficial effects of metering, water audits and supply pipe repair schemes.

There is no allowance for this item in the baseline forecast of the supply demand balance. Where we have proposed demand reduction or efficiency schemes in our final planning solution we anticipate that there would be a normal distribution of error regarding the central forecast for reduction in water use or losses.

Section 9. Baseline supply-demand balance

9.1 Supply-demand balance assumptions

The company has followed the extensive guidance provided by the Environment Agency to establish the balance between future predictions of demand for water against the amount of water available. We have done this on the following basis for the baseline position using the key components detailed below:

A ‘business as usual’ approach, or an assumption that economic activity will continue at the long term growth rate and there will be no severe impacts from war, terrorism or other sources.

A ‘twin track’ approach considering options schemes to improve water network efficiency and reduce demand and increase available water resources.

In defining our supply demand balance we have taken account of the following resource issues:

- The operation of our system as an integrated zone where resources are shared
- That we have no peak demand criticality issues
- The effect of dry weather on source yields
- The effect of drought on the River Severn
- The long climate record to 1829 and the impact on drought frequency
- The impact of treatment works maintenance and outage
- The effect of future climate change on source yields

Looking forward we have considered forecast for future demand for water based upon:

- The government forecasts for growth in population of 1% p.a.
- The government forecasts for housing growth of 1.5% p.a.
- The forecast decline in non-household consumption due to loss of heavy industry
- Household appliances are replaced to be most efficient at 100 % ownership by 2020
- All new housing built to a high level of water efficiency (code 3)
- Per household consumption falling
- Per capita consumption static or rising slightly (due to occupancy falling)
- The impact of climate change on demand

Current baseline policy assumptions will remain as in previous years:

- Current water efficiency programme in line with Ofwat guidance maintained
- All new properties and businesses metered
- Full optant metering programme continues at recent historic rate
- Leakage analysis takes power/carbon costs into account
- Leakage maintained at the economic level (i.e. leakage rises as costs rise)
- Infrastructure maintenance at current allowed rate (network replacement in 200 years)
- Current level of service for customer water use restrictions unchanged
- Headroom target to ensure at least 80% certainty of maintaining level of service
- Consideration of other risk items through calculation of headroom target

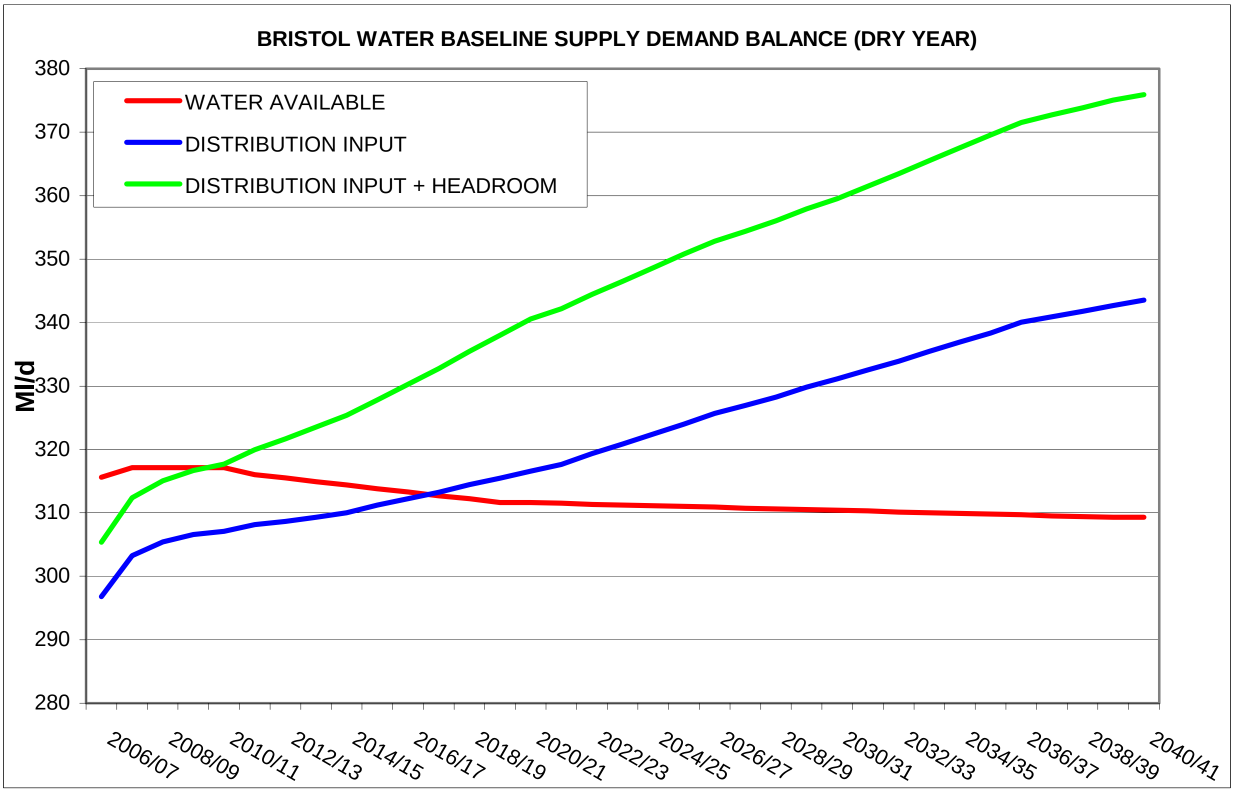
9.2 Baseline supply-demand balance

The forecast of supply and demand together with other forecasts and assumptions described above indicate that in the short term, there is not an immediate deficit of available water. However it is important to note that the margin of surplus water available is very small (only 6% of water available as actual headroom). This small surplus decreases rapidly over the next 5 years.

The combination of decreasing water available and rapidly increasing population and household formation together with the problem of ageing infrastructure result in a potential deficit in water supply by approximately 2012.

After 2011, we predict a theoretical deficit, as the forecast of future dry weather demand plus the 2006/07 allowance of target headroom of 10 Ml/d will be less than the water available. At this point the security of supply index will be below 100% and will continue to decrease in future without action to improve the situation. This indicates that there is an increasing risk to customers of water use restrictions at a frequency greater than stated in our level of service (a hosepipe ban once in fifteen years).

If no action is taken, the forecast predicts there will be an actual deficit in supply during dry years after 2016, resulting in the need for frequent hosepipe bans and other demand restrictions and an increasing possibility of supply failure in future.



Without activity to restore the balance between supply and demand by 2020, customers will face a rapid reduction in their level of service together with the increasing risks of inconvenience, loss of utility and in the worst case, loss of supply and need for emergency measures such as the use of standpipes.

9.3 Supply-demand deficits – key drivers

There is no single driver that can be identified as triggering any deficit in the supply-demand balance. In order of magnitude of effect, growth issues exert by far the greatest influence.

Growth
The greatest impact on the supply demand balance is the forecast rate of growth in population and housing. The company has used the most likely scenario produced by the South West Regional Assembly (SWRA) and one that is consistent with forecasts made by the local authorities in the company area.

As previously explained, there appears to be no trend for a reduction in household per capita consumption (PCC) over the last ten years. Our best forecast is for PCC to remain static at the current level in the long term despite all of the most optimistic assumptions regarding the uptake of water efficient devices and new home construction at high levels of water efficiency. The main driver for maintaining PCC at current levels is the occupancy rate, in turn driven by the forecast for household formation. These effects lead to a steady increase in water consumption in future.

There is also a much higher growth scenario for the area under consideration by the SWRA. We have considered the impact of the high growth forecast on timing of the supply-demand deficits. If the higher rate growth forecast becomes a SWRA policy, it will advance the actual supply-demand deficit by approximately 2 to 3 years. We will be monitoring the outcome the Examination in Public of the SWRA policy. We will incorporate the revised forecasts of population growth and housing development from the SWRA in the final version of our Water Resources Plan.

We have also investigated whether the high growth scenario would significantly change the balance of options or their scale within our preferred management plan. This aspect is detailed in the section on appraisal of options.

Leakage
The company has met the target economic level of leakage for many years. However, the growth in the network and increasing age of the network means that this is becoming increasingly challenging. In addition, the cost of finding fewer smaller leaks will increase considerably in future, which is why the short term economic level of leakage is forecast to increase in our baseline forecast.

This increase in leakage may advance the timing of the deficits by approximately a year. However, a rising level of leakage would be unacceptable, even if part of a least cost plan. Interventions to reduce leakage below the economic level are considered as part of our preferred management plan in the section on maintaining the supply-demand balance.

Climate Change
The impact of Climate change for the ‘average’ scenario on the supply-demand balance is small. It is during the period 2011 to 2025 that the greatest rate of climate change is predicted. Even so, the rate of reduction in water available is only of the order of 0.5 Ml/d/p.a. and not an effect that significantly alters the choice or timing of interventions to restore the supply-demand balance.

Section 10. Maintaining the supply-demand balance

10.1 Overview of process

The baseline supply-demand balance forecasts that an available water deficit begins to emerge at or about 2015 and is potentially extremely large by 2035. Given this, additional measures beyond those included in the baseline forecast are required to ensure current levels of service can continue to be delivered.

Initially, we considered a broad range of options covering the three main areas of:

- Customer side demand management affecting water use and supply pipe losses
- Water efficiency options to reduce distribution and raw water losses
- Resource schemes to provide new sources of water or increase existing yields

From this initial list a number of options were discarded on grounds of technical feasibility.

The remaining options were then reviewed in terms of acceptability, effective yield and social and environmental costs, the latter including carbon footprint. This process was used to identify a subset of schemes to go forward into a detailed economic appraisal to identify the appropriate mix and timing of schemes to balance supply and demand.

The aim of this economic appraisal is to arrive at a planning solution for the future supply-demand deficit that delivers the greatest benefits to the widest group of stakeholders taking into account the costs of the schemes, their environmental and social benefits, and customers willingness to pay for changes to the level of service they require.

10.2 Consideration of options

We have considered approximately fifty options that individually can contribute to improving the balance between supply and demand.

These options have been screened according to the criteria outlined below and ranked in terms of how appropriate they were for further consideration. The screening criteria used were:

- Yield Uncertainty
- Lead Time
- Flexibility
- Security of Supply
- Environmental Impact
- Sustainability
- Promotability
- Suitability
- Technical Difficulty

A list of the unconstrained options is set out below together with its score based on the screening criteria. . The score is based on consideration of each option as a single scheme.

	The following unconstrained list of options was identified in a workshop held at Bristol Water on 28/08/07	
Option Code	**Option Title**	**Ranking**
S006	**Minor sources**	18
S007	**Effluent re-use commercial**	19
S012	**Docks Scheme**	20
S001	**Cheddar Reservoir**	21
S004	**Southern Source consolidation**	22
S014	**Stowey WTW Washwater Recovery**	22
S015	**Pumped Refill of Chew Valley Reservoir**	22
S017	**Southern sources upgrade (unconsolidated)**	22
S013	**Purton Res and transfer**	23
S016	**Avonmouth WWTW Direct Effluent Re-use**	23
S022	Huntspill transfer	23
S002	**Severn Spring and transfer**	24
S003	Reduction of bulk transfer agreements	24
S008	**Desalination and transfer scheme (full and peak managing)**	24
S005	Brean Down groundwater scheme	27
S009	Aquifer Storage and Recovery	27
S010	Artificial Recharge	27
S011	Disused 3rd Party Licences	27
S021	Imports by road - tankers	31
S019	Imports by sea - tankers	36
S020	Imports by sea - bags	36
S018	Imports by sea - Icebergs	38
S000	Quarry de-watering recovery	38
L002	**infrastructure replacement and CP replacement**	17
L006	**Permanant Zonal monitoring**	17
L001	**Infrastructure replacement**	18
L003	**CP replacement**	18
L007	**Pressure reduction**	19
L004	**CP and subsidised SP replacement**	21
L008	**Leakstop enhanced**	21
L005	**ALC increase**	22
D005	**Business audits**	22
D002	**Selective metering (agricultural troughs)**	23
D010	**Selective metering of remaining unmetered commercial propertie**	23
D016	**Cistern displacement device distribution**	23
D017	Water efficiency audits of schools	24
D006	**Retro-fit WC with dual/variable flush devices**	26
D014	Rising block tariffs for domestic customers	26
D001	**Optant metering**	27
D011	**Compulsory metering of domestic customers**	27
D003	**Change occupier metering (all domestic customers)**	28
D004	**Change occupier metering (large gardens only)**	28
D012	**Change of occupier metering**	28
D013	**Seasonal tariffs for domestic customers**	28
D015	White goods subsidy	28
D008	Rainwater harvesting as a retrofit option	30
D007	Customer education programme	31
D009	Grey water recycling as a retrofit option	33

Some of the options, such as optant metering, or free supply pipe repair activity (leakstop), are included in the assessment of the baseline forecast. They are included as potential schemes to allow different levels of activity from that included in the baseline to be considered.

Schemes with a low score for ranking are considered to be more suitable for further consideration than those with a high score. Broadly we have considered as feasible and worthy of further detailed consideration all schemes with a score of less than 27, although for some of the demand management schemes we have included options with a higher score such as change of occupier metering.

The following options have been rejected as having a low overall feasibility due to the overall balance of yield, costs and practicality.

The following options have been rejected as having a low comparative feasibility due to the overall balance of yield, costs and practicality.

Imports by road - tankers
Imports by sea - tankers
Imports by sea - bags
Imports by sea – Icebergs
Use of tankers and other methods of importing water may be viable for a short-term emergency, but none is suitable for resolving a long-term resources problem.

Grey water recycling as a retrofit option
Rainwater harvesting as a retrofit option
These were costed for the 2004 Water Resource Plan and found to very poor value schemes for household plumbing systems, with high ongoing maintenance costs customers are not willing to support. Rainwater harvesting is of little resource value during dry years.

Customer education programme
The company already carries out significant work in this area in accordance with the Ofwat Best Practice guidelines. There is no evidence that further activity would result in a significant benefit in terms of available water that would justify the extra cost. In addition there is a danger that too much baseline activity would reduce the impact of requests to save water during a drought. Given this we believe extra activity is best applied in a targeted fashion during dry years or in unusual circumstances

White goods subsidy
Water efficiency audits of schools
Over 50% of customers already have dual flush cistern devices, or low volume cisterns. We forecast that over the next 15 years, the natural replacement cycle will result in most households having modern low volume appliances, including cisterns, dishwashers and washing machines. The water efficiency audit of schools is expected to have an insignificant yield for the cost involved (although we will continue our education programme for schools). We prefer an approach targeted at non-household metered customers with large consumption through general business audits

Optant metering
The practical consequences of additional optant metering are similar to those of metering on change of occupier and therefore we have not considered them separately.

Seasonal tariffs for domestic customers
We have concerns about the customer reaction to seasonal tariffs whilst significant numbers of customers are unmeasured and consequently we do not believe such tariffs are appropriate in

the short term. In addition there is great uncertainty about the benefits that such tariffs will bring.

Reduction of bulk transfer agreements
We have already agreed terms with Wessex water for a bulk transfer of 11.37 Ml/d until 2030. This transfer is required to alleviate environmental problems in the Hampshire Avon. This is considered to be a secure supply for water resource planning purposes by both parties.

Aquifer Storage and Recovery
Artificial Recharge
Huntspill River transfer
Disused third party licences
Brean Down groundwater scheme
These are considered to be high-risk, high cost resource schemes when compared to others listed. All would require substantial investigation at considerable cost. The local aquifers in the company area are generally of low quality and small scale. The transfer from the Huntspill River is out of our company area and a very long distance away. The only unused large licence of which we are aware is also on the Huntspill. Flows of potable water have been detected underground at Brean, but the water is hard and has a high chloride content. Abstraction may cause rapid saline invasion may be an issue due to proximity to the coast.

Quarry de-watering recovery
This has been investigated in the past at Whatley, Gurney Slade and other sites. There proved to be little or no yield during dry years or during summer periods when it would be beneficial to have the water.

10.3 Options for management of customer demand

The demand reduction schemes for consideration within the final planning solution are:

- Business audits
- Selective metering (agricultural troughs)
- Selective metering of remaining un-metered commercial properties
- Cistern displacement device distribution
- Change occupier metering (large gardens only)
- Change of occupier metering
- Compulsory metering of domestic customers

10.3.1 Business audits

This is intended to be an ongoing scheme targeting non-household customers with the aim of visiting between 70 and 80 business customers p.a. that have a consumption of water in the range of 5 to 20 Ml per year.

There are at present 423 business customers of the target size band. The benefits are assumed to be a reduction of 25% in water demand for two-thirds of the target group. (Assumptions based on the WR25B project 28, Water Audits for Non-domestic Customers, SWW, 2004).

The estimated yield of the scheme will increase to 1.6 Ml/d at the end of the 5-year period. The option would have to be maintained over the full planning period to retain the benefits.

This would require one individual staff member operating full time with normal overheads, together with vehicle and publishing as extra support. The cost is estimated at £50k

10.3.2 Selective metering of agricultural troughs

Billing records identify approximately 1800 agricultural troughs that are not metered. It is also estimated, based on historical survey data, that there are up to 650 "illegal troughs" i.e. neither metered or on charge. Experience has shown that the greatest component of leakage from farms is from leaking troughs. This scheme is intended to meter all known troughs over a ten-year period.

The scheme will require installation of approximately 200 trough meters per year for ten years (allowing for some metering of illegal troughs) with an expected saving of 200 l/d per trough, resulting in an total yield in 2020 of 0.4 Ml/d.

In many cases the supply arrangements for troughs are complex and in a number of cases supplies will need to be separated before meters can be installed. Consequently the cost of each installation has been estimated at £800. The total cost of the scheme is estimated to be £1.6m, however some of this cost will be offset by additional revenue from meters previously not charged.

Carbon emissions from the scheme have been based upon 2 Kg brass plus 20 km vehicle movements per meter.

10.3.3 Selective metering of un-metered commercial properties

Billing records indicate just over 5000 commercial properties other than troughs remain un-metered. The current programme of metering non-household customers is expected to reduce this number to about 4,000 by 2010. The average consumption of these customers is 590 l/prop/d, 50% higher than the average domestic consumption. This scheme is intended to meter all of the remaining non-household customers by 2020. The baseline metering activity will continue to 2015 at 400 units per year therefore there are 2000 properties above baseline that need to be metered

The option will require installation of 200 metersper year for ten years to fully meter all commercial properties. The estimated savings are based on similar assumptions to those used for household customers i.e. a 15% saving of supply pipe leakage and a reduction in demand of 7%. This results in an expected saving of 45 l/d per installation, resulting in a total yield by 2020 of 0.1 Ml/d.

The cost of this scheme has been estimated assuming an average cost per meter of £225 with additional operating costs of £12 per meter. The total capital cost is estimated to be £0.9m by 2020.

Carbon emissions from the scheme have been estimated assuming 2 Kg brass plus 20 Km vehicle movements per meter.

10.3.4 Cistern displacement devices

This scheme is for the large-scale distribution of cistern displacement devices to customers. The scheme envisages distribution of 20,000 bottles to customers per annum at a cost of £37k pa. Customer surveys indicate that almost half of toilets installed within our supply area are already low volume/dual flush and the bottles are unsuitable for these toilets. It is assumed that 70% of the remaining households will install the devices leading to 7,000 devices installed per annum.

Savings are based on an assumption of 11.5 flushes per property per day. Assuming installation of a 1 litre displacement device, the savings will be 11.5 l/d (4.2m3p.a) per property. For 7,000 customers this equates to 0.77 Ml/d. It is assumed that these savings will decay over the 5 year programme so that the maximum water saving will be 0.21 Ml/d on average.

Surveys indicate that the current rate of replacements of toilets is such that the within 15 years or so the number of large cistern toilets will be small. This has been taken into account in the baseline forecast of demand and thus this scheme can only deliver benefits for a short period.

10.3.5 Change of occupier metering (large gardens)

This scheme is to install meters on change of occupier for those households with the largest gardens. In general, such customers have the highest levels of discretionary use and are thus likely to make the largest savings on being metered. Customers with large gardens can be identified by our GIS system.

It is estimated that the scheme will lead to just over 2,000 meters being installed per annum, with an estimated saving of 30m3 pa per meter from reduction in garden watering of 1.5 m3 per week over 20 weeks (82 l/p/d). The annual yield will be 0.178 Ml/d for 2150 installations. After ten years the option will be completed and the total yield will be 1.8 Mld.

Operating costs are estimated at £12 per meter p.a.

10.3.6 Compulsory metering of domestic customers

This scheme is to compulsory meter household customers. The scheme is assessed at a unit cost level – the actual scale of activity (if any) is determined as part of the overall supply/demand optimisation.

It is assumed that Bristol Water will be able to compulsorily meter household customers from 2020.

Savings are forecast to be 7% of demand and 15% of supply pipe leakage calculated to be 32 l/p/d per meter installed. This would represent 0.19 Ml/d per target installation of 6000 meters.

Assuming installation of 6000 meters p.a. above the baseline could be maintained for the duration of the plan, the total water saving from 2020 to 2035 would be 2.9 Ml/d

The estimated cost of the scheme is £180 per meter, with an additional £12 opex per annum. The social and environmental costs of the scheme have been estimated assuming 2 Kg brass and 20 Km vehicle movements per meter.

10.3.7 Retro-fit WC variable flush devices

This option is to install cistern dual flush devices to 2000 customers per annum together with an advertising campaign to support the project. The water saved would be 0.15Ml/d over 15 years.

Surveys indicate that the current rate of replacements of toilets is such that the within 15 years or so the number of large cistern toilets remaining will be small. This has been taken into account in the baseline forecast of demand and thus this scheme can only deliver benefits for a short period.

The estimate of saving would be 18 l/p/d at average occupancy with an assumption that 2000 units are fitted each year with a total saving of .036 Ml/d. The cost is estimated at £370k per annum for contract plumbers, management and support to carry out both survey and installation.

10.4 Options for resource development

From all of the options designed to increase yields or provide new water resources we consider the following to be the most feasible:

For schemes designed to increase yields or provide new water resources we consider the following to be the most viable:

- Minor sources returned to service
- Effluent re-use for commercial only
- Docks to Barrow transfer scheme
- Cheddar Reservoir enhancement
- Southern minor source consolidation to single treatment works
- Stowey TW water recovery
- Pumped refill of Chew Valley Reservoir
- Southern sources upgrade (individually and unconsolidated)
- Sharpness Reservoir and transfer
- Avonmouth WWTW Direct effluent re-use to distribution
- Severn Spring and transfer
- Desalination and transfer scheme (full or peak demand managing)

10.4.1 Minor sources returned to service – yield estimate 5.0 Ml/d

The company owns abstraction rights at three small sources that are currently unused because of the poor water quality and high risk of contamination from the Cryptosporidium parasite.

The unit cost of constructing and operating suitable modern treatment works for these small sites is too great at present to make them economically viable. However, as the future supply-demand balance deteriorates, it would become attractive to develop these three sources by some means. The sources and estimate of individual dry weather yield are:

Gurney Slade spring	yield	1.5	Ml/d	TW capacity	6Ml/d
Honeyhurst spring	yield	2.4	Ml/d	TW capacity	6Ml/d
Holes Ash group	yield	0.8	Ml/d	TW capacity	2Ml/d

This scheme will develop these three sources as ‘stand-alone’ sites as they were operated many years ago. The output of these small springs has a great seasonal variation. In order to fully capture the yield, the treatment works will need to have a higher maximum capacity than the dry weather yield to process high winter flows.

In order to deal with the risk of Cryptosporidium and variable water turbidity, the treatment method is expected to include membrane filtration with UV as part of the disinfection process. All will be developed within the confines of existing works sites and buildings.

Infrastructure

- Three new fully functional treatment works using submerged membrane technology together with UV treatment for neutralisation of cryptosporidium.
- New spring collection pumps and distribution pumps will be required at each site.

10.4.2 Effluent re-use for industrial supply – yield target 20.0Ml/d

This option is to use a proportion of the treated effluent from Avonmouth sewage works to supply large industrial customers in the Avonmouth area. Water taken from the sewage treatment works source has a high calcium, nitrate, phosphate and salinity content that will be removed before the water would be considered by most industries. Depending upon the market for the water, further treatment may make the water more attractive to specialised customers. However, this scheme does not treat the water to potable standards and will not be transmitted via the company treated water mains.

The option will release raw water resources from industrial use and allow it to be made available to be treated to support the growth in domestic demand.

Infrastructure

- Partial reverse osmosis treatment for STW effluent at Avonmouth.
- 10 Ml two compartment reservoir at Severn Beach.
- New 7000m 600mm main from treatment plant to raw water reservoir.
- 20 Ml/d pumping plant with 30m lift to new raw water reservoir .
- Extra treatment and pumping capacity at the treatment works will be required to handle the 20 Ml of raw water released from River Severn/Sharpness sources. The existing process of: pre ozone, flocculation/clarification, post ozone rapid gravity filtration and carbon adsorbtion will be extended.
- Additional pumping plant rated at 30 Ml/d and 30m lift to take water to Almondsbury and Thornbury (Marlwood reservoir). Possible reinforcing main required from Littleton to Marlwood to transfer extra volume to supply. Approximately 5 Km of 300mm main allowed for.

10.4.3 City docks to Barrow treatment works scheme - yield target 30Ml/d

River Avon water from above the tidal limit supplying the Floating Harbour (Bristol City Docks) is usually discharged to join large flows in the tidal Avon at a rate between 50 and 500 Ml/d. This option is to capture the water before it is discharged, and transfer it to existing reservoirs at Barrow, approximately 8 Km to the west of Bristol city centre.

Water from this source will be used to offset demand on Mendip resources allowing more to be taken from these reservoirs to supply growth in the south of the company area, and maintaining security of supply overall.

The water is of poor quality containing pesticides and herbicides, and has an occasional chloride load with a high silt load. It is intended to blend this water with better quality water from the Mendips in the raw water reservoirs. However additional treatment to remove organic compounds and nitrates from the water entering the reservoirs has been included.

Infrastructure

- Hidden intake works and pumping station in historic Bristol Floating Harbour heritage site with 40 Ml/d 50m lift pumps.

- 3600m of 700mm id mains in fields with one road crossing and one river crossing to second pumping station.

- Secondary pumping station 40 Ml/d and 60m lift in 10m2 building close to industrial area and landfill site at Yanley

- 3000m of 700mm id mains from PS to Barrow plus 400m into works and 200m into Barrow reservoir.

- Flow/energy disperser for discharge to reservoir.

- Extra process required to treat the poor quality water from the docks prior to discharge to the reservoir, using biological aerated filters. Other process include a complete new 120 Ml/d carbon adsorbtion stage configured as a GAC sandwich within the existing slow sand filters for organics remova

There uncertainty about the yield that could actually be achieved from the scheme in a very long drought. In addition, there is a risk that the resultant water quality from the scheme will be worse requiring additional treatment to that proposed.

10.4.4 Cheddar reservoir enhancement - yield target 20 Ml/d

The existing raw water reservoir at Cheddar constructed in the 1930's was part of a design intended to have a storage capacity of 12000 Ml. At the time a decision was made to not store the water locally, but pump the water on to the reservoirs at Barrow, as that was where the main demand for water was. The reservoir was finally constructed at half the original design size.

This option envisages constructing the 6000Ml 'second' half of the originally designed reservoir as a means of providing additional yield and security of supply in a vulnerable area of the company water supply zone. In addition, local storage should reduce the amount of pumping, both to Barrow reservoirs for the purposes of capturing the water and back from Barrow treatment works for distribution of the water.

It is anticipated that reservoir construction will take full account of modern approaches to enhanced ecological and environmental design techniques (as at Rutland Water). The existing reservoir intakes at the cheddar the spring will require improvement to increase the capacity to capture higher volumes of water in the winter. It is likely that the abstraction licence at Cheddar will need to be varied subject to low flow conditions to realise the full design yield of the scheme. The reduction of flooding risk at Cheddar gorge may be an incidental benefit of the scheme.

Infrastructure

- Pump storage/off-line earth bund reservoir, 6000Ml capacity with inflow weir and multi level draw off tower.

- Re-design of intake arrangements for new monitoring weir and to increase intake capacity to full 250 Ml/d to capture high winter inflows. Requires 10m by 20m concrete intake chamber on existing intake site and automated valves and automated compensation control.

- 4000m of 1500mm mains from new intake pond to link to draw off on existing reservoir and new reservoir, mains laid through town along similar route to existing 56" main

- 2500m of main to divert River Axe pump storage water from existing Brinscombe main to west of reservoir, around and into existing River Axe treatment works.

10.4.5 Southern sources consolidation – yield target 8Ml/d

This option is to link all of the individual smaller springs, wells and boreholes sources in the south of the company supply zone to a single central consolidated treatment works, then redistribute water back to the supply areas. The sources considered for this scheme and existing problems at each source are:

Charterhouse & Forum:	small unreliable treatment works
Sherborne, Oldford, Egford:	evidence of raised alpha activity
Egford:	high nitrates
Holes Ash, Honeyhurst & Gurney Slade:	out of service due to poor water quality

The scheme is considered to have the following advantages:

- One single treatment works to operate and upgrade
- Allows blending of water to cope with quality issues
- Avoids the need to upgrade for removal of nitrates
- Improved yield from conjuntive water use
- No additional abstraction licence required

The option is complex, requiring the transfer of raw water from the existing sites to a centralised treatment works of 40 Ml/d capacity at or adjacent to the existing company site at Maesbury. From this site, treated water will be pumped back to the Shepton Mallet, Frome and Cheddar areas. To ensure operational security, two additional 10 Ml reservoirs will be required.

Infrastructure

- Pumping stations

Pumping stations	lift	flow
Lift at Honeyhurst	262m	6Ml/d
Lift at Gurney Slade	85m	6Ml/d
Lift at Wells	91m	3Ml/d
Rookham	10m	12Ml/d
Charterhouse	51m	4Ml/d
Shepton Mallet	65m	5Ml/d
Egford	70m	6Ml/d
Egford(Frome TW)	75m	24Ml/d

Sherborne	175m	7Ml/d
Bristol Plain	20m	10Ml/d
Oldford	90m	18Ml/d

- Mains

Diam mm	Total length m
200	1400
300	12200
350	7240
450	14225
500	6000
600	4000
700	19700

- Reservoirs two of 10000m3

- Treatment works using submerged membrane technology capable of a peak capacity of 50 Ml/d, expected to run at 40 Ml/d

10.4.6 Stowey treatment works washwater recovery – target yield 3 Ml/d

This option is to improve the efficiency of the fifty-year old Stowey treatment works by recovering water lost in the treatment process. This will involve improvement to the works settling and effluent return arrangements and rehabilitation of filters and storage tanks on site.

Some investigative work is taking place at present. The findings will determine whether this option continues as a PR09 objective, or is implemented before that date if the cost is low. If this work is successful, no additional activity will be required.

Infrastructure

The infrastructure requirements are relatively modest, with the largest costs associated with repairs to structures. Some investigative work is taking place at present. The findings will determine whether this option continues as a PR09 objective, or is implemented before that date if the cost is low.

- Low lift pumps 20m 3.5Ml/d
- Mains 300mm 500m
- Civils structures as required by survey

10.4.7 Pumped refill of Chew Valley Reservoir – yield target 30 Ml/d

This option is to transfer water from the River Avon downstream of Bath during periods of high flow to Chew Valley reservoir in order to accelerate the re-fill of the reservoir. The appearance of the reservoir would change significantly, as the artificial recharge would allow much more water to be taken, resulting in rapid drawdown and re-fill profiles.

The option will require the raw water from the River Avon to be treated to remove nitrates and phosphates, together with any alien life forms, before discharge to the reservoir. In addition the scheme is essentially a winter abstraction, so the infrastructure has to be of a relatively high capacity in order to capture high volumes for a short period to achieve the expected annual yield.

Chew Valley reservoir is an important designated site, being both an SSSI and Special Protection Area. Under the Water Framework Directive, any modification or substantial changes to current operation will need to be carefully assessed to ensure there is no impact on the current ecological status.

Infrastructure

- Intake works and screens on River Avon with low lift pumps 15mhd to transfer water to high lift pumping station.
- High lift pumping station close to River Avon to transfer water over Marksbury Plain to treatment works adjacent to Chew reservoir 80 Ml/d capacity 120m lift.
- Main 80 Ml/d capacity from River Avon to Chew 1000mm 15200m length.
- Raw water treatment works to improve quality of River Avon for discharge to Chew treating 30 Ml/d average, 80 Ml/d peak, probably using submerged membrane technology and incorporating full water recovery and sludge handling.
- Additional treated water potable capacity for 30 Ml/d at or close to Stowey treatment works, this may also require an additional draw off structure for the reservoir as the existing does not have the required capacity.
- Additional distribution zone pumps to South Bristol Ring Main of 30 Ml/d at 50mhd.
- Partial main reinforcement of treated water trunk mains to South Bristol Ring Main 600mm 3000m to increase capacity and transfer the extra yield.

10.4.8 Southern sources upgrade of individual works – yield target 8Ml/d

This is a scheme to return to service the three disused groundwater sources referred to earlier. In addition, the scheme will restore the yield that was lost at other Mendip treatment works when these sources had membrane treatment plants installed in 2002.

Restore to full yield the following:

Source	Current	Full	Increase
Charterhouse	1.3	**2.1**	.8
Shepton Mallet	1.2	**2.2**	1
Egford	4.7	**5**	0.3
Sherborne	3.7	**4.7**	1
Wells	0	**.8**	.8
Gurney Slade	0	**1.5**	1.5
Honeyhurst	0	**2.4**	2.4

Total yield increase (Dry Weather) 8 Ml/d

Infrastructure

- Most of the infrastructure is in place and no significant extra lengths of main are required. New treatment plant capable of producing the required output at observed maximum levels of turbidity will be required. The treatment process will need to meet the current DWI requirements for removal of cryptosporidium. The treatment works capacity will be as in the table below:

Source	**Current**	**Full**	**Increase**
Charterhouse	2	3	1
Shepton Mallet	2	4	2
Egford	5	6	1
Sherborne	4	7	3
Wells	0	2	2
Gurney Slade	0	6	6
Honeyhurst	0	6	6
Total TW capacity			**34 Ml/d**

A key factor for this scheme is its interaction with the quality programme to deal with issues at a number of these sources. We are currently investigating whether there are alternative approaches that provide the combined quality and supply/demand benefits at a lower total cost. If such an approach is identified it will be included for consideration in the final water resources plan.

10.4.9 Sharpness reservoir and transfer – target yield 25 Ml/d

This is a major resource development scheme based on an increased abstraction from the River Severn. Because of the issue of low flows on the lower Severn during summer, it is anticipated that this will be an abstraction with flow conditions, with water transferred to a new raw water reservoir of approximately 6000Ml capacity.

The water treatment works will be extended to treat the extra water available. Associated pumping plant and mains will be upgraded to transfer the extra water south to offset demand on the Mendip reservoirs. The issue of additional transfer of water via the Sharpness canal has been discussed with British Waterways who raised no objection in principle.

Infrastructure

- New Abstraction licence for further abstraction from Severn at Gloucester Dock of up to 25 Ml/d annualised average with high daily allowance subject to Deerhurst flow conditions.
- A second raw water intake on the Sharpness canal for up to 75 Ml/d flow.
- New low lift PS for intake to reservoir of 75 Ml/d at 15m lift.
- 1000m of twin 600mm intake mains to the reservoir.
- New 6000 Ml fully or partially bunded pump storage reservoir.
- Draw-off structure to low lift pumping station into treatment works sized at 200 Ml/d.
- 1000m of twin 800mm mains from low lift pumping station to treatment works.
- Extension of treatment capacity by 50 Ml/d at with following processes
  Pre ozone
  Flocculation clarification
  RGF
  Post ozone

GAC
Chlorination

- Aditional pumping capacity of 50 Ml/d 160m lift at .

- New intermediate potable water pumping station at Rangeworthy, 200Ml/d, 100m lift.

10.4.10 Avonmouth effluent re-use domestic distribution target yield 20 Ml/d
This option is to use a proportion of the treated effluent from Avonmouth sewage works to supply domestic customers.

Water taken from the sewage treatment works source has a high calcium, nitrate, phosphate and salinity content that will be removed by a reverse osmosis plant. Other processes such as re-mineralisation will be required to treat the water to potable standards. The costs of operating will be much higher than for the scheme described for the provision of water for industrial use.

The treated water will be pumped to Almondsbury reservoir for blending with water from the treatment works.

Infrastructure

- Reverse osmosis treatment for STW effluent at Avonmouth with full re-mineralisation and other treatments to potable standards.

- New 7000m 600mm main from treatment plant to Almondsbury reservoir.

- 20 Ml/d pumping plant with 30m lift to reservoir .

- Additional pumping plant rated at 30 Ml/d and 30m lift to take water to Almondsbury and Thornbury (Marlwood reservoir).Possible reinforcing main required from Littleton to Marlwood allow for 5 Km of 300mm main

10.4.11 Severn Spring and transfer – yield estimate 15Ml/d
This option is to take the water from Great Spring discharge at Sudbrook and pump it across the Severn estuary via mains carried on the Second Severn Crossing.

The Great Spring was intercepted during the construction of the Severn railway tunnel in the 19th century. Very large flows of groundwater through fissures have been trapped and culverted to Sudbrook on the Welsh side of the Severn estuary, where it is pumped to the surface and discharged to tidal waters. The spring yield declines in drought conditions, but this is not thought to be an issue as the company is not resource critical at peak demand periods.

The scheme uses water that would otherwise be discharged to the Severn estuary. Because of the quality issues, it is anticipated that the water would be targeted to industrial customers in the first instance. This would displace 15 Ml/d of raw water taken from the River Severn via the Sharpness canal and allow the better quality water to be used to meet the growth in household water demand.

Infrastructure

- Intake on Network Rail land at Sudbrook depot, together with 15 Ml/d, 30m lift pumping station.

- 10000m of 600 id main from Sudbrook to Severn Beach to connect to exiting raw water main between Avonmouth and Littleton.

- As with TTE scheme, there will need to be an increase in the potable treatment capacity of the treatment works together with increased treated water pumping capacity of up to 15 Ml/d.

- There would be a significant charge for both the raw water to be purchased from Railtrack and the operating charges for a main attached to the SSC. An alternative would be to lay a submarine pipeline, but the technical difficulties and cost would be much greater.

A key issue in respect of this option is potential use of the source by Welsh Water. This may result in the source not being available for use by Bristol Water. We have not discussed this in detail with Welsh Water or the Welsh Assembly Government.

10.4.12 Desalination and transfer scheme – target yield 30Ml/d

This option will take partially saline or brackish water trapped in the tidal reservoir at Oldbury Naite in the Severn Estuary. This would be pumped to new a pre-treatment works for solids removal at an existing treatment works site. A reverse osmosis desalination plant, with further treatment as required to potable standards will be used to carry out the removal of chlorides.

The extra water available will be pumped to Almondsbury at a high rate and Almondsbury boosters will operate at higher output to move the water to Bristol east. The pipeline from Littleton to Almondsbury will require reinforcement. Avonmouth boosters will operate at higher rates to move the water to Bristol south and the Portishead zone. A reinforcement pipeline from Littleton to Marlwood reservoir at Thornbury will also be required.

Infrastructure

- Water taken from Oldbury tidal reservoir utilising 40 Ml/d marine/brackish water intake screens and biological control.

- 30 Ml/d PS with 30 M lift via 6000m of 600mm sea water main to the treatment works to be treated in desalination reverse osmosis membrane plant.

- 30 Ml/d reverse osmosis plant with full re-mineralisation and treatment to potable standards, together with sludge and saline discharge arrangements.

- 2000m of saline/effluent discharge main to estuary.

- Additional pumping plant to take water to Almondsbury reservoir and Thornbury (Marlwood reservoir) 20 to 30 Ml/d 30m lift.

- Possible reinforcing main required from Littleton to Almondsbury, allow for 10 Km of 600mm main.

- Possible reinforcing main required from Littleton to Marlwood reservoir, Allow for 10 Km of 600mm main.

10.5 Options for distribution management

For water loss reduction and network water efficiency, the feasible options under consideration are detailed below. With low yield options of this type, it is considered likely that several may be implemented together for maximum effect on the supply demand balance at the optimum costs.

The baseline forecast includes an assessment of leakage based on sufficient mains replacement being undertaken to maintain stable serviceability with lead supply pipes being replaced alongside the mains. The level of activity required to achieve this is approximately 60km of mains replacement per annum (0.9%). This represents a considerable increase over the current rate of mains replacement of about 30km pa (0.5%). The infrastructure options considered below are in addition to this activity.

The details (in terms of cost and yield) of each scheme are set for a particular level of activity (e.g. replacement of 1km of main). The actual levels identified in the final plan (if any) will be those that result in the optimal overall approach to balancing supply and demand.

10.5.1 Infrastructure replacement and CP replacement

This scheme is to reduce distribution losses of water by undertaking additional mains and service pipe replacement.

Two forms of the scheme have been considered:

- A zonal approach that targets waste districts with the highest levels of leakage
- Additional activity targeted in line with our current approach to maintenance (targeting mains with the highest burst rates)

Under the zonal approach each zone targeted would result in replacement of c2km of mains and over 200 lead and galvanised CPs. It is assumed that half of the mains replacement is already included in base maintenance, so that there is replacement of 1 Km of main per zone above the baseline activity. The cost of renovation for each zone is estimated at £286k.

The predicted water savingfrom reduction of bursts and leakage would be 0.03 Ml/d per zone. If the target 6 zones p.a. are rehabilitated in this manner, the total water saved would be 0.18 Ml/d. When the scheme was completed after 25 years, the indicative yield would be 4.5 Mld.

10.5.2 Permanent zonal monitoring with increased district monitoring

This is a leakage reduction scheme targeted on the zones that appear to perform poorly in terms of having night flows that are difficult to control (unusually high flows of water into a zone at night may sometimes indicate a leakage problem).

Over 98% of the company area is already covered by metered zones (DMA’s). A large number of these meters return data to the Netbase leakage monitoring system for analysis of night flow. The proposed option works by using more sophisticated loggers that can rapidly identify and report changes in night flow that could be due to a new leak. This will enable immediate action to be taken to isolate districts, locate and repair the leak.

The planned activity for this scheme will be to use this advanced flow monitoring for the worst 30 zones per year over the next 10 years to detect increased night flows. In addition to this, districts subject to frequent leak noise detection surveys will sub-divided into smaller units for night-flow monitoring to pinpoint the worst performing sectors. The combined effort is forecast to save 0.75 Ml/d on average during the year over the 30 zones investigated.

The reduction in leakage is derived from the speed of response and the fact that the run time of the leak is significantly reduced. The new meters will be moved from zone to zone each year to maximise the benefit from their deployment. The reduction in leakage would represent a step change and not accumulate from year to year.

10.5.3 Communication pipe (CP) replacement

The communication pipe is the connection from the Company owned main to the customers supply pipe, and is the responsibility of the Company to maintain. Leakage on communication pipes and fittings is approximately 50% of the total leakage.

The option will lead to savings of 0.1 Ml/d per every 1000 CPs replaced. After 25 years this would result in a total saving of 2.5 Ml/d when the option was complete.

The estimated cost would be £850k per 1,000 CPs replaced.

10.5.4 Pressure reduction additional schemes

This is a scheme intended to reduce leakage by establishing further pressure reduction zones to add to those already in operation as part of the baseline. Reducing pressures in the mains network helps to reduce losses from leaks too small to detect by active leakage control. Reduced pressure may also reduce the frequency of bursts as there is less stress on the aging pipes and joints.

The planned activity for this scheme will be to establish 10 new pressure reduced zones per year over the next 6 years, resulting in 60 new zones, with a forecast maximum saving in leakage of 3.9 at the end of the scheme.

The company outturn for each year would be:

- 10 new PV zones
- 0.55 Ml/d average leakage reduction on completion of each years programme
- 3.9 Ml/d leakage reduction when all 60 zones were completed

10.5.5 Subsidised supply pipe (SP) and Communication pipe replacement

This scheme is an extension of the communication pipe replacement scheme identified above. Taken together, leaks on communication pipes, supply pipes and fittings is over 70% of the total leakage. However, the supply pipe is the property of the householder so we are not able to make the householder replace this leaking part of the network. It is hoped that by offering to subsidise the repair, householders will welcome the opportunity of a complete renewal of their service connection.

It is anticipated that a subsidy of £250 will lead to about 2000 requests from customers per annum. (This compares to 600-700 replacements per year at present with no subsidy). In most cases the communication pipe will be replaced together with the supply pipes.

- The cost of replacing 1000 SPs and 1000 associated CPs is calculated to be £1.1m (assuming a subsidy of £250). The associated leakage savings are forecast to be 0.17 Ml/d.

- On average 5000 installations p.a. will be completed over the plan period. On completion of the option after 25 years, the total savings will be approximately 20 Ml/d.

10.5.6 Leakstop enhanced level of free/subsidised repair at faster rate

This option would reduce leakage by accelerating repairs to household customers leaking supply pipes. Reported and unreported leaks on customer supply pipes account for over 15% of the total leakage.

The company has offered a free or subsidised repair arrangement for customer supply pipes for many years. In the base year, approximately 500 supply pipes were repaired, saving an estimated 0.5 Ml/d in leakage. This programme is operated through the 'LeakStop' scheme contract where customers agree to have the first leak repaired free, but subsequent repairs attract a charge.

We consider it would be beneficial to increase the activity rate for this scheme so that enforcement notices and repairs are carried out faster, possibly on the assumption that the customer will accept the terms of the 'LeakStop' contract retrospectively (most customers do agree to the first free repair but need to be aware that further repairs on the same supply pipe will attract a charge for part of the cost).

By doubling the activity from the current baseline to 1000 'LeakStop' contract repairs, the indicative activity for each year would be:

- Additional 500 repairs carried out on supply pipes (total 1000 p.a.)
- Annual leakage reduction 0.5 Ml/d (total 1.0 Ml per year non accumulating)

10.5.7 Active leakage control (ALC) increased effort

Active leakage control (ALC) targets larger leaks from mains (both visible and invisible). This source of leakage represents approximately one third of the total leakage. The methods of this form of leakage control include sounding using leak noise detection equipment and zonal step tests to isolate areas of leakage.

This extra activity will not increase the awareness time, but should reduce the length of time that leaks run as the location time will be faster, which the most significant component of leakage. Our baseline resource for ALC is 14 leakage inspectors. Their combined effort is to restrain this component of leakage to 13 Mld.

The level of activity set for this scheme will be such that is balances the cost of the activity with the cost of lost water, customers willingness to pay to avoid supply restrictions, and customers' willingness to pay to reduce leakage.

A doubling of activity to 28 leakage inspectors is estimated to lead to additional active leakage control costs of £619k p.a. It is estimated that the resultant reduction in leakage would be 5.7 Ml/d.

10.6 Environmental and social impacts

The feasible options described above have been analysed in terms of their potential effect in monetary terms on the wider environment. This has been carried out based upon the methodology described in the Environment Agency's Benefits Assessment Guidance (2002).

A more detailed approach has been taken than described in the guidance, particularly with respect to impact on climate change through carbon emissions. The following have been taken into account when deriving the environmental and social impacts:

- Environmental impact categories
  - Recreation
  - Heritage, Archaeology and Landscape
  - Amenity, property prices and regeneration
  - Land take and non water based recreation
  - Biodiversity and non-use
  - Works Related Impacts
  - Land Take
  - Landscape Impacts
  - Property based disamenity effects
  - Traffic related impacts

- Construction considerations
  - Size of project and period
  - Carbon emission during construction
  - Embodied carbon in materials used for project
  - Energy use in construction

- Operating costs
  - Power in kWh
  - Carbon embodied in chemicals used for treatment
  - Carbon tonnes of CO2 for life of the scheme

The carbon assessment for each option has been broken down into operational (i.e. annual, recurring carbon impacts) and construction impacts (one-off impacts during the construction period). The following sections set out how the operational and construction carbon impacts of supply, leakage and water efficiency options were calculated.

The carbon footprint of options has been assessed over a 100 year accounting period. The following simplifications have been made:

- The construction impacts are accounted for once. No account is made of replacement of materials as they become life-expired.

- Carbon emissions calculated during the construction phase have been included in year 1 of the construction period.

- The yield of supply side options, metering and water efficiency options (and therefore the impact on operational energy requirements) is assumed to remain constant over time. The exception to this is the distribution of cistern displacement devices, where the yield is assumed to reduce to zero 5years after the implementation is completed.

- At the end of the accounting period, the yield of infrastructure replacement leakage schemes is assumed to decrease to one third of the yield at the point where implementation ceases. For all other leakage reduction options the yield is assumed to be constant over time.

An annual carbon footprint in tonnes of CO_2 has been calculated for each option. This has been converted to a financial cost of carbon using the shadow price of carbon, as stated in the latest Environment Agency Guidance.

A full report on the derivation of social and environmental costs, and analytical tables are included in the appendices for this section. A summary of the methodology used to assess the differing groups of options is provided below.

10.6.1 Supply side options

The table below sets out the assessment of social and environmental costs for resource development schemes. The costs are expressed as a net present value in thousands of pounds calculated over a 100 year period using a 4.5% discount rate:

Scheme Name	NPV Operational environmental cost	NPV Construction environmental cost	Carbon construction and operation cost	NPV Total SEC costs
Desalination and transfer scheme	93,653	149	14,051	107,853
Avonmouth WWTW Direct Effluent Re-use	2	3	7,589	7,594
Effluent re-use commercial	2	16	4,962	4,980
Pumped Refill of Chew Valley Reservoir	906	409	1,296	2,611
Southern Source consolidation	1,919	68	624	2,611
Docks Scheme	0	1,276	984	2,260
Severn Spring and transfer	0	86	550	636
Stowey WTW Washwater Recovery	0	427	100	527
Southern sources upgrade (unconsolidated)	0	62	332	394
Minor sources	0	24	166	190
Purton Res and transfer	-1,726	34	1,504	-187
Cheddar Reservoir	-1,017	88	724	-205

The operational energy requirements for supply side options have been calculated using the following approach:

Annual energy requirement (Eo*Y)*365 = Ea

Where;

Eo = Operational Energy Requirement (kWh/Ml)
Y = Option Yield (Ml/d)
Ea = Annual energy required to operate scheme

The annual energy consumption in kilowatt hours was converted to emissions in CO2 using the standard Defra energy conversion factors for grid electricity of 0.43 kg CO2 per kWh (Defra, 2005).

The operational energy requirement in kWh/Ml for each option includes pumping and treatment energy requirements. Also taken into account in the operational carbon impacts are the carbon emissions associated with vehicle movements during operation. An allowance of one operational vehicle movement per week for each option was included in the carbon assessment.

Emissions were calculated using standard Defra conversion factors for an articulated lorry assumed to be 50% laden (Defra, 2005) and the following approach:

Carbon Dioxide emissions (D*Fc)*Co= C
Where;
D = Assumed distance travelled (km)
Fc = Fuel Consumed (litres/km)
Co = Conversion Factor for a 50% laden articulated lorry (kg/litre)
C =Annual carbon dioxide emission (kg)

The carbon emissions for construction have been quantified for two elements; the embodied carbon included in construction materials (where available) and the emissions from plant on the construction site.

Embodied carbon values have been taken from the University of Bath Inventory of Carbon and Energy (ICE) (University of Bath, 2006). The ICE uses published information to quantify the carbon emissions from the production of one kilogramme of various raw materials used in construction ranging from paper, through to plastics, fuels and metals.

Estimates of construction materials for supply side option have been limited to the mass of 3% reinforced concrete for the two reservoir options (information is not available for the other supply side options) and the mass of MDPE pipe material for all supply side options. It is acknowledged that by restricting the assessment to these materials some of the embodied carbon will not be taken into account. However, this is a best estimate of embodied carbon using information available at the time of the study. The assessment of embodied carbon in this assessment can be summarised by the following equation:

Embodied Carbon M*Ec = Tec
Where;
M = Mass of material required during construction (kg)
Ec = Embodied carbon in material (kg CO_2/kg material)
TEc = Total Embodied Carbon (kg)

The carbon impacts of plant movements during construction have been calculated using the simplified approach used by the Environment Agency’s engineering teams for determining carbon footprint of engineering schemes based qualitatively on four categories from small to very large.

Very large
Construction costs more than £10 million, more than 25 people permanently on site during construction period - 25 tonnes CO_2 emissions

Large
Construction costs £5 to £10 million, between 16 and 25 people permanently on site during construction period 12 tonnes CO_2 emissions

Medium
Construction costs £1.5 to £5 million, between 9 and 15 people permanently on site during construction period 5 tonnes CO_2 emissions

Small

Construction costs less than £1.5 million, fewer than 8 people permanently on site during construction period 2 tonnes CO_2 emissions

10.6.2 Leakage Options

The table below sets out the assessment of social and environmental costs for leakage control schemes. The costs are expressed as a net present value in thousands of pounds calculated over a 100 year period using a 4.5% discount rate:

Scheme Name	NPV Operational environmental cost	NPV Construction environmental cost	Carbon construction and operation cost	NPV Total SEC costs
Infrastructure replacement	£0	£7,383	£225	£7,608
Infrastructure replacement and CP replacement	£0	£5,482	£146	£5,628
CP and subsidised SP replacement	£0	£5,515	£20	£5,535
CP replacement	£0	£5,515	£9	£5,524
ALC increase	£0	£3,694	-£840	£2,855
Permanant Zonal monitoring	£0	£0	-£36	-£36
Leakstop enhanced	£0	£14	-£57	-£42
Pressure reduction	£0	£0	-£66	-£66

To quantify the carbon emissions associated with leakage reduction options the following operational (annual, recurring) impacts have been taken into account:

- Reduction in operational pumping energy requirements as a result of the reduction in leakage
- Effect on the number of vehicle movements required as a result of the leakage options
- Construction impacts from the embodied carbon in replacement pipes

Bristol Water provided the marginal energy requirement to supply 1 Ml/d of water in the supply area (830 kWh/Ml). The reduction in the energy requirements due to the reduction in leakage has been calculated as:

Annual reduction in energy requirement (Meo*Y)*365 = RE

MEo = Marginal Operational Energy for supply in the WRZ (kWh/Ml)
Y = Option Yield (Ml/d)
RE = Annual reduction in energy required (kWh/a)

One-off embodied carbon cost has been accounted for in the infrastructure replacement options. Bristol Water provided an estimate of the length of pipe to be replaced in each infrastructure replacement option and an estimate for the mass of MDPE Pipe in kg/metre. Embodied carbon was calculated using values for this material from the University of Bath Inventory of Carbon and Energy Report.

No embodied carbon has been accounted for in the other (non-infrastructure replacement) options such as active leakage control, permanent zonal monitoring and leakstop enhanced options. This is due to uncertainties over the mass of material that might be required in each option. The mass of material in the infrastructure replacement options is more readily quantifiable.

10.6.3 Water efficiency and metering options

The table below sets out the assessment of social and environmental costs for water efficiency schemes. The costs are expressed as a net present value in thousands of pounds calculated over a 100 year period using a 4.5% discount rate:

Scheme Name	NPV Operational environmental cost	NPV Construction environmental cost	Carbon construction and operation cost	NPV Total SEC costs
Optant metering	243	214	-135	322
Change occupier metering (all domestic customers)	292	257	-237	311
Compulsory metering of domestic customers	584	280	-776	88
Change occupier metering (large gardens only)	146	129	-269	5
Retro-fit WC with dual/variable flush devices	0	113	-110	3
Selective metering of remaining unmetered commer	1	4	-10	-5
Cistern displacement device distribution	0	0	-7	-7
Selective metering (agricultural troughs)	0	0	-8	-8
Business audits	0	2	-172	-170

Carbon has been assessed in three ways for the water efficiency and metering options:

- Embodied carbon from materials
- Changes in demand (and thus changes in energy use in the supply system)
- Vehicle movements associated with the installation of meters/water efficient devices

Embodied carbon has been assessed based on the mass of brass within a water meter and the mass of plastic and paper within the water efficiency options. Although this will not quantify all embodied carbon within the metering and water efficiency options, it is a necessary simplification.

The carbon impact of vehicle movements has been quantified by using an estimate of the number of vehicle movements for each meter or water efficient device installation. The Defra value for a large diesel car (engine size greater than 2.0 litres) has been assumed to equate to the emissions that might be expected from a light van.

Section 11. Options appraisal

A spreadsheet optimisation tool has been used to carry out the economic appraisal and determine relative cost benefit for the feasible options. The approach taken has been to use the intermediate methodology outlined in the Environment Agency guidance document, Economics of Balancing Supply and Demand (2002). The analysis we have used is not fully stochastic as described in the advanced methodology as the selection of the optimum solution is achieved by linear programming. However, we have included significant elements of the advanced methodology within the optimisation tool. These are:

1 Scalability of individual schemes to optimum levels
2 Customers' willingness to pay for leakage reductions
3 Customers' willingness to pay for security of supply
4 Inclusion of a risk element to the leakage cost function

Customers' willingness to pay exerts a very strong influence on the outcome of the selection routines, driving large reductions in leakage and supporting current target level of service.

The result of the optimisation process used is that no single option is a perfect solution to the supply demand-planning problem. The outcome has resulted in the selection of a basket of options of increasing scale over the planning period. The implication in terms of carbon dioxide emissions has also been considered as part of this process.

11.1 Overview of process

The optimisation tool includes and allows for the following elements:

- A sophisticated leakage model with a stochastic cost function
- Allowance for scalability of schemes where divisible
- Consideration of social and environmental costs as scaleable elements
- Impact of options in terms of carbon cost or saving over 40 years
- Interlinking of component effects (i.e. infrastructure replacement reducing leakage)
- Variability of headroom outturn within target
- Customer willingness to pay

The tool is set to optimise scheme selection with reference to the net present value of the following parameters:

- Customer willingness to pay for changes in:
  - Frequency of hosepipe bans and imposition of standpipes
  - Leakage
  - Replacement of lead communication and supply pipes
  - Reductions in the number of interruptions
  - Total operating and annualised capital costs of selected schemes
- The cost of carbon
- Social and environmental costs

The optimisation process is iterative, requiring initially the optimisation of active leakage control. The next step is the selection of additional metering, demand, resource and infrastructure options in various combinations scale and timings to generate the lowest cost total NPV of all capital, operating, environmental and social costs. The leakage control element is re-optimised to take account of any impact the implementation of the other options and check if the preferred option set is still optimum.

11.2 Willingness to pay

We have carried out a programme of customer research through both questionnaires and focus group meetings during 2007, with the following objectives:

- Which service areas of most concern customers
- Willingness to pay for service improvements
- Attitudes of different customer groups

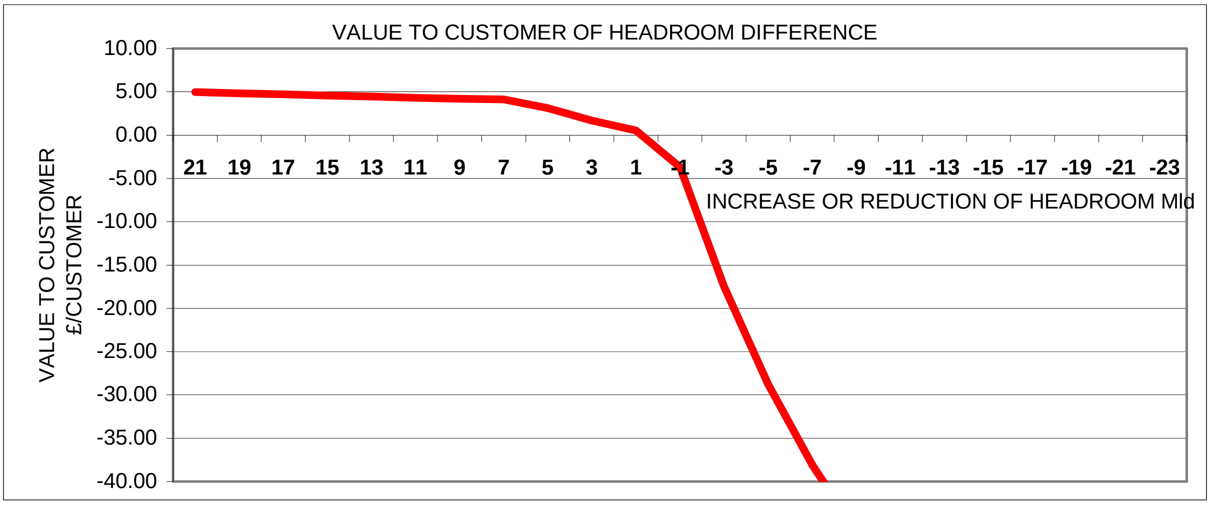
The quantitative element of the research consisted of 1,000 face to face interviews with customers. Of all of the service attributes, safety and quality of water supplied scored the highest in terms of concern. Second to this was security of supply and avoidance of the need for standpipes and third was leakage.

The research investigated customers' willingness to pay for changes in the following service attributes:

- Frequency of hosepipe bans
- Frequency of imposition of standpipes (due to extreme drought)
- Level of leakage
- Replacement of lead communication pipes
- Replacement of lead supply pipes
- Risk of receiving a supply interruption of greater than six hours
- Risk of receiving low pressure
- Risk of receiving discoloured water
- Availability of continuing piped water supply in the event of a failure in the normal route of supply (e.g. due to fire at a pumping station)

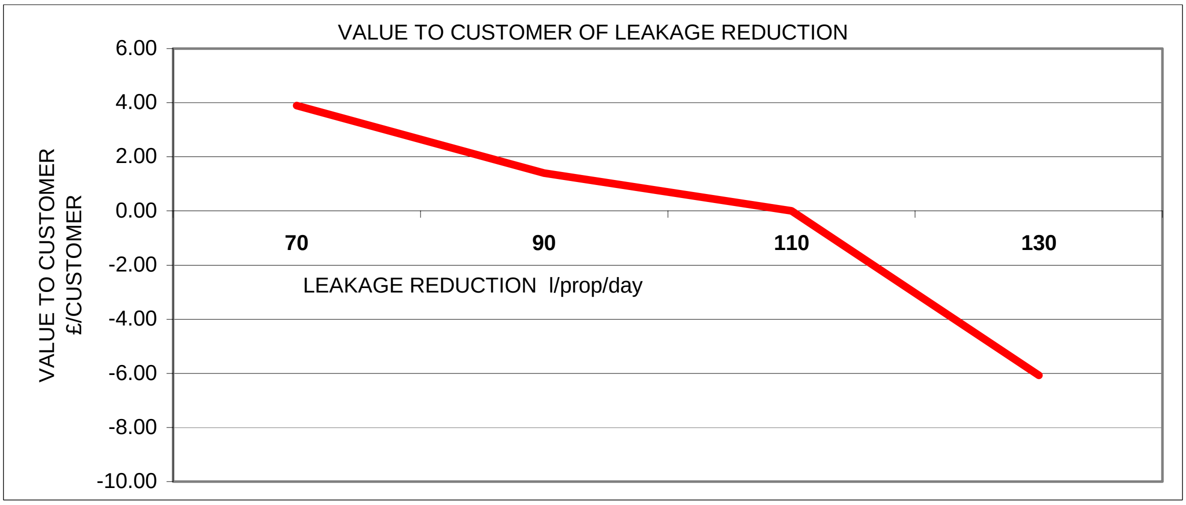
Customer's willingness to pay for the first six of these attributes has been taken into account within the optimisation method used to derive the total cost of the company preferred water resources plan strategy.

The expected frequency of hosepipe bans and imposition of standpipes depends upon the extent of spare headroom. An assessment was made of the impact of changes in headroom on the frequency of these measures and this used to convert the observed willingness to pay for changes in frequency into a willingness to pay for changes in headroom. The willingness to pay for the two measures was combined and is shown in the graph below.



The chart shows that willingness to pay increases rapidly up to about £5 per customer for small increases in spare headroom, but that above an additional 10 Ml/d further increases in willingness to pay are small. The chart also shows that customers expect significant reductions in bills if their level of service is to reduce.

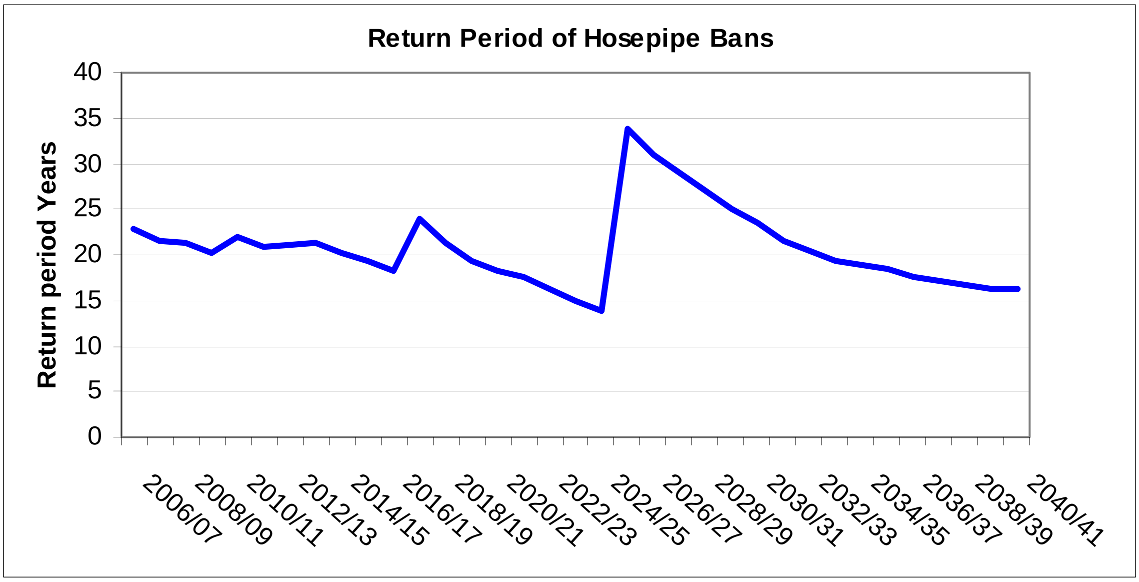
The figure below shows the willingness to pay for changes in the level of leakage (expressed in l/prop/d). This shows that customers are willing to pay up to £4 extra on their bills to see a significant reduction in leakage.



An analysis of the findings of the survey also indicated that customer's willingness to pay to remove lead service pipes was equivalent to £201 per CP and £339 per SP.

Additionally, customers were willing to increase their bills by £1.65 to reduce the risk of an interruption of greater than 6 hours to 0.1% per annum.

The optimisation process does not directly take into account the supply/demand balance, only customers' willingness to pay for the amount of spare headroom and the other benefits arising from the plan. A consequence of this approach is that the final level of service achieved is an output of the optimisation, rather than an input, as shown in the graph below.



11.3 Ranking of options

The full results of the analysis and ranking of options are detailed in the Water Resource Plan tables (WRP2) and in appendix 11. The figures set out in table WRP2 do not include the impact of customer willingness to pay.

For some schemes the benefits and costs are dependent upon the timing of the schemes or their interaction with other schemes. Examples of such interactions include the increase in the cost of carbon over time, the benefits of reduced numbers of bursts from infrastructure schemes being lower when active leakage control activity is higher, and savings as a result of installing a meter depending upon unmeasured demand. These interactions are taken into account in the optimisation, but they are not reflected in table WRP2 which only show the benefits of the schemes on a stand alone basis as if implementation was to begin immediately.

The table below provides a simplified listing of the individual options ranked by the cost expressed as the equivalent cost of one m3 at the point the option is implemented. This cost includes the social, environmental and carbon costs (and is the column AISC). The costs net of social and environmental costs and option yields are also shown in the table.

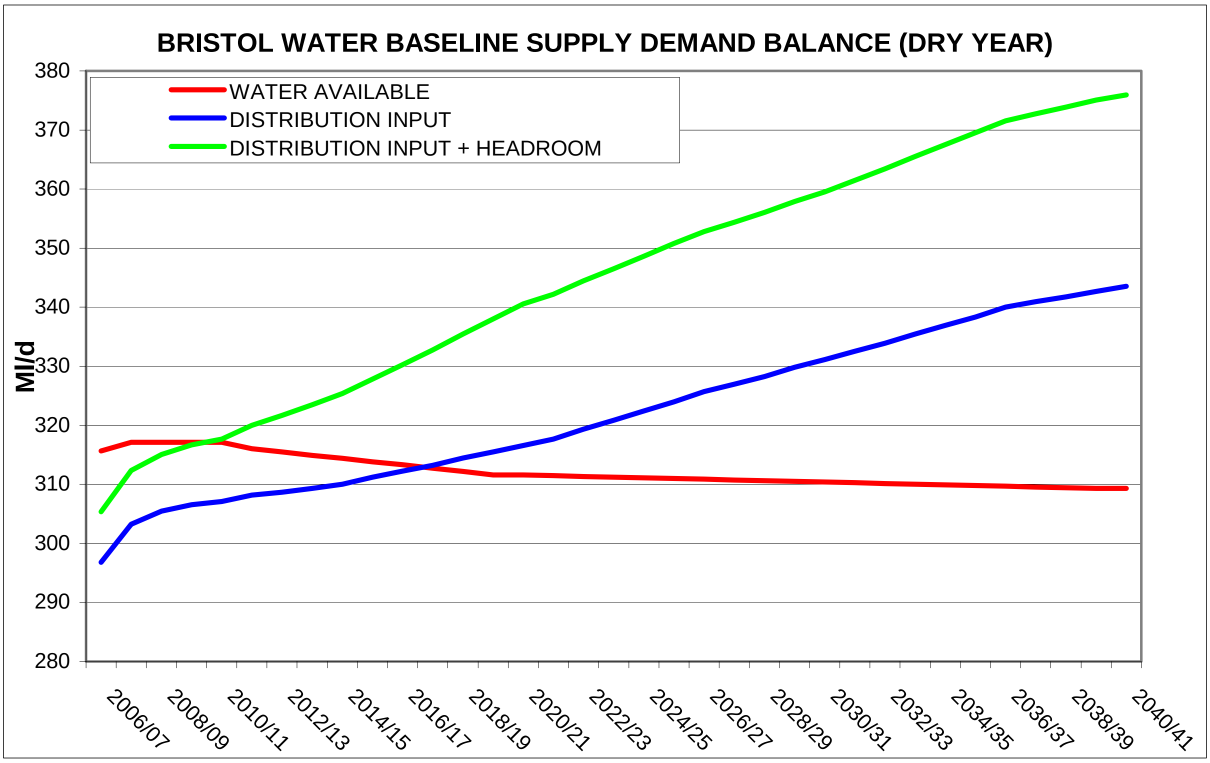
OPTION DESCRIPTION	OPTION REFERENCE No.	WAFU ON FULL IMPLEMENTATION (Ml/d)	AIC (p/M^3)	AISC (p/M^3)
Customer Side Management, Specify Below....				
Business Customer Audits	D005	1.50	21.2	20.3
Change of occupier large garden	D004	1.21	71.2	57.0
Non-Household metering	D010	0.28	87.0	72.6
Cistern displacement device distribution	D016	0.30	130.8	139.5
Retro-fit WCs with dual/variable flush devices	D006	0.30	130.8	140.1
Compulsory	D011	1.15	177.4	154.9
Change of occupier	D003	1.10	304.0	244.5
Distribution Side Management, Specify Below....				
ALC	L005	0.00	0.0	0.0
Pressure Scheme summary	L007	3.89	0.9	0.2
Leak noise loggers ALC freq/year > 5 per wwwmd	L000	0.18	1.6	2.5
Permanent WWMD logging	L006	0.53	-0.9	4.4
Extension of Free Private Leak to all households	L008	0.57	49.8	49.2
Subsidised Service Pipe Replacement	L004	0.33	51.4	50.4
Lead CP Replacement	L003	0.47	76.3	75.2
Zonal Replacement	L002	0.61	80.0	81.2
Mains Replacement with Services	L001a	0.18	203.1	210.4
Mains Replacement	L001	0.03	913.8	955.9
Production Side Management, Specify Below....				
Stowey WTW Wastewater Recovery	S012	2.00	5.0	8.9
Resource Management, Specify Below....				
Minor Sources	S006	5.00	45.2	45.6
Southern Sources Upgrade	S017	8.00	50.3	51.1
City Docks/Barrow Transfer	S012	30.00	52.2	53.6
Cheddar New Reservoir	S001	20.00	59.6	59.2
Severn Springs	S002	15.00	60.3	60.9
Chew Valley pumped storage	S015	30.00	71.0	73.9
Effluent Reuse Commercial	S007	20.00	91.0	93.9
Effluent Reuse	S016	20.00	112.8	116.8
Purton Bankside Reservoir	S013	25.00	117.2	121.3
Desalination	S008	30.00	84.9	127.7
Consolidated Mendip Sources	S004	8.00	171.8	179.4

The inclusion of interactions, temporal effects and customer willingness to pay means that the optimal planning approach may necessarily reflect the order of AISCs set out above. In particular, the willingness to pay for reductions in leakage, replacing lead service pipes, and reducing the risk of interruption increases the attractiveness of infrastructure options.

Consequently our investigation of the optimal planning approach has only used the calculated AISCs as a guide, but has identified the optimum scale and timing of individual options and therefore the lowest cost overall solutions.

11.4 Company proposed strategy

The baseline supply demand balance was set out in section 9. If growth in population and housing takes place at the forecast rate and we only maintained leakage strictly at the economic level, there would be a planning deficit in water supply by 2012. This is clearly shown in the graph below.



11.4.1 Options and cost of resolving the supply deficit

We plan to restore the balance between supply and demand by implementing the optimised lowest cost management options identified from the outcome of the economic analysis. The options to be carried out as part of our strategic plan are described below:

- Carrying out extra free repairs to customers' leaking supply pipes from 2010 -- saving water by cutting the length of time taken to stop leaks
- Establishing up to 60 new pressure reduction zones by 2015 -- cutting water losses from small leaks and bursts.
- Using new leakage metering technology from 2010 in a rolling programme to monitor poorly performing zones, together with additional deployment of leak noise detection equipment.
- Redeveloping three smaller water sources in the Mendips in 2017 -- using new and efficient water treatment plant to ensure reliability and water quality can be maintained at all times of year.
- Completely refurbishing five other Mendip water sources in 2017 -- improved treatment plant would ensure the full yield of these sources can be maintained during periods when the quality of natural sources is poor.
- Auditing of larger non-household customers to encourage demand reduction by efficient water use.
- Completing the metering of all non-measured non-household customers by 2020.

- Offering subsidised customer supply pipe replacements coupled with replacement of the company's communication pipe after 2010.
- Metering household customers with large gardens on change of occupier up to 2020.
- Undertaking a step change in leakage management to bring leakage significantly below the present economic level to 45 Ml/d by 2020.
- Planning for an additional major water resource to be constructed by 2025, most probably as the second phase of the existing Cheddar Reservoir.
- Compulsory metering of all household customers from 2020 onwards, to achieve full metering penetration by 2035.
- Trialling differing tariff types, including of rising block tariffs.

All of the options that comprise our proposed long term best value water resources management plan are tabulated below.

REF	**OPTION NAME**	**DATES**
L005	Active Leakage Control	2010 to 2035
L007	System pressure reduction	2010 to 2015
L000	ALC leak noise logging	2010 to 2035
L006	Permanent district logging	2010 to 2035
L008	Extending free supply pipe repair scheme	2010 to 2035
L004	Subsidised supply pipe replacement	2010 to 2035
L002	Zonal based replacement of infrastructure	2010 to 2035
D005	Business customer audits	2010 to 2035
D004	Change of occupier metering (large gardens)	2010 to 2020
D011	Compulsory metering	2020 to 2035
D010	Non household metering	2010 to 2020
S017	Southern sources upgrade	2017
S001	Cheddar reservoir extension	2025

The implementation of this basket of options results in the following costs:

NPV of total solution	£161 million
NPV of carbon costs	£ 1 million
NPV of social costs	£-96 million
NPV of total strategy cost	**£66 million**

The optimum scenario set out above did not strictly have the lowest overall NPV that can be achieved. Strategic and practical considerations have led to a preferred plan with a slightly higher NPV due to:

1 Slightly higher metering than optimal
2 Slightly higher replacement of lead CPs than optimal
3 Inclusion of a reservoir at Cheddar in preference to the Docks scheme

The overall NPV of the strategy was relatively insensitive to the level of metering. The additional NPV of moving from the optimal approach to achieving full metering by 2035 was just under £1m. The removal of unmeasured billing would lead to non-monetary benefits that have not been included in the analysis. For example, metering is considered to have social benefits as it is perceived to be the fairest way to pay.

The overall NPV of the proposed solution is about £2m higher than optimum to allow replacement of all lead pipes by 2040. Removal of lead pipes would allow plumbosolvency control to be discontinued and the benefits of this have not been taken into account in the determination of the NPV. We believe that the benefits of being able to discontinue phosphate dosing are greater than this additional cost.

There was a possible lower cost solution available by substituting scheme S012, transfer of water from Bristol City docks to Barrow in place of S001. The overall NPV for the scenario using the docks transfer scheme would have been £58 million, although the social and carbon costs are higher.

On balance we prefer the reservoir scheme because:

- There is much less uncertainty associated with the scheme
- Its environmental impact is lower
- The impact on bills is marginally lower
- Winter storage schemes are likely to be more robust to the impact of climate change

The risks associated with the City docks transfer scheme that we do not fully understand at present relate, in addition to yield uncertainty, to water quality and the implications for future treatment.

- The achievable yield in a dry year
- The impacts on water salinity at Barrow reservoirs
- The impact of diffuse pollution from urban surface water drainage to the docks
- Bacteriological quality is very poor
- Concentrations of domestic pesticides and herbicides are high
- Nitrate concentration is high at certain times of year
- Other substances such as methaldehyde may be present
- NPV cost of carbon for docks scheme is marginally higher than S001 by £300k

The reservoir has a lower impact on bills than the Docks transfer scheme despite a higher net NPV. The docks scheme has a yield of 30 Ml/d compared to 20 Ml/d for Cheddar. This leads to higher headroom post implementation to which customers attach some value. This additional value results in a lower overall NPV despite the higher real costs incurred.

Our view is that the balance of risk between the schemes is such that the reservoir is clearly preferred despite the current assessment of slightly higher net costs. We intend to investigate this issue further and reflect our findings in the final water resources plan.

11.4.2 Impact of selected options on deficit

As well as generally being the lowest cost, the options we have selected also have considerable social benefits and make a useful contribution to the principles of sustainable development.

The impact of the implementation of the preferred strategy over time in terms of the gain in water available, or water saved is set out in table WRP3, appendix 11. A summary of the impact of the various options we have chosen, and how they contribute to reducing the supply demand deficit is set out in the table below

	2016	**2021**	**2031**
BASELINE DEFICIT FORECAST	**17**	**29**	**49**
SCHEME NAME			
Total yield of Active Leakage Control	**7**	**7**	**3**
System pressure reduction			
ALC leak noise logging			
Permanent district logging			
Extending free supply pipe repairs			
Subsidised supply pipe replacement			
Zonal based replacement of mains/meters			
Total yield of leakage schemes	**7**	**12**	**20**
Business customer audits			
Change of occupier metering			
Compulsory metering			
Non household metering			
Total yield of efficiency schemes	**3**	**4**	**6**
Southern sources upgrade		8	8
Cheddar reservoir extension			20
Total yield of resource schemes		**8**	**28**
Total water available or saved	**18**	**31**	**57**
PLANNING SUPPLY SURPLUS Ml/d	**1**	**2**	**8**

We believe our proposed strategy is well balanced and subscribes fully to the principle of a 'twin track' approach for the following reasons:

- Over the planning period, over half of the gains in water available come from efficiency and demand management activity

- Efficiency and demand management schemes are implemented early in the planning period, allowing flexibility in responding to growth

- Proposed leakage activity reduces water lost to the minimum that can be achieved through active leakage control using the latest technology available today. Further reductions in leakage would be achievable by the more costly method of replacing water mains.

- The efficiency schemes have a considerable beneficial dividend in reduction of power consumption and CO2 emissions over the planning period

- Options to increase resources output relay initially on maximising the output of existing sources and removing the constraints of water quality and treatment capacity

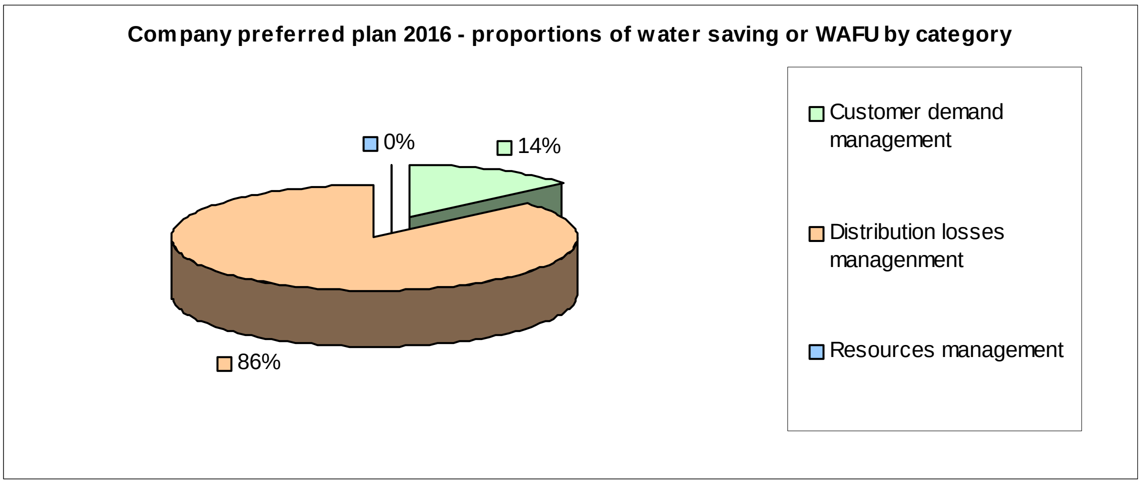
- The proposed extension to Cheddar reservoir is delayed for as long as is possible to allow our radical approach to cutting leakage and increased metering to deliver the maximum practicable yield. However, even with the most optimistic assumptions regarding per capita demand, it is highly likely that a substantial resource scheme will need to be planned for.

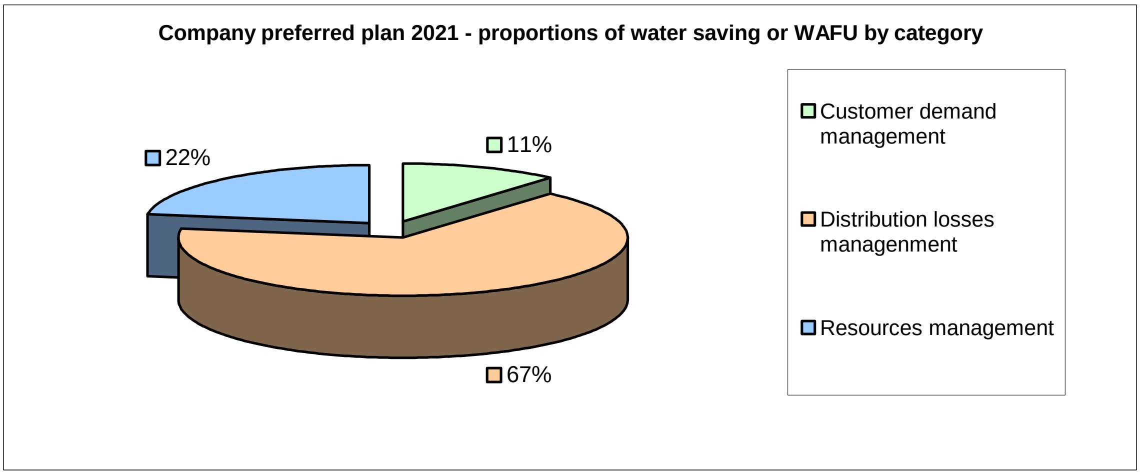
- There are considerable benefits associated with extending Cheddar reservoir including improving local resilience to effects of climate change and improvements to local biodiversity. In addition, Water is captured in winter when it is abundant and held it for local use over summer, reducing transfer pumping

In the early years of the planning period, our proposed strategy relies to a large extent on the assumption that per capita consumption remains broadly static, together with the belief that the metering, leakage and efficiency schemes will deliver the stated yields.

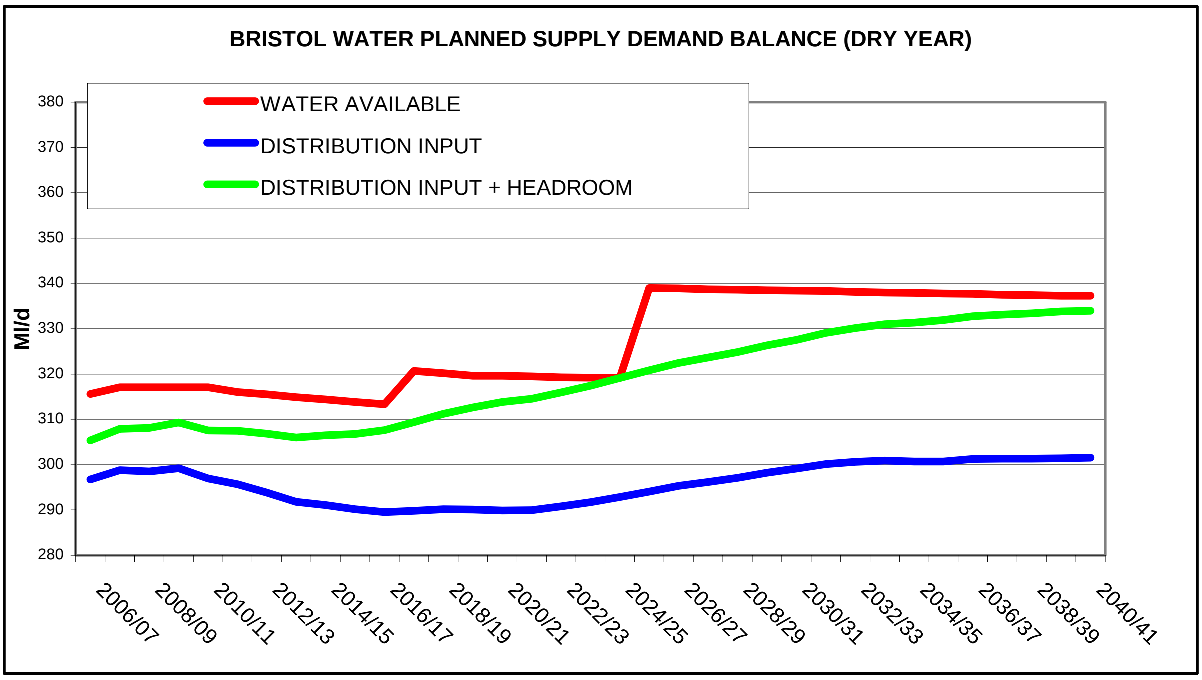
We will in any case prioritise these leakage and efficiency schemes, as these are the most cost beneficial to carry out in the short-term and will deliver considerable environmental benefits. If yields of the efficiency schemes turn out not to be practicable, or demand for water is greater than forecast, development of additional resources will become inevitable if security of supply is to be maintained.

The balance of the of the contributions from water efficiency, leakage reduction and resources development to reducing the supply-demand deficit as set out in our preferred is shown in the two plots below, covering the period from to 2021.





Over the planning period, our preferred plan would ensure there was no supply-demand deficit by a combination of activities targeted mainly at reducing leakage and customer demand to delay the implementation of higher cost resources development schemes. The supply-demand balance that would result from our preferred strategy is summarised in the graph below.



Once the leakage and efficiency options are fully implemented and minor sources are refurbished or brought back into service, a significant resource development appears inevitable in the future. These have been identified as:

- Cheddar reservoir extension
- City docks to Barrow reservoir transfer

Because of the anticipated time that will be needed to take either of these two schemes through the planning and development process, we need to start the initial studies for planning applications for both resource schemes in 2010. In the early stages of the initial investigations, we expect to treat the City docks transfer scheme being as viable as the reservoir extension option.

Of the two schemes, we prefer the reservoir extension. Reservoirs can provide a flexible and resilient way of mitigating future increases of volatility in supply and demand predicted as result of climate change. Apart from this, there are wider benefits associated extending Cheddar reservoir, including:

- Limited and low grade land loss
- Improved opportunities for conservation
- Increase biodiversity
- Locally available materials
- Social and recreational potential

However, we will also continue investigations into the viability of the Bristol docks transfer scheme in order that our long-term plan remains flexible.

The Water Resources Plan is kept constantly under review and re-published for consultation every 5 years, or if there are other material changes to circumstances. This process is adequate to identify any rapid deterioration in the supply demand balance, or other implications for our preferred strategy. Stakeholders will be consulted on all future versions of our Water Resources Plan when they become due.

11.5 Carbon Footprint

We have assessed the baseline carbon footprint of the company from 2004 as on the basis of power consumption and tonnage of chemicals used for water treatments. These are the largest contributors to the amount of carbon dioxide generated. They can also be directly related to the volume of water put into supply.

11.5.1 Historic carbon dioxide emissions

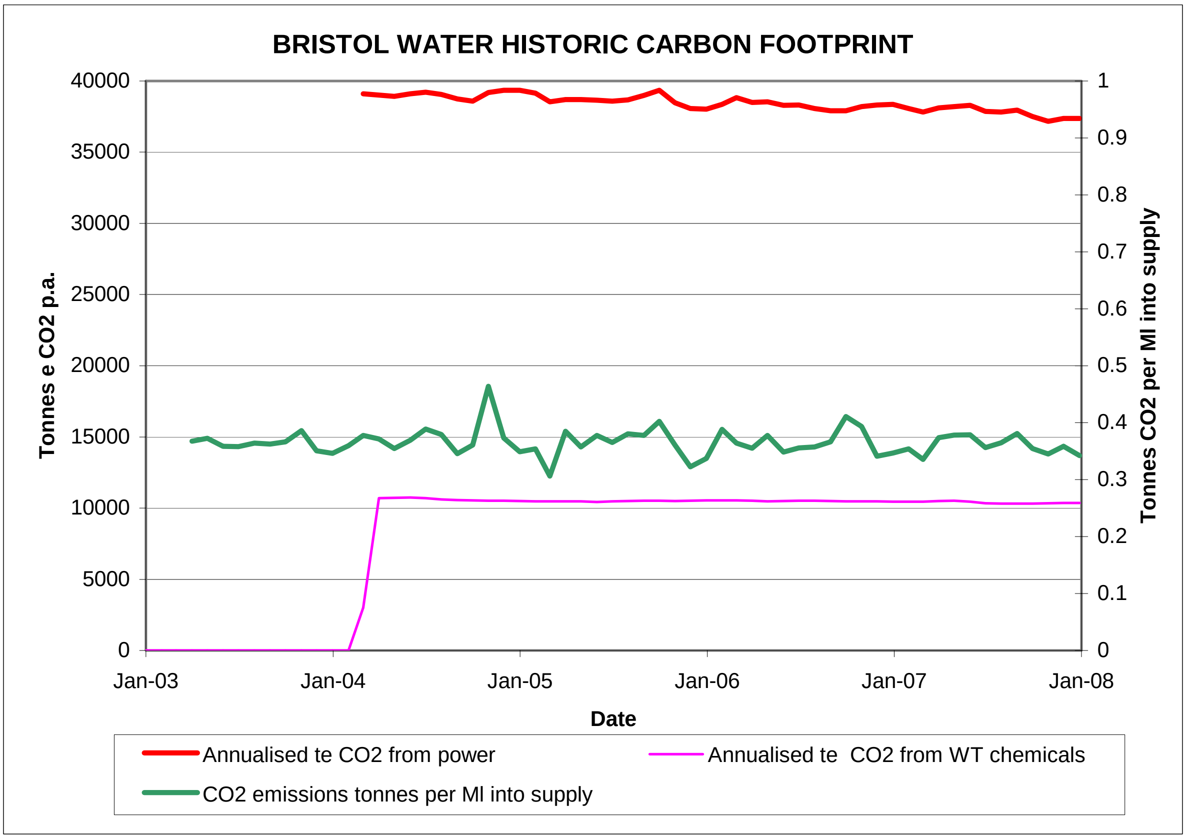
Since 2005 the company has:

- Used between 805 to 802 kWh/ Ml of water put into supply
- Used 0.029 tonnes of treatment chemicals per Ml of water put into supply
- Water put into supply has fallen by approximately 1% since 2005

We have used the following conversion factors to relate power and chemicals to tonnes of carbon dioxide emissions:

- kWh multiply by 0.43 = kg CO_2
- tonnes treatment chemical multiply by 0.7 = tonnes CO_2

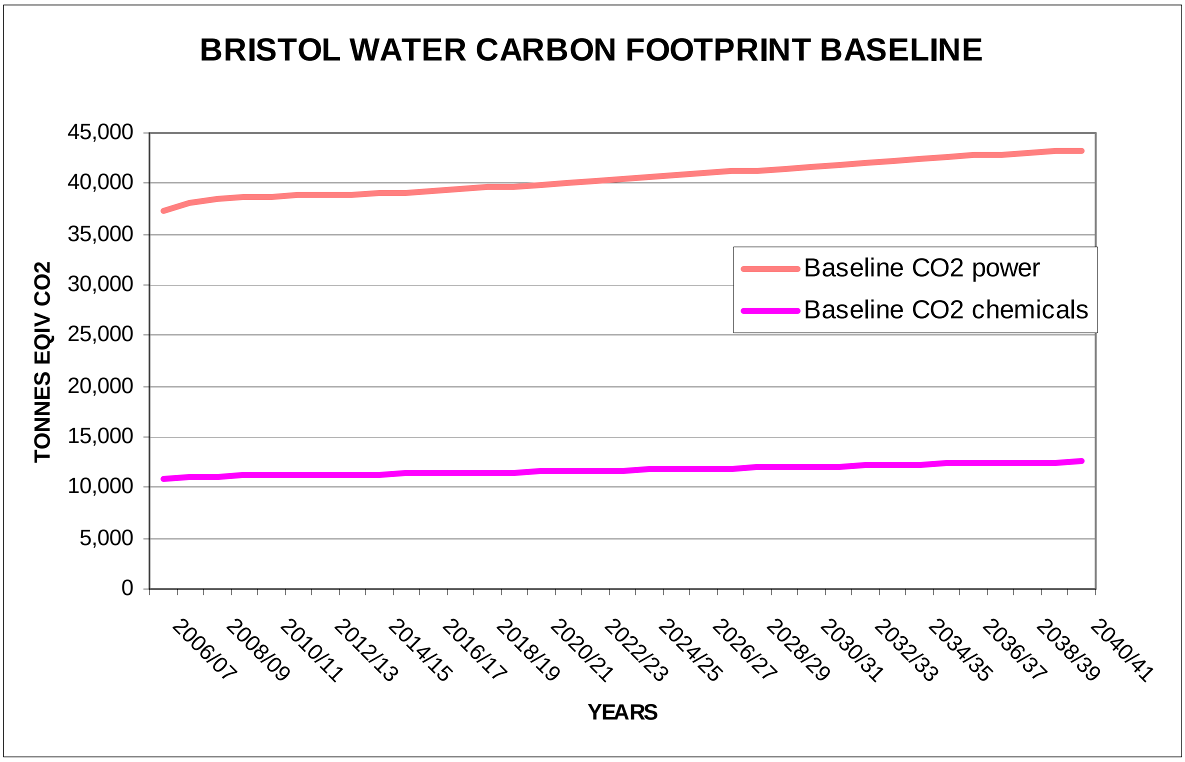
The largest contribution to CO_2 comes from the power required to transfer water across the supply and distribution system. Over the past four years, company emissions have been relatively stable at 38,000 tonnes CO_2 p.a. from energy use and 3000 tonnes CO_2 p.a. from the use of treatment chemicals, as shown in the graph below. In addition, vehicle movements associated with operation, maintenance and repair account for a further 1000 tonnes of CO_2 emissions.



11.5.2 Baseline future carbon dioxide emissions

In assessing the implication of the baseline forecast on future emissions, we have taken account of power use per Ml and Chemical use per Ml over the next 25 years. The power constant of 803 kWh/Ml is unlikely to vary significantly in future. We have made the same assumption for chemical consumption/Ml (although in reality, this may increase slightly if further treatment processes are required in future comply with changed drinking water standards). We would expect that the general overhead of emissions from office and vehicular activity to remain broadly constant at the current value of one eleven hundred tonnes p.a.

The graph below shows the forecast increase in carbon emissions due to the increasing demand for water (dry year).



11.5.3 Scenario future carbon dioxide emissions

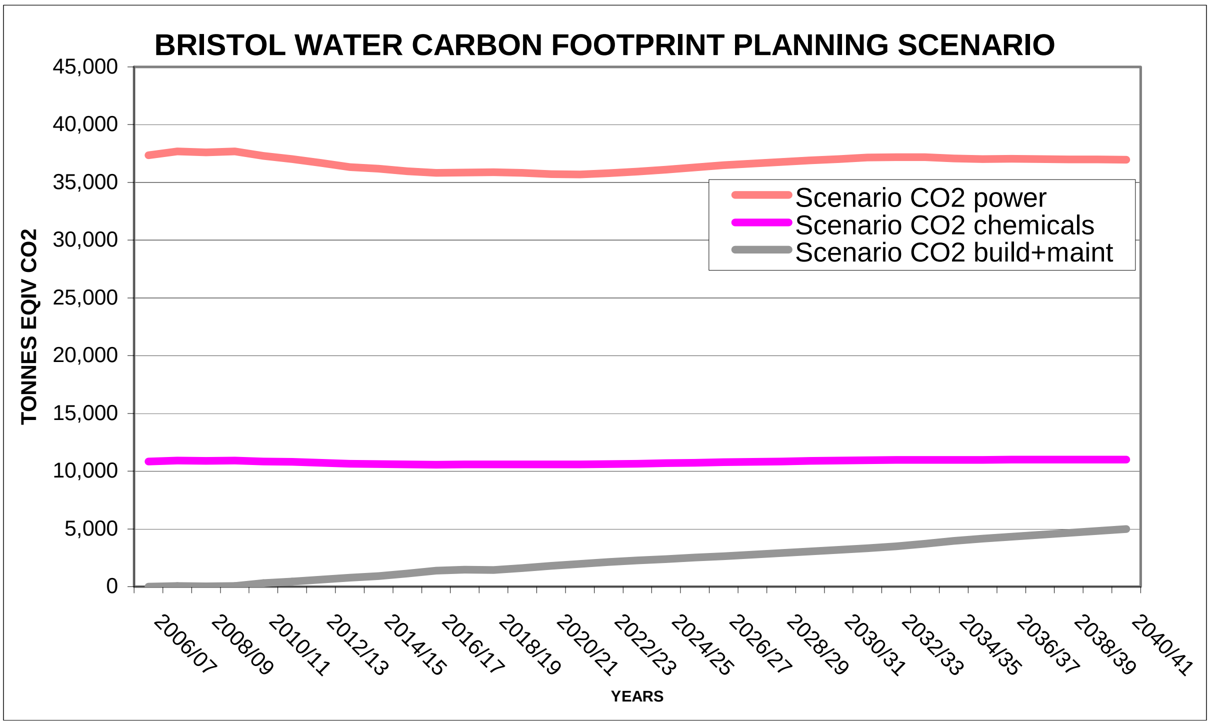
Our proposed water resources management plan is based upon implementation of number of options designed to increase water efficiency, reduce leakage and eventually provide further water resources. The timing and scale of options described in section 10, have been optimised over the 25 year period to arrive at the lowest cost solution to resolve the developing supply demand deficit and maintain current security of supply.

In considering the options to manage supply and demand, we have calculated for each case the following:

- The embodied carbon in construction materials such as meters, concrete and pipe
- The carbon associated with the process of construction (related to project scale)
- The extra power required (or saved if an efficiency option)
- The carbon associated with vehicle movements for construction
- The carbon associated with vehicle movements for operation and maintenance

The cost benefit analysis carried out within the optimisation routines takes account of all of these impacts as well as the shadow cost of carbon. This is one of the factors driving the optimisation of options to favour schemes that help to improve overall efficiency of water use through leakage or demand reduction.

The impact of the preferred scenario on carbon dioxide emissions is shown in the graph below. As can be seen, effect on carbon emissions is significant with respect to the decrease in power consumption. However, carbon dioxide emissions are still largely a function of water demand. The total carbon dioxide emissions would be the sum of all components in the graph for any year.



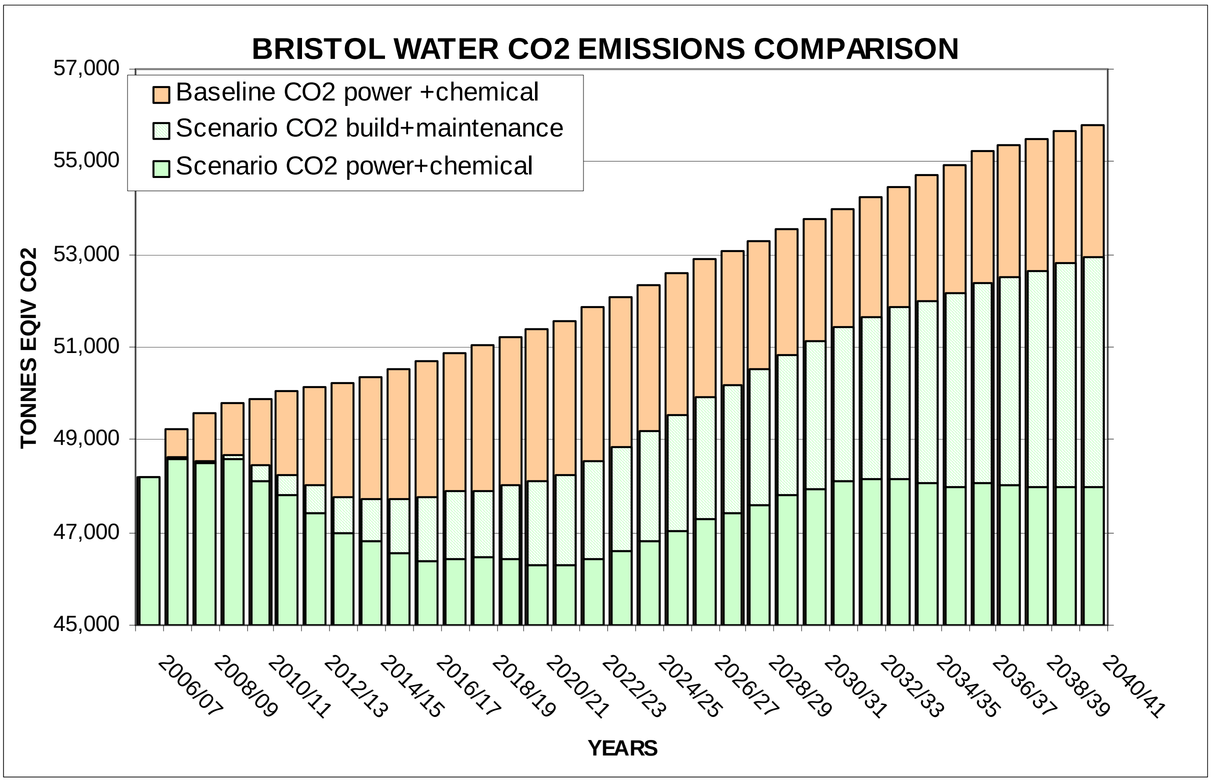
Over time, the company preferred scenario is effectively ‘carbon neutral’ in terms of power consumption. By focusing on the most cost effective options to improve all aspects of water efficiency, in the early years of the scenario, the volume of water pumping required to meet demand is reduced. However, there is an increasing carbon dioxide emissions component due to the addition of meters and extra meter reading, together with the replacement of service pipes as identified in our preferred scenario. This is small in the early years, but increases as the metering base increases.

Eventually the early reductions in emissions from reduced distribution input are overtaken by additional construction and the growth in population after leakage reduction options have achieved their maximum yield. In the longer term, the growth effects on power are mitigated by the continuing programme of communication pipe and supply pipe replacements, together with universal metering that results in improved water efficiency. However the extra ongoing carbon impact of metering results a steady increase in emissions to the end of the plan. The final outturn is for a lower level of carbon dioxide emissions than predicted for the baseline condition.

The comparison of the baseline emissions forecast with the company preferred strategy is shown in the graph below. The main driver for carbon dioxide emissions is the volume of water pumped. Because of this, it is unlikely that there could be a significant emissions reduction as a result of planning further reductions in distribution input.

For example, it may be possible to half the carbon emissions by halving the water put into supply. However, this would imply a per capita consumption of less that 60 lcd across the household customer base. It would not be feasible to achieve this with the current set of policies in the context of a 'business as usual' forecast.

Further reductions in carbon dioxide emissions would need to be achieved by policy and actions that are not directly connected with issues of the supply demand balance.



The graph shows the baseline total CO2 emissions from power and chemical use as the background in light brown. The green foreground shows emissions associated with power and chemical use as the solid green bars and the component due to construction as hatched green bars, to give the cumulative total for the company scenario compared to the baseline

11.6 Sensitivity of strategy

We have tested our preferred option list against different scenarios to investigate the change in costs and see if alternate strategies emerge. The scenarios investigated are:

- Growth rate for populations and properties at the higher RSS forecasts.
- Growth rate at higher RSS <u>and</u> maximum impact of climate change on source yield.

The balance and timing of schemes in our strategy favours those targeted at reducing leakage and improving water efficiency. This approach has not changed as a result of the sensitivity analysis set our below. The optimisation process still tends to favour leakage and metering schemes. However, in both scenarios the supply demand deficit occurs much earlier and is much larger than for the company forecast.

The overall costs of the strategy for both scenarios increases due to the difference in timing that options are implemented to restore the supply-demand balance.

11.6.1 Regional Spatial Strategy (RSS) high growth scenario

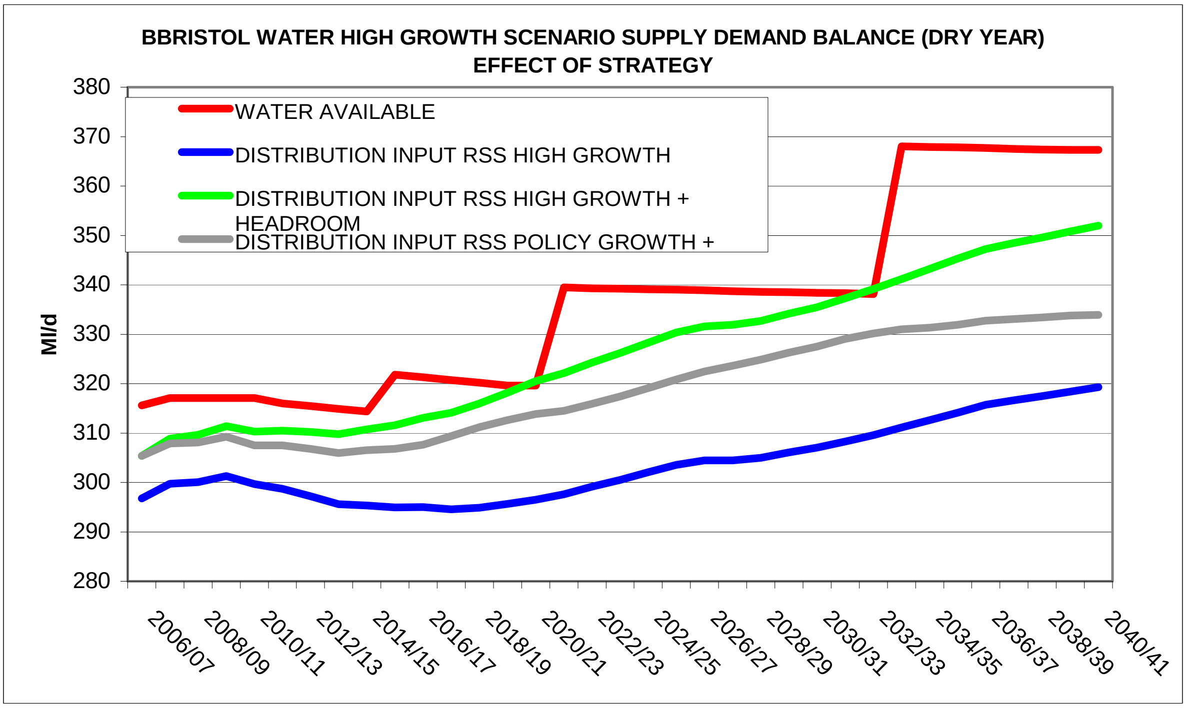
The Southwest Regional Assembly (SWRA) produces forecasts of population and housing growth for the region based on planning policy. We have so far considered the RSS preferred planning policy (identified as scenario zero in their documentation). This is the planning policy for population and housing growth that the local authorities in our water supply zone appear to have used, as there is a very close match between the policy and the planning forecasts.

The SWRA have produced alternate versions of the RSS, with differing distributions of population and housing. RSS scenario 2 is the SWRA high growth scenario. This policy forecasts an additional 5000 properties on top of the 23,000 new properties per annum to be built across the region. The extra properties will be specifically targeted at designated urban growth point, including Bristol.

Using this growth strategy has the following effects:

- Annual housing build increases by 25% to 6500 p.a.
- Annual population increase by 50% to 10,000 p.a.
- The implementation of options is advanced and more are required
- By 2035, population will increase by 25% to 1.35 million
- By 2035, number of houses will increase by 35% to 620,000
- All resource development schemes are advanced by approximately 5 years
- Cheddar reservoir enhancement required by 2021
- City docks transfer scheme required by 2031

The impact on demand and the supply demand balance is illustrated in the graph below, which also shows the comparison between the high growth planning forecast of demand (as distribution input) and the planning forecast of demand used in our preferred strategy.



The options implemented are very similar to those in our preferred forecast, including:

- Meter installation – progress to fully metered by 2035 (effectively a maximum rate)
- Pressure reduction schemes and zonal monitoring all implemented by 2015
- Infrastructure CP and SP replacement at maximum cost effective rate
- Rapid early increase in leakage control to bring leakage down

The major difference to the normal growth scenario is the optimisation model implements the refurbishment of minor Mendip sources and Cheddar reservoir enhancement at an earlier stage. The component of headroom generated at this time means that further reductions in leakage below 43 Ml/d do not become socially or economically cost effective until 2028. After this date, further leakage reductions continue until it becomes more cost effective to construct the third resource option. Bristol city docks to Barrow transfer.

The total NPV of costs to implement all of the options to reduce demand and ensure there is sufficient water available is:

NPV of total solution	£ 195	million
NPV of Carbon costs	£ 1	million
NPV of Social Costs	£ -96	million (due to reservoir construction)
Total Scenario Costs	**£100**	**million**

11.6.2 High growth and maximum climate change impact

This scenario predicts assumes the highest policy driven forecast of growth, together with the maximum predicted effect of the impact of climate change.

The effect of the higher growth rate for populations and properties is detailed in the section above.

There are three forecast for the impact of climate change upon the yield of water resources (effectively reducing the water available). The 'average' climate change impact is considered in our company strategy as required by guidance.

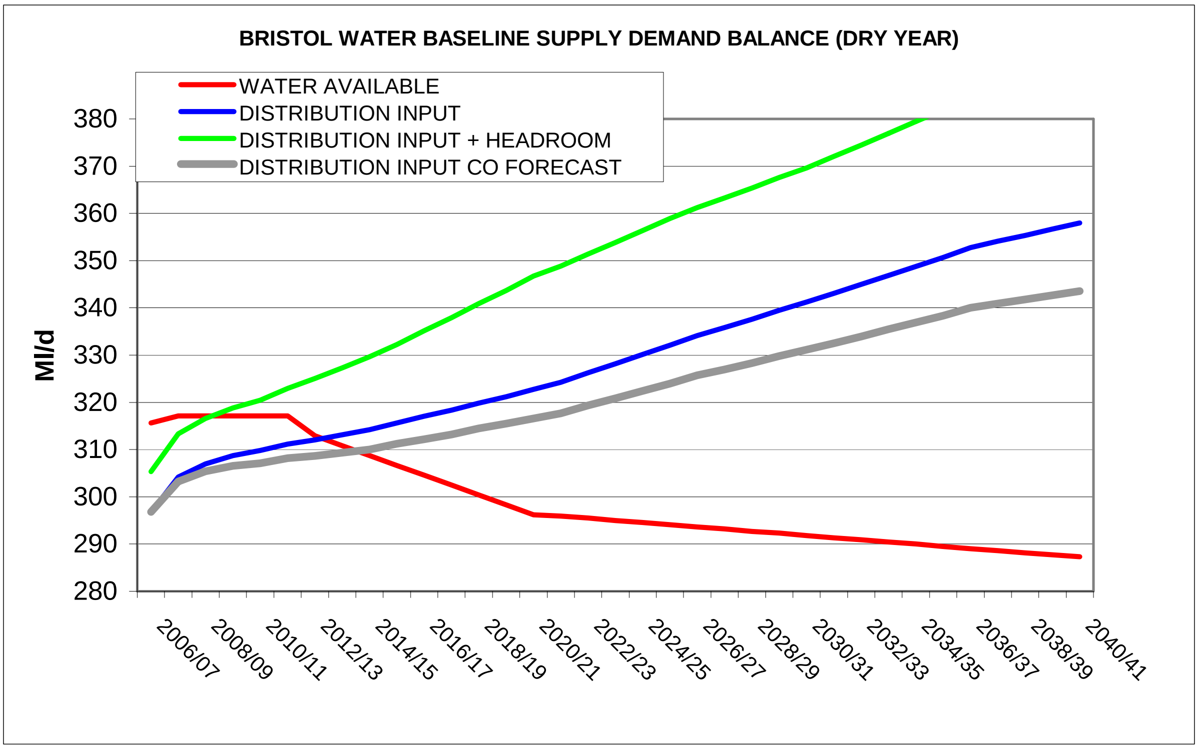
The effect of the UKCIP 'dry' forecast has been explained in section 7. This is summarised as:

- Overall reduction in water available of 10% by 2035
- Rapid reduction in water available by 21 Ml/d at 2025
- Water available reduced by 30 Ml/d by the end of the planning period

When these effects are combined with rapid growth, balancing supply and demand becomes challenging, as maximum rate of growth in demand for water occurs during a period of maximum climate change effect. This scenario is effectively 'the worst case' under the present planning policies available (Updated UKCIP climate models will be available late in 2008).

Demand for water may also be slightly higher than predicted, as we have not considered the further effect of the 'dry' scenario as an additional driver for water demand (over that predicted for the 'average' climate change scenario). Undoubtedly, demand for water will increase if the average UK summer temperatures increase significantly. However, the effect is not likely to be material when compared to the impact magnitude of growth and reduction in water available and growth. We would not expect per capita consumption to rise to the levels observed in southern Europe (in the range 190ld to 260 ld).

The graph below shows the impact of high growth and maximum climate change impact on the baseline supply-demand balance.



The options implemented to restore the supply-demand balance include:

- Meter installation – progress to fully metered by 2035 (effectively a maximum rate)
- Pressure reduction schemes and zonal monitoring all implemented by 2015
- Infrastructure CP and SP replacement at maximum cost effective rate
- Rapid early increase in leakage control to bring leakage down
- Continued leakage control to below 35 Ml/d
- Increase in infrastructure, CP and SP replacement

The major difference to the normal growth scenario is the optimisation model implements Cheddar reservoir enhancement at 2015, and the Bristol city docks to Barrow transfer in 2023.

The total NPV of costs to implement all of the options to reduce demand and ensure there is sufficient water available is:

NPV of total solution	£ 243	million
NPV of Carbon costs	£ 1	million
NPV of Social Costs	£ -95	million (due to reservoir construction)
Total Scenario Costs	**£149**	**million**

The effect of the optimum cost strategy on the supply demand balance is illustrated in the graph below, which also shows the comparison between the high growth planning forecast of demand (as distribution input) and the forecast of demand used in our preferred strategy.